2022 August
Vol. 132 No. 4

Journal of the British Astronomical Association

A new era

Journal of the British Astronomical Association

2022 August Vol. 132 No. 4

Editor: **Mr Philip Jennings**
Papers Secretary: **Prof Jeremy Shears**
Meetings Recorder: **Alan Dowdell**

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Contributions

Papers should be sent by e-mail (preferred) or by post (**three** copies) to the **Papers Secretary** at the address shown inside the back cover of each issue. They will be refereed, and, if approved by Council, published as soon as reasonably possible. Those wishing to speak at a meeting should contact the Meetings Secretary.

All other contributions should be sent to the Editor, at **pjennings@britastro.org**. As well as Letters to the Editor, he 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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Membership of the BAA

The annual subscription for Ordinary standard membership of the Association for the 2022–2023 session is £50.50. For details of concessionary rates, digital-only membership and other information, see page 239 of this issue. Members who pay UK income tax are requested to complete a Gift Aid certificate in order to benefit the Association, which is a registered educational charity. [To claim Gift Aid you must pay an amount of UK income tax and/or Capital Gains tax at least equal to the tax which we reclaim on your donations in the relevant tax year (currently 25p for each £1 you give us).]

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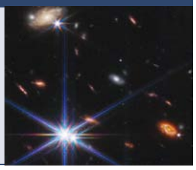
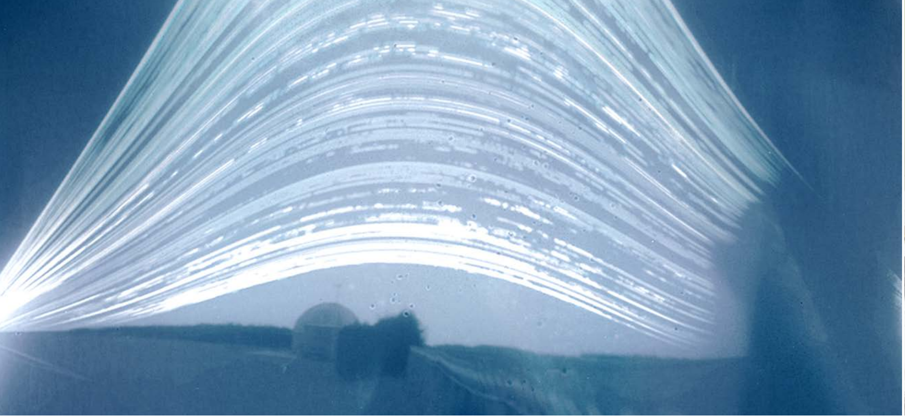




▲ The President with committee members of Nottingham AS in their observatory. Left to right: Dr David Arditti, Mike Provost, Chris Sneddon, Leigh Blake, Dr Julian Onions, Richard Severn and James Dawson. ***(Chris Jackson)***

Left: **A solargraph taken using a pinhole camera, showing the changing path of the Sun above the Nottingham AS observatory over six months (2021 Dec 21 to 2022 Jun 24).** ***(James Dawson)***

From the President

David Arditti

If you receive the printed *Journal*, you will have noticed the ballot paper and candidate biographies that arrived with this issue. If you are a member with whom we communicate by e-mail, you will have received an invitation to complete the ballot by the alternative online method.

This year there are fewer candidates than there are places to be filled. I ask you to vote, however, to show membership participation in the governance process. The Council have considered changing the by-laws to not require an election in years where the number of candidates equals, or is less than, the number of positions to be filled. Such a change could happen in future if sanctioned by a Special General Meeting of members. In the meantime, bear in mind that any member can stand for any of the positions listed on the ballot paper, if they can get two other members to nominate them. We have (occasionally) had contested elections for officer positions (including President). But I would advise any member wanting to get involved in the running of the Association to stand for an ordinary place on Council first, to gain experience of how it operates.

Introducing the Cicely Botley Prize

Cicely M. Botley (1902–1992) was a prolific contributor to this *Journal* and a much-loved figure in the Association. Her obituary here (by Patrick Moore) was followed by this note:

> The Council has decided to award a book prize, to be known as the Cicely Botley Prize. This award will be made from time to time to a person who is considered to have made the best contribution to one of the Association's publications in the period under review. All sorts of contributions (*e.g.*, articles, papers, letters, reviews) will be eligible. Further details will be published in due course.

They never were (until now!), and the prize has never been awarded. Following research on Miss Botley's life by Martin Mobberley that brought this fact to light, Council reconsidered this, and charged me with implementing this 30-year-old decision.

We have slightly modernised the terms of the award, to make eligible any contribution to the Association's publications, including video and online content. You can now nominate someone to receive the Cicely Botley Prize (as well as the Sir Patrick Moore Prize). See p.211 for details. Of the six previously existing awards of the Association, only one was named after a woman, so I think it is good that we now have another.

The BAA visits Nottingham

Our one-day Summer Meeting was held this year on Jun 25, at the University of Nottingham. We had no fewer than four talks from leading professional researchers on subjects including cosmology, planetary formation, and life in the Universe; we heard about the history and current activities of Nottingham Astronomical Society; and we had talks from two BAA Directors on the work of their Sections. The outstanding success of this day was down to the excellent organisation by our Meetings Secretary, Hazel Collett, and the committee of Nottingham AS.

A 'fly in the ointment' was the occurrence of a national train strike that day, which probably prevented some people from attending, and meant that I needed to stay an extra day in Nottingham. However, this 'fly' was turned into something more fortuitous, as the Nottingham AS committee invited me to visit their observatory on the Sunday, before I returned home. It is always interesting seeing these major projects by local societies, involving hard work by many people over many years. They can create facilities of wide community benefit, as well as for the enjoyment of members.

The Nottingham AS observatory, on a hilltop at Cotgrave, east of the city, is an excellent dark-sky site. Established in the 1980s, until 2021 it housed a 24-inch Newtonian telescope, but this was receiving little use. In a major society project conducted during the lockdown it was replaced by a more modern system, consisting of a Celestron 14-inch SCT plus a Sky-Watcher 80mm ED refractor, both on a Sky-Watcher EQ8 GoTo mount. Both night and daytime observations are now possible, far more members than before are enjoying the observatory facilities, and visits from youth groups have been accommodated.

The facilities are still being improved, with ongoing work to motorise the dome and provide a warm room (using a shipping container). I was impressed to see how everything on the site is powered by a combination of solar and wind generation, as it has no mains electricity. This includes the kettle for making the tea! The society made me very much at home there.

The President presents Andrew Robertson with his Sir Patrick Moore Prize certificate. ***(James Dawson)***

Sir Patrick Moore Prize for Andrew Robertson

It also gave me great pleasure at the start of the Nottingham meeting to present to Andrew Robertson his Sir Patrick Moore Prize certificate (awarded last October).

Andrew received the Prize for 'the encouragement of a public interest in astronomy'. His proposers, Dr Steve Hubbard and Owen Brazell, attested how Andrew has organised and led countless outreach sessions within local societies as well as at star parties, and how his contribution to the founding and continuation of the star parties at Kelling Heath and Haw Wood has been pivotal. He has given many talks to societies and other groups, including the BAA Deep Sky Section, and served as chair of Loughton AS, and on the committees of the Webb Deep-Sky Society and several other local organisations. They nominated him for his 'lifelong and overwhelming enthusiasm for, and knowledge of, amateur astronomy, and for his enduring desire to communicate it to everyone who wants to hear'.

New postal address

The postal address of the Association has changed, as shown on the inside covers of this *Journal*. There is also a new registered office address –the legally required location at which the company documents may be inspected – and it is different to that for post. All postal correspondence with the Association should now be sent to PO Box 702, Tonbridge TN9 9TX.

IN BRIEF

The Sun is not sun-like

A newly published review of extreme solar events argues that the Sun is not 'sun-like', being less eruptive and rotating more slowly than is typical of its spectral class. However, the authors caution that its present mellow mood may be a 'lull', with more extreme space weather possible in future.

The review, by Cliver *et al.* and published in *Solar Physics*, traces the observational record for flare activity, starting with the disruptive Carrington Event of 1859 Sep 1. For those who fear the damage to power and communications that would be dealt by a present-day repeat of this powerful eruption, the review offers little comfort. The Carrington Event is rated as 'only' class X35, while the authors predict that every 1,000 years or so, events as powerful as X180 may occur.

Cliver recently appealed for surviving images of Carrington, who is the only great solar observer of the 19th century for whom no photographic portrait is known.

Help catalogue Jupiter's storms

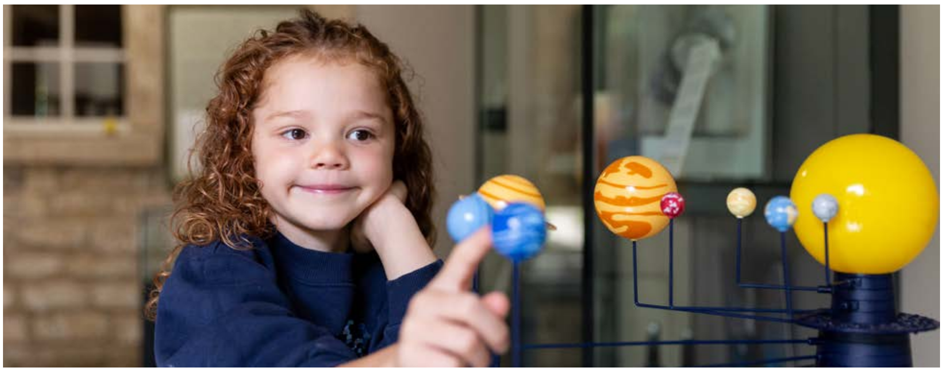
A new citizen science project invites volunteers to study imagery of Jupiter's cloud tops, in a bid to improve understanding of the planet's dynamic atmosphere. Anyone can take part in 'Jupiter Vortex Hunter', which presents users with imagery obtained by the *Juno* orbiter. By identifying vortices and classifying them according to colour, volunteers help establish categories of features in the Jovian atmosphere. To join the project, visit **bit.ly/3OFpYoM**.

Notice

Diversity & Inclusion Officer

The BAA Council has voted to create a new voluntary post within the Association, of a Diversity & Inclusion Officer. This person would be a member of the Association and would become an appointed member of Council. They would be responsible for promoting and monitoring good practice in diversity and inclusiveness in all of the Association's activities, particularly with a view to improving the gender balance and representation of different ethnicities. Prior professional experience in this area would be an advantage. Any member interested in taking up this new challenge is invited to write to the President to discuss, by e-mail at **president@britastro.org**, or *via* the Office.

David Arditti, *President*



(Bath Preservation Trust)

Exhibition celebrates Herschel bicentenary

The bicentenary of the death of William Herschel (1738–1822) is being marked by a major new exhibition at the Herschel Museum of Astronomy, 19 New King Street, Bath.

Featuring items on loan from the Royal Astronomical Society (including Herschel's observing notes from the night he discovered Uranus in 1781 March) and the Herschel family (such as never-before-displayed letters from Herschel to his brother Alexander), 'Herschel 200' charts William's life in Bath as a musician, astronomer and celebrity. A collaboration with Slough Museum continues the story of Herschel after he was appointed King's Astronomer and left Bath, moving to Slough with his sister Caroline.

Other events marking the bicentenary are listed in the Meetings Diary on p.266. For more information, see **herschelsociety.org.uk/**. The exhibition runs until December 31.

Venus cloud discontinuity returns

A long atmospheric wave with a rotation period of around five days has again been detected in infrared by BAA members. The feature, observations of which from 2015–2020 were previously described in the *Journal*, returned in May. A report will follow in a later issue.

Philip Jennings, *Editor*

Variable Star Section

Follow-up observations of recent novae requested

This edition of the *Journal* contains a paper on recent novae ('Six remarkable northerly novae in 2020–'21', p.221) observed by BAA members and others. One of these is RS Oph, which has long faded but always warrants monitoring, whilst the other five are still above their quiescent states. I therefore encourage further observations of these novae until they finally drop below their thresholds of visibility. They are V1391 Cas, V1112 Per, V1405 Cas, V1674 Her, and V606 Vul.

V1405 Cas, in particular, is still relatively bright (magnitude ~11 to 12), so remains an easy object for many observers, especially as it is circumpolar from the UK. It has been keeping observers entertained with a complex light curve since its eruption on 2021 Mar 18.

Long-term monitoring of old novae often falls to the amateur, and it is during the return to quiescence that these objects sometimes reveal more of their secrets. However, very often, observers lose interest after a while as their attention is attracted by new objects. The observations in the databases begin to get sparse and we lose track of a nova's return to quiescence. Help us make sure that this does not happen with these recent novae!

Jeremy Shears, *Director*

Editor sought for *Popular Astronomy*

The Society for Popular Astronomy is looking for a new editor for its magazine, *Popular Astronomy*. This is an unpaid post, but it provides a unique creative opportunity which could interest either an experienced amateur or a younger person wishing to gain experience in journalism, and could provide an important addition to a CV. The magazine has already helped launch the careers of a number of previous editors and contributors. It is produced in full colour to the highest editorial standards, and includes material covering amateur interests and news and features about professional astronomy and space exploration.

The job involves all aspects of editing a magazine – finding authors and commissioning articles, copy editing and preparing material for layout, which is handled separately. An understanding of both amateur and professional astronomy, and of course a deep interest in language and editorial judgement, are needed. The 48-page magazine appears bimonthly so adherence to the schedule is vital, involving a commitment of approximately 30 hours a month.

If you do not have enough time to devote to the role of editor, you may still be able to help the SPA in another contributory role. Anyone interested in offering their services should please e-mail the Acting Editor, Robin Scagell, at **robin.scagell@gmail.com**.

Robin Scagell, *Chair, SPA*

The Carina Nebula. (NASA, ESA, CSA, and STScI)

James Webb Space Telescope: a new era

Katie Sawers

More than 25 years and $10 billion in the making, the release of the first images from the *James Webb Space Telescope* (JWST) have certainly lived up to the hype. The five images were carefully curated to show the full breadth of JWST's observing capability across its four on-board instruments – giving a taste of what is to come as we enter a new era of astronomy.

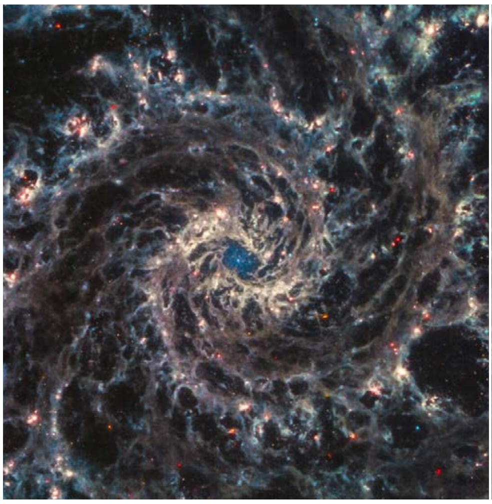
JWST observes across the infrared (IR) range, a part of the electromagnetic spectrum which probes the Universe much more deeply than visible light, allowing usually unseen structures to be observed and examined in unprecedented resolution. As I write, a new compound image of M74 from JWST data (below) is starting to do the rounds online – an intricate, lacy spiral, reminiscent of a Mandelbrot set. Viewing it alongside *Hubble*'s well-known image of the same target, rendered in infrared it is unrecognizable. No longer soft, but strikingly dramatic – we can see the IR light radiated out by the dust itself rather than the shadows of visible light absorbed by gas and dust. Looking at JWST images after those of *Hubble* or *Spitzer* feels like putting glasses on for the first time, and being able to see detail you hadn't even imagined was there.

Nowhere is this new detail more striking than in the first of the images, the remarkable deep field (see cover). The image unveils the distant Universe, showing a galaxy cluster 4.6b ly from Earth with clear gravitational lensing. In high contrast, we can see the image is crowded with hundreds of galaxies, and all in a patch of sky the same size as a grain of sand held out at arm's length. These glimpses into the distant past allow the chemical composition of the earliest galaxies to be analysed, slowly filling the holes in our knowledge of early-Universe formation.

Amongst the images, there is a transmission spectrum of an exoplanet 1,000ly away (below). Less beautiful, perhaps, but no less thrilling, as this represents an incredible new dawn in exoplanet discovery. This could be aided by a global community of amateur astronomers, who can provide the transit timing accuracy necessary for telescopes like JWST to organise observations as efficiently as possible – a crucial task with so many potential targets. For amateur astronomers keen to get involved, but who lack the clear skies or telescopes for practical observations, the JWST data is available for anyone to download and (with a little Python experience) attempt their own data analysis.

By the time this arrives at your doorstep the first images will be old news, and every subsequent release publicised a little more quietly. But even in this new age of astronomy, where previously unthinkable observations become the norm, I cannot for a second imagine they will ever lose their impact.

Katie Sawers is a science writer and associate editor at IOP Publishing



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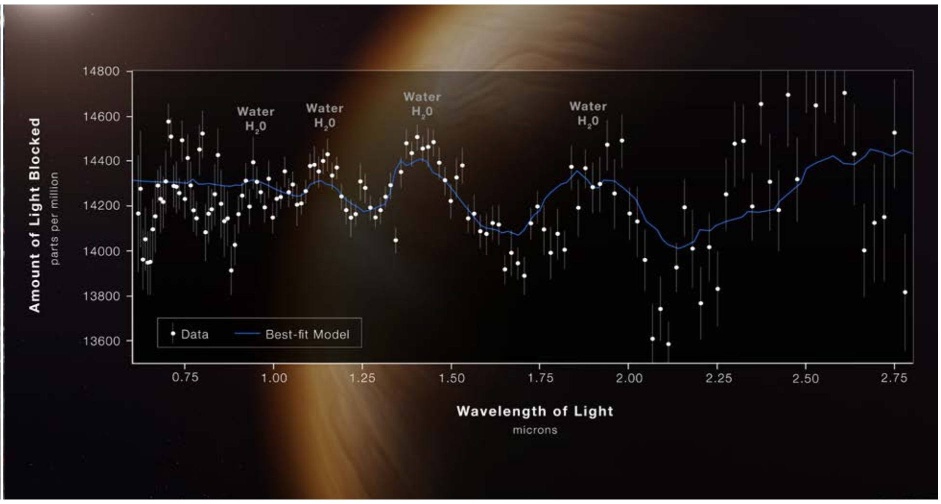


NASA, ESA, CSA, and STScI

Saturn, Uranus & Neptune Section

URANUS *'A rose by any other name...'*

Kevin Bailey
Uranus Coordinator

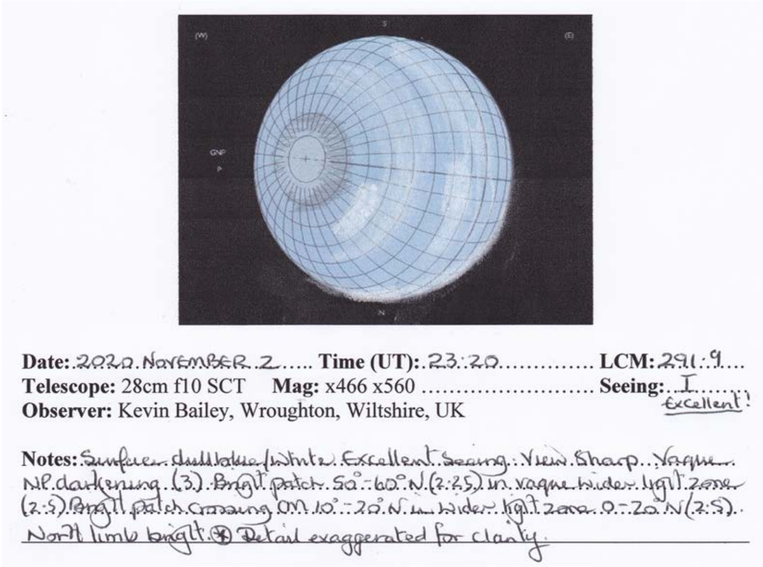


Figure 1. Example of a visual observation of Uranus by the author.

Uranus (*Yew-ran-us* – no smirking at the back…) has endured a 200-year-old PR problem; its name, which (in English) has generated much low humour and comic double entendres (as anyone giving a talk to teenagers on the subject can testify). I am sure the reputation of this enchanting planet would have been enhanced with the application of a little gender equality: 'Minerva' (for example) would have been a more suitable name – she being the goddess of wisdom; the equal of Jupiter, and celebrated by a Roman festival in March (as 'Sulis Minerva') at Bath, where Uranus was discovered. But the dull name stuck, and as a consequence 'Uranus' has never acquired the attractive associations we tend to make with the names of the other major planets. This may seem a trivial point, but is possibly one of many reasons for the relative neglect of the planet as a subject for research and observation.

Uranus has always had its advocates, but study of it has been something of a professional backwater, and its neglect by amateurs has in no small measure been the result of prejudice on the part of the authors of popular astronomy books. To quote two writers I hold in high regard, J. B. Sidgwick and Sir Patrick Moore, '[Uranus] offers no scope for amateur work…' (*Observational Astronomy for Amateurs*, Sidgwick), and 'Even large telescopes will show virtually nothing on Uranus' pale disk … Uranus is a very bland world' (*New Guide to the Planets*, Moore). Any of us who came to astronomy over the last 50 years will be familiar with the couple of pages devoted to Uranus at the back of otherwise useful astronomy books. Even space probes, generally opening up greater understanding and interest in their assigned subjects, have ignored Uranus – except for *Voyager 2*, beaming back those 'bland' images as it sped past in 1986, adding yet another negative to the planet's reputation.

But things change, and a small number of devoted amateur observers are proving that Uranus is very far from being a bland planet. This is demonstrated by the growing number of articles and reports relating to Uranus published in the *Journal* over the last few years. Uranus now represents a final frontier for visual and digital planetary observers – and, while 'the professionals' have time-limited access to the world's largest telescopes (from which they derive highly detailed data), amateurs are increasingly making a complementary contribution by observing and recording Uranus over whole apparitions, which, in time, will add to a more general understanding of the planet's nature.

If I have tempted you to observe Uranus, here are a few notes that I hope will get you started.

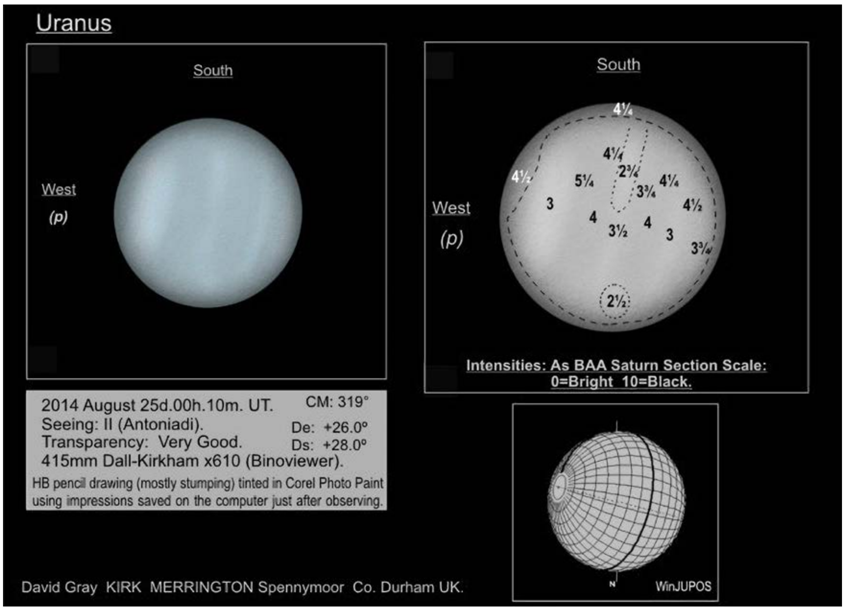


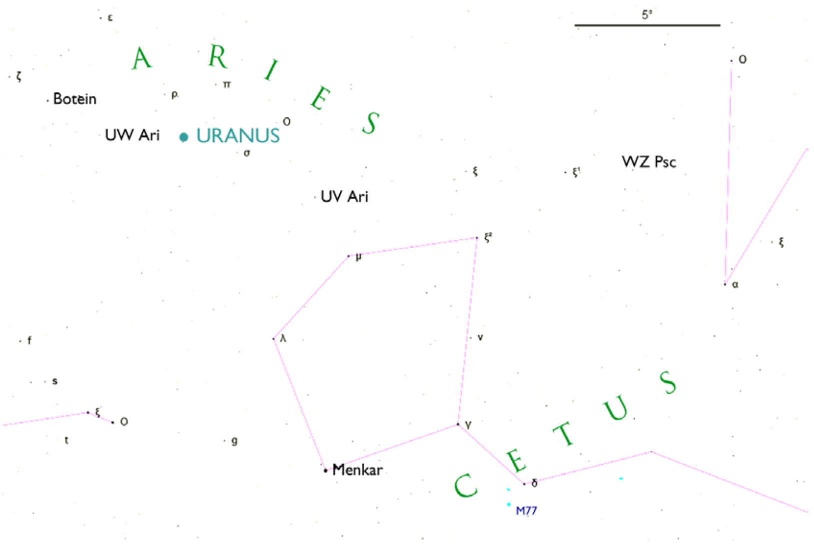
Figure 2. Observation of the planet by David Gray.

Locating

Uranus reaches opposition on 2022 Nov 9 (magnitude 5.6, diameter 3.8 arcseconds). It can be easily found using the coordinates published in the BAA *Handbook*, with reference to *Norton's Star Atlas* – or digital programs such as *Stellarium* – and then sweeping for the small blue disc in the traditional way. Even with a relatively low-power eyepiece, Uranus will appear distinctly 'planetary'. Of course, a GoTo mount will do the job for you.

Observing

Uranus is at present (in the northern hemisphere) the best-placed major planet in the night sky, but it is far from being an easy observational subject. It took me four years to 'get my eye in' regarding the disc 'detail'. It helps to make as many observations as possible over an apparition. Some keen-eyed and experienced observers have recorded detail on Uranus' disc using



(P. Jennings, from astrometry by D. Ford / in-the-sky.org)

The position of the planet at opposition, on 2022 Nov 9.

152mm instruments – but these are exceptions, and I would say that a 215mm-aperture instrument is the minimum adequate size.

As always, light and magnification are the essential factors, and to get a bright decent-sized disc in the eyepiece requires ×400+ magnification and a telescope that can take such a power. Using my 28cm $f/10$ Schmidt–Cassegrain telescope, I get the best results using a magnification of ×466 and ×560 – and I only make observations when the seeing is I or II on the Antoniadi scale (I = excellent; V = very poor).

At the beginning of an observation, make sure you have got the orientation of the planet fixed. With the drive off (or temporarily impeded using light finger pressure on the tube), the preceding (*p.*) edge of the planet will drift out of the field of view. Bearing in mind that the N/S axis of Uranus is effectively horizontal, this will indicate the location of the planet's north pole, which is at present near to the centre of the *p.* edge – *i.e.*, the one leading out of the field of view. (See Figures 1 & 2.) By 2028, the north pole will have moved to the centre of the planet's disc.

Recording

For recording, I use a coloured 2-inch (50mm) disc with latitude and longitude lines derived from *WinJUPOS* at the start of each apparition. I use white chalk to depict lighter features and a soft dark pencil for the darker areas (as shown in Figure 1.)

David Gray, probably the BAA's most experienced visual observer of Uranus, makes a comprehensive record of each observation, including a drawing, intensity estimates (using the 'Saturn scale'), and other useful data. Figure 2 shows one of his observations from 2014.

Reading

The Planet Uranus by A. F. O'D. Alexander provides the best history of the planet, and *Uranus, Neptune, and Pluto*, by Richard Schmude Jr., is the most up-to-date publication regarding observing advice and information. You will find any of the reports and articles on Uranus published in this *Journal* useful.

Your vote for the BAA Trustees & Council

This issue of the *Journal* contains the ballot papers for the election of the Board of Trustees and Council for the next session. CIVICA (formerly ERS) will manage the process of voting online. If we have your up-to-date e-mail address, CIVICA will send you a personal e-mail with the details of how to cast your vote at a secure website. Experience has shown that online voting is quick, easy and saves everyone's time and money, including yours.

Please take a few minutes to visit the website and record your vote. If you do not receive an e-mail from CIVICA by mid-August at the latest, then we do not have your correct e-mail address. Please phone the office on 020 7734 4145 so we can make the correction.

If you need or prefer to vote using the paper 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 and if we can't, then your vote is invalid. The Scrutineers will not open the envelopes until after 2022 Oct 10 when the ballot closes. Anything in the envelope other than the balloting list will be discarded. If you vote electronically, please do not return the paper ballot as it will not be counted.

Please vote online if you can.

Bill Tarver, *Business Secretary*

******

If you have not observed Uranus before, then I encourage you to give it a go. For anyone who likes a challenge, it is the perfect subject – and that little blue disc is very enchanting. All you need is a dark-adapted eye, a pencil and paper, and a lot of patience… and do not forget to send in your observations regularly to the Saturn, Uranus & Neptune Section.

[hqbailey@googlemail.com]

Nominations invited for the Sir Patrick Moore Prize & the Cicely Botley Prize

The **Sir Patrick Moore Prize** of £500 plus a year's membership of the BAA may be awarded to any person, group, society or school (whether member or affiliate of the BAA or not) for one or more of the following areas of activity, selected to reflect Sir Patrick's life and enthusiasms:

– The encouragement of a public interest in astronomy
– A contribution to the understanding of the history of astronomy
– Outstanding observational work by a member or members under 21 years of age
– The encouragement of participation in observational astronomy by youngsters
– The carrying-out of a collaborative research project, whether between amateurs only, or also involving professional astronomers.

Last year's prize was awarded jointly to Mary McIntyre, Howard Parkin and Andrew Robertson, whom Council felt had all made significant contributions to the encouragement of a public interest in astronomy.

The **Cicely Botley Prize** of a book token for £100 may be awarded to a member who has made an outstanding contribution to one of the Association's publications, to include all types of media, including print, video and online. This is the first year that nominations have been sought for this prize.

Nominations for either of these prizes may come from the nominee or from others. Please send nominations, including a short statement explaining the reason the person or group should be considered for the awarding of a prize, to Madelaine Davey at the Office (e-mail **office@britastro.org**) by September 30. Nominations will be considered by a committee, which will make recommendations to Council, and the prizes will be presented at the Christmas Meeting, if possible.

David Arditti
President & Chair, Sir Patrick Moore Prize Committee

Variable Star Section

An unexpected eruption of U Scorpii

Jeremy Shears
Director

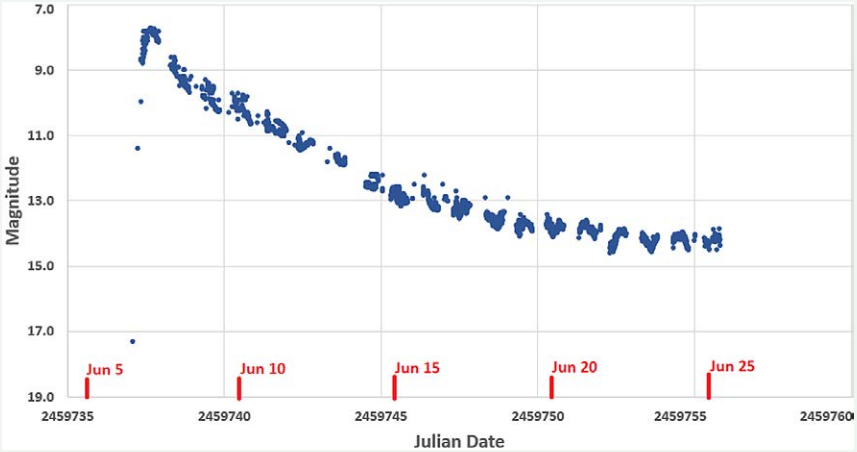
U Sco is a recurrent nova: one of only 10 known in our galaxy. In quiescence it is 18th magnitude, but it brightens to magnitude 8 during eruptions. Eruptions have been observed in 1863, 1906, 1917, 1936, 1945, 1969, 1979, 1987, 1999 and 2010. According to Prof Brad Schaefer (Louisiana State University) there was a further eruption in 2016, which was missed due to solar conjunction (similarly in 1927 and 1957).

The reason for U Sco's frequent eruptions is that it has one of the highest accretion rates of all known cataclysmic variables. Its white dwarf is close to the Chandrasekhar limit of ~1.4 solar masses, which is the theoretical maximum mass a white dwarf can sustain before turning supernova.

A further eruption in 2022 therefore came as something of a surprise. The eruption was detected on the rise by Masayuki Moriyama (Nagasaki, Japan) on Jun 6.720 at magnitude 11.4, using a 0.25m Schmidt–Cassegrain telescope and unfiltered CCD camera. His previous observation, only 3.7 hours earlier, placed it fainter than 17.3. A BAA Alert e-mail was sent by the Director shortly afterwards to members that have signed up for this service (you can do so here: **britastro.org/baa-alerts**). The nova continued to brighten rapidly over the next hours, reaching a maximum magnitude of 7.8 on Jun 7.1. It then faded rapidly, losing two magnitudes (t_2) in about one day and three magnitudes (t_3) in 3.5 days. The light curve of the eruption accompanies this article.

The 2010 eruption was intensively covered by amateurs worldwide, leading Prof Schaefer to comment that 'such an awesome data set is impossible for professional facilities'. Analysis of these data revealed mysterious half-magnitude flares lasting an hour just after maximum, then much later, half-magnitude dips at ~4-hour intervals. It is hoped that the 2022 eruption will shed further light on these phenomena, which might be related to re-forming of the accretion disc.

The eruption of U Sco comes close on the heels of another recurrent nova eruption: it is less than a year since we were treated to the recurrence of RS Oph. All eyes are now on a sibling of RS Oph and U Sco. T CrB erupted in 1866 and 1946 – a gap of 80 years. In 2026, 80 years will have elapsed since the last event, but we have no idea when it will actually grace our skies in glory again (it reaches magnitude 2 to 3). Keep watching!



U Sco eruption light curve. The first two data points are Moriyama's nova patrol measurements; the rest are BAA Variable Star Section and AAVSO data (visual, V and CV).

BAA variable star observers contribute to research on quasars & dwarf novae

The lure of the variables is strong. Variable star observers go out whenever the sky is clear to observe 'their' stars. Many become lifelong friends. We dutifully record our observations and at the backs of minds we hope that our data might one day be useful in revealing new insights about our stars. The icing on the cake is when our data are combined with those of others, resulting in the publication of a paper citing our work.

Two papers which include BAA members as authors have recently been accepted for publication by the *Monthly Notices of the Royal Astronomical Society*.

OJ 287

OJ 287 is a quasar in Cancer, in which the active galactic nucleus normally outshines the host galaxy by an order of magnitude. Generally, it varies between magnitude 14 and 15. It undergoes quasiperiodic optical outbursts roughly every 12 years, with double peaks.

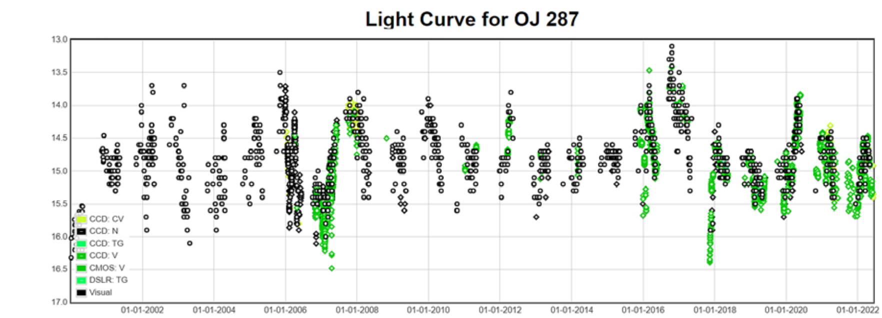
OJ 287 is a binary black hole system where a smaller companion (150 solar masses) punches through the accretion disc of the supermassive primary black hole (18 million solar masses) twice each orbit, causing the outbursts. The period is variable due to relativistic and gravitational effects.

What is less well known is that OJ 287 also shows prominent low-activity states called fades, at similar intervals to the outbursts. Such a fade occurred in 2017 November (see light curve, below) and is the subject of a paper by Prof Mauri Valtonen of the University of Turku, Finland, and his co-authors.[1] These include BAA members David Boyd, Guy Hurst, Mark Kidger and Gary Poyner. Gary has led amateur observing campaigns on OJ 287 for many years in support of Prof Valtonen's and others' work.

The paper compares the characteristics of the 2017 dip with those of similar events observed in 1989, 1999, and 2010. The authors go on to consider the astrophysical origin of the fades, which might be related to changes in the orientation of high-energy jets in the nucleus.

V392 Persei

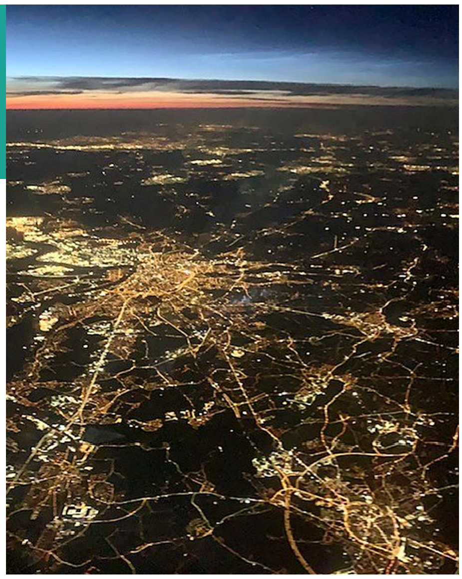
V392 Persei is a dwarf nova that underwent a classical nova eruption in 2018. A team led ►



Contributors: C D Beech, B J Beesley, D Boyd, G D Coates, G Darlington, G Fleming, R K Hunt, G M Hurst, R D Januszewski, S Johnston, C P Jones, M L Joslin, C Knight, I Miller, M Mobberley, W Parkes, R A H Paterson, R Pearce, R D Pickard, G Poyner, G W Salmon, J Shears, D Storey, J Toone, I L Walton, A J Wilson, W J Worraker

Aurora & Noctilucent Cloud Section

Auroral & noctilucent cloud activity 2022 April 19 – June 20



A display on Jun 14/15, imaged from 5,000ft above Luton Airport. *Louis Rushforth*

Noctilucent cloud imaged from St Andrews, Jun 6/7. *Roger Stapleton*

A display over Glenbarry, Banff on Jun 5/6. *Sandra Brantingham*

Sandra Brantingham
Director

With coronal mass ejections and sunspot numbers regularly in double or even triple figures, as well as several coronal holes, the Sun is out of minimum, However, lighter skies have meant fewer detections. Aurora sightings over this period are at zero, while noctilucent cloud (NLC) sightings are at 42, as the season gets off to a good start.

Aurora

In late April there were two G1-class storms as well as four R1, one R2 and two R3, with no sightings. In May there were two G1-class storms, eight R1, two R2 and two R3, with no sightings. In early June there were two G1-class storms, three R1 and no sightings.

Noctilucent cloud

There is no new information on the effects (if any) of the Jan 15 volcanic eruption on Tonga, but I will let you know if anything is discovered. The first detection of ice in the mesosphere occurred on May 22, indicating the start of the northern season, and it has been gradually increasing ever since. The number of sightings has been helped by the night-camera operations of Ken Kennedy and Nick James.

In May, there was one sighting by Ken Kennedy from Dundee on May 26/27.

There were 41 in early June. 12 were on Jun 1/2, by myself from Glenbarry, Banff; Gordon Mackie from Oban, Tracy Harty from Llandudno, Nick James from Chelmsford, Bill Parks from Glasgow, Ken Kennedy from Dundee, Alastair McBeath from Morpeth, James Fraser from Alness, Brian Topping from Colwyn Bay, Pam Foster from Pitlochry, Alan Tough from Elgin, and James MacKintosh from Cromarty.

There was one sighting on Jun 4/5, by Ken Kennedy from Dundee.

There were nine sightings on Jun 5/6, by myself from Glenbarry, David Paterson from Pitlochry, David Rees from Salehurst, Ken Kennedy from Dundee, Ronan Newman from Ballina, Co. Mayo; John Vetterlein from Orkney, Roger Stapleton From St Andrews, Alan Tough from Elgin and David Arditti from Edgware.

There were five sightings on Jun 6/7, by myself from Glenbarry, Ken Kennedy from Dundee, Grant Privett from Llangrannog, Pamela Foster from Pitlochry and Roger Stapleton from St Andrews.

There was one sighting on Jun 9/10, by Ken Kennedy from Dundee.

There were three sightings on Jun 10/11, by myself from Glenbarry, Trevor Smith from Codnor, Derbyshire, and Steve Brown from Castleton, North Yorkshire.

There were six sightings on Jun 11/12, by Graham Rule from Edinburgh, Ken Kennedy from Dundee, Nick James from Chelmsford, Tim Hayes from Steeple Aston, Oxfordshire; Neil Morrison from Crawley and Roger Stapleton from St Andrews.

There was one sighting on Jun 14/15, by Louis Rushforth at 5,000ft over Luton. There were two sighting on Jun 17/18, by Ken Kennedy from Dundee and Roger Stapleton from St Andrews. There was one sighting on Jun 19/20, by Ken Kennedy from Dundee.

This brings the total number of sightings so far to 42, and this does not include sightings from the NLCnet website run by Tom McEwen.

General

There is a site for those of you who are stuck in light-polluted areas or out of range of the aurora. It is a webcam (**bit.ly/3ffFAA7**), operated by the Shetland tourist board, that looks north and, if there is no cloud, it will give a good view of any aurora or NLC (and you can listen to the waves and sea birds). In addition, they have added two more cameras further north specifically for the aurora. These are at **bit.ly/3Ghkg9j** and **bit.ly/3w2vfBl**.

I would like to thank all the observers who have contributed, and I ask you to keep sending in those reports to **sandra-b@hotmail.co.uk**.

► by researchers at the Astrophysics Research Institute, Liverpool John Moores University, followed the eruption for three years using multiwavelength ground-based optical and satellite observations.[2] This included observations by BAA members: spectroscopy by Robin Leadbeater, and photometry by David Boyd and the late Ian Miller.

V392 Per is one of the fastest-evolving novae yet observed, with a decline of two magnitudes (t_2) in two days. It is especially interesting since relatively few cataclysmic variables have been observed to undergo both classical nova eruptions and dwarf nova outbursts. The paper characterises various mass ejections and their associated shocks during the eruption. Following eruption, the system remained in a nova-like high-mass-transfer state, rather than returning to its earlier dwarf-nova-type low-mass-transfer configuration. The authors suggest that this high state is driven by irradiation of the donor star by the nova eruption.

Your observations count

Further observations of both OJ 287 and V392 Per are most welcome. These will allow researchers to progress our understanding of these fascinating, but very different, variable objects.

If you would like to become involved in observing any type of variable star, further information is available from the Variable Star Section (VSS) website (**britastro.org/vss/**). If you wish to receive the *VSS Circular*, published quarterly, please contact the Director. Back numbers are available at **bit.ly/3Pss0cQ**.

