The Annual Meeting of the Webb Society, Cambridge, 2015 June 20

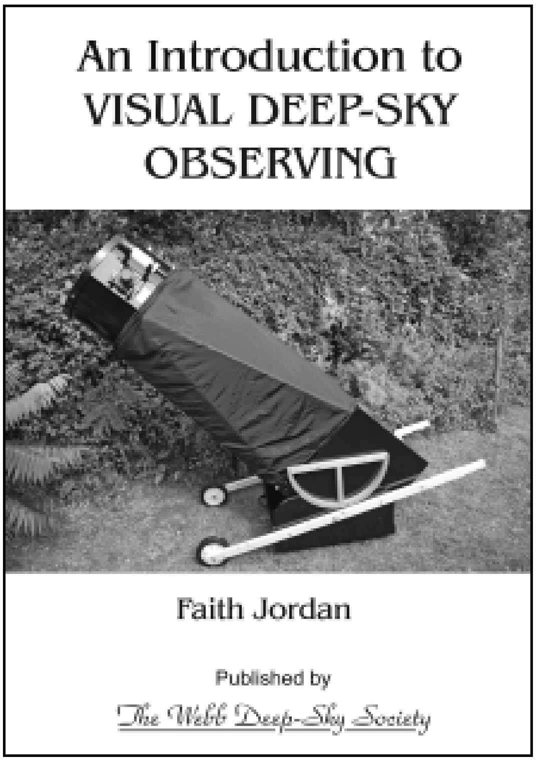
Introduction

The President (Bob Argyle)

I welcome you all to this year's midsummer meeting of the Society, here at the Institute of Astronomy. As we all know the answer to the Universe is 42 - it is also the answer to the question - how many Annual Meetings of the Society have we had including this one.

We are already beginning to start thinking about the golden jubilee (which occurs formally on 2017 June 12th) so any suggestions would be welcome - should we hold it here, who would you like to see speaking and so on?

This year is the centenary of the birth of Kenneth Glyn Jones, co-founder and first President of the Society. He died in 1995 so I would think that there are a few people in the audience who did not meet him or perhaps are aware of his contribution to the Society, so I will briefly say something about him, after lunch.



The DSO, under the renewed editorship of Owen Brazell has continued to go from strength to strength, and we thank both him and Don Miles for the continuing splendid quality of the DSO over the last year. Whilst we always require a flow of interesting contributions for the DSO at the moment the situation is serious and we have little in stock for future DSO articles. If you have any observations we would love to hear about them. Images are most welcome too but we need some text to go with them. Have you read a book recently which you admire, or can't stand? Write us a review. Please see Owen today if you can help. Alternatively contact him at the e-mail address on the website and on the DSO inside back page.

This year we have decided to convert some of our cash reserves into stock and we have now produced more paper copies of some of the lists of objects from Alvin Huey's Faint Fuzzies website, specifically *Observing the Herschel 400 Part 3*, *Flat Galaxies*, *Planetary Nebulae and Supernova Remnants* and *Galaxy Clusters*.

In harmony with the general increase of interest in double star measurement around the world the Double Star Section has continued to participate in this work. DSSC 23 which contains 9 papers occupying 95 pages was released a few weeks ago and can be found in its entirety on the website.

We have now issued the I*ntroduction to Deep-Sky Observing* by Faith Jordan. I'd also like to thank Don Miles, Owen Brazell and Stewart Moore for their input into the second edition which we trust will breathe new life into one of our most popular publications.

Before we can get to the speakers we need to conduct some business starting with Steve Rayner.

Secretary's Report

Steve Rayner

In the year to March 31st we have had 170 renewals, 23 resignations and lapsed subscriptions and 2 UK members passed away.

The Speakers pose by the statue of Sir Fred Hoyle. Left to right: Dr Andrew Crumey, Dr Mike Irwin, Dr Wolfgang Steinicke, Magda Streicher, Bob Argyle and Olivier Thizy

We have gained 34 new members of whom 10 have opted for the paper subscription and 24 are PDF only. The vast majority of new members (27 in all) are based in the UK.

In addition, 9 current members have switched from paper to PDF.

I continue to send out reminders. In response to 22 final reminders I got renewals from 9 and the remaining 13 did not renew. I also enquire why people are leaving. Few seem to be dissatisfied with the service that the Society provides – it's more often a case of not having enough time, or interest having changed etc.

So at the issue of DSO 166 we have 265 members of whom 146 are in the UK, 57 in North America, 27 in Europe, 11 in Asia/Australia/NZ and 2 in South Africa. There are 22 PDF only subscribers.

In the North America Section we lost 6 members and gained 5. In the Southern Section we lost 2 members.

Treasurer's Report

Steve Rayner

The accounts are presented at the end of this AGM report. The fluctuation in the exchange rates makes it difficult to set subscription rates. Against the $US the £ varied between $1.72 and $1.49 which is good for us. The Australian dollar varied between $A1.74 and $A1.99 to the £ and the Euro changed from •1.19 to •1.41, also bad for us.

The subscription rates were last changed in 2011 (DSO 155) and since then postal rates to Europe have risen by 100%, whilst rates to North America and Asia have gone up between 100 and 300%. We have decided to make the following changes: UK rate will remain the same at £18, the European rate will rise from •25 to •30. The North America surface sub will rise from $32 to $37 whilst the airmail rate for that region will increase from $40 to $45. Southern Section (Australia and NZ) subscription rates will change from $32 to $40 (surface) and from $40 to $50 (airmail).

The webmaster is looking at putting the use of Pay Pal for subs on the website. This will attract a small supplement as we will have to pay charges but will give us greater flexibility, and it also avoids currency fluctuations.

The long running saga of Gift Aid and battles against HMRC drags on. I have sent in a number of claims for Gift Aid from members and this is the third time I have had to do so.

The President: Can we have a proposal to accept the accounts as presented?

Proposed: Alan Dowdell.

Seconded: Peter Hudson.

Carried nem con.

The President: We have been extremely fortunate in obtaining the services of James Whinfrey as Web Administrator. James took over last year and has been very busy maintaining and improving the website. He's here to give us some further details:

Website Manager's Report

James Whinfrey

I'm a keen visual observer with small telescopes with 4 years experience and enjoy observing double and variable stars. I joined the Society at last year's AGM and responded to an advert for the new Website Manager!

Digital distribution of the DSO continues to work well. Individuals log in with a password and have access to every issue in one place. This makes the area easier to administer and more robust.

I have been working with Steve Rayner towards the introduction of Pay Pal to allow on-line subscriptions to be handled. Payment will be made directly in GB pounds and this should be introduced very soon. There is still quite a bit of work to do to get 'Online Shopping' up and running.

I maintain the website which means I'm always looking for new and different items to keep it fresh and relevant, and your observations are always welcome. As you know we highlight sketches and images and have the regular *Double Star* and *Galaxy of the Month* columns as well as the *Object of the Season*. Please contact me if you have interesting deep-sky news. The Twitter account @webbdeepsky has 21 followers. Does anyone fancy running a Facebook page?

As far as the website itself goes, most visitors arrive directly and Google supplies most of the surfers (94%). The readership is mostly UK and USA but there are significant downloads from Germany and Canada. We are on course for about 25,000 visits annually to the website and this figure shows a regular increase year-on-year.

Election of Officers

The President: I've recently heard from Jenni Kay - our Southern Section Secretary who has expressed a wish to stand down from the post which she has filled so ably for the last 15 years. Please join me in passing on to Jenni our best wishes for the future but mostly our gratitude for all of the unstinting work she has done on our behalf, I think she deserves our thanks.

[Applause].

All the remaining Officers in post are willing to stand again. In addition we would like to add two members to the Committee and the proposals are for Andrew Robertson and Jon Gale. Can someone please propose Andrew (Nick Hewitt) and second him (Dale Holt)?

Can we have a proposer for Jon Gale (Owen Brazell) and seconder (Fred Thomason).

Carried nem con.

And would those members in the Antipodes consider nominating one of their number to look after the Southern Sky Section?

Can we have a proposal to re-elect the current officers who are willing to stand again?

Proposed: Peter Hudson.

Seconded: David Reynolds.

Carried nem con.

Peter Hudson proposed a vote of thanks to the retiring Officers. (Applause).

The President: The business meeting is now closed and we can proceed to the talks. Our first speaker is a regular speaker at the annual meetings. Its always a pleasure to welcome Wolfgang Steinicke.

He is, of course, a most valuable member of our committee and runs the *Object Of The Season* column for the DSO as well as heading the Nebulae and Clusters Section. But he has also gained a considerable reputation as a historical researcher with a particular interest in the Herschel's, Dreyer, and the Earls of Rosse. Today he will lead us into the intricacies of

'John Herschel's Cape Observations'

Dr. Wolfgang Steinicke

Today I want to talk about John Herschel's systematic observations of nebulae and star clusters, made 1834-38 at Feldhausen, now a part of Cape Town, South Africa. Previously he had surveyed the northern sky at Slough, revisiting a large number of the deep-sky objects found by his father, William Herschel. The southern campaign was much different, inspecting mainly "terra incognita" between -2.5° and -90° declination. However, the Slough observations reach to about

Dr. Wolfgang Steinicke

-33°. Only Halley, Lacaille and Dunlop had observed farther south, though with much smaller instruments.

John Herschel's telescope was an azimuthally mounted metal-mirror reflector with 18.25-inches aperture and 20-feet focal length. He used the technique of "sweeping", i.e. covering a rectangular sky area by turning the tube up and down in the (north) meridian at a certain elevation whereas the horizontal motion is due to the earth rotation. The standard power was 180x, giving a 15' field of view. To reach the region around the south celestial pole, the telescope was rotated in azimuth by 180 degrees. The coordinates of deep-sky objects were determined by reference stars (mainly from the Brisbane Catalogue), i.e. the relative position plus the star position gives the object's right ascension and declination. The quality of the calculated coordinates is pretty good: +/-30" (RA) +/-15" (Dec).

The result of John Herschel's southern survey, known as the *Cape Catalogue*, was not published until 1847. It contains 1733 entries, ordered by right ascension and counted by a number (h), starting with 2308 (in continuation of the northern *Slough Catalogue*). For each object are given: possible identification to a former catalogue (William Herschel, Messier, Dunlop etc.), description and the sweep(s) in which it was observed. 382 sweeps were performed in 349 nights. The first (number 429) was made on 5 March 1834, the last (810) on 22 January 1838. The original sweep records were not published; they are stored in the archive of the Royal Astronomical Society, London. This material is the very source of this talk. A comprehensive analysis gives a deep inside into John Herschel's methods and the resulting data.

