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Journal of the British Astronomical Association

The core of Jupiter's Great Red Spot

Journal of the British Astronomical Association

Editor: **Mrs Hazel McGee**

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All other contributions should be sent to the Editor. As well as *Letters to the Editor*, she will be pleased to receive contributions to *Observers' Forum*, particularly interesting astronomical images, drawings and photographs. Colour images are especially welcomed. Photos and media will be returned only if a suitable stamped addressed envelope is enclosed.

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On the cover

The core of Jupiter's Great Red Spot

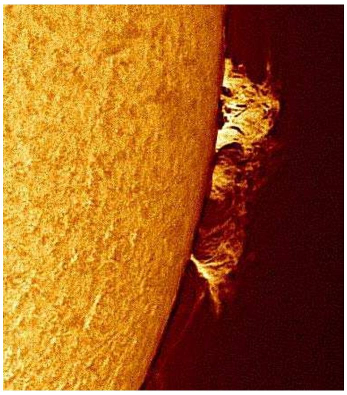
NASA's Juno mission has returned spectacular images of Jupiter from each of its close approaches to the planet. This image was received during Perijove 7 on 2017 July 11, when the spacecraft passed directly over the Great Red Spot. For more about the Juno mission, see John Rogers' article on p.193. *Image credit: NASA/SwRI/MSSS/Gerald Eichstädt/John Rogers*

Notes and News

From the President

I know that many members will be heading for the United States to stand in the Moon's shadow on August 21. For some this is an opportunity to witness a total solar eclipse for the first time. I wish everyone safe travels and clear skies and look forward to seeing photos and reports. For those staying in the UK, there will be a very small partial eclipse visible just before sunset – see Peter Macdonald's note in the April *Journal*, (**https://britastro.org/journal_item/9416**), and keep an eye on the website front page (**https://britastro.org**) for more as the time draws closer.

The Sun offers plenty of opportunities for observation, whether in eclipse or not, providing suitable precautions are taken. Although we are near sunspot minimum, there is still activity to be seen, especially if you have a hydrogen-alpha (Hα) telescope. Solar Section Director Lyn Smith has an Observer's Challenge on the Sun at solar minimum, with plenty of tips on what to look out for on our website. Why not share your results with fellow members by posting to your BAA Member's page? Do also send your observations to Lyn and, if you have not already done so, sign up for her monthly Solar Section *Circular*.



Prominences on the Sun's western limb in Hα on 2017 June 25. ***(Arthur Coombs, Victoria, Australia)***

Saturn has been putting on a grand show recently, although very low in the sky from my location. I needed to move the telescope around the garden to see it between trees, but it was well worth the effort especially with his rings resplendent. Andy Li took a fine image of the planet using an atmospheric dispersion filter, which helps to compensate for differential refraction at low altitudes. Have a look at the article by Damian Peach in the Tutorials section of the website for suggestions about combatting atmospheric dispersion: **https://www.britastro. org/node/9058**

Saturn on 2017 June 16 imaged with a Celestron C9.25, a ZWO ASI224MC camera and an Astro Systems Holland atmospheric dispersion corrector. ***(Andy Li, West Sussex, UK)***

Some of the best images we receive are displayed in the 'Picture of the Week' section of the website and having one's work selected is high praise indeed. I am very grateful to Paul Downing for managing this for several years. A recent Picture that caught my eye was of IC 1396, the 'Elephant's Trunk' in Cepheus. It was captured by Graham Winstanley, who imaged it not from a remote mountaintop with a large telescope, but from his observatory in Lincolnshire using an 80mm refractor!

IC 1396 – The 'Elephant's Trunk'. Skywatcher ED80 refractor. ***(Graham Winstanley, Lincolnshire)***

Chester Weekend meeting and a Lunar & Solar Observers' Workshop

I hope to see many of you in Chester on September 8–10 for what promises to be a most enjoyable BAA Autumn Weekend, with talks on the theme of 'Stars: Life and death of the Universe'. Our hosts are my own astronomy club, Chester Astronomical Society. We have a fantastic line-up of talks which take place on the Friday evening and all day Saturday. On Sunday morning there is an excursion to The OpTIC Centre at St Asaph in North Wales. You can come along to all or just part of the weekend. Spaces at the meeting are still available, but do book your place by August 21.

Also look out for our Lunar and Solar Observers' Workshop on Saturday September 30 at Burlington House in London. Participants will get advice on the latest techniques for observing these objects from experts in the field. There will be plenty of time to ask questions about what particularly interests you.

Further details of both events, including how to book, are on the BAA website.

New Scientist Live 2017, a visit to the Royal Society and Back to Basics in King's Lynn

The BAA will again participate in the *New Scientist Live* science festival, taking place at ExCeL London from September 28 to October 1. The show will feature five exhibition zones covering Humans, Engineering, Technology, Earth and Cosmos, whilst playing host to over 100 speakers in 6 lecture theatres. The gathering of more than 20,000 people with an interest in science under one roof offers a great opportunity to promote the BAA and amateur astronomy. If you do come along, be sure to visit stand 441 and say hello to Janice McClean and her band of helpers from Hampshire, Newbury, Crayford & Flamsteed Astronomical Societies.

Another regular fixture in the calendar concerning public science outreach is the Royal Society Summer Exhibition, held since 1770, and I was proud to be invited to attend a Soirée to mark the occasion. The walls of the Royal Society's premises overlooking the Mall in London exude history and I enjoyed viewing exhibits on Isaac Newton, William Herschel and other great astronomers who once were Fellows of the Society. But it was the displays about current research that really caught my imagination. I had many opportunities to speak to other guests about the BAA and its objectives in promoting amateur astronomy at home and abroad.

We are honoured to count a former President of the Royal Society, Sir Paul Nurse, amongst our members. Sir Paul won the Nobel Prize for Physiology or Medicine in 2001 and is currently Chief Executive and Director of the Francis Crick Institute in London. Sir Paul re-

Andrew Bate, Chair of Chester AS shows the Lord Mayor of Chester the Sun during a public observing event for the partial solar eclipse of 2015 March 20.

Meeting an early career researcher at the Royal Society Summer Science Exhibition in London.

lates how his interest in science was kindled as a boy through his fascination for astronomy and space. Describing himself as very much an amateur astronomer, his love of observing the night sky has stayed with him and somehow he still finds time to observe with his 14cm refractor and 30cm SCT.

Making the first steps in practical astronomy can be daunting – the BAA Back to Basics Workshops are designed to address questions such as what telescope and equipment you need and what you can observe. Our next Workshop will be held in King's Lynn, Norfolk, on Saturday October 7. Do encourage any beginners you might know, whether members of the Association or not, to come along.

A new member of the BAA team

I am delighted to announce that Andrew Wilson has recently joined the Office team as our Systems Administrator and Web Content Editor. Andy knows the Association well, being a long-standing member with a particular interest in variable stars and spectroscopy – he developed both the VSS database and the spectroscopy database for us. He holds undergraduate degrees in Astronomy & Physics from UCL, and Mathematics from the Open University, and brings with him a wealth of experience of software development and business analysis in the finance industry. He is currently studying part time for a PhD in Astronomy at the University of Exeter.

We are very lucky to have Andy joining the team and I wish him well in his new rôle. Dominic Ford continues to have overall responsibility for the website as Website Manager.

New BAA systems administrator Andy Wilson.

Elections, subscriptions and international members

You should find your ballot paper for the election of the next Board of Trustees and Council included with this *Journal*. I am pleased to see that we have a strong field and I'd like to thank all the candidates for standing and for showing their willingness to support the Association in this vital way. Do note that this year there are more candidates than places, which is a healthy situation for any organisation. So every vote counts – please read the candidates' notes and make your selection. This is one way you can share in the governance of your Association and show your support for those wanting to serve the BAA.

Most members will also be due to renew their subscription on August 1. If you pay by Direct Debit you need do nothing unless your bank details have changed, as your renewal will be automatic. However, if you still pay by cheque or credit card, please remember to renew as soon as possible. You can do this either by post or on the BAA website at **www.britastro.org/renew now**. If you are a UK taxpayer and have not already done so, please let us know if you are happy for us to reclaim your tax via Gift Aid. This really does help the Association financially and it won't cost you a penny extra!

From August 1, new members living overseas will be able to join the Association using

Commission for Dark Skies

Cranborne Chase AONB dark skies initiative recognised with CfDS' Joy Griffiths Award

The Commission for Dark Skies' Joy Griffiths Award for 2017 was presented on June 5 to Linda Nunn, Director of the Cranborne Chase Area of Outstanding Natural Beauty (AONB). The terms of the award specify that it is to be given to an individual, but both CfDS and the AONB staff understand that a team effort was very much what was being recognised.

Sky Quality Meter readings taken by CfDS members on moonless nights on the Chase confirm that its northern half, away from the large conurbation of Bournemouth and Poole beyond its southern border, has the darkest skies in south central England. The 380-square-mile Cranborne Chase AONB, which spans the border between Dorset and Wiltshire, aims to become the UK's first AONB to achieve International Dark Sky Reserve status within the scheme promoted by the International Dark-Sky Association (IDA).

Linda and the team have done sterling work to publicise and perpetuate the area's starry skies, and the Wessex Astronomical Society and the Commission for Dark Skies have supported them with observing evenings and talks to raise public awareness of their precious asset. More details of this work can be found on the excellent website www.chasingstars.org.uk which advertises stargazing events, and gives advice on good lighting and exploration of the night sky.

Among the many previous recipients of the Joy Griffiths Award are Emma Marrington, light pollution campaign officer at the CPRE, James Abbott, tireless dark-skies advocate in Essex, and CfDS committee member Daniel Nixon (**www.need-less.org.uk**), who has produced some wonderful graphics on light pollution and recently designed the Commission's striking display screen and banners.

Bob Mizon, *Coordinator, CfDS*

Howard Lawrence (*left*), CfDS committee member, and Bob Mizon present the award to Linda Nunn. *(Photo by Julie Harding, Cranborne Chase AONB.)*

our new digital membership category. This has all the benefits of traditional membership, but with the *Journal* and *Handbook* delivered digitally. The BAA enjoys an international reputation and has members in 44 countries worldwide – we hope that the lower cost associated with digital membership will encourage many more international members to join our global community. For further details about international digital membership, visit **https://britastro.org/digital**.

We plan to roll out digital subscriptions to UK members during the coming session – watch this space! And of course traditional subscriptions, with printed publications sent by mail, will always still be available to members both at home and overseas.

The BAA Journal Editor

Finally, I have to let you know that our longstanding *Journal* Editor, Hazel McGee, has signalled her wish to stand down from the position at the end of the 2017/'18 session, *i.e.* in 2018 October, coinciding with the end of her 25th year in the rôle. The *Journal* is the Association's flagship publication, presenting the observations and work of all BAA members, and is highly regarded by astronomers around the world. The Association is most grateful to Hazel for her unstinting service and her diligence over the past quarter of a century during which she has carried the *Journal* from strength to strength.

We are therefore starting to look for a new person, or possibly a group of people, to take on this responsibility. Hazel has offered to help with training and any transition for as long as is required. Might this be something you or someone you know could be interested in becoming involved with? If so, do get in touch in confidence with Hazel or myself for an informal chat.

Jeremy Shears, *President*

Jupiter Section

NASA's *Juno* provides spectacular views of Jupiter

NASA's *Juno* mission has been proceeding perfectly since the last report in these pages [*Journal* vol.**126**(6), p.333 (2016)]. Aficionados of Jupiter have settled into a 53-day cycle of activity synchronised with *Juno*'s orbits. The spacecraft passed through its seventh close approach (perijove-7) on 2017 July 11, when it passed directly over the Great Red Spot, and took splendid close-ups of it including the one on the cover of this *Journal*.

Although the mission is primarily to study the interior of the planet, its most eye-catching results are those from the 'public outreach' camera, JunoCam. The quality of the images in mid-latitudes is now astonishing, surpassing the *Voyager* close-ups. At perijoves-5 and 6 they revealed a plethora of tiny bright clouds casting shadows, widespread over many regions of the planet, which had rarely if ever been seen before.

Images from amateur observers are essential for putting the spacecraft images in context, and are also used by the undersigned, in collaboration with the *JUPOS* team, to predict what will be visible under *Juno*'s track at the next perijove. Thus we recommend what imaging targets will be most worth voting for, and so far, our recommendations have all been 'elected'. They include long-tracked ovals in various zones, and also belts which are changing with major cycles of activity. *Juno* images have monitored the North Temperate Belt ('Big Red Stripe'), maturing after its spectacular revival late last year, and also the North Equatorial Belt (NEB), which has produced many convective storm outbreaks and has rapidly broadened to the north. Even when no specific features are targeted, the turbulent chaos of the high temperate latitudes is dazzling.

JunoCam's images of the polar regions are revealing previously unknown features, now being studied by the mission's scientists. Turbulent patches and small anticyclonic ovals are scattered throughout most of the polar regions, although there is a strange 'bland zone' at ~60–65°N, between the two most northerly jets, which contains long narrow haze bands. Other haze bands are widespread over the polar regions, sometimes appearing to cast brown shadows. At the poles themselves there are clusters of circular cyclones, quite unlike the poles of other planets.

Meanwhile the first science results, mainly from perijove-1, have been released by NASA and published. Of most relevance to those of us concerned with the atmosphere, the first north–south scan with the Microwave Radiometer has led to a surprising model for ammonia distribution in the deep atmosphere. It suggests that the visible pattern of belts and zones does not extend below the known cloud layers; instead, from there down to ~60 times Earth's atmospheric pressure, there is a previously unsuspected layer, depleted in ammonia, except for enhancement (a rising plume?) under the northern equatorial zone and futher depletion (sinking?) under the NEB. If this model is confirmed by further observations and analysis, the planet's dynamics will have to be re-thought. At even deeper levels, the first low-altitude pass through the gravitational and magnetic fields suggests that these also differ from expectations. It looks as though the *Juno* mission will indeed give important new insights into Jupiter's interior.

NASA has decided to leave Juno in its present 53-day orbit, rather than risk firing the main engine again. Future perijoves will be on 2017 Sept 1, Oct 24, Dec 16, and 2018 Feb 7, April 1, May 24, July 16... and so on.

John H. Rogers, *Director*

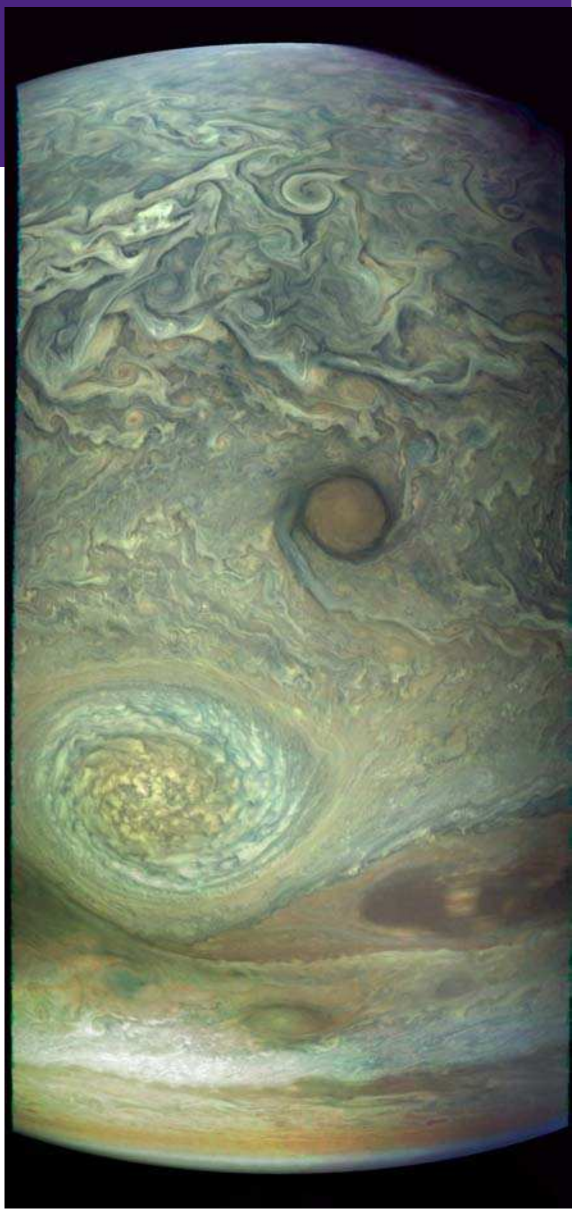


Image 53: This image from *Juno* on July 11, taken from an altitude of 11,444 km, shows turbulent chaos in the high northern latitudes at top, and a long-lived anticyclonic oval named NN-LRS-1 just below and left of centre. The dark circle near the centre is a smaller anticyclonic vortex. The North Temperate Belt is at the bottom. ***NASA / SwRI / MSSS / Gerald Eichstädt / John Rogers***

Notes and News

Asteroids & Remote Planets Section

The Triton stellar occultation of 2017 October 05

On 2017 October 05 Triton, the largest satellite of Neptune, will occult a 12.7 V-mag star, visible from the US east coast, Northern Africa and Europe. This will be the first opportunity to monitor Triton's current atmospheric state and possible changes since the 1990s.

Introduction

On 2017 October 05 Neptune's largest satellite Triton will occult the 12.7 V-mag star UCAC4 410-143659, as seen from the US east coast, Northern Africa, and Europe. After almost 10 years since the last documented Triton occultation (observed on 2008 May 21), this event will be a new opportunity to gather data about Triton's current atmospheric state and possible changes.

About Triton

Triton is the largest natural satellite of Neptune. It was discovered on 1846 October 10, by the English merchant and amateur astronomer William Lassell (1799–1880), just 17 days after the discovery of Neptune itself by the German astronomer Johann Gottfried Galle (1812–1910). The satellite is named after the Greek sea god Triton, the son of Poseidon. The name was proposed by Camille Flammarion in 1880, though until the discovery of the second moon Nereid in the year 1949, the name was not used and Triton was commonly referred just as 'the satellite of Neptune'.

With a diameter of 2700 km, Triton is the seventh-largest moon in the Solar System. Its mean density is 2.061g/cm^3. Triton orbits Neptune in a retrograde, almost perfect circular orbit with a sidereal period of about 5.9 days, at a mean distance of 354,760 km or 14.3 Neptune radii. In contrast to the Earth–Moon system the tidal interactions with this retrograde motion of Triton will cause it to spiral inward on a long-term scale. As soon as Triton falls inside Neptune's Roche limit this will result in a collision with Neptune and/or a tidal breakup of the satellite, forming a ring system similar to that around Saturn.

Because of its retrograde orbit (moons in retrograde orbits cannot form in the same region of the solar nebula as the planets they orbit), and its size and composition which is similar to Pluto, Triton is believed to be a dwarf planet captured by Neptune's gravity from the Kuiper Belt.

Similarly to Pluto, Triton has a thin nitrogen-dominated atmosphere, driven by surface ices, primarily N_2 and CH_4 frost. From stellar occultations[1] we know that Pluto's atmosphere has changed significantly due to seasonal effects (doubling of atmospheric pressure between 1988 and 2002). Pluto's orbit is much more elliptical than that of the other planets, and its rotational axis is tipped by a large angle relative to its orbit. Both circumstances in combination cause this effect.

As the heliocentric distance of the Neptune–Triton system doesn't change very much over a sidereal period of about 165 yrs, due to Neptune's nearly circular orbit, Triton's seasons are caused by a combination of exceptional orbital plane and spin axis orientations and the influence of Triton's orbital precession period (~680 yrs). Triton's orbital inclination wrt Neptune's equator is 157° (an inclination over 90° means retrograde motion) while Neptune's axis is tilted by ~30° against its orbital plane. Thus Triton's spin axis tilt wrt Neptune's orbit can vary between 127° and 180° (the current value is 130°),

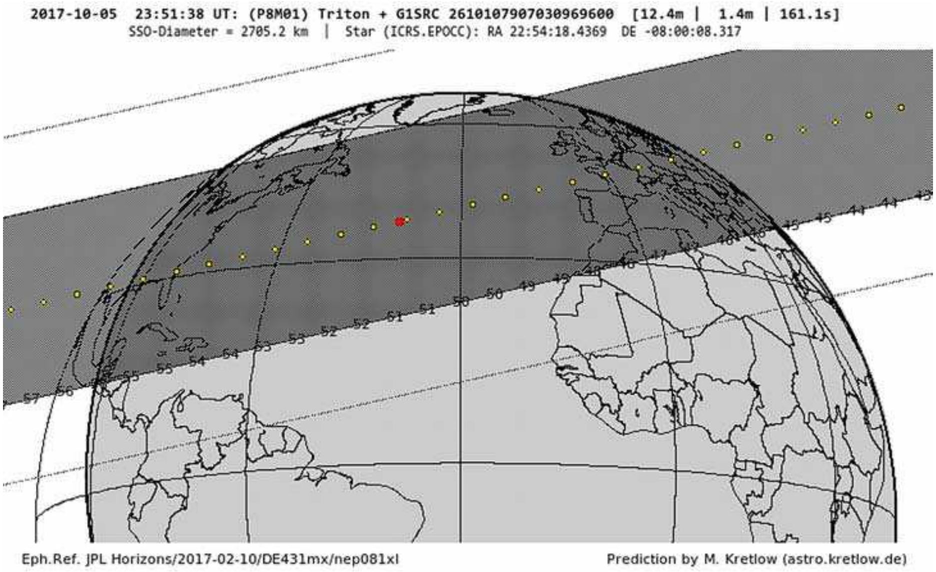


Figure 2. Prediction of the occultation by Triton on 2017 October 05 by the author using JPL's nep081xl+DE431mx ephemeris and *Gaia*'s DR1 star position. Later a *Gaia* DR2 pre-release star position became available, but the shift wrt to this DR1 release is marginal (some 10 km in cross-track direction and some seconds in time). The red dot marks the central occultation time (23:51:38 UT); the yellow dots correspond to the time ticks (seconds) on the southern shadow border.

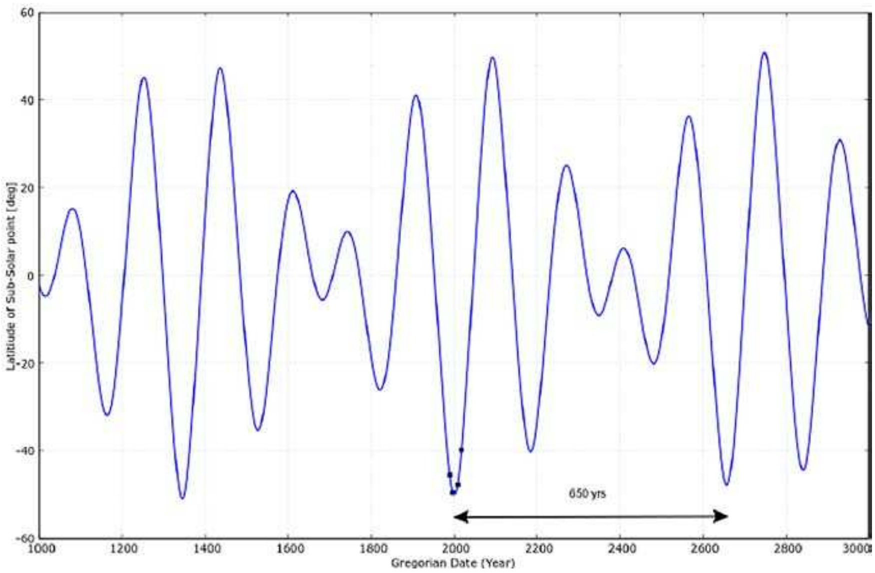


Figure 1. In the year 2000 Triton underwent an 'extreme' solstice, where the sub-solar point reached 50° South. This happens about every 650 yrs. The following events (in time order) are marked by a dot: (1) The *Voyager 2* flyby in 1989 August; (2) the stellar occultations of 1997 Jul 18 and (3) 2008 May 21 and (4) the upcoming stellar occultation of 2017 Oct 05. Data computed with IMCCE's Miriade service (http://vo.imcce.fr/webservices/miriade/).

Table 1. Main occultation data and circumstances for the UK

Date	Thursday 2017 October 5
Observing time for UK	23:48 UT ± 5 to 10 minutes (suggested recording time)
Star position (Gaia DR2)	RA 22 54 18.4364; Dec –08 00 08.318
Star magnitude	12.7V, 12.5R, 12.4I (APASS magnitudes)
Triton magnitude	13.5V
Magnitude drop	1.4 mag
Maximum duration	161 sec

giving it extreme seasons. The superimposition of Neptune's 165 yrs orbital period and Triton's ~680 yrs orbital precession period results in a double sinusoidal waveform as the Sun (or the latitude of the sub-solar point) shifts alternately north and south with a varying amplitude (see Figure 1).

Currently the southern hemisphere of the satellite is being illuminated by the Sun, after centuries of winter. Every 650 years a hemisphere faces an 'extreme solstice', as was the case in 2000 for Triton's southern hemisphere, where the sub-solar latitude reached 50° south.

From occultation observations in 1997 Elliot *et al.*[2] derived a global warming on Triton and a significant increase of atmospheric pressure since the 1989 *Voyager 2* flyby.

Another 10 years passed before another stellar occultation by Triton was successfully recorded.[3] Unfortunately the geometry of the chords (two almost grazing chords at the southern limb) limited the derived astrometry and therefore, within a 3-sigma confidence level, no significant value of the atmospheric pressure (and possible changes since 1997) could be derived. It is important to note that with occultation chords from the 2017 October 05 occultation, these data from 2008 can be re-analysed and possibly a reliable result for the atmospheric pressure can be retrospectively obtained.[4]

Scientific rationale

The stellar occultation technique is a very powerful tool for probing and monitoring planetary atmospheres. Not only can the atmospheric pressure be measured, but also haze layers can be detected through multi-wavelength observations, and by observing the so-called central flash, wind regimes in the atmosphere can be analysed.

Key questions are:

– What is the current atmospheric state (pressure)?

– Are there any (drastic) changes since the 1990s?

– Are the haze layers seen by *Voyager 2* in 1989 still present?

– Can wind regimes be constrained from central flash observations?

Predictions

Occultation predictions for this event are provided by several sources. For example by theEuropean Research Council (ERC) Lucky Star project group (**http://lesia.obspm.fr/lucky-star/predictions**) and by the author on his website (**http://astro.kretlow. de/?Occultation-Predictions**). See also Figure 2. The main occultation circumstances for the UK are given in Table 1.

Observation campaigns

Further information in addition to practical tips and suggestions will be available from a variety of websites, like the International Occultations Timing Association, European Section (IOTA-ES) (**http://iota-es.de**), BAA ARPS (**http://britastro.org/asteroids**) and dedicated individual webpages.[5,6] Announcements on mailing lists like PLANOCCULT and the release of a BAA e-bulletin are also planned.

It is noteworthy that SOFIA (Stratospheric Observatory for Infrared Astronomy) is also scheduled to observe this occultation.[7,8]

Some practical issues

1. The elongation to the full Moon will be only 34° at the time of occultation.
2. The angular separation between Neptune and Triton will be ~12 arcsec at occultation time. The use of a Barlow lens might be indicated for a better separation of the planet and the satellite.
3. Neptune will be much brighter and probably saturated on most cameras, so it cannot be used as a photometric reference object.
4. It is important to measure the target (occulted) star against reference stars on at least one night before (or after) the event, when the stars and Triton are clearly separated). This makes it possible to calculate the contribution of the occulted star to the total flux (star + Triton) during the event, and then to subtract Triton's flux from the lightcurve.

Mike Kretlow, *IOTA-ES*

Rittergut 1, 27389 Lauenbrück, Germany.
[mike@kretlow.de]

References

1 Sicardy B. *et al.*, 'Large changes in Pluto's atmosphere as revealed by recent stellar occultations', *Nature* **424**, 168–170 (2003)
2 Elliot J. L. *et al.*, 'Global warming on Triton', *Nature* **393**, 765–767 (1998)
3 Sicardy B. *et al.*, 'The Triton stellar occultation of 21 May 2008', *EPSC 2008* abstracts (2008)
4 Sicardy Bruno, *pers. communication* (2017 July)
5 Webpage by Tim Haymes, Assistant Director (Occultations), BAA Asteroids & Remote Planets Section. **http://www.stargazer.me.uk/call4obs/NextEvent.htm**
6 Webpage by Mike Kretlow, **http://astro.kretlow.de**
7 Person M., 'A new look at Triton's atmosphere', *SOFIA Proposal, Cycle 5*, ID. 05_0125 (2016)
8 **https://eclipse2017.nasa.gov/content/sofia-triton-occultation-observations**

Tim Haymes (BAA ARPS) adds:

Many thanks to Mike for an excellent introduction to this important occultation.

Suggested instrumentation would be of long focal length (e.g. SCT or Newtonian + Barlow lens) and CCD/video at 1 sec exposure (say), shorter if possible. We recommend trial observations of Triton on an earlier night (preferably the night before), or during the lead up to the event itself. The occulted star will be brighter than Triton but a full Moon will also be close by, so it may be worthwhile erecting a temporary 'moonshade' to prevent moonlight entering the telescope directly. Since timing is important, computer clocks need to be sync'ed to UT. For more information on video & CCD monitoring of occultations, see the web pages referenced in Mike Kretlow's article.

The ARPS Section would also be pleased to receive visual observations from observers using telescopes of 30cm aperture or larger in good seeing. At 10 arcseconds separation from Neptune, the 12.5-mag star will be a difficult object but do give it a try! Visual observers could make audio recordings (*e.g.* with a smartphone), adding a UT time marker at the start and end of recording to a precision of ±0.5sec or better.

Please send observations to the ARPS (Dr Richard Miles, **arps@britastro.org**) copied to Mike Foulkes (Saturn, Uranus & Neptune Section), **mike.foulkes@btinternet.com**.

Good luck and clear skies!

Tim Haymes, *Assistant Director, Occultations*
[tvh.observatory@btinternet.com]

Notes and News

Aurora and NLC Section

Auroral & NLC activity, 2017 April 28 – June 25

With no coronal mass ejections and sunspot numbers only just in double figures or at zero, the majority of aurora sightings are now coming from coronal holes. Activity on the Sun is in its downward trend and aurorae are now few and far between. It is also now too light to see aurora in northern Scotland, and that will be the case until early August. And yet on May 27/28 a weak CME struck, and aurora was picked up by Mary Spicer in Oxfordshire and Jay Brausch in North Dakota.

The NLC season started without warning on May 25/26 when NLC was noted by Adrien Mauduit in Odsherred, Denmark. It was detected again on May 30/31 by Ken Kennedy in Dundee and Don Mathews in Kincardine, Fife. Nothing more has arrived as I write this, and combined with the bad weather, the lack of information from the AIM satellite means we are back to ground based observers for any information.

For those who read my article in the December *Journal*, I have an update regarding the Proton Arc/Auroral Comet/stable auroral red arc (SAR arc). It is now called 'steve'! It seems this phenomenon was also seen in Canada and was published on their website by Canadian aurora hunters. They called it a proton arc and it came to the attention of Prof Eric Donovan at the University of Calgary. He knew it wasn't a proton arc since they can only be seen from space. So he contacted the Alberta Aurora Chasers and asked them to let him know when they next saw it. They decided to call it Steve, something a character in a book called something if he didn't know what it was, and they also went through their photographs to see the dates of previous sightings.

Meanwhile Prof Donovan checked with ESA's swarm satellites and found a satellite had passed straight through a beam. It turns out to be a jet of gas 300km above Earth's surface with a temperature of 3000°C above the surroundings, and the data revealed it to be 25km wide, flowing westwards at about 6 km/s compared to a speed of about 10m/s either side of the jet.

This was all worked out in a very short space of time and was the result of co-operation between professional scientists and the observing public, and it really does prove that the observations you send in do matter. It will be interesting to see how this develops, and where 'steve' stands in the general scheme of the planet's magnetic field.

Sandra Brantingham, *Director*

Meanwhile Assistant Director Ken Kennedy writes:

A rise in the mesospheric temperature in late May and early June led to virtually no NLC being seen in the first two weeks of June. This recovered from June 14/15 but there were still only relatively few displays during the remainder of the month. However, July has started with a bang and there were excellent and widely seen displays on July 01/02 and 02/03. The above image was taken by me in Broughty Ferry, Dundee on the night of July 01/02 at 01:37UT. You will see that it was a very complex display. I am now receiving quite a number of observations from these two evenings. The NLC season is back on course!

Panorama of aurora and 'steve' by Alan Clitherow on 2016 March 6/7, taken from south of Dundee.

Solar Section

2017 April

April showed an upsurge in white light activity in both hemispheres, especially the south. Overall activity all but doubled on March figures and the quality of sunspots also improved. However, some spotless disks were recorded and most observers reported no sunspots seen on Apr 8, 9, 15, 16 & 17.

AR2644 N12°/055° survived on the disk from March, now approaching the NW limb. The group was type Eao on Apr 1 with an area of 290 millionths, few sunspots being seen between the penumbral leader and follower. This situation changed the next day with many more sunspots and pores seen between the leader and follower. The group was type Esi on Apr 3 and a similar configuration persisted on Apr 4 when the group was rotating over the NW limb.

AR2645 S10°/016° also survived from the preceding month, being type Eac on Apr 1 with an estimated area of 420 millionths. The group was centre disk and seen with the protected naked eye on Apr 1, 2 & 3. The leader and follower penumbral sunspots were of approximately similar size with several smaller penumbral spots in between. The group was larger on Apr 2 with an estimated total area of 610 millionths, being type Ekc before reducing in area to 500 millionths on Apr 3 and 450 millionths on the following day. On Apr 5 & 6 the group extended further in longitude to become type Fac with no spots being seen between the leading and following sunspots on Apr 6. Only the following sunspots were seen close to the SW limb on Apr 7.

AR2648 S03°/293° was seen just over the SE limb on Apr 2 type Bxo consisting of just two small sunspots. The group had developed by Apr 4 consisting of a triangle of four small sunspots amid faculae. The group was of similar configuration on Apr 5 & 6 being type Bxo but was not seen in white light the next day.

AR2649 N15°/036° formed to the east of AR2644 on Apr 3 and was seen following close to that group on the following day as the larger group neared the limb. The group consisted of just two small sunspots type Bxo and crossed the NW limb on Apr 5.

AR2650 N08°/191° was first seen on Apr 10 close to the NE limb type Bxo consisting of two small sunspots, the strongest of which was the leader. The group was reported also on Apr 11, 12 & 13 with a maximum size of 50 millionths and achieving type Cso on Apr 11, type Cro on the 12th and a single Axx sunspot on Apr 13.

AR2651 N11°/069° rotated on to the disk on Apr 18 being type Dso on Apr 20 consisting of a small penumbral leader with a small sunspot to its north and a penumbral follower with double umbrae. By the following day the two leaders had merged to form one single penumbral sunspot, the follower remaining unchanged. The group developed to its maximum area of 150 millionths on Apr 24 and progressed across the disk rotating over the NW limb on Apr 30.

AR2652 N13°/060° formed on the disk to the east of AR2651 on Apr 24 consisting of four faint pores type Bxo. The group was also reported type Bxo on the following day.

AR2653 S10°/027° was seen close to the SE limb on Apr 21 a single Hsx type sunspot. The group developed to a small Dso type group by Apr 24 & 25 before reducing back to a single penumbral sunspot type Hsx on Apr 29 & 30. The group achieved a maximum area of 120 millionths on Apr 24.

15 observers reported a Quality number of 4.80 for April.

BAA sunspot data, 2017 April–May

Day	April g	April R	May g	May R
1	3	56	1	11
2	2	61	2	23
3	4	81	1	15
4	3	55	1	16
5	2	38	2	27
6	2	33	2	23
7	1	11	2	21
8	0	1	1	8
9	0	3	0	0
10	1	11	0	0
11	1	12	0	1
12	1	11	0	2
13	1	15	0	0
14	1	9	0	0
15	0	1	0	0
16	0	0	1	17
17	0	0	1	13
18	1	13	2	18
19	1	14	2	23
20	1	21	2	23
21	2	29	2	30
22	2	28	3	45
23	2	35	3	38
24	3	40	1	17
25	3	36	1	22
26	3	32	1	21
27	2	24	1	20
28	2	30	1	18
29	3	29	1	12
30	2	20	0	0
31			0	0
MDFg	1.60 (48)		1.07 (46)	
Mean R	24.93 (42)		14.99 (40)	

North & south MDF of active areas g

	MDFNg	*MDFSg*
April	0.97 (36)	0.70 (36)
May	0.85 (35)	0.23 (35)

g = active areas (AAs)
MDF = mean daily frequency
R = relative sunspot number
The no. of observers is given in brackets.

Prominences and a CME on 2017 April 14 imaged by Gary Palmer.

H-alpha

Prominences

22 observers reported a prominence MDF of 3.00 for April.

A loop prominence was seen on the SE limb on Apr 1 and also a double arch prominence was on the NE limb around 20,000km high and 120,000km long.

On Apr 3 a set of three arch prominences were on the NW limb with plasma extending from the southernmost prominence to the top of a central arch prominence. Two large arch-type prominences were on the NE limb on Apr 4 with a small prominence in-between. The larger prominence appeared almost twice as high as its northern companion, around 80,000km in height.

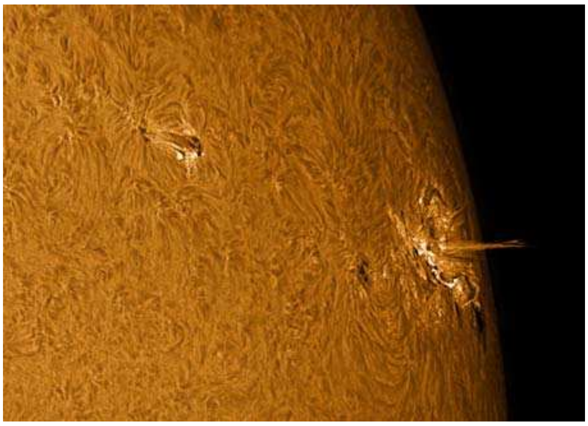
A detached prominence was seen on the NW limb on Apr 6 as well as a curtain type prominence on the NE limb around 30,000km high and 70,000km in length. On Apr 7 a hedgerow prominence was reported on the NW limb with arching at the northern end. On the NE limb, two fork type prominences were connected by a fine arch prominence.