Jeremy Shears

1 Valtonen M. J. *et al.*, 'Host galaxy magnitude of OJ 287 from its colours at minimum light', accepted for publication in *Mon. Not. R. Astron. Soc.*, pre-print available at: **arxiv.org/abs/2205.15589**
2 Murphy-Glaysher F. J. *et al.*, 'V392 Persei: a γ-ray bright nova eruption from a known dwarf nova', accepted for publication in *Mon. Not. R. Astron. Soc.*, pre-print available at: **arxiv.org/abs/2206.03443**

Solar Section

Lyn Smith
Director

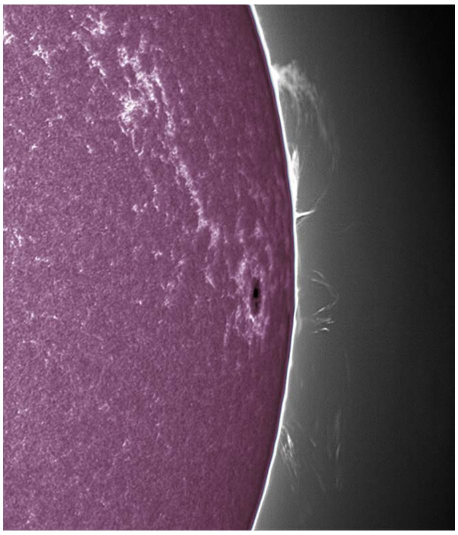
2022 April

White-light activity continued in its five-months-in-a-row upsurge with the Relative sunspot number (R) being the highest logged by the Section since 2015 May, when 70.73 was recorded. The increase of activity in the southern hemisphere and decline in the northern hemisphere seen in March was reversed, with the north once again becoming dominant. The Quality number (Q) also increased, reflecting the large and complex sunspot groups that we are now witnessing. 26 sunspot groups were recorded during April; the main groups are reported below.

AR2975 N15°/086°, AR2976 N17°/066° & AR2984 N12°/080°. The two large groups that dominated the latter half of the previous month were still conspicuous on Apr 1. AR2975 was a line of penumbral sunspots of which the largest was the follower; it was now rapidly approaching the NW limb, type Dac and with a total area of 400 millionths. AR2976 followed, the leader being a large penumbral sunspot but with a diminishing follower. The group was Eko with an estimated area of 530 millionths. As the two groups approached the limb on Apr 2, a new group, AR2984, formed between them. It was type Dro, consisting of two small penumbral sunspots. The entire area rotated across the limb on Apr 3 & 4. The leading sunspot of AR2976 was seen with the protected naked eye on Apr 1.

AR2978 S17°/006° & AR2981 S24°/005°. These two groups also survived on the disc from the previous month. AR2978 was the most impressive, sporting a large penumbral leader and several smaller followers, type Ekc and with an area of 520 millionths. Directly south of this group was AR2981, which had strengthened significantly. The group was type Dac, comprising an arc of small penumbral sunspots and accompanying pores. Over the next few days, both groups lost sunspots so that by Apr 8, as both groups approached the SW limb, only a single penumbral sunspot remained for AR2978 and a single Axx sunspot for AR2981. Both groups rotated over the limb on Apr 9. The leading sunspot of AR2978 was seen with the protected naked eye on Apr 2 & 3.

AR2983 N20°/328° also survived from the previous month, as a small Hsx sunspot in the NE quadrant, not far from the limb. The group did not develop further and reduced on Apr 6 as it approached the central meridian (CM), then dissolved on the disc. Two days later, on Apr 8, the group reappeared as two small sunspots in the NW quadrant, of type Bxo. It rotated around the NW limb on Apr 10, basically unchanged.



The solar limb hosted plenty of activity in the Calcium K waveband on 2022 Apr 30, at 11:00 UT, as shown in this image by Alun Halsey.

AR2985 S20°/289° rotated over the SE limb on Apr 3, type Hsx. On Apr 7, midway across the SE quadrant, it developed to type Cro. However, it reduced again on the following day to type Bxo and dissolved on the disc by Apr 10, near the CM.

AR2993 N21°/110° & AR2994 N14°/107°. The first sign of these two groups that traversed the disc together came on Apr 16, when two large penumbral sunspots rounded the NE limb, aligned north/south. By the following day AR2993 was type Cho, consisting of a large penumbral leader and a few accompanying pores. AR2994 was larger, consisting of two large penumbral sunspots of type Eho. On the next day, the full extent of the two groups could be seen. The pores with AR2993 were starting to develop and the large leading sunspot now sported an elongated umbra. AR2994 was quite impressive, with two large sunspots. The penumbra of the follower was becoming asymmetric, with minor umbrae forming along the northern edge in addition to the larger central umbra.

Both groups continued to develop on Apr 19, and by Apr 20 the umbra of the leading sunspot in AR2993 had split into three sections. The umbra of the leading sunspot in AR2994 had elongated and formed a shallow ‘U’ shape. AR2993 had an estimated area of 620 millionths, and AR2994, 830 millionths. Both groups evolved each day. Pores accompanied AR2993 to the north and south of the main sunspot on Apr 21 & 22, and it still sported three umbrae within its penumbra. The follower of AR2994 became almost circular on both days, containing many small umbrae and numerous photospheric light bridges. A small penumbral sunspot had formed between the main sunspots of AR2994 on Apr 19 and it was present up to Apr 22. On Apr 23 this had gone, but a similar sunspot developed to the south of the leader, close to the penumbra.

In the following days, both groups slightly reduced in size, as did the number of accompanying pores. On Apr 26, AR2993 comprised an elongated irregular sunspot with an area of 330 millionths, whilst AR2994 was still bipolar, with an area of 740 millionths. On Apr 27, AR2993 had reduced to type Dso and AR2994, although type Eko, consisted of a penumbral leader with a double umbra and two small penumbral sunspots following, accompanied by a pore. Both groups rotated over the limb on Apr 29 and were seen with the protected naked eye on Apr 20, 21, 22 & 23.

AR2995 N13°/077° was the third group in the AR2993/2994 region, although it was separated from the other two by some 30° in longitude. The group rotated over the NE limb in the wake of AR2994 on Apr 19, type Hsx. On Apr 21, the group developed a single pore follower, and this became two followers on Apr 22. The main sunspot was 310 millionths in area and was large enough to be seen with the protected naked eye on Apr 24 & 26. When seen in the NW quadrant on Apr 27, the main sunspot had lost its followers. The group was close to the NW limb on Apr 30.

AR2999 S20°/017° was seen close to the SE limb on Apr 23, as a single penumbral sunspot. The group travelled across the disc more or less unchanged to the end of the month, with a few sporadic faint pores accompanying it from Apr 28.

19 observers reported a Quality number of Q = 12.75 for April.

H-alpha

Prominences

17 observers reported a prominence mean daily frequency (MDF) of 6.67 for April. Many prominences were recorded by the Section throughout the month, but few were worthy of particular note.

On Apr 1, a notable double-arch prominence was seen on the SE limb, rising to about 50,000km and expanding along the limb for 170,000km.

A conspicuous pyramid prominence was noted on the NW limb on Apr 15, rising to a height of 70,000km. A fine loop prominence was on the SE limb on Apr 19.

A hedgerow prominence extended around the SW limb for about 100,000km on Apr 21, consisting of four tree-type prominences with a height of around 25,000km.

On Apr 26, another conspicuous prominence was noted on the E limb and further south, a small plasma cloud hovered about 60,000km above the SE limb. The following day, a faint high arch prominence was seen on the NE limb.

Bipolar magnetic regions, filaments & plage

15 observers reported a filament MDF of 6.23 and 11 reported a plage MDF of 3.65 for April.

Extensive plage was recorded during the month, particularly with and trailing the major sunspot groups. Prominences were numerous but none of particular note, while several filaments were lengthy and notable throughout the month.

On Apr 1, a long filament aligned east/west trailed AR2978 and another preceded AR2981, measuring about 210,000km and 120,000km respectively.

On Apr 8 a long north/south-aligned filament was in the northern hemisphere, not far from the CM, while another shorter north/south filament was east of it. The long filament persisted through to Apr 12, being broken at points but altogether extending for about 400,000km. One observer noted 23 filaments on the disc on Apr 10, the most ever recorded by him.

The bipolar magnetic region (BMR) accompanying AR2993 and AR2994 became more evident as the groups rotated fully onto the disc. The BMR associated with AR2998 was fully on the disc on Apr 26, and on Apr 29 a large tapering BMR was noted with AR2999.

On Apr 21, a filament on the eastern side of AR2993 broke away and moved a distance of about 100,000km.

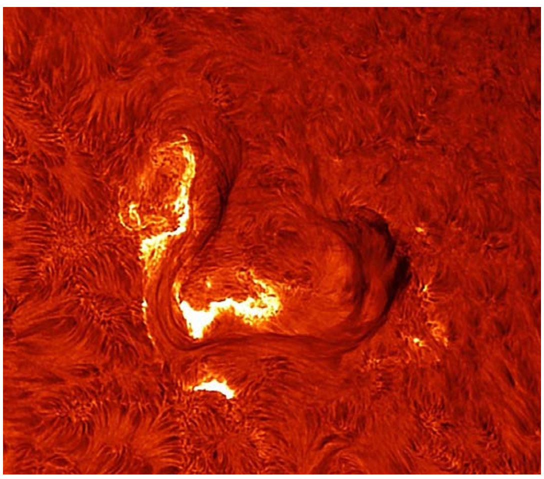
In the southern hemisphere on Apr 23, two long filaments were seen at around 120,000km and 150,000km in length, while another 200,000km-long filament was noted in the northern hemisphere.

A large fila-prom was noted near the NE limb on Apr 29.

CaK

An unusual CaK feature was seen between Apr 7 & 15. Very long (up to 50° in longitude) CaK emission lines appeared repeatedly. These were seen on four separate occasions, being just continuous lines of CaK emission.

CaK MDF 5.76 (1 observer (Brian Mitchell), 21 days).



The unusual Hyder flare of 2022 Apr 27, imaged by Gary Palmer. It was classified as a C7.7 eruption.

Flares

Numerous flares were recorded and imaged by Section members throughout the month. The most unusual was a Hyder flare on Apr 27 that formed around a filament to the north of AR2995, in the NW quadrant. The filament appeared to have two arms, with the southern being the longest, and the flare appeared in three hot spots around these arms. The southern arm broadened out significantly as the flare peaked and then subsided. NOAA recorded it as event 9340, commencing 14:15, peaking at 14:54 and ending at 15:29 UT; it was X-ray class C7.7.

2022 May

The upward trend of white-light activity continued apace, with the present cycle out-performing predictions. The northern hemisphere experienced a small decline in activity, which was more than counterbalanced by an upsurge in the southern hemisphere. Southern-hemisphere activity was the highest recorded by the Section since 2015 January, as was *R*. Multiple sunspot groups were recorded on all days of the month. 27 active regions received numbers during May; the main sunspot groups are reported below.

AR2999 S20°/014° survived on the disc from the previous month as a single Hsx sunspot. The group rotated around the limb unchanged on May 6.

AR3001 S32°/339° was a similar sunspot to AR2999, to its south-east. This sunspot also progressed unchanged, rotating around the limb on May 9.

AR3004 S13°/322° was first reported on May 2 as a Bxo group forming in the SE quadrant, approaching the CM. By May 4 it had undergone rapid development to type Dac, consisting of a well-developed penumbral leader and two elongated penumbral sunspots with multiple cores. The following day, the leading sunspot had an area of 540 millionths, and on May 6 it sported a U-shaped light bridge. Also noted was a bright-edged S-shaped streak on the southern umbra/penumbra border. The leading sunspot continued to increase in size, whilst the followers reduced in size and number. As the group approached the SW limb on May 8, it had reduced in size to 440 millionths, before appearing as a single Hsx-type sunspot on May 9 just before it rotated around the limb. The group was seen with the protected naked eye on May 5 & 6.

AR3006 S29°/238° rotated over the SE limb on May 4 at high southern latitude, type Cso. The group remained class C for some days, forming a long string of sunspots. It grew to type Eai on May 10, and subsequently to type Eao, lengthening in longitude and fading as it did so.

BAA sunspot data, 2022 April–May

Day	April *g*	April *R*	May *g*	May *R*
1	5	88	2	31
2	6	92	3	39
3	6	79	4	56
4	4	81	4	57
5	4	56	4	58
6	4	46	3	55
7	3	37	3	47
8	3	36	4	57
9	2	25	4	52
10	1	12	2	42
11	0	5	3	55
12	1	11	4	78
13	2	21	5	83
14	2	29	5	83
15	3	32	6	104
16	4	50	5	97
17	5	59	6	105
18	5	66	6	89
19	4	74	7	103
20	4	65	5	89
21	5	79	7	109
22	5	82	7	112
23	6	88	7	121
24	6	84	6	80
25	6	82	5	67
26	7	89	5	61
27	8	93	4	42
28	7	98	2	26
29	5	64	3	28
30	3	33	3	42
31			3	41
MDFg	4.28 (47)		4.70 (48)	
Mean R	64.02 (44)		75.23 (45)	

North & south MDF of active areas g

	MDFNg	*MDFSg*
April	2.66 (36)	1.78 (36)
May	1.79 (39)	2.99 (39)

g = active areas (AAs)
MDF = mean daily frequency
R = relative sunspot number

The no. of observers is given in brackets.

By May 14 very little remained: just a sporadic sprinkle of faint pores approaching the SW limb.

AR3007 S22°/185° was initially seen on May 8 as an Hsx sunspot on the SE limb, before undergoing development overnight to be type Eso on the following day. However, the group only comprised two small penumbral sunspots and a pore at this stage. It underwent rapid development over the next few days and by May 12 consisted of several penumbral sunspots and pores. It had an estimated area of 530 millionths and was of a similar structure the following day. On May 14, a large irregular sunspot formed in the middle of the group as it approached the CM, type Ekc. The irregular sunspot had decayed by May 16, with a reduced number of penumbral sunspots and pores. The group started ►

fading on May 17 & 18, being seen as a small Cso group near the limb on May 19 and rotating around the limb on May 20.

AR3010 S13°/131° rounded the SE limb on May 12 as a small Hsx-type sunspot. The following day, bright faculae were noted with the region. On May 14, the group was made up of four strong sunspots and a few pores with associated bright faculae. The group became quite extended as it travelled across the disc, with the strongest sunspot being approximately in the centre of the active area. AR3010 crossed the CM on May 18 and continued across the SW quadrant, with a collection of pores changing position around the central strongest sunspot. The group was rapidly fading on May 21 and had reduced to type Bxo by May 22. It rotated around the limb amidst faculae on May 24.

AR3011 N16°/123°, AR3014 N22°/110° & AR3015 N14°/108°. All three groups appeared over the NE limb on May 13 & 14, in fairly close formation. AR3011 was the weakest of them at type Bxo; it extended in longitude before fading on the disc around May 18. AR3014 was the most northerly of the trio and although starting modestly as type Axx on May 14, it soon developed into a very substantial sunspot group. AR3015 was to its south and appeared as a small penumbral sunspot, also on May 14.

By May 16, AR3014 had developed to type Dac, and by the following day it had expanded from 250 millionths in area to 440 millionths. The group continued to grow and was 830 millionths by May 18, when it consisted of a large irregular leader with follower sunspots. Both grew further, so that by May 19 the area reached 1,250 millionths, making it the largest sunspot group so far seen in Cycle 25. Multiple umbrae were observed in the leading sunspot and two elongated penumbral sunspots followed, also with multiple umbrae, the group being type Eko. By May 21 the leading sunspot was beginning to divide, with a light bridge forming. The followers were also showing signs of decay and many of the associated pores had faded. As the group approached the NW limb on May 24, AR3014 appeared as a single irregular penumbral sunspot of type Hkx, with an area of 1,030 millionths. It was of similar appearance on May 25 and was seen on the limb on May 26 as a Dso group, before it was lost from sight.

In contrast, AR3015 showed little development from a more promising start. It achieved type Cso on May 19 before returning to type Hsx on May 21. The group then faded in the NW quadrant.

AR3023 S13°/325° appeared over the SE limb on May 24 as an Hax sunspot. Once further on the disc, it could be seen that two umbrae were contained within the penumbral area. The group crossed the SE quadrant unchanged to the end of the month; however, it had a north/south alignment when first seen and this slowly rotated into a more east/west alignment of the two umbrae.

AR3024 S33°/322° appeared over the SE limb on May 25, type Hsx. The group progressed across the quadrant unchanged and was not noteworthy other than for its high southern latitude.

AR3025 N30°/029° formed on the disc on May 29, near to the NW limb and at high northern latitude. Initially type Cro, the group became type Dso the following day and rotated over the limb at the end of the month.

20 observers reported a Quality number of Q = 14.29 for May.

H-alpha

Prominences

18 observers reported a prominence MDF of 6.30 for May.

On May 8, a uniformly bright prominence was seen above the SW limb and a moderately sized arch prominence was on the NE limb.

A particularly large prominence eruption was seen on the SW limb on May 11 and a small, detached plasma cloud was noted off the SSE limb. A large pyramid prominence was reported on May 19 on the NW limb, reaching a height of about 60,000km.

An active prominence was observed on the SE limb on May 22, showing movement between 09:05 and 09:34 UT, but it had mostly dissipated by 09:45 UT.

An inclined prominence on the NE limb extended to a length of 120,000km on May 24.

An extensive prominence hearth was seen around the SW limb on May 25, extending for over 200,000km and rising to about 50,000km. The following day, the shape of the hearth had altered, contracting in extent and forming a large arch prominence.

A large and rapidly decaying prominence was observed off the NW limb on May 29.

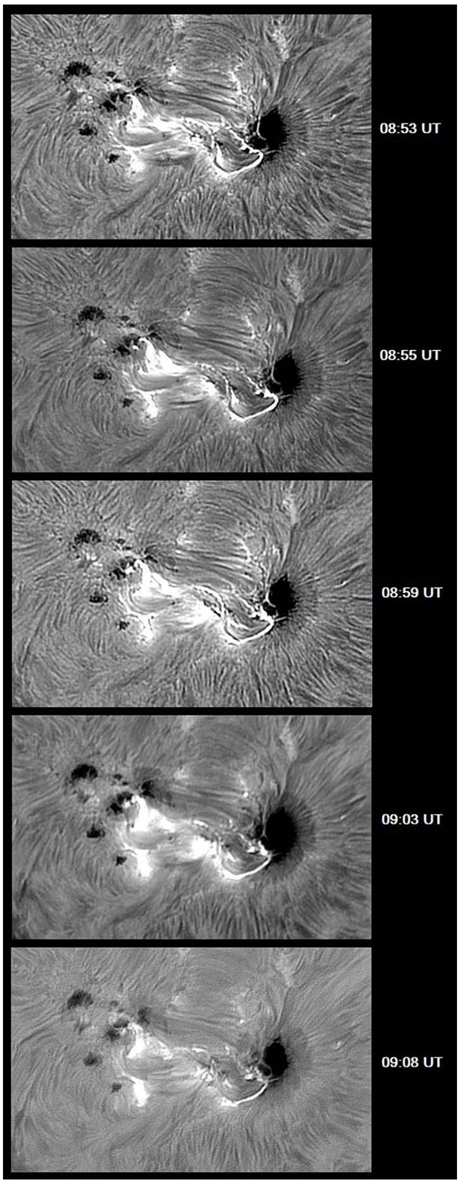
Bipolar magnetic regions, filaments & plage

17 observers reported a filament MDF of 6.76 and 15 reported a plage MDF of 4.14 for May.

May proved to be a notable month for long filaments. On May 4, six long examples were counted. The following day, three filaments in the southern hemisphere were estimated at being 100,000, 150,000 and 200,000km in length. Also, in the northern hemisphere, two further filaments were estimated to extend around 100,000km and 250,000km.

On May 8 a strong, broad filament was seen in the SW quadrant, persisting the following day.

The dark BMRs underlying AR3006 and AR3007 were especially conspicuous on May 12. Of particular interest were linear features, forming a cross-shape that protruded from the following end of AR3006's magnetic



A solar flare erupting from the group AR3004 on 2022 May 5. This C4.1 event's rapid evolution between 08:53 and 09:08 UT was captured by Carl F. Bowron (Doncaster, Yorkshire) using a 120mm refractor at *f*/18, a DayStar C Quark and a ZWO ASI 183MM camera.

region. The following day, a large number of dark filaments populated both hemispheres, in particular along the following eastern side of AR3007 and extending southwards in a curve.

By May 19, AR3014 was the largest sunspot group so far seen in Cycle 25

On May 17, a bright whirlpool of plage was reported in association with AR3014. On May 19, a bright plage field was seen extensively around AR3014, 3015 and 3017.

On May 25, a hooked prominence was seen mid-disc to the west of AR3020 and a north/south-aligned filament preceded AR3024 near the SE limb. The following day, this filament had grown extensively, reaching up to and seeming to bisect AR3023. It persisted through to the

Mercury & Venus Section

Nightside observations by the *Parker Solar Probe*: implications for the reality of the Ashen Light?

Paul G. Abel
Director

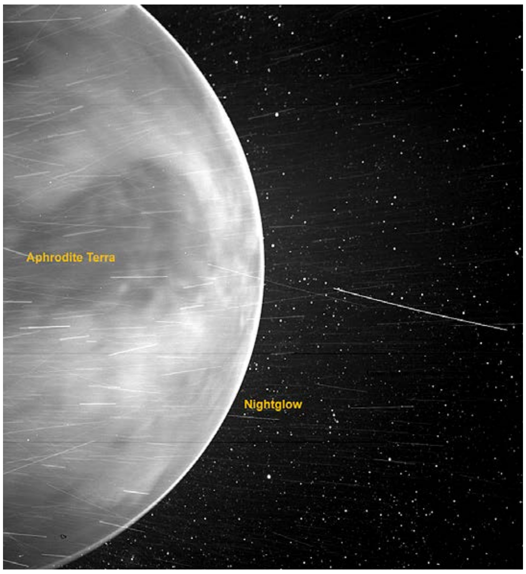
The *Parker Solar Probe* is a NASA mission designed to investigate the Sun's outer corona. Launched in 2018, it will be the first spacecraft to fly into the corona. In 2020 July, it flew past Venus and captured images of the surface in visible wavelengths. The probe performed another flyby on 2022 Feb 20 and all of these observations have allowed a video to be constructed (a still from this is shown).[1]

The most remarkable aspect of the *Parker* probe's results is that the nightside of Venus was seen in visual wavelengths. The surface is incredibly hot, at around ~460°C, and as a result the rocks glow due to the heat. Normally the surface is hidden by the clouds, but *Parker* used its wide-field imager – the WISPR – to image the nightside in infrared (IR) and visual wavelengths close to the IR end of the spectrum. A remarkable amount of surface detail is visible through the cloud tops, including plains and plateaux.

This is the first time observations of the surface have been made in visible wavelengths. Also observed was a thin luminous halo, which is caused by ionised oxygen in the atmosphere. These results have been published in the *Geophysical Research Letters* journal.[2] It is nice to see that the paper references an elongation report by McKim, which gives a good description of amateur attempts to capture infrared thermal emission.[3]

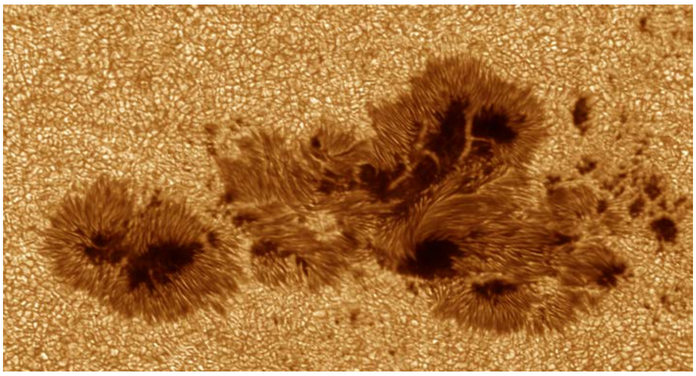
Naturally this recent discovery has prompted speculation amongst both professional scientists and amateur astronomers about the reality of the Ashen Light. For those of you unfamiliar with the phenomenon, the Ashen Light is the reported visual glow of the nightside of the disc when the planet is in the crescent stage. The phenomenon was first reported in 1643, and although a number of reliable observers have reported it over the decades, there has yet to be a firm confirmation of the effect. If the glowing surface can sometimes be seen (perhaps caused by thinning clouds over the nightside, or active volcanoes making portions of the surface hotter), then this may be the explanation behind this elusive phenomenon.

I must confess that I have never seen the Ashen Light in all the years that I have been observing the planet – but I am more sensitive to the blue end of the spectrum, and if the glowing surface is the explanation then one would require sensitivity at the red end. I had many conversations with the late Sir Patrick Moore about the Ashen Light, as he was absolutely certain the phenomenon was real. Much more work needs to be done of course, but perhaps we might now finally have some sort of explanation!

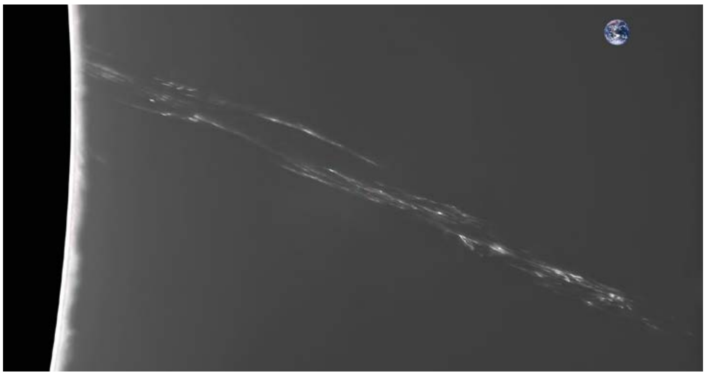


NASA / Johns Hopkins APL / Naval Research Laboratory

1 NASA *Parker Solar Probe* website: **go.nasa.gov/3cwQUcX**
2 Wood B. E. *et al.*, 'Parker Solar Probe imaging of the night side of Venus', *Geophys. Res. Lett.*, **49**, issue 3 (2022 Feb 16)
3 McKim R. J., 'The eastern and western elongations of Venus, 2007–2017 II: The nocturnal hemisphere', *J. Br. Astron. Assoc.*, **129**(3) (2019)



AR3014, imaged in white light by Luigi Morrone (Agerola, Italy) on 2022 May 21 at 12:00 UT.



Philippe Tosi (France) obtained this image of a 180,000km prominence on 2022 May 19, at 13:06 UT. The relative size of Earth is shown for scale.

► end of the month, rotating across the southern hemisphere.

A filament in the shape of a question mark was noted on May 27, north of the disc's centre and associated with a bright area of plage. The following day this filament had a hook-like appearance, with subtle changes occurring between 09:32 and 09:46 UT.

Plage was noted with most sunspot groups throughout the month.

CaK

For the first nine days of the month, a very long pronounced band of CaK 'speckles' persisted along the mid latitudes of the northern hemisphere, longitude 360–260°. From mid-month to the end of May, CaK emissions around sunspot groups gradually became larger in area.

CaK MDF 5.63 (1 observer (Brian Mitchell), 16 days).

Flares

Numerous flares occurred during May and reports were received from Derek Glover, Brian Halls, Peter Meadows, Mick Nicholls and Anthony Stone. Peter Meadows reported an X1.5 flare on May 10, an M1.6 flare on May 11 and an M2.4 flare on May 16. Derek Glover reported a ribbon flare on May 17, with a length of about 50,000km.

Commission for Dark Skies

James Paterson & the Moffat Dark Sky venture

Stars over Galloway Forest Park. *(James Hilder)*

At the opening of the observatory. *Left to right:* Jim Connechen (new chair), Prof Catherine Heymans, and James Paterson. *(David Borthwick)*

Bob Mizon, *Coordinator*

Since its inception in 1989, the BAA's Commission for Dark Skies has maintained friendly relations with lighting professionals. It is, after all, their expertise in design and selection which will eventually bring us environmentally sensitive lighting to relight the stars and promote, rather than damage, biodiversity.

One of the most useful tools in the CfDS kit has been the CD-ROM *Understanding and Dealing with Obtrusive Light* (2000) by Peter D. Wright and James H. Paterson. In 2008 and 2009, CfDS members were involved with James Paterson and others in the preparations for the UK's first International Dark-Sky Association (IDA) Dark Sky Park. Only the fourth in the world, Galloway Forest Park was designated an IDA Gold Tier Park in 2009 for its pristine night-sky vistas. James was the lighting engineer who translated the IDA's technical specifications for the award into reality.

Since then, he has gone on to master-plan 14 other dark-sky award areas in the UK and elsewhere, from as far north as the Orkney island of North Ronaldsay to as far south as the South Atlantic island of Saint Helena. These include the recently announced International Dark Sky Reserves in both the Yorkshire Dales and North York Moors National Parks.

Areas where night skies are protected by local efforts – and remember, there is still no legislation to defend them – need not be large. In 2011, James gave a presentation in the town of Moffat on the River Annan in southern Scotland, that led in time to its designation in 2016 as an IDA Dark Sky Community. Moffat worked with Dumfries and Galloway Council on outdoor lighting policies, enabling its successful bid. According to the IDA, 'the resulting lighting plan goes above and beyond IDA minimums'. The Council gave Moffat better LED street lighting well before the rest of the region. The connected load was reduced from 50 to 30kW, without reducing illumination levels on the streets, and sky darkness quality measurements improved, as did the appearance of the streets at night.

From the IDA award grew the Moffat Astronomy Club and Community Observatory. The club first purchased a 6-inch telescope, but soon their ambition to explore further into the cosmos led to plans for a permanent observatory. Enthusiastic chair Evelyn Atkins found a receptive landowner with a location in a field just south of Moffat Academy.

Moffat Community Observatory. *(David Borthwick)*

Structure plans ready for a planning application were drawn up by James Paterson, now an Astronomy Club member. Planning approval was granted in 2019 April and a building warrant was granted at the end of 2019 October. With all the building materials on site and many energetic club volunteers ready for action, the construction of two log cabins started on 2019 Nov 8. Access to the observatory, *via* a new path and ramp for wheelchair users, was provided as part of Sir Robert McAlpine's commitment to community access improvement schemes.

The structure was covered for months against the winter storms at the start of 2020 and no actions were undertaken during the ensuing national COVID-19 lockdown. A Meade *f*/8 advanced coma-free (ACF) 16-inch telescope on a WiFi-compatible equatorial mount, made by iOptron, is now in place below a three-metre-diameter dome. With a focal length of 3,251mm, the optical tube provides a light-gathering capability for viewing a range of deep-sky objects.

After being closed for summer maintenance, the observatory will open again for introductory astronomy viewing, weather permitting, in October. The booking system on the Astronomy Club website (**moffatastronomy.com**) will also open that month.

In ***James Paterson's*** *words:*

'Moffat Dark Sky started as a lighting engineering challenge – there was no astronomy club – but there were about 20 residents who put their name to an astronomy interest list which I started when I did a dark-sky public awareness open day at the Moffat Town Hall. I started the work on developing a lighting master plan for the area and carrying out a lighting audit in the town. The street light conversion reduced upward light into the sky and we got the Dark Sky Town award, but the outreach continues to get other lighting installations to point downwards and not upwards.

'The control of light is not just for stargazing – there are other areas of benefit. The residential neighbourhood and the flora and fauna all benefit in some way from reduced visual obtrusion. Unlike energy [wastage], light obtrusion is visible to everyone, and its reduction can be immediately appreciated by all in the town. Thousands of visitors return home with a mental picture of a town with something rather unique about it.

'I keep repeating the message that the dark-sky award has something in it for everyone. It is a partnership of disparate residents, professions and trades, all working together to keep the stars visible at night. It also has an important educational outreach message, something which I know which is very dear to the heart of the Astronomer Royal for Scotland. We may have little control over the clouds at night – the changing climate is creating greater cloud cover – but we make an annual report to the IDA to show that we are working together to mitigate upward light.

'Incidentally, Dumfries and Galloway Council is the only local authority region in the UK with two IDA Dark Sky Places.'

Access for pupils from the adjacent Moffat Academy, which had an astronomy club 40 years ago, will also form an essential part of the ongoing educational outreach. With WiFi capabilities, it may be possible for the students to view the night sky from their classrooms.

The grand formal opening took place on 2021 Oct 16, with the recently appointed Astronomer Royal for Scotland, Prof Catherine Heymans, unveiling the brass commemorative plaque.

Equipment & Techniques Section

An introduction to spectroscopy

| Part I: What is spectroscopy?

Andy Wilson

Astronomical spectroscopy is a fascinating and rewarding pursuit, enabling us to learn about the composition, environment and processes of distant astronomical bodies. In the past 20 years there has been a revolution in the spectrographs available to amateur astronomers, ranging from simple diffraction gratings such as the Star Analyser for the cost of a filter, to highly capable, advanced spectrographs for the cost of a good-quality telescope.

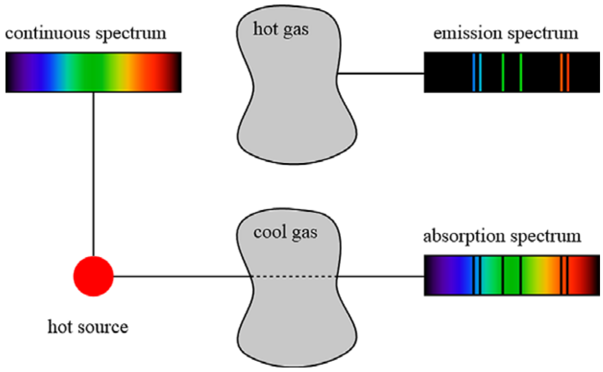
I will be introducing spectroscopy across a set of articles. First the basics are introduced, followed by what we can learn from the spectra of astronomical objects, then some of the spectrographs available to amateurs and the methods needed to generate scientifically valuable results.

Light & the electromagnetic spectrum

The knowledge we require for astronomical spectroscopy comes from Earth-based laboratories. These are environments we control, where we can conduct experiments to understand the processes that affect how light is emitted and absorbed by matter. Where we see similar spectra in the Universe, we can infer what is happening without physically visiting those places.

Light has long been known to possess a dual personality, demonstrating properties of both waves and particles we call photons. The wavelength of the light corresponds to the energy of the photon, with shorter wavelengths having higher energy. It is the wave nature of light that interests us in spectroscopy. We are familiar with very low-resolution spectroscopy in our everyday lives, as we perceive the wavelength of light as colour. The fine details of the varying intensity with wavelength hold a wealth of information about how the light was created and what it has passed through on its way to us.

Visible light occupies a small part of the electromagnetic spectrum, covering roughly 3900–7000 ångströms,[1] where 1 ångström is 10^{-10} metres. Blue light has a shorter wavelength than red light. To longer wavelengths than red, we have the infrared, microwaves and then radio waves. To shorter wavelengths than blue, we have the ultraviolet, then x-rays and finally gamma-rays. Amateur astronomical spectroscopy is possible from the infrared to the ultraviolet, though the majority is performed in the visible region.



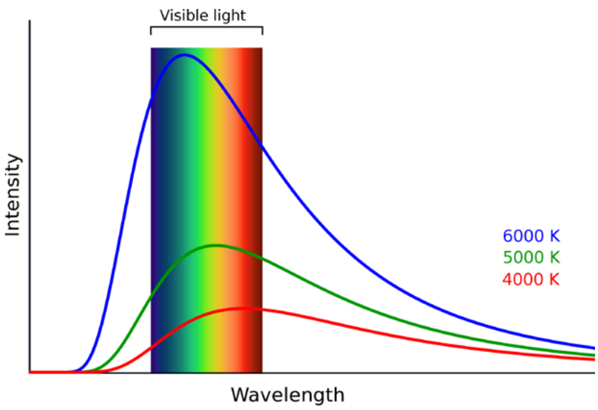
(Courtesy of Tatoos from Wikimedia Commons)

Figure 1. Illustration of Kirchhoff's three laws of spectroscopy.

Types of spectra

Spectra broadly fall into three categories, illustrated by Kirchhoff's laws of spectroscopy; see Figure 1. Hot dense matter will generate a continuous spectrum, without gaps. Hot low-density gas or plasma will generate an emission line spectrum. Finally, a cool low-density gas will cause dark lines in a continuous spectrum that passes through it. To give these some astronomical context, nebulae generate emission line spectra, while stars usually generate continuous spectra with absorption lines superimposed.

Many astronomical objects emit a spectrum that approximates a black-body spectrum. This is a theoretical spectrum produced by an object that is perfect at absorbing and emitting light. It has a particular smooth, continuous shape, where the peak tells us the temperature of the body emitting the light; see Figure 2. A peak at a shorter wavelength corresponds to a higher temperature. As these spectra are continuous, they provide a backdrop for absorption lines. The wavelength and shape of these lines hold the key to unlocking the physics and chemistry of distant objects.



(Courtesy of Maxmath12 from Wikimedia Commons)

Figure 2. Black-body spectrum.

Line spectra

The wavelengths of emission and absorption lines are understood in terms of quantum-mechanical processes. In the visual part of the spectrum, lines are created by electrons transitioning between energy levels in atoms, molecules and their ions (an ion is an atom or molecule with one or more electrons removed). When an electron loses energy transitioning from a higher to a lower energy level, it emits a photon. When an electron absorbs a photon, it transitions from a lower to a higher energy level. These transitions involve a very precise energy change, giving rise to narrow spectral lines whose photon energy matches the transition energy.

If all matter was stationary, then we could potentially identify an atom or molecule from a single spectral line. However, the motion of matter shifts spectral lines *via* the Doppler effect. We are able to identify atoms and molecules from their spectra as the multiple energy levels of a given atom or molecule are unique, giving rise to a specific pattern of spectral lines for the transitions between those levels. These patterns act like a fingerprint, allowing us to uniquely identify that atom or molecule, even when this pattern is shifted in wavelength. Any shift relative to the rest wavelength tells us how fast the object is moving and its direction: a blueshift is observed if it is moving towards us and a redshift when moving away from us.

It is possible for sufficient energy to be absorbed by an electron that it completely escapes the atom or molecule: a process called ionisation. This does not happen at a precise energy. Instead, there is a minimum energy needed to ionise a specific electron from an atom or molecule. There is no upper limit to the energy, as higher-energy photons will remove the electron and impart progressively larger amounts of kinetic energy to the electron. This creates a broad absorption band with a hard edge on the long-wavelength side, corresponding to the minimum ionisation energy. Equivalent emission band spectra are produced by the process of recombination, where a free electron is captured by an atom or molecule.

In astronomy, spectral lines are rarely sharp and at their rest wavelength. As previously mentioned, the bulk motion of objects shifts the lines due to the Doppler effect. The motion of gas and plasma (ionised gas) within a body will broaden the lines *via* the same Doppler effect – for example, due to the rotation of a star and the motion in convection cells at the surface of a star. Collisions between atoms and molecules perturb the energy levels, also broadening the lines, and magnetic fields cause lines to split.

In my next article I will show how we can apply this knowledge to astronomical spectra.

1 Trypsteen M. F. M. & Walker R., *Spectroscopy for Amateur Astronomers*, Cambridge University Press, 2017

From the *Journal* Archive

throw light on certain observations of long ago. In this connection I will ask Mr. Comrie to speak on some past records of occultations of stars by planets and their satellites which he has been investigating.

Mr. L. J. Comrie: The notes from which I am about to speak were written for another purpose, but I think they might prove interesting.

The first instance of an occultation of a star by a satellite, in this case Titan, goes back 230 years, to an observation made by Cassini at Paris on June 19, 1691 (N.S.) and recorded in the *Memoirs of the Paris Academy of Sciences.* The account is in the third person, but it is really a translation of Cassini's original paper. There has been some confusion about the date of this

Commander Ainslie: I do not think that we can be at all certain that the stars were really occulted on the occasions mentioned. The aperture of Cassini's telescope was, I believe, only two-and-a-half inches, and it was not achromatic. Under these conditions there would be the appearance of an occultation if the discs of satellite and star were anywhere within two or three seconds of one another. For the same reason I do not believe that any telescope of that date, or even in 1820, could have shown any deformation of the disc of a satellite, or that any such deformation was ever seen until recent years. Even in the 10-inch at Four Marks, with good seeing, the ellipticity of the disc is not very obvious.

John Chuter
Archivist

There are two interesting lunar occultations coming up, one of which may have occurred by the time you read this piece and one which is to come. The Moon occults the star delta Scorpii (magnitude 2.3) on Aug 6, and on Sep 14 it will occult Uranus. Both events will be Observers' Challenges on the website.

Whilst researching this piece, I came across a rare (I think) typo in the *Journal* record (*below*). In the 1897 August *Journal* index, a piece about the lunar occultation of the Pleiades on 1986 Dec 17 is recorded as being on p.178. It is actually on p.108. This is a reminder to keep looking if a reference does not appear to be where you expect it. The actual piece is worth looking up.

Occultation of Pleiades 1896,
December 17 (**B.A.**), 178.

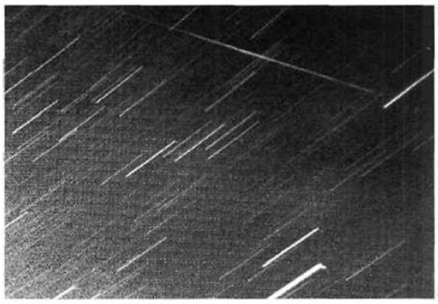
In the 1922 August issue is a long report by Dr Leslie Comrie (who, amongst other things, began the BAA *Handbook* in 1922) on occultation events, beginning with the piece shown here (*top left*). The report finishes with interesting comments from Commander Ainslie (*top right*). Ainslie was the subject of a paper by Martin Mobberley in the 2010 February issue of the *Journal*, which I recommend reading.

In the past, the BAA held an annual exhibition in the summer. Exhibits would be listed in the *Journal*. The 1972 August issue had the usual list, with many references to occultation events. Shown here is a picture from the issue (*below left*) and a few of the exhibits that were on show (*above right*).

H. R. Hatfield	Photographs with selected moonscapes (including colour), an earthshine photograph and one fake occultation!
J. C. Miller	Drawing of lunar occultation of Mars.
M. H. Gaiger	Photographs of Moon, Venus and occultation of Mars.
Presented by S. R. Dunlop	Chart recordings from three stations and descriptive notes of the grazing occultation of Z.C.900 on 1972 March 21.

Also in that issue are the notes for a meeting held on 1972 Jun 28, where Cicely Botley talked about the occultation of beta Scorpii by Jupiter on 1971 May 13, observed by a member in Colombo.

Finally, I show a picture (*right*) taken by Neil Bone that appeared in the 1997 August issue, of a bright Perseid. Sadly, the Perseids will be affected by the Moon this year, but maybe an observation might be made of a very bright Perseid 'occulting' the Moon!



A bright Perseid streaks above Sagitta, 1993 August 12/13 at 21h 37m UT. Exposure 15m on Ilford HP5plus 400 ISO, 28mm f2.8 wide angle lens. *N. M. Bone*

Members viewing exhibits. *Photograph by K. W. Mardle.*

Six remarkable northerly novae in 2020–'21

Jeremy Shears

A report of the Variable Star Section. Director: J. Shears.

During late 2020 and 2021, six relatively bright novae appeared in the northern celestial hemisphere. The light curves of V1391 Cas, V1112 Per, V1405 Cas, V1674 Her, V606 Vul and RS Oph are presented and discussed. They illustrate the remarkable diversity of nova behaviour and include representatives of the major classes of novae: fast, slow, dusty, and recurrent.

Figure 1. V1391 Cas on 2020 Jul 30, at 22:36 UT. 28cm Schmidt–Cassegrain telescope (Celestron 11 Edge) and Finger Lakes FLI 6303 camera. Exposure 10×60s. Field 33×22arcmin. *(Nick James)*

Figure 2. New Milky Way survey camera. *(Image courtesy of Kirill Sokolovsky)*

Introduction

Novae represent a class of cataclysmic variable star, which are known to be interacting binaries where a cool secondary star loses mass to a white dwarf primary. Material from the secondary falls through the inner Lagrangian point, L1, and because it carries substantial angular momentum, it does not settle on the primary immediately, but instead forms an accretion disc around the primary. Material flowing through the accretion disc accumulates on the surface of the white dwarf and eventually sufficient material builds up to trigger a runaway thermonuclear reaction. The ensuing eruption causes the system to increase in brightness dramatically – perhaps 10 million-fold or more – in a matter of hours or days, blowing the outer layers of the white dwarf away into space as an expanding gas shell. With time, the gas cools and the once bright nova begins to fade: the outburst is over.