The catalogued objects are mainly galaxies (56.2%) and open clusters (29.6%). A few are stars (1.4%), e.g. NGC 2542 (h 3115) = 19 Puppis; 0.2% are lost. There are both identities (i.e. objects with two different h-numbers) inside the *Cape Catalogue* and also with the *Slough Catalogue*. Counting the independent deep-sky objects we get 1649. The analysis shows that 1125 of them were new (180 belong the Large Magellanic Cloud). 524 objects were already known, of which 270 are discoveries by Dunlop and 203 by William Herschel. The mean visual magnitude is 12.2 mag. The brightest object is NGC 6383 = h 3689 (5.5 mag), an open cluster in Scorpius; the faintest is NGC 1135 (14.8 mag), a galaxy in Horologium. John Herschel also identified clusters of galaxies. For instance, he found 16 of 17 NGC-objects in the Centaurus cluster and 15 of 28 in the Fornax cluster.

How many objects were missed? This means nebulae and clusters inside his limits of magnitude and declination. The number is 638. Among them are bright objects like the globular cluster NGC 6539 (8.9 mag) in Serpens, discovered 1856 by Brorson, or the planetary nebula NGC 6302 (9.6 mag) in Scorpius, first seen by Barnard in 1880. With the mentioned numbers, one can calculate John Herschel's success rate, i.e. the fraction of the observed deep-sky objects to all observable: 1649 / (1649 + 638) = 0.72, i.e. 72% were seen. Why not 100%? The sweeping method does not lead to a complete coverage of the rectangular sweep area! Only about 2/3 of it actually appears in the field of view. William Herschel's rate for the northern sky is 0.67; a comparable value, due to the same method. But what makes John Herschel really unique is the fact that he is the only visual observer in history who surveyed the entire sky with a large telescope!

The President: I'm delighted to say that our next speaker will be Magda Streicher.

Many will know that Magda is the leading visual deep-sky observer in South Africaand has spent many years gaining an intimate knowledge of the southern sky which she has recently transferred to her book called *Astronomical Delights*. Some years ago, on a trip to South Africa, I had the great pleasure of presenting Magda with the *Webb Society Award* for 2006 in the dome of her 16-inch telescope sited near the border with Zimbabwe. Magda was ASSA President for the 2007-2008 term, and became an Honorary Member in 2009 (the Society only allows for 15 Honorary Members). She received the *President's Award* (for Deep-Sky Observing) in 2011 and today she will tell us about 'Treasures of the Southern Skies'.

Treasures of the Southern Skies

Mrs Magda Streicher

It's an honour to be talking to you in England today. I'm from the southern hemisphere and would like to talk about our wonderful night skies. I'm going to describe my observing procedures before I take you on a tour of some of the most beautiful and interesting areas of the southern sky.

If you are observing you should:

Make an estimate of the limiting sky magnitude.

Note your location, and the date and time of each observation for each object recorded.

Note the particulars of telescopes or binoculars

Magda Streicher

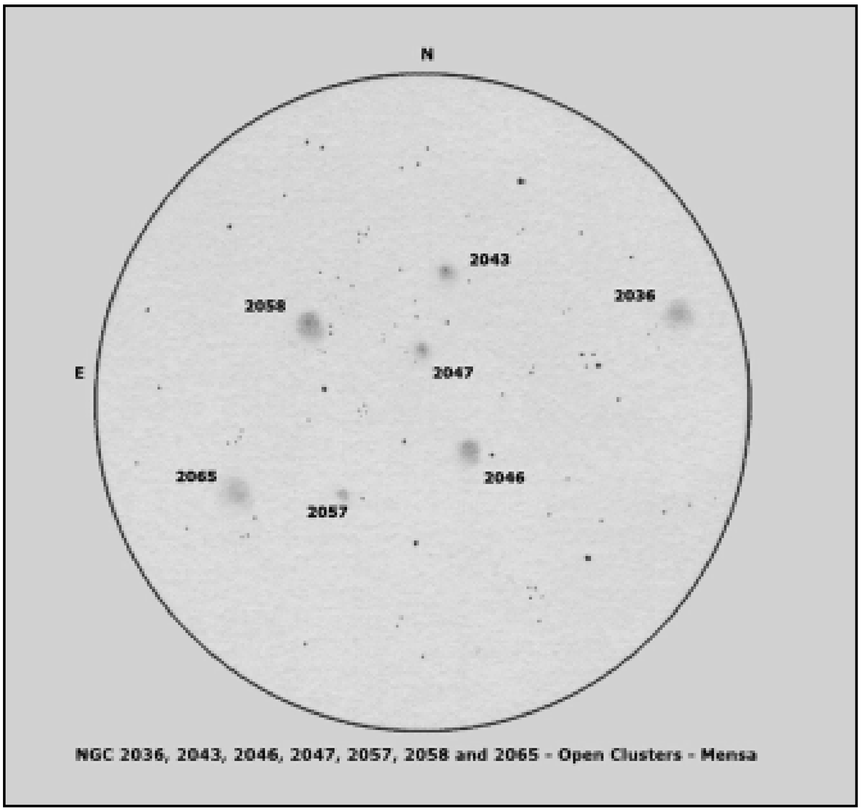


Fig 1
Open Clusters in Mensa

used - size, type and focal lengths of eyepieces. Plan your observations with star charts and know the constellations. Observe objects when they are at their highest point in the sky.

When observing deep-sky objects I find the following points are important:

Note your first impressions and see if the object is clearly visible against the background star field.

Note shape and size: Is it round, oval, rectangular and does it extend in a particular direction?

Note any objects on the periphery of vision.

Be patient and take your time.

Try sketching - you don't have to be an artist. A sketch makes you look at an object for longer than a glance so don't just look and not see.

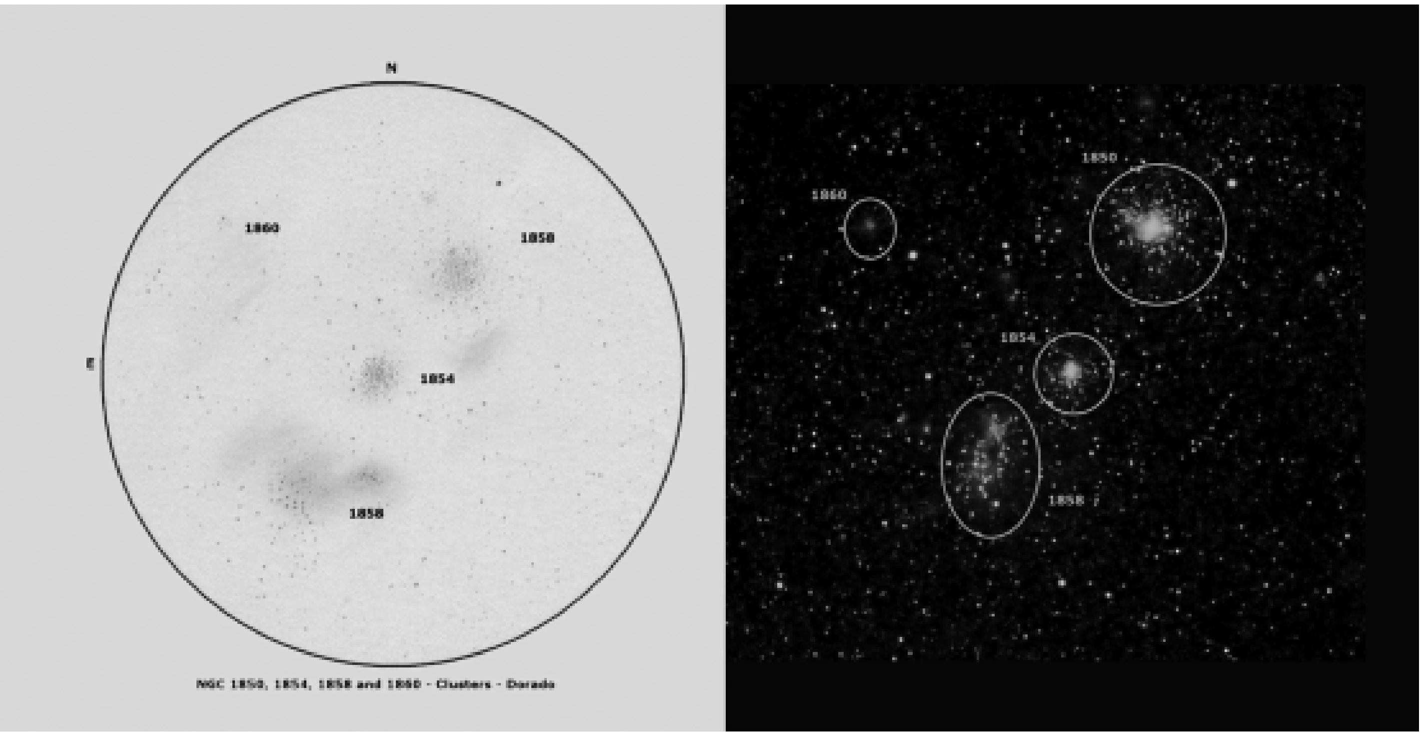
My telescope is a 16-inch Meade and it was located in an observatory at my farm in the northern part of South Africa.

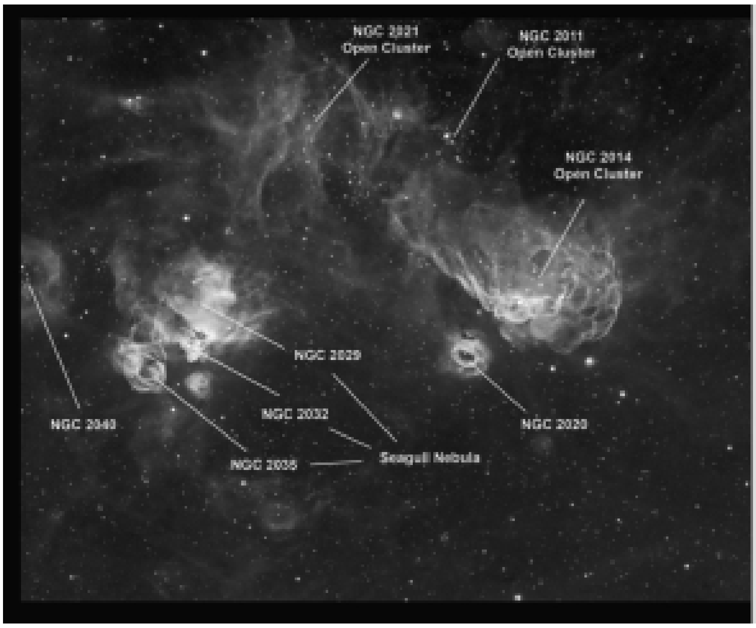
I'd like to show you a slide of the whole southern sky taken from the Waterberg mountains which shows the main features - the bright Milky Way, the Southern Cross, Coalsack and the Magellanic Clouds.