A pillar prominence around 30,000km high was on the W limb on Apr 10 with a plume of plasma streaming from the top of the pillar, stretching to around 50,000km in length. On the same day, about 20° south of the eastern equator, a large square arch prominence was seen with scattered material within and surrounding it, estimated to be 63,000km high.

On the W limb on Apr 11, two pillar prominences were seen the larger being around 70,000km in height. The larger pillar was still present on the following day although the smaller one had gone. Also on Apr 12, a fine tall spire type prominence was reported on the NE limb.

A hedgerow prominence stretched across the NE limb for approximately 214,000km on Apr 15 and reached a height of around 47,000km. On Apr 19 faint post-flare loops were seen on the NE limb estimated to be 85,000km in height.

Notes and News



AR2644 with an eruptive prominence, and also AR2649, imaged on April 3 at 10:28UT by Gottfried Steigmann.

A column type prominence reached a height of 84,000km on the NE limb on Apr 24 and on Apr 28 an incomplete arch prominence also reached a height of around 84,000km. On Apr 29 a surge prominence with a small tilt to one side, was seen rising to around 50,000km.

Bi-polar magnetic regions, filaments & plage

18 observers reported a filament MDF of 1.86 for April.

At the start of the month, the large bipolar magnetic regions associated with AR2644 and AR2645 were very conspicuous. The AR2645 BMR was estimated at 215,000×110,000km, not as extensive as some of those observed at the end of 2016.

Plage seen with AR2648 on Apr 4 & 5 persisted on Apr 7 & 8 when the white light group was no longer visible. A filament was seen in the SW quadrant on Apr 14 around 110,000km in length which had extended to 140,000km the following day. On Apr 13 three distinct filaments were in the SE quadrant all rather complex in shape.

A long filament with a barb hook at its southern end was situated close to the CM on Apr 19 with an estimated length of 140,000km. On the following day AR2651 displayed plage and four filaments around the group.

On Apr 21 a strong filament was seen to the north of AR2651 and another long but more diffuse filament stretched westwards from the NE limb to the north of the first. A large filament was reported on Apr 22 around 40°N/60°E around 150,000km long and 30,000km wide, tapering off into a wedge shape. This feature persisted on Apr 23 but was not present the next day.

The BMR in the southern hemisphere underlying AR2653 was reported as extremely large on Apr 24 measuring some 240,000×140,000km, the white light sunspot group being constrained entirely with the preceding end of the BMR. On Apr 30 AR2653 exhibited elongate 'S' shaped plage and two small filaments were associated with the group.

Flares

Flares were reported by John Cook, Andy Devey, Derek Glover, Alan Heath, Mick Jenkins, Ken Medway, Peter Meadows, Mick Nicholls and Anthony Stone.

Peter Meadows reported a bright flare within AR2644 on Apr 2 (M5.3 flare peaking at 08:02UT) which he observed from 08:15UT to 08:45UT during its fading from maximum brightness. Andy Devey recorded a further M class flare from AR2644 on Apr 2 at 13:50UT.

CaK

Activity in Calcium K-line was very subdued during the month and confined within 20° north or south of the equator. On Apr 2 a very hot bright emission was seen near AR2644.

CaK MDF 3.50 (1 observer).

2017 May

After the upsurge in April, activity dropped back to levels similar to March confirming the downward trend of sunspot group frequency. This was largely due to a reduction in southern hemisphere groups with the overall quality of sunspots also in decline. Most observers reported a blank disk from May 9–15 and again on May 30 & 31.

AR2653 S10°/026° survived from the previous month as an Hsx type sunspot with an area of about 50 millionths. As it approached the SW limb on May 2 it had reduced to type Axx and was difficult to observe. By May 3 the sunspot had rotated around the limb although extensive faculae remained in its wake.

AR2654 N11°/314° faint pores belonging to this sunspot group were just about visible on May 1 in the NE quadrant which had developed by May 2 but seemed to be again in decline by May 3 when the group was around the CM. By the following day the decline continued particularly in the following sunspot. The preceding sunspot had developed a light bridge across its penumbra to the east of its umbra and a small dark spot or lobe of the umbra was seen in the penumbra south of the main umbral region. On May 5 the group continued to decay being type Cso with an area of 50 millionths. By May 6 the group was type Hsx and then type Axx on May 8 when it was close to the western limb.

AR2655 N12°/252° formed in the NE quadrant on May 5 as a type Csi sunspot group with an area of 40 millionths. By May 7 the group had declined to a single Axx sunspot and had decayed on the disk by May 9.

AR2656 N12°/067° was first seen on May 16, an Hsx type sunspot near the E limb. The single penumbral spot progressed westward unchanged with an area of about 30 millionths until May 23 when it was observed as an Axx spot. The group then dissolved on the disk in the NW quadrant.

AR2658 S08°/066° appeared on the disk in the SE quadrant on May 19 type Hsx. On the following day the group consisted of a very

Mercury & Venus Section

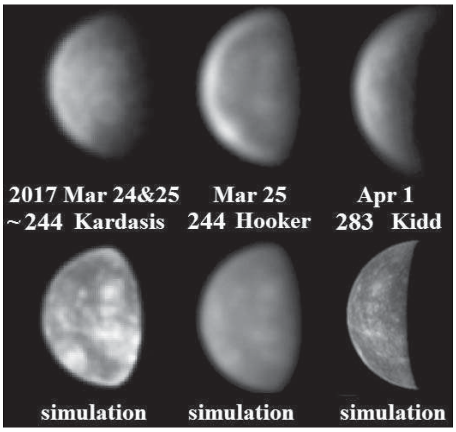
Mercury at eastern elongation, Spring 2017

The spring evening elongation of Mercury is often the best-observed for northern hemisphere observers, and 2017 proved no exception. Reaching greatest elongation east on April 1, Mercury was captured by the cameras of several observers. In the figure we show the work of three of these. It was pleasing to see many objective details captured, and the simulations that they provided for comparison clearly show how the various bright areas can be positively correlated with bright ray craters and their ejecta.

The UK weather was not very cooperative at the critical time this year, but the results achieved are some of the best so far obtained from this country. All observers used different specifications of ZWO ASI cameras. Hooker made images from independent videos using nearly 100,000 frames to demonstrate the objectivity of all the albedo details he recorded. Kidd writes that clouds initially helpfully shaded his C14 from the Sun.

A Section Report by the Director, published elsewhere in this *Journal*, summarises all Mercury observations submitted to the BAA during 2007–2016, and provides useful comparisons and maps.

Richard McKim, *Director*



Images of Mercury by M. Kardasis (Mar 24 & 25 combined; 356mm SCT, ASI290MM camera & 900nm filter [Greece]); C. J. Hooker (Mar 25, 15:00–15:45UT, 254mm refl., ASI120MM-S camera & Baader infrared pass 685nm cut-on filter [UK]); and A. S. Kidd (Apr 1, 17:29UT, 356mm SCT, ASI224MC (colour) camera with 610nm filter [UK]). The simulations submitted by the observers for comparison are, from left to right: *WinJUPOS*, a heavily defocused *Messenger* image, and *WinJUPOS*. South is uppermost and the CM longitude is shown beneath each image.

close pair of north-south orientated sunspots with fainter pore activity to the east. By May 23 it had decayed to type Bxo and was not seen on May 24.

AR2659 N14°/042° was first reported on May 23 near the CM. By the following day the group had developed several pores to become type Csi and on May 25 had further developed to become type Dac with an area of 130 millionths. The preceding sunspot was the most developed in the group with multiple umbrae. The leading sunspot developed a well defined penumbral region around its multiple umbrae and the following end consolidated into two more defined structures. By May 27 the group was 180 millionths in area and on May 28 was type Dac, close to the NW limb.

13 observers reported a Quality number of 2.50 for May.

H-alpha

Prominences

20 observers reported a prominence MDF of 2.35 for May.

On May 3 an arch prominence around 55,000km long and 30,000km high was seen on the NW limb, with an eruptive type prominence in front of the northernmost pillar of the arch. An active prominence on the NW limb on May 4 reached a height of 56,000km and a single arch prominence rose to 47,000km on May 5.

A bent pillar prominence was on the NE limb on May 6 and a broken arch prominence and a fork type prominence were reported on the W limb on May 7.

On May 16 an arch prominence was seen on the SW limb around 15,000km high with a span of around 40,000km. A double pillar prominence was reported on the NE limb on May 22 with some faint plasma material between.

A hedgerow prominence hearth comprising three tree type prominences was on the NE limb on May 23 with a height of around 40,000km and a width of about 100,000km. Close by was a pillar prominence with plasma streaming to one side.

On May 24 a small multi arch prominence was seen along the SE limb and a very large hedgerow prominence hearth was reported on the SW limb with a height of around 20,000km and a length of 220,000km. This hearth had split into two by the following day. A long hedgerow prominence was also seen along the E limb extending from about 10°N to 10°S.

On May 26 a large detached prominence was observed off the NW limb at 09:40UT. During the morning the shape changed and enlarged with a circumferential length estimated at 120,000km. The feature had dispersed by mid afternoon. On the same day on the E limb a detached pillar was seen reaching a height of around 70,000km.

Bi-polar magnetic regions, filaments & plage

17 observers reported a filament MDF of 1.79 for May.

Bright plage was observed with AR2654 on May 3 & 4 and also present on May 5 & 6. On May 3 an extensive magnetic field pattern was seen around this sunspot group with filaments across the most active central areas.

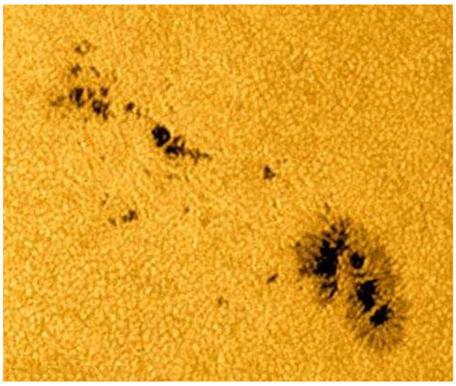
On May 8 the BMR associated with the decayed AR2655 remained as a marked disturbance to the chromospheric network. A small filament was visible on the NE limb.

In the northern hemisphere on May 12, a filament around 70,000km in length was reported which had extended to 90,000km the following day and 100,000km on May 14.

On May 18 the decayed AR2657 was visible as a dusky BMR sitting near the CM. Near the SW limb a large filament was seen around 80,000km long and 40,000km wide. Also on May 18 a large but ill-defined filament was noted on the E limb. By May 20 this filament was estimated to be 150,000km long and 30,000km wide, 100,000km long on May 21 and 150,000km on May 22 but was not reported on May 23. On this date, an ‘enormous’ BMR associated with AR2656 extended halfway across the W hemisphere. Plage was noted around AR2658 and AR2659 also on May 23.

On May 26 AR2659 contained bright plage and a small filament to the north.

A large filament around 200,000km in length was seen in the SW quadrant on May 29 which had extended to 240,000km by the following day but was not reported on May 31.



AR 2659 imaged in white light by Carl Bowron on 2017 May 26 at 08:05 UT.

Flares

Several small flares were reported during the month by Andy Devey, Joe Gianninoto, Derek Glover, Monty Leventhal and Ken Medway.

CaK

May showed reduced CaK activity, with about half the CaK plage in the form of ‘speckles’. Solid CaK plage were small in area.

CaK MDF 3.11 (1 observer).

Lyn Smith, *Director*

The BAA Exhibition 2017: an interim report

In recent years the Exhibition has moved away from central London and been taken around the country to serve the membership and the public in as wide an area as possible: the Old Royal Naval College in Greenwich, Manchester Metropolitan University, St David’s Hall in Cardiff, and this year in the splendid surroundings of the National Museum of Scotland in Edinburgh. Section Directors and Coordinators again produced impressive displays using poster boards and, interchangeably, several large monitors in conjunction with laptops, iPads, and other devices.

Groups of short talks summarising the aims and objectives of the Association and the work of the Sections were presented in the auditorium throughout the day, and the talk by the guest speaker, Professor Ian Robson, was well received. Since the event, feedback from members and other visitors has been very positive. A comprehensive illustrated report will be published in the October issue of the *Journal*.

Lorraine Crook, *Exhibition Organiser*
[http://britastro.org/exhibition/]

Sandra Brantingham (Director, Aurora and Noctilucent Cloud Section) & Dr Richard Miles (Director, Asteroids and Remote Planets Section). *Photo by Bob Marriott.*

Absolute Beginners
by Paul Abel

10. An introduction to solar observing

Introduction

With summer now well underway, the Sun is high in UK skies for much of the day, and this is a great time to make a start on solar observing. Although in astrophysical terms, the Sun is a rather ordinary (somewhat feeble) star, it is important to us since all life on Earth is dependent on it – indeed the Sun's influence extends far beyond the solar system into the realm between the stars. There are many stars like our Sun in the galaxy and by studying the Sun we can build up a general picture of how stars work.

Observing the Sun can seem like a daunting task for a beginner and we must remember it is a dangerous object if it is not treated with due respect. I feel I must reiterate my usual warnings about solar observing: **NEVER look directly at the Sun through binoculars or a telescope**; instant blindness will result. A second is all it takes to do a lifetime's worth of damage.

With due care and attention however, the Sun can be a very rewarding body to observe and the BAA Solar Section has been recording and studying a wide variety of solar phenomena for many decades. In this article we shall look at some of the simple things which can be done with regards to solar observation.

The Sun as a star

Our Sun is classed as a dwarf star and like all stars, it was born when a molecular cloud rich in hydrogen and helium collapsed under its own weight. When the young proto-sun was massive enough, nuclear fusion ignited in its core and our nearest star was born. The early days of the Sun would have been quite tumultuous but eventually it settled down into a quiescent middle age.

For the last 4.6 billion years the Sun has been slowly turning its hydrogen fuel into helium as it passes through the main sequence (that region on the Hertzsprung–Russell diagram where stars burn their fuel at a steady rate). The Sun is about halfway through its lifetime, and in about 4.5 billion years time, it will run out of hydrogen fuel and move off the main sequence. As a result its surface will swell considerably, consuming the inner planets Mercury and Venus and quite probably the Earth as well. The Sun will then begin a new phase of life as a red giant star, the retirement period for stars the size of our Sun.

Eventually it will shed its outer atmosphere into space, and all that will remain is the core – by now a dead hot white dwarf – and as all nuclear activity has ceased, it will slowly cool although it will take billions of years to do so. The material ejected into space will eventually become a planetary nebula (the Ring Nebula in Lyra is a particularly fine example) and new stars may well form from the material in this nebula as nature's cosmic recycling scheme continues.

Projecting an image of the Sun with a small refractor.

Observing the Sun in white light

The simplest and safest way to observe the Sun is to use the method of projection. If you have a refracting telescope, the process works because the image of the Sun is formed by the main objective lens of the telescope, and is then projected through the eyepiece where it can be focussed on white paper or card a short distance behind it. It is a good idea to have an eyepiece which you use just for solar observing, as some heating of the eyepiece lens is likely to occur over time.

You will also need white paper or card attached to a clipboard which can be used as a surface on which to project the Sun's image. When you're ready to observe, the first thing you should do is cap the finderscope: this is important as even a small finder can still cause damage if you look into it by accident or if you get paper or cloth too close to it!

Finding the Sun is the next challenge. Obviously we cannot look directly through the telescope or finder as we would with astronomical objects at night, so instead we use the telescope's shadow on the ground as a guide. Point your telescope in the general direction of the Sun, and you will notice that the telescope's shadow becomes smaller and sharper the closer it get's to the Sun's position in the sky.

When you have the Sun's image on the card, you can focus it to get the best image possible – if seeing is poor stick to lower magnifications. It can be difficult to keep the clipboard steady if you're holding it by hand, and many people have the board set up on a suitable surface so they can project the Sun directly onto it without having to hold the paper, turn the telescope and focus the Sun all at the same time!

You can also use a Newtonian reflector to project the Sun's image but as a personal choice I would never do that, simply because I have heard of occasions of the mirror cracking or shattering. In any case it is not a good idea to use a telescope larger than 4 inches [100mm] to project the Sun, simply because you are focussing a lot of heat and light and you can risk damaging either the primary or secondary. Personally, I prefer to do most of my projection work with a 3-inch refractor; this provides me with safe, excellent views of the Sun.

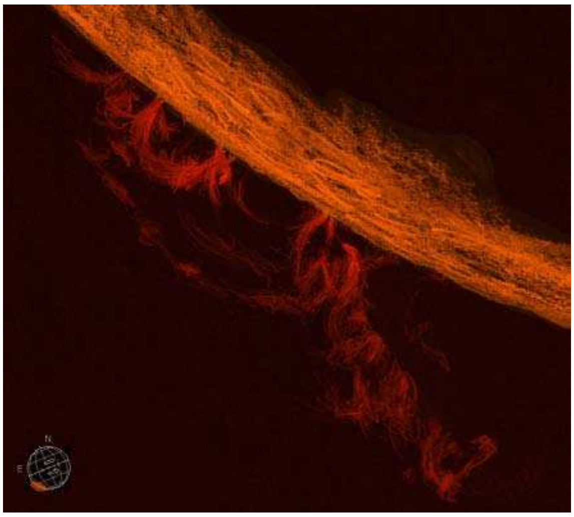
When we look at the projected image of the Sun, we are looking directly down onto the photosphere. The most common features visible on the photosphere are sunspots: these take the form of a dark spot (called the umbra), surrounded by a light region called the penumbra. They may appear on their own or in groups. An individual sunspot can vary enormously in size, typically ranging from 16km to 160,000km in diameter. The number of sunspots present depends on the solar cycle. We are currently at a solar minimum and so at the moment there will be very few (or no) sunspots visible. However, over the course of 11 years the number of sunspots will build as solar activity increases towards the next maximum of the 22-year cycle.

Sunspots arise due to magnetic field lines passing through the Sun's surface (if you put a sheet of paper over an ordinary magnet and sprinkle iron filings over it, the filings reveal the field lines). These magnetic lines hinder convection, making the regions they pass through cooler than the surrounding regions – this is the reason why sunspots appear dark compared with the surrounding photosphere.

The Sun rotates on its axis, so any sunspots will appear to move across its surface. They usually change over time, and some will last only a few days while others may survive for many months. Regions of sunspot activity are called 'Active Regions' and they are numbered to aid identification. You can use the website **www.spaceweather.com** to identify which active regions are present on the Sun's disk.

It is always a good idea to record your observations and send them in to the BAA Solar Section. One way of doing this is to use a solar blank – these can be found on the Section website together with directions on what to record. All you need to do is print out the form and you can then project the Sun directly onto it. Some observers like to sketch any sunspots present separately from the main disk drawing – with all your drawings make sure you record the date, time (in UT) and telescope details.

It is not only drawings and images which are of interest to the Solar Section – sunspot counts in white light are extremely important. So, if you do not feel up to drawing or imaging the Sun, you can still contribute some useful data by undertaking a regular sunspot count (see the Solar Section website for details).



Drawing by Les Cowley of a very large prominence on the SE limb in H-alpha light, 2014 Jun 01, 13:15 UT.

Hydrogen alpha

In recent years telescope manufacturers have produced a variety of reasonably priced hydrogen-alpha (H-alpha) telescopes. Unlike ordinary 'scopes, these instruments can only be used for observing the Sun. They contain a filter which stops all of the damaging heat and white light from passing through, and only transmits a small amount of H-alpha light.

H-alpha is the wavelength transmitted by excited hydrogen atoms, and it has a distinctive red/crimson hue. Since only a small amount of H-alpha is transmitted it is safe to look through these solar telescopes. The light we see now comes from a higher region in the Sun's atmosphere called the chromosphere. Before the development of H-alpha filters, this region was only visible during a total eclipse of the Sun, so their development was of great significance to solar physicists who no longer have to rely on fleeting glimpses during totality.

The view in H-alpha is quite different to a white light view – sunspots are visible but they are much more indistinct. However if you look at the edge of the Sun, called the solar limb, you can usually pick out a number of so-called prominences. These are vast plumes of hot gas or plasma which can reach altitudes of 150,000km above the solar surface. In moments of good seeing they can show some splendid delicate structure as they evolve over the course of a few minutes.

In time, prominences either rotate onto the Sun's disk or pass behind it and are lost from view. When we view prominences directly against the background of the solar disk they appear darker and we then refer to them as filaments – it is fascinating to watch them change over time. Some observers choose to make drawings in H-alpha; this can be done either in monochrome using a pencil or in colour using crayons or pastels. An increasingly common way to record solar observations in H-alpha is to use a smartphone. If you have an iPhone, Android or equivalent you can try taking a picture through the eyepiece – although it can take some time to align it, good images can be obtained with practice. Expert imaging with CCD cameras is beyond the scope of this article, but has become a powerful technique for recording solar phenomena in the past couple of decades.

Even though we are on our way to solar minimum, decent sized groups can still appear. Now is a good time to take advantage of the long summer days. With the Sun high in the sky, get outdoors and take a closer look at our nearest star.

Paul G. Abel

Sunspots drawn in white light by Sally Russell using a 105mm refractor, 2011 April 25, 10:47/11:27 UT.

See also a tutorial by Solar Section Director Lyn Smith on observing the Sun on the BAA website: **https://britastro.org/node/10604**

Notes and News

FROM THE *JOURNAL* ARCHIVE

In my last 'From the *Journals*' piece I mentioned the Rev T. E. R. Phillips and William Herbert Steavenson, two members who made significant contributions to the BAA and amateur astronomy. In this piece, I will mention another.

George Alcock will be well known to many members as a school teacher known for discovering novae and comets from his back garden. Fifty years ago, the 1967 August *Journal* has two references to him. He is mentioned as shown to the right. Below is shown the second reference. It is about the first of the Novae that George discovered in 1967 July.

NOVA ALCOCK

G. E. D. Alcock found this nova at about $5^m{\cdot}6$ on 1967 July 8·94 in position $20^h\ 40^m{\cdot}0$, $+18°\ 59'$, 1950·0 (early estimates gave a position 4′ south of this), that is, on the northern border of Delphinus. The discovery was made during a routine nova-sweep with binoculars. The area had previously been searched on the evening of July 4.

A spectrogram obtained at the Royal Greenwich Observatory, Herstmonceux, on July 9·94 shows broad emission features of Hydrogen and Calcium with absorption features displaced about 700 km/sec towards the blue.

Magnitude estimates near July 10·0 by Alcock, P. Lancaster Brown, M. P. Candy and G. E. Taylor range from 5·9 to 5·5. The Director of the Variable Star Section, J. S. Glasby, is preparing charts of comparison stars, and all magnitude estimates should be sent to him.

Twenty-five years ago, in the 1992 August issue, the BAA honoured George with the Merlin Medal and gift as shown below.

As will be seen in the picture, Harold Ridley was also presented with the Walter Goodacre Medal and gift at the same Exhibition Meeting, as it was called then.

In fact, throughout this piece, you will see several other familiar names of people who have made significant contributions to the BAA and amateur astronomy.

John Chuter, *Archivist*

360 *Radio Astronomy Section* *J. Brit. astr. Ass.*

RADIO ASTRONOMY SECTION J. R. SMITH, *Director*

SOLAR AND SOLAR SYSTEM ACTIVITY

1967 MAY AND JUNE

SOLAR ACTIVITY

RADIO		SUNSPOTS	
a < 1 min.		×	appearance or disappearance
b = 1 m–10 m		|	spot on limb
c = 10 m–1 h		●	date on central meridian
d > 1 hour		s	small
m = multiple		m	medium
		l	large
		S	single
		B	bipolar
		B_1	bipolar with one pole multiple or diffuse

NOTES

The following notes refer to the roman numerals in the figure:

I. Sunspot data provided by W. M. Baxter.

II. G. E. D. Alcock reports a telescopic meteor hourly rate of 6·9 from May 9 0037–0227, the highest he has seen since 1960 July 31. The meteors were sporadic and seen with a 25×105 mm binocular telescope.

III. Ashen Light of Venus seen by M. R. Whippey.

IV. Bright aurora seen on May 25 in many parts of the country with a maximum at 2 348Å with green rays edged with red and purple to the west following a strong solar radio burst at 1100 recorded by E. Doylerush at 185 Mc/s and M. J. Hale and J. R. Smith at 136 Mc/s. Doylerush also reported T.V. interference at 1835–40 on 51·75 Mc/s and at 2245 on both 51·75 Mc/s and 191·25 Mc/s in North Wales.
A "fine active" aurora was seen by G. E. D. Alcock on June 6 between 0010 and 0102.

V. Flare seen with a spectrohelioscope on May 3 1600 until obscured by cloud at 1610 by H. Hill. Changes of shape and brightness were seen during this period.

VI. Audio frequency whistler and tweek rates recorded nightly by P. Buchan at Bristol. ('X' on the chart indicates missed observations.)

VII. 220 Mc/s full power observations by K. Tapping at Abbey Wood.

VIII. 136 Mc/s interferometer observations by M. J. Hale at Rochester and full power interferometer by J. R. Smith at Halstead, Kent.

Harold Ridley (left) and George Alcock (right), with the President of the BAA, John Mason, after being presented with their medals at the Exhibition Meeting on 20 June 1992. *(Photo: Alan Heath)*

Merlin Medal and Gift

George Alcock

George Alcock joined the BAA in 1936 and soon became a tireless meteor observer, working with the Meteor Section Director, J. P. M. Prentice. From their respective locations at Peterborough and Stowmarket they had a decent baseline from which to calculate the heights of meteors they observed.

When Jodrell Bank started meteor observations, George realised that the usefulness of amateur meteor observations might decline and he looked for other areas of observation in which to excel. Never a man to accept the easy option, George decided that comet discovering was the most valuable work he could undertake. After acquiring some 25 x 105 mm binoculars in 1959, he discovered two comets in one week in August of that year. Other comets (bearing his name alone) were discovered in February 1963 and September 1965.

He discovered the Earth-grazing Iras-Araki-Alcock in May 1983 with hand-held 15 x 80 binoculars, through his upstairs landing window. By the 1960s, George had acquired an impressive knowledge of the sky but decided to go one step further. He decided to memorise the night sky as seen through his 15 x 80 binoculars. This remarkably ambitious strategy paid off, netting him nova discoveries in 1967, 1968, 1970, 1976 and 1991. He also independently discovered an outburst of the recurrent nova, RS Ophiuchi, in 1985.

His most recent nova (Nova Herculis 1991) was discovered on 1991 March 25 at 04h 35m UT. George was using 10 x 50 hand-held binoculars whilst looking through a double-glazed downstairs window! Now in his eightieth year, George still sweeps the night sky every clear night.

Observing Uranus and its satellites, 2006–2016

John Sussenbach

For amateur astronomers the distant planet Uranus is a considerable observing challenge. With its angular size of about 3.6 arcseconds it is not easy to detect details in its atmosphere, and imaging of its faint satellites requires relatively long exposure times. Nevertheless, with the development of new digital cameras with increased sensitivity the planet and its satellites have become interesting objects of study. In this report covering the period 2006–2016, progress in imaging Uranus by the author is demonstrated. In particular this shows that the detection of features in the atmosphere of Uranus has become a promising field for future investigation.

Introduction

Uranus is one of the remote gas giants of our Solar System. The planet was discovered by William Herschel in 1781 using a 7-foot reflector with an aperture of 6.2 inches [157mm]. Observed from the Earth the planet has a very small angular size of about 3.6 arcseconds and is a real challenge for small telescopes. Visually it is a pale tiny greenish-blue disk. Occasionally some bands have been recorded visually by amateurs.

A concise report of the discovery and history of observation of this planet is the classic book *The Planet Uranus* by A. F .O'D Alexander.[1] Uranus is unique in the extreme tilt of its axis of rotation of 97.8°. The planet has more than 25 satellites of which only the five largest can be detected with amateur telescopes (Figure 1). With larger telescopes faint banding has been reported visually.

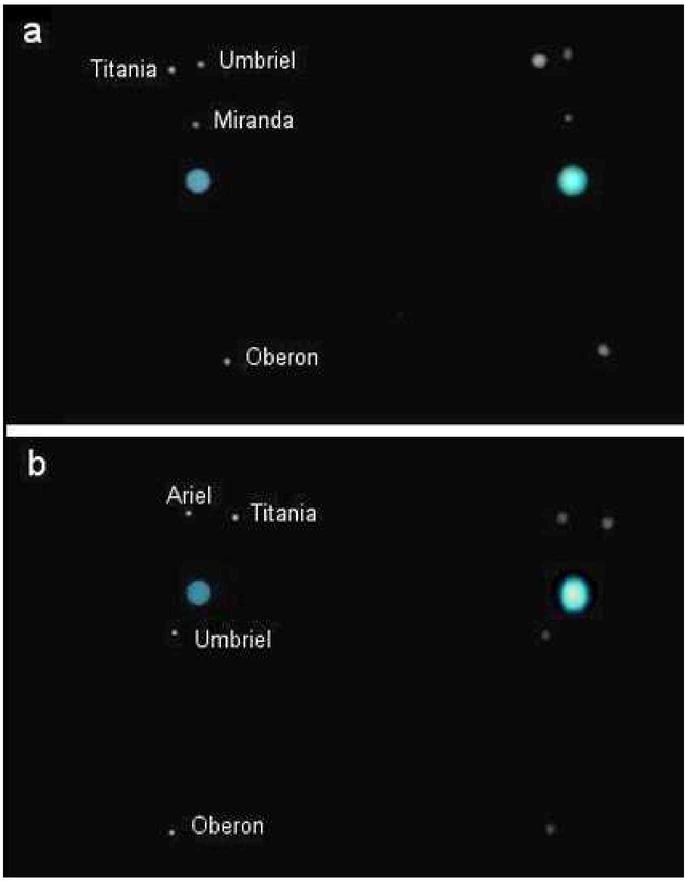


Figure 1. Uranus and satellites. **a)** 2004 July 24, 00:53 UT; **b)** 2004 July 27, 00:37 UT. *Left:* simulations; *right:* images with a C11 [279mm SCT] at prime focus. *All images by J. Sussenbach unless otherwise noted.*

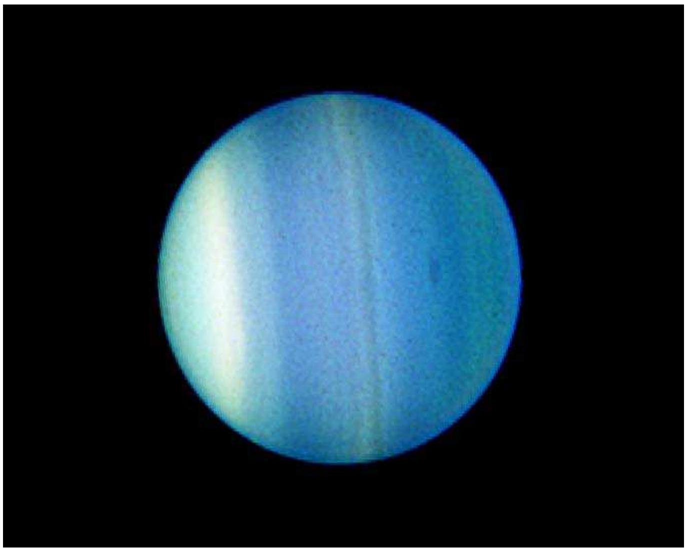


Figure 2. Uranus imaged on 2006 Aug 23 with the Hubble Space Telescope. *NASA, ESA, L. Sromovsky & P. Fry (Univ. of Wisconsin), H. Hammel (Space Science Inst.) & K. Rages (SETI Inst.)*

Atmospheric features on Uranus

In contrast to Jupiter and Saturn, Uranus is rather featureless. NASA's *Voyager 2* spacecraft flew close to the planet in 1986 and revealed some banding and white clouds in the Uranian atmosphere. The Hubble Space Telescope has imaged bands and spots on the distant planet (Figure 2).

This image also illustrates one of the consequences of the peculiar large tilt of Uranus' axis. During its 84-years' revolution around the Sun, in certain phases only the northern hemisphere is illuminated by the Sun and 42 years later the southern hemisphere. The appearance of Uranus in the period 2006–2016 is shown in Figure 3. In this paper all Uranus images are presented for the appropriate date with north at the top. In 2007 the Earth passed the equatorial plane of Uranus (on 2007 February 20, May 3 and August 16, respectively) leading to a view of the planet very similar to the 2006 image.

At the start of this century amateur astronomers in increasing numbers began digital imaging of the planets using webcams and

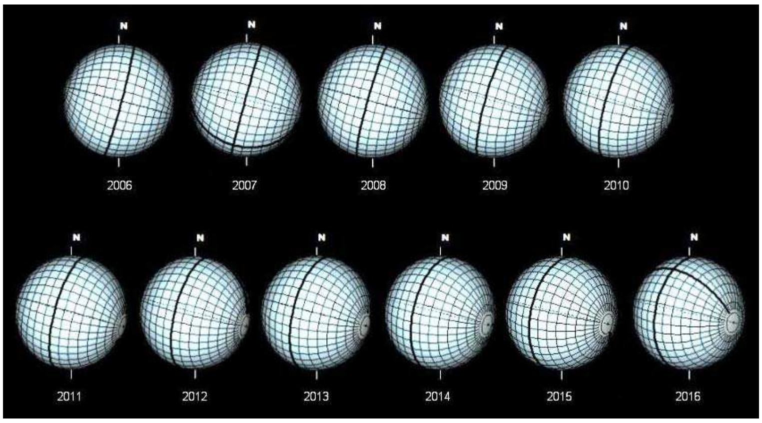


Figure 3. Appearance of Uranus from 2006 July 1 to 2016 July 1. (*WinJUPOS*[2] *simulations*).

other cameras. In the beginning Jupiter, Saturn and Mars were the favourite objects. However in 2006 August & September members of the Dutch Working Group on the Moon and Planets initiated a campaign to image Uranus.[3] The objective was to investigate what amateurs can detect and observe with the help of the latest digital cameras and other technical equipment.

It should be noted that circumstances for observing Uranus from The Netherlands were quite unfavourable during this apparition. In 2006 the altitude of the planet was not more than 30°. Despite these conditions several acceptable images were obtained (see **http://maanenplaneten.nl/documenten/report_uranus_campaign_2006.pdf)**. The general conclusion was that with amateur instruments no details could be imaged on the tiny blueish disk of Uranus in RGB or IR (Figures 4 and 5). No distinct spots or other features could be detected in the RGB, R or IR images. Limb darkening was very clear and in some images the southern hemisphere was a bit brighter than the northern.

I imaged Uranus in the years that followed, but since it travelled through the summer ecliptic, conditions for high resolution imaging of the planet were not very favourable. In 2008 I noticed in the images that the northern hemisphere was a bit brighter than the southern, and this difference became more distinct in the years that followed. In 2012 I also noticed faint banding on the southern hemisphere and this became clearer in the following years (Figures 6 & 7).

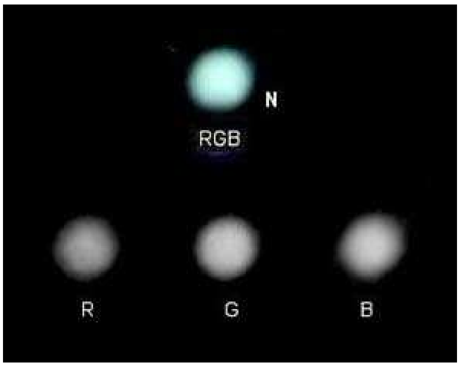


Figure 4. Uranus on 2006 Aug 22. C11, ATK2HS camera with Astronomik RGB filters.

Figure 5. Uranus on 2006 Sept 11. C11, ATK2HS camera with Astronomik RGB filters or Baader IR filter.

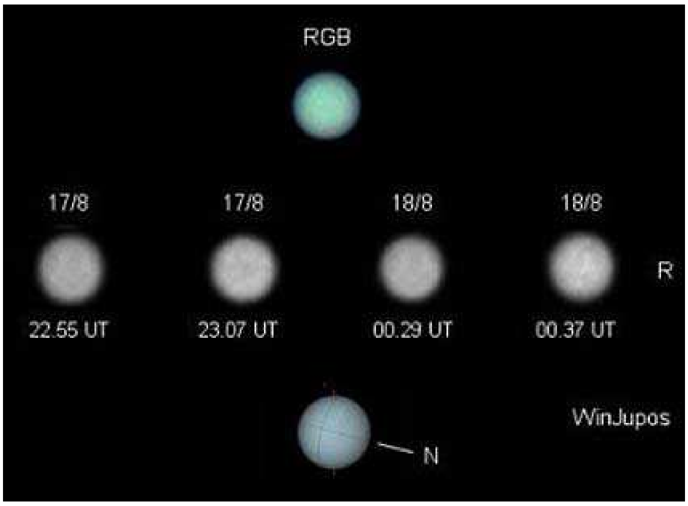


Figure 6. Uranus on 2012 Aug 17 & 18. C11, Flea3 camera and Astronomik RGB filters.

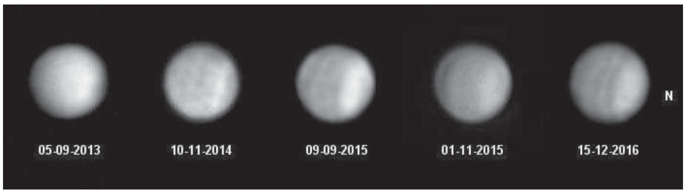


Figure 7. Uranus from 2013 Sept 5 to 2016 Dec 15. C14 [355mm SCT] and different types of cameras. Red long pass (>610nm) or IR filters.