Novae can be classified by the times taken for the brightness to decline by two or three magnitudes: t_2 and t_3. For example, according to the *General Catalogue of Variable Stars*, fast novae have $t_3 < 100$ days, while slow novae take more than 150 days. Fast and slow novae are generally referred to as classical novae. A further class is that of the 'recurrent novae', which undergo two or more outbursts, usually separated by many years.

During late 2020 and 2021, we were treated to six relatively bright novae in the northern hemisphere. They include representatives of the major classes: fast novae; slow, dusty novae; and a recurrent nova. This paper presents the light curves of these objects, which illustrate the remarkable diversity of nova behaviour. It also highlights the importance of amateur observations of these exciting transients, both in their discovery and in follow-up. It is a pleasure to showcase the hard work of the many dedicated observers that have followed these novae. Note that whilst some representative spectra are shown, they are only the 'tip of the iceberg' from the rich collection in the BAA spectroscopy database; these warrant further analysis but that is beyond the scope of this paper.

Nova Cas 2020 (V1391 Cas)

Nova Cas 2020 (Figure 1) was discovered on 2020 Jul 27 by Stanislav Korotkiy & Kirill Sokolovsky. Their 'New Milky Way' survey,[1] operating at the Ka-Dar Observatory in the Russian Caucasus at an altitude of 2,000m (Figure 2), makes use of off-the-shelf equipment to discover transient objects. The equipment would be familiar to many amateur observers: a Canon

Figure 3. View of the Ka-Dar Observatory in the Russian Caucasus. *(Image courtesy of Kirill Sokolovsky)*

135mm *f*/2.0 lens with an SBIG ST-8300M CCD camera, mounted on a Sky-Watcher HEQ-5 Pro mount (Figure 3).

The discovery magnitude was 12.9 CV. Spectroscopy by Sokolovsky *et al.* (2020) suggested that this was an Fe II-type classical nova near maximum.[2] The expanding velocity of the nova ejecta was initially around –850 ±100km/s. A spectrum by David Boyd on 2020 Jul 30.905 (Figure 4) showed an apparent full width at half maximum for the H-alpha line of 508km/s, while there is evidence of weak P Cygni absorption on the blue side of H-alpha, extending to –800km/s relative to the peak of emission. There are also emission lines of Fe II (5018Å), Fe II (5169Å) and O I (5577Å). A low-resolution objective prism spectrum by Mike Harlow taken on Jul 31 is shown in Figure 5.

The light curve (Figure 6) shows that at its brightest the nova reached magnitude 10.6, on Aug 10. After maximum, the nova became fainter and fell to magnitude ~13.2 around Aug 16, before becoming brighter again. It subsequently varied between magnitude 11.6 and 13.6 for around three months; such oscillations are typical of dusty novae. Then, in the second week of December, it faded rapidly and was below magnitude 21 in the late part of that month. The fade appears to have been due to dust absorption.[3] There was then a recovery in brightness to magnitude ~16.4 by late 2021 April, presumably as the dust cleared. From this point, it exhibited a very gradual fade, reaching magnitude 17 by the end of 2021. Due to the complexity of the first part of the light curve, we did not determine t_2 and t_3.

The pronounced 'dust dip' is similar to that observed in DQ Her (Nova Her 1934) roughly four months after peak brightness. This was caused by dust forming as the ejected shell expanded and cooled. About 20% of novae show evidence of dust formation within months of the eruption. However, the precise mechanism responsible for dust formation is still a mystery. One hypothesis is that once the temperature in the nova shell drops to ~1,000–2,000 K, atoms of carbon and silicon as well as molecular species condense

Table 1. Novae discussed & their characteristics

Nova	*GCVS Designation*	*RA (J2000.0)*	*Dec. (J2000.0)*	*Date*	*Range (mag)*	*Amplitude (mag)*	t_2 *(days)*	t_3 *(days)*	*Speed class*
N Cas 2020	V1391 Cas	00 11 42.96	+66 11 20.8	2020 Jul 27	10.6 – 21.3	10.7	ND	ND	
N Per 2020	V1112 Per	04 29 18.85	+43 54 23.0	2020 Nov 25	8.2 – 20.1 V	11.9	19	30	Fast
N Cas 2021	V1405 Cas	23 24 47.73	+61 11 14.8	2021 Mar 18	5.1 – 15.6 V	10.5	ND	ND	
N Her 2021	V1674 Her	18 57 30.98	+16 53 39.6	2021 Jun 12	5.9 – 20.5	14.6	1.0	2.1	Very fast
N Vul 2021	V606 Vul	20 21 07.70	+29 14 09.1	2021 Jul 16	9.9–21.9	12.0	ND	ND	
–	RS Oph	17 50 13.17	–06 42 28.6	2021 Aug 8	4.4 – 11.2	6.8	4.0	8.2	Very fast

Notes:

ND = not determined. The speed class is according to the definition of Payne–Gaposchkin.[28]

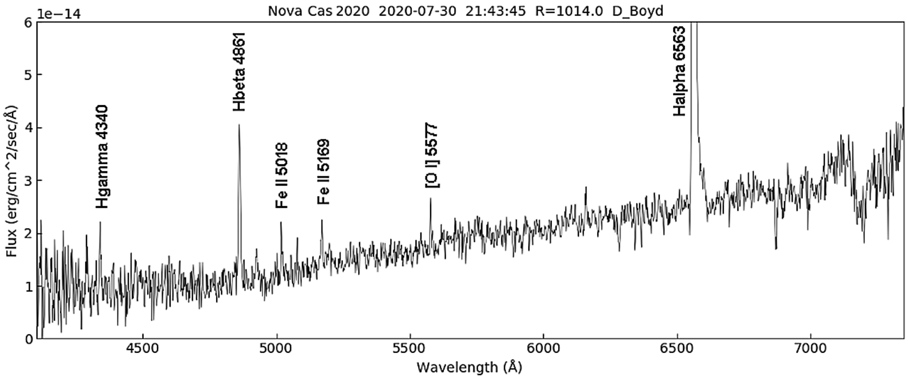


Figure 4. Spectrum of V1391 Cas on 2020 Jul 30.905. *(David Boyd)*

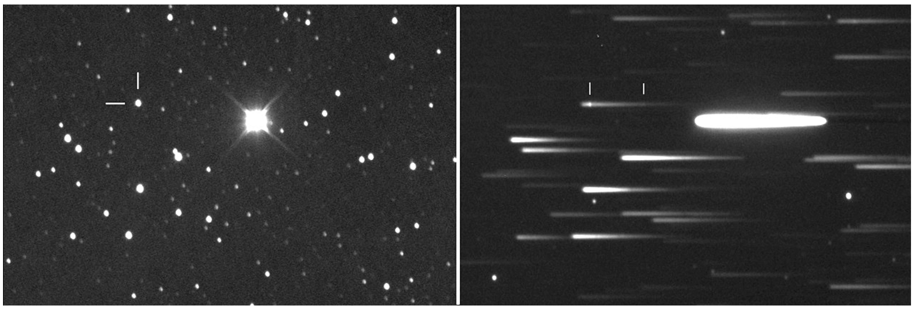


Figure 5. Image of V1391 Cas on 2020 Jul 31. 30cm *f*/3.6 astrograph and Starlight Xpress H16 CCD camera (left) and the same field through a 3° objective prism (right), revealing its low-resolution spectrum. The spectrum has red to the left and tick marks show strong H-alpha and much weaker H-beta emission lines on a continuum. The field is 15×10 arcminutes, with north to the left. *(Mike Harlow)*

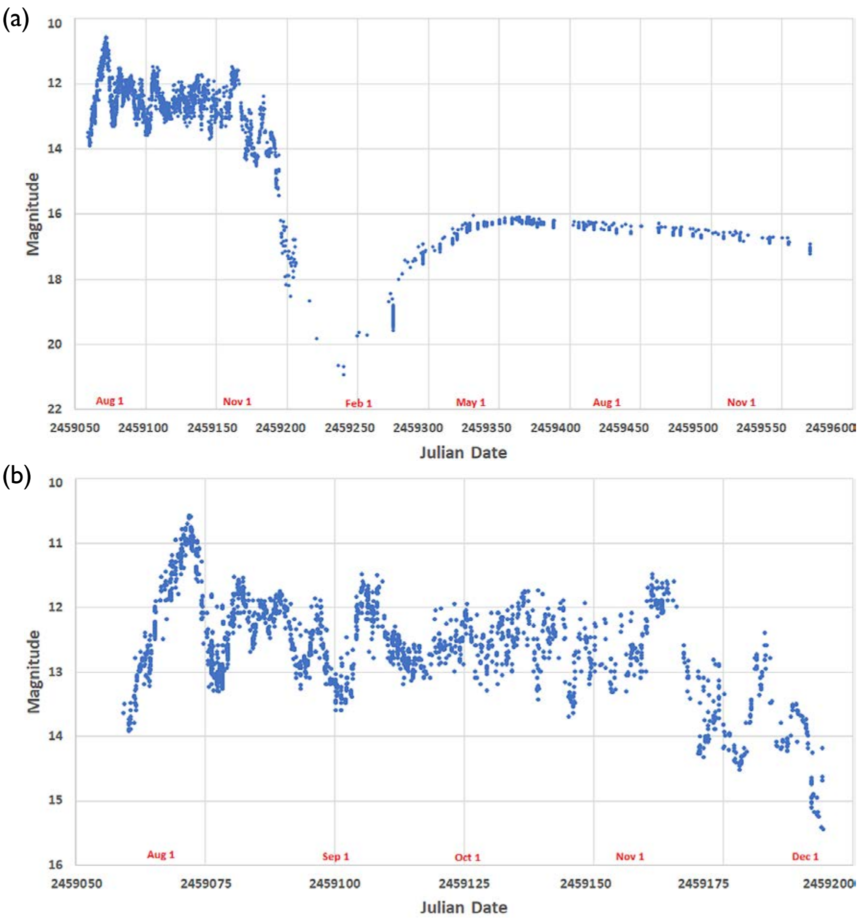


Figure 6. Light curve of V1391 Cas. **(a)** The complete light curve, from discovery until 2021 Dec 31. **(b)** Expanded section of the light curve.

BAA and AAVSO databases combined vis, V, CV and TG data (note that data after 2021 Jan 1 are exclusively from the BAA, as some other observations appear to be contaminated by a nearby field star which results in a much brighter measurement of the nova). Months shown in red start with 2020 Aug 1.

into very small grains, typically 0.01 to 1 microns across. This 'dust' blocks the radiation from the nova and its luminosity drops. The onset of dust formation is usually rapid, since when a few grains form, they block the radiation, causing more grains to condense. As the shell continues to expand, the dust dissipates and the radiation can once again pass through, causing the nova to apparently brighten. Recently, however, Derdzinski *et al.* (2017) suggested that strong shocks in nova ejecta might precipitate dust formation.[4] They proposed that dust formation occurs within the cool, dense shell behind the shock, where the density is high enough for rapid dust nucleation.

Spectroscopy of V1391 Cas by Fujii *et al*. (2021) revealed the presence of the diatomic molecules C_2 and CN on 2020 Aug 12,[5] but these were only in evidence for about three days. The formation of C_2 and CN indicates that the nova envelope gas was carbon-rich. This is only the second example of a C_2/CN-forming nova, the other being V2676 Oph. This latter nova exhibited a late-phase grain-formation episode, which is also the likely explanation of the V1391 Cas fade in 2020 December, as described on p.223.

Dust formation and subsequent dissipation might also explain the oscillations in the light curve of V1391 Cas observed in the early part of the eruption, before the pronounced dust dip. According to this model, the dust formation leads to a fade, then if the dust traps enough energy to destroy the grains, the nova can rebrighten – and the cycle continues. However, such oscillations are poorly studied and even less well understood.

Nova Per 2020 (V1112 Per)

The first report of Nova Per 2020 came from Seiji Ueda (Kushiro, Hokkaido, Japan), who found it on 2020 Nov 25 at 19:22 UT. Ueda has dedicated himself to the detection of novae using relatively simple equipment: a Canon EOS 6D digital camera with a 200mm *f*/3.2 lens. The Russian team of Korotkiy, Sokolovsky & Olga Smolyankina were pipped at the post, making an independent discovery at 20:15 UT on the same night.

The VS-Alert e-mail community was informed of Ueda's magnitude 10.6 CV discovery in a report sent at 21:37 UT.[6] This e-mail was picked up by the author a few minutes later, when he came inside for a break from routine observing. There being no charts available at the time, he produced his own using planetarium software. This allowed him to pick up the nova *via* CCD imaging at 21:55 UT, and it was brightening rapidly. Gary Poyner (Birmingham) observed it visually at 22:31 UT. This exciting evening showed how quickly discoveries

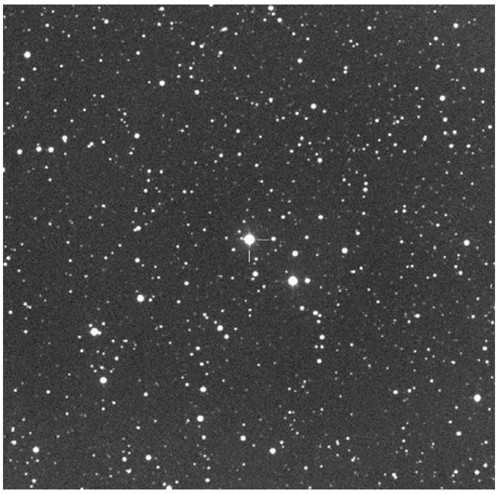


Figure 7. V1112 Per on 2020 Nov 27. Imaged at 04:13 UT *via* iTel New Mexico (0.42m CDK, FLI PL6303E, 120s). A V image taken two minutes later gives V = 9.15. *(Martin Mobberley)*

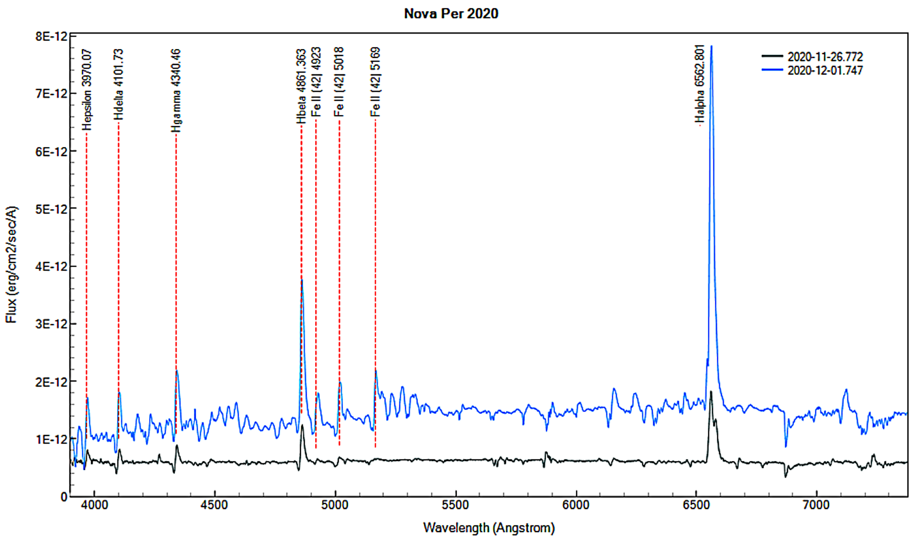


Figure 8. Spectra of V1112 Per from Nov 26.772 and Dec 1.747. LISA spectroscope on a 28cm SCT with a SXVR-H694 CCD camera. *(David Boyd)*

can be communicated and followed up worldwide. An image of the field by Martin Mobberley is shown in Figure 7.

Spectroscopy on Nov 26.05 by Munari *et al*. (2020) showed it to be a classical nova.[7] Banerjee *et al.* (2020) reported its transition to a typical Fe II nova.[8] David Boyd was the first amateur to obtain a spectrum, on Nov 26.772 (Figure 8). It shows characteristic H Balmer and He I emission lines, with prominent P Cygni dips on their blue edges caused by absorption in the material expanding towards us from the nova explosion. David's spectrum taken five days later (also shown in Figure 8) shows the dramatic change which took place shortly after the initial eruption. In addition to the general increase in the energy being emitted across the visual spectrum, the strength of the hydrogen Balmer emission lines and the depth of the P Cygni absorption dips on the blue side of the lines had both increased. The components of the singly-ionised iron Fe II multiplet, produced in the so-called 'iron curtain' which forms after the initial explosion, had become prominent.

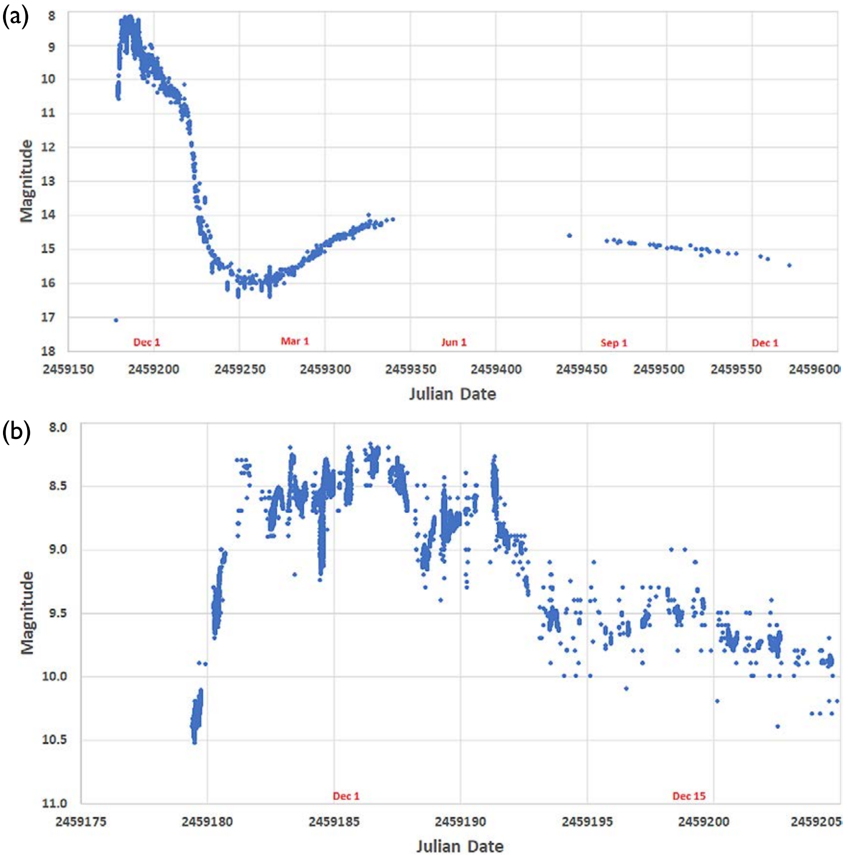


Figure 9. Light curve of V1112 Per. **(a)** The complete light curve, from discovery until 2021 Dec 31. **(b)** Expanded section of the light curve.

BAA and AAVSO databases vis and V data, except that the first data point in (a) is a pre-discovery measurement from the ASAS-SN survey (g-magnitude). Months shown in red start with 2020 Dec 1.

The light curve (Figure 9) shows that the nova displayed significant variation during the first two weeks of the eruption (Figure 9b). It reached magnitude 8.2–8.3 during flares on Nov 29 and Dec 1, 2, 3, 4 & 7. A gradual decline began around 2020 Dec 11 and by 2021 Jan 4 it was magnitude ~11, at which point a rapid fade set in. This decline was accompanied by a marked reddening, suggesting the onset of dust formation. This was confirmed by Banerjee *et al.* (2021) using near-infrared JHK-band photometry on 2021 Jan 15.[9] (The reddening was evident in many of the unfiltered CCD observations submitted during this period, which were 0.5 to 0.8 magnitudes brighter than V and visual data – it is for this reason that only V and visual data are included in Figure 9.)

This was thus a typical 'dust fade', which reached a minimum of magnitude 16 at the end of 2021 January. After that, the nova gradually brightened again, reaching magnitude 14.2 in early May before a gap in observations until mid-August of 2021. From this point there was a slow fade, from magnitude 14.6 to 15.5 by the end of 2021. As the year closed, the nova was still 4.5 magnitudes above quiescence.

Robin Leadbeater obtained a low-resolution spectrum at 280 days on 2021 Sep 2, by which time the nova had faded to magnitude 15 (Figure 10). It is a nebula-type spectrum with strong forbidden emission lines, particularly O III, and a very weak, almost undetectable continuum. Leadbeater estimated that 78% of the light in the V passband came from just the O III pair of lines at 4959/5007Å.

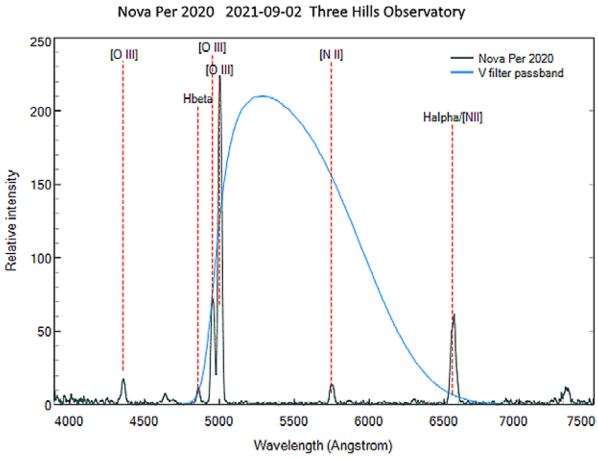


Figure 10. Spectrum of V1112 Per on 2021 Sep 2. *(Robin Leadbeater)*

The measured values of t_2 and t_3, 19 and 30 days respectively (Table 1), are consistent with this being a fast nova.

Figure 11. V1405 Cas and the Bubble Nebula. 2021 Oct 24. Sky-Watcher Quattro 200mm $f/4$ Newtonian, Sky-Watcher Esprit 100ED and Optolong L-Pro filter. *(Mazin Younis)*

Nova Cas 2021 (V1405 Cas)

A northerly nova which is bright enough to be seen in binoculars is a rare treat. It is even more of a treat when one appears in a photogenic field. Such was the case with Nova Cas 2021 (V1405 Cas), which was set amid a beautiful field, close to the open star cluster M52 and the emission nebula NGC 7635, also known as the Bubble Nebula. An image taken by Mazin Younis of Hale Barnes, Manchester on 2021 Oct 24, some seven months after the discovery, is shown in Figure 11.

The story of this nova began on 2021 Mar 18, when Japanese nova patroller Yuji Nakamura reported his discovery of a magnitude 9.6 object as a possible nova to the Central Bureau for Astronomical Telegrams 'Transient Objects Confirmation Page'.[10] Nakamura found PNV J23244760+6111140 on four frames taken with a 135mm $f/4.0$ lens and a CCD camera. Shortly after, it was confirmed spectroscopically as a classical nova by a team from Kyoto University.[11] A spectrum obtained on 2021 May 8.094 showed that it was finally looking like a textbook example of an Fe II nova around maximum brightness.[12]

The complex light curve of the eruption, with multiple variations and flares, is shown in Figure 12. For the first seven months, the nova was around maximum brightness in a sort of plateau, varying between magnitude 5.1 and 8.9, with no fewer than 12 distinct brightening episodes. Considering this interval in

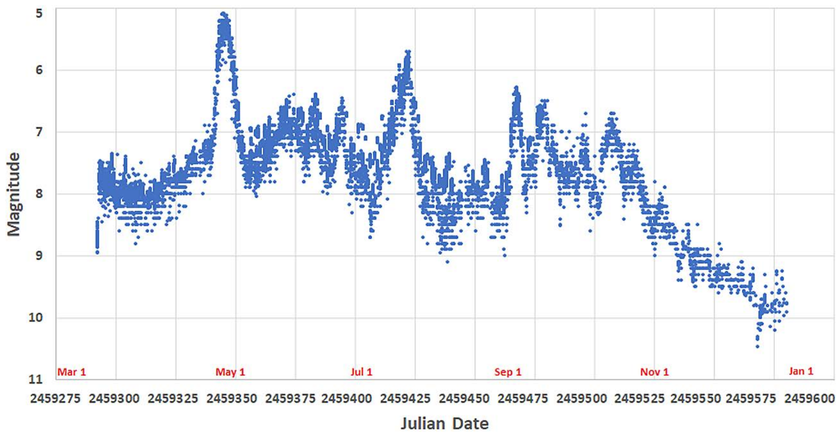


Figure 12. Light curve of V1405 Cas (Nova Cas 2021). BAA and AAVSO databases combined vis, V, CV and TG. Months shown in red start with 2021 Mar 1.

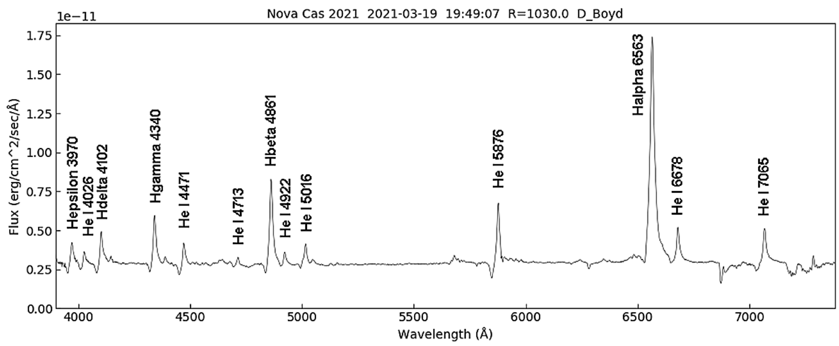
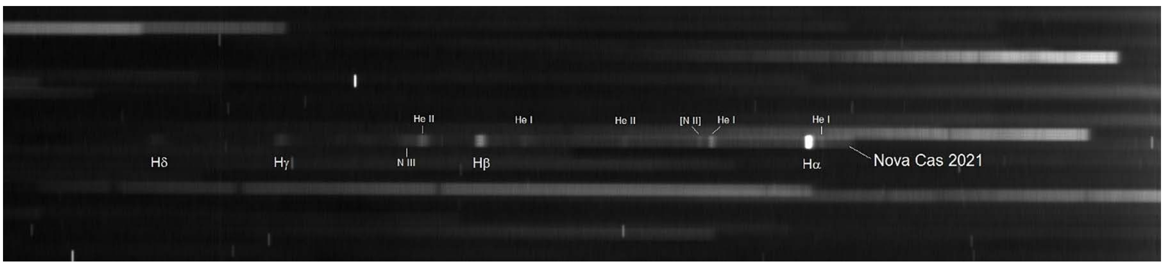


Figure 13. Spectrum of V1405 Cas on 2021 Mar 19. *(David Boyd)*

Figure 14. Objective-prism spectrum of V1405 Cas and its field on 2022 Jan 5. 30cm $f/3.6$ astrograph, Starlight Xpress H16 CCD, Astrodon luminance filter (400–700nm), and 23cm-diameter 12° flint objective prism; exposure 32×20 seconds. Field 0° 47′ in width. *(Mike Harlow)*



more detail, there appeared to be a pre-maximum phase of about seven weeks from discovery before a surge in brightness, reaching naked-eye visibility and attaining maximum brightness on May 9 at magnitude 5.1. This surge lasted about 12 days. There then followed a further period of gross variation, with flares reaching magnitude 6.4 on three separate occasions, before a second surge to magnitude 5.7 on Jul 27, lasting about 14 days. In late October, a steady decline set in at ~0.04mag/day, with the nova reaching magnitude 10 by the end of 2021. It was thus still above the quiescence magnitude of 15.6. Munari *et al.* (2021) noted that during the decline, B–V measurements showed the nova becoming progressively bluer.[13] Due to the complexity of the first part of the light curve, we did not determine t_2 and t_3.

The nova also received the attention of BAA spectroscopists. A spectrum by David Boyd on Mar 19, the night after discovery, was recorded with a LISA spectrograph on a 28cm Schmidt–Cassegrain Telescope (Figure 13). It showed strong emission lines of the hydrogen Balmer series and He I, with P Cygni profiles extending to around –2,500km/s, relative to the rest wavelength, on all emission lines. Mike Harlow used his objective-prism spectroscopy technique to follow the nova, and a spectrum he took on 2022 Jan 5 is presented in Figure 14.

The oscillations which dominated the light curve from discovery until the onset of decline might be understood in terms of dust condensation and dissipation cycles, described in the section on V1391 Cas. However, there also appear to have been multiple short flares, or maxima, on top of the slowly evolving light curve. Several explanations have been suggested to explain these flares, such as pulsations/instabilities in the envelope of the white dwarf,[14] possibly leading to multiple ejection episodes;[15–17] instabilities in a massive accretion disc that survived the eruption;[18] or mass transfer bursts from the secondary to the white dwarf.[19] No preferred model to explain the optical flares has emerged, either observational or theoretical.

Nova Her 2021 (V1674 Her)

Nova Herculis 2021, officially designated V1674 Her (Figure 15), was also discovered by Seiji Ueda (Hokkaido, Japan), on 2021 Jun 12.537.[20]. He found the nova at an unfiltered magnitude of 8.4 in three exposures. By the time dusk arrived in the UK, the nova was clearly visible at 6th magnitude; it was an easy binocular object picked up by Gary Poyner, Daryl Dobbs and the author, as discussed on the BAA Forum. Several visual observers, including Paul Abel using a 30cm reflector, noted how red the nova appeared.

Ueda had evidently caught the nova near the start of its eruption. The All-Sky Automated Survey for Supernovae (ASAS-SN) detected it on Jun 12.1903, only 8.4 hours before discovery, at g = 16.62. The previous observation of the field without a detection was on Jun 10.9660, which places the start of the eruption between these two dates.

However, the excitement of the nova discovery, and the hope that it might brighten further, proved to be short-lived. The light curve in Figure 16 shows that peak brightness was magnitude 5.9 at around Jun 12.9, only a few hours after its detection by Ueda. By the following evening, 2021 Jun 13, the nova had faded to below magnitude 8. A week after discovery, V1674 Her was already 11th magnitude. The decline from maximum towards quiescence was very smooth. It took only 1.0 days to drop two magnitudes and 2.1 days to drop three magnitudes (Table 1), making it one of the fastest novae on record, if not *the* fastest. By contrast, the very fast nova V1500 Cyg (N Cyg 1975) faded by three magnitudes in 3.6 days, and George Alcock’s V838 Her (N Her 1991) took 3.2 days.

Before the eruption, V1674 Her was magnitude 20.5g, making the amplitude at least 14.6mag.

Hugh Allen reported a spectrum taken on Jun 12 which shows the P Cygni profile of the H-alpha emission, characteristic of a nova, along with other Balmer emission lines (Figure 17). From the blue-shifted H-alpha absorption, he estimated the velocity of the ejected material to be about 3,450km/s.

The spectrum evolved rapidly during the first six days of the eruption. Initially, the nova showed signatures suggesting it belonged to the Fe II class, but it later became more representative of the He/N class. Then, a spectrum obtained by Wagner *et al.* (2021) on

Figure 15. V1674 Her on 2021 Jun 14 at 01:12 UT. Field 0° 55′ × 0° 37′. Sky-Watcher Quattro 20cm *f*/4 Newtonian with ZWO ASI 294MC-Pro camera. Exposure: 65 frames of 60s each. The bright star in the image is a 5.3mag FF Aql, which has a range of magnitude 5.2–5.5 V. *(Mazin Younis)*

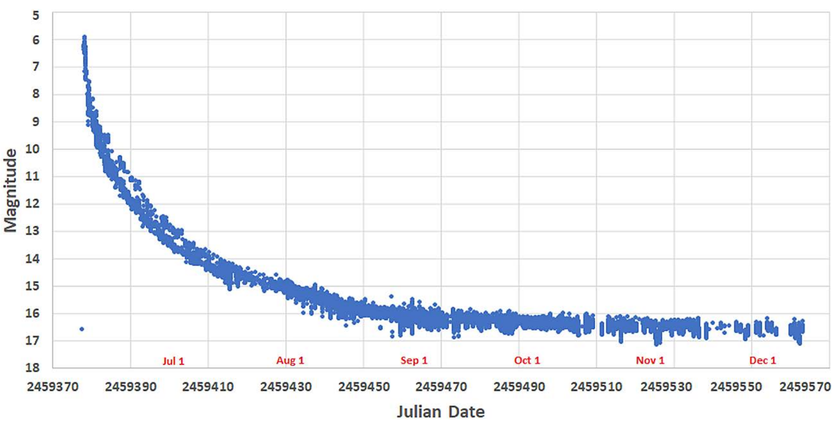


Figure 16. V1674 Her light curve. BAA and AAVSO databases combined vis, V, CV and TG, except for the first data point which is a pre-discovery measurement from the ASAS-SN survey (g-magnitude). Months shown in red start with 2021 Jul 1.

2021 Jun 30 revealed the presence of strong neon emission lines,[21] likely attributable to overabundances of neon. This demonstrates that V1674 Her is a member of the class of neon novae that includes QU Vul (1984), V838 Her (1991), and V1974 Cyg (1992) among others. Robin Leadbeater reported prominent Ne lines in the spectrum on 2021 Aug 27, 76 days after maximum, when the object was 16th magnitude.

Based on analysis of pre-eruption Zwicky Transient Facility photometry, the white-dwarf primary could be an intermediate polar with a spin period of 0.00580356d (8.357min).[22]

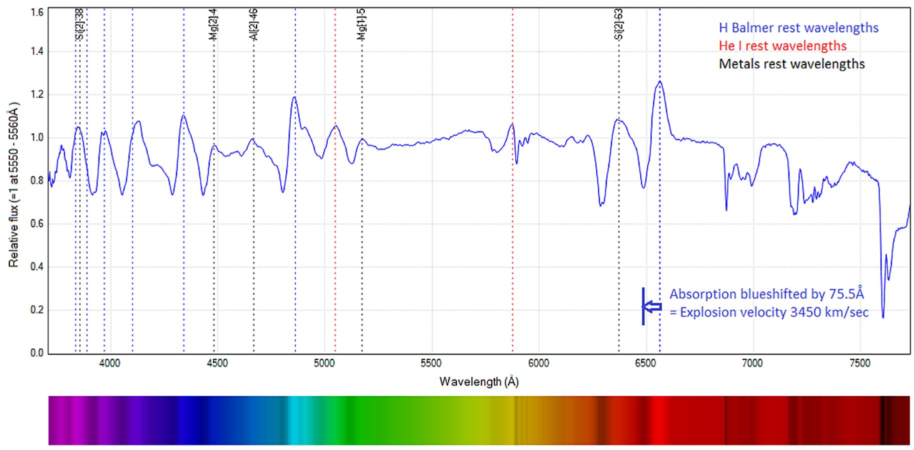


Figure 17. Spectrum of V1674 Her on 2021 Jun 12.939. *(Hugh Allen; generated using BASS Project 1.9.9)*

Nova Vul 2021 (V606 Vul)

This nova was discovered as a magnitude 12.0 transient in Vulpecula on 2021 Jul 16.475 by the nova patroller Koichi Itagaki (Yamagata, Japan).[23] Itagaki was using a 180mm camera lens with a CCD camera, continuing the recurring theme of simple imaging set-ups being used in nova discoveries. The precursor appears to have been a magnitude 21.9 star.

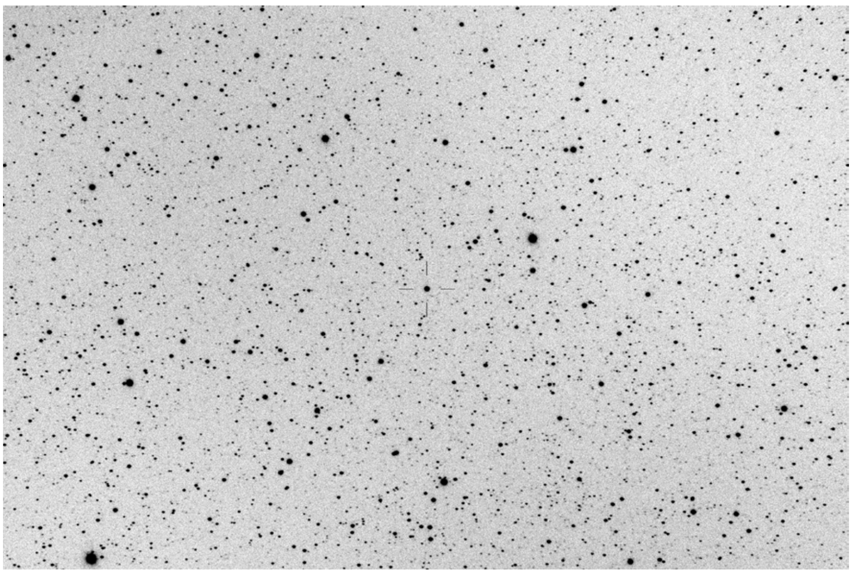


Figure 18. V606 Vul on 2021 Jul 16 at 21:37 UT. Field 28×18arcmin. 28cm SCT (Celestron C11 Edge) and ASI 6200MM; 10×60s. *(Nick James)*

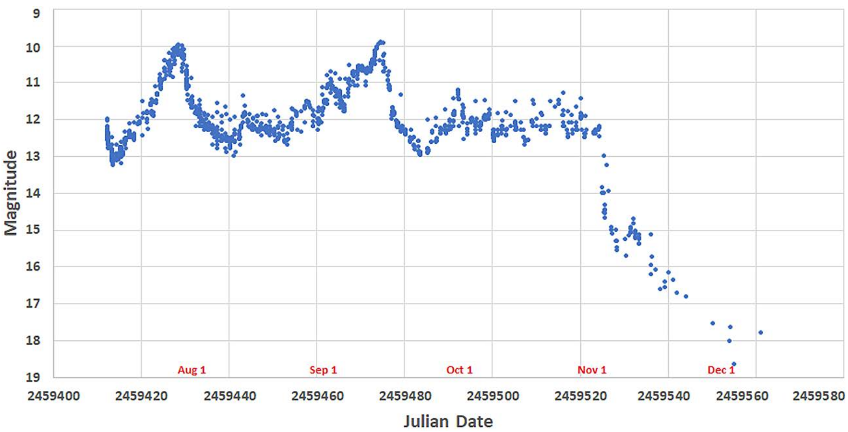


Figure 19. V606 Vul light curve. BAA and AAVSO databases combined vis, V, CV and TG. Months shown in red start with 2021 Aug 1.

The object was picked up after dusk in the UK on the same day (Jul 16) by Nick James in Chelmsford, at magnitude 12.0 in an electronic image (Figure 18), and visually by Gary Poyner in Birmingham, at magnitude 12.3. Early reports suggested that it was already declining in brightness soon after the discovery, reaching magnitude 13.2 on Jul 18, but it then started brightening again. The light curve shown in Figure 19 reveals a double-peaked maximum. The first maximum was magnitude 10.0, around Aug 2. The second was marginally brighter: magnitude 9.9 on Sep 17. The nova then varied between magnitude 11 and 13 until Nov 6, some seven weeks after discovery, when it began to fade towards quiescence. By the end of 2021 it was around magnitude 18: still approximately four magnitudes above quiescence. Due to the complexity of the first part of the light curve, and its double maximum, we did not determine t_2 and t_3.

Robin Leadbeater obtained a spectrum from Cumbria on discovery night, Jul 16.915 (Figure 20). This showed strong H Balmer, P Cygni-profile emission lines (with a velocity of ~1,400km/s) and other broad emission lines including He, indicating the object to be a nova. Once again, an amateur astronomer was able to provide spectroscopic confirmation of a nova.

Munari *et al.* (2021) obtained a spectrum on Jul 17,[24] suggesting it resembled novae of the He/N type, with Balmer, He I, and N II lines present in emission. However, they warned that with the nova possibly still progressing toward maximum light, the spectral type could evolve toward the Fe II type. Their warning was valid, as they subsequently confirmed it as a textbook example for a nova of that type on Jul 28.[25]

Rare eruption of the recurrent nova RS Oph

The binary system at the heart of a nova is not destroyed by the eruption. Therefore, some time afterwards, the accretion process can start again and

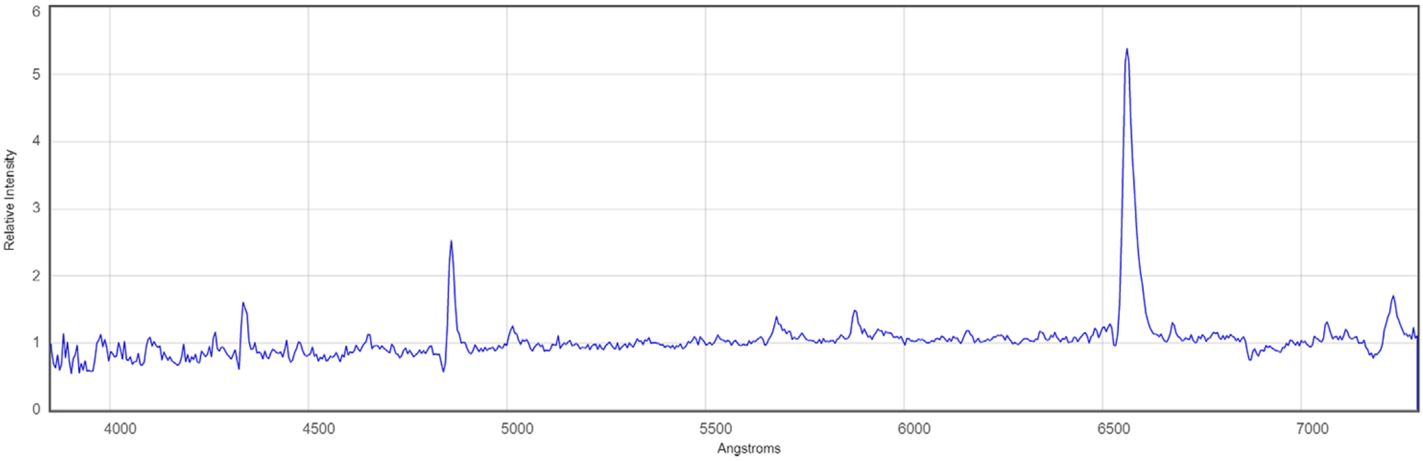


Figure 20. Spectrum of Nova Vul 2021 on 2021 Jul 16.915. *(Robin Leadbeater)*

eventually lead to a recurrence of the nova eruption. Most, if not all, novae are thought to recur on some timescale, although this might take many thousands of years. Recurrent novae are objects that have been seen to experience multiple nova eruptions. There are 10 known galactic recurrent novae, as well as several extragalactic ones.

The recurrent nova RS Oph was reported in eruption on 2021 Aug 8 by Keith Geary (Ireland), Alexandre Amorim (Brazil) and Eddy Muyllaert (Belgium), at magnitude 5. It was gratifying to see visual observers successfully detecting this astrophysically important event (it is worth noting that in eruption, the object is simply too bright for many survey patrols). The mean magnitude in the three weeks prior to the eruption was 11.2, which we take as quiescence. It has previously been observed to erupt in 1898, 1933, 1958, 1967, 1985, and, most recently, in 2006. A further two eruptions, in 1907 and 1945, have been inferred from archival data.

The light curve of the eruption is shown in Figure 21. Less than one day elapsed between the last observation at quiescence (magnitude 11.2) and it reaching magnitude 5, showing just how fast nova eruptions can be. The nova reached a peak magnitude of 4.4 the day after discovery and it was seen with the naked eye by some observers. No sooner had the peak been reached than the object started fading, dropping two magnitudes in 4.0 days and three in 8.2 days. It finally reached quiescence during the first week of 2021 November, giving a total eruption duration of ~93 days. The measured values of t_2 and t_3, 4.0 and 8.2 days respectively (Table 1), are consistent with this being a fast nova.

