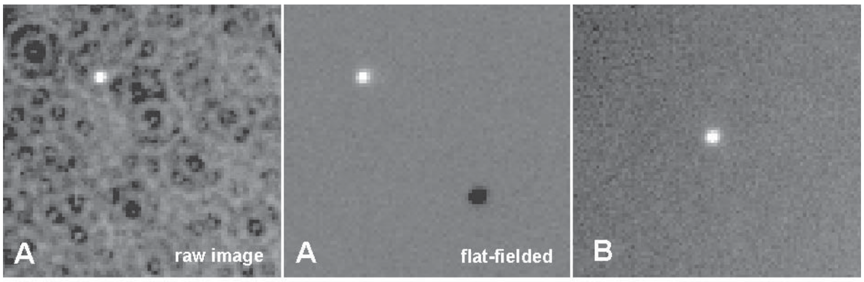
Observers' Forum

Daytime photometry of stars and planets

Recently, after a long period of rainy weather and cloudy skies, I began to consider observing variable stars using a CCD camera during the daytime, reckoning that this would increase the number of potential observing opportunities. The problem with daytime observation is the sheer brightness of the sky, which overwhelms the visual observer especially for objects located near the Sun. By contrast, an observer equipped with a CCD camera can take many images of the same patch of sky and then, by adding these together, can stretch the contrast to bring out very faint objects only a percent or two brighter than the sky background. My particular interest is photometry (i.e. the accurate measurement of magnitudes) so my task was not merely to register an image of an object but also precisely to measure its brightness relative to known stars.

That all sounds straightforward, but to avoid saturating the CCD camera, very short (millisecond) exposures would normally be required and this would ordinarily lead to unacceptably high fluctuations in the apparent brightness of objects owing to scintillation. The trick I used to overcome this limitation was to interpose a grey, neutral density (ND) glass filter in the optical train to cut down the intensity of light reaching the CCD camera. For a typical camera, an ND filter transmitting just 1% of the incident light (optical density = 2.0) reduces the light sufficiently that the daytime sky can be recorded with an exposure of a few tenths of a second. In my setup, I fixed the filter *in front of* the objective lens of a 60mm refractor stopped down to 40mm, thereby avoiding excessive scattered light within the telescope tube. The camera, a Starlight-Xpress SXV-H9, was also fitted with a green V filter.

The next task is to point one's telescope and camera so as to record the object of interest. Not so easy in the day when stars are generally invisible. However, if the sky is clear, one star, the Sun, is always visible. So



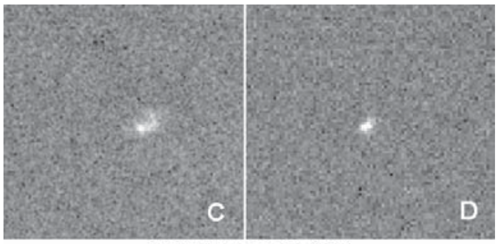
Mercury
A: 2007 August 05 08:08 UT (V = -1.363 +/- 0.025) 100 x 0.18 sec frames
B: 2007 August 07 08:14 UT (V = -1.551 +/- 0.020) 50 x 0.17 sec frames

using a modern 'go-to' mounting, it is possible to align the scope by pointing it at our nearest star. In my case, I temporarily taped a second filter (optical density 5.0) in front of the first filter so as to cut down on the amount of light reaching the camera – that way it was possible to centre the image of the Sun on the CCD frame before activating the single-star alignment required for the polar-aligned equatorial mount. Thereafter it was possible to control the telescope pointing by manually entering suitable values of RA and Dec. I usually picked a bright star such as Capella or Vega for the first move of the telescope away from the Sun, to check the focus and the value of any positional offset.

Finally, to maximise the signal-to-noise in the image, it is necessary to take as many images as possible in a few minutes. With a fast download, for example aided by windowing down the frame so that the file size is just less than 64Kb, it is possible to take several hundred frames and average these to bring out faint objects.