In particular the northern hemisphere is brighter than the southern in 2015 and 2016. In addition a distinct banding pattern is present, with a darkening of the north polar region and two darker bands in the northern temperate and tropical zone. Subsequently, towards the south pole a brighter zone can be distinguished and a relatively dark band in the most southern region (Figure 7).

Separation of the bands is highly dependent on the seeing conditions. It is striking that in the course of the years the dark banding pattern has become more pronounced. This is probably a seasonal effect. The bands are most easily detected when red or infrared filters are used.

In the past, besides banding, no other features have been detected except for some occasional bright spots. Anthony Wesley and others detected a bright spot in 2014.[4] Spots on Uranus are in

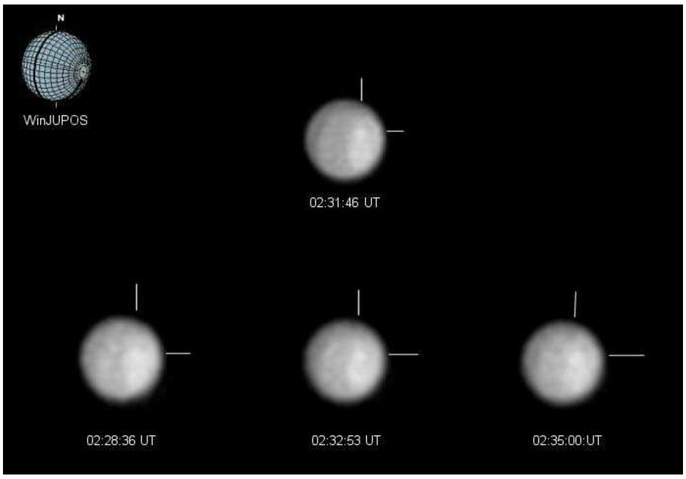


Figure 8. Bright spot on Uranus, 2016 Aug 15. C14, ASI290MM camera & IR filter. At the top the combination of the three lower images. In the left upper corner a *WinJUPOS* simulation.

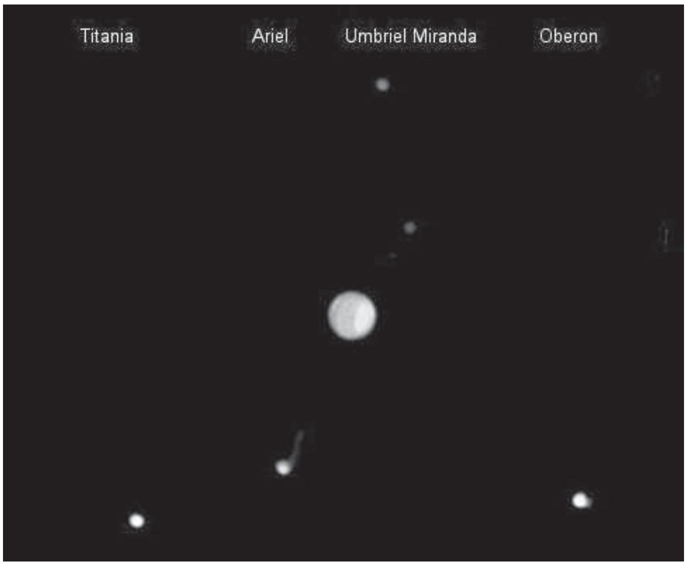


Figure 9. Uranus and satellites, 2015 Sept 9. C14, ASI224MC camera & IR filter.

general short-lived. Interestingly, on 2015 August 15 I noticed a bright spot on the northern hemisphere (Figure 8). Since the images are rather grainy, one should be aware of the possibility of artefacts. However, when the images obtained at 2:28:36 UT, 2:32:53 UT and 2:35:00 UT are compared, in all three images a bright spot is found with the same coordinates (longitude 241.9°, latitude +56.7°). Unfortunately, bad weather conditions did not permit a follow-up of these observations.

Satellites of Uranus

Uranus has five major satellites, Miranda (magnitude +16.3), Ariel (+14.2), Umbriel (+14.8), Titania (+13.9) and Oberon (+14.1). Direct imaging of these satellites leads to overexposure of the Uranus image. For Figure 9 a briefly exposed Uranus image is combined with a longer exposed satellites image.

Miranda is the most difficult satellite to record, because it is sometimes positioned very near to Uranus and consequently disappears in the glare of the planet. In 2015 from Earth we viewed the north pole of Uranus and the orbits of the satellites were seen as ellipses as projected onto the sky. However, in 2007 the Earth passed through the equatorial plane of Uranus and in the period 2006–2008 the satellites moved apparently in a straight line.

In 2007 the satellites occasionally showed mutual occultations. Due to the faintness of the satellites these events were not easy to detect. On 2007 August 13 at 03:04 UT an interesting event took place: the partial occultation of Umbriel by Ariel (Figure 10).

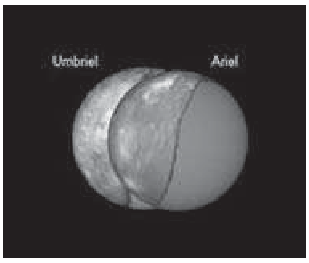


Figure 10. *WinJUPOS* simulation of partial occultation of Umbriel by Ariel, 2007 Aug 13, 03:04 UT.

To record the partial occultation I used the C11 SCT and an ATK 2HS camera. The images of Uranus and its satellites were made at the prime focus of the telescope. Frames were collected with an exposure time of 3 seconds per frame. The first image was made at 02:40 UT and the last at 03:17 UT. A total of 352 frames was obtained. The brightness of the combination of Ariel and Umbriel was compared to that of Titania. Since no photometric equipment was available an alternative procedure was applied.

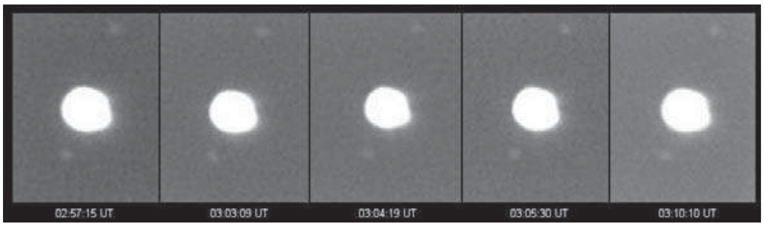


Figure 11. Images of Uranus and satellites Ariel, Umbriel and Titania during the partial occultation of Umbriel by Ariel on 2007 Aug 13. 279mm SCT and ATK2HS camera.

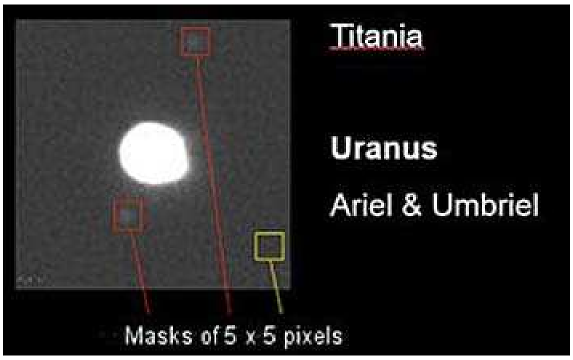


Figure 12. Photometric analysis of the occultation of Umbriel by Ariel using 5×5 pixel masks. The values for Ariel plus Umbriel and for Titania were corrected for background values and the ratio (A+U)/T was calculated.

Frames were grouped in batches of 20 frames and stacked with *Registax 4* followed by a slight sharpening using the wavelet function of *Registax 4*. A selection of images is shown in Figure 11. The brightnesses of the combination of Ariel (A) & Umbriel (U), and of Titania (T), respectively, were measured using the colour sampling tool of Photoshop CS2 with masks of 3×3 and 5×5 pixels (Figure 12). With these masks the images of the satellites are fully captured with a limited amount of background. Before measurement the images were enlarged to 300%. The brightness values of the satellite images (red masks Figure 12) were corrected by subtracting the background values (yellow mask Figure 12). Subsequently the ratio (A+U)/T was calculated. The results of the 3×3 and 5×5 masks were averaged and the final result plotted (Figure 13). As shown in Figure 11 the background values increased in the course of the occultation due to the fact that the occultation took place shortly

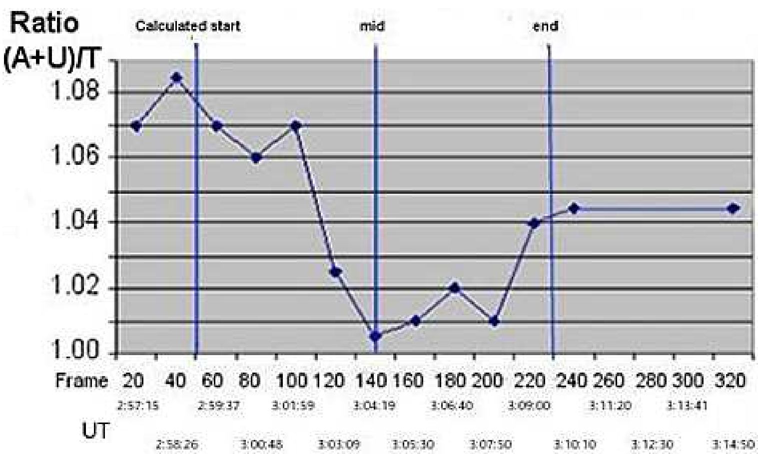


Figure 13. Photometric analysis of the partial occultation of Umbriel by Ariel on 2007 Aug 13 using masks of 3×3 & 5×5 pixels. The theoretical values of the start and finish of the occultation were calculated with *WinJUPOS*.

before sunrise. At 02:57:15 UT the altitude of the Sun was –11.2° and at 03:10:10 UT it was –9.7°.

Figure 13 indicates that indeed a drop in brightness of the combination of Ariel & Umbriel took place relative to the brightness of Titania, close to the times calculated with *WinJUPOS*.

Conclusions

The results presented in this report indicate that with the current generation of digital cameras a new field of imaging has opened up. The remote gas giants Uranus and Neptune are now open for investigation with amateur telescopes. In particular the seasonal changes in the Uranian atmosphere are now within the reach of amateurs. In some recent reports it is shown that even on the tiny disk of Neptune bright spots have been detected.[5,6] Comparison of the occurrence of bright spots on Uranus and Neptune suggests that at least in the current stage of its orbit Neptune shows more atmospheric activity than Uranus.

Unfortunately, it will be another 30 years before the Earth will again pass through the equatorial plane of Uranus and we will be able to study mutual occultations and eclipses of its satellites. But there are other challenges on Uranus. Recently, amateurs have reported the detection of its ring system using the 1.06m telescope of the Pic du Midi Observatory.[7] There are also indications that the rings can be detected with smaller telescopes.[8,9]

It is evident that with the current and future generations of cameras with good sensitivity in the IR region new steps will be made by amateurs in the exploration of the remote gas giants in our Solar System. The development of cameras with increased sensitivity in the methane band (800–1000nm) will be very welcome for this type of study.

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Thomas Hughes Buffham – Uranus pioneer

Kevin Bailey

An outline of the life and work of amateur astronomer and microscopist Thomas Hughes Buffham, with reference to his observations of Uranus in 1870–'72 and an assessment of the validity of two observations of white spots on the surface of Uranus made by him in 1870 January.

Thomas Hughes Buffham was born at Long Sutton in Lincolnshire on 1840 December 24. At the age of 16 he became a clerk to a business in Earith, Huntingdonshire, where he acquired an interest in astronomy as a result of his membership of the local Philosophical Society. A member of the Baptist church, he taught regularly at the local Chapel Sunday School and became a respected member of the local community. In 1864, at St Ives in Cambridgeshire, he married Caroline Walden (originally from Stepney in London). They set up home at a house in Main Street, Earith, where their two daughters Caroline and Alice were born in 1867 and 1869 respectively.

From this domestic setting in Earith Buffham submitted his twelfth 'correspondence', dated 1869 May 1, to the Editor of the *Astronomical Register.* Entitled 'Reflectors and Refractors', this was a very thorough like-for-like comparison of the two types of instrument.[1] The contents of this study show that at the age of twenty-eight Buffham was an experienced and well-informed amateur astronomer, and his work was significant enough to be referenced by the Revd T. W. Webb as a footnote in Part I of his book *Celestial Objects for Common Telescopes*.[2] Buffham's main observing instrument at this time (and throughout his short life) was, as he describes, 'a silvered-glass 'With–Browning' alt-azimuth Newtonian of 9 inches clear aperture and 77 inches focus' (228mm, f8.5).

At Earith, in 1870 January, Buffham embarked on a series of observations of Uranus that were concluded in 1872 (Figure 1), and the results published in the MNRAS in 1873 under the title 'Markings observed on Uranus'.[3] From the publication of these observations onward, doubts have arisen about the observability of features on Uranus. Webb commented 'Buffham (1870–'71) considered that he had succeeded in detecting... white spots'.[4] A hundred years later A. F. O'D. Alexander (Director of the BAA Saturn Section 1946–1951), in *The Planet Uranus*, states that Buffham's observations were 'probably the first in which fairly definite disk features seem to have been repeatedly seen'.[5]

Webb's use of the word 'considered' and Alexander's 'seem' represent an ambivalence towards the subject that has been repeated in a succession of popular astronomy books published over the last hundred years. Even such open-minded writers as J. B. Sidgwick have said 'Uranus is easily enough located... It offers no scope for amateur work'[6] and Patrick Moore, 'Even large telescopes will show virtually nothing on Uranus' pale disk. In 1992 I had the chance to observe it with the 60-inch reflector at Palomar... and to me the planet was completely blank. I am unhappy about 'details' shown on drawings made by observers with much smaller instruments. Uranus is a very bland world...'[7] And the pictures from *Voyager 2* seemed conclusive – Moore added, Uranus was 'depressingly featureless'.

So it is worth considering the validity of Buffham's original observations. He states that on 1870 January 25 at 11h to 12h GMAT (23:00–00:00UT) using a power of ×320 with his 228mm f8.5 Newtonian, 'two round spots were perceived' (Figure 2).[8] On 1870 Jan 27 at 10h to 10½h (22:00–22:30UT) 'the appearance of the spots was almost exactly as on the 25th.'[9,10]

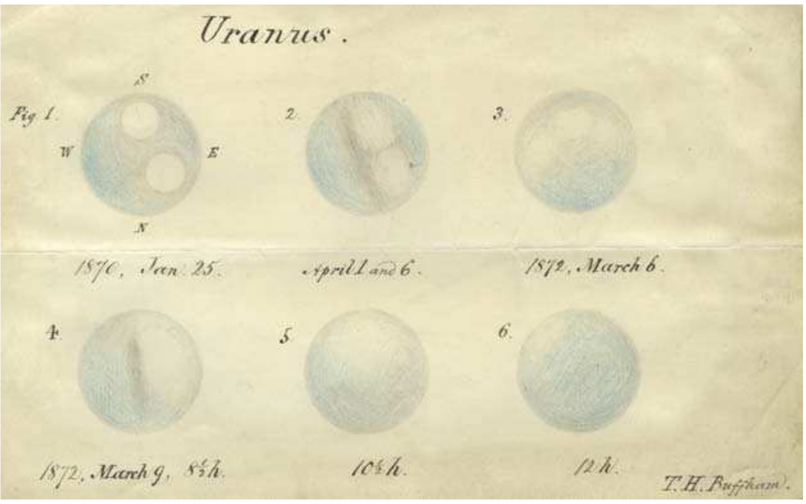

Figure 1. The original drawings of Uranus made by T. H. Buffham presented to a meeting of the RAS in 1872 December. ***Reproduced by kind permission of the Library of the Royal Astronomical Society.***

When referencing these observations in *The Planet Uranus*, Alexander, quoting Buffham's statement 'The appearance of the spots was almost exactly as on the 25th', responds, 'if he meant that the spots were at about the same position as 47hrs. before, they could not have been the same real spots, since rotation of Uranus in a period of 10h 49m would have carried them about 4 and one-third times around the globe in the interval'.[11] Even the revised post-*Voyager 2* rotation period of 17h 14m fails to support Buffham's observations, as following Alexander's method, 47 hrs divided by 17.25 hrs results in the spots being carried only 2.7 times 'around the globe in the interval'.

However, recent professional studies published by Prof P. G. J. Irwin *et al.* in the UK[12] and Prof L. A. Sromovsky *et al.* in the USA[13] have shown that (in common with the other giant planets) the rotation speed of the atmosphere of Uranus changes with latitude North and South. The best current estimates for Uranus are, 18 hrs at the equator, 16.5 hrs at 30° lat. N/S, 15.5 hrs at 45° lat. N/S and 14.5 hrs at 60° lat. N/S. (Irwin and Sromovsky, via private communication). Thus, if we render the mid-point of

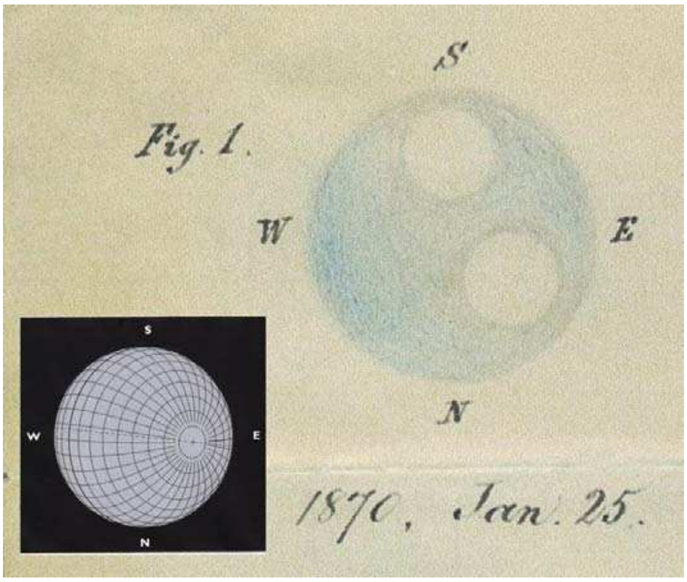

Figure 2. Uranus on 1870 January 25, 23:30 UT drawn by T. H. Buffham, with inserted *WinJUPOS* reference diagram for the same date and time. *Original image reproduced by kind permission of the Library of the Royal Astronomical Society.*

Buffham's first observation from 1870 Jan 25 (23:00–00:00UT) – 23:30UT – as a Julian Date 2404088.47917, and his second observation on Jan 27 (22:00–22:30) – 22:15UT – as Julian Date 2404090.42708, we get a period of 1.94791 Julian days between the two observations.

Superimposing Buffham's RAS drawing of 1870 Jan 25 onto a *WinJUPOS* graphic using the same data places the two spots at approximate latitudes 45° and 60°. If we take the mean rotation speed of these latitudes as 15 hours (0.625 Julian days) and divide 1.94791 JD by 0.625 JD we get 3.116656 – or for simplicity, 3.12 rotations – which, allowing for small variables in the calculations, gives credence to Buffham's statement that 'the appearance of the spots was *almost* exactly as on the 25th.' While these approximate calculations based on data 140 years old cannot *prove* the validity of Buffham's observations, they do support them.

In 1870 Buffham and his family moved to Bethnal Green in London where he entered the offices of Warren & Co. (Coal Merchants) as a clerk, rising to be the company's London manager by the end of his life. In the winter of 1872 Buffham presented his drawings and observations to a meeting of the RAS. These 14 detailed observations (without the drawings) were published in the *MNRAS* in 1873.[14] He had by this time moved to what was considered the 'healthier' atmosphere of Walthamstow in Essex.

Unfortunately the move was not beneficial, and due to continued ill health, Buffham was unable to continue his astronomical work, but during recuperative holidays to the Devonshire coast, became, as his obituary describes, 'devotedly attached to microscopical work'.[15] He became an expert on the subject of British marine algae and was elected an Associate of the Linnean Society in 1891. He is immortalised in the genus 'Buffhamia speciosa' and species 'Gonimophyllum Buffhami'. His 1,330 marine algae specimens and slides are housed at the Natural History Museum.

Buffham died at Walthamstow on 1896 February 9 aged 55. His obituary in *The Journal of the Linnean Society of London* begins: 'A very constant but unassuming attendant at our meetings has passed away...'[16] Not long after, his widow and daughters moved to East Grinstead in Sussex, where Buffham's younger daughter Alice married William Stockdale, and his Stockdale descendents still reside.

Buffham's legacy as an Uranus pioneer is a valuable one, and just as modern technology and research offer support to the validity of Buffham's original Uranus observations, so they in turn play a part in the acceptance of contemporary visual observations made by amateurs equipped with telescopes not much larger than his. The current favourable position of Uranus in the night sky – and the increasing sophistication of amateur optical and imaging equipment – have given amateurs the confidence to test the observability of Uranus for themselves.

Inevitably, both professional and amateur astronomers have questioned the reliability of these new observations (especially those made visually), arguing that the use of such small aperture telescopes puts the observation of atmospheric features on Uranus beyond the range of the human eye, while allowing that digital imaging using NIR filters has produced s*ome* objective results. But enthusiastic amateurs are steadily building up a body of observational evidence to challenge these doubts, and in 2014 professional astronomers had to acknowledge that amateur visual observers were the first to identify the 'white spot' on Uranus during that apparition.

A report on 'Uranus in 2014'[17] further demonstrated significant levels of agreement between visual, digital and professional NIR observation, and this growing contemporary archive of regular amateur observations, whether made visually or digitally, will undoubtedly contribute to a better understanding of Uranus.[18] After more than a century of relative neglect, it is time to build on T. H. Buffham's legacy and give this beautiful blue planet the attention it deserves.

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17 Bailey K. & Foulkes M., *J. Brit. Astron. Assoc.*, **125**, 68–70 (2015)
18 For anyone interested in taking up the challenge of observing Uranus, I recommend the following books and articles: *The Planet Uranus* by A. F. O'D. Alexander (Faber, 1965) for a full (but now rather dated) account of the planet, and *Uranus, Neptune, and Pluto and How to Observe Them* by Richard Schmude Jr. (Springer, 2008) – currently the most informative book on the subject. For a concise observing history of Uranus, see the section *Uranus* in F. W. Price's *The Planet Observer's Handbook* (Cambridge, 1994). Advice on making visual observations of Uranus (by this author) can be found in an article entitled 'Uranus Ascending' in the 2016 September issue of *Sky and Telescope*; and for a straightforward 'how to' guide regarding the digital imaging of Uranus seek out the article entitled *Imaging Uranus and Neptune* by David Arditti, that appeared in the 2014 October issue of *Astronomy Now*.

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The elongations of Mercury 2007–2016, and the 2016 solar transit

Richard McKim

A report of the Mercury & Venus Section (Director: R .J. McKim)

In this paper we review telescopic observational data of Mercury from 2007 November to 2016 October inclusive, and describe the results of the 2016 solar transit. A gradual improvement in imaging technique has enabled observers to record albedo features upon Mercury's surface as well as many bright patches corresponding to the ejecta regions of bright craters. An albedo chart and a *Messenger* map are presented for comparison. At the solar transit, observers obtained images in white light as well as in the wavelengths of Hydrogen alpha and Calcium K, timed the various contacts, and re-observed certain optical effects, comparing the results with those obtained at previous events.

Introduction

In early 2008[1] we summarised the best BAA Mercury observations for the 1978–2007 period, with collages of the highest resolution images and drawings available from our files. This paper acknowledges more recent efforts and summarises the period from late 2007 to the end of 2016. It would not have been worthwhile to analyse a shorter time period. The improvement in resolution since 2007 is sometimes noticeable in the submitted data. Ironically, with the completion of the mapping process by the *Messenger* spacecraft, we now receive fewer observations than in the past. Nevertheless, it is worth putting on record what the amateur astronomer can now resolve upon the little disk of Mercury.

In this paper we also discuss and illustrate the solar transit of 2016. Even better amateur images of Mercury's albedo markings have been seen online from time to time, but in this paper we use only those contributed to the Section.

Figure 1. Wide angle photographs of Mercury. **(A)** Mercury above the towers of Crescentino, Italy, 2012 Feb 26, 18:05UT, Canon EOS 450D, 2.5s at f/5.6. *Mario Frassati.*

Only a few elongations of Mercury per year are relatively favourable for observation: the BAA *Handbook* always gives full details. It is suggested that the writer's previous Section note[1] should be read for some details about the planet's observational history. Since its publication, a number of other Section notes and relevant papers about telescopic observations of Mercury have appeared in the *Journal*.[2–8]

Observers

Many of the observers (Table 1) will be recognisable for their regular work for other BAA planetary Sections. Most appearances in this list represent the result of chance opportunities for an occasional view, for few observers concentrate upon the planet.

All observers provided images except those marked **V** (visual data only). Drawings and images were supplied by Adamoli, Bailey and Niechoy. An image by Boudreau was received via Melillo. Johnson contributed wide-angle sky photos and the other observers contributed telescopic observations at east or west elongations. We list the 2016 solar transit observers separately (Table 3).

Observations of Mercury's sunlit disk, 2007–2016

Observational circumstances

The difficulties in observing Mercury hardly need restating here: its small angular separation from the Sun coupled with its tiny angular diameter frustrate most observers' attempts even to locate it, while low altitude and consequent poor seeing often prevent any useful observation being made. Furthermore, the observable part of any elongation is brief. But for many observers a nice wide-angle photograph, perhaps of some conjunction involving Mercury, represents an achievable goal: see Figures 1A and 1B.

Figure 1. (B) Mercury's conjunction with Venus and the Moon from Terrigal Beach, NSW, Australia, 2008 Mar 6, Canon 350D. *Mike Salway.*

Elongation data

In Table 2 we list the greatest elongation (GE) dates from 2007 Nov to 2016 Oct. In his Section Reports, the late J. Hedley Robinson found it suitable to summarise Mercury observations every two calendar years. (F. J. Melillo, who is the current Mercury Recorder for the ALPO, reports upon the work of his contributors annually.) The sheer number of these elongations is immediately apparent from the table. (The BAA *Handbook* also gives the times of superior conjunction.) We also indicate the number of contributors.

We have shown the availability of observational material in **bold** type. Each **bold** entry is accompanied in brackets first by the number of visual observers, followed by the number of imaging observers (*e.g.*, (2/1)). A number of elongations, particularly the morning ones, went unobserved.

Observational results

It can readily be seen that most eastern elongations received observational coverage, but that an increasing number of western elongations were not observed. The majority of BAA work has always taken place at the more favourable Spring eastern elongation each year, although some observers such as Gray are obliged to concentrate upon western elongations due to local obstructions. The best-observed elongations in terms of volume of data were the eastern ones of 2008 May (bringing drawings from Adamoli, Frassati, Niechoy and Phelps, and images from the Ackermanns, Arditti, Kivits, Lomeli, Niechoy and Walker) and 2010 Apr (drawings by Adamoli, Bailey, Frassati, Grego and Niechoy, and images by the Ackermanns, Edwards, Ikemura, Kivits and Meredith). Understandably, some of the best quality images and drawings were obtained in the still morning air at western elongations.

For ease of reference we present the Camichel–Dollfus telescopic albedo map[9] in Figure 2. This lower resolution chart is more suitable in making comparisons with our results. It will be useful to give one of the final *Messenger* mosaics[10] to refer to for the higher resolution data: see Figure 3.

As in the previous report we display images in a single collage in order of central meridian longitude rather than by date: see Figure 4. This Figure includes some particularly fine work by the late Willem Kivits. It can be seen that several observers achieved a slightly higher resolution than the work published up to the end of 2007.[1] If we compare our current data with the previous collage, we can see that the results are complementary: longitudes imaged at crescent phase in one may be compared with nearly full phase ones at another. Even over nearly a decade we did not gather enough images to record every longitude at a high gibbous phase.

Some of the better drawings are given likewise in Figures 6A and 6B.

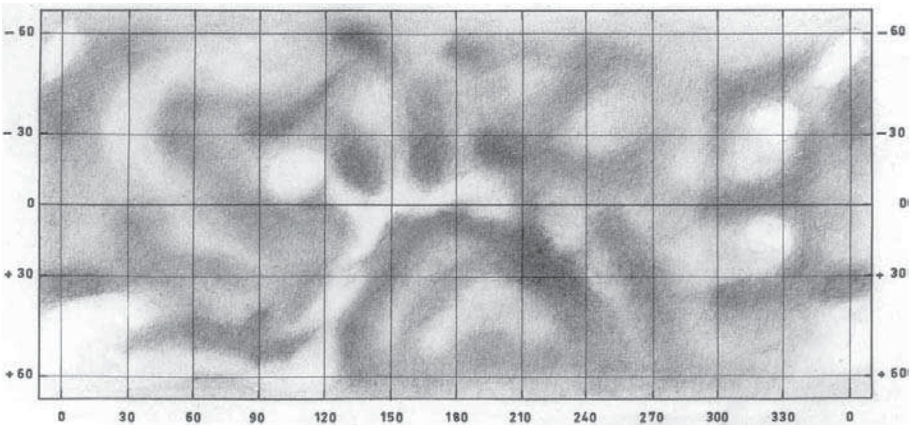

Figure 2. Albedo map of Mercury by H. Camichel and A. Dollfus, reproduced from their paper in *Icarus*, 8, 216–226 (1968). *Note:* In this map and all telescopic drawings and images, south is uppermost.

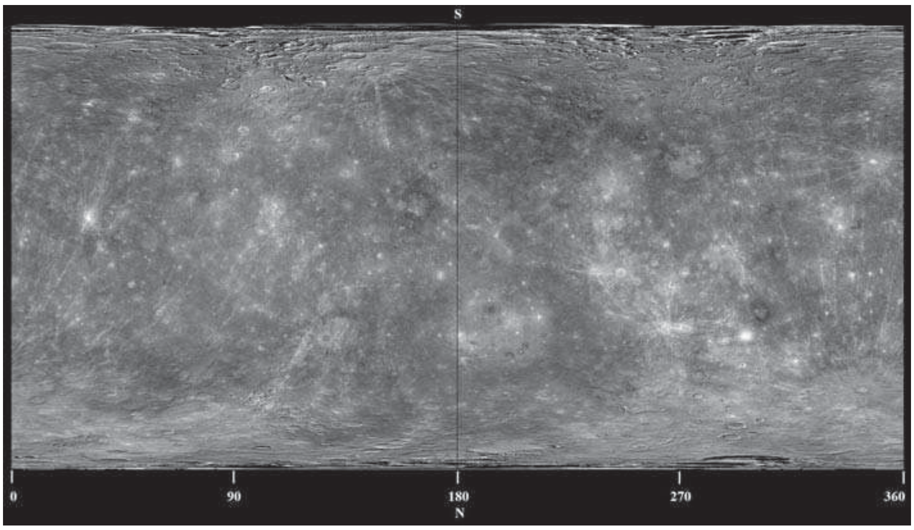

Figure 3. The *Messenger* Low Angle Incidence Mercury Mosaic: http://messenger.jhuapl.edu/Explore/Images.html#global-mosaics. 'This monochrome mosaic complements the morphology mosaic by using images that minimize shadows on the surface, and hence this ...mosaic highlights different reflectance properties of the materials on Mercury's surface. Projection: simple cylindrical, centered on 0° latitude and 0° longitude.' For reproduction here we have rearranged the mosaic to show longitude 180° at the centre, and south at the top.

The bright spots

Note that these spots, representing the ejecta from ray craters, are seen at their brightest under a vertical Sun. Thus if the phase is slightly gibbous they will be best seen towards the limb, which is where the subsolar point will be located. On the disk of the planet close to Full they may be bright near the centre. For example, witness Kuiper (−11°, 31.5°) as the bright spot near the *p.* limb under CM= 080 and 081° (Figure 4). At this longitude the Sun would be close to being directly overhead at the equator. On the image at CM= 028° in Figure 4, Kuiper is seen to be just *f.* the CM, and it is light but not bright. There are many examples of these bright spots on the images (and on several drawings).

Anomalous observations

At the 2010 April eastern elongation Frassati on Apr 1 and 5 (drawing; see Figure 6A, CM= 087°), and Edwards on Apr 5 (image) both showed the N. cusp protruding against a convex terminator. This may have been

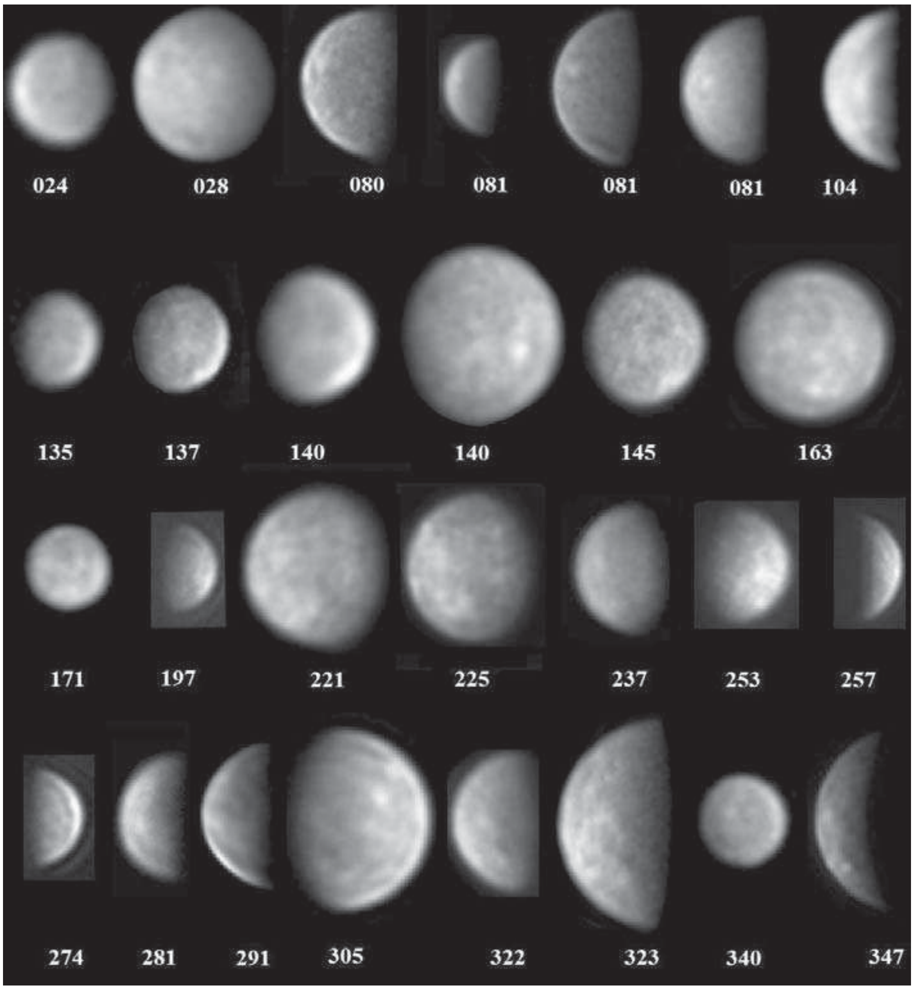

Figure 4. A selection of the best BAA images of Mercury, 2007–2016, using cameras with infrared pass filters, by Gabriele & Joerg Ackermann (DMK21AF04 camera); David Arditti (SkyNYX 2-0); John Bourdreau (DMK21AF04.AS); Daniele Gasparri (Lumenera LU075m); Chris Hooker (DMK21AU04.AS); Manos Kardasis (DMK21AU618); Willem Kivits (ATK 2HS & (2010–) DMK 21AU04.AS); Ed Lomeli (DMK21BF04); Paul Maxson (Lumenera SkyNyx); Tiziano Olivetti (Flea 3); John Sussenbach (Flea 3) and Sean Walker (DMK 21AU04.AS). The slow rotation rate of Mercury enables observers to employ long integration times. Given the very variable disk diameter of Mercury, no attempt was made to achieve a constant scale, but the better images have obviously been enlarged to a greater extent. All images have necessarily been considerably enhanced in contrast. In many instances this has resulted in a spurious grainy appearance due to amplified noise, which may well be visible upon the page.
Top row: CM= 024° (2016 Jul 13, Hooker), CM= 028° (2011 Mar 7, Kivits), CM= 080° (2008 May 5, Kivits), CM= 081° (2011 Mar 9, Arditti), CM= 081° (2008 May 5, Walker), CM= 081° (2011 Mar 19, Kivits), CM= 104° (2008 May 10, Ackermanns);
Second row: CM= 135° (2010 Jun 17, Hooker), CM= 137° (2011 Jun 2, Sussenbach), CM= 140° (2016 Oct 19, Hooker), CM= 140° (2012 May 17, Kivits), CM= 145° (2009 Jul 5, Kivits), CM= 163° (2010 Jun 24, Kivits);
Third row: CM= 171° (2010 Jun 26, Hooker), CM= 197° (2008 Mar 10, Lomeli), CM= 221° (2010 Jul 8, Kivits), CM= 225° (2010 Jul 9, Kivits), CM= 237° (2008 Jan 16, Boudreau), CM= 253° (2008 Mar 22, Lomeli), CM= 257° (2010 Sep 17, Maxson);
Bottom row: CM= 274° (2009 Oct 6, Maxson), CM= 281° (2013 Jun 4, Kardasis), CM= 291° (2013 Jun 6, Gasparri), CM= 305° (2014 Jul 26, Olivetti), CM= 322° (2009 Aug 15, Kivits), CM= 323° (2011 Jul 15, Kivits), CM= 340° (2016 Jul 2, Hooker), CM= 347° (2013 Jun 17, Gasparri).

due to the presence of a large dark marking near the cusp. Indeed, if we look at the image by Walker under CM= 081° in Figure 4 we can see a very dark candidate marking near that cusp which could make the terminator appear to recess visually, or upon a processed image.

The smallest observable phase?