Within a few days of the eruption detection, RS Oph became distinctly orange as shown in the day-five eruption image by Mazin Younis (Figure 22).

At quiescence, RS Oph exhibits variability on a minute-to-hour timescale with amplitude 0.2–0.3mag. This is usually referred to as 'flickering' and is thought to be associated with the stochastic nature of the accretion flow from the secondary star as it interacts with the accretion disc. However, CCD photometry on 2021 Sep 2, Oct 4 and Oct 7 showed that there was no evidence of flickering, which confirms that the accretion disc around

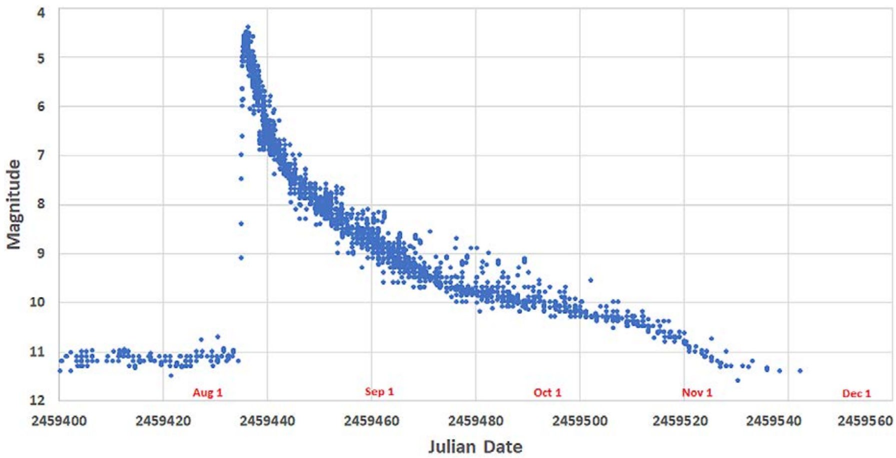


Figure 21. Light curve of RS Oph. BAA and AAVSO databases combined vis, V, CV and TG. Months shown in red start with 2021 Aug 1.

Figure 22. RS Oph on 2021 Aug 13. Sky-Watcher Quattro 200mm Newtonian *f*/4 and ZWO ASI 294MC-Pro; exposure 14min. *(Mazin Younis)*

the white dwarf was destroyed by the nova eruption.[26] Flickering disappeared after the 2006 outburst and was first detected again 240 days later.[27]

With a range between eruptions of nine to 26 years (mean, 15 years), we will have to wait a while until the next time RS Oph returns to the stage.

Discussion

One of the most exciting astronomical events is the occurrence of a nova. Such 'guest stars', whose sudden appearance can change the view of the heavens, have been observed since antiquity. During the last century, more than a dozen novae were bright enough to be visible to the unaided eye. The brightest of them all was Nova Aquilae 1918 (now known as V603 Aql), which for a time outshone all the other stars in the night sky apart from Sirius.

Whilst none of the novae discussed in this paper have been especially bright (although some did reach naked-eye visibility), they have provided immense pleasure to the people observing them. Their appearance has also attracted the attention of amateur astronomers who have never before observed a nova, or any other variable star for that matter. It appears that the occurrence of several novae in a relatively short period of time, and ones that have presented intriguing long-term variations in their light curves (such as the two novae in Cas), has attracted new people to the ranks of variable-star observers.

The six novae have also provided new astrophysical insights into these fascinating eruptions. The intent of this paper is to provide a timely update on the eruptions. The last word has yet to be written on these novae: the professional literature is already rich with citations and, undoubtedly, further papers will appear in due course. As noted in the Introduction, further analysis of the rich database of amateur spectroscopy of these systems, in particular, is warranted.

The discoveries reported here also show that amateur astronomers are still instrumental in the discovery of novae. It might be thought that the golden age of amateur nova discovery, epitomised by the achievements of George Alcock of Peterborough, is long gone in the present era of large synoptic sky surveys. Yet, we might now be in a new golden age when discoveries are made using off-the-shelf equipment, such as DSLR or CCD cameras coupled to telephoto lenses. The case of RS Oph also shows that visual observers are still very much 'in the game'.

Amateur astronomers play a vital role in follow-up observations of novae, both photometric (digital and visual photometry) and spectroscopic. The latter is set to be increasingly important in confirming and classifying nova eruptions, as well as shedding light onto the astrophysical evolution occurring during the nova light curve.

At the time of writing this paper, in 2022 January, all six of the novae discussed here are still being followed by amateur astronomers. Observers are urged to continue to follow them into the future until they finally drop below their thresholds of visibility. Very often, observers lose interest in an object after a while as their attention is attracted by new targets. The observations in the databases begin to get sparse and we lose track of a nova's return to quiescence. I therefore encourage readers to monitor them for as long as possible.

Acknowledgments

The author gratefully acknowledges the use of observations from the BAA, American Association of Variable Star Observers (AAVSO) and ASAS-SN databases. This research made use of SIMBAD, operated through the Centre de Données Astronomiques (Strasbourg, France) and the NASA/Smithsonian Astrophysics Data System.

Above all, he thanks all those who go out night after night to search for and follow up on these fascinating objects.

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The brighter comets of 2018

Jonathan Shanklin

A report of the Comet Section. Director: N. D. James.

This report describes and analyses observations of the brighter or more interesting comets at perihelion during 2018, concentrating on those with visual observations. Magnitude parameters are given for all comets with observations. Any evolution in the magnitude parameters of those periodic comets with multiple returns is discussed. Additional information on the comets discussed here, and on other comets seen or at perihelion during the year, may be found on the Section visual observations web pages.

Figure 1. 2016 M1 near 8th-magnitude globular cluster NGC 6352, imaged by Gerald Rhemann on 2018 Jul 3.

Introduction

57 comets or potential comets were assigned year designations for 2018, and 43 previously numbered periodic comets returned to perihelion. 193 comets detected by the SOHO satellite and 15 from STEREO were credited during 2018, including one returning object. 186 were members of the Kreutz group, 10 were of the Meyer group, seven were of the Marsden group (one a return), none were of the Kracht group and five were not associated with any known group. None of these objects were given a designation. There were three possible amateur discoveries (2018 E2, V1 and Y1), for which João Ribeiro de Barros, Don Machholz, Shigehisa Fujikawa and Masayuki Iwamoto may gain the Edgar Wilson Award, though there has been no formal announcement to date. 12 periodic comets were numbered during the year. One comet was reported as visible to the naked eye. Overall, 2018 was another disappointing year for visual comet observers, though brightened by the return of two periodic comets making close passes of Earth.

The remainder of this report covers only the comets that were at perihelion during the year. When periodic comets have visual or electronic observations at five or more returns and have not previously been analysed in detail over the past decade, the secular behaviour of the comet is considered, even though it may not qualify as a 'brighter' comet during the present return. Any evolution in behaviour is of interest, as is observation of a steady state.

Orbital elements for all the comets discovered and returning during the year can be found on the JPL Small-Body Database Browser,[1] which will also generate ephemerides. Discovery details and further information for the other comets found or returning during the year are available on the Section visual observations web pages,[2] which also contain links to additional background information. The raw visual observations for the year are on the Section visual observations web pages in ICQ

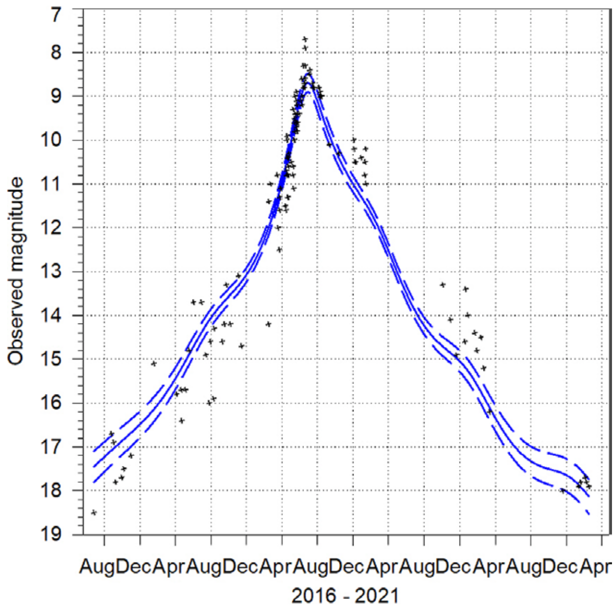

Figure 2. The observations of 2016 M1 with a standard light curve fitted to them. The dashed lines show the 95% confidence limits.

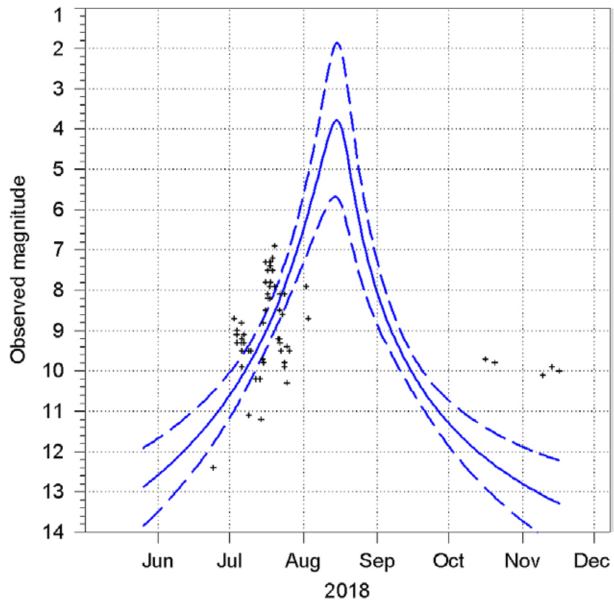

Figure 3. The observations of 2017 S3 with a nominal standard light curve fitted to them.

format, and in the Comet Observations database (COBS).[3] The full dataset from COBS is used for the multi-return analyses presented here, but otherwise only those submitted to the Section are included. Additional images of the comets are presented in the Section image archive.[4]

The comets given a discovery designation

2016 M1 (PanSTARRS)

Pan-STARRS discovered this comet on 2016 Jun 22.5 as a 20th-magnitude object. A few days later, Kevin Hills imaged it at 19th magnitude. He and a few other electronic observers continued to monitor it as it approached the Sun. Visual observers picked it up in 2018 February and in the northern hemisphere it was followed until June, but it was a southern-hemisphere object when at its brightest at the end of the month. Southern-hemisphere visual observers continued to follow it until early in 2019. Despite only reaching 9th magnitude, it was one of the better followed non-periodic comets of the year, saying something about the paucity of decent comets in this class.

Unusually, the observations were initially not well fitted by a single light curve, with the comet being distinctly brighter than indicated by the mean curve at the first two oppositions post-perihelion. However, at the third opposition in 2021 they were once again a good fit, showing that a partial light curve may give misleading predictions. The mean curve is shown in Figure 2, with magnitude parameters also being provided for pre- and post-perihelion fits in Table 3.

2017 S3 (PanSTARRS)

Pan-STARRS discovered this comet on 2017 Sep 23.2 as a 21st-magnitude object. A few days later, Kevin Hills imaged it at 20th magnitude. Visual observers suddenly picked it up at 9th magnitude in early July of 2018, when it was in outburst, several magnitudes brighter than expected. A second outburst took place later in the month, bringing it up to 7th magnitude. By late in the month it was best seen in the morning sky, so the number of observers declined. It was then at a high northern declination and passed close to open cluster NGC 2281.

It entered solar conjunction in early August and then remained too close to the Sun for further observation until October. It was intrinsically faint and did not survive its perihelion passage at 0.2au. The sequence of events leading to its demise is discussed by Zdeněk Sekanina & Rainer Kracht (2019).[5] Although there are some visual observations from October and November, these are

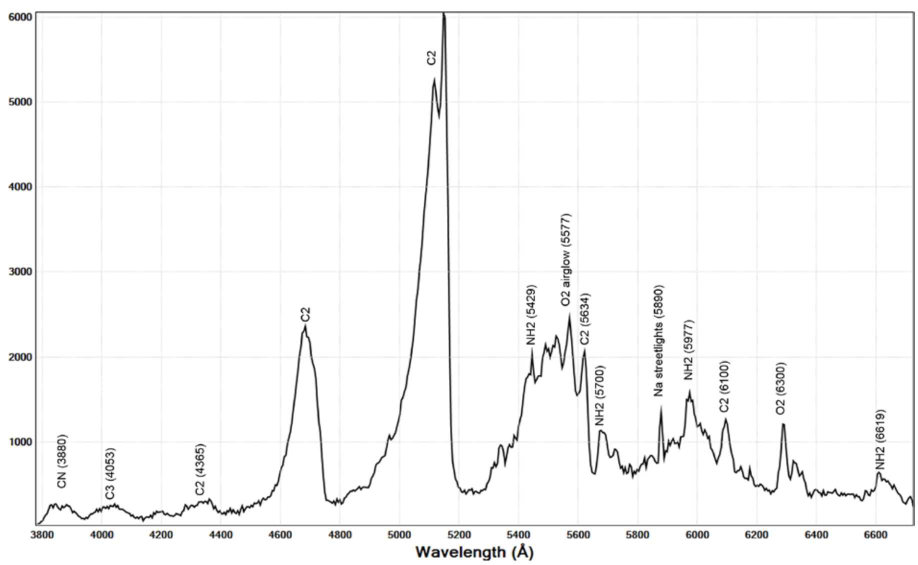

Figure 4. Spectrum of 2017 S3 obtained by Erik Bryssinck on 2018 Jul 18, 00:11 UT. C11 with L200–150l/mm grating spectrograph. 2×1200s exposures.

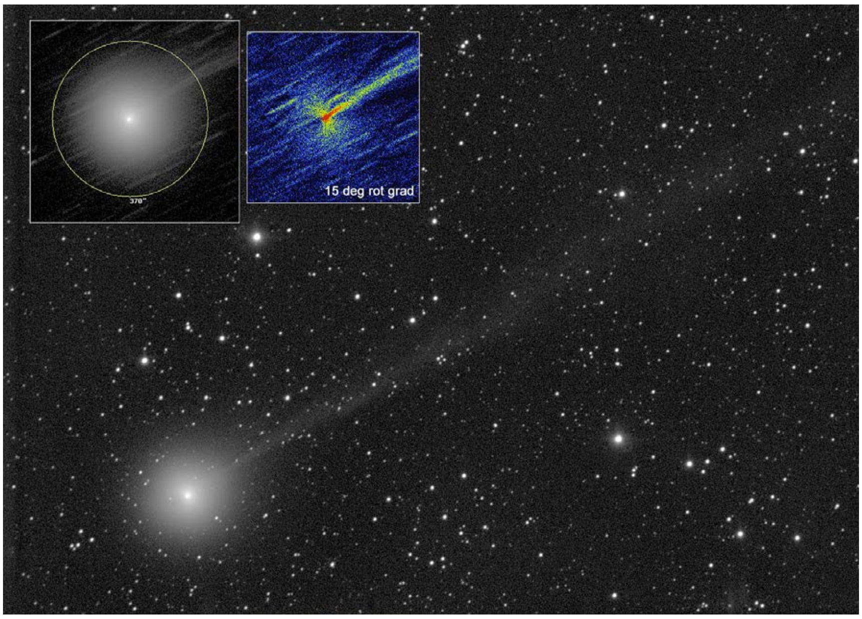

Figure 5. 2017 S3 imaged by Nick James on 2018 Jul 20, showing detail in the ion tail and jet activity in the coma. C11 Edge HD and Finger Lakes 1.211 Version N. 23×60s exposures.

Table 1. Photometric observers

Observer	*Location*
James Abbott	Witham, Essex
Alexander R. Baransky	Okhnovka, Ukraine
Denis Buczynski	Ross-shire
Nicolas Biver	Hawaii
Mike J. Collins	Everton, Beds.
Pieter-Jan Dekelver	Belgium
Len Entwisle	Elland, W. Yorks.
James Fraser	Alness, Ross-shire
Stephen Getliffe	Haverhill, Suffolk
Marco Goiato	Brazil
J. J. Gonzalez	Asturias, Spain
Werner Hasubick	Germany
Kevin Hills	Cheshire
Nick James	Chelmsford, Essex
Andreas Kammerer	Germany
Timo Karhola	Sweden
Carlos Labordena	Spain
Thomas Lehmann	Germany
Martin Masek	Prague, Czech Republic
Yoshimi Nagai	Koufu, Japan
Mieczyslaw L. Paradowski	Poland
Nirmal Paul	India
Jan Qvam	Borrevannet, Norway
Jonathan D. Shanklin	Cambridge
William C. de Souza	Brazil
David Swan	Tynemouth
Johan Warell	Sweden
Graham W. Wolf	New Zealand
Chris Wyatt	New South Wales, Australia
Seiichi Yoshida	Japan

much brighter than expected and were not confirmed by other observers. They could be illusory or might relate to the dispersing debris cloud of the disrupted comet nucleus.

2017 T1 (Heinze)

Aren (Ari) Heinze discovered an 18th-magnitude comet in images taken with the ATLAS (Asteroid Terrestrial-impact Last Alert System) 0.5m Schmidt at Mauna Loa, Hawaii on Sep 28.6. It was another intrinsically faint comet. However, it passed close to Earth on its way to perihelion and reached 10th magnitude when it did so. Closest approach was at 0.22au on Jan 4, when it was at high northern declination and convenient for viewing in the early evening. The orbit has a miss distance of 0.014au, and therefore a meteor shower might be possible, though no meteor shower was reported. The comet moved rapidly across the sky and became poorly placed after early February.

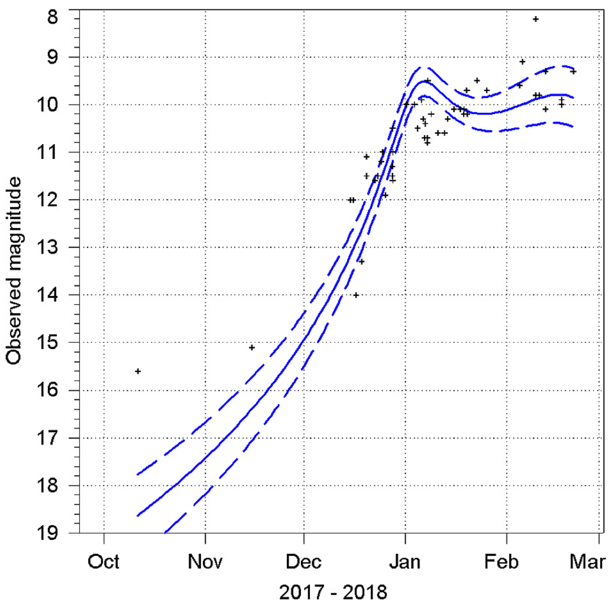

Figure 6. The observations of 2017 T1 with a standard light curve fitted to them.

2018 V1 (Machholz–Fujikawa–Iwamoto)

Don Machholz visually discovered a 10th-magnitude comet from Colfax, California on Nov 7.5, with a 0.47m reflector. This was his 12th discovery, with 746 hours of searching since his last. Two Japanese CCD imagers also discovered the comet, with Shigehisa Fujikawa (Kan'onji, Kagawa, Japan), finding it in images taken on Nov 7.82, and Masayuki Iwamoto (Awa, Tokushima, Japan) in

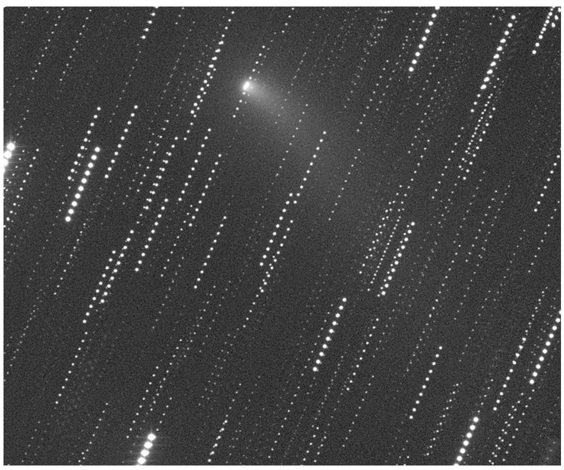

Figure 7. 2017 T1 imaged by Peter Carson on 2017 Dec 28, showing a curved dust tail. 315mm *f*/8 Dall–Kirkham reflector on a Paramount with a 0.66× focal reducer and ST8300 IR/UV cut-off filter. 10×120s exposures.

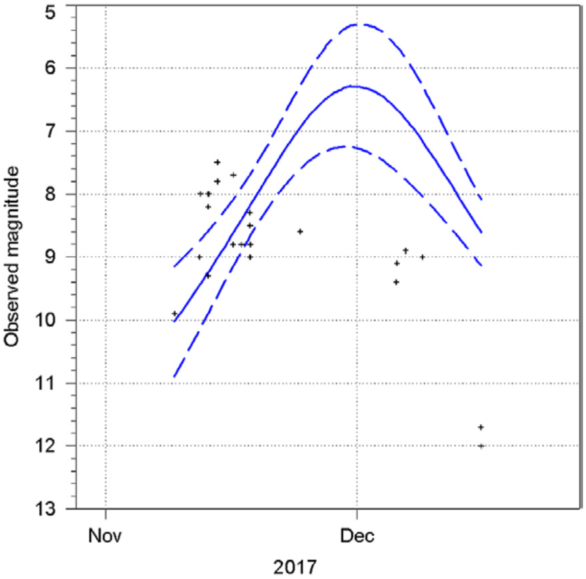

Figure 8. The observations of 2018 V1 with a standard light curve fitted to them.

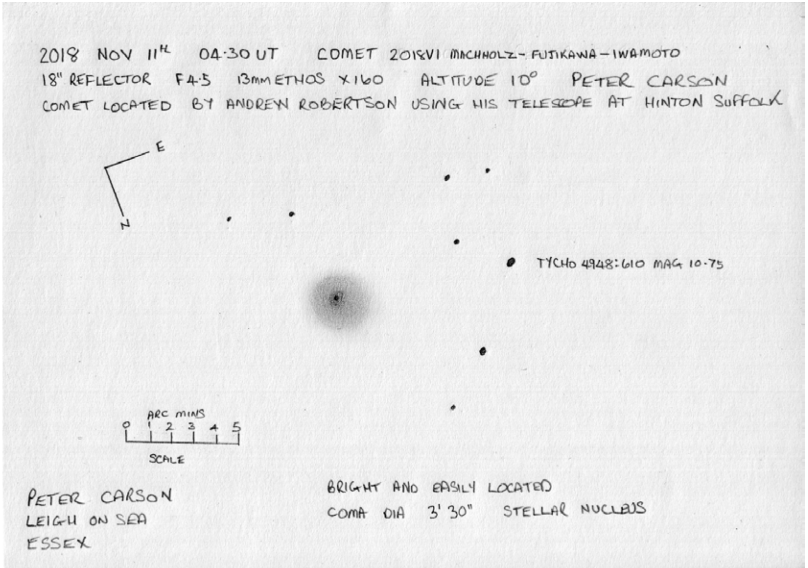

Figure 9. 2018 V1 drawn by Peter Carson on 2018 Nov 11, using Andrew Robertson's 0.45m reflector at Hinton, Suffolk.

images taken on Nov 7.84. The comet was emerging from solar conjunction and nearing perihelion at 0.4au in early December. It should have brightened throughout November, but the observations show little change in brightness. After perihelion it faded rapidly. This suggests that it was another intrinsically faint comet that barely survived perihelion.

The numbered periodic comets at perihelion in 2018

21P/Giacobini–Zinner

The comet was described and the observations up to that return analysed in the paper on the comets of 2012.[6] The 2018 return was a very good one and when the comet was at its closest, in September, it was 0.39au from Earth.

It came into visual range in June and brightened rapidly. The first binocular observations were made in early August, with Jonathan Shanklin estimating it at 8.5 in his 25×100 pair. By the end of the month, it was visible in smaller binoculars, with James Fraser seeing it in 20×60s and Stephen Getliffe using 7×50s. It peaked at 7th magnitude in early September. It was then moving south and back into the morning sky, but suitably placed visual observers were able to follow it until the end of November. It passed relatively near several open clusters, and these provided good opportunities for imagers, with many excellent photographs contributed to the BAA archive. The linear magnitude curve is a better fit to the observations than the standard logarithmic curve.

The magnitude parameters for this return are similar to the mean parameters determined using the combined observations from all previous returns, confirming the long-term stability of the comet. In the paper on 2012 comets, it was suggested that it might show a delta effect, whereby the comet appears fainter than expected when having a large coma. At this return the coma was well condensed at the time of closest approach, and never became greater than 15 arcminutes in diameter, with most observers not reporting it greater than 10 arcminutes. The H_{10} magnitude is 0.4mag fainter than the long-term mean, though this is much smaller than the difference expected for the delta effect, suggesting that this was not a major factor in the light curve at this apparition.

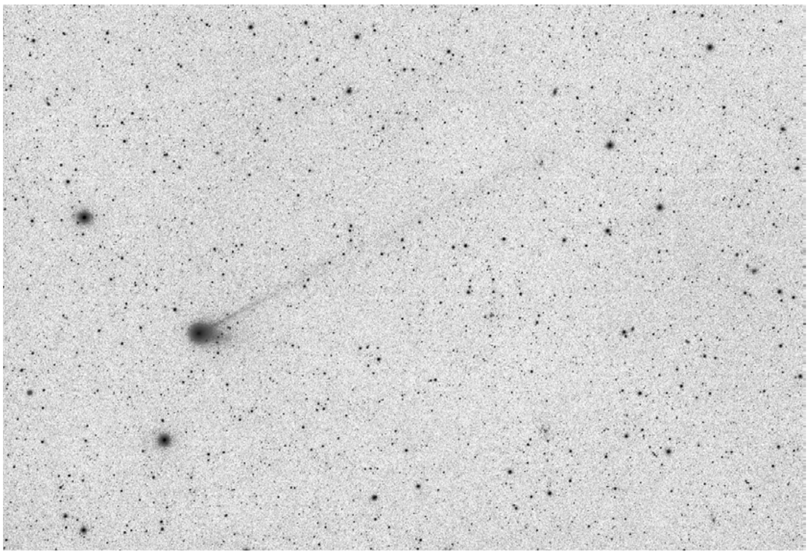

Figure 10. 2018 V1 imaged by José J. Chambó on 2018 Nov 16.

38P/Stephan–Oterma

This comet was actually discovered by Jérôme Coggia at the Marseille Observatory, but the credit was taken by the Observatory Director, E. J. M. Stephan, who obtained the first accurate position. It was then lost until a comet found in 1942 by Liisi Oterma at Turku, Finland was computed to be a return of Stephan's comet. It is a Halley-type comet with a period of 38 years. The Section observed it at its last return in 1980/'81, when it reached

9th magnitude. Sky conditions were very different then, when Jonathan Shanklin was able to observe the well-condensed comet in 10×80 binoculars from Cambridge Observatory. At this return three observers did see it in binoculars, but all used 10cm-aperture instruments. It was around 12th magnitude at the beginning of August and brightened to a peak of 10th magnitude in November, around the time of perihelion. Electronic observers followed it until 2019 June. It developed a short tail, with visual observers reporting it to be up to 15 arcminutes in length.

The magnitude parameters used at the last return are quite different to those found at this return, with the comet apparently brightening and fading much more rapidly at the previous return and consequently having a much brighter absolute magnitude. This is probably due to the analysis being heavily weighted by the author's own observations, the instrument for which switched between 10×80 binoculars at perihelion and the 0.32m Northumberland refractor when the comet was fainter. The large refractor makes comets appear much fainter than when viewed through a shorter-focus reflector or binoculars, but no aperture correction was applied in the derivation. Both the linear and standard parameters found for this return are a reasonable fit to the observations at the last one, but unfortunately looking forward to 2056 the comet will not put on a good display. It reaches perihelion when some 2au from the Earth.

46P/Wirtanen

Carl A. Wirtanen discovered this comet at Lick in 1948. It is in a chaotic orbit, and its perihelion distance was much reduced due to approaches of Jupiter in 1972 and 1984. It has been reported to outburst, but BAA data suggests that it was just rejuvenated after the

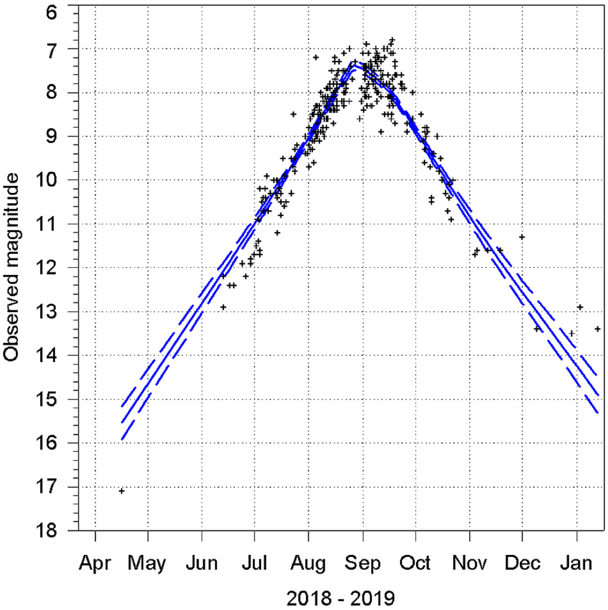

Figure 11. The 2018 observations of 21P/Giacobini–Zinner, with a linear light curve fitted to them.

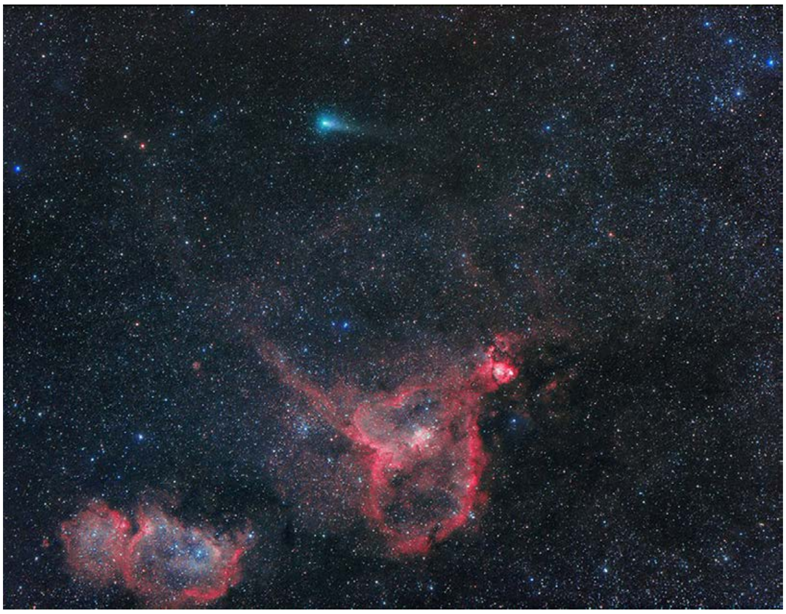

Figure 12. 21P/ Giacobini–Zinner near the Heart & Soul nebulae, imaged by Michael Jäger on 2018 Aug 16.

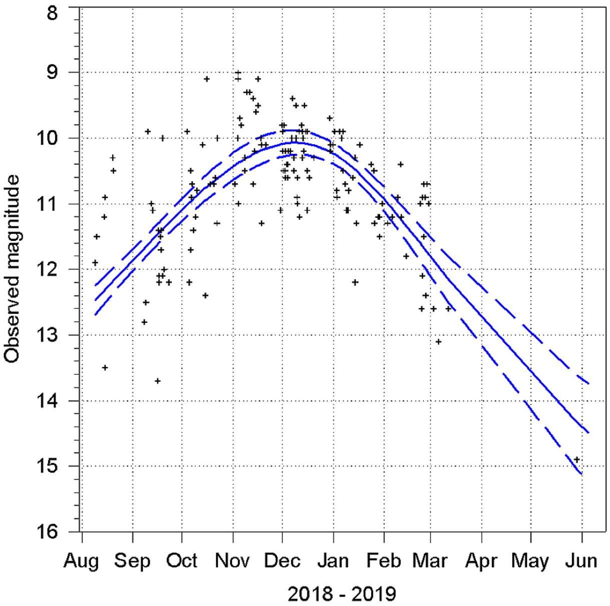

Figure 13. The 2018 observations of 38P/Stephan–Oterma, with a standard light curve fitted to them.

Figure 14. 38P/Stephan–Oterma imaged by Damian Peach on 2018 Nov 15.

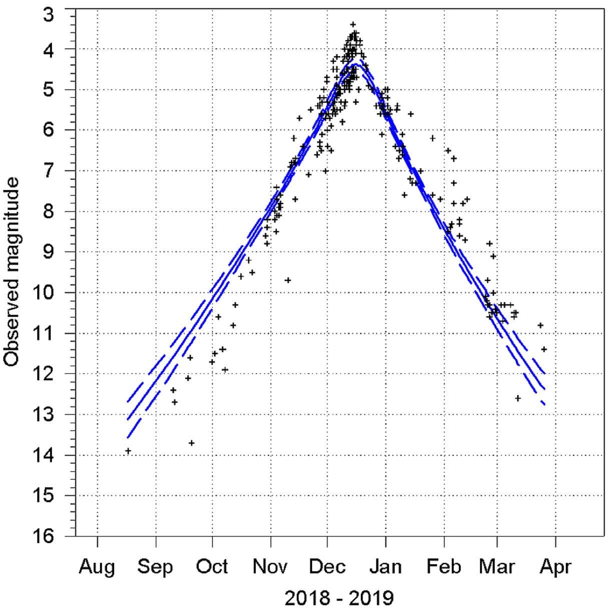

Figure 15. The 2018 observations of 46P/Wirtanen, with a standard light curve fitted to them.

Figure 16. A composite series of images of 46P/Wirtanen taken by Justin Tilbrook, showing the increasing coma diameter between Sep 15 and Oct 18.

Figure 17 *(right)*. 46P/Wirtanen, imaged by Martin Mobberley on 2018 Dec 1 at 11:20 UT. TeleVue NP127FLI and PL16803 CCD; LRGB. L = 3×180s, RGB = 120s each.

perihelion distance was reduced. A December perihelion gives a very close approach to Earth and this was achieved in 2018, when the comet passed 0.078au from us.

Kevin Hills made an electronic observation of the comet in mid-August, when it was 14th magnitude. The first visual observations were made in September, with J. J. Gonzalez estimating it at 12th magnitude mid-month, and Werner Hasubick making it some two magnitudes fainter. The comet was brightening rapidly when it came into general view in October. By late in the month, it was already visible in large binoculars. Through November it brightened further and was seen with the naked eye by a few observers at the end of the month. It had remained poorly placed for UK observers until mid-November, and it was not until Dec 2 that the combination of weather and moon allowed widespread observation. Jonathan Shanklin made it 6.5 in 20×80 binoculars from central Cambridge, whilst Mike Collins and Stephen Getliffe both made it 5.9 in 7×50 binoculars. It was brightest in December, peaking at 4th magnitude around the time of perihelion in mid-month, with several observers reporting a naked-eye coma diameter of over 90 arcminutes. It faded rapidly but remained well placed for northern-hemisphere observers. By mid-January it was already down to 7th magnitude, with James Fraser putting it at 7.0 in 10×50 binoculars on Jan 12, with a coma diameter of 24 arcminutes. Mike Collins continued observing it into early March, when it had faded to 10th magnitude in his 0.25m Schmidt–Cassegrain telescope. Kevin Hills made a final observation on Jun 2, by which time it had faded to 16th magnitude.

The coma was generally reported as being more condensed in December, despite its large apparent size. Nicolas Biver and Stephen Getliffe were the only observers to report any tail development, though the direction reported by Getliffe was not consistent with that reported by imagers. The majority of images only show an elongated coma; a few show a narrow ion tail with occasional hints of two tails.

The comet was a target for a pro-am observing campaign, though few results have been published so far. Professional observations suggest that the nucleus has a possible rotation period of 9.2 hours and is about 1.2km in diameter. TESS observations caught a minor outburst of 0.5 magnitudes on 2018 Sep 26, which was followed from the start. It may have arisen from a source region of a few tens of metres in diameter.

There are observations in the COBS database over six returns. These suggest that there is a slow secular fading of the comet, which shows when all the observations are plotted together in Figure 19. The average K value over all returns (16.0) was used to compute the corresponding H value at each return, which is plotted in Figure 20. The best fit shows the decline in absolute magnitude, although the confidence lines indicate that the null hypothesis (*i.e.*, no change in absolute magnitude) is also compatible with the observations. The perihelion distance has only changed by a small amount over the six returns, which suggests that the theory that the

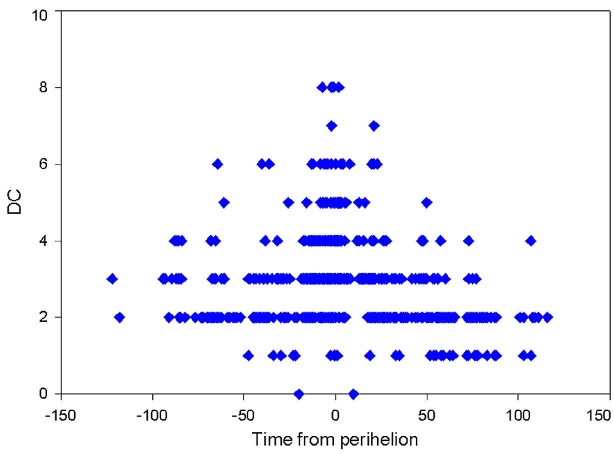

Figure 18. The degree of condensation (DC) of the coma of 46P/Wirtanen. Whilst the overall increase in DC around perihelion is clear, so is the huge disagreement between observers.

comet was rejuvenated following the reduction in perihelion distance may be correct. The perihelion distance remains near its current value until after the 2040 return, but then Jupiter encounters progressively increase it to 2au by the end of the century.

59P/Kearns–Kwee

This was definitely not one of the brighter comets of the year. However, there are observations over seven returns since its discovery. It was found during a search for the then lost 11P/Tempel–Swift–LINEAR at the Palomar Observatory by E. Kearns and Kiem King Kwee in 1963 August. The comet had been put into its present orbit during a close encounter

Table 2. Astrometric, electronic, photographic & visual imagers during 2018

Observer	*Location*	*IAU Stn. No.*
Paul Abel	Leicester	
Tony Angel	Spain	Z85
Alexander Baransky *et al.*	Ukraine	585
Peter Birtwhistle	Great Shefford	J95
Erik Bryssinck	Belgium	B96
Denis Buczynski	Tarbatness	I81
Montse Campas	Spain	213
Peter Carson	Leigh-on-Sea, Essex	K02
José Chambó	Spain	
Alfons Diepvens	Belgium	C23
John Drummond	New Zealand	
Dave Eagle	Higham Ferrers, Northants.	
Nick Evetts	New York, USA	G40, U69
James Fraser	Alness, Ross-shire	
Mike Glenny	Gloucestershire	
Ernesto Guido *et al.*	Italy	H06, Q62
Tim Haymes	Reading	
Kevin Hills	Cheshire	J22
Michael Jäger	Austria	
Nick James	Chelmsford, Essex	970
Manos Kardasis	Greece	
Rob Kaufman	Australia	
Rolando Ligustri	Italy	235
Gordon Mackie	Caithness	
Mikhail Maslov	Russia	
Martin McKenna	Maghera, Co. Derry	
Richard Miles	Stourton Caundle, Dorset	J77
Martin Mobberley	Cockfield, Suffolk	480
Mike Olason	USA	
Nirmal Paul	India	G40, Q62, W88
Damian Peach	Selsey	
Danilo Pivato	Italy	
Grant Privett	Fovant, Wiltshire	
Alex Pratt	Leeds	Z92
Jan Qvam	Norway	
Gerald Rhemann	Austria/Namibia	
Andrew Robertson	Broome, Norfolk	
Richard Sargent	Chester	
Chris Schur	USA	
David Storey	Isle of Man	987
David Strange	Worth Matravers, Dorset	
David Swan	Tynemouth	
Justin Tilbrook	South Australia	D86
Alan Tough	Elgin, Scotland	
Adriano Valvasori	Italy	H06
John Vetterlein	Rousay, Orkney	
Johan Warell	Sweden	K60

Many additional observers submitted their images to the BAA archive, but for brevity only the BAA and *The Astronomer* observers, together with those whose images are utilised in this paper, are listed in this table.

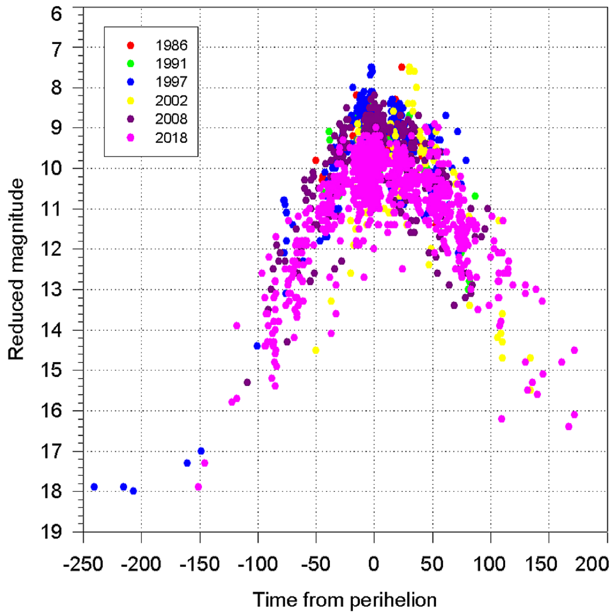

Figure 19. Composite plot showing the magnitude of 46P/Wirtanen at returns since 1986, corrected for its distance from Earth.

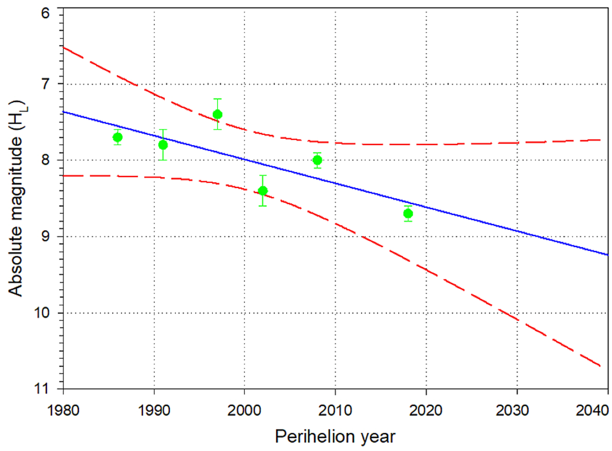

Figure 20. The change in the H_{16} absolute magnitude of 46P/Wirtanen with time, showing a possible slight fading. The red dashed lines show the 95% confidence interval.

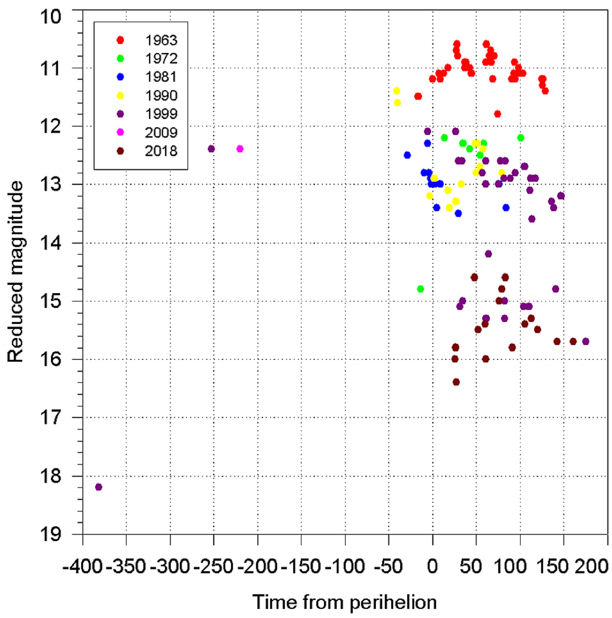

Figure 21. Composite plot showing the magnitude of 59P/Kearns–Kwee at returns since 1963, corrected for its distance from Earth.