Today I'd like to concentrate on an area of the sky containing Vela, Carina, Canis Major and the two Magellanic Clouds.

Carina contains eta - the well-known variable stars which sits in the Keyhole Nebula. In the mid-nineteenth century John Herschel in South Africa saw the Keyhole Nebula much brighter that it is today, because eta Car had become very bright around 1834. The Keyhole is a naked-eye object from a dark site and in and around it are a number of interesting objects. I'd like to show you a sketch which I made (Fig 1). The two lobes due to the eruption can be seen and I have taken care in observing them. There is a close-up at x500 and you can see dark spots embedded in the NW lobe with barely seen dents on the edge with bladed super-thin flares between the lobes. Follow-up observing with visible changes over 12 years paid off.

Fig 2
Clusters in Dorado





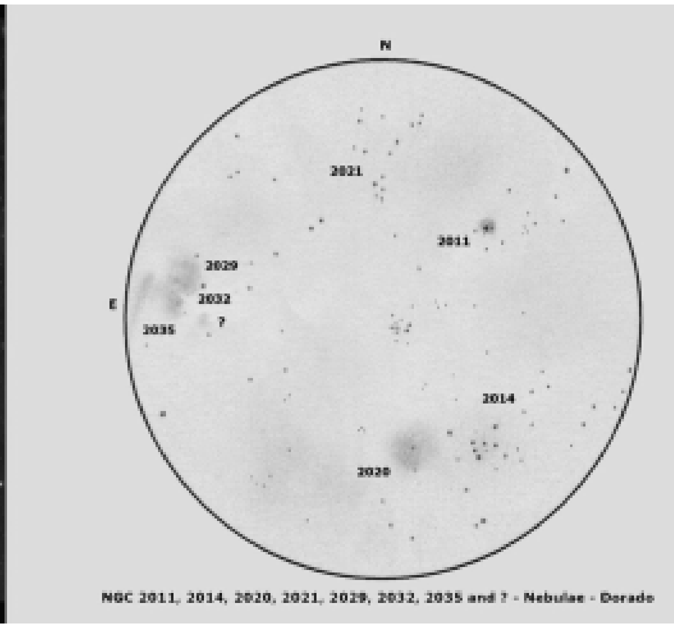


Fig 3
Nebulae in Dorado

Inside the surrounded Carina Nebula are a number of delicate small clusters some of which were observed by Robert Trumpler. He put his name to 37 clusters which he used to derive distances. Tr 14 and Tr15 in Carina are lovely and you don't need clear skies to see them well.

Omega Cen is a very special object containing 2 million stars and if you look closely you can see a little footprint hiding in the core - just a small area where there are fewer stars.

The Boomerang Nebula in Centaurus was found by Ian Glass in 1978 on the Franklin-Adams Atlas plate taken in 1910, and is apparently the coldest known place in the Universe. I found the object by star hopping, the central star is a GO giant of visual magnitude 12.7 surrounded by a dust shell some 30" x 15" in size. In my telescope the first impression of the nebula was that of an elongated tiny haze about 1' in size. High power shows two out-of-focus stars in close proximity, what a surprise! Achievement and success.

There is also 47 Tuc, the second best object of its type after omega Cen. In the Small Magellanic Cloud there are a number of very compact super-small star clusters which cannot be resolved into stars in an amateur telescope. There is a group of 7

Fig 4
The Night Sky

Dr. Andrew Crumey

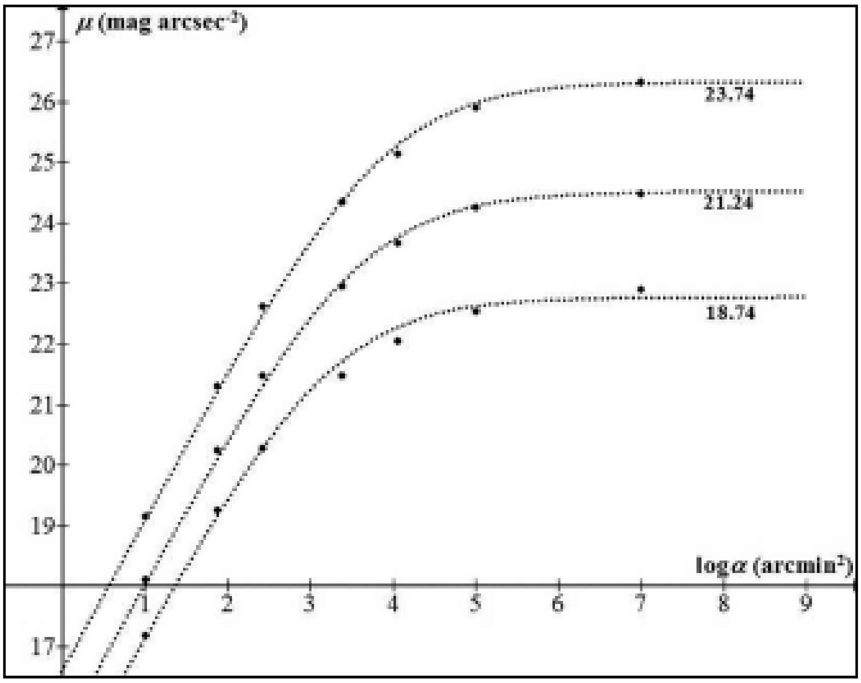
NGC clusters in Mensa (NGC 2036 - 65), for instance, seen as only little hazy knots in an area of only 40'. Each cluster is probably home to hundreds of stars.

Our showpiece satellite galaxy, the Large Magellanic Cloud, is covered in lacy filaments with star smoke. Four NGC clusters including NGC 1850, 1854, 1858 and 1860 in Dorado have been studied and sketched. The way to go is to select and identify all of the objects in the field of view.

Another area is NGC 1760 - 1776 and IC 2115-6. All indicated catalogue areas have been lifted out with mapwork, a mine of information.

Karl Henize was a space scientist and astronaut who worked in South Africa in the 1950s doing a survey for stars and nebulae with H emission. His observatory, near Bloemfontein and situated close to the Lamont-Hussey Observatory, is being renovated. He gives his name to a number of southern objects - one of which, Henize 44 (NGC 1929 - NGC 1937), has been studied in detail through my telescope.

Another complex area in Dorado on which I spent time observing contains no less than 9 objects (NGC 2032 ext) in the same field of view of 40'. All the nebulae have been highlighted in my sketch with indicated catalogue numbers (Fig 2). In it I found a small roundish hazy nebula which did not seem to be in the available catalogues. I asked Brian Skiff of Lowell Observatory about it and he said, the object you have spotted was catalogued by Karl Henize in 1956 as 'N59c' or more fully LHA 120-N59c but had not been included in a catalogue because it was thought that it would not be visible through amateur telescopes. A 14th magnitude star illuminates the nebula and causes it to shine.



I'd like to end by leaving you with the following suggestion - make the impossible possible, because the key to success is dedication.

Lunch

The President: Our next speaker is Dr. Andrew Crumey from the University of Northumbria. ????

Following a PhD in theoretical physics and research on nonlinear dynamics at Leeds University, Andrew has had a varied career including teaching, book reviewing and latterly writing - his sixth novel, Sputnik Caledonia (2008) won the Northern Rock Foundation Writers Award, was shortlisted for the James Tait Black

Memorial Prize and Scottish Book of the Year, and was longlisted for the Arthur C Clarke Award. He joined the University of Northumbria in November 2011 and his current research is around astronomy and visual perception, involving both scientific and creative work. In 2014 he published 'Human contrast threshold and astronomical visibility' in MNRAS. The subject of his talk today is 'Modelling the Visibility of Deep-Sky Objects'

Dr. Andrew Crumey

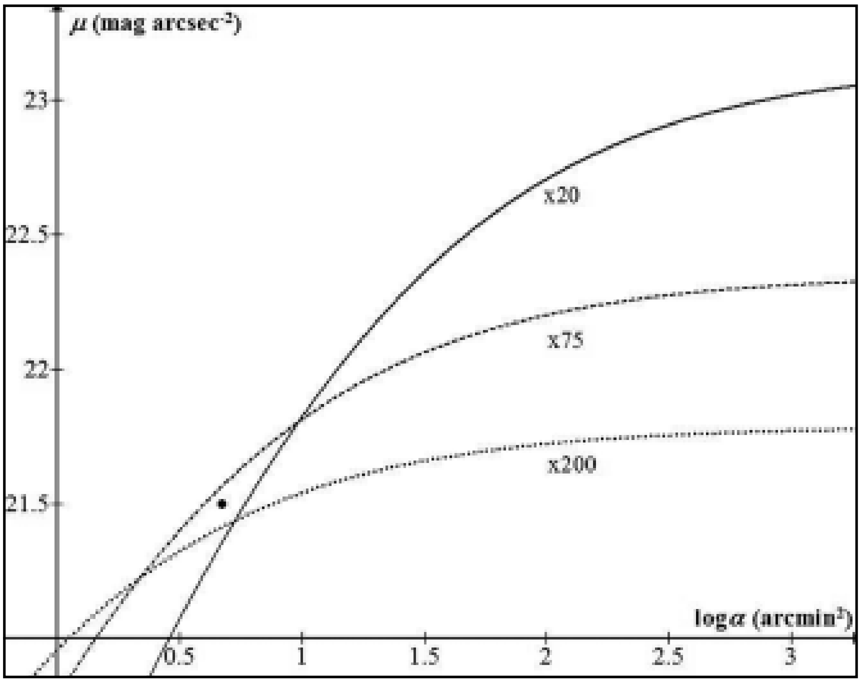
I started as a deep-sky observer 15 years ago, and after a while I began to wonder, if you measured the night-sky brightness with a sky quality meter and got a certain SQ reading, what kind of visual magnitude limit should you expect? How faint a galaxy (or other extended deep-sky object) might you see with a given aperture? How do magnification and light pollution affect things? There were some existing mathematical models and on-line calculators, but they didn't match my own experience. So in 2011, while I was a visiting fellow at Durham Institute of Advanced Study, I began to study the subject seriously, eventually publishing a paper that is freely available online at {\tt arxiv/org/abs/1405.4209}.

One aim of my research was to investigate what counts as a "dark" sky for visual astronomy. Experience told me that to get good views of galaxies I had to be able to see the Milky Way naked-eye. The IDS bronze award benchmark was SQ 20 but you would probably not see the Milky Way at this level so it seemed a questionable criterion. My research suggests 20.3 as a better minimum figure for what we might call a "grey" sky, with 21.3 being a lower bound for what we might consider "truly dark". The darkest sites on Earth have a sky brightness of about 22.