To date, I have managed six observing runs during the day using a V filter and neutral density filter. On three occasions I obtained accurate V photometry of Betelgeuse; for example on 2007 July 24 at 09:04UT a measure of V= 0.59 ± 0.03 was obtained. How was this possible without recording a comparison star on the same frame as the variable? This is the final twist in the tale. Daytime photometry is only really possible if the sky is properly clear – in other words that the sky is clear blue with no trace of clouds visible. With such a sky, the apparent brightness of the stars and planets depends only on the altitude above the horizon, and so the extent to which stars brighten or fade as they rise or set can be accurately measured. In a clear sky this amounts to an extinction of close to 0.20 magnitudes per atmosphere, or airmass. When a star is close to the zenith it is seen through an airmass of about 1.00, whereas stars at an altitude of 30° above the horizon are seen through an airmass of 2.00 and so would appear about 0.2 magnitudes fainter than if located at the zenith. By imaging and measuring stars of known magnitude at different altitudes, a value for the extinction coefficient can be determined. So there you have it: separately image your variable plus one or more reference stars and hey presto, the magnitude of the variable can be obtained.

There are several potential advantages of daytime photometry. One is that it becomes feasible to follow a star such as Betelgeuse for twelve months of the year, thereby avoiding the usual gaps in the lightcurve when the star is too close to the Sun. Another advantage is avoiding having to get up early to observe stars in the morning sky before the Sun rises! Finally, with a bright sky in each image, the flat-field issue which normally bedevils photometry becomes a trivial matter, as there is normally only a single source visible in each image.



Beta Lyrae (V=3.4)
C: 2007 August 04 18:25 UT, 600 x 0.5 sec frames
D: 2007 August 05 04:44 UT, 60 x 1.5 sec frames

Examples illustrating daytime photometry are shown in the accompanying images. For Mercury, I measured the planet's magnitude on August 5 and August 7 when at solar elongations of 11.4° and 9.3°. You can see from the first image (A), where I have co-added 100 frames, that the raw images show Mercury superimposed on a strongly-patterned sky background. Each image covers an area of sky some 5 arcmin square and the background pattern is in effect the flat-field for this fraction of the CCD frame. The trick now is to move the telescope a few arcminutes and then take a further set of 100 images. This second set can then serve as the flat-field correction for the first image (and *vice versa*). Doing this results in the second of the three images from which photometric measurements can be made. The third image ▶

▶ fessor von Zahn had been invited, and the IAGA meeting. Our last contact was during the IUGG meeting of 1999.

Gadsden was a very kind man and a good friend. He was also an excellent mentor, with clear ideas, and insight into many different problems. I am thankful that we had a similar hobby, the observation of noctilucent clouds, the legacy of which is many nice photographs and letters. I will never forget him.

Wilfried Schröder

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1 Obituary, *J. Brit. Astron. Assoc.*, **114**(1), 47 (2004)
2 Gadsden M. & Schröder W., *Noctilucent Clouds*, Springer–Verlag, Berlin, 1989

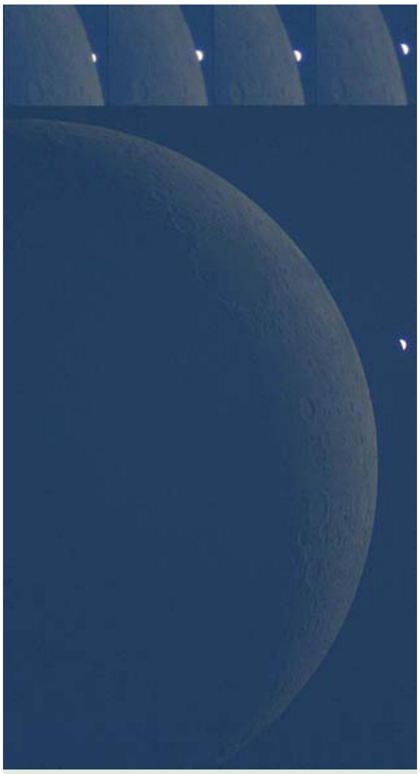
A daylight occultation of Venus

The daylight lunar occultation of Venus on 2007 June 18 (whose circumstances are given in the *Handbook)* was not widely observed in the UK, with much of the country suffering from heavy cloud-cover. The Director had no chance at all to observe, as it was raining throughout most of the event in Northamptonshire. Fortunately several observers have contributed their results, and some are illustrated here.


The reappearance imaged by John Vetterlein, with a 175mm Mak–Cass. ×175. Image taken through the eyepiece using a digital camera (1/750 sec).