Table 3. Magnitude parameters of comets

a) Standard magnitude parameters

Comet	No. obs.	r (au)	H_1	K_1	H_{10}	
2015 O1 (PanSTARRS)	70	3.7–8.1	4.5±0.6	7.7±0.8	3.0±0.1	
2016 M1 (PanSTARRS)	130	2.2–8.9	5.1±0.2	6.9±0.3	3.5±0.1	
2016 M1 (PanSTARRS) (pre-perihelion)	98	2.2–7.7	4.9±0.2	7.7±0.5	3.8±0.1	
2016 M1 (PanSTARRS) (post-perihelion)	32	2.2–8.9	4.4±0.4	7.3±0.5	2.6±0.2	
2016 N6 (PanSTARRS)	93	2.7–6.9	4.9±0.4	8.9±0.8	4.3±0.1	
2016 Q4 (Kowalski)	3	7.1–7.5			4.8±0.5	
2016 R2 (PanSTARRS)	194	2.6–6.1	7.9±0.4	1.5±0.7	3.8±0.1	
2017 K4 (ATLAS)	14	2.7–4.3			7.8±0.2	
2017 K6 (Jacques)	7	2.0–4.5			7.0±0.2	
2017 S3 (PanSTARRS)	65	0.5–5.0	8.0±0.2	4.8±0.9	8.0±0.2	
2017 S6 (Catalina)	4	1.7–2.2			10.2±0.9	
2017 T1 (Heinze)	52	0.6–2.4	11.2±0.1	10.2±1.0	11.2±0.1	
2017 T3 (ATLAS)	17	0.8–3.9	8.6±0.1	8.5±0.2	8.4±0.1	
2018 A3 (ATLAS)	32	3.3–4.7	4.4±0.6	13.3±1.0	6.4±0.1	
2018 C2 (Lemmon)	8	2.0–2.3			10.3±0.1	
2018 EF_9 (Lemmon)	2	1.6			8.0±0.1	
2018 F1 (Grauer)	3	3.3–3.9			8.8±0.1	
2018 L2 (ATLAS)	20	1.7–4.5	3.2±0.4	16.6±1.1	5.5±0.3	
2018 L5 (Leonard)	4	2.4–2.5			11.5±0.3	
2018 M1 (Catalina)	4	1.3–2.3			13.6±0.2	
2018 N1 (NEOWISE)	32	1.3–1.6			9.2±0.2	
2018 V1 (Machholz–Fujikawa–Iwamoto)	25	0.4–0.7			11.1±0.3	
21P/Giacobini–Zinner	282	1.0–2.1	8.9±0.0	10.8±0.6	8.7±0.0	
37P/Forbes	39	1.6–2.5	7.6±1.0	14.7±4.0	8.8±0.2	
38P/Stephan–Oterma	151	1.6–2.9	8.6±0.3	5.4±1.3	7.5±0.1	
46P/Wirtanen (2018)	951	1.1–2.2	9.5±0.0	12.0±0.3	9.7±0.0	
46P/Wirtanen (all)	1778	1.1–2.8	8.6±0.0	16.0±0.5	9.0±0.0	
48P/Johnson	39	2.0–2.3			7.5±0.2	
49P/Arend–Rigaux	10	2.1–3.1			10.5±0.2	
59P/Kearns–Kwee (2018)	16	2.4–2.7			10.5±0.2	Secular fade
60P/Tsuchinshan (2018)	112	1.6–2.3	11.1±0.6	8.0±2.0	10.7±0.1	
60P/Tsuchinshan (2012 + 2018)	113	1.6–2.3	11.3±0.6	7.3±2.3	10.7±0.1	
60P/Tsuchinshan (1999 + 2005)	16	1.8–2.0			12.7±0.3	
60P/Tsuchinshan (all)	129	1.6–2.3	10.7±0.8	10.9±3.0	10.9±0.1	
64P/Swift–Gehrels (2018)	521	1.4–2.4	9.8±0.2	5.0±1.2	8.9±0.1	
64P/Swift–Gehrels (all)	794	1.4–3.4	9.9±0.3	3.5±1.4	8.8±0.1	Poor fit
66P/du Toit	33	1.3–2.4	8.3±0.6	17.9±2.8	9.8±0.2	Poor fit
74P/Smirnova–Chernykh (2018)	77	3.5–4.4	7.8±1.8	9.0±3.0	7.2±0.1	
74P/Smirnova–Chernykh (all)	205	3.5–4.8	6.8±0.9	10.0±1.5	6.8±0.1	
105P/Singer Brewster	5	2.1–2.3			10.9±0.3	
125P/Spacewatch	2	1.8–2.2			13.2±0.0	
130P/McNaught–Hughes	6	2.4 –3.0			8.3±0.5	
137P/Shoemaker–Levy	11	1.9–2.4			11.8±0.2	
143P/Kowal–Mrkos	13	2.5–3.4			10.2±0.1	
159P/LONEOS	15	3.7–4.8			7.5±0.2	
164P/Christensen	12	2.1–3.3			9.8±0.1	
185P/Petriew	16	0.9–1.2	10.0±0.3	23.9±5.5	10.5±0.2	
187P/LINEAR	6	3.9–4.2			9.1±0.4	
235P/LINEAR	5	2.7			10.9±0.1	
240P/NEAT	19	2.3–3.4			6.8±0.2	
247P/LINEAR	6	1.5–1.6			15.2±0.2	
250P/Larson	1	2.2			13.1	
361P/Spacewatch	4	2.8–3.0			8.5±0.2	
364P/PanSTARRS	14	0.9–2.2			13.3±0.5	
365P/PanSTARRS	5	1.4–1.6			14.7±0.2	
368P/NEAT	6	2.1–2.3			11.5±0.1	
369P/Hill	4	2.0–2.1			10.7±0.3	
370P/NEAT	3	2.8–3.1			11.4±0.1	
371P/LINEAR–Skiff	4	2.2–2.3			13.5±0.0	
(400) Phaethon	5	1.0–1.3			14.9±0.8	
(944) Hidalgo	5	1.9–2.0			9.0±0.1	

b) Linear magnitude parameters

Comet	No.	Days	H_1	K_1	ΔT
21P/Giacobini–Zinner	282	–147–125	8.7±0.0	0.0283±0.0014	14.9±1.1
37P/Forbes	39	–14–210	10.3±0.4	0.0216±0.0069	–45.6±10.5
38P/Stephan–Oterma	159	–94–206	9.6±0.1	0.0057±0.0014	12.2±11.7
60P/Tsuchinshan (all)	129	–104–173	12.9±0.2	0.0115±0.0030	–55.3±9.0
64P/Swift–Gehrels (2018)	521	–90–184	9.0±0.1	0.0330±0.0009	–52.5±1.1
64P/Swift–Gehrels (all)	794	–90–311	8.9±0.1	0.0325±0.0015	–57.3±1.9
66P/du Toit	33	–90–165	9.4±0.3	0.0443±0.0053	–23.8±4.0
74P/Smirnova–Chernykh (2018)	77	–893–580	12.4±0.2	0.0014±0.0004	159.2±71.3
74P/Smirnova–Chernykh (all)	205	–1204–1698	12.2±0.1	0.0010±0.0002	30.6±63.5

with Jupiter in 1961 November, when it passed 0.03au from the planet. The perihelion distance was reduced from 4.3au to 2.2au. A more distant encounter in 1997 March increased the perihelion distance slightly, to 2.3au.

The mean light curve is not well defined, as most observations are near to or post perihelion. It is however clear from Figure 21 that the absolute magnitude of the comet has decreased since its discovery. Assuming a standard *K* value of 15, the corresponding *H* value was computed for each return. There was only one observation in 2008 and this was made a long way from perihelion, so the *H* value is not used. Figure 22 shows that there has been a significant fade in the absolute magnitude. If the decline continues, the comet will again be around 16th magnitude during the next return, when at its brightest in late 2027.

60P/Tsuchinshan

This comet was the second discovered in 1965 January at the Purple Mountain Observatory. The perihelion distance has been slowly decreasing over the last 100 years, with it being 1.8au at discovery and 1.6au at this return. There are observations in the COBS database over four returns, with the best covered being the one in 2018, when it reached 13th magnitude when brightest.

At the 1999 return the comet was best observed prior to perihelion, whilst in 2018 it was better covered after perihelion. The two intervening returns were poorly observed. The scatter in the observations makes it difficult to say much

The magnitude of the comets can be calculated from the equation:

$$m = H_1 + 5.0 \log(\Delta) + K_1 \log(r)$$

For many comets there are insufficient observations or too small an arc to calculate K_1 accurately and so a value of 10 is assumed, which gives the constant H_{10}. CCD observations approximating to visual, which include a measure of the coma diameter, are included. A correction for aperture of 0.0033mm^{-1}, and the observer corrections derived in previous papers,[8,9] have been applied and the *H* values are reduced to zero aperture.

Some comets do not follow the standard equation and are better fitted with a linear equation:

$$m = H_1 + 5.0 \log(\Delta) + K_1 \operatorname{abs}(t - T + \Delta t)$$

where *t* is the Julian Date, *T* the Julian Date of perihelion and Δt an offset. If Δt is positive, the comet is intrinsically brighter prior to perihelion.

about the long-term photometric behaviour, though taking all of them together, there is a slightly better fit to a linear light curve peaking about 55 days after perihelion. An alternative view would be that the comet was significantly brighter at the 2018 and 2012 returns than it was at the 2005 and 1999 returns, which would tie in with the reduced perihelion distance. If this view is correct, the comet will be at a similar brightness as in 2018 at the 2025 return, which is at a similar perihelion distance.

64P/Swift–Gehrels

This object just qualifies as a brighter comet as it reached 9th magnitude in 2018. Observations have been made over five returns, though it was only well observed at two of them. It was discovered by Lewis Swift in 1889, then lost until re-found by Tom Gehrels in 1973.

The comet is in a relatively stable orbit and the perihelion distance has remained steady at around 1.3au. It has only been well observed when perihelion has coincided with opposition, as it did in 1981 and 2018 and will do so again in 2046 and 2092. The two well-observed returns show a similar absolute magnitude and there is no evidence for secular fading. The peak brightness occurs 57 days after perihelion, in one of the clearest linear light curves for any comet.

74P/Smirnova–Chernykh

The comet was discovered following a pair of encounters with Jupiter that reduced its perihelion distance from 5.7au to 3.5au by 1963. The perihelion distance has remained near this value, but another encounter in 2021 will push it out to 4.8au. The comet was found by Tamara Mikhajlovna Smirnova in 1975 on plates taken at the Crimean Astrophysical Observatory, with Nikolaj Stepanovich Chernykh confirming it on a plate taken a fortnight later. A pre-discovery image was later found on a plate taken in 1967, reported as an asteroid.

Four returns since 1992 have observations in the COBS database, with the comet reaching 13th magnitude at the 2018 return. Because it is in a low-eccentricity orbit, the rate of brightening is slow and the comet can be observed over several oppositions at each return. The fit of the observations to both standard and linear light curves is similar. For the linear curve, the slowly changing brightness makes the timing of when the comet is intrinsically brightest indeterminate. The observations show no secular change in absolute magnitude.

Acknowledgements

Thanks are due to Guy Hurst for preparing cometary material for publication in *The Astronomer* magazine. Acknowledgement is also given to the British Antarctic Survey and the Institute of Astronomy, Cambridge for the use of computing facilities. Information on comet orbits was also obtained from Internet pages by Kazuo Kinoshita.[7]

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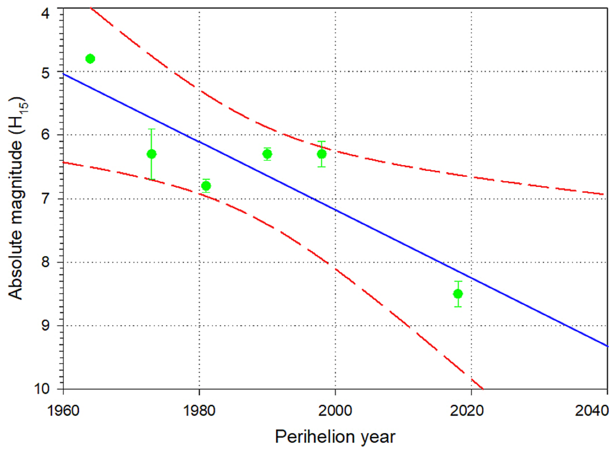

Figure 22. The change in the H_{15} absolute magnitude of 59P/Kearns–Kwee with time, showing a fading. The red dashed lines show the 95% confidence interval.

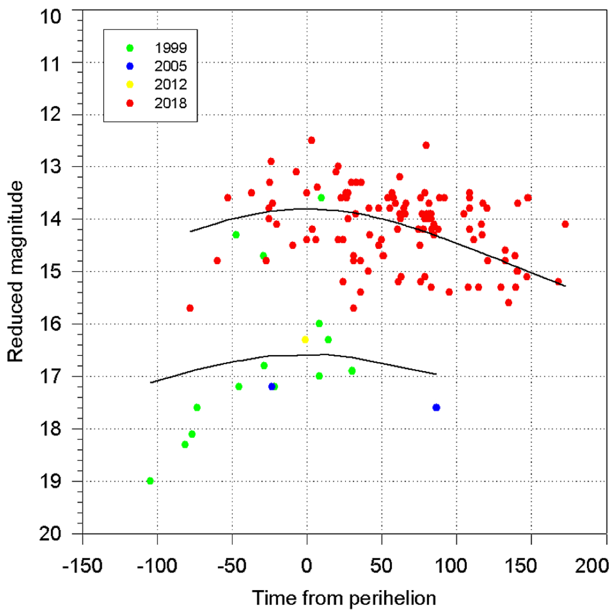

Figure 23. Composite plot showing the magnitude of 60P/Tsuchinshan at returns since 1999, corrected for its distance from Earth. The curves show the means for 1999/2005 and 2012/2018.

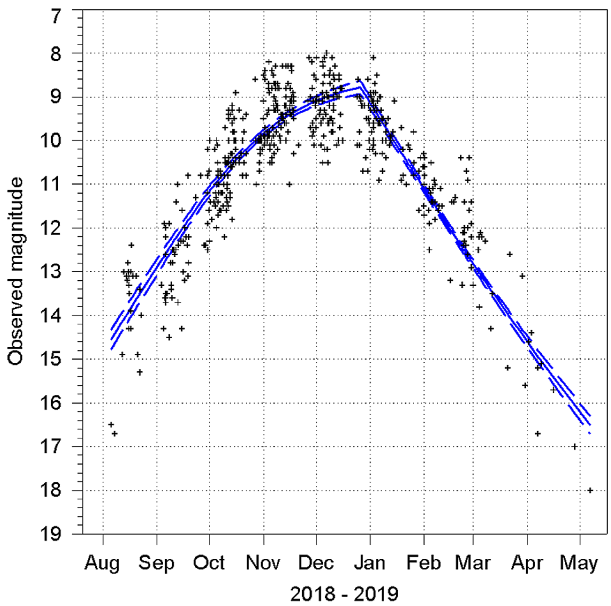

Figure 24. The 2018 observations of 64P/Swift–Gehrels with a linear light curve fitted to them.

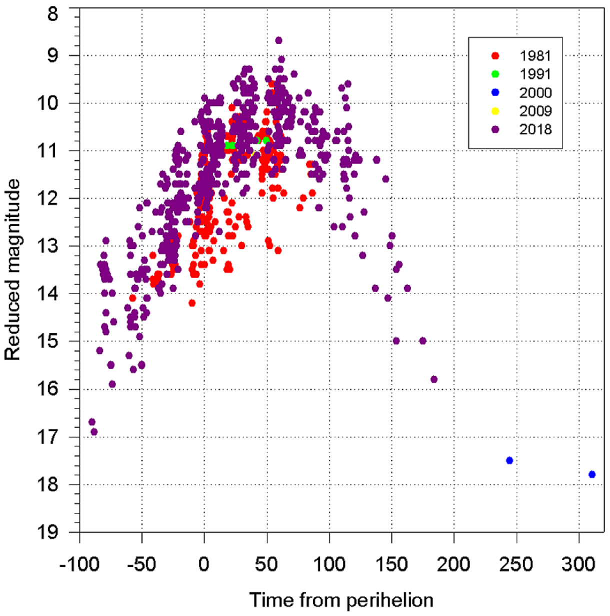

Figure 25. Composite plot showing the magnitude of 64P/Swift–Gehrels at returns since 1981, corrected for its distance from Earth.

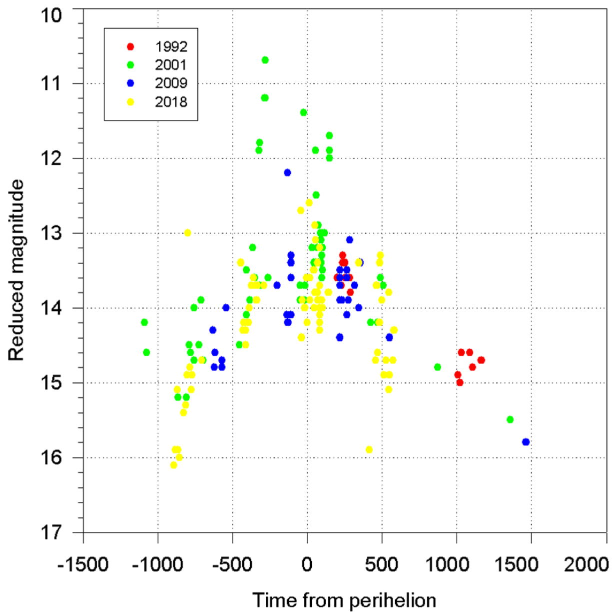

Figure 26. Composite plot showing the magnitude of 74P/Smirnova–Chernykh at returns since 1992, corrected for its distance from Earth.

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Visibility times of Martian afternoon clouds

Richard W. Schmude, Jr.

This paper reports local times when afternoon clouds become telescopically visible for several locations on Mars. With the exception of dust storms, the times are consistent with historical records. It is concluded that late afternoon orographic clouds form near at least one of the four large *Tharsis* volcanoes throughout the Martian year. During 2018 and 2020, *Argyre* appeared as a northward projection on the South Polar Cap, near L_s = 170°. This is in line with the analyses of BAA observations reported by R. J. McKim for 1999 and 2001.

Introduction

This paper summarises formation times of telescopically visible clouds throughout the Martian year. Diurnal clouds (those that form and dissipate each day) are examined here. The word 'cloud' refers to a white patch that is bright in blue and ultraviolet light; it is believed that a feature with this characteristic is a condensate cloud. Clouds in many areas are examined and visibility times are reported. They display regular patterns. Nearby dust storms, however, may prevent clouds from forming. In this study, the Martian year is broken into 20-degree increments of areocentric longitude (L_s), starting with 0–20°. The beginning of northern spring, summer, autumn and winter are at L_s = 0, 90, 180 & 270°, respectively.

Phase-angle brightening

Under clear Martian skies, a few of the large volcanoes become bright near opposition.[1–3] For example, a *Hubble Space Telescope* image made on 2005 Nov 7 shows the *Elysium* volcanoes as bright spots.[1] Much of this brightening may be due to the phase angle dropping.[3] The brightening is most obvious when orographic clouds are not present, during southern spring and summer. During the other two seasons, clouds usually mask this brightening.

The 'W' Cloud & Equatorial Cloud Belt (ECB)

During northern spring and summer, many of the late-afternoon clouds discussed in this report become part of either the W cloud or the Equatorial Cloud Belt (hereafter ECB) systems. Slipher (1962) shows several photographs of the W cloud.[4] It forms in the *Tharsis* area. Figure 1A shows an image of it and Figure 1B shows the outline of a 'W'. The top-right point of the W is near *Arsia Mons*, and the bottom-right point is near *Ascraeus Mons*. This cloud system has been observed since at least 1907.[4]

The ECB is a second type of seasonal cloud system that develops. Two images of it are shown in Figure 1. It is usually more transparent than the W cloud and is best seen in blue and ultraviolet light. It lies near the equator and is visible at most longitudes.

A brief history of the repeating nature of white clouds

The repeating nature of cloud development on Mars has been known for many decades. For example, Slipher (1921) points out that the clouds he observed over *Syrtis Major* in 1920 were similar to those Lowell observed in 1903 and 1905.[5] Thomson (1924)

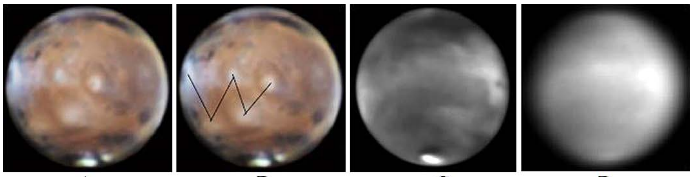


Figure 1. Images of the W cloud and the Equatorial Cloud Belt (ECB). **(A)** 2014 Apr 9 (03:58 UT) by E. Morales Rivera (W cloud). **(B)** Same as (A), except the writer has drawn an outline of a 'W' to show the cloud pattern. **(C)** 2012 Mar 30 (02:21 UT), blue filter, by D. Parker (ECB). **(D)** 2017 Dec 9 (23:31.4 UT), blue filter, by T. Olivetti (ECB).

reports a diurnal cloud over *Syrtis Major* in 1918 as being similar to one observed in 1903.[6] British observers saw a 'zig-zag' streak near *Ceraunius* in 1935,[7] which was probably associated with the W cloud. Capen (1966; p.23) reports that 'recurrent clouds have been observed to form over the same areas of the Martian surface for the past 62 years'.[8]

Smith & Smith (1972) carried out an extensive study of blue-light photographs made at the Lowell and Pic du Midi observatories.[9] They focused on *Hellas*, *Elysium* and *Nix Olympica* (the bright spot associated with *Olympus Mons*) and studied photographs made between 1924 and 1971. They conclude that the white spots (probably clouds) follow a seasonal cycle for all three features, but only *Elysium* and *Nix Olympica* brighten as the day progresses. They also report that *Elysium* and *Nix Olympica* reach peak activity during L_s = 90–130°. Spacecraft results are also consistent with clouds following regular seasonal patterns. For example, Smith (2009) reports that the water ice aerosols forming the Equatorial Cloud Belt developed at nearly the same seasonal date between 2002 and 2008.[10]

McKim summarises BAA results for all Mars apparitions between 1980 and 2012.[11–26] Later in this paper, the general trends in evening cloud visibility are compared to the results here.

Goal of the study

The goal of this study is to estimate cloud visibility times in selected areas. McKim (2018) describes the difficulty of comparative meteorology and stresses the need for a database of ground-based observations over many years.[25] He describes over three decades of cloud observations.[11–26] Furthermore, the current ALPO Japan website has thousands of Mars images spanning over 20 years.[27] Therefore, the writer believes a sufficient number of ground-based images is available to construct a table of afternoon-cloud visibility times throughout a Martian year.

Table 1. Locations of features used in this study

Feature	*Location*	*Feature*	*Location*
Aeria	310°W, 17°N	Edom Pr.	346°W, 2°S
Alba Patera	110°W, 39°N	Elysium	214°W, 24°N
Arabia	321°W, 31°N	Libya	275°W, 2°N
Argyre	42°W, 50°S	Olympus Mons	134°W, 20°N
Arsia Mons	121°W, 9°S	Pavonis Mons	113°W, 1°N
Ascraeus Mons	105°W, 11°N	Syrtis Major	295°W, 10°N
Eden	351°W, 28°N	Zephyria	190°W, 10°S

Table 2. Apparitions from which images were used, for the different L_s ranges

L_s range (deg)	*Apparitions used*	*L_s range (deg)*	*Apparitions used*
0–20	2007, 2010	180–200	2003, 2020
20–40	2010	200–220	2003, 2020
40–60	2010, 2012	220–240	2003, 2020
60–80	2010, 2012	240–260	2003, 2005
80–100	2012, 2014	260–280	2005, 2020
100–120	2012, 2014, 2016	280–300	2005, 2018
120–140	2014, 2016	300–320	2003, 2005
140–160	2014, 2016, 2018	320–340	2005, 2009
160–180	2016, 2018, 2020	340–0	2005, 2009

In spite of the large set of images now available, those from 2007 June–November could not be used because of the planet-encircling dust storm then taking place.[28,29] This created uncertainty in cloud formation times for L_s = 320–360°. The writer believes cloud activity returned to normal by early December of 2007.

The areas described here include *Arsia*, *Pavonis*, *Ascraeus* and *Olympus Mons*; *Alba Patera*, the *Elysium* region, *Syrtis Major*, *Libya*, *Edom Promontorium* (*Edom Pr.*), *Eden*, *Arabia*, *Aeria*, *Argyre I* (*Argyre*), and *Zephyria*. The results are believed to correspond to times when there are no large dust storms. Therefore, they may be used in measuring the impact of dust storms on cloud formation times. One may also determine year-to-year differences in formation times.

Method & materials

The writer used images from the website of the ALPO Japan to determine the visibility of afternoon clouds.[27] He used blue and colour images made between 2003 and 2020. Blue-filter images showing detail similar to that in red, as well as green filter images, were avoided because of the possibility of a red leak. He also wanted to determine afternoon-cloud visibility times throughout the Martian year. The local Martian time for a feature was determined using a method described elsewhere.[30] The coordinates of a feature were used to determine the local time.[31,32] (See Table 1.)

A Mars map by Antoniadi (1930) was used for the locations of the selected albedo features examined in this study.[32] Since some clouds only form near the afternoon terminator, it was crucial to analyse images made before opposition. At other times, images made after opposition were examined to determine when certain clouds first formed, since the morning terminator is visible then. The objective was to determine the latest time when a cloud in a particular area was not visible telescopically; and the earliest time when it was visible. In many cases, the software package *WinJUPOS* was used to verify cloud positions. Estimated times of cloud visibility were determined.

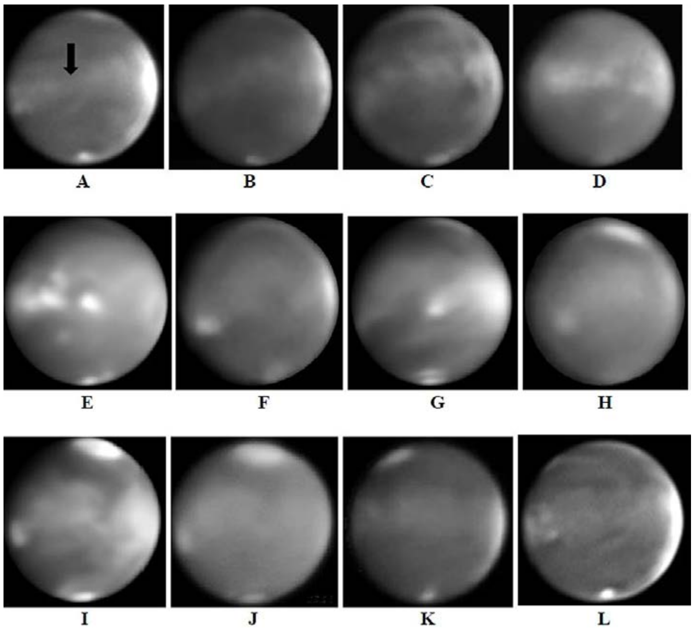


Figure 2. Images of the ECB for L_s = 92–103°. South is at the top in all images. All were made in 2014 in blue light. **(A)** Mar 10 (02:35.6 UT), λ = 13°W, by C. Pellier. (Note how thin the ECB is at the arrow.) **(B)** Mar 13 (05:39 UT), λ = 31°W, by E. Morales Rivera. **(C)** Mar 10 (06:23 UT), λ = 68°W, by E. Morales Rivera. **(D)** Mar 7 (06:46 UT), λ = 101°W, by E. Morales Rivera. **(E)** Mar 4 (07:05 UT), λ = 131°W, by D. Parker. **(F)** Feb 27 (07:21 UT), λ = 182°W, by E. Morales Rivera. **(G)** Feb 23 (07:41 UT), λ = 224°W, by D. Parker. **(H)** Feb 20 (07:14 UT), λ = 245°W, by E. Morales Rivera. **(I)** Feb 18 (07:34 UT), λ = 268°W, by D. Parker. **(J)** Mar 15 (23:11 UT), λ = 298°W, by M. Kardasis. **(K)** Mar 13 (01:11.5 UT), λ = 326°W, by J. J. Poupeau. **(L)** Mar 13 (03:02 UT), λ = 353°W, by C. Pellier.

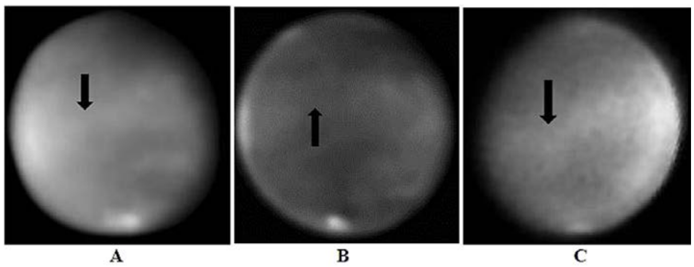


Figure 3. Similar ECBs in different years. South is near the top in all images. The arrows point to the thin portion of the ECB near 10°W. **(A)** 2010 May 22 (20:04 UT), λ = 18°W, by D. Peach. **(B)** 2012 Apr 3 (02:55 UT), λ = 24°W, by E. Morales Rivera. **(C)** 2016 Feb 17 (03:17.8 UT), λ = 19°W, by C. Foster.

The historical records were examined to look for consistency with the reported values in this study.[11–22] Essentially, the writer constructed a table showing the areocentric longitude values of the Sun as seen from Mars (L_s value) at the middle of each month for the relevant years (1980–2003). This enabled the clouds, as reported by McKim on a terrestrial, monthly basis, to be placed into L_s intervals. Those observations were compared to those reported here.

Results

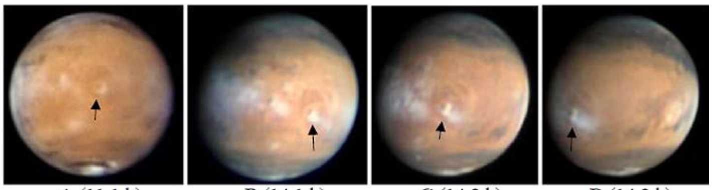
The local times when afternoon clouds develop in 14 selected areas are reported. Images made during the planet-encircling dust storm in 2007 were used,[28,29] to determine how a global dust storm affects the visibility of afternoon clouds in two areas. This is discussed later. Table 2 shows the oppositions used for each 20-degree increment of areocentric longitude. Before specific clouds are discussed, an overview of the ECB is given since clouds in many of the 14 selected areas become part of it.

Equatorial Cloud Belt

McKim makes a quick seasonal comparison of the ECB based on images made over several apparitions.[23–26] Data from the *Mars Odyssey* spacecraft show that the Belt is composed of water ice crystals.[10] Figure 2 shows images of the ECB at different central meridian longitudes for L_s = 92–103°. All images were made in 2014. Its shape changes with longitude. For example, it is narrow, in the north–south direction, at 10°W (Figure 2A) but is wide at 270°W (Figure 2I). The mean 2014 latitudes of the ECB in Figure 2 are 2°S (southern edge) and 23°N (northern edge). This is consistent with spacecraft data.[10,33] The ECB has an average width of 25° of latitude, or just under 1,500km. This is close to the estimated span of 20° of latitude reported by Capen on 1965 Mar 19.[8]

The ECB does not have a uniform brightness; parts of it have brighter clouds than others. For example, the *Elysium* area in Figure 2G is much brighter than clouds to the left (east) of it. Some of the late afternoon clouds over the *Tharsis* volcanoes, *Syrtis Major* and *Aeria* are also brighter than much of the ECB. The ECB is broken up by the *Tharsis* volcanoes, although they may possess individual orographic clouds.

Does the ECB change from one year to the next? In Figure 2A (arrow), one may see that the ECB is narrow near 10°W. This is evident in the L_s = 84–97° map in Wang & Ingersoll (2002),[33] made in late 2000, and in images made in 2010, 2012 and 2016. See Figure 3 (arrows). Furthermore, the mean 2014 ECB latitudes are consistent with the maps of water ice crystals for 2002–'08.[10] These observations show some year-to-year consistency of the ECB. Nevertheless, dust storms may affect the ECB. McKim reports that at least seven dust storms, or about 4% or those between 1704 and 1993, developed in the area and seasonal date of the ECB.[34] Therefore, changes may occur.



A (11.1 h) **B** (14.1 h) **C** (14.2 h) **D** (14.2 h)

Figure 4. Development of orographic clouds near *Olympus Mons* (arrowed) and surrounding areas for L_s ~ 125°. The local time for the disc centre (or central meridian) is given below each image. In all cases, south is near the top. **(A)** 2014 Apr 24 (12:58 UT), by T. Kumamori; local time of 10.8h for *Olympus Mons*. **(B)** 2016 Mar 25 (08:26.5 UT), by D. Peach; local time of 12.2h for *Olympus Mons*. **(C)** 2016 Mar 18 (06:00.7 UT), by D. Peach; local time of 14.3h for *Olympus Mons*. **(D)** 2016 Mar 18 (08:20.8 UT), by D. Peach; local time of 16.6h for *Olympus Mons*.

Afternoon clouds over the *Tharsis* volcanoes, *Elysium* & *Syrtis Major*

Table 3 shows approximate local times when clouds are first visible over these areas. The local times correspond to when clouds are visible in images made through Earth-based telescopes. Clouds may form earlier but could be either too thin or too small to be seen from Earth.

The *Tharsis* volcanoes are among the most consistent cloud-forming areas on Mars. McKim (2019) shows a set of images illustrating the development of the *Tharsis* volcano clouds at different times for 2012.[26] Figure 4 shows a similar cloud development for local times between 10.8 and 16.6h. Apparently a ring of clouds forms around *Olympus Mons* (arrow) in the late morning and also develops near *Ascraeus* and *Pavonis Mons*. This happens near the northern summer solstice, (L_s = 90°). As these volcanoes reach local noon, the clouds become thicker and also start forming near *Arsia Mons*. The cloud around *Olympus Mons* is larger than the one around *Arsia Mons*. Near southern summer solstice (L_s = 270°), clouds form around *Arsia Mons* before *Olympus Mons*. Furthermore, the cloud near *Arsia Mons* is larger than the one near *Olympus Mons*. This is apparent in Figure 13A in McKim (2010),[22] and is confirmed here. The differences are largely due to the different latitudes of those two volcanoes. Essentially, they sample different water vapour abundances. At L_s = 90° the water vapour source is the North Polar Cap, which is closer to *Olympus Mons*, but at L_s = 270° it is probably within the south polar area, which is closer to *Arsia Mons*.

Orographic clouds develop in the *Tharsis* region throughout the Martian year. The clouds start forming at an earlier time near the northern summer solstice than at other times. An analysis of the reports by McKim for 1980–'93 shows that at least one of the four *Tharsis* volcanoes (*Arsia*, *Pavonis*, *Ascraeus* or *Olympus Mons*) has late-afternoon orographic clouds throughout the

Table 3. Approximate times when afternoon clouds form: *Tharsis* volcanoes, *Elysium* & *Syrtis Major*

L_s interval (deg)	FEATURE *Olympus Mons*	*Arsia Mons*	*Pavonis Mons*	*Ascraeus Mons*	*Alba Patera*	*Elysium*	*Syrtis Major*
0–20	12	12	14	14	13	11	13
20–40	12	13	13.5	13.5	13	12	15
40–60	10.5	13	13	13	AD	12	14.5
60–80	10[a]	13.5[a]	13[a]	12.5[a]	11	AD	14
80–100	10	12	10.5	10	10	12	13.5
100–120	9.5	12	11	11	10	8	12.5
120–140	10	12	10	10	10[b]	AD	13
140–160	10.5	13	13	13	14	10	14
160–180	15	12	12.5	12.5	13.5	13	16.5
180–200	15	13.5	16	16	D	17	17
200–220	16	13	15	15	D	NV	16
220–240	>17	13	17	17	D	17[c]	17
240–260	15	11	18	18	D	NV	NV
260–280	16	13	17	NV[d]	D	NV[e]	15
280–300	17	11.5	15	15	D	17	16
300–320	15.5	11	14	14	D	17.5	14
320–340	15	13	14.5	14.5	D	>15	16.5
340–360	>17	13	>15	>15	D	>13	13.5

[a] A thin morning haze surrounded *Olympus*, *Arsia*, *Pavonis* and *Ascraeus Mons* in 2012 mid-March and in 2012 April. The four volcanoes appeared as dark spots, and hence the writer considered these volcanoes to be free of orographic clouds.

[b] *Alba Patera* appears bright on the morning limb. It is difficult to distinguish between morning hazes/frosts and orographic clouds.

[c] Grafton and Parker imaged a bright spot near *Elysium Mons* on 2003 Aug 11 and Aug 12, respectively. The *Elysium* region, however, is not bright.

[d] Nearby clouds imaged on 2005 Aug 30 by C. Pellier.

[e] Peach imaged bright spots at *Elysium Mons* and *Hecates Tholus* on Sep 6; see Figure 5G. The *Elysium* region is not bright. Each of the bright spots is about 150km across.

Notes
The times are based on an analysis of images made between 2003 and 2020 (excluding those made during 2007 June–November). The number represents the estimated local time when significant clouds were imaged (for example, 12h = local noon); AD means clouds were present all day; NV means clouds were not imaged at any time of the day; D means the feature was too far north or south to be studied; >15 means no significant clouds formed before this time but may have developed later.

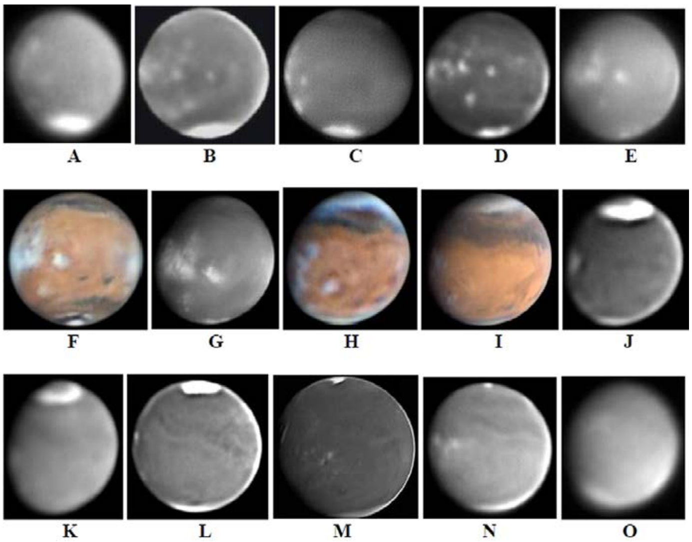


Figure 5. Orographic clouds near *Olympus Mons* and other *Tharsis* volcanoes throughout the Martian year. These clouds are on the left (eastern) half of the disc. South is near the top in all images. **(A)** L_s = 17°, 2009 Nov 30 (19:08 UT), by T. Ikemura; blue. **(B)** L_s = 36°, 2010 Jan 9 (18:02 UT), by A. Yamazaki; blue. **(C)** L_s = 54°, 2010 Feb 20 (22:31 UT), by B. A. Kingsley; blue. **(D)** L_s = 71°, 2012 Feb 16 (06:12 UT), by E. Morales Rivera; blue. **(E)** L_s = 88°, 2014 Feb 10 (17:59 UT), by J. Kazanas; blue. **(F)** L_s = 106°, 2014 Mar 26 (21:40 UT), by A. Obukhov; colour. **(G)** L_s = 124°, 2016 Mar 18 (06:00.7 UT), by D. Peach; blue. **(H)** L_s = 155°, 2018 Apr 8 (09:00 UT), by Y. Goryachko, K. Morozov, M. Abgaarian, and D. Kananovich; colour. **(I)** L_s = 175°, 2018 May 13 (08:38.6 UT), by D. Peach; colour. **(J)** L_s = 198°, 2003 Jun 5 (09:46 UT), by D. Parker; blue. **(K)** L_s = 211°, 2020 May 31 (10:13.9 UT), by M. Hood; blue. **(L)** L_s = 240°, 2003 Aug 13 (06:09 UT), by D. Parker; blue. **(M)** L_s = 277°, 2020 Sep 13 (03:17.7 UT), by D. Peach; blue. **(N)** L_s = 299°, 2005 Oct 3 (03:18 UT), by M. Mobberley; blue. **(O)** L_s = 325°, 2009 Aug 22 (02:35 UT), by M. Abgarian, Y. Goryachko, and K. Morozov; blue.

Martian year.[11–17] Figure 5 confirms this for 2003–'20. A large dust storm, however, may prevent clouds from forming.

Elysium is also bright during much of the Martian year. Table 3 shows frequent cloud cover occurs for L_s = 0–180°. In some cases, this area is bright throughout the day. During L_s = 180–360°, clouds may develop during the late afternoon or not at all. Figure 6 shows *Elysium* clouds at different times of the day for L_s = 60–80°.

During 2003 Aug 11–12 and 2020 Sep 6, the *Elysium* region was not bright; however, *Elysium Mons* was bright on these dates and *Hecates Tholus* was bright on 2020 Sep 6. See Figure 7G. It is not clear whether the brightening of just the volcanoes is caused by clouds, frost, their slopes facing the Sun more directly, or some other factor. The phase angle of Mars for 2020 Sep 6 was 30°, which is too high for phase brightening. Others also imaged *Elysium Mons* as bright in 2020 September–November.[27]

Afternoon clouds often form over *Syrtis Major*. These were noted at most L_s intervals between 1995 and 2007 June.[18–24] Historical observations are generally consistent with the results in Table 3. Figure 8 shows clouds over *Syrtis Major* for different values of L_s. Afternoon clouds over this area for L_s = 40–140° may be part of the ECB.[24–26]

Afternoon clouds over *Arabia, Aeria, Libya, Zephyria, Edom Pr. & Eden*

Typical start times for the formation of clouds over *Arabia*, *Aeria*, *Libya*, *Zephyria*, *Edom Pr*. and *Eden* are summarised in Table 4.

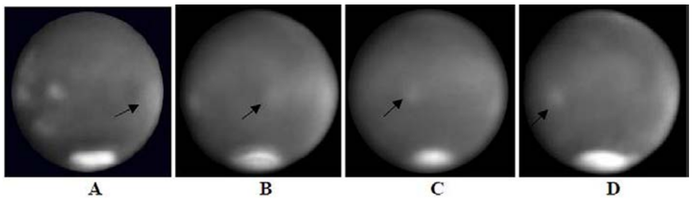


Figure 6. Images of cloud cover over *Elysium* during late northern spring (L_s = 60–80°). South is at the top for all images and the number followed by h is the local time of the centre of *Elysium* (214°W, 24°N) where 12h means the Sun is transiting the meridian as seen from the region. **(A)** 2012 Jan 29 (22:12 UT), by S. Ghomizadeh; blue, 10.1h. **(B)** 2012 Feb 2 (02:56 UT), by D. Peach; blue, 12.7h. **(C)** 2012 Feb 6 (07:03 UT), by E. Morales Rivera; blue, 14.2h. **(D)** 2012 Jan 27 (02:40 UT), by D. Peach; blue, 16.3h.