We need to distinguish two kinds of "brightness". Think of a streetlight at night (a depressingly familiar sight). If you walk away from it you receive less light on your hand, say; but when you look at the lamp itself, it doesn't appear dimmer, only smaller, because it's further away. The first kind of brightness is illuminance, the amount of illumination received from a source. In astronomy we call this apparent magnitude, and measure it in a unit called (confusingly) "magnitude". The second kind is luminance, and it's independent of distance. In astronomy we call that surface brightness, and measure it in mag psa (magnitudes per square arcsecond). When we say a star has a certain magnitude, we're saying in effect how much it would lighten our hand. The reading on a sky quality meter is the overall surface brightness of the patch of sky its sensor sees: the unit "SQ" is for our purposes the same as mag psa.

If you point a telescope at the Moon and put your hand under the eyepiece you'll see a bright spot of illumination on your skin. We understand from this that a telescope improves the apparent magnitude of targets. But a telescope doesn't improve surface brightness, it just makes the target look bigger, and in fact usually dimmer, because of course the target isn't really brought closer but is simply having its light spread over a greater apparent area. This highlights a fundamental difference between the visibility of point sources (stars) versus extended ones (DSOs). Stars viewed through a telescope remain pointlike while the background sky gets magnified and dimmed, making the stars more conspicuous. A nebula or galaxy, on the other hand, gets magnified and dimmed to the same extent as the background sky, so in fact there is no change of contrast. You might then wonder why a telescope helps at all, and it's because of the way our visual system operates.

Contrast has two aspects – colour and luminance. A red disc will be visible against a green background even if both have exactly the same surface brightness, and a grey disc on a grey ground will be visible as long as there is some difference in brightness. In very low light levels we lose our colour sensitivity and rely on luminance alone (using "scotopic" vision mediated by rod cells on the retina), so shades of grey are all we see, and for dark-site deep-sky astronomy we can restrict our attention to that case. The visibility of objects is also influenced by factors such as shape, texture and motion, but for simplicity let's always assume



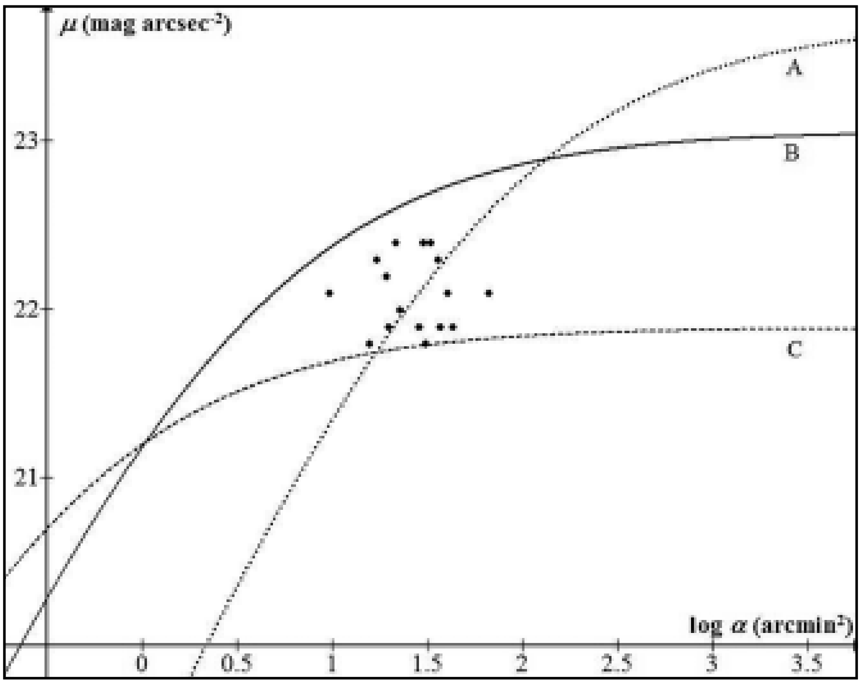
the target is a uniform grey disc against a grey background. Then the key factors are the size of the disc and the surface brightness of the background (to which the eye is assumed adapted).

Imagine reading a newspaper by moonlight – you can only make out the headlines. Or think of the scene at a dark site, where all you can make out in the surroundings are large shapes. At low light levels we have poor resolution, and targets need to be bigger in order to be visible. We can frame this as an experimental question involving grey discs on grey backgrounds. For a given background brightness and target size, how much brighter (or darker) than its surround must the target be, in order to be seen?

This was investigated in a famous study by Blackwell carried out in America during World War Two, and later extended by Taylor. There are various ways to define whether a target is "visible"; Blackwell's procedure was to project a disc of light in one of eight positions on a screen, or not at all, and subjects had to record where they thought they saw it. "Visibility" was defined as a success rate of 50% over many repeated occurrences. There has been much misunderstanding of this, for example supposing that it equates to being "50% confident" of seeing a target, or seeing it 50% of the time. In fact it's a somewhat unrealistic measure of "visibility", as Blackwell acknowledged, but he showed how the results can be rescaled to something closer to actual experience. The Blackwell-Taylor data are still used in areas such as lighting engineering and road safety, and a key part of my research was to find a good mathematical model for their results.

The data can be plotted as a series of "threshold curves", choosing astronomical units for convenience (Figure 1). Reading from left to right we go from smaller to larger target size (actually the logarithm of angular area), and as we rise vertically we go to higher (fainter) values of surface brightness. The three curves correspond to three different backgrounds, which we can think of as different levels of sky darkness. The bottom curve is for a background comparable to an urban light-polluted sky (18.74 mag psa). Any target whose size and surface brightness place it below the curve is more than 50% likely to be visible, while for a target above the curve the likelihood would be less than 50%, and the higher it is, the less likely it is to be seen. The two other curves are for darker conditions: the top one corresponds to a background darker than the actual night sky (these were laboratory data, remember), while the middle one would be for a sky that is almost "truly dark". We see that as the sky darkens, the threshold curve rises, so more targets become potentially visible. We also see that the effect is most marked for larger targets: light pollution hurts galaxies more than stars, robbing urban dwellers of the Milky Way.

All the curves are asymptotic at either end: they can each be thought of as two straight lines joined by a bend. The oblique straight line at the left side, relating to small target sizes, illustrates "Ricco's law", an important physiological effect discovered by the nineteenth-century astronomer Annibale Ricco. It says in fact that for small targets the required level of contrast is inversely proportional to target size, but we can understand it in terms of how the eye works. If a single photon hits a single rod cell it will cause a chemical reaction on the retina, but we won't perceive a visual stimulus. In order to "see", there have to be a certain number of photons hitting a bunch of rod cells within a very short time. Our visual system adds up the energy received by this group of cells, and if the total energy is high enough we perceive a visual response. This is a good evolutionary adaptation for filtering out random noise, but it explains why we lose resolution, and it means that if a faint target is below a certain size we won't be able to tell if it's pointlike or extended. This has a familiar consequence in deep-sky astronomy: the NGC contains many "nebulae" that are really faint stars or close pairs; while a small, faint galaxy can easily be overlooked because it appears stellar to the eye.



On the Blackwell-Taylor curves, the height of the Ricco (left-hand) asymptote actually corresponds to the threshold illuminance, or in other words the limiting magnitude for stars. The higher the asymptote, the fainter the limit. At the other end, the curves are asymptotically flat, indicating a limiting surface brightness for large targets, where higher again means fainter. We draw two lessons from this. First is that there is a link between magnitude and surface brightness limits. Second is that while magnitude is the best indicator of visibility for small targets, surface brightness is best for large targets, and for intermediate ones (near the bend) we should know both.

For each curve we can extend the two asymptotes to their point of intersection and read off the corresponding target size, called the Ricco area. We can think of this as a dividing point between "small" and "large" targets, or as an approximate estimate of the largest size for which Ricco's law applies (Blackwell defined something similar, which he called the "critical visual angle"). I found a simple formula for Ricco's law in terms of luminance that had not previously appeared in the literature, and this enabled me to construct a theoretical model of the Blackwell-Taylor data that was more accurate, and contained fewer free parameters, than previous attempts.

Everyone's eyes are different, as Blackwell realised, but he showed that, to a good approximation, the effect of things such as age and motivation is to move the threshold curve up or down, not change its shape. We also need to shift the curve to get a more realistic threshold than the

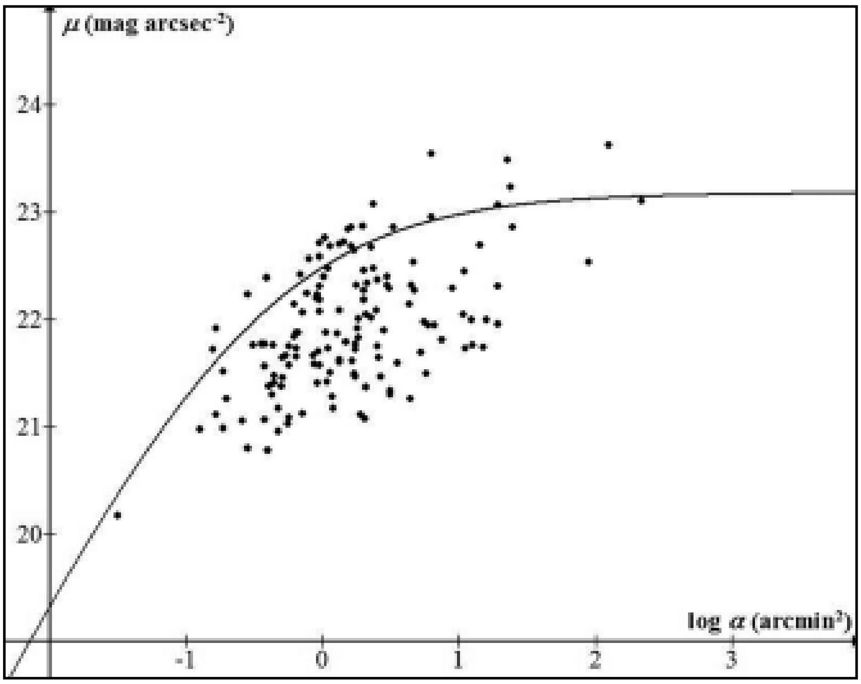
50% criterion: we want to say that objects below or above the curve are predicted to be visible or invisible. We can encapsulate these requirements within an overall shift parameter or "field factor", *F*. Blackwell considered a value of 2.4 to give realistic thresholds, but it will depend on the specific observer and viewing situation. To take my own example, in Northumberland I have skies as dark as SQ 21.7, but I can't see fainter than 5.9 mag. That in fact implies an *F* value of 2.4. Someone with better eyes, on the same night and looking at the same patch of sky, might see for instance to 6.5 mag which would correspond to $F = 1.4$. A value $F=1$ would give a limit of 7 mag.