The Director has often wondered what is the smallest phase at which the crescent of Mercury can still be distinguished from the background sky. Rarely do we see drawings or images with a phase below about 0.25. We know it is possible to see the New Moon from a little under 16 hours old, corresponding to a theoretical phase of 0.005. But Mercury is so close to the Sun that few observers have ever viewed a really narrow crescent, when daytime view-

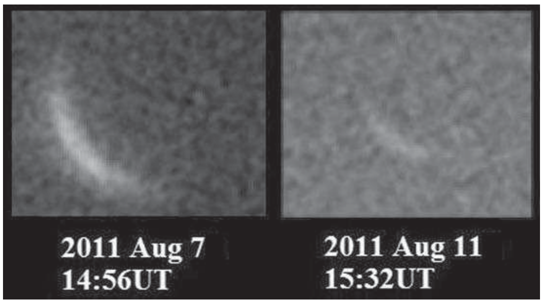

Figure 5. Mercury at very narrow phase, imaged in daylight by Willem Kivits (DMK 21AU04.AS camera) on 2011 Aug 7 & 11.

ing becomes essential. Moreover, being a rocky planet like the Moon, its magnitude drops off rapidly with decreasing phase.

Extracts from correspondence with Kivits show that Mercury was always invisible to the naked eye (and even on his CCD screen) in daylight at narrow phase. However, Kivits was able to extract the planet's feeble image from the background noise. His narrowest crescents were obtained in early to mid-afternoon on 2011 Aug 7 (0.114) and 11 (0.05). The planet's magnitudes were +2.3 and +3.4 respectively, and the corresponding latter image was obtained just six days prior to inferior conjunction. These remarkable images are given in Figure 5. Note the extreme faintness of the horns; indeed, they are not visible at all in the second image.

Adamoli is another frequent observer of the planet, and often takes up the same challenge from the visual point of view. During the 2010 April evening elongation he was able to follow Mercury on ten evenings in Mar–Apr, and found an apparent phase of 0.16 on Apr 18. But the record of Kivits – phase 0.05 – will be hard to beat.

Filters for visual daytime use

Gray (2012 Dec 2) wrote about his experiments with various Wratten filters: 'Usually the W22 [orange] copes well, with this planet in particular, but on this occasion it became fairly ill-contrasted against the sky background. So after some experimentation a W15 [yellow] stacked with a W13 [yellow-green] proved very effective… this combination rendering the sky much the colour of olive oil, with Mercury relatively more yellow.'

The 2016 solar transit

Circumstances

The event took place on 2016 May 9. The circumstances were reviewed by Macdonald[9] and the Director,[10,11] and also given in the 2016 BAA *Handbook*. Observers submitted their results to the writer, to the BAA Transit Website and to the Director of the Solar Section. Some images have already featured on the cover of the 2016 August *Journal*.[12]

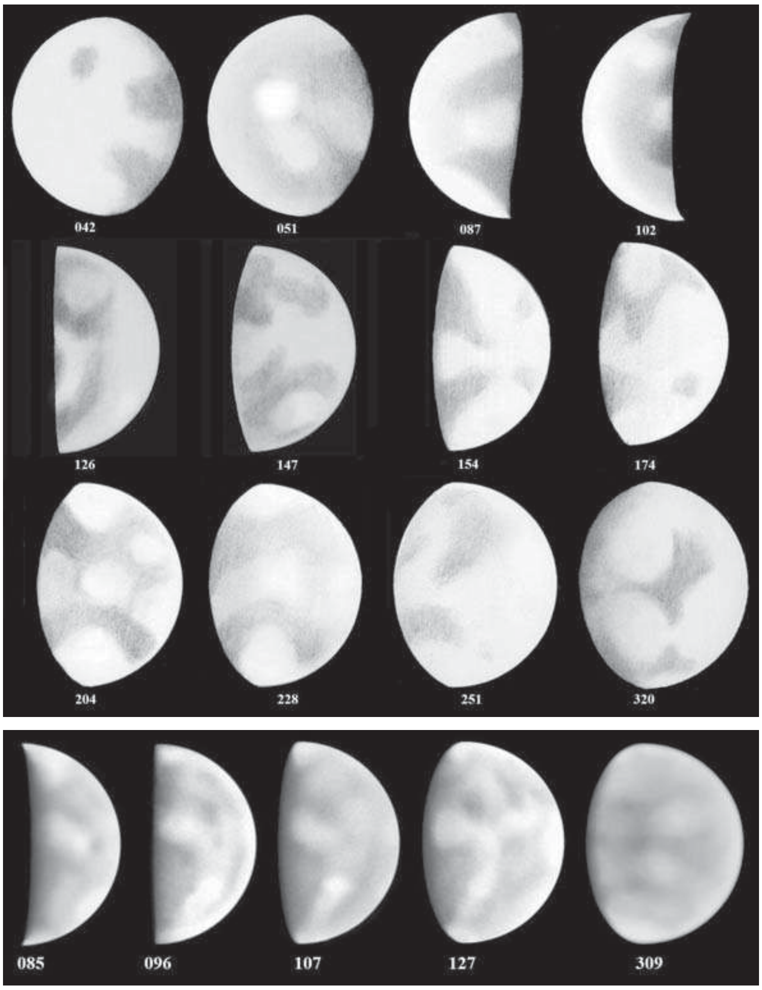

Figure 6. Collages of Mercury drawings, 2007–2016.

A *(top)*. Drawings by Mario Frassati, W21 or W23A filter, ×250. *Top row:* 2010 Mar 26 (CM= 042°), Mar 28 (CM= 051°), Apr 5 (CM= 087°) & Apr 8 (CM= 102°). *Middle row:* 2009 Feb 9 (CM= 126°), Feb 13 (CM= 147°); 2008 Mar 2 (CM= 154°) & Mar 6 (CM= 174°). *Bottom row:* 2008 Mar 12 (CM= 204°), Mar 17 (CM= 228°), Mar 22 (CM= 251°); 2009 Oct 16 (CM= 320°).

B *(bottom)*. Drawings by David Gray, W22 or W15+W13 combined filters, ×365. *From left to right:* 2012 Nov 30 (CM= 085°), Dec 2 (CM= 96°), Dec 4 (CM= 107°) & Dec 8 (CM= 127°); 2008 Oct 29 (CM= 309°).

Observers

A few observers went abroad to seek more reliable weather, but in the end the conditions in the UK proved to be good for many observers. The weather favoured observers in the Midlands and in the north, with those further south either having had a reasonable view only at the start, or been troubled by cloud all day. The 3rd and 4th contacts were only observed in the north. Many observers were able to view in hydrogen-alpha light. Most of the material sent in consisted of images of part of or the whole solar disk. Abel, Heath, McKim and Phelps also made drawings. The observers are listed in Table 3 and selected work illustrated in Figures 7–12.

Table 1. Observers of Mercury, 2007 Nov–2016 Oct

G. & J. Ackermann	Zaberfeld–Michelbach, Germany	180mm MK & 310mm DK Cass.
G. Adamoli	Verona, Italy	125mm MK & 235mm SCT
T. Akutsu	Cebu City, Philippines	355mm SCT
D. L. Arditti	Edgware, Middlesex	355mm SCT
K. N. L. Bailey	Swindon, Wilts.	127mm OG
J. Boudreau	Saugus, MA, USA	279mm SCT
C. Dole	Newbury, Berks.	180mm MK
P. Edwards	Horsham, West Sussex	279mm SCT
M. & L. Frassati **V**	Crescentino (VC), Italy	203mm SCT
M. H. Gaiger	Tolworth, Surrey	254mm refl.
D. Gasparri	Perugia, Italy	355mm SCT
M. Giuntoli **V**	Montecatini Terme, Italy	102mm OG
D. L. Graham **V**	Richmond, N. Yorks.	152mm OG
D. Gray **V**	Kirk Merrington, Co.Durham	415mm DK Cass.
P. T. Grego **V**	St Dennis, Cornwall	203mm SCT
C. J. Hooker	Didcot, Oxon.	254mm refl.
T. Ikemura	Nagoya, Japan	380mm refl.
R. Johnson	Ewell, Surrey	Digital camera
M. Kardasis	Athens, Greece	279mm SCT
W. Kivits	Siebengewald, Netherlands	355mm SCT
H–G. Lindberg	Skultuna, Sweden	180mm MK
E. Lomeli	Sacramento, CA, USA	235mm SCT
S. Macsymowicz **V**	Ecquevilly, France	102mm OG
G. McLeod	Bower, Wick	80mm OG
P. W. Maxson	Surprise, AZ, USA	254mm SCT
F. J. Melillo	Holtsville, NY, USA	254mm SCT
C. Meredith	Prestwich, Manchester	203mm SCT
D. Niechoy	Göttingen, Germany	203mm SCT
T. Olivetti	Bangkok, Thailand	410mm DK Cass.
I. S. Phelps	Warrington, Cheshire	152mm refl.
M. Salway	Central Coast, NSW, Australia	305mm refl.
J. Sussenbach	Houten, Netherlands	279mm SCT
J. Vetterlein	Rousay, Orkney	102mm OG
S. Walker	Manchester, NH, USA	317mm refl. & 355mm SCT

Abbreviations: Cass.= Cassegrain; DK= Dall–Kirkham; MK= Maksutov; OG= Refractor ('Object Glass'); Refl.= Reflector; SCT= Schmidt–Cassegrain. **V** *indicates visual data only supplied.*

Solar activity

Solar activity was low, with the last solar maximum well past. On the previous day, the Director (H-alpha and white light) had seen only a few small limb prominences, a number of small plages, and little evidence of flocculi.

The day of the transit was not dissimilar, and the small E. limb prominences provided a photogenic accompaniment to the entry of Mercury's small black disk. There were three small sunspot groups, the largest of which was west of the meridian and several times larger than Mercury in area. Mercury's transit track did not

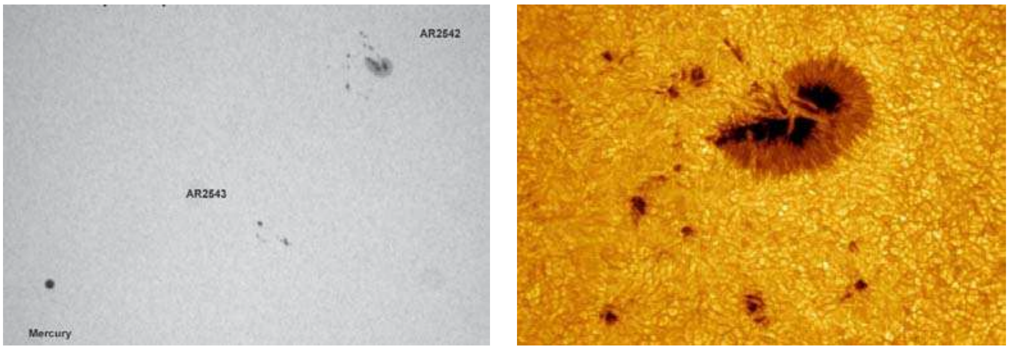

Figure 7. The solar transit, 2016 May 9. Sunspot activity.
A *(left)*. Mercury and sunspot groups at 13:50UT with 102mm OG with green filter and DMK21AU.04 monochrome camera by Ron Johnson.
B *(right)*. Enlargement of the largest sunspot group at 09:45UT with 178mm OG, Herschel wedge, ND + Baader solar continuum filter and ZWO ASI120MM-S camera by Dave Tyler. Note: All the solar transit images are oriented as the Sun would be viewed with the protected naked eye, with north uppermost.

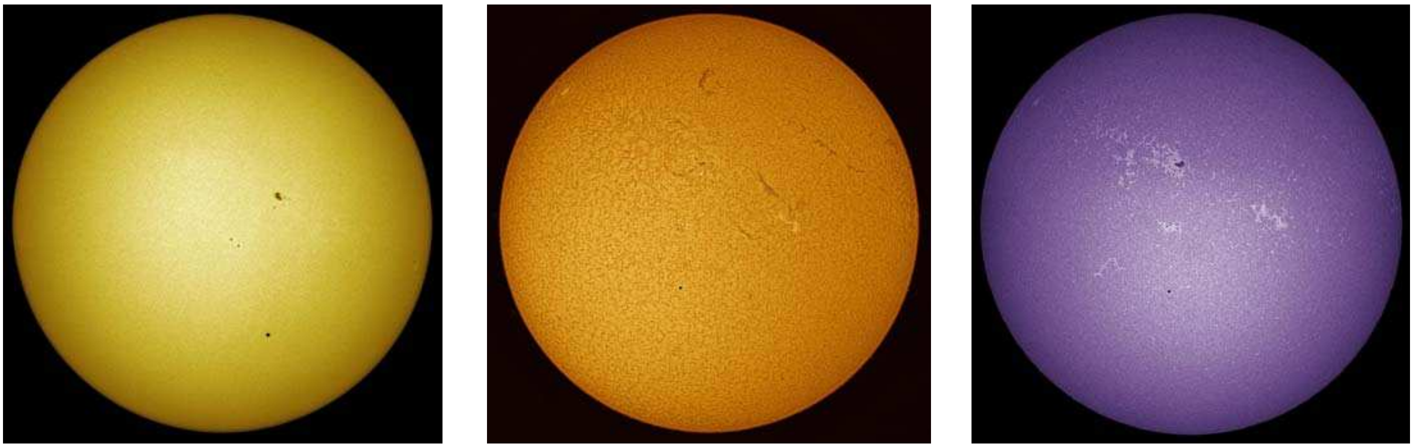

Figure 8. The 2016 solar transit. Comparing the view in white light with hydrogen alpha and calcium K.
A *(left)*. White light image at 13:05UT by Manos Kardasis with an 80mm OG, full aperture solar filter and DMK21AU618 camera.
B *(centre)*. Hydrogen alpha image at 14:55UT by Alan Tough with a 60mm Lunt LS60THa H-alpha telescope and DMK51AU02.AS camera.
C *(right)*. Calcium K image at 14:57:32 UT by Pete Lawrence with 40mm CaK PST and ZWOASI174MM camera. This was taken at the point of greatest transit.

bring it close to any spot. However, the changing aspect of the east limb prominences was interesting to follow as the day progressed. Figure 7 by Ron Johnson shows Mercury and two sunspot groups, and Figure 7B shows a close-up of the largest group by Dave Tyler.

Several observers took H-alpha images on the day of the transit, while Pete Lawrence and Sheri Lynn Karl[12] made Calcium K images too, which make fascinating comparison to the white light aspect. Compare Figures 8A, 8B and 8C, with mid-transit images by Manos Kardasis (white light), Alan Tough (H-alpha) and Lawrence (CaK).

Table 2. Greatest elongation (GE) and observational data, 2007 Nov to 2016 Oct

Date of GE East (evening)	*Date of inferior conjunction*	*Date of GE West (morning)*
– – –	2007 Oct 23	**2007 Nov 8 (1/1)**
2008 Jan 22 (2/2)	2008 Feb 6	**2008 Mar 3 (1/3)**
2008 May 14 (4/6)	2008 Jun 7	**2008 Jul 1 (0/1)**
2008 Sep 11 (1/1)	2008 Oct 6	**2008 Oct 22 (2/1)**
2009 Jan 4 (1/0)	2009 Jan 20	**2009 Feb 13 (1/1)**
2009 Apr 26 (4/0)	2009 May 18	2009 Jun 13
2009 Aug 24 (1/1)	2009 Sep 20	**2009 Oct 6 (2/2)**
2009 Dec 18 (1/0)	2010 Jan 4	2010 Jan 27
2010 Apr 8 (5/5)	2010 Apr 28	**2010 May 26 (0/3)**
2010 Aug 7 (1/1)	2010 Sep 3	**2010 Sep 19 (1/2)**
2010 Dec 1	2010 Dec 20	2011 Jan 9
2011 Mar 23 (2/4)	2011 Apr 9	**2011 May 7 (0/2)**
2011 Jul 20 (1/1)	2011 Aug 17	2011 Sep 3
2011 Nov 14	2011 Dec 4	2011 Dec 23
2012 Mar 5 (3/2)	2012 Mar 21	**2012 Apr 18 (0/1)**
2012 Jul 1	2012 Jul 28	**2012 Aug 16 (0/1)**
2012 Oct 26	2012 Nov 17	**2012 Dec 4 (2/1)**
2013 Feb 16 (1/1)	2013 Mar 4	2013 Mar 31
2013 Jun 1 (1/3)	2013 Jul 9	2013 Jul 30
2013 Oct 9	2013 Nov 1	2013 Nov 16
2014 Jan 31 (1/0)	2014 Feb 15	2014 Mar 14
2014 May 25 (1/0)	2014 Jun 19	**2014 Jul 12 (0/1)**
2014 Sep 21 (1/0)	2014 Oct 16	**2014 Nov 1 (0/1)**
2015 Jan 14 (1/0)	2015 Jan 30	2015 Feb 24
2015 May 7 (2/1)	2015 May 30	2015 Jun 24
2015 Sep 4 (1/0)	2015 Sep 30	2015 Oct 16
2015 Dec 29	2016 Jan 14	2016 Feb 7
2016 Apr 18 (2/2)	**2016 May 9 (transit)**	**2016 Jun 5 (0/1)**
2016 Aug 16 (1/1)	2016 Sep 12	**2016 Sep 28 (0/2)**

The availability of observational material is indicated in **bold** type. Each **bold** entry is accompanied in brackets first by the number of *visual* observers followed by the number of *imaging* observers [*e.g.*, **(2/1)**]. A number of Elongations, particularly the morning ones, went unobserved.

Ingress & egress and optical effects

At the 1973 Nov 10 transit, observing in the bright continuum adjacent to the H-alpha line, Harold Hill[13,14] had observed the planet's black disk projected upon the inner solar corona beyond the solar limb up to 1.5 minutes after 4th contact. In fact this was

Table 3. Observers of the 2016 May 9 solar transit

P. Abel & P. Lawrence (Leicester), G–L. Adamoli (Verona, Italy), R. M. Baum (Chester), K. W. & R. Blaxall (Colchester, Essex), G. Di Giovanni (Colle Leone Observatory, Italy), C. Fattinnanzi (Montecassiniano, Italy), C. Foster (Centurion, S. Africa), M. Foulkes (Grantham, Lincs.), M. Giuntoli (Montecatini Terme, Italy), R. Hartness (Barnard Castle, Teesdale), A. W. Heath (Long Eaton, Notts.), R. Hill (Tucson, AZ, USA), N. D. James (Chelmsford, Essex), R. W. Johnson (Ewell, Surrey), M. Kardasis (Athens, Greece), S. L. Karl (Aberdeen, Scotland), W. J. Leatherbarrow (Sheffield), P. Macdonald (Harrow, Middx.), R. J. McKim (Oundle & Upper Benefield, Northants.), P. Meadows (Crete, Greece), F. J. Melillo (New York, NY, USA), M. P. Mobberley (Bury St Edmunds, Suffolk), P. Mulligan (Sheffield), D. Niechoy (Göttingen, Germany), P. W. Parish & T. Cannon (Gillingham, Kent), I. Phelps (Warrington, Cheshire), A. Tough (Elgin, Moray, Scotland), D. B. V. Tyler (Flackwell Heath, Bucks.), A. Vandebergh (Wittem, Netherlands), A. G. Vargas (Cochabamba, Bolivia), T. Wakefield (Manchester) and S. Williams (Leighton Buzzard, Beds.). Images by S. L. Karl and T. Wakefield were kindly contributed by the Solar Section Director, Lyn Smith.

Figure 9. The 2016 solar transit. Hydrogen alpha images at 11:12:16–11:12:26 UT showing the planet crossing the spicule layer at the edge of the chromosphere just prior to 1st chromospheric contact, with 102mm OG, Quark H-alpha filter and ZWOASI174MM camera, by Pete Lawrence.

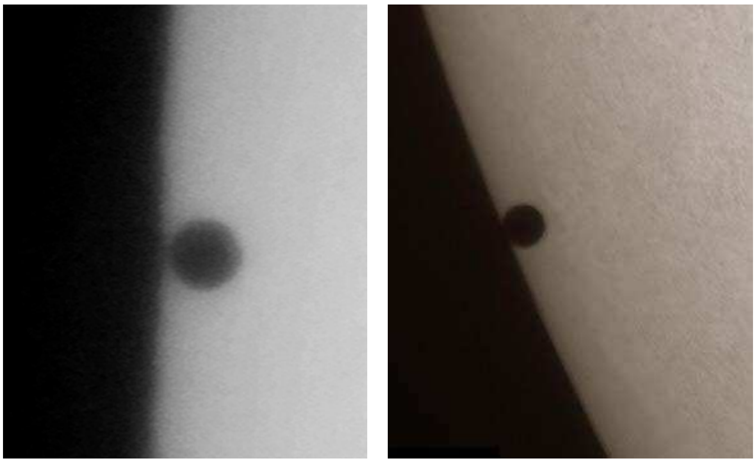

Figure 10. The 2016 solar transit. Second contact white light images showing how the appearance of the Black Drop was seeing-dependent.
A *(left)*. 11:15UT, 150mm OG and Sony TRV-740 video camera, *Ralf Vandebergh*. If this image taken in average seeing is viewed from a distance, a trace of the Black Drop effect – or at least a darkening of the surface between the Sun's limb and planet – is evident.
B *(right)*. 11:15:12 UT 178mm OG, Herschel wedge, ND + Baader solar continuum filter and ZWO ASI120MM-S camera, *Dave Tyler*. There is no trace of the Black Drop in this image taken in very good seeing, which was clearly obtained a few seconds before that in **(A)**.

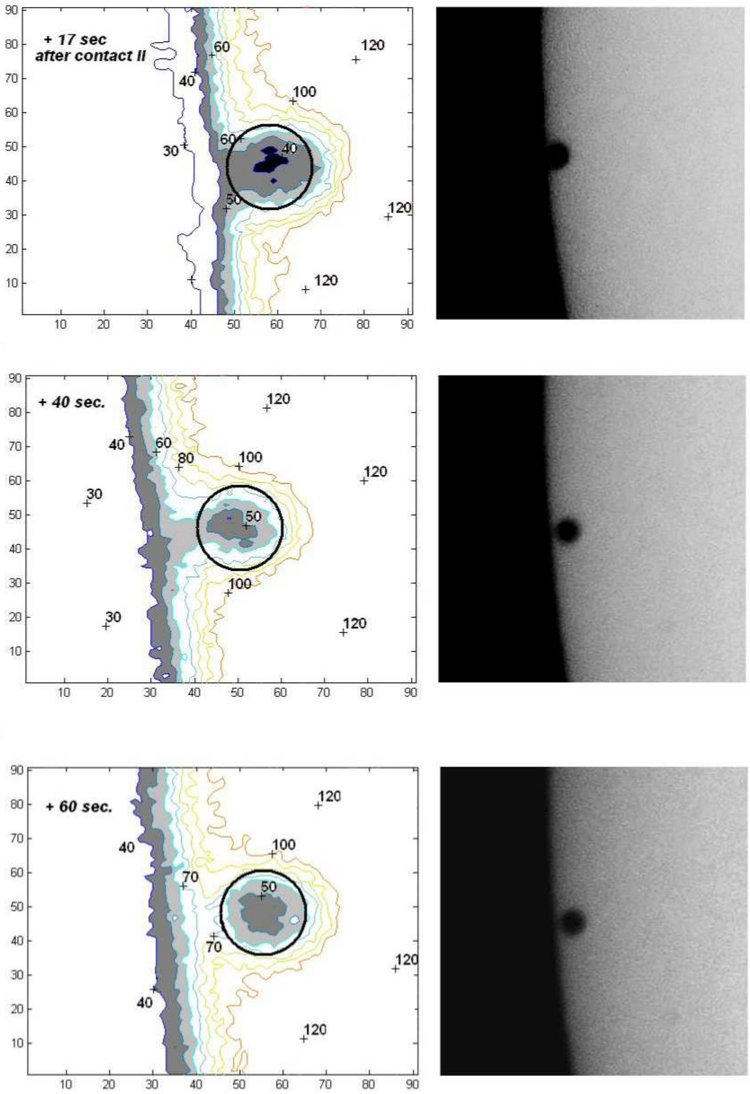

Figure 11. The 2016 solar transit. Images and photometric scans taken in fair seeing (Antoniadi III–IV) 17s, 40s and 60s after second contact with 150mm OG and Nikon D3000 camera by Giovanni Di Giovanni. The second of these pairs hints at the presence of the Black Drop. The images have been sharpened so that the position of the true limb has been lost.

another observation of a type previously made at several transits, dating back to the 19th century.[14] Just prior to first contact on 2016 May 9, Pete Lawrence experienced very good conditions and was able to make the same sort of observation before the transit began. Lawrence described his images as showing the planet silhouetted against the spicule (transition) layer before reaching the chromosphere proper: see Figure 9. Lawrence was able to observe that the transit began earlier in H-alpha than in white light, due to the extra depth of the chromosphere. This difference in time is known from previous events. Others attempted to see Mercury prior to 1st chromospheric contact but did not succeed due to the presence of cloud.

Seeing was very favourable for many observers, and those who were able to time the contacts mostly did not experience the once-dreaded Black Drop effect. The latter is now recognised to be more an effect of lack of resolution, which is exacerbated by bad seeing, rather than the result of bad seeing alone (as it was earlier believed to be). Little sign was seen of the light aureole around the planet either, though it can always be mimicked by over sharpening an image. The white spot in the centre of Mercury's disk (an effect of diffraction, reported at some past events) was also not observed. Ralf Vandebergh produced an image hinting at the Black Drop effect at 2nd contact, in fair seeing (Figure 10A). In contrast the image by Dave Tyler in better seeing at the same point shows only a sharp disk (Figure 10B). The ingress sequences of Alan Heath and Ian Phelps (Figures 12 and 15) may also be compared on this point.

Timings

Various predicted timings were given in the 2016 *Handbook*. Actual timings are given in Table 4 (I= 1st contact, etc.), with the geocentric ones for comparison.

Table 4. UT timings of the 2016 May 9 solar transit

All timings made in white light except where stated.

Observer	*I*	*II*	*III*	*IV*
Pete Lawrence: white light	11:12:33±4	11:15:40.7±1		–
H-alpha (102mm OG)	11:12:24±4	–	–	–
Manos Kardasis (279mm SCT)	–	11:15:03	–	–
Richard McKim* (254mm refl.)	11:12:30	11:15:40	–	–
Ian Phelps (152mm refl.)	–	11:15:32	–	–
R. Hartness (203mm SCT)	–	–	–	18:40:20
AlanTough (100 mm OG)	–	11:15:38	18:37:23	18:40:02
Sheridan Williams (98mm OG)	11:12:28	11:15:38	–	–
Geocentric (predicted)	**11:12:18**	**11:15:30**	**18:39:12**	**18:42:24**

*These measurements may generally be reliable to ±5s, but we quote the error estimates of Lawrence which are smaller due to better conditions. The first and second UK contact times differed little from the geocentric ones. A greater deviation can be seen with the third and fourth contacts. For Leicester (Lawrence) the predictions for the contacts were 11:12:19, 11:15:31, 18:39:14 and 18:42:26. Foster stated that for Pretoria (S. Africa) the time predicted for 2nd contact was 11:15:08. He confirmed that this had already occurred by 11:15:32, but did not obtain a precise timing.

Solar parallax

In principle we could compare the UK data with those from South Africa or South America in order to determine the solar parallax, as was done in the distant past.

Observers' comments (extracts)

Paul Abel & Pete Lawrence: 'We were able to follow the transit until the end, although by this point we were observing the Sun through gaps in the trees!'

Gianluigi Adamoli: 'Around 15:30 UT there was a temporary thinning of the clouds. Mercury was a perfectly round spot, absolutely black, with very definite edge. I've been lucky that this transit was a very long affair, so allowing me to take advantage of a limited opportunity window, during an otherwise very bad day, quite rare for May, in Italy.'

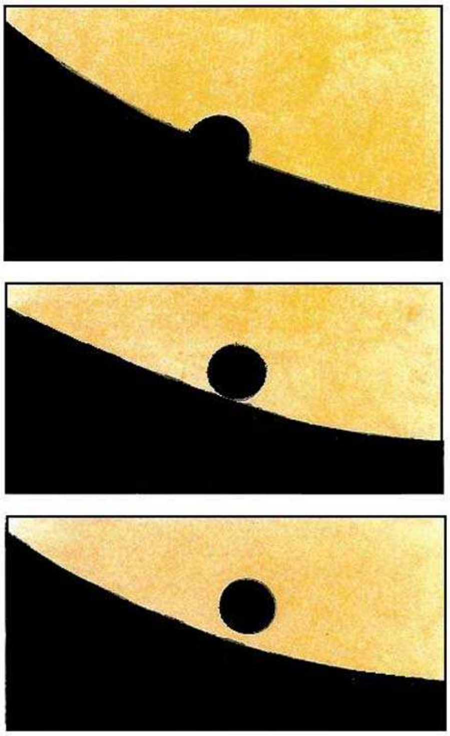

Figure 12. The 2016 solar transit. Drawings at ingress by projection with 75mm OG, ×90, by Alan Heath.

Richard Baum: 'Cloud and haze proved a nuisance, but we had good moments. Both ingress and egress were lost to cloud but in the time it was possible to have a decent sight of the event it was fascinating. Thinking back to June 2004 and Venus, Mercury seemed more like a full stop! Of course there was no comparison with the observations made during the transit of 1973 when after a morning of exceedingly heavy rain the cloud abruptly cleared with remarkable rapidity, and rushing home from work, I was able to catch egress very well. At that time I was much taken with historical reports of white spots and haloes round the planet. Artefacts obviously, yet I did catch a glimpse of whiteness around the planet.'

Giovanni Di Giovanni: 'These results [with 150mm Cass. in seeing Antoniadi III–IV] show a slight Black Drop effect at ingress, less prominent than had been expected.' The observer submitted photometric scans of the ingress image series (Figure 11).

Clyde Foster: 'As Ingress time approached, weather conditions were very uncertain, although definitely better than forecast… There were substantial breaks in the cloud… All in all, an eventful day, not least of all that it started at about 02:00 a.m. with me up early for some Mars imaging.'

Mike Foulkes: 'The forecast indicated it would be very clear north of Peterborough but with some thin cloud around first/second contact, but very clear into Lincolnshire. I decided to travel north up the A1 and ended up in a lay-by on the A46 to the east of the A1. As I headed north it was cloudy but slowly blue skies appeared. I did think of stopping near Grantham but there was a bit of thin cloud around, so went further north in line with the forecast. I set up my trusty 70mm refractor with an imaging camera. I did get a few funny looks from other people parked in the lay-by throughout the time I was there. Then Mr Spode appeared. A couple of minutes before first contact my drive stopped. By the time I changed the batteries and checked the connection and got the drive going again and slewed back to the east limb, first contact had taken place. But I managed to see second contact with the webcam going. I had to leave around 15:00 BST to get back to Stevenage.'

Alan Heath: 'No Black Drop seen [at ingress; 75mm OG]. The planet was completely black and well seen and darker than the umbra of a sunspot.' Alan's ingress drawings are given in Figure 12.

Bill Leatherbarrow: 'I did try to replicate Harold Hill's famous observation of Mercury before transit, silhouetted against the solar corona, but without success either visually or imaging.' Bill rightly considers that the slight whiteness around Mercury in transit was an effect of processing: however, this is hardly visible in Figure 13.

Richard McKim: 'The transit was shown to many pupils and staff at Oundle School using a 254mm Newtonian to project the image. There was a distinct gap between Mercury and the Sun's limb by 11:16:00 UT, and at 11:17:45 UT I noted that any light aureole around Mercury was barely visible upon the projection screen in good seeing, and any such appearance was regarded as illusory. Images were also made with a 60mm Coronado H-alpha telescope (Figure 14). Conditions were quite good until 18:20 UT, less than 20 minutes before 3rd contact, when cloud cover gradually increased to 100%.'

Peter Meadows: 'The transit was observed using telescopes set up by the Crete Astronomy Friends Club in the picturesque Venetian Harbour in Chania. I observed the transit at around 15:50 UT (18:50 EEST local time). Both the telescopes showed that Mercury was darker than the umbra of the few sunspots that were visible.'

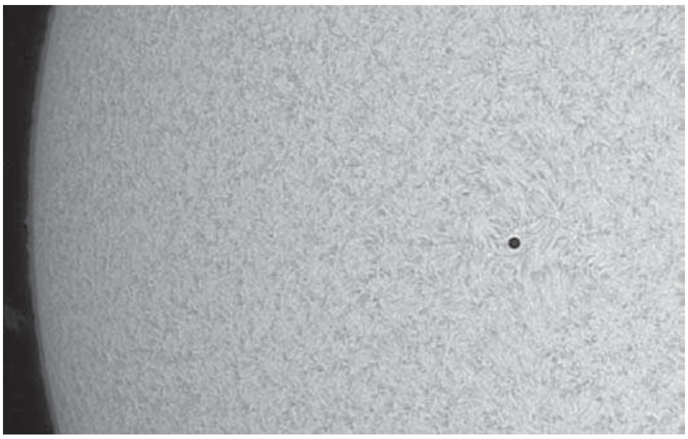

Figure 13. The 2016 solar transit. H-alpha image at 13:36:51 UT with Solarscope SV50 (50mm aperture) and DMK21AU04.AS camera by Bill Leatherbarrow. Notice the very slight whiteness around the planet; an effect of image-processing.

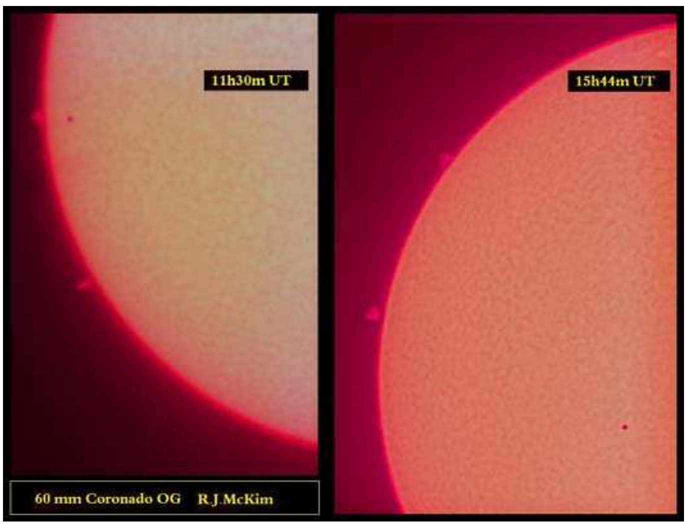

Figure 14. The 2016 solar transit. Two H-alpha images at 11:30 & 15:44UT with 60mm Coronado solar telescope and Phillips ToUCam camera by Richard McKim.

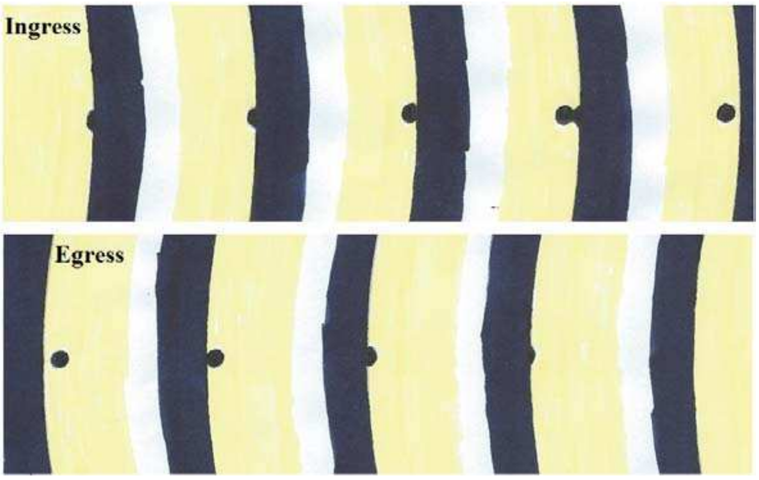

Figure 15. The 2016 solar transit. Ingress and egress sequences with 152mm refl. ×45 and full aperture ND5 Baader solar filter, drawn with direct vision by Ian Phelps.

Peter Parish: 'The weather forecast for Sunday May 8 had been for unbroken sunshine all day and they were right, but for Monday the 9th it said that cloud and rain was coming up from the south. This cloud was forecast to appear during the morning. At around 11 a.m. BST despite the weather forecast, the Sun in Rainham was shining off and on… as second contact approached I could not see any sign of the Sun stretching around Mercury as I saw in hydrogen alpha with Venus in 2004… by 15:00 BST the cloud had built up to such an extent that it prevented any further observation. I discovered later how lucky I was even to see this event from Rainham in Kent. My sister who was in Eastbourne, on the Sussex coast on May 9, told me that whilst the Sun was shining at 08:30, by 12:00 BST it was very overcast. The cloud was thick and unbroken during that afternoon and for the whole duration of the transit.'

Ian Phelps: 'Although having clear skies throughout was an ultimate advantage, I did have to contend with some gusty wind and episodes of poor seeing.' The Black Drop was very marked in poor seeing at 11:14 UT, but the 'thread' was timed to break at 11:15:32 UT, and this can be taken as 2nd contact. Better conditions were experienced at 3rd and 4th contacts and the Black Drop was not seen then. (See Figure 15.)

Alan Tough: 'I took the day off work on Monday to see the entire Transit of Mercury (my first one). Conditions were, generally, very good here in Elgin, with a clear blue sky and just a few wispy, high-altitude clouds.' See Figure 7B. Alan was the only observer to report accurate timings of 3rd and 4th contacts.

Figure 16. The 2016 solar transit. White light image at 13:41:52 UT with 98mm OG and Canon EOS 60Da camera by Sheridan Williams.

Gonzalo Vargas: Setting up his telescopes in a public area together with his wife Cristina and sons Alioth and Arturo, he noted: 'Two scopes were used. A Meade 10-inch [203mm] with a solar filter for direct observation and a homemade 8-inch [216mm] for projection… More than one hundred persons of all ages came to visit us.' The visitors included a local journalist and some local TV crews.