Two of the general trends are that clouds form at all times of the Martian year in *Libya* whilst those in *Arabia*, *Aeria*, *Edom Pr*. and *Eden* form more frequently during L_s = 0–180° than during 180–360°. Another trend is that clouds in *Libya* may spill over into *Moeris Lacus* and *Isidis Regio*; Figure 7 shows examples of clouds in these areas.

Afternoon clouds/frost over *Argyre*

Argyre is centred at 50°S, 42°W,[31] and hence is often too far south to be observed from Earth. Furthermore, the South Polar Hood may move over it during L_s = 0–160°. Dust storms also develop in *Argyre* (see Figure 9C) and they may lead to an absence of clouds. Finally, *Argyre* should get colder than the other areas in Table 4, because of its southerly latitude leading to frost formation. During L_s = 160–360°, Mars' southern hemisphere is usually tipped towards Earth, and this allows for the study of *Argyre*.

Figures 9D & E show examples of afternoon clouds (or frost) in *Argyre*. Table 4 gives times when afternoon clouds develop there. During L_s = 340–360°, morning clouds (or frost) also develop in *Argyre* and may persist after 11h. Apparently, *Argyre* has appeared as a bright extension of the late winter South Polar Cap (SPC; L_s ~ 170°) several times since 1905. Fischbacher *et al.* (1969) report mean SPC boundaries based on an analysis of over 3,000 photographs made between 1905 and 1965.[36] There is a ~4° northward-pointing bulge in the SPC map at L_s = 170°, centred at 51°S, 43°W.[36] This corresponds to *Argyre*. McKim points out that part of the SPC extended into *Argyre* during 1999 July and 2001 May,[20,21] near L_s = 170°. Ng's 2003 Apr 27 (L_s = 175°) image shows a bright *Argyre* next to the SPC.[27] Finally, the SPC extended into *Argyre* in 2018 and 2020 near L_s = 170°. See Figures 9A & B. Therefore, the extension of the SPC in *Argyre* is probably a regular event. It should be visible again near 2033 May 22 and 2035 Apr 8. This, together with data on the SPC and NPC annual recessions, may serve as a test to see if climate change is taking place on Mars.

Afternoon clouds over *Chryse, Xanthe & Tharsis*

The ECB extends into *Chryse*, *Xanthe* and *Tharsis* during much of the northern spring and summer seasons. Good examples of it can be seen in several images made in 2014 March,[27] as well as in Figure 2. Foster may have also imaged it on 2020 Jan 6,[27] extending into these three areas.

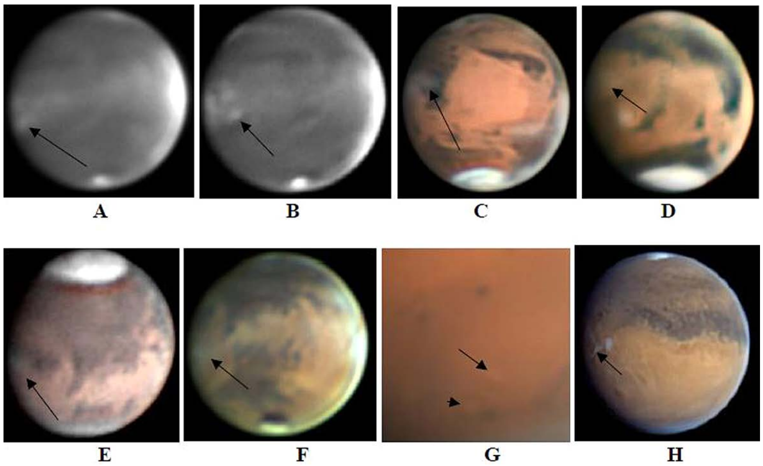


Figure 7. Images of clouds in other areas of Mars. In all, south is near the top and an arrow points to the relevant cloud. **(A)** L_s = 100°, 2014 Mar 10 (02:35.6 UT), by C. Pellier; clouds covering part of *Arabia*. **(B)** L_s = 102°, 2014 Mar 13 (03:02 UT), by C. Pellier; clouds covering *Aeria*. **(C)** L_s = 63°, 2012 Jan 27 (07:28.7 UT), by D. Parker; clouds over *Libya* and *Syrtis Major*. **(D)** L_s = 22°, 2009 Dec 10 (07:04 UT), by D. Parker; clouds over *Zephyria*. **(E)** L_s = 206°, 2003 Jun 19 (08:44 UT), by D. C. Parker; clouds over *Edom Pr*. **(F)** L_s = 98°, 2014 Mar 6 (02:26.1 UT), by C. Pellier; clouds over *Eden*. **(G)** 2020 Sep 6 (03:49.3 UT), by D. Peach; note small bright spots near *Elysium Mons* (longer arrow) and *Hecates Tholus*. **(H)** 2020 Sep 6 (00:14.2 UT), by L. Dauvergne; clouds in *Valles Marineris*.

Clouds in *Valles Marineris*

Figure 7H shows clouds in a portion of *Valles Marineris*. This may be another area to watch in the 2020s with improved cameras and image-processing software.

Discussion

In this section, the effect of the 2007 global dust storm on cloud formation is investigated. Furthermore, the results presented here are interpreted in light of other studies, including results from spacecraft.

Effects of dust storms

Smith (2004) shows that a dust storm elevates the atmospheric temperature.[37] This will cause the relative humidity to drop and prevent cloud formation. Martin (1975) points out that dust affects the development of the North Polar Hood.[38] Therefore, the effect of the planet-encircling dust storm in 2007 June was investigated. This storm lasted until 2007 October.[28,29] Orographic clouds were not observed near *Arsia Mons*, even at a local time of 17h for L_s = 300–320° in 2007. Similar clouds, however, were imaged in 2003 and 2005 for L_s = 300–320° as early as 11h. See Table 3. *Syrtis Major* also lacked clouds as late as 17h for L_s = 300–320° in 2007, but had them as early as 14h in 2003 and 2005. Therefore, the 2007 planet-encircling storm prevented the formation of afternoon clouds in these two areas. This is consistent with the smaller size of the North Polar Hood in 2001 and 2007 during large dust storms.[30]

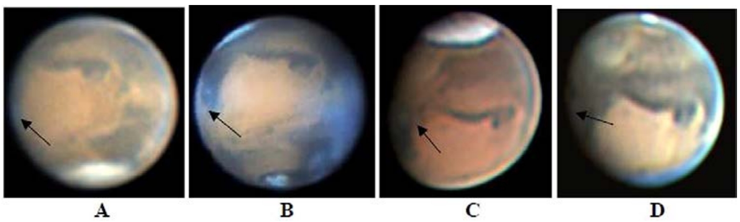


Figure 8. The clouds over *Syrtis Major* at all Mars seasons. South is near the top. **(A)** L_s = 32°, 2010 Jan 2 (04:43.2 UT), by C. Pellier. **(B)** L_s = 122°, 2014 Apr 26 (04:24.6 UT), by G. Walker. **(C)** L_s = 195°, 2020 May 5 (03:47.1 UT), by C. Foster. **(D)** L_s = 287°, 2005 Sep 13 (02:31 UT), by M. P. Mobberley.

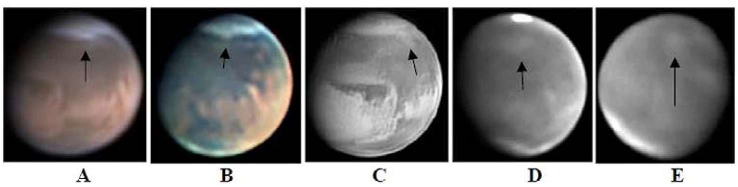


Figure 9. Images of *Argyre* (arrowed). South is near the top. **(A)** L_s = 169°, 2018 May 2 (16:11 UT), by T. Tranter, colour; ice in *Argyre*. **(B)** L_s = 170°, 2020 Mar 21 (03:32.7 UT), by C. Foster, RGB; ice in *Argyre*. **(C)** L_s = 174°, 2018 May 12 (20:50.8 UT), by T. Olivetti, red light; dust in *Argyre*. **(D)** L_s = 284°, 2005 Sep 7 (03:42 UT), D. Peach, blue light; clouds in *Argyre* at 14.4h local time. **(E)** L_s = 0°, 2006 Jan 21 (17:07 UT), by D. Peach, blue light; clouds in *Argyre* at 11.9h.

Intensity values of *Syrtis Major* & *Elysium*

Members of the BAA have estimated the intensity values of *Syrtis Major* and *Elysium* for over three decades.[11–20,39–47] Intensities are estimated on a scale of 10 = night sky to 0 = the brightness of the South Polar Cap. There is no obvious seasonal trend of intensity for *Syrtis Major*, but *Elysium* is brighter between L_s = 50–140° than at other times. This is consistent with the cloud trend in Table 3.

Comparison of the results in Tables 3 & 4 with other studies

The cloud summaries by McKim are organised into a table similar to Table 3.[11–22] (This is described in the Method & Materials section on p.242.) These observations are based mostly on drawings and, hence, may not be as accurate as for images made after 2002. Nevertheless, the results are consistent with those in Tables 3 & 4. For example, between 1982 and 1995, at least one cloud was observed near one of the four highest *Tharsis* volcanoes for all times of the Martian year. As a second example, evening clouds were reported in *Libya* for all times of the Martian year for 1980–'93, which is consistent with the results in Table 4. Thirdly, McKim presents evidence that clouds were thicker at *Olympus Mons* than at *Arsia Mons* near L_s = 90° during 1980, 1995 and 2012.[11,18,26] Beish (1991) and McKim (2011) present evidence that clouds formed at *Arsia Mons* before they formed at *Olympus Mons* near L_s = 270°, during 1988 and 2005, respectively.[35,23] Therefore, these early results are consistent with Table 3. Finally, the observations summarised by McKim show general agreement with the results in Table 3.[11–17] One difference is that *Elysium* was not bright in February and March of 1982 (L_s ~ 90°), when near the central meridian. The regional dust storm that occurred between Feb 26 and Mar 10 may be responsible for this negative observation.[12]

The results of Smith & Smith,[9] based on photographs made between 1924 and 1971, are consistent with the trend for

Olympus Mons and *Elysium*, the only discrepancy being that the author found a little cloud activity for L_s = 180–260° for these features, whereas Smith & Smith report none. This discrepancy is undoubtedly due to the higher sensitivity of 21st-century images. Lee *et al.* (1990) carried out a multi-year study using polarimetry.[48] They report cloud abundances in nine areas on Mars. Their afternoon limb results show cloud maxima during the late northern summer. These results are consistent with the earlier appearance of most of the clouds summarised in Tables 3 & 4.

The *Mars Global Surveyor* spacecraft yielded many high-resolution images of Martian clouds. This spacecraft crossed Mars' equator near 14h local Martian time.[33] Wang & Ingersoll report cloud maps for 21 intervals of L_s made between 1999 May and 2001 January.[33] Their maps show that clouds persist throughout the Martian year near at least one of the large *Tharsis* volcanoes. In two additional studies,[49,50] Benson *et al.* (2003, 2006) report cloud areas near *Olympus*, *Ascraeus*, *Pavonis*, and *Arsia Mons* along with *Alba Patera* for just over two Mars years between 1999 and 2003. The areas correspond to a local time near 14h. Their data show that the cloud near *Olympus Mons* is larger than the one near *Arsia Mons* for L_s = 90°, but the reverse is the case at L_s = 270°. The results from Benson *et al*. are consistent with the results in this study.[49,50]

Fedorova *et al.* (2004) report maps of water vapour abundances throughout the Martian year. There is a large amount of water vapour near 45°S, 270°W for L_s = 225–300°. This may be why *Arsia Mons* develops clouds before *Olympus Mons* near L_s = 270°. They also state the water cycle on Mars 'did not reveal dramatic change' between the late 1970s and two decades later.[51] This is consistent with the results presented here.

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Table 4. Approximate times when afternoon clouds form: *Arabia*, *Aeria*, *Libya*, *Zephyria*, *Edom Pr.* & *Eden*

L_s range (deg)	*Arabia*	*Aeria*	*Libya*[a]	FEATURE *Zephyria*	*Edom Pr.*	*Eden*	*Argyre*
0–20	>15	>15	14	17	15	NV	D
20–40	NV	NV	16	17	15	NV	D
40–60	NV	15	15.5	NV	16.5	17	D
60–80	16	15	15	>17	>17	14.5	D
80–100	17.5	13	16	17	>16	16	D
100–120	16	15	14	16	17	14	D
120–140	12	12	15	17	17	13.5	D
140–160	13.5	13	14	17	16.5	16	D
160–180	NV	NV	16	17	16	NV	b
180–200	17.5	17	17	17.5	16.5	17.5	NV[c,d]
200–220	NV	NV	17	17.5	16	17	NV
220–240	D	NV	17	NV	17	D	15
240–260	D	NV	17	NV	NV	D	15
260–280	D	NV	17	NV	NV	D	>16.5
280–300	D	NV	14	16	16	D	>16
300–320	D	NV	14	15	14	16	NV
320–340	D	15	15.5	>15	15	D	>16.5
340–360	D	>13.5	14	>13	13	D	>12

[a] Often includes *Isidis Regio*.
[b] Frost seen or imaged in the southern portion of *Argyre* in 1999, 2001, 2018 and 2020.
[c] Northern half of *Argyre* filled with frost/ice on 2018 May 2.
[d] Dust activity in *Argyre* on 2020 Jun 24.

Notes
The times are based on an analysis of images made between 2003 and 2020. Numbers and symbols are the same as those in Table 3.

ζ Herculis: a case study in the magnitude differences of close, unequal binary stars

Christopher Taylor

Two slightly novel methods of visual observation in small telescopes of close, very unequal double stars are presented here and applied to the famous binary ζ Herculis with interesting, and possibly controversial, results. The comparison with the travails often experienced by professional astronomers observing this system with far larger instruments is highly instructive of the possibilities of 'small-telescope astronomy'. The writer strongly urges other BAA members equipped with similarly modest instrumentation to 'have a go' at this fascinating and challenging binary.

Resolving ζ Herculis & the relative brightness of its components

The famous binary star ζ (zeta) Herculis (Σ 2084) is currently approaching widest separation (1.53 arcseconds or so, due 2024–'26; see Figure 1) in its 34½-year orbit – the same position at which it was discovered by William Herschel in 1782 July. Even compared with other 1–1½-arcsecond pairs, this is a difficult double around a large part of its orbit due to the great inequality in brightness of its two components. Night after night for many years the writer has been trying unsuccessfully, with both a 12½-inch reflector and a 4-inch refractor, to see the little companion star which Herschel, without any prior information or expectation, discovered with a 6.2-inch speculum-metal reflector well over 200 years ago – a humbling experience for a long-standing double-star observer who specialises in close, difficult binaries. Unsuccessfully, that is, until autumn of 2019 when the 4-inch gave the first glimpse and, conclusively, crosswire estimates of position angle a year later, which were closely confirmed afterwards by the ephemeris given in the BAA *Handbook* (neither that, nor any other source of the 'expected' value, having of course been consulted in the previous 12 months).

Those repeated failures with two instruments – both of which have on many occasions easily resolved more equal binaries at well below this angular separation, as well as slightly wider doubles having large, well-determined inequalities between the two components (the Δmag) – have long made this observer deeply sceptical of the surprisingly small Δmag = 2.5 listed for ζ Her in standard references (see Figure 2).[1] Having completed 2020's convincingly positive observations, the writer now has quite definite observational evidence on the issue, which appears to disagree with that quoted figure by a considerable margin and thus makes perfect sense of the earlier failures. This raises interesting issues of wider relevance in double-star astronomy and is the main point of the present paper.

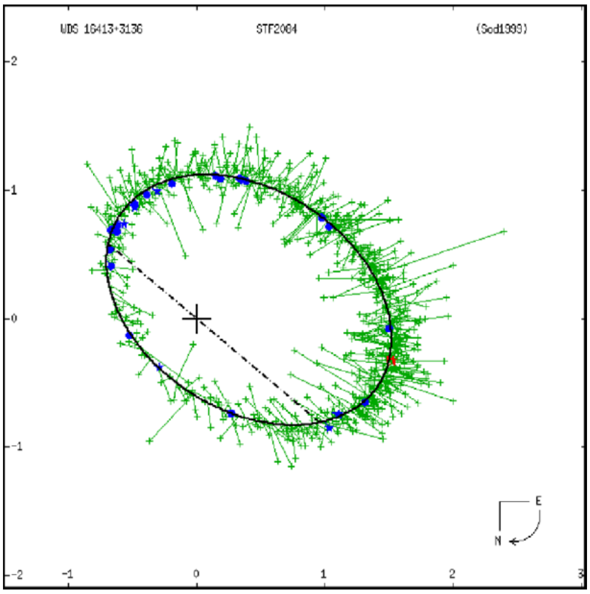

Figure 1. The *Washington Double Star Catalog* measures of ζ Herculis, with computed orbit superimposed. The 2024–'26 apastron is at the NE extremity of the ellipse. *(Courtesy William Hartkopf, USNO, Washington)*

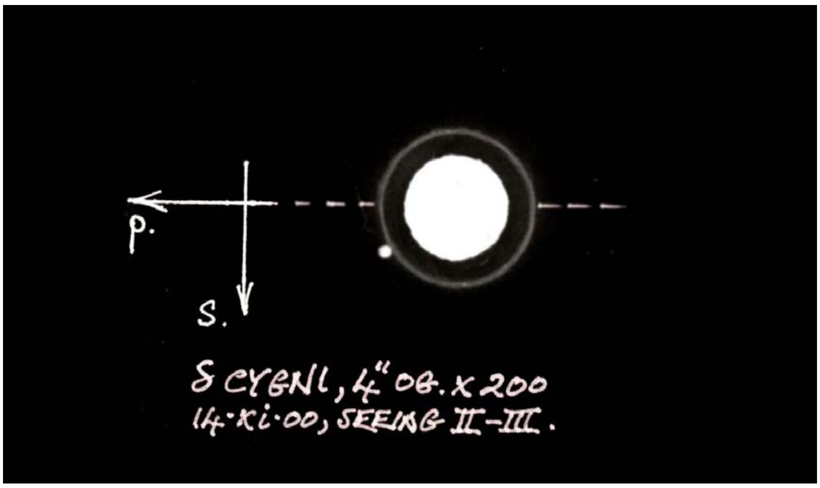

Figure 2. δ (delta) Cygni at ×200 in the 4-inch refractor on 2000 Nov 14, when at 2.58 arcsec separation. Despite a quoted Δmag of 3.4 or 3.7, this double star is far easier in the 4-inch, even in rather indifferent seeing, than ζ Herculis ever is.

The role of the brighter star's diffraction rings

In a small telescope, the observational case of ζ Her and all comparable close, unequal doubles hinges entirely on the diffraction rings of the primary star's Airy pattern. Small refractors consistently produce much clearer views of the diffraction rings of bright stars than do larger reflectors,[2] but even they often show the rings as broken into short arcs, or visible only on one side of the star-disc, and that even in excellent seeing when both instruments define the Airy *disc* perfectly. The evenness of the rings' illumination is, in fact, hypersensitive to the slightest optical disturbance, atmospheric or instrumental, at a level well below the limit at which that begins to distort the *shape* of either disc or rings at all.[3] In the writer's experience, the ring fragmentation seems to be an atmospheric 'seeing' effect, while the lopsidedness appears to be due to temporary coma at the 0.1–0.2λ level, possibly induced by uneven cooling of the telescope's objective. Both effects vary widely from night to night, even when the seeing is good enough to see the rings at all.

It is, of course, a commonplace of double-star astronomy that the primary's diffraction rings are a great nuisance in cases like this, where a faint companion lies at just that distance which puts it right on the first ring produced by the telescope used,[4] so rendering the small star practically invisible. That is one major factor in making the resolution of close doubles having Δmag > 2 far more difficult than that of equal pairs at the same separation. The autumn 2019 and 2020 observations of ζ Her with the 4-inch refractor have, to the contrary, stood this situation on its head completely by turning those travails to positive advantage: rings, arcs, coma and all.

Turning the behaviour of the rings to advantage

First consider the 180° lopsidedness, caused by coma, in the light distribution of the primary's first ring. Computer simulations show that a very small amount of coma of order $\lambda/5$ or less is sufficient to drain all the illumination in the first ring of the Airy pattern round to one side.[5] This leaves the opposite side right up to the edge of the central disc completely dark, without causing the slightest geometrical distortion of either disc or rings – that is, the effect is purely one of tangential or azimuthal redistribution of light in the undistorted diffraction image: see Figure 3. This is precisely what is quite often (but not always) observed with the 4-inch refractor on nights of good definition.

The possible strategy this offers for very significant improvement in the visibility of close, faint companion stars was discovered by the writer quite by accident on just such a night in 2017 May, when he was unexpectedly granted an exquisite view of ι (iota) Leonis (Σ 1536, missed by Herschel and discovered by Struve in 1827). The effect just happened on that occasion to drain all the light of the primary's rings clear of the tiny companion star, leaving it plainly visible on a dark ground (see Figure 4).[6] In the autumn 2019 and 2020 observations of ζ Her with the 4-inch, this was quite deliberately put to good use, by turning the telescope tube in its cradle to place the lopsided ring arcs in the quadrant away from that in which the companion star was known to lie (the only prior information known to the observer at the time). Even with such assistance and extremely good seeing, this particular double is a very tough target in this aperture, but the companion was nevertheless seen repeatedly as a minute needlepoint of light just clear of the edge of the big star's disc – a very beautiful sight, if evanescent.

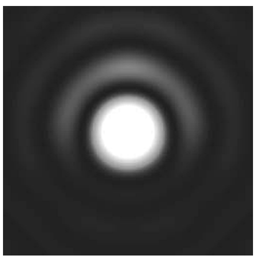

Figure 3. A sharply focussed star image, having $\lambda/5$ of coma. The redistribution of light in the first ring starts to become visible at $\lambda/10$ of the aberration, but coma causes no significant geometrical distortion of the image below about the $\lambda/2$ level.

Secondly, having used that trick to enhance the visibility of the companion star, the primary star's rings become a positive advantage in providing a calibrated image scale, allowing quite close estimation of the two stars' separation. In difficult cases where the companion lies anywhere from the primary's first dark space to its second diffraction ring, this is useful in then providing one objective criterion for subsequent verification of the observation by comparison with authoritative published data (the other such criterion being the position angle).

Finally, and most relevant for the purposes of this paper, is the fragmentation of those rings into short arcs, especially the primary star's first (and therefore brightest) ring, in cases such as that of ζ Her currently observed with the 4-inch aperture. In these cases, the companion and the ring arcs lie at much the same distance from the primary,[7] and the arcs therefore provide legitimate 'comparison stars' for visual estimation of the stellar magnitude of the companion relative to the primary. Standard diffraction theory gives precise values for the proportions of the total light sent into the central disc and each ring, in stellar images produced by a well-corrected objective (which the 4-inch refractor is). Of course, we have no immediate way of estimating closely how much of the light of, for instance, the complete first ring is present in any one of those arcs into which it is often broken, but given that there are always at least two or three arcs of comparable brightness, it is clearly never more than about 40–50% *in extremis*. This, combined with the diffraction theory results, therefore provides an objectively calibrated upper limit on the brightness of the ring arcs, so that their visual comparison with the faint companion star provides a secure lower bound on the double's Δmag. As a simple, and admittedly crude, visual photometric method we can do no better and it is sufficient for present purposes.[8]

The classical diffraction theory of the Airy pattern requires 7% of the total light in a telescopic star image to go into the first ring, which is 8.4% of that in the central disc, in an optical system free of significant spherical aberration.[9,10]

2019–'20 observations of ζ Herculis & implied lower bound on Δmag

ζ Her was observed with the 4-inch refractor on nine nights in these two years, of which four produced positive results, with a more doubtful fifth. On none of the nights of positive detection of the faint companion was the seeing worse than II on the Antoniadi I-to-V scale, well above average, and mostly I–II.

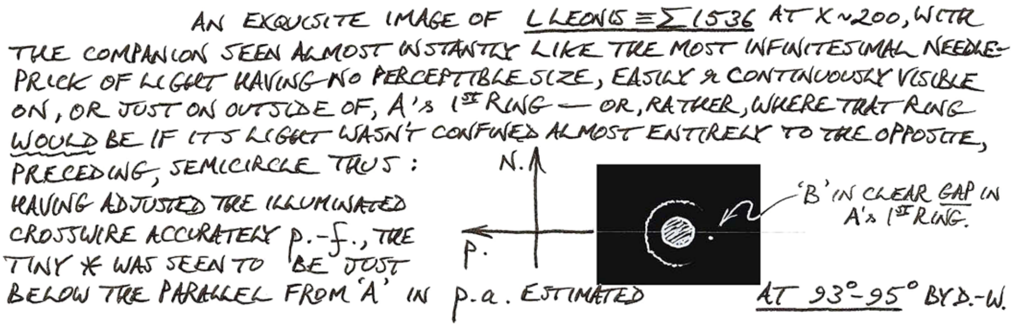

Figure 4. The 2017 observation of ι Leonis with the 4-inch OG. This binary was then at 2.17 arcsec and has a quoted Δmag of 2.7.

All the observations were made at a magnification of ×200, the minimum required to show the disc and diffraction rings of the primary star A easily and clearly separated. A sufficient image scale to display all the detailed internal structure of a bright star's diffraction image is absolutely essential in this class of observation. On all of the four successful nights, the diffraction rings of ζ Her A were very clearly visible most of the time, at least in broken arcs, and well separated radially; on three of those nights the rings were confined to 180° or less to one side of A. This was taken advantage of, as previously explained, to maximize the visibility of B. The four definitely positive observations were as follows (all times are given in UT):

2019 September 19

The first definite glimpse:

> 20:05–20:40. '*Seeing II–I, disc of A well defined almost constantly, rings frequently so and lopsided, so tube rotated to remove the arcs from the side to which B believed to lie. After some time, it became clear (but not easy) that there is a v. persistent small companion to A, almost in contact just where that part of A's 1st ring was before rotating the tube, in position angle* ['PA' hereafter] *120° approx. By comparison, definitely no such appendage in that PA to neighbouring ε Her.*'

It is clear from this entry, and that of the following night when only the most fleeting suggestions of 'B' (if that – the observer did not then know for sure) were picked up in lesser seeing, that the possible companion was (a) point-like, being a minute pin-prick quite distinct from A's ring arcs; and (b) substantially fainter than each of those arcs. To eliminate the possibility of a telescopic 'ghost' image, the tube on the second night had been rotated a further 30 degrees, despite which '…the PA tonight more like 100–110°.'

After the close of the 2019 season's observations, reference to the ephemeris in the BAA *Handbook* showed that the expected position of B at 2019.72 was (1.39 arcsec, 107.7°): in very close agreement with these rough estimates 'by eye', *i.e.*, without use of crosswire. Although not yet quite conclusive, at that point things were looking very promising, but foul weather then closed in for the autumn and it was time to forget about ζ Her for a year. What 2019's observations had already proven quite conclusively was the extreme difficulty of this double star in a 4-inch aperture – confirming yet again the lesson of all those failures of earlier years – and the obvious inference that its Δmag cannot possibly be as small as the 2.5 figure now commonly quoted.

2020 November 3

Conclusive confirmation, after three unsuccessful attempts in seeing II–III or III:

> 18:35–19:00. '*Seeing II–I, A's rings well-defined and symmetrical, which almost instantly showed 'a vanishingly minute needle-prick of light exactly on A's first ring' in the (slightly south) following direction, then formally estimated very consistently at PA = 105–110°, using an illuminated crosswire set accurately preceding/following as reference (a 'driftwire estimate'). Towards the end of this observation, the seeing had become slightly more fretful at II. The companion was occasionally very clear, and definitely visible most of the time, but not an easy object even in the best of tonight's seeing. [It] would have been much less difficult if it had been possible to move the light of A's first ring to the opposite side – but no help from coma tonight!*'

If the sighting was of the real companion, this and 2019's observations now put one thing beyond all possible doubt: B can be no brighter than each of the two or three short arcs into which A's first ring frequently concentrates and fragments under these conditions. If, on the other hand, this is not the real thing, the true B must be even fainter and this conclusion then follows *a fortiori*.

2020 November 4

Further glimpses:

> 18:15–18:30 approx. '*Seeing II veering towards II–III, A's rings v. fragmentary and now again lopsided, lying entirely to A's north. A number of clear glimpses of last night's B, despite the lesser seeing, aided by A's first ring being out of the way. This tiny pinprick, at exactly the same distance from A, is actually significantly fainter than the principal arc of that first ring but completely distinct from the ring arcs as (a) it is a needlepoint of no visible diameter, not an extended structure like the arcs, and (b) its PA remains absolutely fixed through all the seeing-induced fluctuations in its actual visibility, unlike the arcs, which oscillate and revolve around A's disc.*'

2020 November 5

> 18:05–18:25. '*A fine image in seeing I–II, A's disc and rings extremely well defined almost constantly, the rings in broken arcs*

to one side of the disc, the tube therefore rotated to place these preceding A. Result: another good view of B, at best a perfectly defined point of light cleanly separated from the edge of A's disc, although not continuously so even in this seeing. Another driftwire estimate again definitely gave PA around 105–110°. At the occasional razor-sharp best moments, this infinitesimal pinprick of light (≤ ¼ A's disc-diameter) definitely appeared a quite intense red: not something the observer had expected. At those instants, it was conspicuously fainter than A's brightest individual ring arc, by at least a full magnitude.'

As the season's observations had now achieved compelling consistency, and any even better view of ζ Her would demand straight class-I seeing (requiring the star to be higher in the sky at nightfall), 2020's observations were concluded at that point in order to check them, post-observing, against the 2019 result and, finally, the orbital ephemeris.[11] Overall, taking the widest interval estimates, 2019's observations implied a PA of 100–120° at 2019.72 and 2020's one of 105–110° at 2020.84, while the ephemeris values for those dates are 107.7 and 101.7° respectively. For observational results which are nothing more than eye estimates, aided only by a marker of the preceding–following direction, this is very respectable agreement in a case of such difficulty. Together with the observation-ephemeris agreement on separation (relative to A's first ring) to within ±¼ of an arcsecond, and the unambiguous image of the companion at best as a clearly defined point of light not present in that PA on other bright stars in the vicinity, this provides three independent checks on the veracity of these observations. Between them, there can be no remaining doubt that what was seen on the four or five nights in 2019 and 2020 was, indeed, the real ζ Her B.

That being the case, the observations can now be used to place a secure lower bound on the A–B Δmag of this double star. At a definitely conservative estimate, they imply that B is at least 1½ stellar magnitudes fainter than the integrated light of A's first diffraction ring, since the 40–50% proportion noted earlier means that the brightest arc is 0.75–1.0mag fainter than the whole first ring, and the observations show that B is anything up to a magnitude fainter than that. As noted previously, the standard theory of the Airy pattern gives the integrated light of the first ring as 8.4% of that of the disc. Taken together, these facts imply $\Delta mag \geq -2.5\log_{10}(0.084) + 1.5$; *that is: Δmag ≥ 4.2 for ζ Her AB.*

This lower bound is quite likely to be a significant underestimate, as the brightness comparison of a needle-sharp star image with a diffused, extended ring arc will obviously tend to bias in favour of the star. The conclusion is therefore inescapable that the figure of 2.5 commonly quoted in this case is irreconcilable with the observations. That figure, only marginally greater than the securely determined Δmag for Albireo, is in any case unbelievable to an observer who has seen ζ Her as clearly resolved, as it was at best in the observations reported here. Even, that is, making all due allowance (of course) for suppression of B's visibility by the overpowering light of A less than 1½ arcseconds away.

Astrophysical considerations

One thing we can be absolutely certain of concerning ζ Her is that its two components are at the same distance from us – they can be seen to be in orbit around each other – and therefore that the difference, Δmag, in their apparent magnitudes is identical with that between their absolute magnitudes. The absolute magnitudes, in turn, should agree closely with the stars' positions on the Hertzsprung–Russell diagram as determined by spectroscopy; that is, by their Harvard spectral types and luminosity classes.

Most published spectroscopy and photometry (see next section) of ζ Her is for the unresolved complete system of both stars A+B (and any possible further components 'a', *etc*., which have been proposed from time to time on astrometric grounds). That poses no significant problem for the derivation of A's individual properties, as the light of the complete system is heavily dominated by that star alone. The merged spectral type of the unresolved system is usually given as G0 IV or G1 IV, the luminosity class IV derived from intrinsic luminosity indicators in the line spectrum, implying that the star is significantly brighter than a main-sequence one of that spectral class.[12]

The separate spectral class F9 IV generally given for A alone (see ref. 12) comes from an entirely reasonable but hypothetical apportioning of the individual spectral contributions of A and B according to their respective magnitudes, assumed to be as given by other sources.[13] For the dominant partner A, the resultant separate spectral type will be very insensitive to errors in the Δmag assumed in carrying out that spectrum decomposition, provided that Δmag ≥ 2 (approx.) and that A and B do not differ spectroscopically by much more than one Harvard type. The F9 IV result can therefore be taken as a very close approximation. This makes A an evolved subgiant well above the main sequence on the Hertzsprung–Russell diagram, somewhere in the absolute-magnitude range ~1.5 to 3; see Figure 5.[14] This agrees well with the figure of 2.7 derived directly from the very reliable *Hipparcos* parallax[15] – giving a distance of 35.0 ± 0.2ly – and the measured apparent magnitude (again apportioned between A and B, the same comments applying as just made). The absolute magnitude of 2.7 for A can therefore be taken as definitive.

The case of ζ Her B is very different. As Edwards (1976) says in setting out the *raison d'être* of his spectrum-decomposition approach,[13] 'Only 131 of the 697 visual binary systems whose orbits are catalogued … have MK spectral classifications for both components. Moreover, since most of the remaining systems have separations less than 2–3 arcsec, standard spectrographic observations of the individual components are unlikely to be obtained.' Similarly, in a more recent study of this particular binary,[16] the authors say: 'With classical 1.5m to 2.0m telescopes ζ Her appears as a single star under average seeing conditions because of the large magnitude difference and of the small angular distance. Therefore isolated spectra of each component cannot be obtained.'[17] Like Edwards, Morel *et al*. (2001) thus set about extracting the properties of the individual stars A and B from merged A+B spectra on the prior assumption of separate magnitudes for the two stars,[16] in their case taken from the *Tycho* and *Hipparcos* catalogues.

Any errors in this necessarily back-to-front process will have far more serious consequences for B than they will for A, as large errors in either the magnitude or derived spectrum of B will have only small effects, thanks to B's relative faintness, on the corresponding observed aggregate values for A+B. This unscrambling process results in Edwards deducing a spectral type of G7 V for B. Morel *et al.* did not give a spectral type as such, being more interested in other properties of the system (especially of A), but they derived an effective temperature of 5300±150K for B which, on the main sequence, is about that of a G9 V star.[18] What, however, neither Edwards nor Morel *et al.* would seem to have noticed is that, despite their respective statements quoted here, high-dispersion resolved separate spectra of B *had* been obtained back in 1953 by Struve & Ratcliffe, at the *coudé* focus of the Mount Wilson 100-inch.[19] They concluded '…the spectrum falls unmistakably between the G9 and K5 comparison stars, and much closer to the former. […] Zeta Her B is therefore assigned the spectral type dK0.' That is, in the terminology of the time, a K0 red dwarf, which would now be assigned to class K0 V or VI: a later spectral type which accords significantly better with the marked red or reddish colour of B seen by some visual observers, including the present writer.

Thus, the complications of deducing the spectral type of B indirectly from merged A+B spectra can be completely side-stepped, thanks to the 1953 result from Mount Wilson. The Edwards and Morel *et al.* results could not in any case have been used for present purposes of setting astrophysical context for, and constraints on, the possible Δmag of A and B: to do so would be logically circular as those results were themselves obtained by assuming separate A and B magnitudes from other sources. Rather, the 1976 and 2001 papers have been included here because they are widely cited as standard authorities on ζ Her, and in order to illustrate the considerable difficulties and complications in arriving at a definitive view of this system.

Finally, taking the Mount Wilson spectral classification of K0 V or VI as definitive, ζ Her B can now be located on the Hertzsprung–Russell diagram together with A, in order to put limits on the possible value of their Δmag. As can be seen from Figure 5, K0 stars on the main sequence mostly lie in the range of absolute magnitudes +4 to +6, but with a scattering of subluminous class-VI cases as faint as +8. It is therefore perfectly possible *in extremis* to accommodate a Δmag of at least 4.2 below A's absolute magnitude of 2.7, without doing any violence whatsoever to the spectroscopic evidence: there is no unavoidable contradiction between the new observations reported here and well-established astrophysical knowledge of the ζ Her system.

There is one other consideration, founded on completely independent evidence. As Morel *et al.* report, radial velocities measured spectroscopically and classical astrometry of the A+B visual binary orbit allow a confident dynamical determination of the mass of B, and this turns out to be $1.00 \pm 0.08 M_\odot$ (where $M_\odot$ = solar mass). That would be incompatible with B's having an absolute magnitude of 6.9 or fainter, required by a Δmag ≥ 4.2. However, it would be equally incompatible with Struve & Ratcliffe's direct spectroscopic classification of B as type dK0, since a main-sequence star significantly redder in type than the Sun should have a significantly lower mass. There is hence a definite inconsistency here, even within the best data available for B.

Fortunately, a way out of this apparent contradiction exists, which is well known in the field of spectroscopic-binary research:[20] the apparently subluminous object is not a single star, so its total mass does not contribute proportionately to the luminosity expected of it on the main sequence. In the present case, it would for instance suffice for that $1.00 M_\odot$ to be divided in a ratio of about 3:2 between two main-sequence stars, to satisfy the requirements. Those two dwarf stars would then need to be in a mutual orbit which is very small, in order to produce no detectable astrometric perturbation, and presented closely 'face-on' to our line of sight, in order to produce no detectable radial-velocity signal. In this scenario, the close companion to B, if itself a main-sequence star, would be nearly two magnitudes fainter than B and so may have escaped detection in the Mount Wilson spectra.[21] Alternatively, the ~40% of mass that is 'invisible' may be in the form of a stellar remnant of even lower luminosity, such as a white dwarf or neutron star. All of this is quite possible, even commonplace, among multiple-star systems. The writer is therefore not persuaded that any

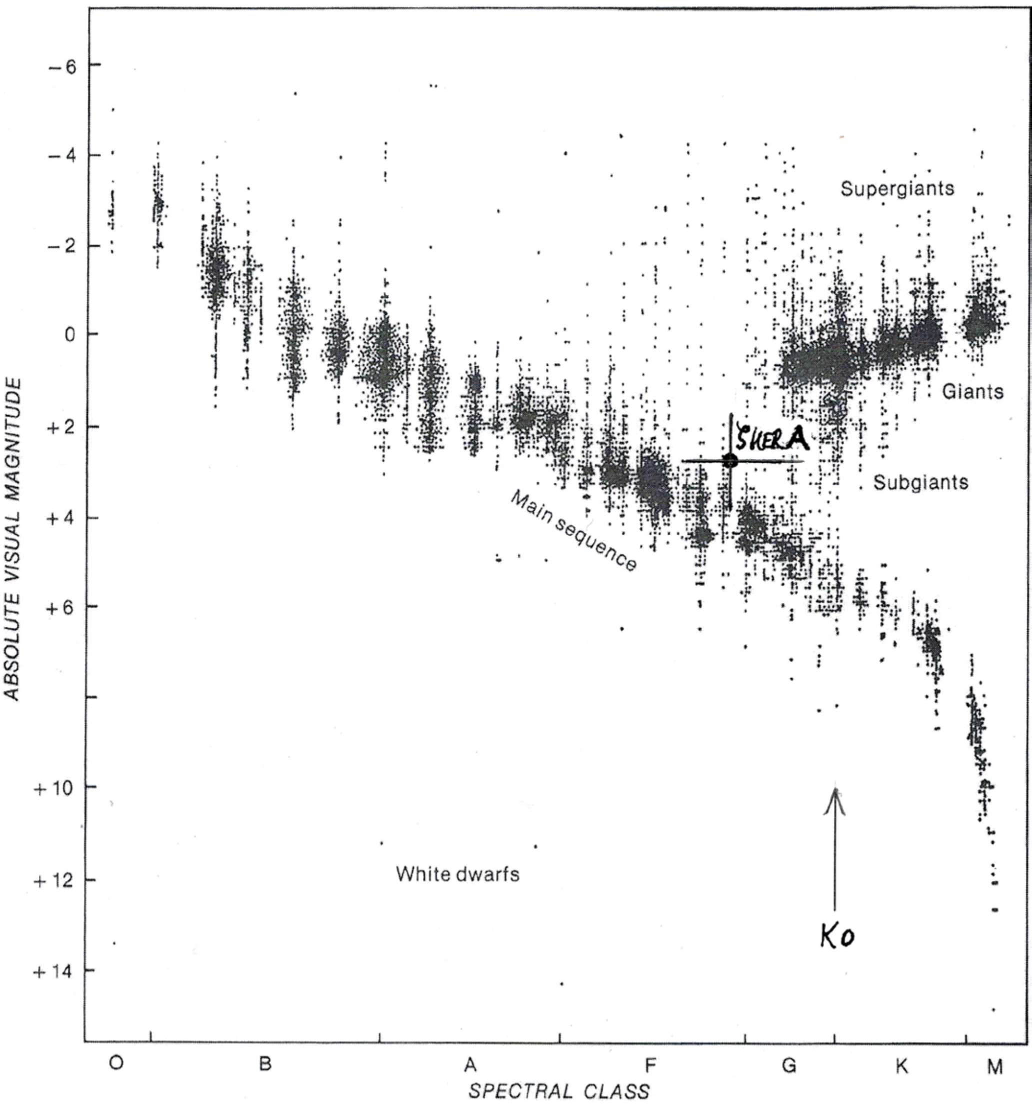

Figure 5. The Hertzsprung–Russell diagram from Kaler's *Stars and their Spectra*, with ζ Herculis A added (marked by cross). The arrow marks the spectral type of star B according to the Mount Wilson spectra.

of the available astrophysical or dynamical evidence concerning ζ Her constitutes compelling reason for rejecting the Δmag ≥ 4.2, derived here from direct observation of A and B resolved.

Some reflections on the reliability of photoelectric photometry of close double stars

In this age of millimagnitude-precision photometry, with its track record even in amateur hands of, for instance, detecting transiting exoplanets, it may seem outrageous to call its results into question at the level of whole magnitudes. Nevertheless, this communication is far from being the first to do so in this context, and with good reason: we are not dealing here with isolated single stars free from photometric contamination of their light by other sources. The photometric situation with the faint companions of ζ Her and other comparable double stars is at quite the opposite extreme, and this consideration is crucial.

Since the early twentieth century, the double-star literature has been peppered from time to time with discussions, occasionally quite heated, of the marked disagreements often arising between visual and photometric estimates of the Δmag values of close pairs. Most of these discussions seem to have accepted as axiomatic that visual estimates are subjective and prone to large systematic bias (which they are), while instrumental photometry, by shining contrast, provides objective, quantitative measurements free of any such bias. This is surely a naive oversimplification.

There is a fundamental difference between what is being done in visual estimation and in photometric measurement of the Δmag of close double stars, so there is no reason why the two should agree even approximately in their results. Photometry is simply a process of 'binned' measurement of the total flux coming from a pre-selected patch of sky, while the human eye-brain system makes no attempt to do that in making visual estimates but operates, essentially and in far more sophisticated mode, as a pattern-recognition system. These are two completely different approaches to the problem, both of which in reality suffer from large systematic bias in this application, and those two biases systematically push the resulting Δmag figures in opposite directions.