The most comprehensive account came from John Vetterlein, observing from his home in Rousay, Orkney (59º 08' 40"N, 2º 58' 48"W): 'It was one of those frustrating days we so often experience at this time of year in the islands – sea mist (haar) and low cloud coming and going on a slack easterly airflow. The morning broke fine but all the conditions just described started to plague Rousay from around 06:00 UT. Some good clearances occurred mid-morning, allowing observations of the Moon and Venus. Venus was readily seen in small binoculars a little to the left of the Moon, but the rather poor atmospheric transparency made naked eye observations very difficult. The weather closed in at around 13:30 UT killing off hopes of seeing the disappearance... Close to the time of reappearance the sky began to break up.... A number of high power images were obtained using a 175mm Maksutov. At 15:30 UT, Venus could be seen quite clearly with the unaided eye a little to the right of the Moon. The weather remained fair for another hour, after which thick mist returned.'

Mark Kilner (Broadstairs, Kent) also witnessed the reappearance only and sent an excellent sequence of images. Malcolm Porter (Petts Wood, Kent) also sent an image of the reappearance. Silvia Kowollik (Rosenfeld–Brittheim, Germany) obtained a good movie of the reappearance, and Detlev Niechoy (Göttingen, Germany) also obtained a good series of images of the reappearance. Alan Dowdell observed the reappearance with the naked eye from Winchester. Andrew Paterson observed the disappearance only, comparing the appearance of the brilliant Venus against the dull Moon with the 'diamond ring' effect witnessed at total solar eclipses.


Reappearance sequence by Mark Kilner, with 102mm OG and digital camera (1/750 sec). The first image in the sequence was taken at approximately 15:23:57 UT.

Richard McKim, *Director, Mercury & Venus Section*

▸ (B) was made two days later and taken shortly before the clouds rolled in. Here another flatfield was used that was not such a good match.

It goes without saying that fainter stars are a more difficult target than planets during the daytime. On July 31, I was able to measure the brightness of Epsilon Aurigae, which at 08:04 UT, I found to be at V= 3.02±0.05. On August 4–5, I was able to follow Beta Lyrae starting a few hours before sunset through the night to just after sunrise. Images C and D have been flat-fielded and show the variable during daytime. For image C, the Sun was more than 10° above the horizon prior to sunset, whilst for image D it was just rising the following day. Unfortunately the focus was incorrectly set in the former case and so the star image is slightly blurred, however this is not problematic when it comes to photometry. In the latter case, the star was at an altitude of only 20° and was imaged through mist, which made the task more difficult especially when the star itself was of about magnitude V= 3.4.

At the end of this exercise, I was pleased to find that daytime photometry is definitely feasible. It seems quite incredible that the brightness of 3rd magnitude stars can be determined from observations made in broad daylight!

Richard Miles

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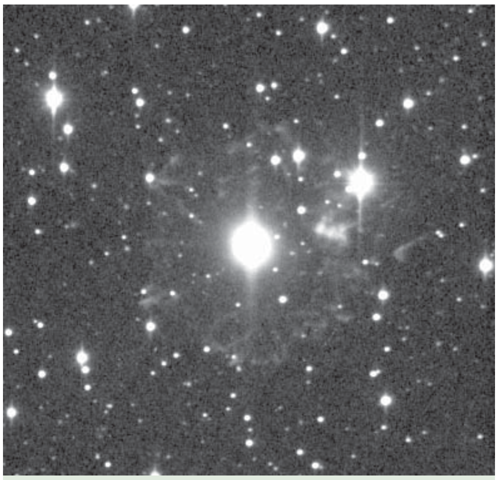
Observing the Cat's Eye Nebula


Detailed image of NGC 6543 by Andrea Tasselli, Lincoln. Intes Micro M809 Mak Cass with Starlight Xpress SXV-H9 CCD camera. East up. North to left.

Like so many deep sky objects, NGC 6543 in Draco, commonly known as the Cat's Eye Nebula, was first observed by William Herschel. He discovered it on 1786 February 15 and it became number 37 in his class IV list of objects: planetary nebulae. Herschel catalogued objects according to their size and brightness, and his planetary nebulae class was so called because the small blue/green discs of many of these objects reminded him of the planet Uranus which he had discovered a few years earlier. Although to be fair to other observers, Antoine Darquier, discoverer in 1779 of



NGC 6543 outer halo imaged by Grant Privett, Ledbury, Herefordshire. 250mm f/4.4 Newtonian reflector and Starlight Xpress SXV-M7 CCD camera. 201×45 secs. North up. East to left.