When we speak of a "mag-6 sky" we mean one where a certain person on a certain night can see stars to sixth magnitude for a certain length of time in a certain patch of sky. Your mag-6 sky might be my 5.5 or someone else's 6.5. It should also be noted that there is no universal agreement on how we should define magnitude limit when observing. Even if we agree to use two eyes and unconstrained (direct or averted) vision, there's still the question of whether we require a star to be steadily visible or merely glimpsed. The latter can be potentially misleading because of scintillation, caused by high-altitude, high-speed winds (and not to be confused with "seeing" due to low-altitude turbulence). Scintillation has a focusing or defocusing effect which in extreme cases can momentarily raise or lower the brightness of a star by more than a magnitude. So at a site with high scintillation (e.g. Mauna Kea or Paranal), a person with a usual limit of 6 mag might get a glimpse of a star with a recorded magnitude of 7 or perhaps even 8. If we view astronomy as a sport then we'll concentrate on extreme achievement, but if our concern is with scientific modelling and public communication then averages are more meaningful. When a distance is described as a "ten minute walk" we assume it's at a normal pace, and in the same way I would argue that in speaking of magnitude limit we should restrict ourselves to stars seen steadily.

I've mentioned that the threshold curve implies a link between (sustained) limiting magnitude and limiting surface brightness, and if the sky is brightened by light pollution then both these limits are compromised in ways we can quantify. For example, suppose that a person can see stars to 6.0 mag at a site with SQ 21 (which would correspond to $F=1.74$). Then the right-hand end of the threshold curve for those values implies a limiting surface brightness of 23.74 mag psa for sufficiently large targets. If the sky brightness were instead a much better SQ 21.75, and if all other variables (e.g. atmospheric extinction) were equal, then the same observer's limits would be predicted to be 6.3 mag for stars and 24.28 mag psa for large targets. So in going from a typical dark-site to a pristine one, we predict an improvement of only 0.3 mag for stars, but 2.53 mag psa for large targets.

The link between small and large target limits implies that the visibility of extended objects such as M33 can be quantified as an equivalent limiting stellar magnitude, independently of the observer's personal *F* value. M33 has a total apparent magnitude of 5.8, and since I can see stars to 5.9 at SQ 21.7 I might suppose the galaxy to be within naked-eye reach. But I've tried many times and never succeeded, because it is an extended object whose equivalent stellar limit is much fainter. The analysis is tricky because of the galaxy's inhomogeneity, but my model suggests that the required limit to see M33 naked-eye is approximately 6.6 mag, which is consistent with visual brightness estimates given by Holetschek (1907) and Weaver (1947). Heis included M33 in his 1872 naked-eye star atlas, and he could see stars to 6.7 mag, a feat long considered exceptional. I can be pretty confident that I will never see M33 without optical aid or a spaceship. For M31 I predict a required stellar limit of approximately 5.2 (though with a wider margin of error), which is again consistent with experience.

A telescope has the effect of changing the shape of the threshold curve. I was able to model this using simple optical principles; the result is that



as magnification increases, the magnitude limit improves while the surface brightness limit worsens. If magnification is not great enough to turn stars into blobs, the stellar magnitude limit is set by the level at which the enlarged background sky becomes so dark that it is effectively black. From laboratory data we know that this occurs when the background reaches about 25 mag psa. With extended objects, magnification leaves unchanged the target's contrast level against the background, but changes the apparent target size and background surface brightness. It is because threshold is a function of both those factors that magnification makes objects visible.

The changing shape of the threshold curve with increasing magnification therefore quantifies a familiar phenomenon in deep-sky observing. An object might be invisible at low power (too small), invisible at high power (too faint) but clearly seen at intermediate power. This is illustrated in Figure 2 for a 100mm refractor, with some assumed values for the instrument and observer. The target, marked by a data point corresponding to its size and surface brightness, is predicted to be visible at x75, but not at x20 or x200. Because of this effect I have long preferred to use a zoom eyepiece for deep-sky viewing.

Of course we have been assuming that targets are uniform discs, and most DSOs aren't like that. Nor do we always want to see an object in its entirety; we might for example be interested in seeing a supernova, even if it means magnifying the host galaxy out of sight. It's impossible to predict an "optimum magnification" for specific objects. There is some historical and physiological evidence that a 3mm exit pupil is particularly favourable, at least for "sweeping", but every DSO is different, and in practice when viewing a particular object we start low, work higher, and stop when there is no more to be gained. The value of mathematical modelling is in enabling us to understand the underlying principles and make comparative rather than absolute statements about visibility.

With this in mind, let's see what the model predicts for an observer with three instruments (10x50 binoculars, a 6-inch refractor and 16-inch reflector), where the big reflector is used at a light-polluted site and the other two instruments are taken to a dark one. We assume typical values for observer, instrument and site parameters, and we suppose that at either site the observer views the same patch of sky (the Virgo Cluster, say) under the same atmospheric conditions. Figure 3 shows the predicted threshold curves, and plots the Messier galaxies in the Virgo Cluster according to their angular size and overall surface brightness. Of course, those galaxies aren't uniform discs, but the spread of points shows us the sort of region of size and brightness that most amateur observers are interested in. We see that the 6-inch telescope at the dark site is easily best for galaxy viewing. The suburban 16-inch wins on stars (the left hand of its curve is highest), while binoculars at the dark site would win for extremely large, faint targets. The 16-inch would catch more galaxies if a larger exit pupil (lower magnification) were used; hence the complaint often made by observers restricted to light-polluted sites, that galaxy viewing is only feasible at low power. For an observer with better eyes (lower *F* value) we would shift all three curves up by an equal amount; that person might then see Virgo galaxies at medium power with the suburban 16-inch, but the comparative predictions would remain unchanged. The person would still be better spending their money on petrol.

I tested my model against historical data from William Herschel. His detailed records enabled me to establish all the relevant parameters, including his dilated eye pupil size (which he measured by looking at stars through holes of different sizes), telescope transmittance, and naked-eye magnitude limit. The latter comes from his observation of double-star H I 69 in Lynx, which he viewed near the zenith, and which has integrated magnitude 6.12 and colour index 0.1. As part of my research I found a way of establishing the correlation between colour index and magnitude limit (related to the Purkinje effect), from which I can conclude that for colour index 0.85 (a typical value for galaxies) Herschel's limit at age 44 was 6.0 mag.

I assembled size and surface brightness data for all the "nebulae" Herschel discovered using his 18.7-inch reflector with a recorded magnification of 157 (exit pupil 3.03mm). Obviously he found these under varying conditions, but we know that he kept his speculum mirrors consistently well polished, observed from a single site, and always searched near the meridian (up to a northerly limit of 82 degrees declination). So if we restrict to objects at sufficiently high declination then it's reasonable to assume we have a sample viewed under fairly similar conditions. I calculated Herschel's telescopic threshold curve based on the recorded parameters and plotted the objects he found at declination greater than 60 degrees

(Figure 4). It can be seen that the vast majority lie under the curve, i.e. are predicted to have been visible, and few lie far above. In the latter case, examination of individual outliers shows these to have been objects that Herschel did not see in their entirety. I also examined data for NGC objects that should have been visible to Herschel, but which he missed. He did not sweep the entire sky, which accounts for many escapees; others lie in crowded fields. Certainly he was not infallible, but my study shows that he was remarkably thorough, with small size being the main reason why objects were missed.

What is your own F value? My model predicts the following approximate formulae linking sky surface brightness (S), personal magnitude limit (m) and field factor:

$m = 0.27S + 0.8 - 2.5\log F$ $18 = S = 20$ mag psa
$m = 0.383S - 1.44 - 2.5\log F$ $20 = S = 22$ mag psa

If you know your sky brightness and sustained magnitude limit you can calculate your F value and predict what you would see if your sky were darker or brighter. To get accurate results you should ascertain the V-magnitude of the faintest steadily visible star to one decimal place, and for highest accuracy you should also record the colour index and convert to a standard value. If your limit is m_c at colour index c, then your limit at colour index zero would be approximately $m_c + 0.27c$.

To find your predicted surface brightness for large targets, it's sufficient to add a supplement (*sup*) to your stellar limit, as tabulated below:

S	22.00	21.75	21.50	21.25	21.00	20.75
20.50	20.25	20.00	19.75	19.50	19.25	
sup	18.06	17.98	17.90	17.82	17.74	17.66
17.58	17.49	17.40	17.32	17.22	17.13	

Suppose, for example, that your sky brightness is $S = 21.25$ and your magnitude limit is 6. Then your predicted surface brightness limit would be $6 + 17.82 = 23.82$ mag psa. Remember this is for "very large" targets, and doesn't mean you should expect to see any DSO with a surface brightness better than 23.82 mag psa. It does mean that if you see an object listed as having surface brightness 24 mag psa then you'll be lucky to see it.

For the faintest star magnitude predicted to be seen in a telescope at a site dark enough for the sky background to be magnified to effective blackness, my research yields the formula:

$$m = 5\log D + 8 - 2.5\log(p^2F/T)$$

where D and p are the clear aperture and observer's pupil diameter (both measured in the same unit, e.g. centimetres) and T is the telescope transmittance (e.g. 0.75 for a typical reflector). This offers another way of establishing the field factor F, if the other parameters are known or estimated. I also obtained a more complicated formula for magnitude limit as a general function of sky brightness and magnification.

My research involved quite a lot of mathematical analysis and historical research, and took a while to complete, during which I laid aside my usual business of novel writing. But the big message from it is very simple, and will come as no surprise to experienced observers. A dark sky is always better than a bright one, and a dark sky means one where the Milky way is easily visible to the naked eye. For DSOs you can't beat light pollution with aperture. A telescope can show stars in daytime, but if a galaxy lacks sufficient contrast against a bright sky then no telescope will render it visible. To get glorious views we don't need superhuman eyesight or fantastic equipment. We just need to get away from light pollution.

The President

This year marks the centenary of the birth of Kenneth Glyn Jones.

KGJ was the first president and co-founder of the Webb Society who died 20 years ago. He was President from 1967 - 1990. He was born in New Tredegar in South Wales in 1915 and was interested in astronomy as a youth. Just before the outbreak

Ken Glyn Jones

of the Second World War he joined the RAF as a Navigator, and served in Blenheims in the Far East. After the war he joined BOAC as a Navigation Instructor and during his career taught many senior Concorde and B-747 pilots the rudiments of navigation, in the days when taking star sightings was still a required skill.