Sheridan Williams: 'I saw the first four hours of the transit but clouds got very annoying after that.' Figure 16 shows mid-event with a little of that cloud.

Conclusions

Nearly a decade of Mercury work has produced relatively meagre imaging results, but we have at least shown how improved technique coupled with persistence can generate excellent daytime images that show recognisable Mercurian features, even from the UK. Although the features of Mercury are static, and have been completely mapped by *Messenger*, any telescopic sighting of this elusive little world is always satisfying. We have shown that the visibility of the bright spots on the surface – regions of ejecta from ray craters – is always brightest under a high Sun, as is seen to be the case with our Moon.

Data from the transit of Mercury confirm earlier findings concerning optical effects. The white ring around the planet is purely an artefact, produced by image processing, and can be replicated visually by a combination of small aperture and bad seeing. The famous Black Drop effect is also primarily an effect of inadequate resolution, but it too is exaggerated by bad seeing.

We invite observers with good images or drawings of Mercury to continue to send them to the Section.

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Video meteor spectroscopic and orbit determination observations, 2015 April to 2016 April

Bill Ward

This paper reviews the combined video meteor spectroscopic observations of the Kilwinning Spectroscopic Survey for Meteors (KiSSMe) and the related mutual capture, multi-video station orbital observations from the Network for Meteor Triangulation and Orbit Determination group (NEMETODE) in the period between 2015 April and 2016 April. A total of eleven mutual events were captured. A brief comment is made about the main lines in each spectrum and orbital elements are presented for eight of the meteors.

Introduction

Many observers, both amateur and professional, use the compact Watec CCTV cameras. These cameras have become particularly popular due to good performance at relatively low cost. The rapid growth in the number of observers using video techniques has led to the formation of many groups undertaking multi-station observations in order to obtain orbital information about meteors.

One such group is the Network for Meteor Triangulation and Orbit Determination (NEMETODE).[1] At the time of writing, NEMETODE has multiple stations with 57 cameras in operation across the UK, Ireland and France. Members of the NEMETODE group use a variety of systems including Watec, Genwac and KPF video cameras

Video meteor observations have been carried out at Kilwinning since 2004. In 2008 a decision was made to develop spectroscopic techniques as there seemed to have been very little done in this field with regards to the use of video systems. Initial results indicated that whilst of limited resolution a sufficient number of spectra could be captured to contribute viable results. The first results of this effort were presented at the International Meteor Conference held in Armagh in 2010.[2] Due to improvements in equipment over time the camera system is now operated in a 'survey mode'. That is, the cameras in the system now use lenses carrying gratings at all times to try to capture as many spectra as possible.

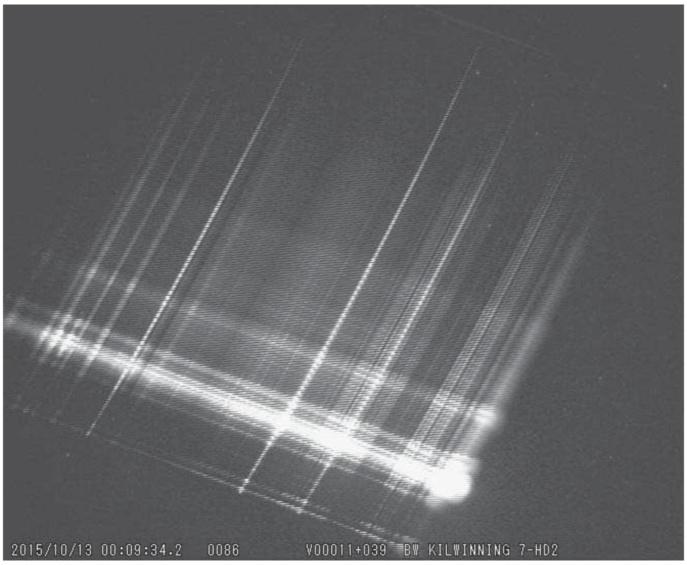

Figure 1. Composite video meteor spectrum image, KSSM/NEM #005.

This review clearly demonstrates the advances now being made in (amateur) meteor astronomy. From orbital studies it is possible to say where the meteoroid 'came from', thus possibly leading to a determination of a parent body. With spectroscopic analysis an outline of the meteoroid's composition can be made, saying what the meteoroid was 'made of' and perhaps indicating whether cometary or asteroidal. By combining the multi-station orbital observations with spectroscopic observations there is the ability to gain a much more complete insight into the Earth's meteoroid environment.

Until recently such work was only possible by a few established professional observatories, but this is no longer the case!

Spectroscopic observations

The spectroscopic observations were made with Watec 902H2 Ultimate and Watec 910 HX/RC cameras. The cameras use 12mm f/0.8 lenses and carry 600 groove/mm or 830 groove/mm fused silica transmission gratings. Gratings produce an almost linear dispersion, making them ideal for this application. However due to the nature of light diffraction through a grating, multiple spectra, called orders, are produced. This can sometimes be problematic as there can be overlap between spectra causing difficulty in interpretation. Only one spectrum in this review has a significant issue with this (KSSM/NEM #010).

Another problem encountered when using a grating dispersing element is the orientation of the meteor with respect to the grating axis. If the meteor falls exactly across this axis the dispersion will be as large as is possible with the given optical configuration. However most meteors fall at an angle that is less than this. The result is a tilted spectrum which requires further processing as described below. The net effect is that the corrections tend to broaden the spectrum lines, thus losing effective resolution.

Outline of processing

An example of a composite image produced by the software used to detect the meteor spectrum is shown in Figure 1.

In Figure 1, the 'blue' end of the spectrum is towards the right and the 'red' is to the left. This example is quite unusual as it is essentially complete. The fortunate position of the meteor with respect to the optical axis has meant the entire span of the spectrum from the near UV to the near IR has been captured. Due to the spatially random occurrence of meteors on the sky, capturing only a part section of the spectrum is much more typical.

Briefly, before producing a spectrum graph the image requires some pre-processing. The geometrical image processing is carried out with the IRIS software.[3] The spectroscopic processing requires that the spectrum runs blue (shorter wavelengths) to red (longer wavelengths), left to right. This is the opposite of what was captured by chance in Figure 1. Therefore it is necessary to rotate the spectrum to the required orientation. Once in the appropriate orientation the spectrum image itself often needs to be 'de-slanted' so that the spectrum lines are vertical. The de-slanting process broadens any line present reducing the resolution. Once in the correct format the image can be imported into the spectroscopic analysis software *Visual Spec* for reduction.[4]

Due to the design of commercially available CCTV lenses and the broad sensitivity of the monochrome sensor used in the Watec camera, defocus is a problem at the extreme ends of the spectrum. This is especially troublesome at the far blue end where prominent lines of magnesium and calcium, as in this example, appear bloated out of focus. A similar but less dramatic effect can be seen at the near IR end of the spectrum (out to >900nm).

Being commercial CCTV lenses for use in security work they are simply not designed to work at the extremes of wavelength under these particular operating conditions. By trying to re-focus, the problem is not improved because the glass in the lenses cannot form a fully corrected image across such broad wavelength range. Any slight improvement at one end of the spectrum results in even greater degradation at the other. The best focus is generally achieved in the blue/green part of the spectrum.

With the limitations imposed by the number of lines on the transmission grating and the focal length of the lenses used, the practical resolution achieved is quite low. Combined with variable observing geometry it is in most cases of the order of a few nm (As measured by the full width half maximum on various representative lines). This is insufficient to resolve the closely spaced emission lines of elements such as magnesium (a triplet around 517nm) or sodium (the famous doublet around 589nm).

Nevertheless some spectra can show considerable detail.

The spectra

This review considers spectra that were obtained between 2015 April and 2016 April. This period is entirely arbitrary and was based on the occasion of securing the first multi-station spectrum observation from the UK on 2015 April 10.[5] It should also be remembered that meteor spectra consist of a number of emission lines, some of which are related to the composition of the meteoroid itself, whilst others are related to the upper atmospheric gases with which it is colliding.

Spectrum graphs

Due to the software used the wavelengths are displayed as Angstroms on the graphs. The Angstrom is not an SI unit but it is frequently favoured in many spectroscopic applications through common use. 1Å is equal to 0.1nm. Thus 5000Å is equal to 500nm. The Angstrom will be used in the description text to minimise confusion when referring directly to the graphs.

An inherent feature of the sensors used in the Watec cameras is that they have a wavelength dependent sensitivity. That is, they are more sensitive to red and near-IR light than to blue. To correctly portray the spectrum it must be adjusted to deal with this variation. The most important is an instrument flux correction. This is normally achieved by dividing the spectrum by a known spectrum flux standard. The spectrum from the star Vega is often used. Whilst this generates a corrected spectrum the graphing produces a spectrum that can be quite steeply curved. This in effect 'compresses' the visibility of some lines.

To present a more uniform appearance the spectra have been normailised, that is numerically set to a value of 1.000, in part of the spectrum where there are no major lines present. For clarity of exposition the corrections described have not been applied to the spectra as presented. For a comparison to older photographic techniques and results the review by Ceplecha is to be recommended.[6]

The spectra themselves illustrate some of the difficulties already mentioned. Each one spans a different range of wavelengths, illustrating the point that few captures ever show the whole spectrum.

The spectrum graph of KSSM/NEM #001 has its main emission lines annotated. Since these are the most common ones found in meteor spectra they can be used as a guide to the other graphs.

Notes on the individual spectra are given. Line identification was done by comparison to known meteor spectrum lines and by comparison to the emission spectrum line database included with the *Visual Spec* software.[7] Once the spectra have been inspected it will be noted that most contain the same well known elements. This gives the subtle yet profound message that the Earth and everything on it are all made of the same 'stuff' as our cosmic neighbourhood.

Figures 2 to 12 show the eleven spectra obtained.

The meteor orbits

The orbital data were derived from observations made by members of the NEMETODE group. The *UFO Capture* suite was used to capture and process the images and produce the orbits.[7]

Examples of orbit plot and ground map are shown in Figures 13 and 14.

Eleven mutual events were captured. KSSM/NEM #001 was the first multi-station/spectroscopy event recorded from the UK and is detailed in ref. 5.

Three meteors could not have their orbits determined. While detected by multiple stations, either poor observing geometry or only very small fragments of the meteor image prevented this. These are included for completeness as a spectrum was captured for these events. Indeed it is great pity that this applies to KSSM/NEM #008. This was a very detailed and complete spectrum. It would have been an excellent result to obtain an orbital solution for this particular meteor.

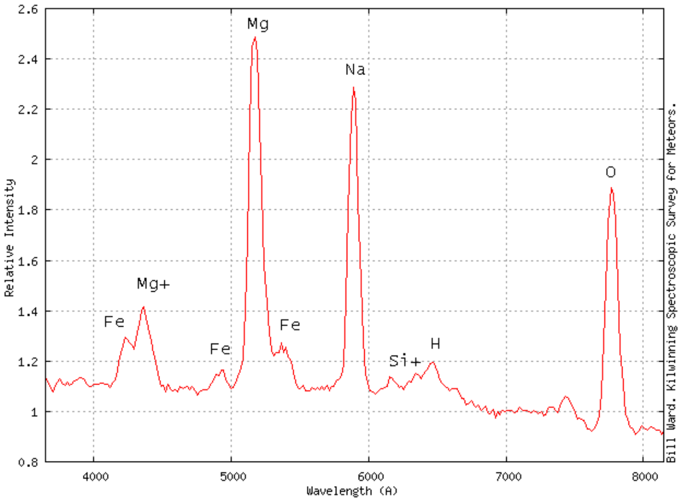

Figure 2. KSSM/NEM #001. 2015 April 10, 00.58.37UT. This spectrum shows fairly typical element emission lines at normal resolution using the type of camera/lens/grating described in the text. The three most prominent lines are of the magnesium (Mg) triplet at 5175Å (green), sodium (Na) doublet at 5893Å (yellow-orange) and oxygen (O) at 7774Å (near-IR). Other lesser peaks can be identified including ionised magnesium (Mg^+) at 4481Å, several weaker iron (Fe) lines at 4326Å, 4921Å & 5270Å, ionised silicon (Si^+) at 6359Å and hydrogen (H) at 6563Å.

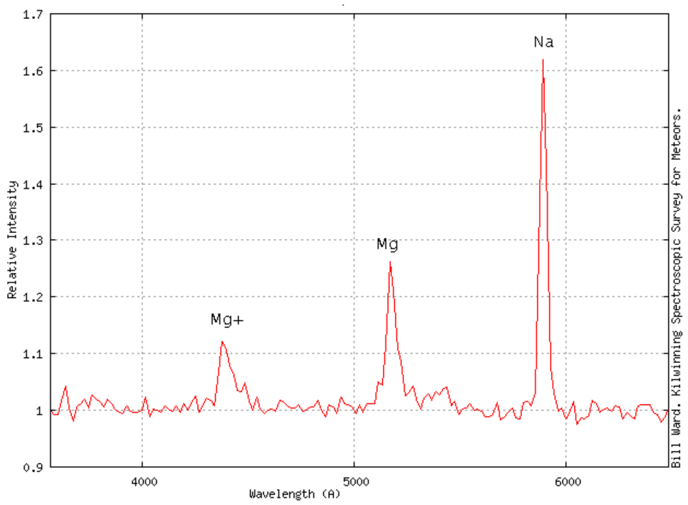

Figure 3. KSSM/NEM #002. 2015 April 21, 01.57.52UT. This spectrum is rather 'noisy' and was relatively weak. Many of the smaller 'peaks' are artefacts from the pre-processing stage. These peaks are caused by the raster scan nature of the video output. With re-processing these can be exaggerated and appear as physical features in the spectrum. Great care must be taken when analysing this type of spectrum; it is easy to fit reference 'lines' to non-existent lines when there are many false peaks. The strongest line here is of Na (5893Å). The other two peaks are Mg^+ (4481Å) and the Mg triplet (5175Å).

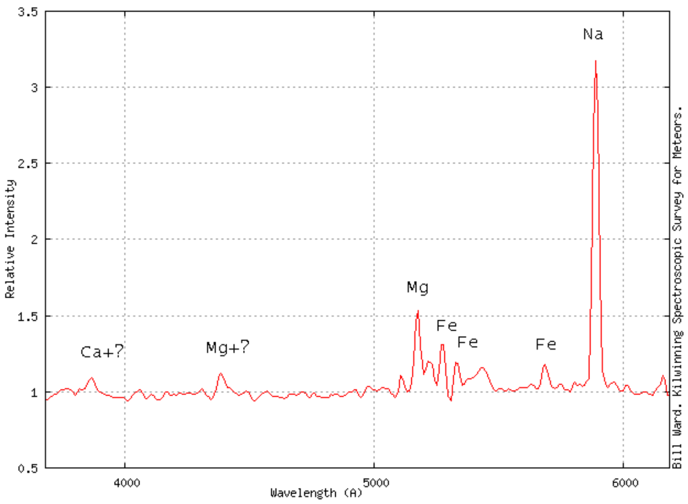

Figure 4. KSSM/NEM #003. 2015 Sep 11, 02.27.19UT. This has a very strong Na (5893Å) signature compared to other lines. The Mg (5175Å) and Mg^+ (4481Å) lines are much weaker but although weak, several Fe lines are visible in the green area between 5228Å & 5615Å.

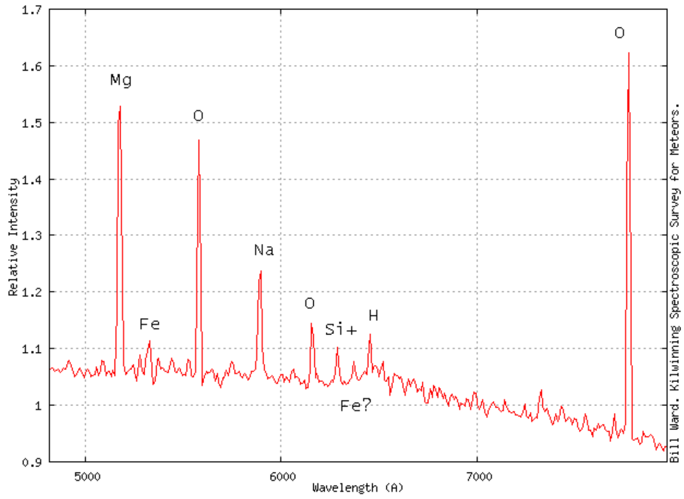

Figure 5. KSSM/NEM #004. 2015 Sep 27, 03.16.02UT. Due to the good dispersion geometry the resolution of this spectrum is better than usual. The presence of the forbidden oxygen line at 5577Å indicates this was a fast meteor. In this case the Mg line 5175Å is stronger the Na 5893Å line. There are lines from O at 6157Å, Si^+ at 6359Å and H at 6563Å. The slight 'run off' of the spectrum longward of 6500Å is due to vignetting being emphasised in the de-slanting process during reduction.

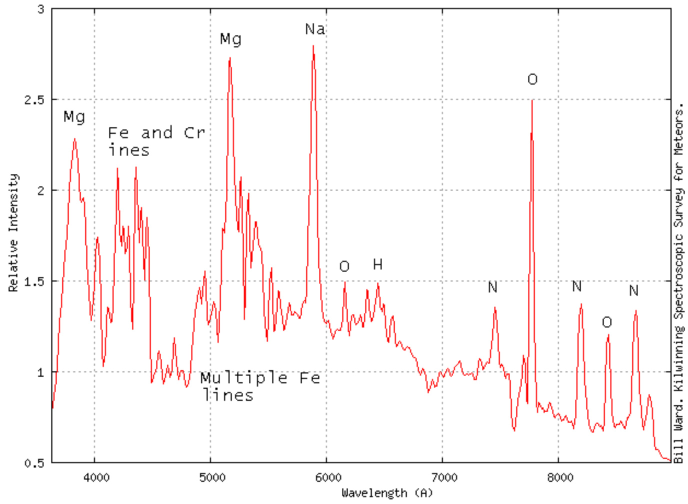

Figure 6. KSSM/NEM #005. 2015 Oct 13, 00.09.34UT. Good dispersion and spanning a wide wavelength range. The leftmost lines (which appear rather broad due to defocus) are of Mg and Ca^+ (ionised calcium). Most of the other peaks are identified as Mg, Na, O, H, Si^+. There are the many lines of Fe. Towards the right is a very distinctive pattern of lines consisting of atmospheric N_2, N (nitrogen) and O. The strong line at 7774Å is an unresolved triplet of oxygen. Due to the resolution limit, some lines in the blue and blue/green parts of the spectrum may be blended lines from multiple elements including nickel (Ni) chromium (Cr) and aluminium (Al).

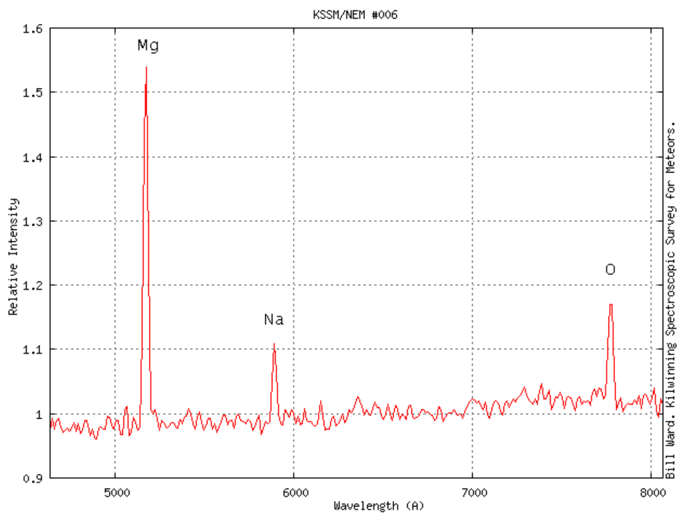

Figure 7. KSSM/NEM #006. 2016 Feb 15, 04.36.49UT. Another 'noisy' and weak spectrum. However in this case the Mg (5175Å) line is much stronger than the Na (5893Å) line. The oxygen line at 7774Å can also be seen.

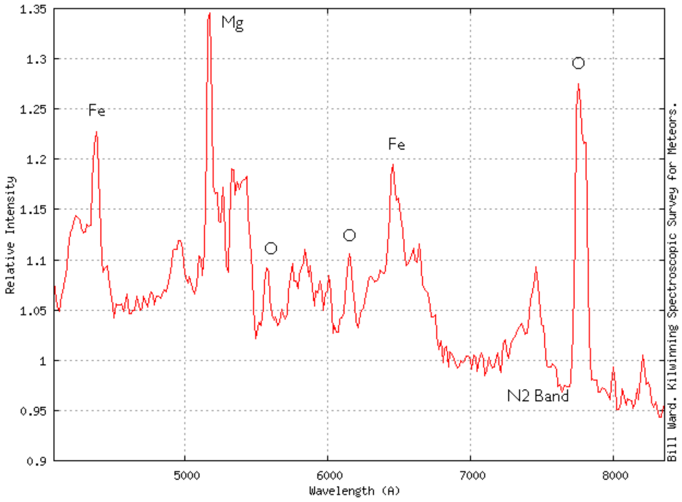

Figure 8. KSSM/NEM #007. 2016 Feb 15, 05.28.57UT. In this example many lines of Fe and Mg are seen (as with #005 and #008). What makes this spectrum rather unusual is the much reduced Na line at 5893Å. This sodium deficiency is quite noticeable compared to the other spectra in this paper. The O line at 7774Å is also particularly strong. There are also several broad features at approximately 6600 & 7450Å. These are emissions from atmospheric molecular nitrogen (N_2).

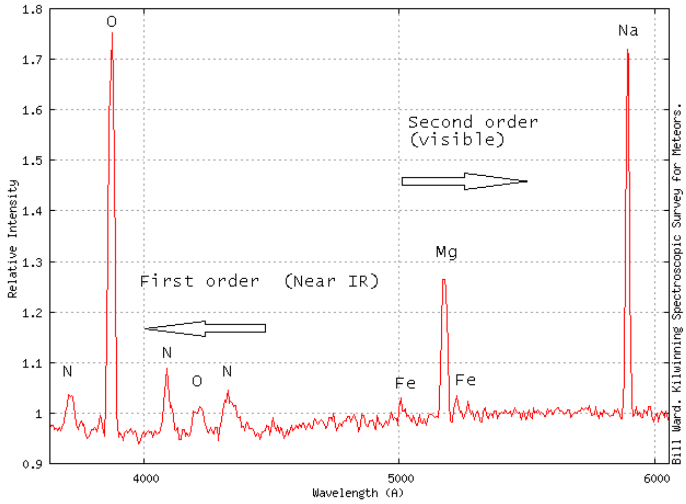

Figure 11. KSSM/NEM #010. 2016 Feb 10, 05.02.02UT. This was an unusual spectrum inasmuch that it is slightly misleading due to the graphing. The five lines centred around 4000Å are in reality the N, O (7774Å), N, O, N near infrared grouping from the first order overlapping with the second order spectrum. In this spectrum only the Mg (5173Å) and Na (5893Å) lines can be seen from the second order.

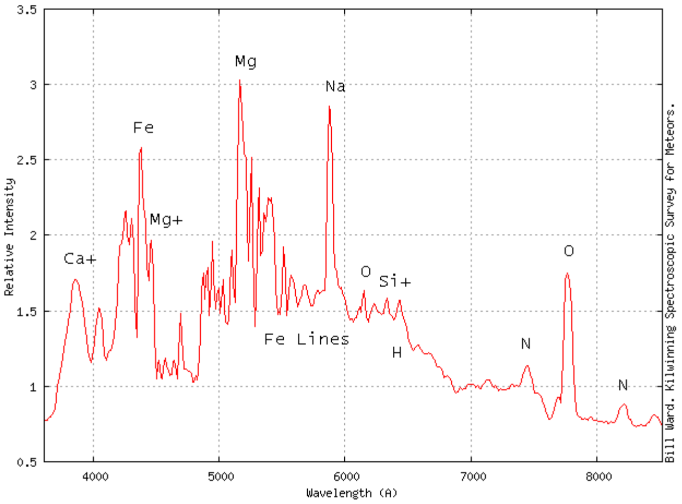

Figure 9. KSSM/NEM #008. 2016 Feb 18, 02. 51.42UT. Another well detailed spectrum with many features in common with #005, in particular the many Fe lines present. The lines of Mg^+ (4481Å) and Mg (5175Å) are relatively strong in this spectrum.

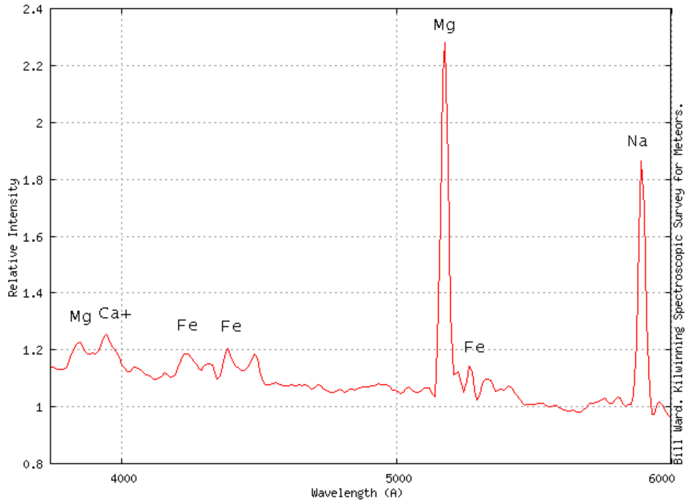

Figure 12. KSSM/NEM #011. 2016 April 20, 02.30.41UT. Spectrum with strong Mg and Na lines. Weaker Mg (centred 3833Å) and Ca^+ (centred 3951Å) lines in the near UV are present, and several weak Fe lines. Although the actual line intensities are different, there is a general similarity between this example and #001, #002, #003 and #009. These have (either) the 5175Å Mg line or 5893Å Na line as the strongest, the Mg^+ (4481Å) and Fe lines being generally weaker.

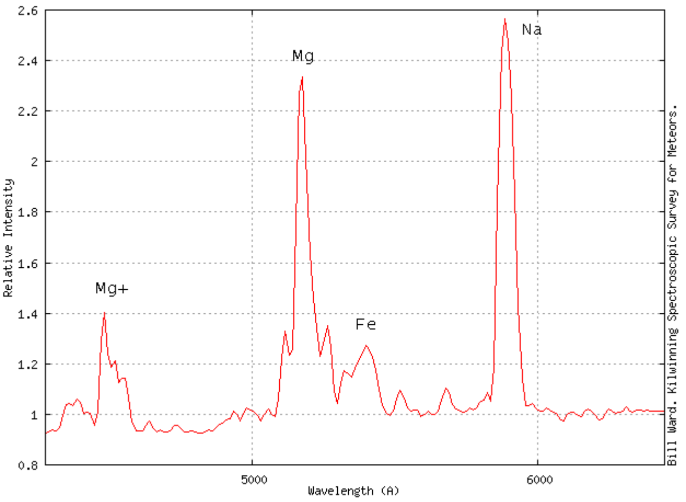

Figure 10. KSSM/NEM #009. 2016 Feb 25, 01.35.19UT. This spectrum has the same basic properties as #001. The effective resolution was slightly lower than #001 but the lines of Mg^+ (4481Å), Mg (5713Å) & Na (5893Å) are prominent. Other weaker lines are from Fe (groups around 4384 & 5328Å).

It should also be noted that the elements presented do not represent definitive orbits. That is, the number of recording stations was either the absolute minimum of two or the respective observing geometry was poor resulting in limited astrometry. Nonetheless within these limitations there is a wide variation in orbital elements illustrating the fact that the Earth encounters meteoroids from many directions in space.

Orbital elements

A summary of the calculated orbital elements is shown in Table 1.

The Tisserand Parameter T(j) is a useful dynamical parameter that is a measure of the interaction of a small body and a planet. In most cases this is referred to Jupiter. Determining the T(j) involves the small body's semi-major axis, eccentricity and inclination. It can be used to classify small bodies and is included here as an

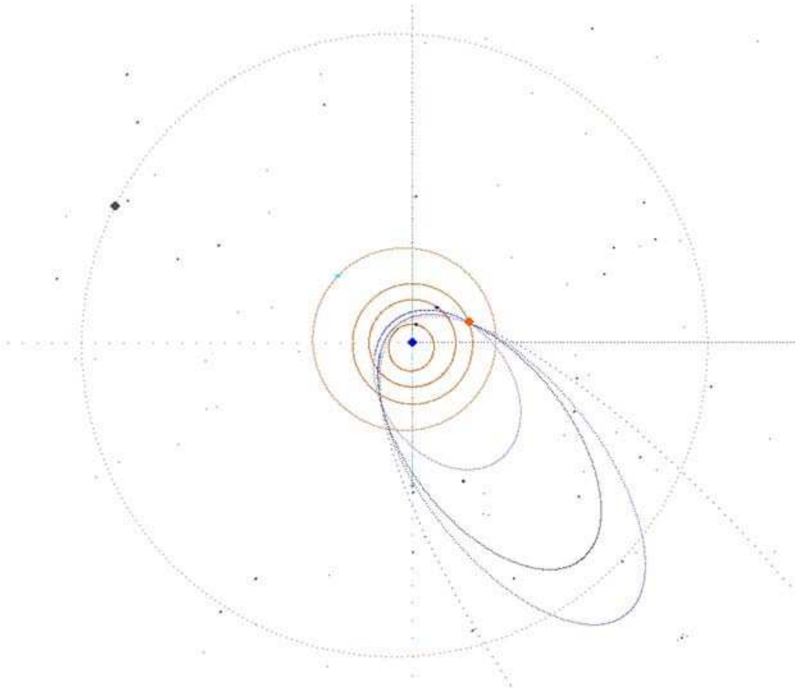

Figure 13. Example plan view of the calculated orbit of KSSM/NEM #005 produced by *UFO Orbit*. Multiple orbits are shown, indicating the orbital solutions obtained from the different stations. The blue orbit in this diagram, is the 'unified orbit'. This is the orbit for which the orbital elements have been tabulated. It is derived from the actual observational data and incorporates various dynamic parameters described in the *UFO Orbit Manual*.[8]

indication of the possible source of the meteoroids observed. For example members of the Jupiter family of comets have a T(j) of between 2 and 3 whereas most asteroids are greater than 3. See Jewitt, ref 8.

Considering Table 1, the T(j) of #001 #006 and #007 could suggest an asteroidal origin, while #003, #005, #009 and #010 could be of cometary origin. #011 has an exceptionally low T(j) but given the very large semi-major axis and high inclination this orbit may not be reliable.

It should be cautioned that T(j) is not a guarantee of any particular association and is only a guide.

The utilities available within the *UFO Capture* suite allow stream identification. The eight meteors for which an orbit was determined, however, were all classed as sporadic meteors.

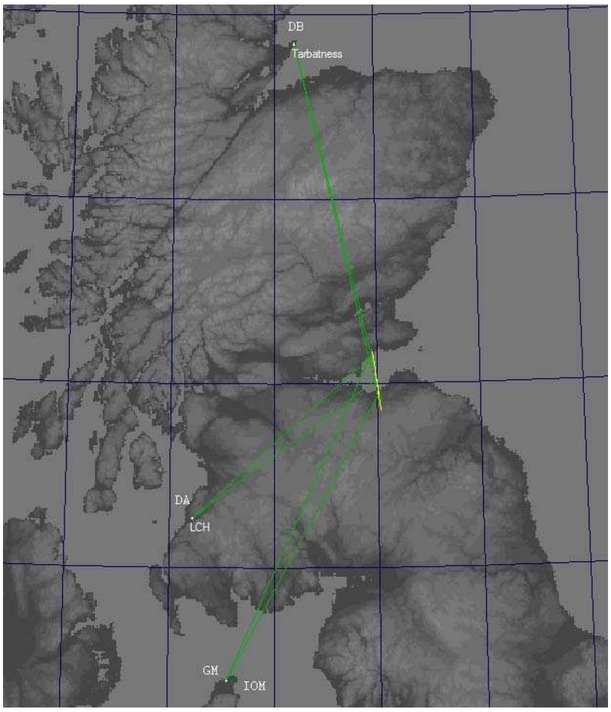

Figure 14. Example ground plot for KSSM/NEM #005, produced by *UFO Orbit*, showing the meteor (crossing the Firth of Forth) and the three observing stations.

Conclusions

Over the past few years meteor astronomy has undergone both something of a renaissance and revolution. The combination of powerful software and commercially available low light-level cameras has given the meteor observer a new arsenal. Previously, spectroscopy was generally only attempted when the chances of success were considered high, during a major meteor shower for example. Occasionally the chance capture of a fireball spectrum would produce exceptional results.

This was the norm for several decades. With the low cost and efficiency of modern cameras it is now possible to operate in continuous 'survey mode', yielding vastly more data and significant new results. The observations presented here illustrate that multi technique and multi station observations can give an insight into the Earth's meteoroid environment that has been hitherto impossible to achieve.

In this field a suitably equipped observer can produce results that are important for the future evolution of meteor astronomy. The results may have even greater significance if they are contributed to a centrally maintained and accessible database. Such databases will ultimately allow statistical examinations of meteors' physical properties once sufficient numbers of such observations have been obtained. Some efforts have already been made but the way forward needs further investigation.[9]

Some of the spectra here certainly present broad similarities but yet have subtle differences. Comparing these results to the older photographic taxonomic descriptions reveals that video spectra, even at fairly low levels of resolution, can provide comparable detail.[10] As the technology continues to advance and the number of spectroscopic observing stations increases it is likely that some new classification scheme will be needed. This represents a considerable challenge in its own right.

Table 1. Orbital elements

KSSM/ NEM #	Date_Time (UT)	a	q	e	ω	Ω	i	T_J
001	2015 04 10_00.58.37	1.5	0.271	0.816	308.5	19.6	10.4	4.095
002	2015 04 21_01.57.52							u
003	2015 09 11_02.27.19	2.8	0.969	0.649	205.4	167.8	4.6	2.221
004	2015 09 27_03.16.02							u
005	2015 10 13_00.09.34	2.5	0.395	0.841	288.8	199.1	0.7	2.832
006	2016 02 15_04.36.49	1	0.192	0.808	323.3	325.7	12.7	5.714
007	2016 02 15_05.28.57	0.7	0.388	0.439	351.3	325.7	156.7	6.829
008	2016 02 18_02.51.42							u
009	2016 02 25_01.35.19	3.6	0.989	0.726	178	335.7	28.3	2.519
010	2016 02 10_05.02.02	2.7	0.957	0.646	155.3	349.8	49.3	2.815
011	2016 04 20_02.30.41	128.5	0.534	0.996	266.4	30.2	75	0.492

Notes:
a = semi-major axis (au); q = perihelion distance (au); e = eccentricity (dimensionless); ω = argument of perihelion (°); Ω = longitude of ascending node (°); i = inclination of orbit with respect to Earth's orbital plane (°); T_J = Tisserand parameter (see text). The letter u in the T_J column indicates the orbit was not determined and hence undefined.

However it may be that the inherent variation in the spectra means that a simple scheme will not be possible. Other methods of analysis will be needed. Such mineralogical ratio techniques are discussed in the review by Borovicka,[11] and are used by professional meteor scientists.

A final thought

The Earth is bombarded daily by many thousands of meteoroids. After orbiting around the Sun, possibly for many thousands of years, maybe even longer, they finally encounter the Earth. After such a long life it is remarkable to consider that it is only in the final seconds they reveal their true nature to us in that last flash of light, a glorious shooting star.

Acknowledgments

The author would like to thank all of the NEMETODE group members who have offered their observations and great support. The observers who contributed their video observations were David Anderson, Denis Buczynski, Jonathon Jones, Glyn Marsh, Graham Roach and Ray Taylor.

The author would like especially to thank Alex Pratt and William Stewart for their own observations and producing the orbit data and plots, and thanks again to Alex for his review and helpful comments on the original text.

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Noctilucent cloud over Britain and Western Europe, 2015–2016

Ken Kennedy

A report of the Aurora & NLC Section (Director: Sandra Brantingham)

2016 July 12/13, 23:40 UT, by Gordon Mackie, Thurso.

The first reliable historical report of noctilucent cloud (NLC) was by Thomas Backhouse on 1885 June 01. A previous report by Thomas Robinson at Armagh[1] has been proposed as an earlier sighting but this was on 1850 May 01, which is outside the now accepted period during which NLC is likely to be seen. Very few reports in more recent times have been before the second week in May or later than the third week in August.

Since the 1880s, NLC has been reported with increasing frequency which may be partly accounted for by the fact that observer numbers have increased over the years and these observers are in widely spread locations. Even with this rider it is generally agreed that the frequency of NLC has increased in real terms since the early sightings in the late 19th century. An association with the solar cycle has been suggested on a number of occasions, and data collected by the author from the work of previous observers and from that gathered by him since 2006 tends to confirm that NLC frequency is greatest at or near solar minimum and least near solar maximum. During a prolonged spell of solar inactivity between 2006 and 2010, NLC frequency reached a maximum, but the solar cycle (24) which followed that minimum, and which is now in decline, has been the least active since solar cycle 14 which began in 1902 February and ended in 1913 August.

Following a number of years when solar activity was at a very low level and NLC frequency was correspondingly high, there was a distinct reduction in its frequency with the commencement of solar cycle 24 in 2010. The question has arisen over the past few years as to the frequency of NLC following this rather poor solar maximum and it is interesting to note that NLC frequency stayed at much the same level through the years of increasing solar activity from 2010, including the year of maximum in 2014.[2] This paper looks at NLC frequency and distribution of observations during the first two years of solar cycle 24's decline from maximum.

A summary of observations received for each night on which NLC was observed in 2015 and 2016 is shown in Tables 2 and 3. A small number of sightings submitted by observers in the USA and Canada has been included for completeness.