M57, the Ring Nebula in Lyra, also likened the appearance of M57 to a fading planet. Herschel of course did not know the true nature of the 'nebulae' he observed and, not surprisingly using a morphologically based system, he made some errors. Some objects catalogued by him as planetaries – which we now know are the remains of dying stars similar in mass to the Sun – are distant galaxies. NGC 6543 though is indeed a planetary nebula, and one of the most beautiful objects of its class in the sky as the many high resolution images – particularly from the Hubble Space Telescope and the Nordic Optical Telescope on La Palma – testify.

The person who discovered the true nature of planetary nebulae was Sir William Huggins, and the Cat's Eye nebula featured centrally in the discovery. Huggins, who was born in 1824, two years after William Herschel died, was a pioneer spectroscopist and observed with his wife Margaret from his private observatory at Tulse Hill on the outskirts of London. On the evening of 1864 August 29 he pointed his telescope to 37 H.IV. '...I looked into the spectroscope. No spectrum such as I expected! A single bright line only! At first I suspected some displacement of the prism ...then the true interpretation flashed upon me. The light of the nebula was monochromatic...the riddle of the nebulae was solved. The answer, which had come to us in the light itself, read: Not an aggregation of stars, but a luminous gas.' Reading Huggins' report of his discovery, the excitement he must have experienced at this eureka moment clearly comes through.

Lying in Draco at RA 17h 58m 33.4s and Dec +66° 37' 59" (2000.0) – approximately 5° east and 1° north of Zeta Draconis – the Cat's Eye is still well positioned in the October sky. With a size of around 20 arcsec and a visual magnitude of 8.1 it is an easy object in even a small telescope. A 15cm reflector will show a small bright disc. I am colour blind, but I am reliably informed that it has a greenish tint to it even in a small instrument. 30 or 40cm telescopes show much more detail – a brilliant pinpoint central star, a dark inner region and a bright and grainy elongated outer envelope. With an OIII filter fitted to the eyepiece I find the planetary appears brighter, less grainy and also slightly less elongated. The mag 10.9 central star also disappears. Telescopes of 50cm or larger are necessary before hints of the structure seen in modern digital images can be glimpsed with confidence.

The Cat's Eye has always been a popular target for observers. Images and visual observations have recently been received from Section members Martin Morgan–Taylor, David Wagstaff, Cliff Meredith and Andrea Tasselli. Andrea's detailed image, which rivals many professional images and shows the complexity of the nebula's internal structure, is shown here. It has been suggested by professional astronomers that this complex shell structure and the two small visible equatorial jets on either side could be the result of a binary central star system. In 2004 even more detail was revealed when images from the Hubble Space Telescope were released showing a series of 11 concentric dust shells around the inner portion of the nebula (see the cover of the 2004 December *Journal*). These shells were thought to have been expelled at roughly 1,500 year intervals as the outer envelope of the dying star was periodically ejected into space.

Many planetaries contain a large outer halo which is faint and difficult to detect, and the halo around the Cat's Eye is a definite imaging challenge. Grant Privett, who enjoys such challenges, has imaged this halo with his 25cm f/4.4 Newtonian reflector. The inner region of the nebula is, of course, hopelessly overexposed, but detail in the outer halo can be clearly seen. As Grant commented 'Who says stupidly faint isn't pretty?' Visually this halo is an extreme challenge but it is possible that the small knot of material visible in the halo to the west (right side of image) might be detected in large telescopes. This knot, designated IC4677 and of photographic magnitude 15.7, was discovered by Barnard and was thought for many years to be a background galaxy – in fact many references and some charting software still refer to it as a galaxy – but it is now known to be a part of the planetary nebula halo. It is a challenge, but not an impossible one, and I would be delighted to hear of any successful observations.

Stewart L Moore, *Director, Deep Sky Section*

Supernova 2007af in NGC 5584

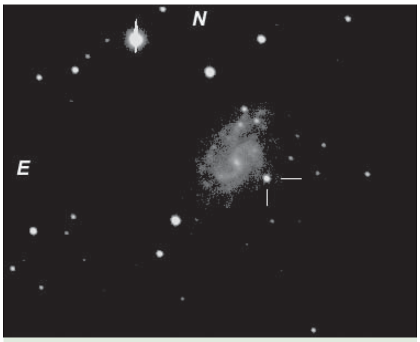
S. Nakano of Japan announced on IAUC 8792 the discovery by K. Itagaki of a magnitude 15.4 supernova in NGC 5584, located at RA 14h 22m 21.03s, Dec –0 23' 37.6" (2000). The discovery image was obtained with a 0.60m f/5.7 reflector and reached about magnitude 19.0.