After the death of his first wife Gwyneth, he married Brenda in 1969.

She was a strong supporter of his activities in the early days of the Webb Society. A keen observer and historical astronomer he was also a skilled instrument maker and woodcarver and his house at Winkfield near Windsor was full of his creations.

He died in 1995 and at his funeral service at Ascot it was announced that Edward Bowell at Lowell Observatory had kindly agreed to name one of his minor planet discoveries (5861 Glynjones) in his honour.

His academic work included proposing the inclusion of M110 as the last in the entries of the Messier catalogue and helping to confirm that the proposed identity of NGC 4568 with M91 by William C. Williams was correct. His most well-known work was '*Messier's Nebulae and Clusters*', the first comprehensive review of the M objects, which was published by Faber in 1968 and reprinted by CUP 23 years later. The observations of the northern objects were made with his 8.5-inch reflector at Winkfield which was mounted upon a horseshoe fork. For the southern objects he used the telescope belonging to Danie Overbeek near Johannesburg in South Africa. He also authored an eight part series called 'The Search for the Nebulae' which appeared in the BAA Journal and was later issued as a book by Alpha Academic (copies of which are still available from the IoA librarian). He also wrote a paper on the events surrounding the discovery and subsequent observation of S And 1885 – the first extragalactic supernova to appear (in M31) for *Journal for the History of Astronomy.*

In 1967, together with John Larard, the Webb Society was formed, and Ken became President and Director of the Nebulae and Clusters Section, with John taking on the twin roles of Secretary and Director of the Double Star Section. Between then and 1990 a series of eight *Observers Handbooks* was produced written by members of the Society and achieving more than 10,000 sales world-wide.

The President: Our next speaker is a co-owner of Shelyak Instruments. He became interested in astronomy in 1980 and started observing stars and deep-sky objects with a small refractor. By 2000 he had become interested in spectroscopy and in 2003 attended a pro-am meeting in France. This led him, with some colleagues to design a suitable spectrograph for amateurs which would give adequate resolution and LHires was the result. Today LhiresIII is available and Shelyak also supply the first commercially available echelle-fed fibre spectrograph. I'm delighted to ask Olivier Thizy to give us '*An Introduction to Astronomical Spectroscopy*'

Olivier Thizy

My plan today is to talk about how an astronomical spectrograph could be used to look in more detail at a particular area of the sky in Cygnus. The spectrograph being used was first produced two years ago. It has a 25 micron slit, and a collimator to produce a parallel beam, which is then directed to a grism. An objective lens is then used to image the spectrum on to a camera. The resulting resolution depends on the slit size but for this instrument (LHiResIII) a value of 25 micron works best with the design. The advantage of the slit was illustrated in a spectrum of the Cat's-Eye Nebula and showed the lines of nitrogen and hydrogen resolved into multiple components. The slit has been aluminized so that an off-axis guiding eyepiece can see the image of the object on the slit in order to guide the exposure.

An artificial lamp source can be used to produce a reference spectrum on to the slit which allows the wavelength calibration to be made. The continuum in the spectrum reflects the black-body nature of the source being observed and has a peak at different wavelengths depending on how hot the source being observed is. Spectra of both components of the bright double star Albireo were shown and its clear that the stars are substantially different in temperature. The blue, fainter star has a peak in the blue part of the spectrum. The spectrum of the orange primary is substantially different reflecting the lower temperature of this star. There are many absorption lines in both stars but the primary does have one emission line.

The first people who used spectra were chemists such as Kirchhoff and Bunsen and they were able to formulate a law to explain the shape of the intensity graphs as a function of temperature.

The LHirRes spectrograph comes with software which allows the user to measure the temperature of any spectra using a facility called Autoplanck. The blue component of Albireo shows a series of absorption lines which reflect the fact that atoms at the surface of the star 'eat' light from beneath creating the dark lines in the spectrum. The element hydrogen which is common in many stars produces a series of absorption lines known as the Balmer series with the first line in the sequence, called H alpha, found at a rest wavelength of 6563Å.

Some stars in Cygnus have very strong Balmer lies and others are rather weaker and also show lines of calcium. The intensity of the Balmer lines is also an indication of stellar temperature. At the end of the C19 researchers at Harvard made a stellar classification table based on the strength of the Balmer series of lines so that the first class was called A, the second B and so on. Annie Jump Cannon, however looked at the spectra again and considered the lines of calcium and helium which also indicated temperature. She then rearranged the stars in the order with which we are familiar today viz. O, B, A, F, G, K, M. Hot B stars had prominent lines of helium, whilst the cooler stars were dominated by lines of titanium oxide.

The width of a spectral line is an indication of the luminosity of a star. The very luminous stars have narrow lines whereas the stars of lower luminosity have broader lines. If we plot the luminosity of a star against temperature we find that most stars lie in a restricted part of the diagram known as the Main Sequence where stars spend most of their lives.

The third Kirchhoff law involves emission lines which are seen in the spectra of the B star component in Albireo. Around this star is a disk of hot material in which excited atoms produce emission lines. Amateurs are observing stars such as P Cygni - a luminous blue variable - because we are not clear about what is going on in these exotic stars. P Cygni is a very massive star which ejects material from its surface with a velocity of 2,000 km/sec. The Hα line is so bright in emission that its adds one magnitude to the V magnitude of the star as a whole. There are absorption features almost at the same wavelength as the emission lines leading to a line profiles which are known as P Cygni profiles. The central part of the stellar ring is in absorption whilst the inner and outer regions of the disk are in emission. Stars in which the outer layer of hydrogen is removed to reveal the carbon and nitrogen layers underneath are known as Wolf-Rayet stars. Further down the evolutionary sequence when the C/N layer is removed then object becomes a planetary nebula.

Novae such as the recent Nova Delphini have P Cygni profiles and then emission lines which

Olivier Thizy

increase in intensity. This star exploded in Aug 2013 and has been followed by a lot of people - 40 observers have taken 1000 spectra which shows the time evolution of the P Cygni profiles. We have been lucky to have the help of astronomer Steve Shaw in Italy who has helped in explaining what to expect as the nova evolves.

There is a great need to do photometry of variable stars in conjunction with spectroscopy, especially in novae. Does brightness change due to increase in emission or decreasing brightness? In addition accurate V magnitudes can be used to rescale apparent spectra into absolute energy spectra. We have looked at RR Lyrae at higher resolution and can see the magnitude vary with time. Calcium lines come and go with pulsation. With spectroscopy we can analyze the evolution. Opacity decreases at one point in the period and we can see the emission? Amateurs have been following neutral He as well as H lines in conjunction with professional astronomers. BW Vul shows lines which double every 5 hours due to the Doppler effect.

I want to conclude by talking about two more classes of star. Symbiotic stars are binaries consisting of a red giant and white dwarf. The WD takes some of the material from the giant and transfers it to the WD surface via a circling ring of material round the WD. If the influx of material is too much for the WDS to deal with then there is an explosion leading to a nova.CH Cyg is sometimes very active. Jack Martin took spectra of it with a 14-inch and LHiRes. The features change every 15 minutes so the star needs continuous monitoring.

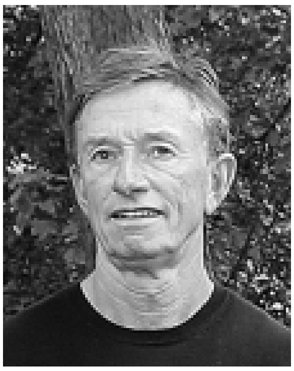
SS433 is what is called a micro-quasar and consists of a supergiant and a black hole which ejects blobs of material at 0.25c. The spectra vary over a timescale of days and a collaborative project involving four small southern school observatories is under way coordinated by Professor Katherine Blundell at Oxford University. (Professor Blundell described this project at the 2012 AGM - (see DSO 161, p9, 2013).

Spectroscopy is an educational tool which helps to understand the physics behind astronomical processes. It provides a good way to observe variable stars and it can help professional astronomers too.

Tea

The President: The last speaker of the day is Mike Irwin who is Head of the Cambridge Astronomical Survey Unit. Dr. Irwin received the Herschel Medal from the Royal Astronomical Society in 2012 and is known worldwide for the leading role he plays in processing of digital optical and infra-red survey data. This began with the APM machine and developed into the extensive large-CCD mosaic surveys which we see today. He also published an automated method for analysing images where objects are crowded together, the genesis of much of today's image detection and analysis. His important contributions to science include the 1994 co-discovery of the Sagittarius dwarf galaxy, an object being disrupted by and heading for a future collision with the Milky Way. This led on to galaxies being discovered in the constellations of Sextans, Cetus and Antlia, with a further 15 found in the last 5 years. I might also add that he is one of the team who were awarded the Supernova Cosmology Project Team Breakthrough Prize for 2015. The title of his talk is '*M31 and its environs*'.

Dr Mike Irwin



Dr. Mike Irwin

I will start by showing you slides of the big telescopes at Paranal, where the VLT and the UK VISTA telescope are located, and Mauna Kea where the two Keck telescopes and the Japanese SUBARU telescope are sited. This is where much of the data comes from that is being handled by the Cambridge Astronomical Survey Unit. SUBARU is particularly interesting as it is the only telescope of its size to have a prime-focus camera. The latest instrument is called Hyper Suprime-Cam and its array of 104 4 x 2 K CCDs gives a 1.5° x 1.5° field on the sky making it the best ground-based imaging facility on the planet.

At present we know that the observable 5% of the material of the Universe is star debris - the rest is dark matter and dark energy. So why do we think there is dark matter? The outer rotation curves of galaxies are flat and this cannot be explained by the matter that we can see in the galaxy - in fact there is a discrepancy of a factor of about 100 in the amount of matter that needs to be in the galaxy to explain the observed rotation curve. Dark energy manifests itself in the fact that we now know that type Ia supernovae are now more distant than we thought and the Universe appears to be accelerating its expansion.

To explain this we need to look back to the Big Bang which was followed by a period of inflation in which a hot opaque fireball of ionised hydrogen and helium did not allow radiation to get out. It was only after the rapid expansion or inflation stage of the early Universe cooled so that the radiation was able to get out and this led to fluctuations in the microwave background which resulted in the formation of the first stars. Then the ionized hydrogen and helium recombined into a neutral medium during what is known as the Dark Ages and the first stars and galaxies formed. Then they started re-ionizing but by this time the Universe had become much bigger. With current instrumentation we can see back to a resdshift of z = 10 which corresponds to an age of 400 million years.