The NLC forms used in Tables 2 and 3 are described below:

- Type I : 'Veil', a faint background brightness which other forms often overlie.
- Type II (IIa or IIb): 'Bands' or streaks either parallel or crossing at small angles.

Table 1. NLC observers 2015–2016

Abbott J, Abein A, Adam T, Anderson S, Arditti D, Arkill J, Balciunas R, Bali A, Barber J, Birtwistle P, Bongartz W, Boyle K, Brantingham S, Brausch J, Breman G, Broekhuijsen K, Brown J, Brugger S, Buczynski D, Cernis K, Clitherow A, Conner D, Crossland P, Dalin P, Deakes K, Dinsbergs I, Dubietis A, Edmundson W, Entwisle L, Evenhuis T, Ferrier M, Ford H, Ford J, Forster K, Foster P, Fraser J, Gajdos P, Gasparu M, Gavin M, Gavine D, Gentle C, Giesau N, Granslo B, Greatrix A, Gronne J, Hackney L, Hamburg W, Hansen O S, Hattinga Verschure P, Haussmann A, Heenan A, Henderson J, Hinz C&W, Jahn J, James N, Jennings P, Jonas K, Kaiser K, Kelly B, Kennedy K, Kiitsak K, Kindsigo T, Kolk M, Kranich L, Kuklok P, Landy–Gyebnar M, Law R, Lawrence K, Leadbeater R, Lees M, Liivand M, Ling A, Livingstone R, MacIver S, Mack N, Mackie G, MacKintosh J, Mattsson M, Mauduit A, McBeath A, McCracken D, McDonald A, McEachran I, McEwan T, Meyerdierks H, Moller A, Morrison N, Mueller U, Nicholls M, Olszyca B, Olesen J, Panzek I, Plumtree I, Pollock E, Pratt A, Pumphrey H, Radoslaw R, Rourke P, Rowlands J, Samson W, Smeaton A, Spicer M, Squarra O, Stables A, Stapleton R, Steele B, Storey D, Teague J, Taylor R, Thomas K, Topping B, Tough A, Trzicky T, Ulbricht H, Untiedt H, Varis E, Vincent F, Vindi A, Vyacheslav O, Wagner R, Wallace A, Ward B, Whipps G, Whitener J, Wolf T, Yakovlev S, Zadorozhny A, Zalcik M.

NLC & aurora seen together, 2015 Aug 15/16, 23:01 UT. Brian Kelly, Stenness, Orkney.

2016 July 25, 02:25 UT. Nick James, Chelmsford, Essex.

– Type III (IIIa or IIIb): 'Billows' or 'waves' which show a typical herring bone or sand ripple pattern.
– Type IV: 'Whorls' of various curvature.

The times stated are the earliest and latest reported sightings for any particular night and may not indicate that NLC was seen continuously between these times.

The 2015 NLC season

Following quite an early start to the NLC season in May, the number of reported sightings in June was disappointingly low. By the end of June only 127 reports had been received, which was far below the particularly good year of 2009 with 302, and fewer than the relatively low total for 2014 June of 154. However, the number of nights on which NLC was seen in June was not particularly low at 24 although six of these nights were reported by a single observer in Canada, which brings the total nights on which NLC was reported in UK and Europe to only 18.

This trend continued into July with the largest number of reports being received for the nights of July 05/06, 10/11, 15/16, 17/18 and 23/24. The total number of reports received during July was 121 which is again lower than all but that of 2012 when there were extremely adverse weather conditions in July of that year. NLC was reported on 24 nights in 2015 July which is close to the average of 25 since 2007. August saw a reduction in reports with only 12 being submitted for 6 nights in the month. However, as a parting shot, on the night of August 15/16 the unusual occurrence of simultaneous NLC and auroral displays was reported by a number of observers in Scotland.

During the season several observers commented that they had a feeling that NLC activity was less than in recent years and the author had the same feeling, probably generated by fewer received reports, although personally recording as many displays as in previous years. The average number of nights on which NLC was reported during the seasons 2007 to 2015 is 60 and in 2015 NLC was recorded on 59 nights which is not significantly lower than the average, especially considering the very active NLC years of 2007–2009 when solar activity was at its lowest.

From data received in 2015 most observers would probably agree that displays were not as extensive as in previous

Table 2. Sightings of NLC over Britain and Western Europe, 2015

Date	*Time (UT)*	*Forms*	*No.of obs.*	*Most southerly*	*Approx,N latitude (°)*	*Comments*
May 20/21	2035–2133	NLC	1	St Petersburg	60	
May 21/22	2250–2325	II	1	Netherlands	53.3	
May 23/24	2030–2100	I,II	1	Perm, Russia	58	
May 27/28	1930–0213	I,II,III	10	Juliusrah	54.6	
May 31/32	2000–2100	I,II,III	2	Vidiskes	55.4	1 Canada
June 01/02	1950–0130	I,II,III,IV	7	Newcastle	55.0	
June 02/03	2245–0230	I,II,III,IV	8	Edinburgh	55.9	
June 03/04	0530–0630	I,II,III	1	Namao	53.7	Canada
June 04/05	0550–0700	I,II	1	Namao	53.7	Canada
June 05/06	1640–0215	I,II,III	7	Stoke-on-Trent	53.0	
June 06/07	2220–0215	I,II,III,IV	18	Veszprem	47.1	1 Canada
June 07/08	0103–0120	I,II	2	Anglesey	53.3	1 Canada
June 10/11	1545–2045	I,II,III,IV	1	Novosibirsk	55.0	
June 11/12	2200–0215	I,II,III	18	Deventer	52.2	
June 12/13	2259–0100	II	2	Dangast	53.5	No UK
June 13/14	0020–0300	I,II,III,IV	4	Anglesey	53.3	1 Canada
June 14/15	0715–0830	I,II	1	Namao	53.7	Canada
June 15/16	0550–0830	I,II,III	1	Namao	53.7	Canada
June 16/17	2030–0330	II,III	6	Drenthe	52.9	
June 17/18	0545–0910	I,II,III,IV	1	Namao	53.7	Canada
June 18/19	0620–0845	I,II,III	1	Namao	53.7	Canada
June 19/20	0115–0210	I,II,III,IV	1	Zalaegerszeg	46.8	
June 21/22	2245–0115	I,II,III,IV	3	Netherlands	53.3	
June 22/23	2215–0200	II,III	10	Anglesey	53.3	1 Canada, 1 USA
June 23/24	2312–0200	I,II,III	5	Lodz	51.7	1 Canada
June 24/25	2015–2300	II	2	Schlaegl	48.6	
June 25/26	2158–2235	I,II,III	2	Wallnau	54.5	
June 28/29	2010–0143	I,II,III,IV	21	Zalaegerszeg	46.8	
June 30/31	2150–2320	I,II,III	4	Oldenburg	53.1	No UK
July 01/02	0800–0900	I,II	1	Namao	53.7	Canada
July 02/03	2030–2230	NLC	2	Rónne	55.1	
July 03/04	2100–0004	II,III	3	Nairn	57.6	
July 04/05	2100–2330	NLC	1	Tartu	58.4	
July 05/06	2030–0215	I,II,III,IV	11	Rivenhall	51.8	1 Canada
July 06/07	2045–2215	I,II,III	7	Swisttal	50.7	1 Canada, 1 USA
July 07/08	0048–0125	I,III	2	Ahlhorn	52.9	1 Canada
July 08/09	0015–0130	I,II,IV	3	Edinburgh	55.9	2 Canada
July 09/10	0530–0630	I,II,III	2	Edmonton	53.5	Canada only.
July 10/11	1950–0150	I,II,III,IV	12	Hárskut	47.2	No UK
July 11/12	2000–2140	II,III	2	Lodz	51.7	
July 13/14	0845	II	1	Namao	53.7	Canada
July 14/15	1955–2315	I,II,III,IV	7	Langen	50.0	1 Canada
July 15/16	2030–0245	I,II,III,IV	15	Morpeth	55.2	
July 16/17	2200–0100	I,II,III	2	Salakas	55.4	
July 17/18	2020–0310	I,II,III	13	Swisttal	50.7	
July 18/19	2118–0100	I,II,III	4	Rostock	54.1	
July 20/21	2230	NLC	1	Tartu	58.4	
July 21/22	2245–0250	I,II,III,IV	10	Deventer	52.2	
July 22/23	2230–0201	I,II	3	Salakas	55.4	
July 23/24	2030–0225	I,II,III	15	Ahlhorn	52.9	
July 24/25	2100	NLC	1	Tartu	58.4	
July 25/26	0205–0220	II	1	Kilwinning	55.6	
July 27/28	2200–0000	I,II,III	2	Ilmatsalu	58.4	1 Canada
Aug 01/02	2335–0130	NLC	1	Austurland	65.3	
Aug 06/07	0005–0230	I,II,III	1	Suourland	64.1	
Aug 07/08	2330–0030	NLC	3	Edinburgh	55.9	
Aug 11/12	0000–0030	NLC	1	Tartu	58.4	
Aug 13/14	?	NLC	1	Karperö Lake	63.2	
Aug 15/16	2145–2245	I,II,III	5	Edinburgh	55.9	

Summary of reported NLC, 2015 season

	May	*June*	*July*	*August*	*Total*
No. of nights	5	24	24	6	59
No. of observations	15	127	121	12	275
No. of nights for UK & Europe					49
Obs. received from UK & Europe					250
Obs. received from Canada & USA					25

Table 3. Sightings of NLC over Britain and Western Europe, 2016

Date	*Time (UT)*	*Forms*	*No.of obs.*	*Most southerly*	*Approx,N latitude (°)*	*Comments*
May 26/27	0105–0117	I	1	Anglesey	53.3	
May 30/31	1815–2130	I,II,III	1	Novosibirsk	55.0	
June 02/03	2220–0230	I,II,III,IV	15	Berlin	52.5	
June 03/04	0545–0753	NLC	1	N54.5 W103.5	54.5	In flight, with aurora
June 11/12	2140–0020	I	3	Barth Mecklenburg	54.3	
June 12/13	2040–0320	I,II,III,IV	8	Warsaw	52.3	1 Canada. No UK.
June 13/14	2315–0230	I,II,III,IV	2	Namao	53.7	1 Canada
June 15/16	0800 - 0900	I,III	1	Namao	53.7	Canada
June 17/18	0800–0845	I,II,III	1	Namao	53.7	Canada
June 18/19	2020–0200	I,II,III,IV	11	Veszprem	47.1	
June 19/20	2100–0135	I,II,III	5	Oldenburg	53.1	1 Canada
June 20/21	0520–0830	I,II,III,IV	1	Namao	53.7	Canada
June 22/23	2130–0230	I,II,III	4	Anglesey	53.3	
June 23/24	2100–0130	II,III	4	Börnchen	50.8	No UK sightings
June 24/25	2335–0245	II,III	1	Fårevejle	55.8	
June 25/26	0400–0450	II	1	Glen Ullin, N Dakota	46.8	USA
June 26/27	0600–0915	I,II,III	1	Namao	53.7	Canada
June 27/28	2145–0117	II,III,IV	4	Lübeck	53.9	
June 28/29	0140–0145	I,II,III	3	London	51.5	1 Canada
June 29/30	0030–0315	II,III	3	Anglesey	53.3	
June 30/31	0100–0120	III	1	Börnchen	50.8	
July 01/02	2345–0230	I,II,III,IV	14	Stoke-on-Trent	53.0	
July 02/03	2115–0035	NLC	3	Ahlhorn	52.9	
July 03/04	2301–0305	I,II,III	8	Dresden	51.0	
July 04/05	1940–0200	I,II,III,IV	6	Budapest	47.5	No UK sightings
July 05/06	2035–0400	I,II,III,IV	34	Frankfurt	50.1	
July 07/08	2040–0030	I,II,III,IV	6	Glentham	53.4	1 Canada
July 08/09	2100–0215	I,II,III,IV	8	Deventer	52.3	1 Canada
July 09/10	2040–0156	I,II,III,IV	10	Budapest	47.5	
July 10/11	2200–0130	II	3	In flight UK	51.5	
July 11/12	2100–0216	I,II,III,IV	11	Veszprem	47.1	1 Canada
July 12/13	2040–0200	I,II,III,IV	12	Tröndel	54.3	
July 13/14	1955–0415	I,II,III,IV	12	Deventer	52.3	1 Canada
July 16/17	0330–0430	II	1	Labrador Sea (in flight)	47.7	Canada
July 17/18	0800–0930	I,II,III	1	Namao	53.7	Canada
July 18/19	1927–0315	I,II,III	19	Zalaegerszeg	46.8	1 Canada
July 19/20	0625–1000	I,II,III	1	Namao	53.7	Canada
July 20/21	2150–0224	I,II,IV	4	Glengarnock	55.7	
July 22/23	2030–0330	I,II,III,IV	15	Börnchen	50.8	
July 24/25	0520–1045	I,II,III,IV	1	Namao	53.7	Canada
July 27/28	0545–0600	II	1	Edmonton	53.5	Canada
Aug 01/02	2030–0315	I,II,III,IV	7	Salakas	55.5	
Aug 06/07	0300–0315	I	1	Edinburgh	56.0	
Aug 07/08	1930–2100	II,III,IV	2	Tartu	58.4	
Aug 09/10	~0200	II,III	3	Alness	57.7	
Aug 12/13	1950–2200	NLC	3	Tartu	58.4	

Summary of reported NLC, 2016 season

	May	*June*	*July*	*August*	*Total*
No. of nights	2	19	20	5	46
No. of observations	2	70	170	16	258
No. of nights for UK & Europe					36
Obs. received from UK & Europe					239
Obs. received from Canada & USA					19

years and the brightness of displays, which is always difficult to estimate, seemed to be lower. The images recorded by the Cloud Imaging and Particle Size (CIPS) instrument of the Aeronomy of Ice in the Mesosphere (AIM) satellite clearly showed ice in the mesosphere from May 19 and it was still quite extensive by mid-August, which suggests that poor weather and sky conditions over the UK and Europe may have contributed to the smaller number of reports received during this year. The jetstream spent some time during the summer months close to northern Spain and this would have produced more cloud to the north of it.

The 2016 NLC season

Anticipation of the noctilucent cloud (NLC) season begins about the middle of May, and around this time it is worth keeping an eye on the images produced by the AIM CIPS instrument to get some idea of when the first ice appears in the mesosphere. For some years NLC have made an appearance during the third or into the fourth week of May with ice appearing in the mesosphere some days beforehand and quite quickly expanding, usually eccentrically round the pole. In 2016 the first signs of ice appeared on May 24. In a communication from Prof Cora Randall on May 30 she said ‘clouds appearing again in today’s CIPS daily daisy (so-called because of the shape of the integrated 24 hour images). But this does seem to be a relatively slow start to the season.’ Mesospheric ice did not increase rapidly until June 1 after which it did increase rapidly and by June 21 had reached a slightly higher level than on any other year since 2007 when the AIM satellite was launched.

Following a significant lack of NLC reports in May, sky conditions in June were poor throughout the UK and, it seems, over much of continental Europe and after a clear night on June 01/02, the author had only two other completely clear nights that month. July was somewhat better but around July 21 ice in the mesosphere diminished rapidly and by July 30 was at a lower level than at any time previously since 2007. This drop in mesospheric ice was reflected by the few sightings from July 24/25 until the last sightings on August 12/13. August only provided one good NLC display, on 01/02, with NLC being reported on five nights during the month. Because of changes made to software, there were no CIPS images after August 04 when ice was still clearly seen round the pole. Cora Randall explained the early end to CIPS imaging as being the result of revising the algorithm used for CIPS images in order to correct for orbital changes, and to make CIPS more sensitive to fainter clouds at lower latitudes.

Acknowledgments

Tom McEwan’s NLC website (**www.nlc.co.uk**) continues to provide an easily used facility for posting NLC observations and images by observers whether BAA members or not, and thanks must go to Tom for this very useful means of collecting data.

2016 July 22/23, 02:38 UT. Ken Kennedy, Broughty Ferry, Dundee.

Thanks also to all observers, listed in Table 1, who have taken the time to submit their sightings, whether to Tom's website or directly to the Section Director or the author.

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Determining the magnitudes and spectral types of the components of the binary Mira star X Ophiuchi

David Boyd

Several values for the magnitudes and spectral types of the components of the binary Mira-type variable star X Ophiuchi have been published in the literature over the last century. Analysis of new photometry and spectroscopy of the star between 2016 May and 2016 December indicates that the V magnitude of the constant star is 9.0 and its spectral type K1III. The spectral type of the Mira changed from M6III at maximum to M7III as it faded and passed through minimum. The Mira's V magnitude varied between 6.47 at maximum and 9.83 at minimum, a range of 3.36 magnitudes.

What do(n't) we know about X Oph?

X Ophiuchi was first found to be variable by T. E. Espin observing at Darlington in 1886.[1] In 1900 W. J. Hussey discovered the star to be a visual double using a power of 1000 on the 36-in refractor at Lick Observatory and measured the separation as 0.22 arcsec.[2] In the *Annals* of the Harvard College Observatory in 1907[3] Annie J. Cannon reported its magnitude range as 6.5 to 9.0, the period of its brightness variation as 335 days and its spectral type as Md on the Draper spectral classification, indicating the presence of Hγ and Hδ emission lines. G. Van Biesbroeck, observing at Yerkes Observatory in 1920–'24,[4] deduced from brightness estimates that the more northerly component was the variable, a conclusion later independently confirmed by C. H. Gingrich at Mt Wilson Observatory.[5] Van Biesbroeck visually estimated the magnitude of the southern constant star as 8.9 and the minimum magnitude reached by the variable component as 9.9, but in any case not fainter than 10.0.

In 1921 P. W. Merrill at Mt Wilson Observatory reported that the Hγ and Hδ emission lines peaked around maximum light and disappeared as the star faded.[6] Two years later he reported the spectral type as M6e at maximum becoming K0 at minimum as the constant component dominated.[7] Spectral type M6e is an extension of the Draper classification scheme adopted by the IAU in 1922, with the letter e indicating the presence of emission lines.

Merrill gave the visual magnitude of the constant star as 8.9 and the visual range of the variable as 6.8 to 12. E. Pettit & S. B. Nicholson[8] found a visual magnitude at minimum of 11.5 for the variable based on radiometric measurements, and a magnitude of 8.9 for its constant companion.

In a comprehensive review of current knowledge about X Oph,[9] J. D. Fernie reported an analysis of the relative intensities of spectral lines which gave the spectral type of the constant star as K1III. Based on several assumptions, he obtained a V magnitude for this star of 8.51 and a maximum V magnitude of the variable as 7.12. He also derived the distance to X Oph as 240±35 pc and its colour excess as E(B−V)= 0.15.

Based on the MK (Morgan & Keenan) spectral classification system using relative intensities of specific absorption and emission features, P. C. Keenan reported a range of spectral types for X Oph between M6e and M8e+K.[10,11] These observations covered the full magnitude range of X Oph and showed the spectral type becoming later as the star faded, with the M-type spectrum almost disappearing relative to the K-type spectrum at minimum light.

B. Skiff's *Catalogue of Stellar Spectral Classifications* available in *Vizier*[12] contains references to several papers reporting spectral types for X Oph ranging from M4e to M9. The current Simbad entry for X Oph lists its spectral type as M0-8e+K2III,[13] M0-8e being the modern equivalent of the old Md classification. The AAVSO Variable Star Index VSX gives its spectral type as M5e-M9e.[14]

X Oph was featured as Variable Star of the Year in the 2014 BAA *Handbook*.[15] The article, written by John Toone, included a visual lightcurve of X Oph (Figure 1) with amplitude around 2 magnitudes and flat-bottomed minima at mag 8.4. These observations by Toone show the consistency expected of a good visual observer. The light of the Mira variable dominates when it is brighter than its constant companion, but as it fades to minimum the light of the constant star dominates.

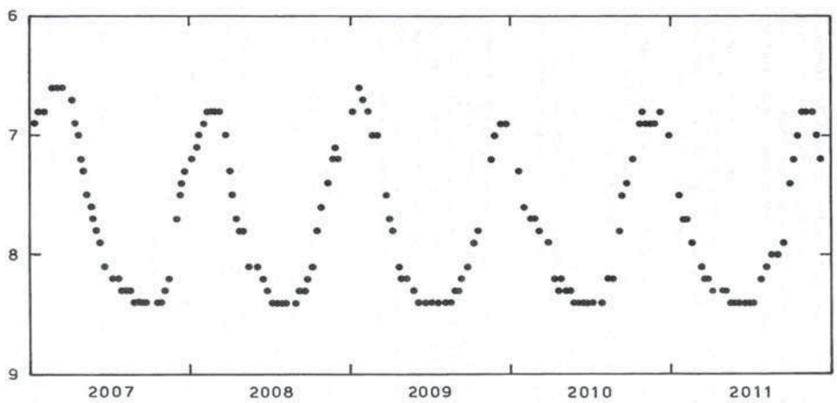

Figure 1. Visual lightcurve of X Oph from BAA Variable Star Section (VSS) observations. (2014 BAA *Handbook*.[15])

Based on a series of separation and position angle measurements of the components of X Oph between 1900 and 1957, Fernie fitted an elliptical orbit and calculated a binary orbital period of 557 years.[9] Including measurements up to 1975, P. Baize calculated a period of 485 years.[16] Further measurements led B. Novakovic to give a period of 877 years in 2007.[17] Given the relatively small fraction of the long highly

Table 1. Standard Johnson B & V magnitudes and B–V colour index of X Oph on 22 nights between 2016 May 24 & Dec 14.

Dates on which spectra were recorded are marked.

Date (2016)	JD	B mag	B err	V mag	V err	B–V	B–V err	Spectra?
May 24	2457533.45802	7.906	0.058	6.414	0.074	1.492	0.109	
May 29	2457538.48586	7.836	0.038	6.372	0.036	1.464	0.064	Y
Jul 03	2457573.43727	8.371	0.021	6.953	0.023	1.418	0.033	
Jul 05	2457575.48740	8.431	0.024	7.024	0.046	1.407	0.054	Y
Jul 18	2457588.43082	8.721	0.019	7.356	0.021	1.365	0.035	Y
Jul 24	2457594.42664	8.828	0.027	7.475	0.027	1.353	0.047	
Aug 06	2457607.38447	9.105	0.021	7.753	0.027	1.352	0.039	Y
Aug 08	2457609.38860	9.132	0.021	7.754	0.033	1.377	0.050	Y
Aug 22	2457623.47365	9.359	0.019	8.039	0.020	1.320	0.033	
Aug 23	2457624.35873	9.399	0.020	8.085	0.008	1.314	0.023	Y
Sep 11	2457643.31395	9.509	0.022	8.282	0.013	1.226	0.027	Y
Sep 13	2457645.37313	9.482	0.024	8.314	0.016	1.168	0.031	
Sep 16	2457648.43751	9.558	0.013	8.375	0.024	1.184	0.023	Y
Sep 22	2457654.31841	9.526	0.014	8.371	0.013	1.155	0.021	Y
Sep 25	2457657.37999	9.571	0.025	8.388	0.020	1.183	0.038	Y
Oct 22	2457684.34154	9.680	0.021	8.524	0.025	1.156	0.035	
Oct 31	2457693.30471	9.714	0.030	8.549	0.034	1.165	0.034	Y
Nov 10	2457703.23880	9.733	0.007	8.582	0.011	1.151	0.014	Y
Nov 25	2457718.22946	9.780	0.013	8.585	0.019	1.195	0.020	Y
Nov 30	2457723.25896	9.711	0.036	8.485	0.032	1.226	0.048	
Dec 01	2457724.21967	9.691	0.013	8.502	0.016	1.188	0.019	Y
Dec 14	2457737.23001	9.601	0.030	8.365	0.050	1.236	0.056	

eccentric orbit of X Oph observed so far, these differences are not surprising.

Clearly there is still uncertainty about many aspects of X Oph, but in particular about the spectral type of both its components and the magnitude of the constant star. X Oph was observed photometrically and spectroscopically by the author between 2016 May and December to see if a combination of these techniques could provide consistent values for the parameters of its component stars. In what follows the presumed Mira variable is referred to as the M star and the presumed constant star as the K star.

Photometric observations

Short series of filtered B and V magnitude measurements were made on 22 nights between 2016 May 24 and Dec 14 using a 0.35m SCT and SXVR-H9 CCD camera. Using B and V magnitudes of five nearby comparison stars from the APASS catalogue,[18] ensemble photometry gave B and V magnitudes of X Oph which were transformed to the Johnson UBV standard system and are listed in Table 1, along with the corresponding B–V colour index. These measurements covered a period of time during which X Oph passed through a maximum around JD 2457548 (2016 June 8) and a minimum around JD 2457695 (2016 Nov 2).

Figure 2 shows magnitudes of X Oph submitted to the BAA Variable Star Section database between 2015 November and 2017 January by Toone and the author.[19] Visual estimates by Toone are shown in black and B & V measurements by the author in blue and green. During the descending part of the lightcurve the visual and V magnitudes agreed well, while the visual estimates underestimated the peak V magnitude and overestimated the minimum V magnitude. Toone, in a private communication to the author, attributes this discrepancy to the change in apparent redness of the star between maximum and minimum.

The V magnitude of the unresolved binary varied between 6.37 on 2016 May 29 and 8.59 on 2016 Nov 25. Variation of the B–V colour index over this period between 1.49 and 1.15 is shown in Figure 3. This change of colour arises from the changing relative brightness of two components with different spectral types as the Mira component fades and passes through minimum.

Given the measured magnitude of the binary (B), and an assumed magnitude of the K star (K), the corresponding magnitude of the M star (M) can be calculated using the formula

$$M = -2.5*\mathrm{Log}_{10}(10^{(-0.4*B)} - 10^{(-0.4*K)}) \quad [1]$$

Figure 4 shows measured V magnitudes for the binary and derived V magnitudes for the M star for a range of assumed V magnitudes for the K star. This indicates that practical bounds on the possible V mag of the constant K star are between 8.6, the brightest it can be given the observed binary minimum, and 9.2, which would re-

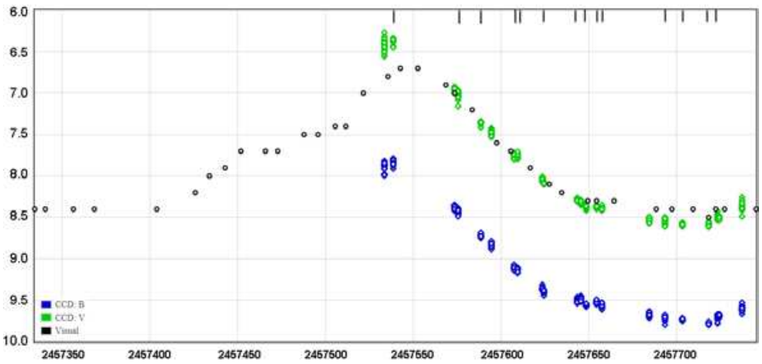

Figure 2. Visual and B & V magnitudes of X Oph in the BAA VSS database contributed by Toone (black) and the author (blue and green) between 2015 November and 2017 January. The dates on which spectra were recorded are marked at the top.

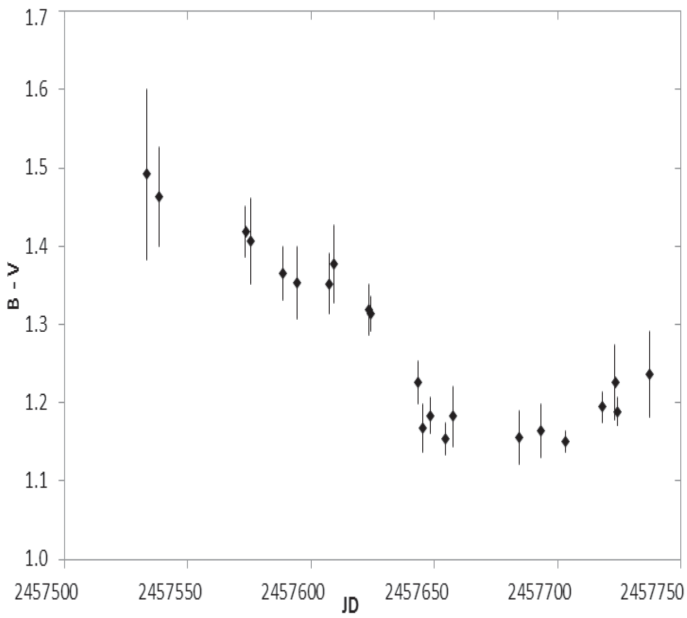

Figure 3. B–V colour index of X Oph between 2016 May and December.

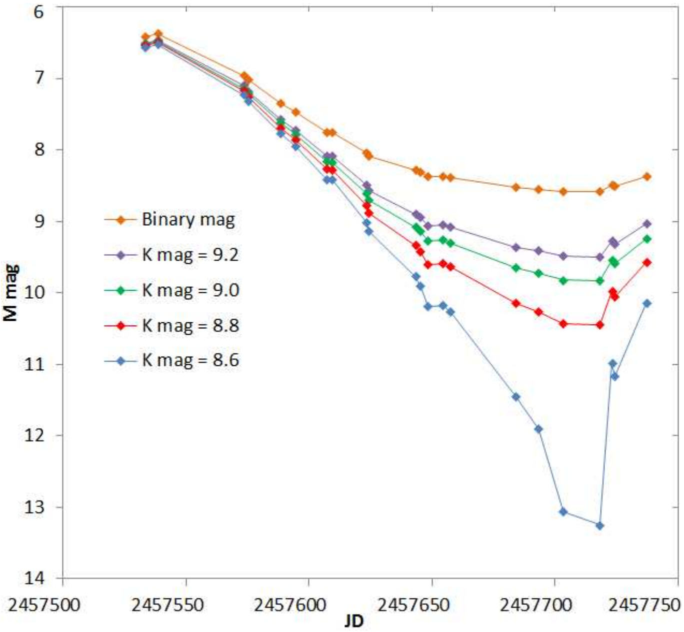

Figure 4. Derived magnitudes for the M star for a range of assumed magnitudes for the K star given the measured binary magnitudes.

sult in an M star amplitude of 2.5 mag, considered to be the smallest range for a Mira star.

Spectroscopic observations

Spectra of X Oph covering the wavelength range 3900 to 7400Å with spectral resolution 5Å were recorded on 14 nights using a LISA spectrograph and SXVR-H694 CCD camera. The dates of these spectra are marked in Table 1 and on Figure 2. These spectra give the relative flux (spectral energy) across the spectrum.

In preparation for converting these to absolute flux spectra, absolute flux spectra of seventeen spectrophotometric standard stars from the CALSPEC HST Spectral Calibration Database[20] were convolved with the profile of the V filter to find the absolute flux transmitted by this filter and hence its mean spectroscopic zero point. This enabled conversion of a V magnitude to an absolute flux. Each measured relative flux spectrum was convolved with the spectral profile of the V filter to give the relative flux transmitted by the V filter. Knowing the V magnitude of the star on that date, each relative flux spectrum could then be scaled to produce an absolute flux spectrum in ergs/cm^2/s/Å.

The absolute flux spectrum of X Oph just before maximum recorded on 2016 May 29 is shown in Figure 5. This shows the characteristic saw-tooth pattern of TiO (titanium oxide) molecular absorption bands expected in the spectrum of a Mira variable. Also visible are Hγ and Hδ emission lines as reported by Merrill[6] around maximum light. By mid-August as the star faded these emission lines had disappeared.

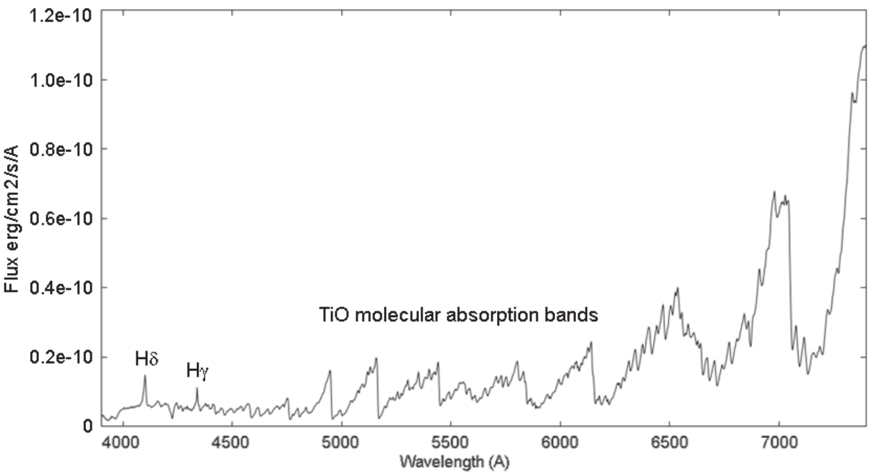

Figure 5. Absolute flux spectrum of X Oph recorded on 2016 May 29 around maximum light. TiO molecular absorption bands typical of a Mira variable are prominent as are Hγ and Hδ emission lines.

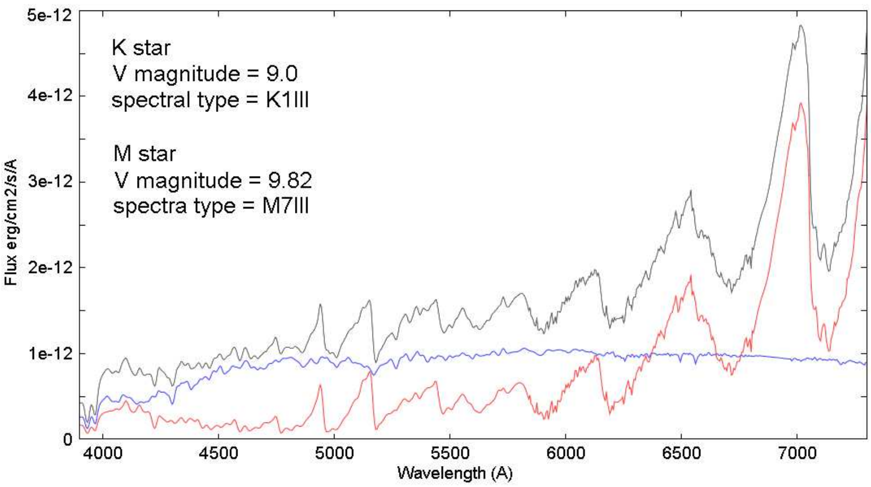

Figure 6. Synthesised spectra for the K star (blue) and M star (red) on 2016 Nov 10 around minimum light with their assumed parameter values and the combined binary spectrum (black).

Determining component magnitudes and spectral types

Adding spectra of the two components in absolute flux units gives the absolute flux spectrum of the binary. This offers a way to investigate the nature of the components of X Oph. Assuming a V magnitude and spectral type for each component, their individual absolute flux spectra can be synthesised using model spectra from the Pickles Stellar Spectral Flux Library[21] and combined to give a synthesised spectrum of the binary.

Figure 6 shows synthesised spectra for the K and M stars on 2016 Nov 10 around minimum light with their assumed parameter values and the combined binary spectrum. At these relative magnitudes the K star contributes more flux to the binary spectrum than the M star except at the red end of the spectrum.

The optimum choice of V magnitude and spectral type for each component on a specific date can be found by synthesising the absolute flux spectrum of the binary as described above and comparing it with the measured absolute flux spectrum of X Oph on that date. The best parameter values are those which give the smallest root mean square (rms) difference in flux between the synthesised and measured spectra over the wavelength range 3900Å to 7300Å. The effect of reddening on the observed spectrum is not clear but is probably relatively small given the value found by Fernie,[9] and so has not been included in the analysis.

Previous analyses have indicated that, as a Mira variable, the likely spectral type of the M star is in the range M5III to M8III and that this may vary during the pulsation cycle. This variation of spectral type has been observed in other pulsating stars.[22] Similarly, the K star spectral type is likely to be in the range K0III to K2III and its V magnitude in the range 8.6 to 9.2. Given the K magnitude, the magnitude of the M star can be found on any given date from equation [1]. There are therefore three independent parameters.