It is 40" west and 22" south of the centre of the host galaxy. The discoverer's unfiltered CCD magnitudes included in the IAU *Circular* are: 2007 Feb 24.81 UT, <19.0; Feb 25.73, <18.5; Mar 1.84, 15.4 (discovery); Mar 2.576, 15.3; Mar 7.648, 13.7. The type Ic supernova 1996aq also appeared in NGC 5584.

Spectroscopic details separately announced on CBET 865 by F. Salgado *et. al.*, of the Carnegie Supernova Project, indicated that it was of type Ia and discovered well before maximum light. A spectrum obtained on March 4.34UT with the European Southern Observatory's 3.5m New Technology Telescope showed a strong resemblance to that of the normal type Ia supernova 1994D obtained 10 days before maximum light.

Supernovae are very important objects to study given that certain types, notably type Ia, are used as prime distance indicators. Recently the dispersion in absolute maximum magnitude of this type has caused concern in their role as distance candles but there has been a suggestion that variation in decline rate may be linked and should therefore be studied.

The difficulty in monitoring extragalactic supernovae as they fade is that most are found near magnitude 15 or fainter and they thus prove a considerable challenge, especially to visual observers. However recent advancement in imaging now presents a chance to follow such objects down to magnitudes of 19 or fainter, although their presence in front of the host galaxy's 'nebulous regions' can cause difficulties in using photometry to arrive at reliable magnitudes. ▸

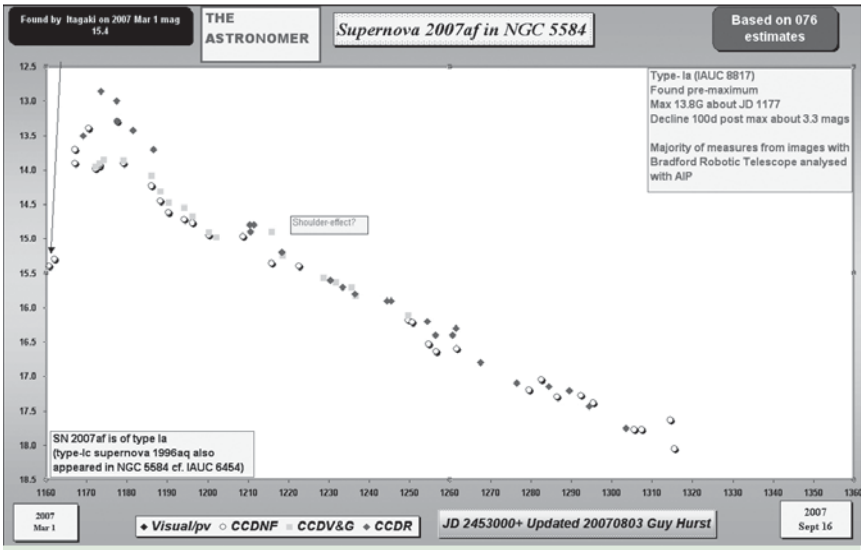


Supernova 2007af when first imaged with the Bradford Robotic Telescope on 2007 April 18 (04h03mUT), then at magnitude 15.0.

During 2007 April the author, who had previously studied such objects by visual means only, decided to start experimental imaging of novae and supernovae with the Bradford Robotic Telescope, which operates in a dome at the Observatorio del Teide 8,000 feet up on the island of Tenerife in the Canary Islands. The telescope is a Celestron 14 of 3910mm focal length and 365mm aperture, and using the CCD ('Galaxy mode') gives a field of view of 24 arcminutes. Although exposures are generally of one minute, limiting magnitudes of around 19 have been reached during periods when the Moon is not nearby.

Supernova 2007af was one of ten supernovae chosen for study, but looked favourable given its expected brightening to maximum and a clear separation from the bright nuclear region of the galaxy. As of 2007 August 14, the supernova has been imaged on 36 dates, mostly in unfiltered mode and occasionally using the red filter. The graph includes some early results from other observers obtained via VSNET and the maximum in 'green' (close to visual) was magnitude 13.8 on 2007 March 18. The decline from maximum by three magnitudes (t3) took about 90 days and was largely linear except for an apparent temporary shoulder around April 19. Monitoring is continuing to enable a more complete analysis to be obtained.

Guy M. Hurst



Light curve of supernova 2007af showing plots of 76 measures in unfiltered, green (near visual) and red filters.