First consider the experience of the visual observer of close double stars. In looking at an unequal pair, the companion star is seen projected on the background illumination created by the brighter primary, whether by Airy diffraction, or light-scattering within the instrument, or eye, or atmosphere, or other causes. The result is that if the two stars are within two or three arcseconds of each other, it becomes increasingly difficult to see the companion at all as an identifiable point of light, when the Δmag is much more than 2 or so (and a smaller margin the closer the separation). There is therefore an inevitable upward (+ve) systematic bias of visual Δmag estimates in these cases, that positive bias necessarily increasing steadily with the real Δmag itself – simply because the companion is getting progressively more difficult to see. That is precisely why the ring-arc comparison method of the present paper is important, as by comparing two things, the primary's ring-arc and the secondary star, equally subject to that biasing effect it should eliminate the bias from such visual estimates.

Photometric measurements, on the other hand, are the output of some electronic detector at the telescope's focal plane, registering the total flux (assumed visual by use of suitable V-band filters) in some pre-selected patch of sky centred on the companion star and therefore very close in these cases to the much brighter primary. The photometric output is simply that generated by all the light entering the photometer's entry-aperture, or falling on the pre-selected sampling area of the electronic detector in cases where that is a resolved-imaging device such as a CCD. In the present situation, the very closely adjacent, much brighter primary star will unavoidably produce substantial photometric contamination – light from the primary which also gets into the photometer along with that of the secondary, and so contributes to its measured flux. For close, unequal double stars, the effect is then the exact opposite of that on visual estimates: a systematic *negative* bias in the measured Δmag, steadily increasing with that Δmag itself.

This effect is very significant for close double stars of large Δmag, and does not seem to have been adequately acknowledged in the 'visual *vs.* photometric' debates. For pairs closer than two arcseconds, the problem is enormously exacerbated from the ground by atmospheric seeing, and little if any of the very small amount of ground-based resolved photometry that has been published for these systems can be trusted.

Much more could be written on the instrumental and observational technicalities of the photometry of close double stars, but that would risk trying the reader's – and certainly the writer's (he being no photometrist) – patience. Rather, on the principle of 'the proof is in the eating', consider the Δmag values implied by the data given in successive revisions of the fourth and sixth *Catalog of Orbits*,[22] and thence in recent years in successive editions of the annual BAA *Handbook*. In the list of 90 visual binaries given in the *Handbook*, no fewer than 14 have been the subject of significant random changes and inconsistencies of their Δmag values over the years 1999 to 2020, averaging changes of 0.76mag in Δmag values, themselves averaging only 1.46 at the last count. Curiously, ζ Her is not one of these erratic cases, but the writer strongly suspects that is merely a reflection of its great difficulty resulting in there being few if any attempts at resolved photometry of it over the last 20 years; only two of the wayward 14 have Δmag values as large as that star. ζ Her is clearly a much more unequal double than most of that sample of 14, and so necessarily a more difficult case for the double-star photometrists.

Taking just a few illustrative examples from that list of 14, choosing only binaries that have been as wide or wider than ζ Her over this period, their given Δmag values have fluctuated as follows: 10 Arietis from 1.4 to 2.1; ζ Cancri AB from 0.4 to 1.0; ξ (xi) Scorpii AB from 0.0–0.3 to –0.3 (thus actually reversing the photometrists' Δmag within the last five years); and γ (gamma) Coronae Australis from 0.1 to 1.9 (!) since 2009. This hardly inspires confidence in the claimed two- or three-decimal 'precision' of these measures.

The important case of the beautiful triple star ζ Cancri is worth a closer look. The system consists of two stars, A and B, closely equal (in fact) in a 60-year orbit, putting them typically at an apparent separation of around one arcsecond, with a more distant star C at about six arcseconds. The Δmag = 1.0 or 0.9 figure quoted for AB in recent editions of our *Handbook* on the authority of the sixth *Catalog of Orbits* notwithstanding, the true value is certainly very much smaller. Roger Griffin included a detailed discussion of this issue in a classic paper devoted entirely to this particular system,[23] in his great series 'Spectroscopic binary orbits from photoelectric radial velocities', which ran in almost every issue of *The Observatory* from 1975 to very recently. After an exhaustive review of the literature on the photometry (visual, photographic and photoelectric) of the ζ Cancri system, Prof Griffin concluded that the best estimate of the AB Δmag from ground-based observations is 0.35, while also citing some measurements significantly lower than that. This is in reasonable accord with the *Hipparcos* value of 0.405.

There are two particularly compelling pieces of evidence for the much smaller Δmag here. As cited by Griffin, Meyer *et al.* (1995) observed a lunar occultation of ζ Cancri – presumably by high-speed photoelectric photometry – in the blue-green and found an AB Δmag of 0.05 ± 0.10.[24] The occultation method is, of course, completely free of the photometric contamination problem which bedevils resolved photometry of close doubles.

Secondly, there exists an uncompromisingly null method of checking the equality of the two stars of a close double: Fizeau-Michelson interferometry, using a twin-slit aperture mask. In this method, stars A and B of the double each generate a set of parallel bright fringes in the telescope, separated by equal dark spaces, so that when the spacing and orientation of the twin slits are correctly adjusted, A's bright fringes just fill in B's dark spaces and the fringes disappear completely – the null position – *provided the stars are equally bright*. For perfect nulling, the two stars must necessarily be equal to within a few tenths of a magnitude, the fringes remaining easily visible in the null position, although of reduced contrast, for a Δmag of 0.5 or even less. As it happens, the present writer used ζ Cancri AB as a test object for this method with the 12½-inch reflector on a night of superb seeing in 1997 March, when the pair was at 0.74-arcsecond separation.[25] The result – perfect nulling with no residual trace of fringes visible in the null position – shows that the Δmag in this case is certainly no more than 0.3 to 0.4: the currently quoted value of 1.0 is incompatible with both this and the Meyer *et al.* occultation result by a large margin, at least in the visible.

So, in short, that figure of Δmag = 1.0 for ζ Cancri AB is clearly very wide of the mark and this case is probably entirely typical of the others quoted earlier. If, then, the photometrists have such evident difficulties even with these relatively equal doubles at around the one-arcsecond level, how much more uncertain must such results necessarily be for a case like ζ Her, whose Δmag is certainly much larger, even discounting the particular result reported here? The writer is not, therefore, unduly troubled by the discordance between the Δmag lower bound given previously and the value generally cited.[26]

Finally, there is *Hipparcos*, high above the atmosphere and so untroubled by its effects on seeing. This has not unreasonably been taken as providing definitive resolved photometry of the components of close double stars, not least because its 0.29m-aperture instrument detected the binarity of many fairly equal pairs down to 0.13 arcsec separation. This was the view taken by Morel *et al.*,[16] who wrote that: 'The Achilles' heel of our calibration is the derivation of effective temperature and luminosity of ζ Her B. It is based on the only reliable measurements of B and V magnitudes *of each component* [their italics] by TYCHO and HIPPARCOS.' Griffin (ref. 23, p.26) was more circumspect when he said: 'There is, to the present author's knowledge, no independent experience of the reliability of *Hipparcos* magnitudes of close multiple systems at the level of precision quoted by *Hipparcos*…'

It appears then, that any credible claim to real precision in published Δmag values for close double stars rests on the sole authority of *Hipparcos*. The present writer is not, however, entirely persuaded of the unimpeachability of that authority, on two grounds, both of which possibly suggest that photometric contamination of much fainter companions close to bright stars may have been a problem even for this space-borne observatory. Firstly, the optical design of the 0.29m telescope. This was an all-reflective Schmidt-camera design with a 30% central obstruction, fed by a corrector mirror divided diametrically in two in order to combine two well-separated fields of view simultaneously.[27] Both of these design features will have caused considerable diffraction and scattering of light from bright stars into neighbouring parts of the instrument's field, especially at only 1–2 arcsec removed from them – hardly an optical system designed to minimise this problem in the photometry of close, unequal double stars.

Secondly, it appears that *Hipparcos* actually failed to detect the companions at all in several very prominent unequal doubles well above its resolution limit. This seems to have happened in the cases of δ Geminorum (Σ 1066; magnitudes 3.6 and 8.2 at 6 arcsec separation), θ (theta) Aurigae (OΣ 545; mags. 2.7 and 7.2 at 3.8 arcsec) and even to such an obvious double as Rigel (Σ 668; mags. 0.1 and 6.8 at 9.4 arcsec). These three contrasted doubles are all fairly easy objects on any middling night in the 4-inch refractor used for the observations reported here. Rigel's companion, in particular, is always very obvious in the 4-inch on all except the worst nights and the writer has seen it clearly in as little as 1½ inches aperture. (Incidentally, ζ Her is substantially more difficult in that instrument than either of the first two of these doubles, again much more in accord with a Δmag ≥ 4.2 than with one of only 2.5.) This comparison, on the same targets, of a very small telescope at the bottom of Earth's atmosphere and of one nearly three times the aperture well above it, very strongly suggests to this writer that scattered light within the latter's optical train was, indeed, a major limitation of its capabilities on very unequal close (and not so close) doubles.

The writer therefore strongly urges that judgment on *Hipparcos* photometry of these targets should be suspended until there is compelling independent corroboration from another satellite observatory at least as well equipped for the task. At the time of writing, GAIA has not yet released results for the resolved photometry of close doubles as bright as ζ Her, it seems,[28] but that may be coming in due course.

Conclusion

This paper has presented two slightly novel methods of double-star observation in cases where that is greatly affected by the diffraction rings of a bright primary star. One is the deliberate use of temporary coma, when it occurs, to remove the obscuring light of the first ring from the immediate vicinity of a faint companion star at that radius, so enhancing the visibility of the companion. The effect is certainly significant. The other is the use as 'comparison stars' of the short arcs into which the first ring often fragments, to put observational limits on the stellar magnitude of such companions, by visual differential estimation. Standard diffraction theory implies strict upper limits on the possible brightness of these comparison arcs relative to the primary star producing them, hence strict lower limits on the magnitude difference Δmag between the primary and companion stars.

The use of these methods, as reported here, shows unambiguously that, as seen in a telescope which places the first diffraction ring of ζ Her A at the same radius as the current A–B separation, the companion B is conspicuously fainter than the brightest of A's ring arcs, despite its being at the same distance as those from A and being a concentrated point-object rather than having the extended, rather diffuse structure of the ring arcs. This is unmistakeably the case when the companion is seen sharply defined and clearly separated from the edge of A's disc, as it was repeatedly on the best nights reported here. The writer is very confident that any other observer accustomed to the critical examination of such double stars will have no difficulty in verifying this observation in the best seeing, using a telescope suited to the task.

That telescope should be of four to five inches aperture, to place A's first ring at the correct radius to make proper comparison with B – larger telescopes should be stopped down to that aperture to make this observation. The optical system must obviously be one giving diffraction rings close to the theoretical brightness, which means a good refractor or equally good, preferably long-focus, reflector with a central obstruction of 20% or less. Spherical aberration such as is common in some short-focus reflectors, especially when prone to thermal changes of figure, will completely vitiate the results by draining substantial amounts of light from the disc of A into its rings: at the Rayleigh quarter-wave limit of what is 'acceptable', this aberration diverts an extra 17% of the total light into the diffraction rings, something wholly unacceptable here. If, on the other hand, the observer cannot detect B despite A's first diffraction ring being plainly visible, that evidently only confirms *a fortiori* what has been said here about the A/B Δmag in this case.

This clear-cut observation poses serious problems in relation to the published photometry of the ζ Herculis A+B system, which implies that B, at 10% of A's luminosity, is actually brighter than the *whole* of A's first ring (8.4% A): an appearance completely ruled out observationally. The observations, on the contrary, immediately imply a minimum visual Δmag over 1½ full magnitudes greater than the photometric value in the current literature. As has been shown here, however, the much larger figure can easily be reconciled with current astrophysical and dynamical understanding of the system, and there are entirely reasonable grounds in such cases as this for questioning the accuracy claimed for the published photometric figures. The writer respectfully suggests that this case remains very much an open one and, in being so, provides an important test case for photometry of double stars below two arcseconds in separation.

Acknowledgments

The writer's sincere thanks go to Bob Argyle of the Institute of Astronomy, Cambridge for updating him on the current status of GAIA data releases as they relate to ζ Her and its ilk; to Bill Hartkopf of the United States Naval Observatory for readily supplying the *Washington Double Star* file for ζ Her in summer 2014 and the diagram used here for Figure 1; and to David Randell, erstwhile webmaster of Hanwell Observatory, for introducing him to an earlier version of Cor Berrevoets' extremely useful programme *Aberrator* nearly 20 years ago, and for drawing his attention to the important 1954 Struve & Ratcliffe paper during the writing of this communication. Last, and by no means least, thanks are due to the referees for suggestions which have improved the presentation of this work.

Postscript

Some means of actively controlling the light distribution within the stellar diffraction rings seen in the telescope would obviously make the ring-asymmetry method of observation described here much more effective and routinely applicable. Since writing this paper on ζ Herculis, a possible optical method for doing this has occurred to the writer and some very preliminary trials commenced. If this succeeds, it will be described in a later brief communication to the Association.

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Notes & references

1 *e.g.*, *Handbook of the British Astronomical Association 2020*, p.109, 'Ephemerides of visual binary stars', 2019
2 That highly experienced visual observer W. H. Pickering stated in *Popular Astronomy*, 1930 March (reprinted in Ingalls A. G. (ed.), *Amateur Telescope Making Advanced*, 1937, p.613) that he had never seen diffraction rings in a reflector of more than about five inches aperture; this observer, on the other hand, has often seen them in a six-inch and occasionally even in the 12½-inch – but the latter not often, and almost never the complete rings of the textbooks.
3 Or, indeed, the radial distribution of light between the disc and rings, which is the datum on which all standard optical-quality criteria such as Rayleigh's '¼' are based. That radial distribution is a relatively crude test and far from the whole story for critical stellar observation.
4 According to the Grade 1 'Definitive' orbital ephemeris quoted in the BAA *Handbook*, ζ Her was at a separation of 1.43 arcsec in autumn 2020, while the primary star's first diffraction ring in a 0.102m aperture working at a mean wavelength of 5,100Å extends from $1.22\lambda/D$ = 1.26 arcsec at its inner edge to $1.638\lambda/D$ = 1.69 arcsec at its intensity maximum, and slightly beyond.
5 For instance Cor Berrevoets' *Aberrator 3.0*, available as freeware at: **http://aberrator.astronomy.net** (Figure 3 was generated with this program). (Accessed 2022 June)
6 This observation is quoted in full in Argyle R. W. *et al.*, *An Anthology of Visual Double Stars*, 2019, p.4.
7 See note 4.
8 The writer is not aware of any previously published reference to this possibility, despite the method being quite capable of producing non-trivial results, if only as lower bounds on Δmag, in just those cases where standard photometric procedures have great difficulty, as will be seen later in this communication. No systematic search of the very large relevant literature has been attempted, however.
9 Jenkins F. & White H., *Fundamentals of Physical Optics*, 1937, p.123, Table 5I
10 Born M. & Wolf E., *Principles of Optics,* 7th edn, 1999, p.443. It appears from what the writer has on his shelves that most of the modern textbook accounts *etc.* of this standard topic of undergraduate mathematical optics give numerical results only for the radii of the rings and not for their total brightnesses (not to be confused with peak intensity), which includes the otherwise excellent and quite sophisticated *Wikipedia* article 'Airy disk' (consulted 2020 Nov 6). Hence citation here of that old faithful ref. 9, which was still one of the main university textbooks in this writer's undergraduate days!
11 As stated in note 4, this is a Grade 1 'Definitive' – unlike most of those listed in the BAA *Handbook* – and is probably trustworthy to the nearest two degrees in position angle and 0.1 arcsec in separation.
12 Hoffliet D. & Warren W. H., *The Bright Star Catalogue*, 5th edn, 1991
13 Edwards T. W., 'MK classification for visual binary components', *Astron. J.*, **81**, 245–249 (1976 April)
14 Copied from Kaler J. B., *Stars and their spectra*, 1989, Fig. 3.6, with ζ Her A added. Perhaps suggestively(?), Kaler makes no mention of ζ Herculis among the very large number of stars discussed in this work, despite A being widely regarded as the classic type-example of a subgiant.
15 van Leeuwen F., 'Validation of the new HIPPARCOS reduction', *Astron. Astrophys.*, **474**, 653–664 (2007). This re-reduction only changed the originally published distance by 0.2ly.

16 Morel P. *et al*., 'The ζ Herculis binary system revisited', *ibid*., **379**, 245–256 (2001)
17 This remark makes an interesting contrast with the direct visual observations with 0.1m aperture reported here. The comparison illustrates two things very strikingly: (i) that bigger aperture, even very much bigger, does not necessarily mean higher resolution, the latter also depending critically on the method of detection employed; and (ii) the profound difference between those methods of observation as employed, respectively, in most modern professional research and by 'old-school' classical visual observers such as the writer.
18 Aller L. H., *Atoms, Stars and Nebulae*, 3rd edn, 1991, p.65, Table 4.2
19 Struve O. & Ratcliffe E., 'The spectrum of zeta Herculis B', *Publ. Astron. Soc. Pac*., **66**, 31–32 (1954 February), accessed online *via* SIMBAD at **simbad.u-strasbg.fr** on 2020 Nov 16 by query 'zeta Her B'. Even these observers open their short note with the words: 'The secondary of the system ζ Herculis is a difficult object for spectrographic observation because of the small separation and considerable magnitude difference of the components'.
20 This has been invoked on a number of occasions, for instance, in the long-running series of papers 'Spectroscopic binary orbits from photoelectric radial velocities' by R. F. Griffin in *The Observatory*.
21 Struve & Ratcliffe (ref. 19) commented on their spectra: 'There are no anomalous features, such as might be expected if the spectrum were composite.' This possibility is always present in stellar spectroscopy, especially that of known binaries.
22 Hartkopf W. I. & Mason B. D., *Sixth Catalog of Orbits of Visual Binary Stars*, successive revisions 1998 *et seq*. The BAA *Handbook* used the fourth *Catalog* up to 2002 and the sixth thereafter.
23 Griffin R. F., 'Spectroscopic binary orbits… Paper 150: ζ Cancri C', *The Observatory*, **120**, 1–47 (2000 February). The photometry of A, B and C is reviewed on pp. 23–26.
24 Meyer C. *et al*., *Astron. Astrophys. Suppl. Ser*., **110**, 107 (1995). The writer has not consulted the original paper.
25 This was just one of many trials of twin-slit interferometry which the writer has made with a variety of designs of mask on a number of close binaries, since first obtaining interference fringes in the 12½-inch in 1971. As an observer he was already very familiar with interferometric images in the telescope at the time of this 1997 observation, and on that occasion was merely using this specific double as a target for testing a particular design of mask.
26 For anyone with a touching faith in those ostensibly millimagnitude-precise values for close double stars, Griffin (2000), pp. 23–26 (ref. 23) should be required reading.
27 Optical layout diagram: **www.esa.int/esapub/achievements/Sc72s4** (accessed 2020 Nov 20)
28 Argyle R. W., *pers. comm*., 2020 November

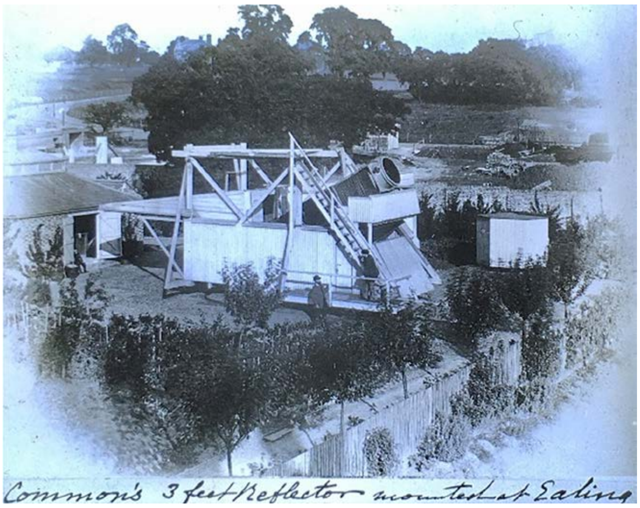
Received 2020 November 26; accepted 2021 January 23

A lunar photograph by Andrew Ainslie Common

Richard McKim
& John Chuter
Archivists

Andrew Ainslie Common (1841–1903) (*above*) was a pioneer astrophotographer of the late Victorian period. No doubt many members have seen some of his famous images of the Orion Nebula and Jupiter (with the early Red Spot) in the frontispiece to Agnes M. Clerke's *A Popular History of Astronomy during the Nineteenth Century* (1885).

Common lived in Ealing and used a series of telescopes, the mechanical parts of which were made by himself, from 18 to 60 inches in aperture. In this note we are concerned with his 36-inch (91cm) or '3-foot' reflector, pictured with Common at the eyepiece *(right)*. Also shown (*lower right*) is a lantern slide in the archive which is labelled as 'Observatories No. 17'. The 36-inch mirror was later used in the Crossley reflector at Lick Observatory, with which two satellites of Jupiter were discovered. In 1884, Common received the Royal Astronomical Society's Gold Medal for his improvements to the science of astronomical photography.



Common joined the BAA on 1896 Jun 24, so he was not one of our 'original members' (defined as those elected in the first session of 1890–'91), but he had become a Fellow of the RAS in 1876 and served as its President in 1895–'97. His address was given as '63 Eaton Rise, Ealing, W. [London]': there were no postcodes in those days! He was one of the many passengers aboard the steam yacht *Norse King* when it sailed to Vadsö in the Varanger fjord, Norway, in 1896 on the occasion of the Association's first eclipse expedition. However, Common and his assistants were travelling under the auspices of the Joint Permanent Eclipse Committee of the Royal Society and RAS.

In March of 2022, Mavis Treen contacted the BAA to offer us an original framed lunar photograph (*left*) taken by Common with the 3-foot reflector. We were of course happy to accept. Her great grandfather, Thomas Treen, was born in Stoke Bruerne, Northamptonshire, and had moved to London around 1862, living about eight miles from Ealing. His birthplace is now the location of an important canal museum and must have been an inspiring location for an engineer, the profession he was later to follow. Common presented the photo to him, as can be seen from the inscription, and it was kept within the family for several generations.

The photo measures 17×23 inches and is a tenfold enlargement of the original glass negative. It bears the date 1880 Jan 27, and a time of 08:47 GMT (20:47 UT); Treen would have been about 44 years old that year. The photo is identical to other prints in the possession of the RAS and the Science Museum. Common is known to have taken at least one other lunar photo, in 1877. The emulsion is now rather cracked (*see below*), but it remains an impressive 142-year-old document.

We have checked several early lists of BAA members, and Mr Treen was never a member. Maybe he knew Common personally, and perhaps this photograph was given to him as a token of appreciation.

Nowadays the Moon is an easy target for the photographer, but in those days of slow and grainy emulsions, a large aperture was needed to obtain a sufficiently short exposure time. It is pleasing to be able to add this photo to our archives.

The sky is for everyone: Women astronomers in their own words

by Virginia Trimble & David A. Weintraub (eds.)

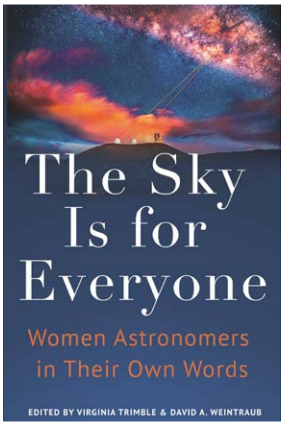
Princeton University Press, 2022
ISBN 9780691207100 | Pp 504 | £25.00 (hbk)

Released in the UK on August 16

There have been numerous books written about the challenges women working in astronomy have faced over the years. Most of them were written by other people, and there is always a risk that an author may slightly bend the interpretation of primary source material to fit their own narrative. This book stands out from others because the majority of the text is a collection of autobiographical essays written by the astronomers themselves.

The first chapter is a summary of the historic achievements of female astronomers, beginning with Dorothea Klumpke who in 1893 became the first woman ever to be awarded a higher degree in astronomy, and ending with Andrea Mia Ghez who in 2020 became the first woman to be awarded the Nobel Prize in Physics for her work in astrophysics. It is a fascinating chapter which is packed with many names you will recognise, but also many you may not.

Following this, there are 37 featured autobiographical essays which give a fascinating insight into the career paths each of these women have followed and the research they have carried out. They talk about the difficulties they have faced with sexism and prejudice, but also about the very supportive members of staff who went out of their way to help these gifted women. Parts of their stories are not easy to read, but their determination to follow their dreams of a career in a field that they love is incredibly inspiring.



A final brief chapter talks about how the landscape is changing for the better and looks back at how far we have come on the journey towards equality for women working in astronomy. Although we still have a way to go to reach true equality, these stories will absolutely inspire our next generation of female scientists. There is an excellent Further Reading section at the end of the book, but the content of these essays alone is an absolute must-read for any young lady who is thinking of starting a career in astronomy. The same applies to anybody who is interested in the history of women in astronomy.

Mary McIntyre

An amateur astronomer based in Oxfordshire, Mary McIntyre is a speaker, author, astrophotographer and space artist. She leads the UK Women in Astronomy Network and in 2021 was awarded the BAA's Sir Patrick Moore Prize.

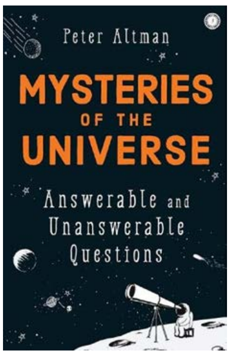
Mysteries of the Universe: Answerable & unanswerable questions

by Peter Altman

Altman Publishing, 2021

ISBN 978-1-86036-062-6 | Pp 304 | £9.99 (pbk)

It is often observed that every answer in astrophysics yields still more questions. By this reckoning, the mysteries of the Universe are less the quarry of scientists and more their tormentors: an infinite series of multiplying riddles without answer. But astrophysicists enjoy a good puzzle. Each new question is a reminder that much of the pleasure in science comes from the journey rather than the destination, whatever that destination may be.



Peter Altman is one such lover of the unknown and unknowable. In *Mysteries of the Universe*, he has fittingly produced a question-and-answer book with more questions than answers. With humour and theatrical flourish – befitting of an author who is apparently a member of the Magic Circle – he addresses one question per chapter, in a whirlwind of astronomy, philosophy, theology, cosmology, history, biochemistry (his own specialism) and even science fiction. (A fun and relevant sci-fi story hidden at the book's end is a welcome 'Easter egg').

It is no great spoiler to reveal that chapters devoted to such questions as 'Do other universes exist?' and 'Is time travel possible?' inevitably conclude with the typed equivalent of a shrug, but much satisfaction may be derived from the lively and engaging discussions along the way. Others – such as one on the veracity of astrology – come to rather more certain conclusions.

The author bounces from one field to another with Tigger-like enthusiasm, and it perhaps goes without saying that the advanced reader will find elsewhere more in-depth treatments of the topics covered. However, the restless energy seems appropriate to a book which is a celebration of curiosity. Peppered with references to papers, books and online articles, it also acts as an effective springboard for further reading.

Although a few images appear pixelated at the scale reproduced – a common problem in modern astronomy books – none of these cases especially affected my enjoyment of the book. Richly illustrated and with a helpful index, it is also a handy size. Your reviewer took to reading a chapter before going to bed, and while an unanswerable quandary may be considered an unsatisfying bedtime story by some, to those who love to ask questions, it is a recipe for happy dreams. This book would make a good gift for those with an interest in 'the big questions'.

Philip Jennings

A keen visual observer of the Moon and planets, Philip Jennings is an astronomy writer, speaker and consultant. He sits on the BAA Council and is Editor of the *Journal*.

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 2021–2022 session, and therefore now become Honorary Members:

	Date elected
Mrs Janice E. Brown	1971 Nov 24
Mr Peter G. Carson	1971 Nov 24
Mr Douglas G. Daniels	1971 Nov 24
Dr Martin L. Fair	1971 Nov 24
Mr Russell G. Folland	1971 Nov 24
Dr Michael A. Hapgood	1971 Nov 24
Mr Peter V. Hudson	1971 Nov 24
Dr Peter L. Jennings	1971 Nov 24
Mr Robert A. Kendall	1971 Nov 24
Mr Lars Lindhard	1971 Nov 24
Mr Jonathan D. Shanklin	1971 Nov 24
Mr Kenneth R. Smith	1971 Nov 24
Mr John F. Wrigley	1971 Nov 24
Mr Richard J. Flux	1971 Nov 28
Dr James S. Albinson	1971 Nov 29
Mr George E. Ollis	1971 Dec 29
Mr Terence C. Platt	1971 Dec 29
Mr Ivan L. Walton	1972 Jan 26
Dr Enrico Stomeo	1972 Feb 22
Mr Keith L. Black	1972 Feb 23
Dr Peter Barnes	1972 Apr 16
Mr Peter Cope	1972 Apr 26
Mr Robin M. Piper	1972 Apr 26
Mr Paul J. Maxwell	1972 May 26
Mr Peter M. Bowers	1972 Jun 28
Mrs Eileen M. Cooke	1972 Jun 28

BAA Ordinary Meeting, 2022 January 22

held at the the London Irish Centre, 50–52 Camden Square, London NW1 9XB

Dr David Arditti, *President*

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

Alan Dowdell
Meetings Recorder

The President, Dr David Arditti, opened the meeting at 2.30 p.m. and welcomed the members present in the McNamara Suite of the London Irish Centre, as well as those watching *via* the livestream made available on the BAA YouTube channel. He noted that the next face-to-face meeting would be on Mar 30, when it was planned to return to the Institute of Physics headquarters.

The first speaker was to be Grant Privett, delivering a talk about variable nebulae. Unfortunately, he was unable to attend, but Dr Nick Hewitt stood in to talk about the same topic.

The BAA President, Dr David Arditti, welcomes members to the McNamara Suite at the London Irish Centre. Masks were worn by attendees to help reduce the risk of spreading COVID-19.




The speakers *(left to right)*: Dr Nick Hewitt, Nick James, Peter Meadows and Mary McIntyre.

'Variable nebulae – an update'

Variable nebulae are typically associated with young T Tauri stars which have thrown off the envelope of material from which they formed and have bipolar outflow.

The best to observe is the well-known object NGC 2261, also referred to as Hubble's Variable Nebula. This was monitored by Carl Lampland from 1919 until 1951, in a series of over a thousand photographs which showed its variation in brightness over time. Dr Hewitt showed a modern-day example of long-period monitoring by BAA member David Boyd, the results of which show how the variability of Gyulbudaghian's Nebula follows that of the star which it hosts.

While some of these objects remain visibly variable over time, others may disappear completely. An object near M78 called McNeil's Nebula has not been visible for a period of years (it was discovered to be 'missing' by Mike Harlow in 2018). We also have new ones being discovered – for example, Borisov's Nebula in Cepheus, discovered in 2020.

There is plenty of work available to amateurs interested in undertaking long-period monitoring, and of course there is the possibility of discovering new variable nebulae.

In answering a few questions, the speaker commented that a telescope aperture of eight inches would be the minimum required for this work. For David Boyd's monitoring and spectroscopy, he uses a 14-inch instrument. Dr Hewitt also clarified why it is that these nebulae seem to vary; the brightness fluctuations are due to the variation of a star being projected on the surrounding nebula, but this is obstructed at times by clouds of denser material.

Dr Arditti thanked Dr Hewitt before asking Nick James to give an update on the *James Webb Space Telescope* (JWST).

'Following JWST through Orion'

At the previous meeting of the Association in early December, it was still uncertain when lift-off of the JWST would happen. When it finally occurred on Christmas Day, it was a perfect launch. At the time of this January meeting, the space telescope was travelling to the L2 Lagrangian point, where it was to remain.

Unlike other spacecraft at this Lagrangian point, JWST only has limited station-keeping movement, since due to the spacecraft's sunshield the rocket thrusts can only be directed away from the Sun. Mr James described how the telescope will operate in the infrared waveband, detecting wavelengths of 0.6–28.3 microns, and therefore needs to maintain a very low temperature. It does this passively, relying on the 21×14m sunshield to keep it cold. The expected lifespan of the craft is now a possible 20 years, as the launch and its trajectory were so successful that they used less propellant than expected.

Denis Buczynski in Scotland managed to image JWST on the night of the launch. Others, including Peter Carson and Nick James, imaged both the telescope and the last stage after the two separated. Once the sunshield was fully deployed, the brightness of the spacecraft became variable and markedly increased at times; an image by Nick Quinn showed it at about 15th magnitude. It may be possible to image JWST at L2, when it will be at about 18th magnitude and might be seen glinting in the Sun.

An interesting effect that JWST must allow for is solar radiation pressure which acts to turn the craft; at its position the pressure is 9.1 micropascals. This pressure also affects the upper stage, the orbit of which has been calculated based on amateur observations. Allowing for this pressure shows that this stage will return to the vicinity of Earth in 2047.

The President thanked Mr James and the meeting was paused for tea. On return, the President introduced Peter Meadows, Assistant Director of the Solar Section.

'The greatest sunspot groups (the Magnificent Seven)'

Mr Meadows explained that the groups referred to in his talk title are the seven largest, in terms of

Papers accepted by Council on 2022 January 22

Three papers proposed by Prof Jeremy Shears, Papers Secretary, were accepted on 2022 January 22 by the BAA Council for publication in the *Journal*:

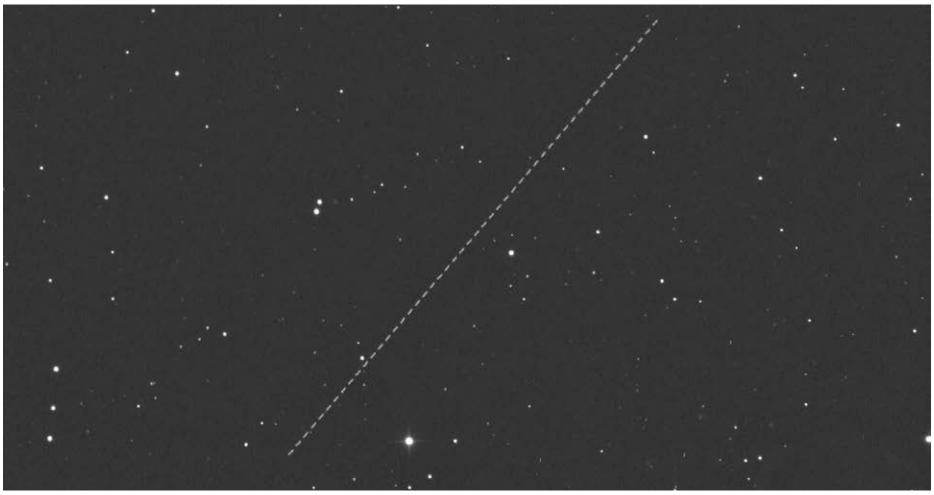
The enigmatic Miss Cicely M. Botley (1902–1991), by Martin Mobberley;

The 2021 superoutburst of the dwarf nova LL Andromedae, by Jeremy Shears;

Backyard lunar mineral prospection, by Mark Kidger.

Philip Jennings, *Editor*

Hisako Koyama, pictured adjusting her telescope in 1951. *(From Asahigraph)*



Peter Carson imaged the near-Earth object 1994 PC1 as it sped past on 2022 Jan 18. The stony asteroid, approximately 1.1km in diameter, approached us at five lunar distances. This image comprises 50 ten-second exposures, taken with a 315mm ƒ/8 Dall–Kirkham reflector and QHY600 CMOS at a remote observatory in Fregenal de la Sierra, Spain. *(Peter Carson)*

area, to be recorded. The largest known occurred in 1947; it covered 0.6% of the Sun's surface.

In carrying out the research discussed in this talk, the speaker used observations from Mount Wilson, California, where drawings of sunspots have been produced since 1917, and by Hisako Koyama in Tokyo, who used a 200mm refractor between the years 1947 and 1991. Another source is the Specola Solare Ticinese observatory in Locarno, Switzerland, where a 150mm telescope is used; these observations started in 1957. Mr Meadows had extracted images of drawings from the different sets of observations at the same scale, and these were shown for comparison.

The speaker then proceeded to show illustrations of these great spot groups. The first was initially seen on the limb in late January of 1946; it was expected that such large spots would not be seen again but a complex group appeared in 1947 February. By April of that year, this group had grown to become the largest seen.

Another major group was seen in 1951 April, reappearing on the next rotation in May when it received a new designation. A Mount Wilson photograph of this active region was shown. We had to wait until 1989 March for the next large group to be seen. In 2014 October, another large group was observed. Images by Pete Lawrence and Andy Davey, together with one from Ron Johnson, were shown.

Peter Meadows concluded by saying that the current solar cycle is performing better than expected. The Solar Section still welcomes drawings of any spots seen, as these can provide comparisons with past observations.

Dr Arditti thanked Mr Meadows for his talk and introduced Mary McIntyre to give the Sky Notes for the current month.

Sky Notes

Ms McIntyre started by showing images of the Sun taken in white light on Dec 14 by Philippe Tosi. These were followed by images recently taken by Stuart Green, Gary Palmer, Ella Bryant, Michael Stephanou, and the speaker.

Aurora activity had been growing and recent images taken by Jim Henderson, Stuart Baldwin, and Tracey Harty were presented. The noctilucent cloud season in the southern hemisphere had been slow to start for 2021/2022, due to the temperature of the mesosphere.

Ms McIntyre showed a video sequence and resultant composite image of the Moon that she had obtained in daylight, showing a transit of the *International Space Station*.

Turning to the planets, there had been an outbreak in the North Equatorial Belt of Jupiter which was imaged by members. Jupiter would still be visible in the west and on Feb 3 it would be situated near the Moon. Venus was in the morning sky; although it was bright at magnitude –4.7 it was quite low. There would be a good photo opportunity on Feb 9, with the Moon in conjunction with the Hyades and Pleiades star clusters. An image of the winter Milky Way was shown, which was taken by the speaker.

Turning to variable stars, Nova Cas 2021 (V1405 Cas), discovered on 2021 Mar 18, was still about 10th magnitude and an image by Mike Harlow was shown. There was a near-pass at five lunar distances of 1994 PC1 on Jan 18, as illustrated with an image (above) by Peter Carson. The comet 67P/Churyumov–Gerasimenko was in Cancer at magnitude 9.5.

Ms McIntyre explained that the recent Geminid meteor shower (2021 Dec 4–20) had been well recorded by observers using video cameras. Some 962 meteors had their trajectories solved using UK meteor network data.

Dr Arditti thanked Ms McIntyre and then thanked the streaming technician for helping to produce a successful transmission for the BAA YouTube channel. The meeting was then closed at 5.45 p.m.

Did a Saturnian Great White Spot occur in 1953?

From Dr Richard McKim & Prof Wayne Orchiston

At the very end of the 1952–'53 apparition of Saturn, an unusual observation was reported by an amateur astronomer. With a south declination of 7°, Saturn was better placed from the southern hemisphere. In *BAA Circular* no. 345, the Section Director M. B. B. Heath reported:

> 'WHITE SPOT ON SATURN. The Director of the Carter Observatory, Wellington, New Zealand, reports the discovery by Mr. Peter Read of a fairly large circular whitish area in high northern latitude on August 31d 8h 10m U.T. Any observations of this from the southern hemisphere will be very welcome. The spot was seen with a 5-inch refractor, using a power ×200, but was not as prominently bright as Will Hay's spot in 1933. In these latitudes Saturn had run into daylight at the time of discovery but, in view of the possibility of activity in the region cited, observations should be recommenced as soon as the planet reappears in the morning sky.'[1]

The possible Great White Spot (GWS) observation was probably reported by telegram direct to the BAA *Circulars* editor, for it is not mentioned in any of the IAU *Circulars* from that time. (Read was not a BAA member.) No further sightings were reported, and the Saturn Section did not mention the observation at all in the final report on the apparition, nor in the subsequent one.[2]

Read's sighting was cited by McKim in a paper in this *Journal* in 2011, which dealt with the Saturnian GWS phenomenon.[3] At the time, the whereabouts of Read's notebook was not known, but recently Orchiston informed McKim that it was actually in his possession, and that he had been able to locate the original observation. Figure 1 reproduces the drawing. The seeing was rated as 7 on a scale to 10 (best). Read (1923–1981) was a well-known amateur astronomer who was heavily involved with popularising the subject.[4]

By 1953, Read had enjoyed several years of active observing, but the feature in question does not seem to have been especially bright, not even being brighter than the Equatorial Zone (EZ). GWS are always brighter than the EZ, and, at least in their early stages, are rather better defined. With only a modest aperture and magnification, Saturn can play tricks on the observer. One well-known illusion is the 'Terby white spot' on the rings,[5] and it is plausible that the placing of the shadow of the globe upon the rings or the presence of details on the North Equatorial Belt (NEB) could also have caused the impression of an adjacent light area. Read made a number of other quite normal drawings at the 1952–'53 apparition, another example of which is given in Figure 2.

From the logbook it was possible to discover that in later years, Read's observations occasionally showed features that could not have existed. Thus on 1957 Aug 28, he drew filaments running north to south from the N. edge of the NEB into the N. Temperate region, these being interspersed with large lighter areas, a phenomenon now known to be dynamically impossible. On this and other occasions the edge of the NEB was shown to be more widely disturbed than had been reported by others using large apertures. It is well known that observers with small instruments sometimes exaggerate the fugitive details that are present. There is no doubt that Read was a good observer and a fine artist,[6] and was able to glimpse features that tested his modest refractor to the limit. One such example was his accurate rendition of the Encke complex upon Ring A. He also witnessed irregularities in ring C in 1958, which have been reported in some other apparitions when the rings have been widely opened.

We have reproduced Read's Aug 31 drawing for the sake of completeness, because Heath had alluded to it in the aforementioned *Circular*.[1] We cannot really conclude that Read observed a GWS. He may have observed (and innocently exaggerated in his drawing) some small-scale disturbance, but if a GWS had really been present we would have expected some confirmatory observations from the southern hemisphere, and perhaps witnessed some greater changes in the belts and zones that persisted into the following apparition. In reality, this does not seem to have occurred. It is very likely that M. B. B. Heath – always a cautious and well-respected analyst – had reached the same conclusion at the time.

For those interested in more details of astronomy in New Zealand, Orchiston has provided further information.[7]

Richard McKim & Wayne Orchiston
[richardmckim@btinternet.com]

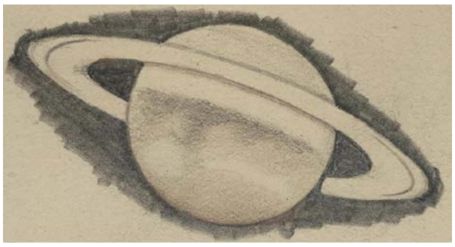


Figure 1. Saturn drawn by Peter Read, 1953 Aug 31 at 08:10 UT. 127mm OG, ×200. (South is uppermost in Figures 2 & 3; Read's sketches, copied here directly from his notebook, originally had north uppermost.)

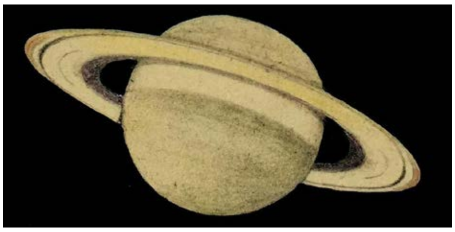


Figure 2. Another drawing by Read, 1953 Apr 15 at 11:45 UT. 127mm OG, ×435. 'Near culmination. Best view of Saturn I have ever had. Absolutely motionless.' Note the fine details of the NEB and of Rings A & B.

Notes & references

1 *BAA Circular*, no. 345 (1953 Oct 6). Saturn's solar conjunction was on Oct 23!

2 Heath M. B. B., *J. Br. Astron. Assoc*., **64**, 23–25 (1954) and **65**, 156–159 (1955)

3 McKim R. J., 'Great White Spots on Saturn: current and historical observations', *ibid.*, **121**, 270–273 (2011). (Figure 5 of this paper has not been reproduced well, but the relevant drawings may easily be found in the literature.)