Table 2. Measured V magnitudes of X Oph and the parameter values of its components which give the best fit between synthesised and measured absolute flux spectra on the dates shown

Date (2016)	*X Oph V mag (measured)*	*K star V mag (fitted)*	*M star V mag (calculated)*	*K star spectral type (fitted)*	*M star spectral type (fitted)*
May 29	6.37	9.0	6.47	K1	M6
Jul 18	7.36	9.0	7.63	K1	M7
Aug 23	8.09	9.0	8.70	K1	M7
Sep 22	8.39	9.0	9.30	K1	M7
Nov 10	8.58	9.0	9.82	K1	M7
Dec 01	8.50	9.0	9.59	K1	M7

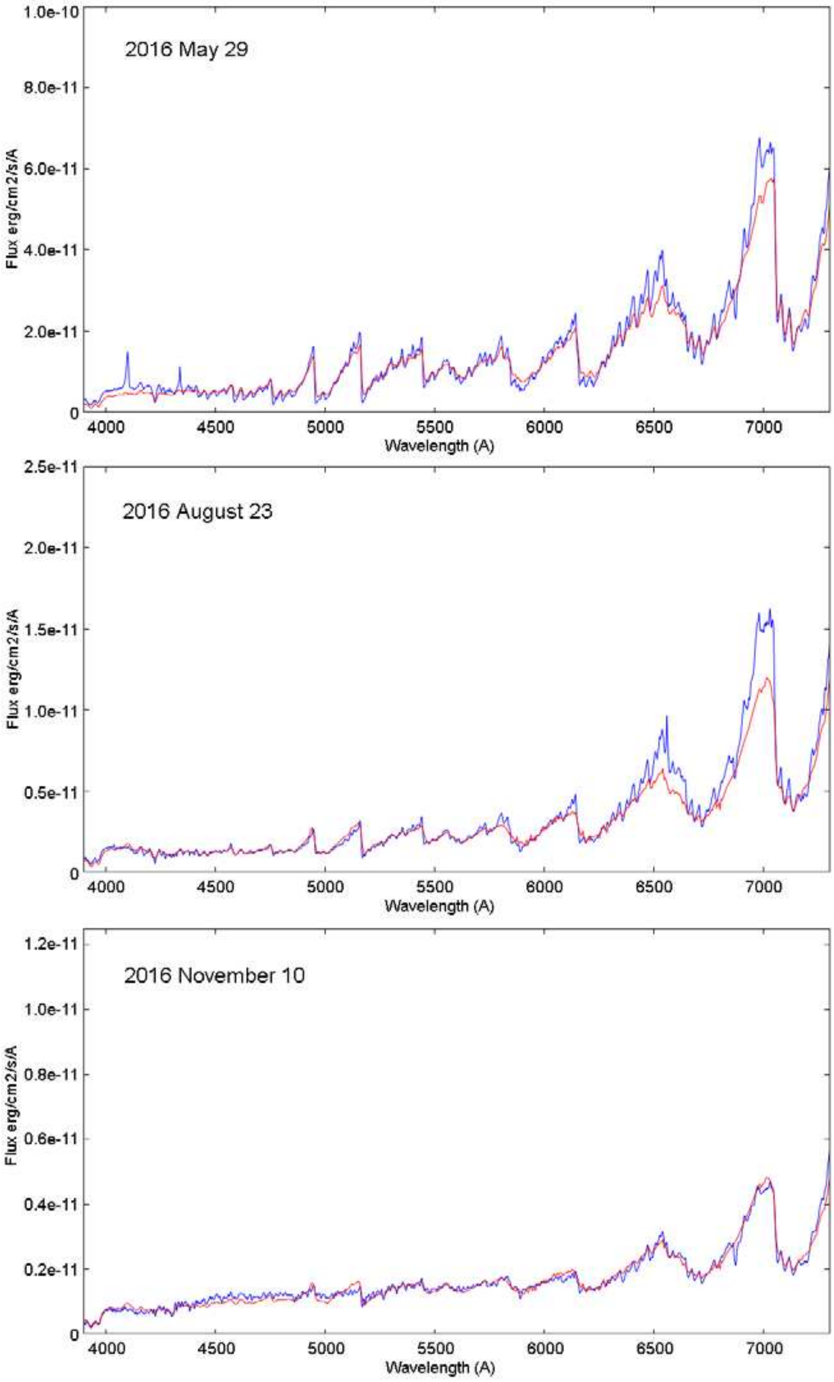

Figure 7. Best fitting synthesised (red) and measured (blue) spectra for X Oph on 2016 May 29, Aug 23 and Nov 10. Note the flux scales are different in each plot.

Six dates with the highest quality spectra spanning the binary magnitude range from maximum to minimum were chosen, the three parameters varied within the above ranges, spectra synthesised for each component and the combined synthesised binary spectra compared with the measured spectra of X Oph on each date. Table 2 shows the parameter values which resulted in the best fits on each date. Figure 7 shows the best fitting synthesised and measured spectra for X Oph on 2016 May 29, Aug 23 and Nov 10. Note that there are different flux scales in each plot. Results for the other dates are similar.

Changing the assumed K star magnitude by 0.1 or the assumed spectral types of both components by one sub-unit (*e.g.* M7 to M8) produced worse rms fits in each case. The largest mismatch between synthesised and measured spectra tends to be at the red end of the spectrum. This is where the change in the M star spectrum between sub-types is largest and as spectra are only being assigned to the nearest sub-type, some degree of mismatch in this region is expected. In all cases changing the sub-type of the synthesised M star spectra produced a larger discrepancy than the ones shown.

Conclusion

Given the consistency of the results in Table 2, it seems likely that the V magnitude of the K star is 9.0 and its spectral type K1III. The spectral type of the M star changes from M6III at maximum to M7III as it fades and passes through minimum. As noted earlier, this variation is expected. With 9.0 as the V magnitude of the K star, the V magnitude of the M star varied from 6.47 at maximum to 9.83 at minimum, a range of 3.36 magnitudes and consistent with its identification as a Mira variable. Figure 8 shows V mag lightcurves of the X Oph binary and of the two components based on the parameter values in Table 2.

These results are consistent with previously published analyses and the use of flux calibrated spectra has provided a possible resolution of the earlier uncertainty about the properties of the components of X Oph. However a word of caution is in order as these results are based on analysing half of one pul-

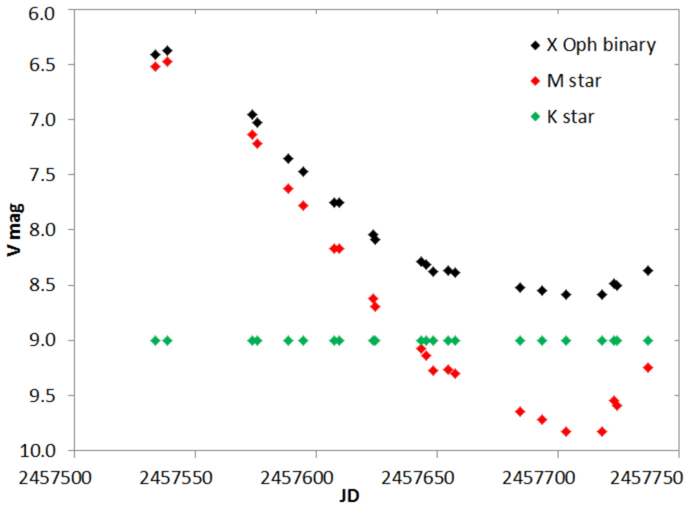

Figure 8. V mag lightcurves of the X Oph binary system and its components based on the parameter values in Table 2.

sation cycle of the Mira variable and the long-term lightcurve of X Oph tells us that every cycle is subtly different.

Acknowledgments

I am grateful to John Toone for originally arousing my interest in this star and to both Toone and Chris Lloyd for providing references to useful background information. My thanks are due also to the referees whose constructive comments have helped to improve the paper.

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Hunting down 'galactic wanderers' – the most remote and obscure globular clusters

by Damian Peach

Globular star clusters are without doubt among the most spectacular objects to be found in the night sky. I'm sure many of us well remember our first views of objects such as Omega Centauri, 47 Tucanae or Messier 13. Indeed I consider 47 Tucanae perhaps the most spectacular object I have ever observed.

There are many other globular clusters scattered throughout the sky. Many are fairly close to us in terms of their distance. However, there are some little known clusters that are incredibly remote, lying further away than the nearest galaxies. There are also many clusters that are heavily obscured by dust clouds in our own galaxy. Hunting these elusive targets down can be both challenging and rewarding. Luckily with the advent of modern imaging technology it is now easily possible to hunt down these little known gems – once you know where to look!

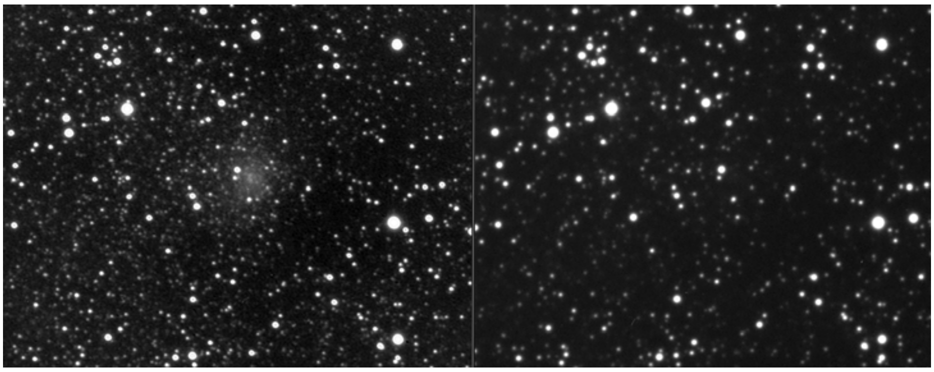


Figure 2. The heavily obscured globular cluster UKS-1 in Sagittarius is an extremely challenging object in visible light (as seen at right), however with IR filters it is possible to penetrate the intervening dust to get clear views of this cluster (at left.)

Some facts and figures

There are more than 150 globular clusters bound to the Milky Way galaxy in a large halo. This number may seem quite high but in fact it is not. Larger galaxies such as Messier 31 have as many as 500 such clusters in orbit around the galaxy, while the largest galaxies known have many thousands. In fact almost every galaxy we look at (of sufficient mass) in the night sky has a system of globular clusters bound to it. Their origin and formation remain a matter of debate among astronomers, however they may be related in some way to dwarf spheroidal galaxies.

Globulars are typically the oldest objects associated with their parent galaxy, containing some of the first collections of stars to have formed. Stars within these clusters are often described as 'metal-poor', meaning they lack the heavier elements found in stars like the Sun. Globular clusters also display no active star formation, which is a good indicator of their ancient nature. Since many clusters are lacking in heavier elements it is thought that small terrestrial planets are probably quite rare within them. The result of just such a search on the bright cluster 47 Tucanae several years ago found no planet candidates within the cluster, however more recently a planet was discovered within the bright cluster Messier 4.

Distant galactic wanderers

While most globular clusters that we can see are within approximately 50,000 light years of us, some are very remote indeed. Many readers may be familiar with NGC 2419 – affectionately known as the 'intergalactic wanderer' as it was once believed this cluster was not in orbit around our galaxy. Although some 275,000 light years away from us, it is still a fairly easy object to observe, glowing at 9th magnitude and within easy reach of small telescopes. Some clusters however are far more remote even than this.

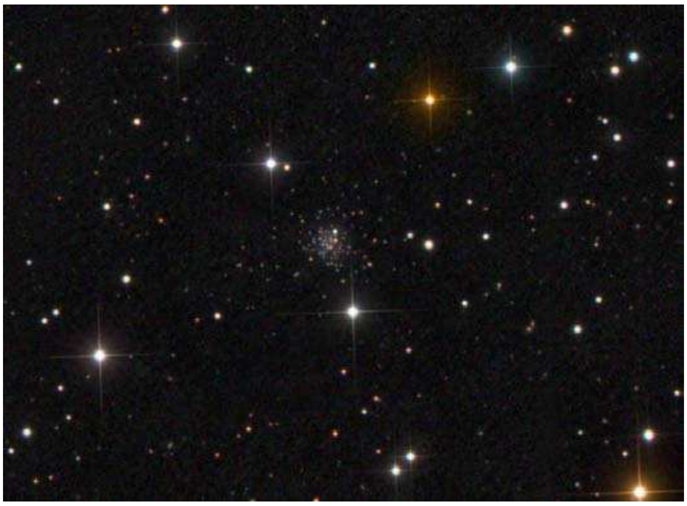


Figure 1. The most remote globular cluster, Arp-Madore 1, captured by the author using a 50cm telescope equipped with CCD camera.

Within the obscure constellation of Horologium in the southern hemisphere is a globular cluster with a rather special status. Glowing dimly at 15th magnitude we find the most distant globular bound to our galaxy – Arp-Madore 1. Located over 400,000 light years away this incredibly remote object was not identified as a globular cluster until 1979 by Halton Arp & Barry Madore while examining photographic plates from the UK Schmidt telescope at Siding Spring Observatory. It is a challenging object to observe visually, even in large telescopes, but can easily be recorded with CCD cameras attached to modest-sized telescopes. As a quick comparison this cluster is around twentyfive times further away from us than Omega Centauri!

There are other remote wanderers out there. A few of the clusters included in the obscure Palomar list of globular clusters are also well over 300,000 light years away. Palomar 4 in Ursa Major and Palomar 3 in Sextans are found out at this distance. Both are around 14th magnitude and within easy reach of telescopes equipped with CCD cameras (and within visual reach of large telescopes.)

As a quick reference for observers the five most distant Milky Way globular clusters are given in Table 1.

Heavily obscured clusters

While remote clusters are certainly difficult objects to observe and image, clusters that are obscured by the dense clouds of dust in our own galaxy are even more challenging to track down. Many are really only within reach of telescopes equipped with CCD cameras, but there are some that can be seen visually.

Table 1. Distant globular clusters in the Milky Way

Cluster	*Const.*	*RA*	*Dec*	*Est. distance*	*Mag*
Arp-Madore 1	Hor	03 55 02.7	–49 36 52	405kly	15
Palomar 4	UMa	11 29 16.8	+28 58 25	365kly	14
Palomar 3	Sex	10 05 31.4	+00 04 17	315kly	14
Eridanus Globular	Eri	04 24 44.5	–21 11 13	315kly	14
NGC 2419	Lyn	16 11 04.9	+14 57 29	275kly	9

The dense star fields and large amounts of obscuring dust that we find in the Milky Way (especially through the constellations of Scorpius and Sagittarius) toward the galactic centre are where we find the vast majority of these elusive objects.

Many of the clusters that are obscured by our own galaxy were not discovered until fairly recent times during searches on photographic surveys, and later infrared (IR) based surveys such as the 2 Micron All Sky Survey – 2MASS. Long wavelength radiation such as IR much more easily penetrates the intervening dust clouds in our galaxy than does visible light. Given modern CCD cameras are very sensitive to near-IR, typically up to around 900nm, it is possible to employ IR filters on amateur telescopes to track down some of these highly elusive objects – and the technique can work to great effect.

The images .in Figures 2 and 3 are fine examples of how effective using IR filters is in obtaining clear views of these elusive objects. Indeed I was quite amazed at the difference compared to the views in visible light where these objects are in some cases completely invisible.

Table 2. Obscured globular clusters for amateur telescopes

Cluster	*Const.*	*RA*	*Dec*	*Mag (visible light)*
UKS-1	Sgr	17:54:27.2	−24:08:20	17
FSR1735	Ara	16:52:10.6	−47:03:27	17
Pismis 26	Sco	17:36:10.5	−38:33:12	13
Liller 1	Sco	17:33:24.5	−33:23:20	17
Terzan 9	Sgr	18:01:39	−26:50:23	16

Figure 3. Heavily obscured globular cluster FSR1735 in Ara. This cluster was only discovered as recently as 2006 by the 2 Micron All Sky Survey. In this false-colour image with luminance taken through an IR800nm filter the cluster can be easily seen.

Some of the best 'obscured clusters' for amateur telescopes are listed in Table 2.

What you'll need

For those wanting to take up the challenge of hunting down these fascinating objects you'll need a reasonably large telescope (20cm or larger), equipped with a CCD camera. Some really good sky charting software is also essential. Since many of these objects are very faint or heavily obscured in visible light, many will be extremely challenging targets for visual observers even equipped with large Dobsonian telescopes under dark skies. Luckily however, with CCD cameras on modest telescopes many of these objects can be observed even from typical suburban back gardens.

An IR pass filter will also be required for hunting down clusters that are heavily obscured. These are widely available from a variety of suppliers. A filter in the 700–800nm pass range would be well suited to the task.

Final thoughts...

There are countless images today of well-known clusters such as M13 or Omega Centauri, but going off the beaten path to explore some of our galaxy's little known wonders can make a fascinating and interesting project. What's more some of these objects have most likely never before been imaged by amateurs. There are a whole host of such objects throughout the sky and with patience you can be rewarded by catching objects few have ever observed or photographed.

Damian Peach

A Pro–Am collaboration covering the 2014MU$_{69}$ occultation event from Bloemfontein, South Africa

A view of the Boyden observatory complex from the Cellphone tower. ***Photo: Daan Notnagel***

On 2017 June 3, the Kuiper Belt Object (KBO) 2014MU$_{69}$ (now numbered (486958) 2014 MU$_{69}$) was expected to occult a 15th magnitude star in Sagittarius. The projected narrow shadow path extended across the South American and South African regions. This KBO, estimated to be 25–45km in size, is the next objective of the NASA *New Horizons* spacecraft, which will perform the flyby on 2019 January 1. Two further occultations are expected to occur this year (on July 10 & July 17), and these three events provide a rare opportunity to obtain further valuable information about this small, faint (mag 27) object. 2014MU$_{69}$ was discovered, and has only once been detected directly, by the Hubble Space Telescope.

The June 3 event would subsequently be described by NASA as 'the most technically-challenging and complex stellar occultation observing campaign ever attempted'.

I was rather surprised, but nonetheless delighted, to receive an invitation from the South African Astronomical Observatory (SAAO) to support them in a pro-am collaboration effort to monitor the occultation in support of the NASA *New Horizons* team. Several international teams were being deployed, using 16" [40cm]


Clyde Foster with his 14-inch [355mm] Celestron SCT.

Skywatcher Dobsonians in both South America and South Africa in order to set up an observing grid covering the shadow path. My home location in Centurion, Gauteng was well north of the projected path, so it was agreed with SAAO that I should consider relocation of my Celestron 14" [35cm] Edge HD SCT and auxiliary equipment to Bloemfontein, and more specifically the Boyden Observatory just northeast of the city. Although outside the high probability path, it was still possible, due to the limited information about the KBO, that the occultation may be detected. Even a good 'no-detection' result could still provide valuable information.

Having visited the Boyden Observatory a number of times over the last few years, it was an excellent opportunity to build further on my relationship with the observatory and the Physics/Astrophysics department of the University of the Free State (UFS), who are responsible for the maintenance and operation of the facility. One of the historic small observatory buildings and onsite accommodation was kindly allocated for my use over the period I would be there.

Boyden Observatory was set up in South Africa in 1927, when Harvard College Observatory of the USA took the decision to relocate its Boyden station, at that stage based in Arequipa, Peru. It has gone through various ownership changes, and challenges, over the years, but I am pleased to say has survived as an important South African astronomical heritage site and is still used as a present-day research facility. Some of its most famous and historic instruments are the Boyden 60" reflector (previously the Rockefeller), the 13" Boyden refractor and the 10" Metcalf refractor. The more modern 16" Watcher robotic scope is managed by University College Dublin. The Observatory also houses an amazing library, containing a broad collection of fascinating and valuable historical documents and books, as well as various exhibits.

Some tests were undertaken from my home observatory in preparation, but, given the local urban sky conditions, it was evident that it would be a very challenging exercise. Given the expected duration of the occultation of less than 2 seconds, exposures of 0.5s, with a minimum s/n ratio of 5–10 were key requirements. Binning (2×2) with my ZWO ASI290MM camera, combined with a focal reducer, were important factors. During this period of testing and self-study, I was ably supported by input and advice from Tim Haymes of the BAA[1] as well as Anja Genade of the SAAO.

The relocation took place on Wednesday prior to the occultation, allowing three days and nights to set up and resolve any last minute issues, where I was grateful for the assistance and support of the UFS Physics/Astrophysics department.

The target field was acquired a few hours before the occultation, and I was delighted to note that the target star was easily detected. With a projected occultation time of close to 03:10UT, data were captured at 2fps from 02:47UT to 03:32UT. 4.6Gb of data in 5457 frames were recorded in FITS format. Initial indication is that the data were of sufficiently good quality (s/n), and are currently being analysed by SAAO, and it will be interesting to see the consolidated results from all observers. For myself personally, it was a huge learning curve but an exciting and rewarding experience.

The latest NASA press releases indicate that good data were obtained from many of the observing teams, both in South America and South Africa, although it appears that no positive detections were observed, leading to the conclusion that 2014MU$_{69}$ may be smaller than originally estimated.[2]

My sincere appreciation to Prof Matie Hoffman and Dawie van Jaarsveld of Boyden Observatory and the UFS Physics/Astrophysics, Anja Genade and Dr Amanda Sickafoose of SAAO, and Tim Haymes of the BAA.

Clyde Foster

Clyde Foster is Director responsible for the 'Shallow Sky' (Solar System) at the Astronomical Society of Southern Africa (ASSA).

1 BAA Asteroids & Remote Planets Section (Occultations)
2 **http://pluto.jhuapl.edu/News-Center/News-Article.php?page=20170706**

Dark skies at France's 'Astrofarm'

Drive or fly to South West France? That was the question faced by eleven intrepid astronomers on how to get to Astrofarm, in Confolens near Limoges. As someone who wanted to travel light and photograph the night sky with my DSLR, the answer seemed obvious. Then when I learnt that Andrew and Sue Davies, the owners of Astrofarm, would pick me up from the airport, provide all toiletries and wash my spare pair of boxer shorts each day, the choice was made for me! Six people in total flew and five drove. Driving does give you the chance to take much more equipment, if you want it, and also means you can use the telescopes that you are familiar with rather than rely on the equipment and roll-off-roof observatory that's provided on site.

During the day there are many places of interest to visit. No worries if you don't have a car because Andrew will drop you off in town or further afield by arrangement. Confolens, the nearest local town is pictur-

Enjoying Ireland's COSMOS Star Party

The COSMOS Star Party[1] took place on the weekend of 2017 March 31 to April 2 in Athlone, in the heart of the Irish midlands. Hosted by Midlands Astronomy Club (MAC)[2] the event celebrated its 26th annual weekend astronomy festival. Previous speakers at the star party included Dr John Mason, the late Neil Bone, Dr Ian Morrison, Damian Peach, Will Gater and Thierry Legault to mention a few.

The event took place in the comfortable surroundings of the Shamrock Lodge Hotel. The star party kicked off on Friday evening with a family-oriented workshop by Seanie Morris on constructing air-and-water bottle rockets. Due to the mixed weather conditions, night sky observing was limited so most attendees retired to the comfort of the hotel lounge to partake in some gentle socialising.

Saturday morning began with a fascinating lecture by author, broadcaster and space historian Dr Brian Harvey on the Soviet Union's lunar exploration programme. Brian provided an excellent insight into the Russian space programme, much of which was previously hidden from the West. This was followed by the well-known astronomer, author and science populariser Prof Nigel Henbest with a beautifully presented lecture entitled 'Science Purists'.

During the lunch break, kids of all ages got to launch their bottle rockets to great excitement and fanfare! Encouraging our youth into astronomy is vital to developing the next generation of astronomers and a great fun way to promote STEM subjects in our schools.

Bottle rockets are go!

Following the lunchtime activities, the author provided a lecture on radio and video observations of meteors. This talk focused on results of meteor analysis from his observatory[3] and the NEMETODE[4] meteor group. The talk highlighted the benefits of using cameras and radio systems for detecting meteors, notwithstanding the limitations the weather can play in the UK and Ireland.

Saturday's lecture programme concluded with a talk by Joe McCauly of Trinity College Dublin regarding the Irish Low Frequency Array Radio Telescope (I-LOFAR)[5] currently under construction at Birr Castle, a short walk from the great 72-inch Leviathan telescope. Later in the evening, the Cosmic Dinner and table quiz took place with tremendous fun had by all.

Sunday morning's programme started with a talk on solar activity by MAC member Ivan Merrick. This was followed by a lecture entitled 'Where on Earth is Mars' by Dr Mary Bourke, Senior Scientist at the Planetary Science Institute. The talk featured the latest information on the geology of the red planet and included some amazing 3D images from the Mars rovers.

The final talk of the event was provided by Stephen Corcoran of KTEC Telescopes who presented 'The Wonderful World of Meteorites'. The talk highlighted the origin and formation of meteorites and their recovery on Earth.

I would like to congratulate Midlands Astronomy Club on an excellent event and encourage possible attendees from near and far to consider marking the 2018 star party from April 13 to 15 in their calendar.

Michael O'Connell, *Dublin*
[michael@astroshot.com]

1 COSMOS Star Party: **www.cosmosstarparty.ie**
2 Midlands Astronomy Club: **www.midlandsastronomy.com**
3 Astroshot Observatory (I87): **www.astroshot.com**
4 NEMETODE: **www.nemetode.org**
5 I-LOFAR: **www.lofar.ie**

Ruined castle at St Germain de Confolens.

esque, only two kilometers away and historical. Medieval structures remain as does the bridge first mentioned in the fourteenth century. Further along the river, within five kilometers, is St Germain de Confolens with its ruined castle and twelfth century church, both prime targets for night-time astrophotography.

Which neatly brings us to the whole point of travelling to a dark site. The night sky. While I was there the sky was measured each night with a Sky Quality Meter and achieved an average of 21.6 magnitudes per square arcsec at zenith, dropping to 21 above the tree line. This means very little to me other than being told, by those who know, it's rather good. But no matter how dark the sky, it's only part of the tale. I looked through a couple of scopes while there and was utterly amazed. I've heard that under good steady conditions the stars don't twinkle and the planets stay rock steady but it's the first time I've actually seen it with my own eyes.

As a keen landscape astrophotographer what interested me was the overall clarity and lack of light pollution. Nowhere I've visited is free from pollution but in and around Astrofarm it is well controlled and was not naked eye visible to me when the thin cloud had gone. The ruined castle I mentioned was in a large village where all the external lights go out at 23:30 – unnerving if you happen to be half way across a broken wall and can't find your head torch.

Depending on how keen you are, Andrew can take you to off-farm photo sites. He showed us general areas of interest and also specific areas he's discovered. There are no time constraints and if you feel brave enough to image or view until dawn, you can, safe in the knowledge that Sue will be around to make breakfast no matter what time you wake the following day.

I stayed with seven others in a dormitory/cabin style room but there is also a double bedroom at the farm and a small house sleeping four in two bedrooms. Contact Sue & Andrew through their website: **http://astrofarmfrance.com/astronomy-centre/**

David Williams

Astronomy at the 'Observatory Science Centre'

www.the-observatory.org

For the past 22 years, the Observatory Science Centre at Herstmonceux, East Sussex, has offered visitors of all ages a 'hands on' approach to science that is both fun and educational. In addition, given its unique location in the former home of the Royal Greenwich Observatory, the Science Centre takes great pride in promoting astronomy and making it accessible to as many people as possible.

Housed in the famous green domes are some of the UK's largest telescopes, two of which are open each day and also feature in our telescope tours. Regular open evenings, which are held throughout the year, offer visitors the opportunity to view the night sky through our telescopes, some of which are not open to the public during the day. No pre-booking is required unless otherwise stated and in the event of poor weather we offer a 'cloudy sky' contingency plan in the form of a planetarium-style talk.

Our range of astronomy courses, conducted in an informal and friendly atmosphere, caters for both beginners and intermediates and includes a four-week spring and autumn Star Search, a twelve-week Astronomy & Space course for beginners, and a four-week Further Astronomy course for intermediates. Additional spring and autumn one-day workshops include Astro-Imaging and a Telescope Clinic.

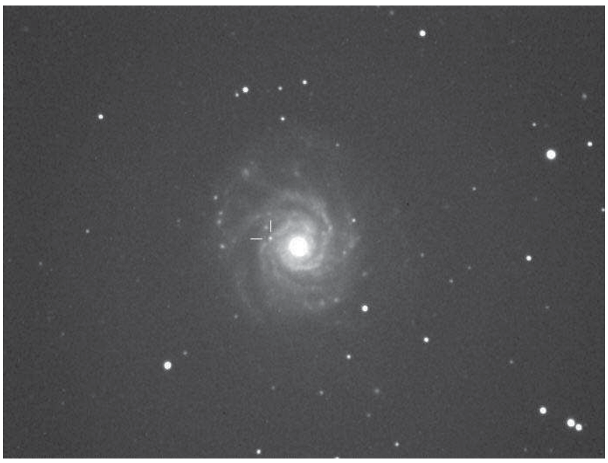
As a registered educational charity we rely entirely on income derived from visitors to the Science Centre and our main fundraising event of the year is the Herstmonceux Astronomy Festival. Since 2005, this annual weekend event has helped ensure that our historic domes and telescopes are kept in good working order so that we can share them with everyone who comes to see them.

This year's Astronomy Festival takes place from September 1 to 3 and once again there will be a full programme of lectures, trade stalls, observing (weather permitting), planetarium shows, family robot workshops and raffles, ensuring a fun, friendly and relaxed weekend suitable for all ages. See the advert on page 232 for the list of speakers.

For anyone wishing to camp under the backdrop of the domes we have a limited number of pitches available. This is always a popular option so early booking is advised to avoid disappointment. Please call us on 01323 832731. Alternative accommodation is also available at Herstmonceux Castle just a short walk from the Science Centre. To book please contact Bader Hall on 01323 834400 or via e-mail: **accom@bisc.queensu.ac.uk.**

Barry Howse, *Observatory Science Centre*

A 45th supernova for Ron Arbour



Congratulations to Ron Arbour on the discovery of his 45th supernova, SN 2017ein, in NGC 3938 on 2017 May 25 at magnitude 17.6. From a spectrum taken by Beijing Observatory it was classified as a Type 1c. NGC 3938 is a lovely face-on spiral galaxy in Ursa Major, perfect for imaging.

Image by Ron Arbour, 2017-05-25.9781 UT. 35cm f/6 SCT + SXVR-H9 CCD, 10×30 secs.

Do we have your latest e-mail address?

All BAA members with an address on our file should now be receiving by e-mail our new monthly digital publication – the *Newsletter*, edited by Janice McClean – that is designed to keep members in touch with BAA activities and events, as well as letting you know when a new edition of the *Journal* has been uploaded to the website.

If we don't have an e-mail address on file for you, or if you have recently changed it, you may not be getting the *Newsletter* – do contact the BAA office [**office@britastro.org**] if this is the case. Please always let the office know if you change your e-mail address. Inevitably in future more and more communications will be sent by this method, saving the BAA both time and money, so do make sure you stay in touch.

Bill Tarver, *Business Secretary*

Meetings

Ordinary Meeting, 2017 May 31

held at the Royal Astronomical Society, Burlington House, Piccadilly, London W1

Dr Jeremy Shears, *President*

Bill Tarver, Hazel Collett & Jeremy Shears, *Secretaries*

At 17.30 the President opened the 5th Ordinary Meeting of the 127th session. The members present approved the minutes of the previous meeting, and 47 new members were elected to membership. New member Andrew Thomas was welcomed by the President and the members.

As Papers Secretary Dr Shears said that four papers had been approved that afternoon by Council for publication in the *Journal*:

The colour and temperature evolution of the plateau phase of SN 2012aw in Messier 95 by Martin Fowler;

RZ Cas lightcurve and orbital period variations by Geoff Chaplin *et al.*;

John S. Glasby (1928–2011): a BAA enigma by Martin Mobberley;

Determining the magnitudes and spectral types of the components of the binary Mira X Ophiuchi by David Boyd.

The President then drew attention to forthcoming meetings, including a Comet Section meeting in Northampton on June 17, the Association's bi-annual Exhibition in Edinburgh on June 24, and the autumn weekend meeting in Chester on September 8–10.

Dr Shears then introduced the George Alcock Memorial Lecture, to be given this year by Dr Richard Miles, a past President of the Association and currently the Director of the Asteroids and Remote Planets Section.

Comet IRAS–Araki–Alcock and other comet discoveries from the UK

Richard Miles began by saying that this memorial talk was a great opportunity to put George Alcock's observations into context. George would scan the sky whenever possible using binoculars, even sometimes viewing through glass windows. C/1983 H1 IRAS–Araki–Alcock was the last comet found from the UK and he found it in April of 1983. The comet has an orbital period of 947 years and is now associated with the weak meteor show in May, the eta Lyrids.

The first comet to be discovered from the UK was a fourth magnitude object by John Flamsteed in 1683. In 1717 a chance observation by Edmund Halley found a comet while using a telescope to look at Mars. Caroline Herschel held the record for discoveries from the UK. She was not only the first woman to discover a comet, but she found eight in total.

The next with five discoveries (1881, 1890, 1891, 1892 and 1894) was William Denning. Denning was a past Director of the Comet Section. His discoveries were the result of attempts to find objects, either comets or nebulae; however some discoveries were made by chance. Michael Candy discovered a comet on Boxing Day 1960 while testing a new small telescope through a window. Other discoveries were made by those with planned observing projects, including Roy Panther who discovered a comet in 1965 after 600 hours of searching.

Before 1953 George Alcock was a meteor observer, however after this date he used a 4-inch [100mm] refractor owned by the Association to attempt to find comets, but this only provided a 1° field of view. In 1959 Alcock bought a pair of 25×100 binoculars for £150. After 650 hours of searching he made his first discovery (C/1959 Q1) only to find another a week later (C/1959 Q2)! He went on to discover five comets in total, C/1983 H1 being his last. This became a noticeable naked-eye comet in UK skies as it passed very close to the Earth.

Comet IRAS–Iraki–Alcock (C/1983 H1) on 1983 May 10 at 21:11 UT. 200mm f/1.5 Schmidt camera, 5 min. on hypered Kodak Technical Pan 2415 film. ***Michael Jäger***

Dr Miles continued by describing his own attempts to find comets using a 300mm f2.8 camera lens on a CCD detector. With an automated system that took images over a planned part of the sky he obtained duplicate images which he then compared by the blinking method. Although this failed to discover new comets he did detect known comets with the system. He feels that although the chance of discovering new comets visually is now most unlikely, a targeted programme of imaging in the dawn sky may still be able to detect a comet that is missed by the many automated systems.

Dr Richard McKim. ***Photo by Alan Dowdell.***

In the time for a few questions Richard explained that he did not include discoveries made from the SOHO images in his talk although the spacecraft is monitored from the UK. He explained briefly the procedure for reporting a discovery if one were made.

Jeremy Shears thanked Richard Miles for his talk, and introduced the second speaker, Dr Richard McKim. Dr McKim is also a past President and is currently Director of the Mars and the Mercury & Venus Sections. His main talk this evening would be preceded by a short note on a significant recent observation of Venus by amateurs in Australia.

Infrared thermal emission from Venus

When Venus is close to inferior conjunction it is possible to make observations of the planet in infrared wavelengths which show high-altitude surface features that correlate with those identified by the *Magellan* spacecraft. This is due to a decrease in temperature with altitude in the planet's atmosphere. In April–May this year Anthony Wesley and Phil Miles in Australia observed the planet using filters working at 850–1070nm in the infrared.

Their observations showed a bright spot on the surface, indicating a hot spot. This is an area on the planet which could have known volcanic activity, and it is possible this new observation could be of an active volcanic eruption. Confirmation from professional observers of the planet is awaited but if confirmed this would be a remarkable discovery by amateur observers.

Dr McKim then introduced his second talk.

The life and times of A. A. C. Eliot Merlin

The Association presents its award the 'Merlin Medal' annually, but Eliot Merlin (1860–1946) the person is rarely referred to in the pages of the *Journal*. So this talk is to give a little more information about this observer. He published only one paper in the *Journal*, but sent many of his observations to the magazine *English Mechanic*.

Aurora imaged from North Oxfordshire on 2017 May 28 at 01:19 UT by Mary Spicer.

Eliot was born in Greece where his father was a diplomat. After education in England he also joined the diplomatic service, acting as British vice-consul at Volo in Greece. He also worked for the local bank and obtained antiques for the British Museum. Due to the fact that the consulate building had a flat roof, Merlin took every advantage of the clear skies for observing from this roof. His telescope was an 8.5-inch [215mm] reflector with a With mirror. Conditions enabled him regularly to use up to ×600 magnification, and to observe almost every night. On returning to the UK after retirement he used a 12-inch reflector within a run-off-roof observatory, and regularly attended BAA meetings.

Merlin died at the age of 86 and when his wife died in 1959 money was left to the Association, which Council decided should be used to found the Merlin medal and gift in his name.

Jeremy Shears thanked Richard McKim for his two talks and introduced the Comet Section Director, Nick James, to present the Sky Notes.

Sky notes for the summer

Nick James then gave the regular Sky Notes summary of past and future events in the sky. The Sun was currently very inactive with long periods with few spots. However images were shown by Peter Meadows on April 2 and Ron Johnson on May 8. Aurora was similarly inactive but a display had been imaged by Denis Buczynski in Ross-shire on April 24 and more southerly from North Oxfordshire on May 28 by Mary Spicer.

Now that evening skies are very light it would be a good time to look at the Moon. An image by Clyde Foster was shown.

Jupiter was still a good evening object and images were shown by Martin Lew, Andy Li and David Arditti. Members were reminded to keep checking the Association's Web page where the results from the *Juno* spacecraft were being regularly uploaded by Jupiter Section Director John Rogers.

Congratulations were due to Ron Arbour who on May 25 had discovered his 45th extragalactic supernova, designated SN 2017ein. Nick also showed a wide view of the Milky Way he took from La Palma. Saturn is now very low in the evening sky, but images were shown from Andy Li, Chris Dole and a drawing by Paul Abel.

Nick then explained that a new comet had been discovered, C/2017 K2 PanStarrs. Although discovered at mag 19, it was 16au from the Earth at discovery, which has caused some excitement, but comets are always unpredictable and we don't really know what will happen. It will be at its closest in 2023 at 1au, so it could be a bright comet, possibly 2nd or 3rd magnitude. However the only thing we do know for sure, is that its orbit will confine it to the southern hemisphere.

In closing Nick reminded us of the forthcoming Perseid meteor shower with its maximum on August 12, and the total eclipse of the Sun visible from the USA on August 21.

The President thanked Nick James and the other speakers and the meeting was closed just before 20:00.

Alan Dowdell

Observers' Workshop – Lunar & Solar

Saturday, 2017 Sept 30, 10:00 to 17:00

Burlington House, Piccadilly, London W1J 0BQ

A workshop to help you get the best from observing our nearest star and the Earth's own satellite.

The topics covered will include:

– Imaging the Moon
– Changes on the Moon
– Observing lunar occultations
– Lunar online resources
– Bipolar magnetic regions on the Sun
– Solar imaging with DSLRs and webcams
– Latest solar equipment for the amateur
– The historical view from Kew Observatory
– Non-visual detection of solar flares

Q&A sessions for both solar and lunar observing will help you find out all you need to know from the speakers and experts on hand.

The workshop costs £2 for BAA and Affiliated Society members, and accompanied young people under 16, and £3 for non-members, to cover refreshments. Lunch is not included as there are plenty of cafes & eating places close by.

To book your place, contact the BAA Office by 2017 Sept 22. **Tel: 020 7734 4145. Email: office@britastro.org**

Attendance is limited to 70 places, and will be issued on a first come first served basis.