The fluctuations in the background only amount to 1 part in 100,000, so what happens in a region the size of a cluster of galaxies? The dark matter and the baryons all interact in a complex way and we end up with an object looking like M31 or the Milky Way from a dark matter point of view. To see these primeval galaxies we look at the Hubble Ultra Deep Field. Here we are looking back to redshift 8 and trying to measure such redshifts is very hard. Simple simulations of what was happening can be done with modern computers providing the effects of gravity only are considered, and we can predict what M31 or the Milky Way would look like if we could see the dark matter which, of course, we can't.

In astronomy we paint the visible material of the galaxy on to the simulation to see what the galaxy would look like if the cosmologists were right. The predictions are that in the middle is the normal galaxy and it should be weird streams of material due to the interaction of gravity but this is very faint, and cannot be seen from the ground.

I now want to go on to the Local Group. There are a number of satellite galaxies around M31 and the Milky Way with a few others sprinkled further out. From an all-sky survey at 2 microns we can see the LMC, SMC and a few globular clusters. The Milky Way has a disk, an external bulge and a halo which contains mainly stars and mixtures of satellites and globular clusters. If we look more deeply at certain areas such as the North Galactic Pole we can see streams of stars being pulled off the Sagittarius Dwarf galaxy (which we found in 1994) during a close approach to the Milky Way. This is not too dissimilar to the image we that we expected from our predictions. We see that the globular cluster Pal 5 is tidally disrupted into a stream of stars which are both leading and trailing. To date for the globular clusters we do photometry with the INT on La Palma. Plotting stars in NGC 5466 for instance in a colour-brightness diagram we can see where the turnoff to the giant branch is located and this, along with the position of the main sequence, each gives us an age. From spectroscopy we can see that certain types of stars have atmospheres which are relatively pristine. If you can see the absorption features due to Fe and Mg then we can characterize the elements the star was born from and we can use isochrones to determine an age. So we can build up a picture of how the chemical composition of the Milky Way changes with time.

M31 is more difficult and the brightest stars are 20th magnitude. Images of the galaxy with the GALEX space-borne UV telescope allows us to pick out star-forming (SF) regions in the galaxy. If we then overlay this image with a far-IR picture from Spitzer we see that the dust emission regions coincide with the locations of these young stars. You can do the same in the radio using neutral hydrogen. The SF regions extend further out than you might think and we can do the same exercise for M33.

Using MegaCam on CFHT which has 36 4.5 x 2 K pixels we obtain a large number of images, stretching between M33 and M31, each of which has about 10,000 stars and galaxies per frame. This allows us to plot a combined colour-magnitude diagram, but because there are so many stars involved the data needs to be binned. Even 100 kpc from the centre of M31 we are still picking up stars in the halo and also a lot of background galaxies all of which need disentangling. By picking out the metal-poor GB stars i.e. the older stars we can see all sorts of star streams and this confirms what the cosmologists predict in their simulations.

We see that M33 is orbiting M31 and is being tidally disrupted which is not surprising as gravity always wins. We have found a giant stream from a galaxy which no longer exists - it was ripped apart after interacting with M31 a long time ago. M31 is surrounded by a spherical thick disk and we can see arcs of stars coming out of M33 and also NGC 147 is being pulled apart.

This led to some papers which we published in Nature. In 2001 we found a giant stream that people then modelled by firing a small galaxy towards M31 in the computer. We can retrieve the size of the original impactor and also estimate the mass of M31 but not to better than a factor of two. We find also that M33 is in polar orbit about M31, the nearest approach will be 53 kpc. The two systems are currently 200 kpc apart. When we look at M33 in the light of neutral hydrogen we see that it is rotating and the rotation curve is distorted further out and in the direction of M31. How long ago was this nearest approach? We can see a peak of star formation occurred in the outer disk of M31 about 1.5 to 2 million years ago. The same is true of M33.

The satellites of M31 are up to 50° on the sky away, equivalent to a distance of 2 million light years. The globular cluster system is equally spread out. In the Milky Way we know of 9 globulars more than 100 kpc from the centre but in the case of M31 there are more than 100 globulars that far out. We distinguish the globulars from the dwarf satellite galaxies by the shape of the size versus luminosity diagram and we think that the globulars contain no dark matter whilst the satellite galaxies are dark matter dominated. Clusters are typically less than 10 pc in diameter whilst satellites are more than 50 pc but they have the same luminosity so it implies that dark matter does not exist is a system with a certain size but we can also tell how fast the dark matter is moving. The distribution of the globular clusters over the star streams - a lot of them appear superimposed on top - tells us where they came from. From small galaxies that get disrupted we expect a small gradient in velocity along the streams which is what is actually what we expect. The same is true for the MW,we think.

From the point of view of an astronomer in M31 the distribution of the satellite galaxies would appear distinctly odd because they seem to stretch in preferred lines or planes and are rotating in the same way as the disk. Cosmologists predict that the satellite galaxies should be uniformly distributed around the big galaxies

To summarize, we see extended structure in M31 out to 0.5 million light years, we have found a funny, giant stellar stream, a huge thick disc, and globular clusters out to great distances. It seems that parts of the MW and M31 overlap.

The President

That is the end of the meeting. Can I ask you to join me in thanking Stewart and Owen for organising the speakers and the trade stands, and Tanya for supplying all the food and drink? (Applause). All being well we will hope to meet again here next year in June and I look forward to seeing many of you again then.

Accounts for the Year to March 31st, 2015

Steve Rayner

INCOME				
Subscriptions	£2,576.63			
AGM income	£720.00			
Sales	£1,018.46	£4,315.09		
Transfer from Virgin (Northern Rock) account	£4,000.00	£4,000.00		
Total Income Lloyds Account			£8,315.09	
Interest Virgin(Northern Rock)	£175.39			
Interest Charities Account	£22.87	£198.26	£198.26	
Total Income All Accounts				**£8,513.35**

EXPENDITURE				
Deep Sky Observer \& Sale Items Costs				
Printing of Deep Sky Observer, etc.	£1,901.00		(4 copies)	
Postage, etc. for DSO despatch	£1,870.73	£3,771.73	(4 copies)	
Committee expenses	£328.10			
AGM Catering Costs	£275.00			
Secretaries supplies - postage	£200.15			
IAS 2014 & 2015	£682.00			
AGM Speaker expenses	£420.69			
Preparation of items for sale	£2,189.45			
Other expenditure	£245.48	£4,340.87		
Total Expenditure Lloyds Account				**£8,112.60**
Other Expenditure				
AGM Catering - food and drink (NR Account)	£210.00			
Total Expenditure all accounts				**£8,322.60**

Surplus of Income over Expenditure (UK Accounts only)				**£190.75**
Cash Float for exhibitions	£126.10 (unchanged)			

INDIVIDUAL ACCOUNTS				
Lloyds TSB Current Account				
Balance at April 1, 2014	£3,923.50			
Income - subs, sales, AGM, etc.	£8,315.09			
Expenditure		£8,112.60		
Balance at March 31st 2015			**£4,125.99**	
Northern Rock Building Society				
Balance at April 1, 2014	£12,219.64			
Income - interest	£175.39			
Income - Transfer from Virgin (NR) account	£4,000.00			
Expenditure - AGM Food and Drink		£210.00	£210.00	
Balance at March 31st, 2015				£8,515.03

Charities Deposit Fund

April 01, 2014	£5,242.33		
Income – Interest	£22.87		
Expenditure	£0.00		
Balance at March 31st, 2015			**£5,265.20**

North American Section Accounts ($US)

Balance at April 1st, 2014	$246.00	$246.00	
Income			
Subscriptions	$1,626.00		
Sales of publications	$208.50	$1834.50	
Expenditure			
Bank	$16.50		
Postage	$3.17	£19.67	
Balance at March 31st, 2015			**$2,060.83**

Southern Section Accounts ($Aus)

Balance at April 1st, 2014	$A1,100.54		
Income			
Subscriptions	$A312.00		
Expenditure			
Reimbursement (micrometer transfer to UK)	$A79.00		
Balance at March 31st, 2015			**$A1,333.54**

Object of the Season: NGC 1501 – Planetary Nebula in Camelopardalis

Wolfgang Steinicke

Discovery and Nature

The small northern sky object was found by William Herschel in sweep 774 on 3 November 1787; it was entered as IV 53 ("planetary nebula") in the second catalogue of 1789. Herschel, was observing at Slough, using the 18.7-inch reflector in the front-view design with a magnification of 157. The instrument was looking to the north. He noted: "A very curious Planetary nebula near 1' diameter, round, pretty well defined of a uniform light and pretty bright"; 9 Cam was used as reference star. A second observation was made 6 days later (sweep 777), now using a higher power: "With 360 much magnified, but still the borders pretty abruptly defined, irregularly elliptical."

The planetary was not observed by John Herschel. He only catalogued it as GC 801 in 1864. But, later it was seen five times with the 72-inch reflector at Birr Castle. The first two observations were made by Lawrence Parsons, the son of Lord Rosse. On 18 December 1867 he noted: "The brightness is not uniform, there appeared to be a bright ring of not quite uniform brilliancy, with perhaps a band of luminosity across the centre, in fact it looked something like M 97. Star in the centre." And on 15 January 1868 he added: "A bright ring and inside a dark annulus, very decided. It is slightly elliptical." The three other observations were made by his assistant Ralph Copeland. On 21 November 1872 he wrote: "Bright, round, nucleus = star 14 m, surrounded by a dark ring, diameter 53.2". Very interesting object." Four days later he noted: "Of the usual blue colour of planetary nebulae." The last observation was made on 15 November1873: "Exquisite planetary nebula. Many stars in field (diameter 8'), powers 414 and 650 showed the nucleus quite stellar."

Schönfeld, Rümker, Engelhardt and Bigourdan observed the planetary nebula with refractors. In 1888 Dreyer catalogued it as NGC 1501, using Herschel's description. It was first photographed by Curtis in 1913 with the 36-inch Crossley reflector at the Lick Observatory (Fig. 1).

NGC 1501, sometimes called "Oyster Nebula", is a medium aged PN, showing a complex filamentary structure. It has a hot central star of Wolf-Rayet type (WO4), also known as the variable star CH Cam. It is pulsating on a time scale of just half an hour (unusual for a central star). The mean visual magnitude is 14.4, a bit fainter than the (integrated) magnitude of the planetary (11.5). CH Cam is classified as a ZZ Ceti type variable. The nebula is about 4200 lightyears away and has a diameter of 1 lightyear. Its spectrum is dominated by the emission lines of Hydrogen.