4 Peter Read was New Zealand's answer to Sir Patrick Moore. Interested in astronomy from childhood, he became a well-known face on NZ television and his popular monthly *Night Sky* ran from 1963 to 1974. Read also served as President of the Royal Astronomical Society of New Zealand and was an FRAS . He built an observatory at home, which housed a 5-inch Watson refractor. Subsequently, this was replaced by a 6-inch Cooke, but he also made use of the ex-Crossley 9-inch Cooke photovisual refractor at Carter Observatory. For further details, see Barton M. L., *Southern Stars*, **29**, 206–207 (1982).

5 Alexander A. F. O'D., *The Planet Saturn*, Faber & Faber, 1962

6 In fact, Read had natural artistic talent and when he left secondary school he worked at the National Publicity Studios creating posters, displays and murals. From there he gravitated to painting oils, acrylics and watercolours, including astronomical topics. For many years his paintings were exhibited at the New Zealand Academy of Fine Arts. There were still various examples of his astronomical paintings at Carter Observatory when one of the authors (WO) was Director there in the 1990s.

7 Orchiston W., *Exploring the History of New Zealand Astronomy: Trials, Tribulations, Telescopes and Transits*, Springer, 2016

Longest-serving Section Directors

From Mr Anthony J. Kinder

I would like to be the first to offer my congratulations to Lyn Smith (Solar), John Rogers (Jupiter), and Richard McKim (Mars), who are now the longest-serving Directors of their respective Sections. Lyn has been Director for 16 years (overtaking Edward Walter Maunder), John for 34 years (overtaking Theodore Evelyn Reece Phillips) and Richard for 31 years (overtaking Edward Howard Collinson, who himself overtook Eugène Michel Antoniadi (21 years)). None of these directorships exceed that of Henry McEwen, Director of the Mercury & Venus Section for 60 years.

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[anthony_kinder@hotmail.com]

Correspondence is welcome. Please e-mail letters to **pjennings@britastro.org**, or post to Mr Philip Jennings, 47 York Road, Malton, York, YO17 6AX, clearly marking your letter 'for publication' if you wish it to be considered for the *Journal*.

Obituary

Rob Moseley (1952–2022)

Rob Moseley, skilled observer and past editor of the Lunar Section publication *The New Moon*, died in 2022 February.

Rob Moseley. *(Courtesy of the Moseley family)*

Rob was a lunar and planetary observer who contributed many observations to the BAA Sections in the 1980s and '90s. He was primarily a visual observer, with perceptive skills and an ability to portray on paper the detail he could see at the telescope eyepiece. He was a keen student of the history of astronomy and spoke at many meetings of the BAA and other groups around the country. He will be missed by all who knew him.

Rob's love of astronomy began in his teens, with the purchase of a book. He taught himself the constellations and observing techniques at a home-made observatory in his garden at Cecil Road, Northampton. His attempts to establish an astronomy club at school met with little support, but led to the establishment of important friendships. He enjoyed formative experiences at an astronomical youth camp in Germany in 1969, and regularly attended meetings of the astronomical section of the Northampton Natural History Society at the Humfrey Rooms, Northampton. His involvement with this local society offered opportunities to observe the skies using their telescope at Gordon's Lodge. He always insisted that as a beginner, he did not need a telescope to get started; just a decent pair of binoculars and a copy of *Norton's Star Atlas* sufficed. At this time, he met Roy Panther. Roy became a valued friend and mentor, whose encouragement was treasured as it set him on the path to further study.

Rob's working life was varied. He taught English and also worked as an expert guide at the Lunt Roman Fort Museum, near Coventry.

His interests other than astronomy were many. He spent time restoring habitats at the bird reserves at RSPB's Leighton Moss and Warwickshire Wildlife Trust's Brandon Marsh. He was a member of the Cloud Appreciation Society. He collected rock and mineral samples on field trips and studied these with a stereo microscope. He was instrumental in cataloguing coins for the Lunt Fort and the Herbert Art Gallery in Coventry. His knowledge of Roman History was extensive. He also followed the many travails of his beloved home town football club Northampton Town (The Cobblers) throughout his life.

Rob joined the Coventry & Warwickshire Astronomical Society (CWAS) and was the editor of their society magazine *Mira* for some years. He also led the project to renovate and reinstall the 6-inch Cooke refractor on top of the college where the CWAS met.

Rob's principal astronomical interests were faithfully recorded in his many logbooks and diaries. His numerous lunar and planetary drawings exemplify the classic manner of recording telescopic observations. He also made extensive observations of double stars and descriptively recording the contrasting, colourful hues of these objects was an ongoing joy and pleasure for him. His enthusiastic approach is summed up in this extract from *Mira*:

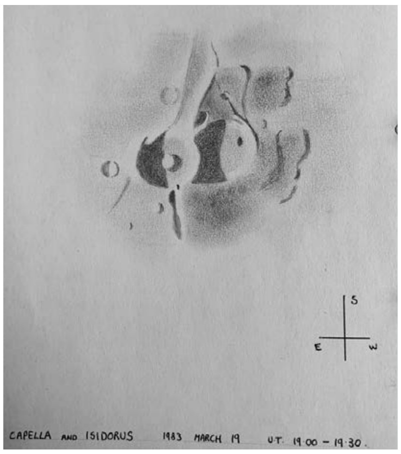
> 'Estimates of colour are of no value in the scientific sense – and yet this is the part of double-star observing I tend to enjoy most. The subtleties of star coloration are only truly appreciated by the double-star specialist. Many are an aesthetic delight. Once my eye became used to perceiving colour at low light levels I found that Webb, Smyth and the other 19th-century observers were not being that fanciful with their 'garnets', 'indigos' and '*olivacea subrubicundas*'! Stars really do have the most gorgeous colorations – if real attention is paid to them. Colours are always more striking with complimentary pairs. The yellow and lilac of Albireo is the most famous example of quite a common combination. My favourite is the pair 32 Eridani (470). The 4th-mag. primary is a rich yellow, with a 6th-mag comes [*'visible companion' – ed.*] I have noted as 'emerald'. Webb describes the pair as 'Topaz and Bright Green'. This companion is one of the few stars I've come across which is unmistakably green - it's a ravishing sight! The red/green combination is best typified by Antares and its companion, but to British observers the 7th mag. attendant is a stiff test due to its low altitude and consequent poor seeing.'

During his membership of the BAA, Rob was editor of the Lunar Section publication *The New Moon*. At the time of his involvement, the study and drawing of lunar features by observers had become somewhat neglected and the practice was in danger of being seen as redundant, with the emphasis having seemed to have shifted towards observations of transient lunar phenomena. However, Rob's successful editorship was rewarded with a significant resurgence of contributions by observers who made lunar drawings. The magazine continued to be published for many years. His own drawings are currently being scanned to be kept in digital form by members of his family (wife Lesley, son Joe and daughter Liz). These will be available for viewing and use, as a lasting legacy and encouragement to young observers. The desire to share his enthusiasm was his lasting gift.

Rob eventually set up an observatory at his home in Coventry, devoted to the observation and measurement of close double stars. His results were published in US Naval Observatory and Webb Deep-Sky Society publications.

He will be remembered by many members of this Association as a careful and diligent observer. The loss of Rob will be grieved by his family and many friends, of whom I was privileged to have been one.

Denis Buczynski



Left: Rob Moseley with the 12 inch Merlin reflector, a BAA loan telescope. ***Right:*** examples of lunar and planetary drawings which Rob made at the telescope. *(Courtesy of the Moseley family)*

Variable Star Section

Two interesting variables in Sagitta & Aquila

Gary Poyner
Coordinator, Cataclysmic Variables & Eruptive Stars

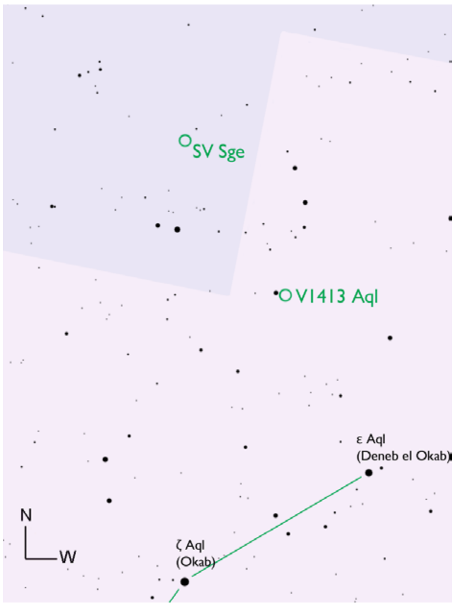
Very often, the visual variable star observer will find that in the crowded Milky Way areas of the night sky, it is possible to observe a number of variables with the minimum movement of telescope or binoculars – even, on occasions, in the same field of view. Straddling the northern border of Aquila and western edge of Sagitta are two interesting variable stars just 1.5 degrees apart, completely different in their make-up. They are excellent objects for small or large telescopes, either visually or with a CCD during the summer months.

SV Sge (RA 19^h 08^m 11.77^s, Dec. +17° 37′ 41.2″) is one of the rarest types of variable stars in the night sky – type RCB, named after the prototype R Corona Borealis. These objects are all F–G supergiants and contain little or no hydrogen at all, but consist mainly of carbon, cyanogen, helium and various metals. Their light variations are caused by 'clouds of dusty carbon' ejected from the star itself. If one of these clouds happens to lie in the line of sight of an observer on Earth, the star is seen to fade, and can take weeks, months or years to recover to its usual brightness.

SV Sge has been monitored by the BAA Variable Star Section (VSS) since 1988, and since that time nine fades have been observed. The fades and recoveries cannot be predicted, making the RCB-type variables some of the most interesting to monitor on a regular basis. At maximum brightness, SV Sge is easily visible with small telescopes, shining between magnitudes 10 and 11. The fades vary in depth but can drop as deep as magnitude 17 (as in the last recorded fade in 2018 December), where a CCD will be needed to record it (Figure 1).

Just 1.5 degrees southwest over the border, in Aquila, can be found a fascinating symbiotic variable star – V1413 Aql (RA 19^h 03^m 46.84^s, Dec. +16° 26′ 17.0″). Symbiotic stars are binary systems containing a late-type giant star and a hot, compact companion – usually a white dwarf. Discovered in 1950 by Merrill & Burwell on plates taken at Mount Wilson, V1413 Aql's symbiotic nature was not identified until 1984.[1] What makes this star so interesting is that its variations have three distinct properties – a quiescent variability, outbursts and well-defined eclipses.

Figure 2 shows the Section's light curve from 1995 to the present. One can see that the amplitude of variations excluding eclipses is over three magnitudes, ranging from 10.3–13.5 visual. This also includes three observed outbursts – 1995, 2010 and the historically bright 2021 event: excellent for 15–20cm telescopes or sizeable binoculars.



The locations of SV Sge and V1413 Aql. Chart for illustrative purposes only. *(Philip Jennings & Gary Poyner, with astrometry courtesy of* Stellarium*)*

The eclipses occur every 434.1 days, with the duration and depth varying depending on the intrinsic brightness of the system as a whole. Observations undertaken by the writer from 1999–2011 show that the depth of the eclipse varies between 1.8 magnitudes when V1413 Aql is bright, to 2.3 magnitudes when fainter (visual), with the duration ranging from 64 days in low state to 85 days if the system is bright.[2] This year's mid-eclipse occurred during early April, and unfortunately no observations were made due to the unfavourable position of the field in the morning sky at that time. Despite this, the intrinsic variability and possibility of outbursts make V1413 Aql a very interesting star to observe during the second half of the year.

The 2023 mid-eclipse is due in early June and will be an excellent target for observers both visual and CCD. More information on this will hopefully appear in the spring 2023 edition of the *VSS Circular*, in March next year.

Charts for SV Sge are available to download from the VSS website,[3] and for V1413 Aql can be downloaded from the AAVSO Variable Star Plotter.[4]

1 Munari U., 'Studies of Symbiotic Stars VI. The eclipsing symbiotic nova AS 338', *Astron. Astrophys.*, **257**, 163–176 (1992)
2 Poyner G., 'Eclipse comparisons of the symbiotic nova V1413 Aql from visual photometry', *J. Br. Astron. Assoc.*, **122**(6) (2012)
3 BAA VSS website: **britastro.org/vss/**
4 AAVSO charts: **aavso.org/vsp**

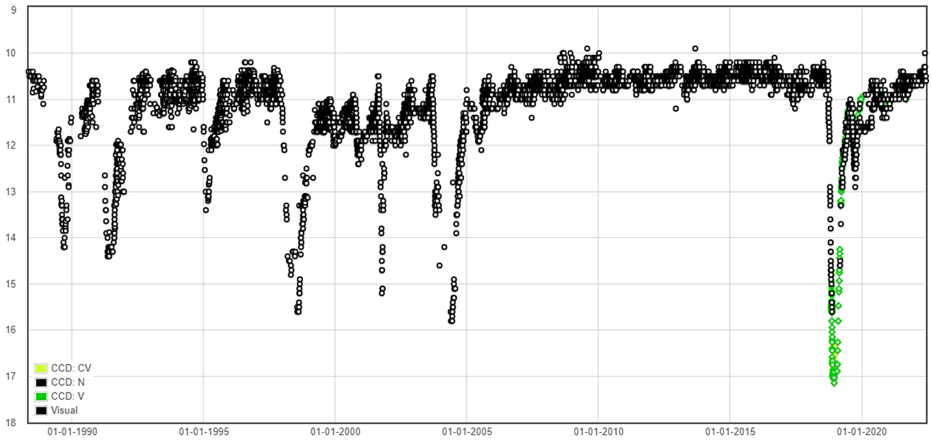


Figure 1. SV Sge, 1988–2022. *(BAA VSS database)*

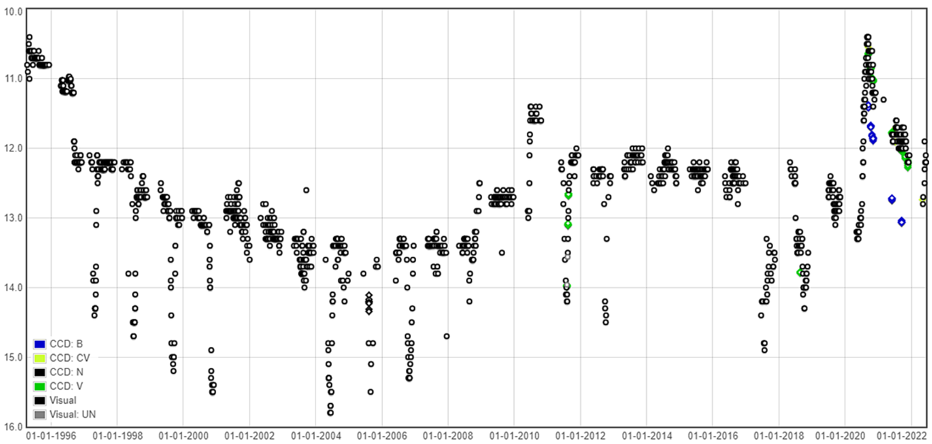
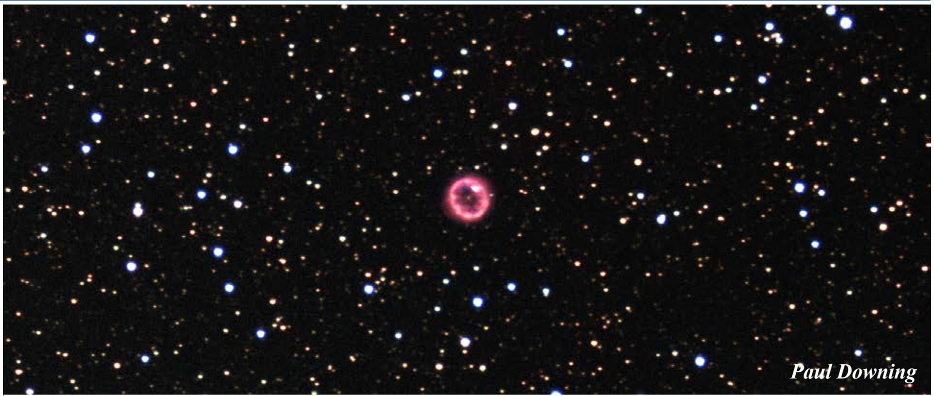


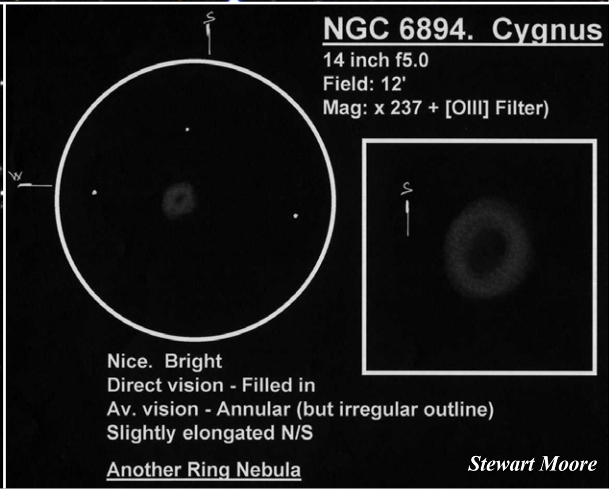
Figure 2. V1413 Aql, 1995–2022. *(BAA VSS database)*

Deep Sky Section

NGC 6894 – A diamond ring in Cygnus

Stewart Moore
Director, 2004–'13





A glorious sight in the late-summer night sky is Cygnus the swan, flying along the Milky Way. This is one of the most distinctive constellations, with the beautiful and easily split double star Albireo (beta) forming the swan's head, magnitude 1.3 Deneb (alpha) the Swan's tail, and delta and epsilon its outstretched wings. Often referred to as the Northern Cross (for obvious reasons), Cygnus has many legends attached to it, one being that it is the Greek god Zeus in disguise, the father of Pollux – one half of the heavenly twins.

The constellation lies in an exceptionally rich region of the Milky Way and is a wonderful area of the northern sky for scanning with binoculars from a truly dark site, particularly in late summer when the constellation lies almost directly overhead.

There are numerous deep-sky objects to examine in the constellation, the most famous probably being the Crescent Nebula, the Veil Nebula and the North American Nebula. However, there are other under-observed gems, especially open clusters and planetary nebulae – Cygnus contains nine NGC planetaries. Perhaps surprisingly considering the number of objects in the constellation, only two of them – the open clusters M29 and M39 – are Messier objects. Of the planetaries, one of the most popular is NGC 6826, the Blinking Planetary, but another and less well known example is NGC 6894, which I always think looks rather like a smaller version of M57, the Ring Nebula.

NGC 6894 was discovered by William Herschel in 1784 July. He described it as 'Pretty faint, exactly round and of equal light…' It lies at RA 20^h 16.4^m and Dec 30° 34′, which puts it approximately six degrees southeast of magnitude 3.9 eta Cygni and seven degrees west-southwest of magnitude 2.5 epsilon Cygni. It has a quoted diameter of 42 arcseconds and a visual magnitude of 12.3; it is estimated to lie at a distance of around 5,000 light-years. The central star is magnitude 17.6, so beyond the reach of most visual observers. In addition to notes and an image included in *The Night Sky Observer's Guide, Volume 2* (Willmann–Bell, 1998), Stephen O'Meara mentions it in his excellent book *The Secret Deep*, where it is number 96, while the venerable *Webb Society Deep-Sky Observer's Handbook, Volume 2* gives notes on it for a range of apertures and also a sketch of it through an 8-inch telescope.

I first observed this planetary in 1999 July under a magnitude 5.0 sky, using a 14-inch *f*/5.0 Dobsonian (see sketch, scanned many years ago by Nick Hewitt). It was an easy object at ×237, with a Lumicon OIII filter used, and it showed an interesting effect when switching between direct and averted vision. With direct vision, it appeared as a filled-in disc (no annularity), while with averted vision, it was clearly annular and very reminiscent of a small version of M57. (I have observed a similar effect when looking at the Helix Nebula through a small telescope.) It appeared slightly elongated north–south, and the outer edge of the envelope was poorly defined. In recent years, NGC 6894 has had the moniker 'Diamond Ring Nebula' attached to it, because of images showing a magnitude 14 star on the northwest side of the ring.

Two images by Section members Nick Hewitt and Paul Downing are shown here. Nick imaged the planetary in 2010 using his TMB 115mm *f*/7 refractor. His image has been cropped and expanded to show the planetary in more detail. The star of the diamond ring mentioned above can just be seen at the 7 o'clock position. Paul's image dates from 2008 and was taken from his observatory in Spain using a Celestron C14 and QSI 683 camera. It is an LRGB image (40min L and 30min RGB in 5min subs). The diamond ring star can be glimpsed at the 2 o'clock position.

Deep images of planetaries often show evidence of faint outer envelopes: material that has been expelled in the early stages of a star's death throes and then ionised by the hot central star, as it settles down to life as a white dwarf. Often these envelopes or haloes appear broken, as later and faster ejections break through the earlier expelled material. Interestingly, although deep images of NGC 6894 show evidence of this expelled material, instead of it appearing as a ring or shell it shows up as stripes lying tangential to the outer halo and thought to be shaped in this manner by the Galactic magnetic field. For further detail on this, see the 1997 paper 'The interaction of the planetary nebula NGC 6894 with the ISM magnetic field' by Noam Soker and Daniel Zucker (**bit.ly/3aIUZul**).

As was mentioned earlier, there are many other planetaries in Cygnus, including one from the Index Catalogue – IC 5117, which surprisingly does not get a mention in *The Night Sky Observer's Guide* despite being a relatively easy visual target – and some from other, more obscure catalogues.

One fascinating object that is worth tracking down is PK 64+5.1, commonly known as Campbell's Hydrogen Star. Discovered spectroscopically by American astronomer William Wallace Campbell from Lick Observatory in 1893, it lies just 2.5 degrees north of Albireo. This is one of the few planetaries best viewed through an H-beta filter, rather than OIII. At magnitude 9.8 it is an easy object in quite small telescopes, but with a diameter of only a few arcseconds, the challenge is to find it among the rich surrounding star fields. This is where blinking with the H-beta filter comes in. When found, crank up the magnification and a small hazy disc should be visible.

Sky Notes

by Nick Hewitt

2022 August & September

(Written for 22:00 BST in the UK on September 1.)

Above: The Cygnus Loop, imaged by Ian Sharp on 2020 Jul 18 at Selsey, Sussex. Takahashi FSQ-85EDX *f*/5.3 quadruplet APO refractor, QHY 268C CMOS OSC camera, Optolong dual-band L-eXtreme filter, and Starlight Xpress five-position 2-inch filter wheel. 18×900s. This is a crop of the full image, which is at **bit.ly/3znJHUD**.

Figure 1. Epsilon Lyrae, the 'Double Double'. 2021 Oct 7; C9.25 and Canon 60Da. *(Nick Hewitt)*

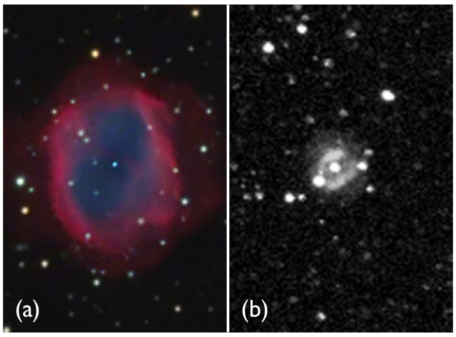


Figure 2. (a) NGC 6772. Imaged by Peter Goodhew on 2021 Jun 30; APM TMB-LZOS 152 refractors (two), QSI 6120 CCD cameras, and 10Micron GM2000 HPS mount. 42 hours total integration in H-alpha, OIII, LRGB. Fregenal de la Sierra, Spain. See Peter's superb gallery on the Community pages of the BAA website. *(Peter Goodhew)* **(b)** NGC 6804. Imaged 2018 Jul 22; TMB 115mm *f*/7 and Trius SX-814 CCD. Luminance, 3×300s, cropped and enlarged. *(Nick Hewitt)*

Figure 3. The bright Crescent Nebula, NGC 6888, is upper right; the ghostly 'Soap Bubble' planetary nebula can be made out at lower left. Imaged on 2021 Jul 16 at Edgware, London. Sky-Watcher Evostar 80ED SharpStar 94EDPH on a Sky-Watcher HEQ5 Pro; ASI 1600MM Pro and ASIAIR Pro ZWO filters. *(Callum Scott Wingrove)*

At last, we have planets to observe at a reasonable hour for those averse to early rising. As the days shorten, a procession of favourite solar-system quarry becomes available – firstly Saturn, then Jupiter, with Mars becoming more prominent towards the equinox on Sep 23. During the warm late-summer nights, the Milky Way offers an array of treats for the deep-sky observer, so all tastes are catered for.

The Summer Triangle is made up of three first-magnitude stars: Vega, Deneb, and Altair. Vega (alpha Lyrae) is a brilliant blue-white treasure that begins August almost at the zenith. Lyra is a small but perfectly formed pattern that contains the famous Ring Nebula (Messier 57), the rather overlooked globular cluster Messier 56, and the 'Double Double', epsilon Lyrae. This is a wide pair of stars, within which each component is again a closer double and a good test for small telescopes. The wide pair is easily split using binoculars, as the two binaries are 208 arcseconds apart. Epsilon-1 (ε^1) has stars of magnitude 4.7 and 6.2, separated by 2.6 arcseconds; epsilon-2 (ε^2) has stars of magnitude 5.1 and 5.5, slightly closer at 2.3 arcseconds.

South of Vega and to the east is Altair, the brightest member of Aquila the eagle and, at magnitude 0.75, the 12th brightest star in the sky. This white A-type star is relatively close at 16.6 light-years from us. It is in quite a spin, rotating at 286km/s and so flattened at the poles. Much faster and Altair would break up! The eagle lies deep in the summer Milky Way and is paradise for enthusiasts of planetary nebulae, particularly the small challenging ones that adorn the constellation like out-of-season Christmas tree lights. The best known is NGC 6781 and is a decent size at 110 arcseconds, but many of the others are much smaller, ranging from NGC 6741 and 6803 (both six arcseconds) to NGC 6772 (62 arcseconds), and therefore more difficult to image. Some fainter planetaries from the Abell catalogue (there are 10, with Abell 70 being one of the easier ones) are increasingly imaged.

Between NGC 6781 and the bright pair of open clusters NGC 6755 (bright, large) and NGC 6756 (smaller, fainter) lies an extraordinary object: SS433 or V1343 Aquilae, a microquasar. This exotic system is within the Milky Way galaxy at around 18,000 light-years distant, and consists of a stellar-mass black hole in an eclipsing orbit with a late A-type star. It varies between 13th and 17th magnitude over a 13.082-day period. The associated gaseous supernova remnant Westerhout 50 (the Manatee Nebula to some) is being distorted by this powerful residual black hole and companion, the system having been formed some 20,000 years ago.

If small planetary nebulae are not to your taste, Cygnus offers a splendid collection for devotees of larger diffuse nebulae. The lead star of the swan is Deneb, the third of the Summer Triangle stars. It takes Vega's place near the zenith at the beginning of September and remains prominent until Christmas. The 19th brightest star, it is a true supergiant searchlight, at an extraordinary distance of 2,616 light-years, giving a magnitude of 1.25. Nestled next to Deneb is the huge North America Nebula (NGC 7000), and its fainter companion nebula, the Pelican (IC 5070). Visible to low-power optics from a very dark sky, the North America Nebula is a dramatic subject for imagers, small refractors being particularly effective. Narrowband filters bring out a wealth of detail, emphasising the dark obscuring clouds adjacent to the bright emission.

The swan has an asterism within: the Northern Cross. Much larger than its southern counterpart, it is nevertheless very distinctive and at its base lies a favourite double star with the most beautiful colour contrast: Albireo or beta Cygni. Between Deneb and Albireo is Sadr (gamma Cygni), an F-type star of magnitude 2.2 that centres on a region that is a mass of glowing hydrogen and dust. One of the brightest parts is the Crescent Nebula (NGC 6888). This is the product of mass loss from a Wolf–Rayet star: an extremely hot evolved massive supergiant. Like many of us trying to live longer, it is shedding mass to avoid ending its days as a supernova. The star responsible for the emission is magnitude 7.5, with a most beautiful visual spectrum. The nebula is a crescent unless imaged deeply, measuring 18×13 arcminutes.

Very close to the Crescent is a relatively new discovery, the Soap Bubble Nebula (PNG 75.5+1.7) – not to be confused with the Bubble Nebula (NGC 7653) in Cassiopeia. This very faint, large planetary nebula was only discovered in 2008 by amateur Dave Jurasevich, demonstrating that even in the seemingly unchanging heavens, discoveries can still be made. In fact, there is a very exciting pro-am project looking for faint planetary nebulae, and discoveries are becoming plentiful, but perhaps not for the average amateur under less-than-optimal skies. (See **planetarynebulae.net**, where observer Peter Goodhew sends many images.)

Another favourite is the Cygnus Loop. This supernova remnant is second in prominence only to the Crab Nebula in Taurus. It lies just south-east of epsilon Cygni, the most easterly star in the Northern Cross asterism. It is made up of different components and these can give rise to many other nicknames, including the Veil or Bridal Veil, the Network, and the Filamentary Nebulae. But they all formed together in a Type II supernova explosion some 15,000 years ago. The brightest segment comprises NGCs 6992–5 (the Veil), but the western part (NGC 6960) can be the easiest to locate as 4th-magnitude 52 Cygni lies in the foreground, a beacon guiding the observer into the area.

A slow sweep north-east with a low-power eyepiece and oxygen filter should bring other gossamer threads into view – even the most elusive part, the northern component known as Pickering's Triangular Wisp. Another fine target, in the extreme east of Cygnus on the Lacerta border, is the Cocoon Nebula (IC 5146): a stunning mix of emission, reflection, and dark nebulosity. The bright nebula is trailed by the dark nebula Barnard 168, the contrast being dramatic.

The famous variable star chi Cygni is always worth monitoring. Extrapolating a line from Deneb through Sadr and continuing halfway from Sadr to Albireo leads to this Mira-type variable. An asymptotic giant branch star, it is cool and luminous with a wide amplitude of magnitude from 3.3 to 14.2, the largest of any pulsating variable. More typically the maximum is around 4.8 and minimum 13.4. The period is around 408 days. This year it will be in decline by September from a maximum just below 4th magnitude in April, but small telescopes should show it before minimum in December.

The smaller summer constellations of Vulpecula, Sagitta and Delphinus lie below Cygnus, east of Aquila, sufficiently within the Milky Way to have numerous objects of interest (see 2020 August *Journal*, **130**(4), p.252). Just north of the celestial equator and between the splendid globulars Messier 15 and Messier 2 lies a small horse's head. (*The Godfather* springs to mind.) Equuleus, the Little Horse, is the second smallest constellation and is ancient, thought to be added by Hipparchus. With nothing of interest within it, one has to ask 'Why?'

To the west, the rich Milky Way constellations of Sagittarius, Scutum, Serpens Cauda and Ophiuchus are dipping into the south-west, but as the days draw in, they can be accessed for a few weeks longer.

By September the flying horse, Pegasus, is becoming prominent and contains AG Pegasi, the BAA's 2022 variable star of the year. It is the slowest symbiotic nova on record, handily placed 3° north of Enif in the westernmost part of the constellation. See the 2022 *Handbook of the BAA* for full details of the history, light curve and chart of this fascinating stellar system.

The solar system

The autumnal equinox is on Sep 23; the days will be shorter than the nights thereafter. But the **Sun** is still well positioned for observation and should remain suitably active. There has been some very enjoyable sunspot activity in the late spring and early summer. There are no eclipses of the Sun or **Moon** during this period.

Phases of the Moon
2022 August & September

First quarter	*Full*	*Last quarter*	*New*
Aug 5	Aug 11	Aug 19	Aug 27
Sep 3	Sep 10	Sep 17	Sep 25

Mercury is a difficult evening planet, and while reaching a greatest eastern elongation of 27° on Aug 27 it is desperately low. Opportunities for imaging are realistically during daytime, with great care needed. Inferior conjunction occurs on Sep 23.

Venus remains brilliant but low in the east-northeast before dawn, shrinking from 10.5 to 9.8 arcseconds as it heads for superior conjunction on Oct 22.

Mars becomes much more prominent, beginning August around magnitude 0.1 and 8.6 arcseconds in Aries. By early September, the Red Planet moves east into Taurus, rather north of Aldebaran. By the end of the month, it has brightened to –0.5 and is 11.7 arcseconds; it achieves a good altitude at midnight. The gibbous phase becomes less noticeable. Southern summer (and hence northern winter) began on Jul 21. Do follow this apparition on the Mars Section blog at: **bit.ly/3RHvASk**.

Jupiter reaches opposition on Sep 26 at a spectacular magnitude –2.9, in a subdued star field in Pisces. The gas giant also reaches an impressive equatorial diameter of 49.9 arcseconds, so much detail should be on offer. Transit phenomena of the Galileans are always interesting and on the night before opposition, Io transits mid-evening and occults its own shadow.

Figure 5. Saturn from Bari, Italy, on 2022 Jun 3. *(Davide Pistritto)*

Saturn arrives at opposition well before Jupiter on Aug 14 (not as stated in the *Handbook*), at magnitude –0.3. The ringed planet is slowly climbing the ecliptic, reaching eastern Capricornus and an altitude of 22°. Although only magnitude +0.3, in this rather barren part of the sky it should stand out well. On the days either side of opposition, the rings appear noticeably brighter: the Seeliger effect.

Uranus lies 1.4° north of Mars in early August, but the two planets soon part. The ice giant will be occulted by a waning gibbous Moon on the evening of Sep 14. The tiny disc will appear from behind the dark limb, but its earlier disappearance beneath the brilliant limb will be difficult to observe.

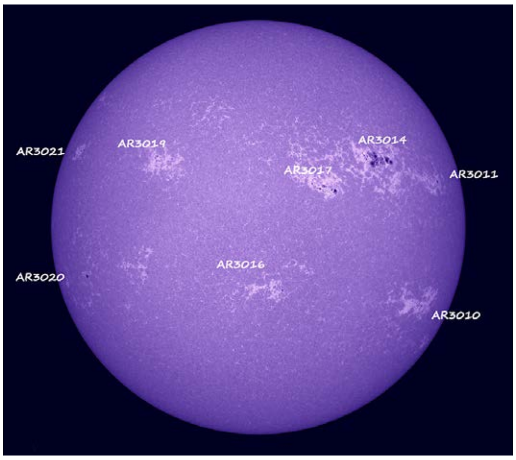


Figure 4. An active Sun on 2022 May 24, imaged at Mt Barker, South Australia. Orion ED80T CF refractor, Lunt B600 Ca II K Filter, and ZWO 174M. *(Gerald Cauchi)*

Neptune in eastern Aquarius beats Jupiter to opposition by 10 days on Sep 16.

Minor planet **4 Vesta** is at opposition on Aug 22 at magnitude +6 in Aquarius, to the east of Saturn. It is quite low on the Aquarius–Capricornus border. On Sep 7, **3 Juno** will be at opposition, also in Aquarius and at magnitude 7.8.

Meteors

The **Perseids** peak on Aug 12, but this reliable and popular shower will be severely compromised by the full Moon this year.

The **kappa Cygnids** are much less rich and will also be affected by the Moon on Aug 14.

Alpha Aurigids are at their maximum around Aug 31 and the Moon will not interfere. A weak shower as a rule, occasional outbursts have been recorded. The meteors derive from comet C/1911 N1 (Kiess).

Comets

This is a barren period for bright comets, with C/2017 K2 (PanSTARRS) moving from Ophiuchus into Libra in early August and disappearing south by the end of the month.

Lunar occultations

Date	*Time (UT)*	*Star*	*Mag.*	*Ph.*	*% Illum.*	*Notes*
Aug 6	21:43	delta Scorpii	2.3	DD	66+	Low
Aug 21	23:41	139 Tauri	4.8	RD	–24	V. low, Moon rising
Sep 6	23:07	60 Sagittarii	4.8	DD	84+	V. low
Sep 14	21:28	Uranus	5.7	DB	–78	
Sep 16	02:56	37 Tauri	4.4	DB	–67	
Sep 17	22:49	125 Tauri	5.2	RD	–49	

Selected occultations of stars brighter than magnitude 5.5 as seen from Greenwich. DB = star disappears at bright limb; RD = star reappears at dark limb. Please see the *Handbook* of the BAA for more details and for occultations of fainter stars.

Grazing occultations

Date	*Time (UT)*	*Star*	*Mag.*	*Notes*
Aug 18	04:37	omicron Arietis	5.8	Isle of Wight to London

Notice Board

Meetings diary

Entries for this diary should be sent to the *Journal* Editor [**pjennings@britastro.org**] 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.

Joining BAA webinars

Webinars are hosted on Zoom and virtual attendance, either online or by phone, is free. Joining instructions for each event are on the BAA website at **britastro.org/meetings**. All times given here are for the UK. Live streams of webinars, and recordings of past events, are also available on the BAA YouTube channel (but please note that those viewing live on YouTube will be unable to take part in speaker Q&As).

Erratum

On p.182 of the 2022 June edition of the *Journal* ['The 2020–'21 western elongation of Venus' by Paul G. Abel, **132**(3), 181–184], an entry was omitted from Table 1 (the list of observers for the elongation referred to in the paper's title). The missing details for Luigi Morrone are as follows:

Name	*Location*	*Instrument(s)*
Luigi Morrone	Italy	355mm SCT

– Ed

Saturday 2022 September 3
Society for the History of Astronomy Webinar, 12:00 on Zoom. 'Telescopes, temples, eclipses, & ethnohistory: Exploring the exciting astronomical history of southeast Asia' – a lecture by Wayne Orchiston and Darunee Lingling Orchiston. BAA members welcome. Places are limited. Zoom link to be made available in advance. Contact **meetings@shastro.org.uk**.

Friday–Sunday 2022 September 9–11
BAA Autumn Weekend Meeting. Moray College UHI, Moray Street, Elgin, Moray, IV30 1JJ. Doors open on Friday at 19:00. Our thanks go to Moray's astronomical club SIGMA, who are hosting this meeting. The theme of the meeting is 'A Sun & its solar system'. Programme details on back cover. To book, visit **bit.ly/38abNsM**. Discount code for BAA members: 'solar'.

Sunday–Friday 2022 September 18–23
Europlanet Science Congress, Palacio de Congresos de Granada, Spain. See **epsc2022.eu**.

Friday 2022 September 23
***William Herschel & the universe* – a film by George Sibley,** 19:30–21:00 at the Bath Royal Literary & Scientific Institution (BRLSI). Preliminary evening showing (in person and online) of *William Herschel and the Universe* film, introduced by the maker, George Sibley, plus discussion. Tickets available at **bit.ly/3BfpHWI**.

Friday 2022 September 30
A celebration of William Herschel's music, 19:30 at St Swithin's Church, Bath. Performed by the Bristol Ensemble and Vauxhall Players; introduced by Dr Matthew Spring. See **bit.ly/3z8Wqu7** for more information and to book tickets.

Saturday 2022 October 1
A celebration of the astronomy of William Herschel, 09:30–18:00 at the BRLSI, Bath, and online. Major conference on William's astronomy, aimed at interested non-professionals. Tickets available at **bit.ly/3cEScCX**.

Friday–Sunday 2022 October 7–9
New Scientist Live, ExCeL London, Royal Victoria Dock, 1 Western Gateway, London E16 1XL. A festival of ideas and discoveries, featuring talks, interactive experiences and exhibitors including the BAA. See **live.newscientist.com** for more information.

Saturday 2022 October 22
Society for the History of Astronomy General Meeting & Autumn Conference, 09:30–17:00 at the Large Lyttelton Lecture Theatre, Birmingham & Midland Institute, 9 Margaret Street, Birmingham B3 3BS. Talks by Daniel Belteki, Christopher Taylor, Mike Leggett & Dr Allan Chapman. Book in advance at £10 per person for members, £15 per person for non-members. To pre-register, please contact **meetingssecretary@shastro.org.uk**.

Wednesday 2022 October 26
BAA Annual General Meeting & Ordinary Meeting, 17:30–20:00 at the Institute of Physics, 37 Caledonian Road, London, N1 9BU BRLSI. Featuring the Presidential Address and Review of the Year. Doors open 17:00, from which time refreshments will be served outside the lecture theatre. For more information, visit **britastro.org/event/baa-agm-2022**.

Saturday 2022 November 12
BAA Asteroid & Remote Planets Section Exoplanet Division Zoom meeting, 10:00-16:00 Details to follow in the October *Journal*. Organisers: Rodney Buckland and Roger Dymock. See **bit.ly/3b31wzX**.

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 PO Box 702, Tonbridge TN9 9TX, UK. Free Members' adverts may be sent direct by e-mail to the Editor: please contact him at **pjennings@britastro.org**

For sale

Boxed atlas-catalogue of the Magellanic Clouds, P. Hodge & F. Wright, 1967. Comprising two books and complete Smithsonian card-printed plate collections. £40 (to Commission for Dark Skies). Bob Mizon, 07969 330247.

Starlight Instruments 2-inch Feather Touch dual-speed focusers: 50mm travel (£300); 20mm travel (£300); Flat adjustable base, usable on both focusers (£45). Perfect for switching focuser travel when imaging or for visual use. Contact: 07826 944 488 (North Essex).

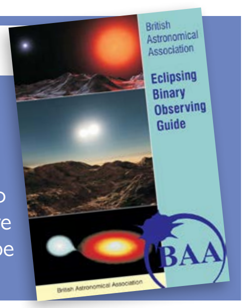
Members' private sales and wants

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.

Eclipsing Binary Observing Guide

Hard copies of the revised Variable Star Section *Eclipsing Binary Observing Guide* by Des Loughney can be purchased from the BAA online shop: **britastro.org/node/26286.**

The standard price is £7.50, or £6.00 for members. Many thanks to Ann Davies for arranging the printing of this valuable book. We will have copies available on the BAA Sales stand at future events. It can also be downloaded free of charge here: **bit.ly/3BTtMwL**.



The British Astronomical Association
Autumn Weekend Meeting
9th – 11th September 2022

'A Sun and its Solar System'

Moray College UHI, Moray Street, Elgin, Moray, IV30 1JJ

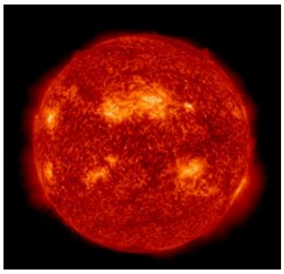
We will be looking at our Sun, related phenomena such as aurora, and some of our solar system bodies. Talks by professional speakers and active observers.

Our speakers for the Weekend will be:

Dr John Mason

Denis Buczynski
Prof Clare Parnell
Sandra Brantingham

Lyn Smith
Dr Paul Abel
Nick James



Friday – Doors open at 19:00 and the meeting will close at approx. 21:00
Saturday – Doors open at 10:00 and the meeting will close at approx. 18:00
Sunday – Local tour starting at 10:00 and finishing approx. 12:30

Full details can be found on the BAA website: **britastro.org/event/elgin-2022**
Booking via Eventbrite: **elgin-2022.eventbrite.co.uk**
BAA & SIGMA member discount code is 'solar'

Event Organiser:	Mrs Hazel Collett	E: **meetings@britastro.org**	T: 07944 751277
Local Co-ordinator:	Mr Pete Sherman	E: **chair@sigma-astro.co.uk**	T: 07464 763690

Everyone attending on the Saturday will be entered into a raffle

Our thanks go to
SIGMA, Moray's Astronomy Club
for hosting this meeting

Images courtesy of ESA, NASA and BAA members