Full details & online booking on the BAA website at **www.britastro.org/meetings**

Meeting of the Comet Section, Northampton, 2017 June 17

Attendees at the recent Comet Section meeting in the Humfrey Rooms, Northampton, enjoyed a very packed agenda, tightly orchestrated by the Director, Nick James, and his infamous eggtimer. Despite its being perhaps the hottest day of the year so far, a cool breeze swept through the hall and with generous tea, coffee and cold drinks on tap from our gracious hosts, the Northampton Natural History Society, we were kept comfortable throughout the day.

Nick opened the meeting, welcoming over 50 attendees, and gave an update on this year's comet activity and on the latest results from the *Rosetta* mission, showing some spectacular images of the surface of Comet 67P.

Jonathan Shanklin then presented his analysis of secular changes in periodic comet magnitudes based on amateur observations. Some of these variations are due to orbital changes arising from planetary perturbations, particularly by Jupiter, and some are due to physical changes in the comet itself or its axial orientation. In mentioning the influence of Jupiter Jonathan said 16P/Brooks will be useful to observe in this regard as it passes close to Jupiter this year.

Peter Carson followed with a demonstration on how to image in light polluted Southend, only 36 miles east of London's Piccadilly, with such other distractions as buildings in the way, smoke from wood burning stoves, and vibrations from traffic. Yet, with all of this, Peter still manages to take some of the best images in the Association. He can image down to 19th magnitude with only a 30cm reflector and a relatively low-cost camera, and obtains astrometry which is sufficiently good to submit to the Minor Planets Center. Playing down the fixation many of us have with sky darkness, he said that it is just as important when imaging to have a good steady atmosphere and a steady mounting. Accurate calibration frames and appropriate exposures which do not saturate the camera are also very important as is very careful processing of the data.

Attendees at the Comet Section meeting *(Photo: Jack Martin).*

Next to speak was Denis Buczynski, who gave a short history of comet magnitude estimation. Comets are difficult to measure since they have such a wide range of different forms, and many different methods have developed over the years. In the 18th century Herschel compared comets' magnitudes with nebulae and deep sky objects. This was challenging as there was no systematic method for determining nebulae magnitudes either! Pogson was later quoted as saying, 'I guess I should describe the comet as three times as bright as the cluster M80'. Denis then went on to describe the origin of current magnitude estimation techniques. He noted that the story went back to Comet Wells, discovered by Charles Wells in 1882. There was some correspondence in *The Observatory* between George Knott and William Backhouse where they discussed magnitude estimates for this comet, and their extra-focal method was eventually adopted and adapted by subsequent observers.

Denis Buczynski, Nick James & Nick Hewitt *(Photo: Janice McClean).*

Following a break for lunch the audience reassembled for a lighter exploration of Politics, Art and Snowy Dirtballs, by Janice McClean. Starting with some very bad comet poetry, she took a quick romp through the centuries from the earliest representation of comets carved 8000 years ago on a stone found in Valamonica in North Italy, through Chinese silken manuscripts, French political cartoons, the Pre-Raphaelite school, and into the 21st century's use of comets in the media. It was seen that comets are still often used to herald doom, gloom or an incoming president, which may be the same thing to some people.

Back to the serious content of the meeting, and Richard Miles spoke on how to monitor cometary outbursts. Outbursts can last for days, or hours. Fragmentation type outbursts can happen as the comet nears the Sun causing it often to break up into smaller pieces. Outbursts can also be due to internal activity in the comet. Richard went on to describe how to observe and record these outbursts. He discussed how the use of robotic telescopes was becoming more prevalent and this enabled round-the-clock monitoring of certain comets in the search for outbursts.

Tony Angel then gave us an interesting Pro-Am perspective. He observes comets using a 0.35m SCT at his observatory in Andalucia, Spain and contributes observations to the BAA, social media groups and the professional/amateur PACA (Pro-Am Collaborative Astronomy) group run by NASA scientist Dr Padma Yanamandra–Fisher. Tony described the benefits (and sometimes difficulties) of working with pros and submitting data that could be used for analysis.

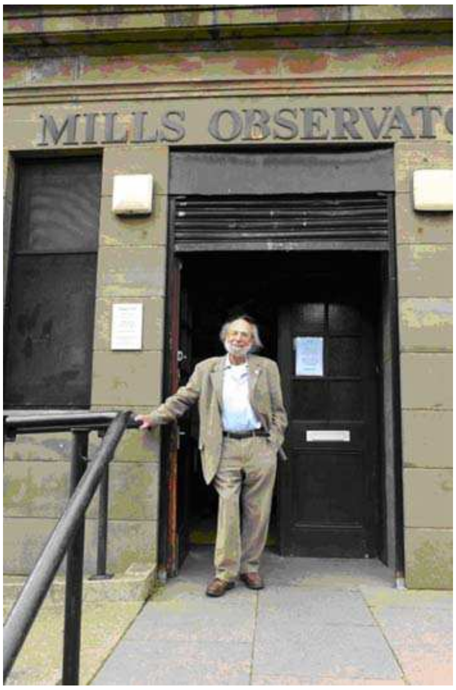
Following Tony's talk Dr Yanamandra–Fisher herself spoke to the meeting via Skype from California (a first for the BAA, and very successful once properly set up). She discussed the origin and classification of comets and reminded the audience why it was so important to study cometary dust, since this is a diagnostic of conditions in the early solar system. She also summarised the various online groups that work together to support cometary Pro/Am work.

The main speaker of the day, Prof Alan Fitzsimmons from Queen's University Belfast, then spoke on 'Unlocking the Secrets of near-Sun Comets'. He said that the brightest comets were those that got closest to the Sun, listing the Great Comet of 1680 which had a perihelion magnitude of –11, and the Great Comet of ▸

Obituary

David Pettitt (1936–2017)

David was born on 1936 May 18 in Darlington, Co. Durham, the elder of two sons. His father was a tool maker, and his mother a commercial artist, decorating ceramics. The family lived in London during much of the war. During the blitz David and brother John were taken by their mother to Lincolnshire. However they didn't like it, and soon returned to London. From their Harrow home, David remembered seeing the docks in London ablaze. He also remembered the buzz bombs being dropped on London, and during his spare time collected pieces of shrapnel. After the war the family returned to Darlington, and then moved to Newton Aycliffe.



David Pettitt at the Mills Observatory, Dundee, during the BAA weekend meeting in 2016 September. ***(Photo: Ken Kennedy)***

After leaving school David went to college in Darlington. He had a keen enquiring scientific mind, and as a child constructed his own radio set, so it is probably not surprising that he began work in the design office at Ferguson's radio manufacturers in Spennymoor. Here he met Marian, who worked in the factory as a radio calibrator. David did National Service with the RAF in Lincolnshire, where he was responsible for looking after the RAF radio transmitters. Everything in the station had to be kept spotless, so they came up with the idea of tying towels around their feet so whenever they went anywhere in the building, the floor would be polished to a high sheen.

Marian and David were married in 1958 in Kirk Merrington, and in 1963 David achieved his electronics certificate. In the early 60s David and Marian moved to Cumbria, initially to Whitehaven, so David could work as an instrument technician at Sellafield. A work colleague suggested David apply for a job with the new ITV station that was starting in Carlisle, Border TV. So in 1963 the family relocated to Carlisle. David's first job with Border TV was as a cameraman. He then moved into video control, ultimately becoming an outside broadcast supervisor until retiring in 1995.

As well as working for Border TV, David created his own 'pirate' TV station. He built a spot scanner out of bits and pieces and would broadcast simple images to a friend living in Newcastle. This pioneering endeavour was brought to an end when a neighbour, who worked for Customs & Excise, knocked on his door, and said 'I know what you're doing, you'd better take it down.'

There were three keys to David's life: family, fell walking and astronomy. He was a keen fell walker and was a National Park Warden for 37 years. Because of his mountaineering expertise, David was called upon to assist with the search for wreckage and personal belongings following the downing of Pan Am flight 103 over Lockerbie. David was assigned to Strathclyde Police as a mountain guide supervisor, to assist them as they swept the mountainside for evidence.

His other great passion was astronomy. He constructed his own telescope and observatory in his back garden and in 1968 he was elected to the BAA. He was also a Fellow of the RAS. His particular interest was in the aurorae. He led the BAA's Aurora Section Magnetometry Group for several years until magnetic data became readily available from online sources. He published a paper in the *Journal* on 'A Fluxgate Magnetometer' (*J. Brit. Astron. Assoc.*, **94**(2), 5561 (1984)). He was also an active observer of asteroidal occultations, obtaining a positive recording of asteroid (112971) 2002 RA20 occulting the star TYC 2865-00415-1 on 2014 Dec 2. He attended the BAA Weekend Meeting in Dundee in 2016 September.

In Carlisle, David was a founder member of the Border Astronomical Society. About 1979 he was offered a 16-inch telescope mirror by Harry Clough, a member of the Scottish Astronomical Group. This led to the building of Trinity School Observatory, as a member who taught physics there and ran an astronomy club persuaded the Education Dept. to purchase the mirror. The school paid for the building and the work was done by Technical College students over a ten year period. Border Astronomical Society (which is open to all) moved there in 1986 and is still thriving 46 years after its foundation. Carlisle would not have a public observatory if David had not founded Border Astronomical Society.

David had a son, Michael, who was born in 1960, and a daughter Claire, born in 1965. He was also grandfather to Harriet, Alexander, Talia & Gabriel. They remember how he would share his love of astronomy with them, showing them the observatory he built in his back garden, and looking at the stars together. David passed away on 2017 January 14, aged 80.

This obituary was originally prepared for the Cumberland News *by David Ramshaw of Border AS. Edited & supplied by Jeremy Shears, with additional input from Alex Pratt, Ken Kennedy, Dave Gavine and Ron Livesey.*

1882 which was the first to be photographed. More recently Ikeya–Seki in 1965 reached magnitude −10 and was photographed near the Sun using a ground-based coronograph. All of these sungrazing comets have almost exactly the same orbit, prompting Heinrich Carl Friedrich Kreutz to speculate that they are all the progeny of an earlier monster comet which split up at perihelion, possibly in AD 386. Many more sungrazing comets have been discovered by the SOHO spacecraft.

Alan noted that the discoverer of the next sungrazing comet was less and less likely to be a human observer and, by 2022, the Large Synoptic Survey Telescope (LSST) was likely to dominate Solar System discoveries in the southern hemisphere. This widefield instrument will be able to detect comets to approximately magnitude 25 in a 9.6 square degree field with an exposure of only 30 seconds.

Alan then described some of his own recent research, specifically some work done to recover two of the periodic near-Sun comets detected by SOHO as they returned to the inner Solar System. This resulted in the recovery of P/1999 R1 (SOHO), now renamed 322P/SOHO, using the FORS camera on VLT in 2016 January. This object was previously categorised as a near-Earth asteroid, near its end state. Alan said that any object becomes a comet if it gets too close to the Sun, since even rocky objects are volatile in the heat at that distance!

After a short tea break, members of the Comet Section gave a series of four ten-minute talks. Roger Dymock gave an update on *Astrometrica*, and the debate on magnitudes and comet tails reopened. Simon White showed how he imaged comets to make stereoscopic pictures, David Eagle gave some more details about PACA and Nick Atkinson gave the closing session on the use of APCC to track comets.

BAA President Jeremy Shears then closed the meeting with thanks to the NNHS, the Director and all those who contributed to an excellent day. Given the temperature of the day the scuttle to the nearest watering hole was fairly orderly.

Janice McClean
Editor – The Comet's Tail and the BAA Newsletter

The BAA Council, 2017 May 31

Left to right, front row: Janice McClean, Richard McKim, Jeremy Shears, Hazel McGee, Paul Abel, Lorraine Crook, Ann Davies. *Back & centre*: Nick James, Mike Frost, Bill Leatherbarrow, Ron Johnson, Geoffrey Johnstone, Richard Miles, Bob Marriott, Richard Sargent, Bill Tarver, Alan Lorrain, David Boyd, Callum Potter, David Arditti. *Photo by Geoff King & Hazel McGee.*

New members

The British Astronomical Association cordially welcomes the following new members:

Elected 2017 March 29

ALECSA Bogdan, Leamington Spa, Warwicks.

BARKER William Ralph, St Saviour, Jersey

BELL Ian, Oldbury on Severn, Bristol

BOHNER Richard, Bexleyheath, Kent

BUSH Martin, Chippenham, Wiltshire

CHURCH William, Malvern, Worcs.

COOKE Chris, Plymouth, Devon

GIBSON Jane, Mill Hill, London NW7

HUMPHRIES Steven W., St Austell, Cornwall

KEELING Simon James, Wombourne, Staffs.

LEE Peter, Warminster, Wiltshire

LEE Elizabeth, Warminster, Wiltshire

LEES Michael, Mill Hill, London NW7

MAGDY ABD EL RASOUL Mohamad, Ajman, United Arab Emirates

NICHOLAS Patricia, Sellicks Beach, South Australia

ODASSO Alessandro, Milano, Italy

PEARSON Keith, Preston, Lancs.

PFITZNER–MILIKA Darryl J., Sellicks Beach, South Australia

RITZEL John, Plymouth, NY, USA

ROBINSON Dr Andrew, Aberdeen

ROBINSON Alison, Aberdeen

SCHMUDE Dr Richard W., Barnesville, GA, USA

SEWELL Robert, West Kilbride, Ayrshire

SIMPSON Dr Richard, Porn, France

STEFFENSEN Steffen, Thyholm, Denmark

STONE Peter, Coulsdon, Surrey

TINKLER Andrew, Solihull, West Midlands

TINKLER Helen, Solihull, West Midlands

WEBBER John R., Taunton, Somerset

WHITBY Samuel, Prince George, VA, USA

YULE John, Ramsey, Cambridgeshire

New Honorary Members

Congratulations to the following, who have been members of the Association for a continuous period of fifty years at the start of the 2017–2018 session, and therefore now become Honorary Members:

	Date elected		*Date elected*
Mr David G. A. Carvin	1966 Dec 28	Mr Paul J. Huff	1966 Nov 30
Mr Charles G. Cottier	1966 Oct 26	Mr Richard A. Knox	1967 June 28
Mr Rowland H. Davies	1967 June 28	Mr Kevin J. Rooney	1966 Nov 30
Mr David H. Frydman	1966 Nov 30	Mr Angus C. Stevenson	1967 Mar 29
Dr Neil B. Havard	1967 Mar 29	Mr Timothy M. A. Tabb	1966 Nov 30
Mr David W. Henderson	1966 Dec 28		

Elected 2017 May 31

ACKLAND Mark, Wanborough, Wiltshire

AGNEW Dr Gerry, Uttoxeter, Staffs.

ANDERSON Pauline, Norwich, Norfolk

ARCHIBALD David, Edinburgh, Midlothian

ATKINSON Noah, Gosport, Hampshire

BALDERSON Martin, Yate, Gloucestershire

BELL Robert, Oxford

BENNETT Mark, Whyteleafe, Surrey

BLACKLOCK Mark, South Shields, Tyne & Wear

BRADDOCK Dr Martin, Radcliffe-on-Trent, Notts.

BROWN Helen A., Birmingham, W. Midlands

BUSBY Nick, Abergavenny, Monmouthshire

BYRAM Vincent P., Southend-on-Sea, Essex

CLARKE Darren, Leigh on Sea, Essex

COCHARD François, St-Pancrasse, France

DUGGLEBY Ryan M., St Albans, Herts.

FANIGLIULO Adriana, London, NW11

FOSTER John, Winchester, Hampshire

FOULKES Dr Letty, London, SW19

FOULKES Dr Matthew, London, SW19

GALLON Michael, Gainsborough, Cleveland

GAMMELL Tom, Pirton, Herts.

GINN Kenneth, Swanley, Kent

GINN Julie, Swanley, Kent

GRANFIELD Alun, Pontypridd, Rhondda Cynon Taf

GREENSLADE Geoffrey, London, SE21

GROGAN David R., Telford, Shropshire

HAWKE, James, Waterlooville, Hampshire

HEZZLEWOOD Michael, Burnley, Lancs.

HOOPER Peter, Banbury, Oxfordshire

KERR Michael, Bangor, Co Down

MCPHAIL Matthew, Stamford, Lincs.

NEWLING Timothy, London, SE3

PEETERS Mathijs, London, SW4

ROGERS Peter, Feltham, Middx.

ROSENFIELD John, Aviemore, Cairngorms

SLENNETT Henry, Sidcup, Kent

SMITH Rupert, London, SE9

STONE Marcus, G., Nottingham

SUDUNAGUNTA Dr Srinath, Borehamwood, Herts.

TONKIN Stephen F., Fordingbridge, Hants.

TOOGOOD Kevin, Rochester, Kent

TWEEDY Derek, Darlington, Co Durham

WARD Dr Anthony, Chiddingfold, W. Sussex

WHITEHOUSE Dr David Robert, Farnborough, Hants.

YANG Selena, Cambridge

Society elected 2017 May 31

SYDNEY CITY SKYWATCHERS (Monty Leventhal), Sydney Observatory, 1003 Upper Fort Street, Millers Point, New South Wales 2000, Australia

Nominations invited for the fifth Sir Patrick Moore Prize

The annual Sir Patrick Moore Prize of £250 is awarded to a member or members, or to an affiliated society or school, for one or more of the following areas of activity, selected to reflect Sir Patrick's life and enthusiasms:

1. Encouragement of a public interest in astronomy;
2. A contribution to the understanding of the history of astronomy;
3. Outstanding observational work by a member or members under 21 years of age;
4. Encouragement of participation in observational astronomy by youngsters;
5. Carrying-out a collaborative research project, whether between amateurs only, or also involving professional astronomers.

Last year's Prize was awarded to Tom Killestein, one of our most industrious young members and a great ambassador for our subject. Council is now inviting nominations for this year's Prize. Nominees may be nominated by themselves or by another. Please send nominations, including a short statement explaining the reason the person should be considered for the awarding of the Prize, to Madeleine Davey at the BAA Office (email **office@britastro.org**) by 2017 September 30. Nominations will be considered by a committee, which will make a recommendation to Council, and the Prize will be presented at the December Ordinary Meeting if possible.

David Arditti *(Chair, Sir Patrick Moore Prize Committee)*

Sky Notes: 2017 August & September

by Brian Mills

(Written for the UK at 23.00 BST on Sept 1.)

Subtle details in the 'Witches Broom' nebula, imaged by Nik Szymanek.

Looking towards the north Ursa Major is about to make its closest approach to the horizon as the head of the Bear straddles the meridian. Despite this M81 and M82 lie at a modest altitude of just over 30°. Ursa Minor points towards the west and in the general direction of alpha Draconis, otherwise known as Thuban, which 5,000 years ago, previously occupied the position of 'Pole Star'. Approaching the meridian to the north of the North Celestial Pole is Cepheus with a number of clusters to its name, some of which are associated with nebulosity. NGC 7160 is the brightest of the open clusters at magnitude 6.1 and was first identified in 1787 by William Herschel.

A little to the east of the meridian, Auriga, with the brilliant Capella, has fully risen. The brightest star in the Charioteer can be easily identified by using Megrez and Dubhe in the Plough and extending a line forwards, in the opposite direction to the Bear's tail, until it passes close to alpha Aurigae. The constellation contains a number of open clusters including M36 and M37 at magnitudes 6.0 and 5.6 respectively.

Turning to the east, that first indicator of approaching colder weather, the Pleiades, has risen and is already 10° in altitude. Due east, the head of Cetus is just visible whilst above it the autumn groups of Pisces, Pegasus and Andromeda are becoming more prominent with M31 already 50° above the horizon. Tiny Lacerta, another of the small constellations added by Hevelius, fills the gap between the Winged Horse and the zenith with its northern portion crossed by the Milky Way. There are a few open clusters, NGC7209 and NGC7243 being the brightest, and a number of faint planetary nebulae.

In the south, Cygnus, sometimes referred to as the 'Northern Cross,' commands the zenith. The area contains numerous open clusters and nebulae of which the Cocoon nebula and the Veil nebula, a supernova remnant, are perhaps the best known. One of the most imaged segments of the Veil nebula is the 'Witches Broom', where the most exquisite and subtle detail can be revealed. The Milky Way runs through Cygnus, more or less along the spine of the mythological swan, and contains the dark dust lane known as the 'Cygnus Rift'.

The other members of the 'Summer Triangle' lie to the west and south of Deneb which itself is just 6° from the zenith. The line of the Milky Way continues towards the horizon passing through the small groups of Vulpecula, Sagitta, Aquila and Scutum before reaching Sagittarius where the galactic core is located. The area is rich with globular and open clusters as well as nebulae. You will be well rewarded if you sweep the area with good binoculars or a rich field telescope.

In the west Arcturus is just 10° above the horizon and will soon be lost along with the large and rather shapeless forms of Ophiuchus and Serpens. Corona Borealis and Hercules are still reasonably well presented with M13 still 45° in altitude.

Planets and dwarf planets

Mercury was at greatest eastern elongation on the penultimate day of July. Despite the planet's angular distance from the Sun (27°) it was a poor apparition with Mercury less than half a degree in altitude at the end of civil twilight. The situation doesn't improve as the planet moves back into the clutches of the Sun with it passing some 4° below our parent star on August 26 when it reaches inferior conjunction. Following that, Mercury gradually moves into the morning sky to reach greatest western elongation on September 12. On that day at 05:55 BST the smallest planet will be 10° above the eastern horizon with the Sun 6° below it.

Venus is a morning object throughout the period although it is two months since elongation. At the beginning of August it is 20° high in the east at the beginning of civil twilight. One month later the altitude of the planet is almost identical despite it moving towards the twilight and even by the end of our period of interest, Venus is still more than 15° in altitude with the Sun 6° below the horizon. Over these two months the phase of the planet has increased from 75% to 90% indicating that next January's conjunction is not that far away.

Earth reaches the Autumnal Equinox on September 22 at 21:03 BST.

Mars was in conjunction with the Sun in late July so is lost in the solar glare in August, but it should become visible as a morning object in mid-September. On Sept 16 it is 10° above the eastern horizon at the start of civil twilight at magnitude +1.8. At that time it is less than half a degree southeast of considerably brighter Mer-

Notice

Your vote for the BAA Trustees and Council

Members will find the ballot list for the election of the Board of Trustees and Council for the next session enclosed with this issue of the *Journal*. Please take a few minutes to vote and return the Ballot List to the office in the envelope provided no later than noon on 2017 October 13.

When returning the ballot list please make sure that you PRINT your name on the reverse of the envelope and that nothing else is enclosed. Your name is required only to verify your membership. These envelopes are not opened by the Scrutineers until after October 13. Anything enclosed other than the ballot list will be discarded.

Bill Tarver, *Business Secretary*

Phases of the Moon: 2017 August & September

Full	*Last quarter*	*New*	*First quarter*
Aug 07	Aug 15	Aug 21	Aug 29
Sep 06	Sep 13	Sep 20	Sep 28

Lunar occultations of bright stars

Date	Time	Star	Mag	Ph	Alt °	% illum.	mm
Aug 02	22.01	ZC 2448	6.3	DD	19	79	70
Aug 06	22.16	ZC 2981	5.1	DD	15	99	60
Aug 14	00.54	ZC 364	4.3	RD	16	62	40
Aug 16	03.34	ZC 661	4.5	RD	29	38	40
Aug 16	03.43	ZC 671	3.4	DB	30	38	90
Aug 16	03.45	ZC 669	3.8	DB	31	38	110
Aug 16	04.44	ZC 669	3.8	RD	39	37	40
Aug 16	04.46	ZC 671	3.4	RD	39	37	40
Aug 16	05.42	ZC 677	4.8	RD	47	37	40
Aug 16	07.42	Aldebaran	0.9	DB	55 (Sun +17°)	36	40
Aug 16	08.40	Aldebaran	0.9	RD	54 (Sun +26°)	36	40
Aug 29	19.54	ZC 2399	4.9	DD	20	54	50
Sep 02	21.35	ZC 2935	7.0	DD	19	88	110
Sep 07	21.54	ZC 49	6.1	RD	13	97	90
Sep 12	05.34	ZC 626	6.3	RD	54	62	50
Sep 24	19.55	ZC 2223	3.9	DD	9	20	40
Sep 28	21.56	ZC 2760	6.9	DD	11	57	80
Sep 29	20.02	ZC 2886	4.9	DD	19	66	40

Lunar graze occultations

Date	Time	Star	Mag	% illum	N or S	Cusp	Limb
Aug 16	04.25	ZC 672	6.7	37	N	6.0	Dark
Aug 16	05.14	ZC 677	4.8	37	N	5.3	Dark
Aug 16	08.01	Aldebaran	0.9	36	N	3.6	Daylight
Sep 17	04.40	ZC 1371	6.5	10	N	7.4	Dark
Sep 17	05.49	ZC 1375	5.4	10	N	7.2	Dark

cury shining at mag –0.7.

Jupiter is still visible as soon as the Sun has set at the beginning of August but by the end of September it will have disappeared into the twilight, and will not be seen again as an evening object until 2018 April. It will be in conjunction with the Sun on October 26, so make the most of the planet and its Galilean satellites while you can. Jupiter's brightness slips from –1.9 to –1.7 whilst its equatorial diameter drops from 34 to 31 arcseconds. The gas giant's declination now becomes more negative, keeping it below the celestial equator until May of 2022.

Saturn was at opposition in mid-June so, with respect to brightness and angular size, it is past its best. It spends the whole period in the southern part of Ophiuchus and transits due south at 21:30 BST on August 1. The planet continues its retrograde travel until it reaches its second stationary point on August 25 after which it resumes direct (west to east) motion. By the end of the period Saturn will set before 22:00 BST. However, before that happens, the rings are inclined towards us by almost their maximum, affording stunning views of the upper surface of the ring system.

Uranus, at mag +5.7, begins the period in direct motion, but on August 3 reaches its first stationary point after which it retrogrades. Having made a close approach to the boundary with Aries it now retreats back deeper into Pisces.

Neptune is in Aquarius where it reaches opposition on September 5 with a magnitude of +7.8 and an angular diameter of 2.4 arcseconds. On October 5 Neptune's largest satellite Triton will occult a 12.7 mag star, giving professionals and advanced amateurs an opportunity to investigate the characteristics of Triton's atmosphere (see page 194 of this *Journal*.)

Pluto reached opposition on July 10 at magnitude 14.2 and remains in Sagittarius, close to the 'Teaspoon' asterism. On Sept 1 it culminates due south at 21:30 BST at an altitude of 17°.

(1)Ceres was in conjunction with the Sun in early June and is now a morning object, initially in Gemini, but in mid-September its eastward motion carries it over the border into neighbouring Cancer.

Lunar occultations of bright stars

In the table I've listed events for stars of magnitude 7.0 or brighter although there are many others that are either of fainter stars or those whose observation may be marginal due to elevation or other factors. DD= disappearance at the dark limb, whilst RD= reappearance at the dark limb. There is a column headed 'mm' to indicate the minimum aperture required for the event. Times are for Greenwich and in BST. On the morning of August 16 the Moon once again cuts a swath through the stars of the Hyades cluster and concludes with a daylight occultation of Aldebaran which, visible from Scotland, will be a graze. The brighter events are included in the table. The Moon visits the Hyades again on September 12 but on this occasion only one event occurs before sunrise.

Lunar graze occultations

Unfortunately all events that occur in August and September take place in the early morning. However, observers are encouraged to attempt these events and submit results, negative as well as positive, to Tim Haymes at **tvh.observatory@btinternet.com**. More details are available in the current BAA *Handbook*.

Meteors

Several minor showers are active with maxima during August and September. The northern component of the delta Aquarids occurs on Aug 6, though a full Moon will severely hamper observations. The alpha Capricornids are at their most active on the night of Aug 2/3 when a gibbous Moon will set just after 01:00 BST.

The Perseids are the main attraction for the period with maximum predicted for Aug 12 at 20:00 BST. Unfortunately on this occasion a waning gibbous Moon will rise just before 23:00 BST to spoil the party, although next year the Moon will play no part when the shower is at its best.

Total solar eclipse

The solar eclipse of August 21 begins in the Pacific, crosses a large portion of the United States and ends in mid-Atlantic. For those not fortunate enough to be travelling to view it, the option is to watch one of the live 'feeds' on the internet of which there are usually a number to choose from. For those of us in the UK there is a small partial eclipse during the evening, though the Sun will be extremely low. For example, as seen from Glasgow (obscuration 2.3%) the partial phase begins at 19:38 BST with the Sun only 6.7° above the horizon, and ends at 20:18 BST when the Sun's altitude is just 1.3°. In Greenwich, where the obscuration is just under 4%, the Sun is just 3.5° high at the start of the partial phase at 19:40 BST but sets before it has completed. Peter Macdonald's article giving details of the eclipse in the British Isles can be found in the April *Journal*, page 78, and is also available on the BAA website.

Brian Mills

Notice board

Meetings diary

Entries for this diary should be sent to the *Journal* Editor [**hazelmcgee@btinternet.com**] as soon as dates and locations are known. Details of all astronomical meetings of regional or national interest are welcome. The Editor's decision on inclusion or otherwise of any meeting in this listing is final.

Saturday 2017 August 12
SW Astronomy Fair at the Norman Lockyer Observatory, Sidmouth, Devon. See notice below.

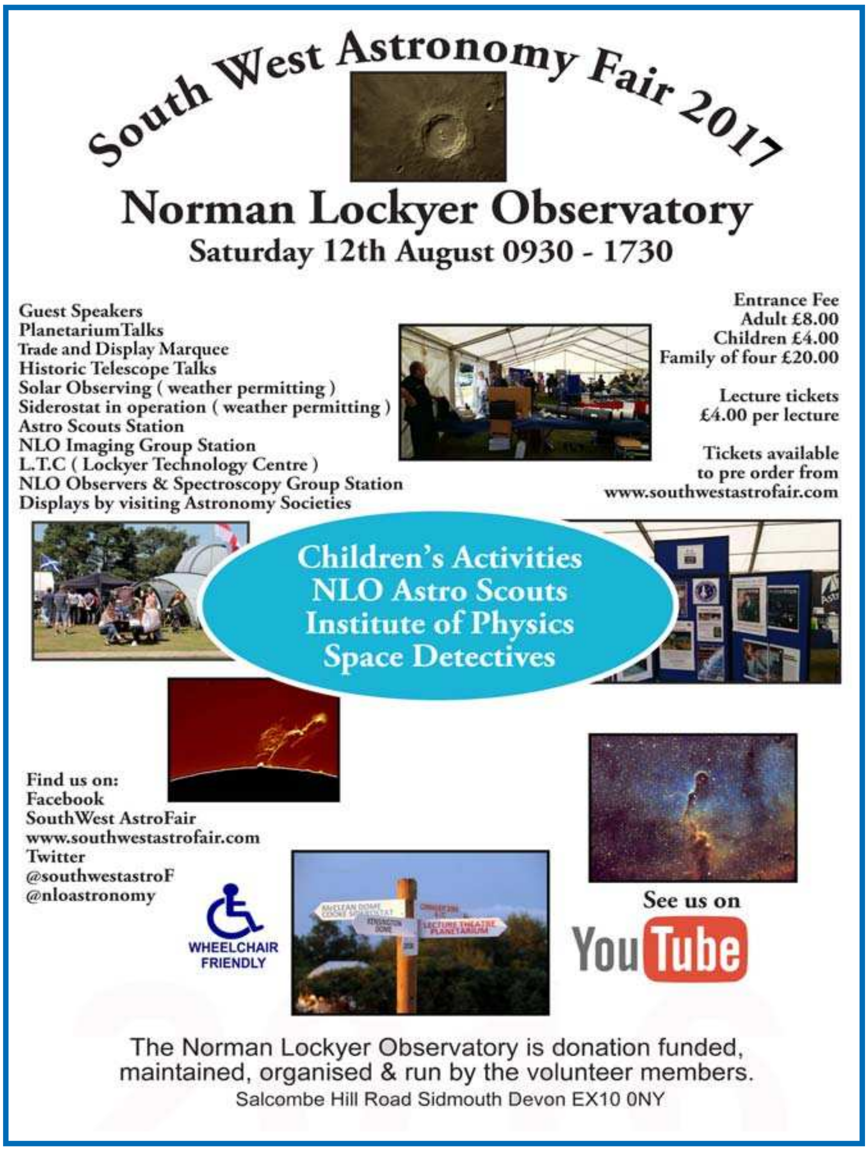
Friday–Sunday 2017 September 8–10
BAA Autumn Weekend Meeting, Chester: 'Stars: Life and death of the Universe'. The Sunday excursion will be to The OpTIC Centre, St. Asaph Business Park, Ffordd William Morgan, St Asaph LL17 0JD. See back cover.

Saturday 2017 September 30
Observers' Workshop: Lunar & Solar observing. 10:00–17:00, Burlington House, Piccadilly, London W1J 0BQ. See notice on p.239

Saturday 2017 October 7
Back to Basics Workshop. Please note that the location of this workshop is now King's Lynn Academy, Queen Mary Road, King's Lynn, Norfolk PE30 4QG and NOT as printed on the booking form enclosed with this *Journal*.

Wednesday 2017 October 25
Annual General Meeting, 17:30–20:00, Burlington House, Piccadilly, London W1J 0BQ. Presidential Address by Dr Jeremy Shears: 'Amateur astronomers and the new golden age of cataclysmic variable star astronomy'; Sky Notes by Dr Paul Abel.

Saturday 2017 November 25
Historical Section Meeting, 10:00–17:00 at the Birmingham and Midland Institute, Margaret St, Birmingham B3 3BS.



Small advertisements

25p per word, minimum £5.00.

Small adverts must be typed or printed clearly and sent with the correct remittance in sterling, payable to the British Astronomical Association, to the BAA office at Burlington House, Piccadilly, London W1J 0DU, UK. Free Members' adverts may be sent direct by e-mail to the Editor, **hazelmcgee@btinternet.com.**

Wanted

Hanwell Community Observatory seeks new recruits as 'sky guides' to host public stargazing events, Oxon/ S.Midlands area; suit enthusiastic beginners or 'old hands', all welcome. Tel. 01295 730762; details **www.hanwellobservatory.org.uk**

For Sale

Collimating a Newtonian by an easier, accurate and more reliable approach. Developed on f/3, 5 & 6 primary mirrors. Incorporating the Cave and Laser Collimators. Please go to the title at **www.NHBS.com**. Peter Clark, 01430-422460.

Telescopes and Telescope Cameras for sale. From the collection of a keen Glasgow amateur astronomer the following items are for sale: Helios PNB 2 binoculars, 110mm aperture; Meade LX200 10-inch (250mm) Schmidt Cassegrain telescope; WW2 anti-aircraft spotting scope; Three telephoto lenses made from aircraft reconnaissance cameras, one possibly WW2; A selection of Meade eyepieces; Astrovid 2000 astronomical CCD video imaging system. Please contact **moirahookham @hotmail.co.uk** for photos and further information.

Meade LX200 12-inch [305mm] telescope with wedge, custom tripod, CCD camera and some accessories. £2000 o.n.o., (or possibly less to a deserving organisation). Transport to be arranged; original Meade packing case available. More details from **jrs@st-andrews.ac.uk**

Members' private sales and wants

One advertisement of up to 35 words per member per issue is accepted FREE OF CHARGE, at the discretion of the Editor. This offer is not available for business advertisements or to non-members.

Trustees and Council — Session 2016–2017

British Astronomical Association Chester Weekend Meeting

The Chester Astronomical Society

Friday 8th – Sunday 10th September 2017

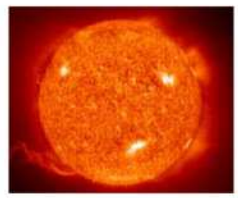
The King's School, Wrexham Rd, Chester, CH4 7QL

"Stars: Life and death of the Universe"

The Chester Astronomical Society are our hosts for this weekend

Meeting programme to include

Friday Evening (19:00 – 21:30)



Lyndsay Fletcher (Glasgow) - "Living with a Star"

Saturday (10:00 - 18:00)

Professor Paul A Crowther (Sheffield) - "Birth, life and death of massive stars"
Professor Simon Goodwin (Sheffield) "The formation of stars and planets"
Dr Jacco van Loon (Keele) - "Stellar Ecology"

Professor Bill Chaplin (Birmingham) - "Sounding stars and the search for other worlds in our Galaxy"
Dr Matt Darnley (Liverpool John Moores) - Novae: (Brief) new life after stellar death

Sunday Morning Visit (10:00 - 13:00)

The OpTIC Centre St. Asaph Business Park, Ffordd William Morgan, Saint Asaph LL17 0JD – A short introduction by Prof Paul Rees and a tour the factory where they polish large mirrors for terrestrial and space telescopes.

Costs for Friday and Saturday: -

Friday evening refreshments only BAA Members, Host AS, BAA Affiliated Societies & under 16's £1.00 Non-Members £1.50. Refreshments on Saturday **excluding** lunch BAA Members, Host AS, BAA Affiliated Societies & under 16's £2.50 & Non-Members £3.00. Refreshments on Saturday **including** a cold buffet lunch BAA Members, Host AS, BAA Affiliated Societies & under 16's £11.00 per person. Non-BAA Members, £15.00 per person,
The cost for Sunday visit to The OpTIC Centre which includes refreshments Members £2.00 & Non-Members £2.50 Return Coach Journey to The OpTIC Centre £12.00 per person from Chester to St Asaph. Depart Chester Station 09.00 return at 13.00 approx.

Retailers attending will be BAA Sales and W&W Astro

Visit our web page **www.britastro.org/chester2017** *or contact the office Tel: 020 7734 4145 to book*

Event Organiser:	**Mrs Hazel Collett**	email: meetings@britastro.org	Tel: 07944 751277
Local Contact:	**Mr Andrew Bate**	email: bate.waverton@gmail.com	Tel: 01244 335254