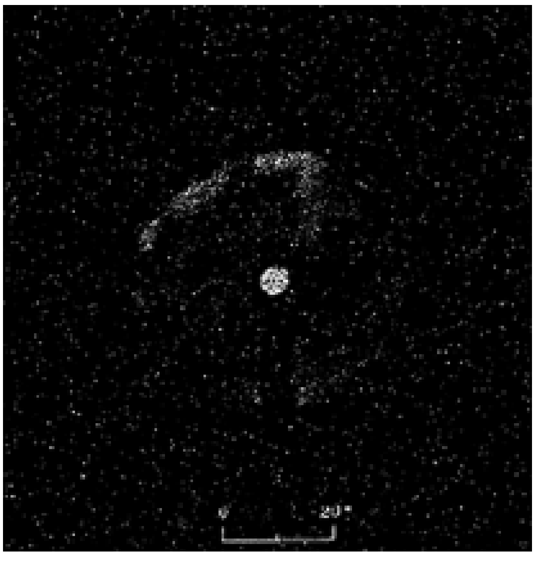


Fig. 1
The first image, made by Heber Curtis in 1913, shows not much more than the central star of NGC 1501.

Data

Position (2000):	4 06 59.4 +60 55 17 (Cam)
Visual brightness:	11.5 mag
Central star:	14.4 mag (CH Cam)
Size:	0.87' (1 ly)
Distance:	4200 ly
Other designations:	IV 53, GC 801, PK 144+6.1, ARO 44, VV 16

Observations

Steve Hubbard

This is just a note to say that for the first time I sought and found your Object of the Season - NGC

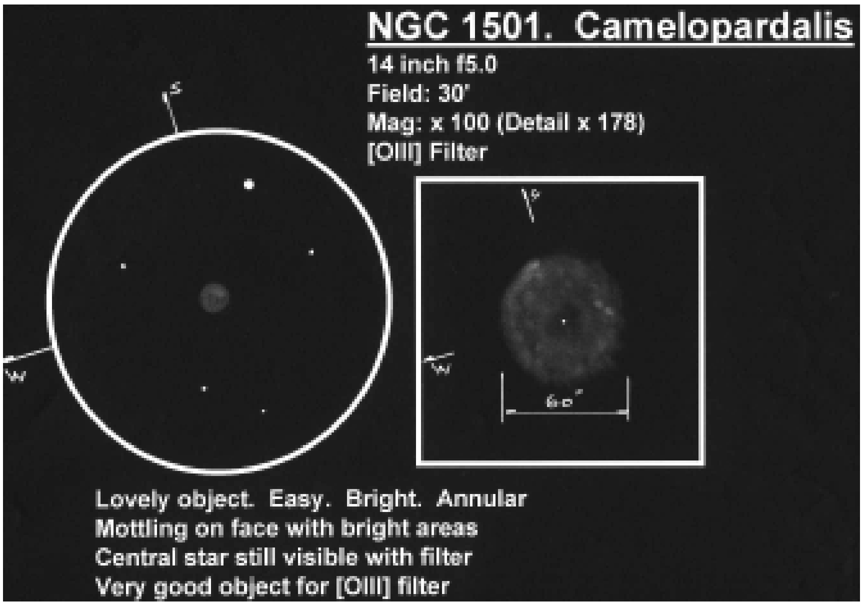


Fig. 2
Stewart's sketches of NGC 1501.

1501 in Camelopardalis. I use a Mewlon 210 from my observatory in Gorleston, Norfolk, UK, and diffuse objects at mag 11.5 are close to my limit given normal conditions and some light pollution.

However on Tuesday 8 December 2015 at 21.15 UT I settled down to try, and after half-an-hour of checking the field using different eyepieces with and without a UHC filter (no OIII at present) I was ready to concede defeat. Then with averted vision near the edge of the FOV......... success! When centred (and with increasing dark adaption) it was visible direct; the best view I thought was with the 20mm Pentax XW giving a magnification of 121 X and without the UHC filter. At 5.45 UT the following morning with 15 x 70 binoculars I had my first view of comet C/2013 Catalina, so an interesting night!

Stewart Moore

Observation made through 14-inch f/5.0 Dobsonian. This is a lovely object and responds particularly well to a [OIII] filter. At x100 with no filter it appears as a bright annular disk with the central star only suspected at times. At x178 the central star is clear, and remains visible even with the filter. The edges of the disk are well defined without the filter, but rather ill-defined with it. However, the overall view is transformed with the filter at high power, and the disk presents a mottled or blotchy face of uneven brightness whereas without the filter it is much more uniform in appearance. A beautiful object.

David Reynolds

Date: 2015 March 10 Tuesday 20:35 to 21:00 UT (night of 10/11)

Place: South Norfolk, England (rural).

Telescope: 600mm f4.5 Dobsonian, not driven.

Sky conditions: Transparency poor. Seeing average. Air Temp -2 °C, a little dew, no wind. Darkness very poor, SQM 20.72 at time of observation (overhead).

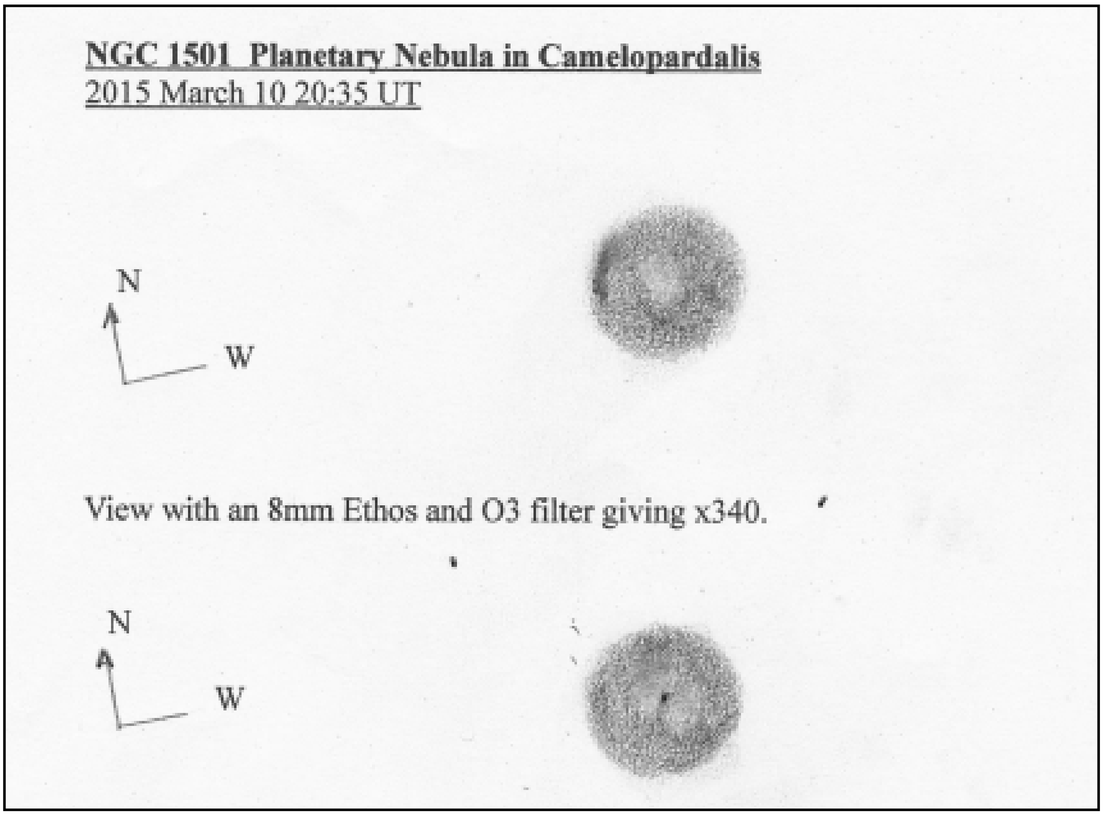


Fig. 3
David Reynolds
With the OIII filter removed the central star jumps into view,and brighter patches were seen in the N and W of the central star

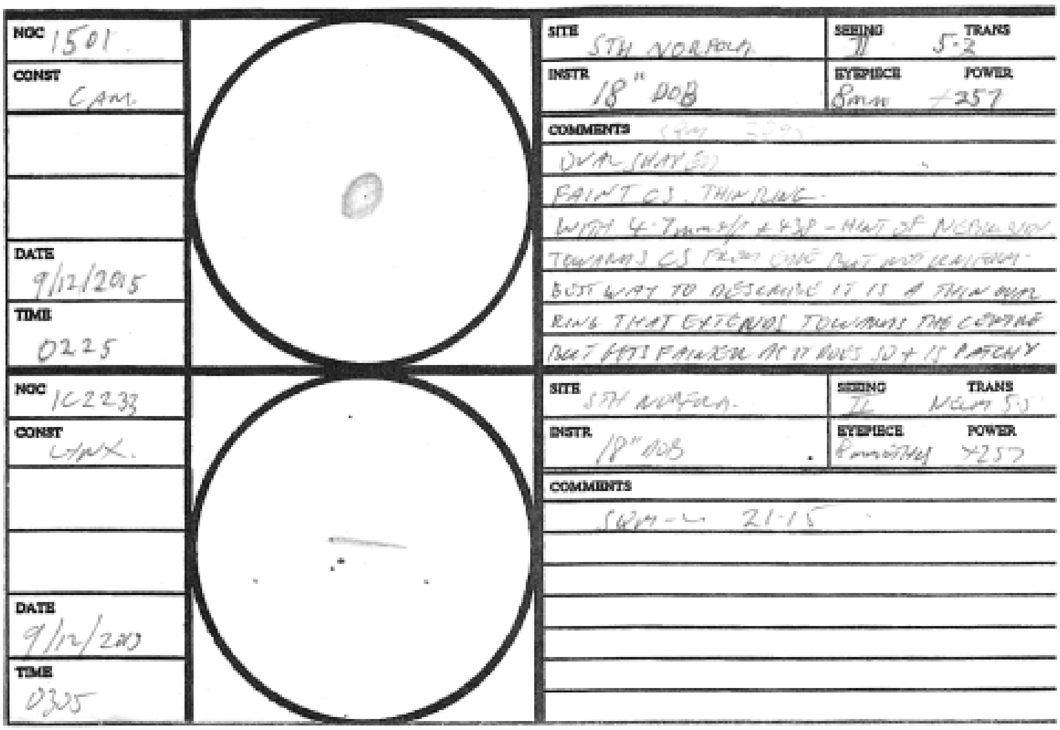


Fig. 4: Andrew's sketches.

I have observed this lovely planetary nebula quite a few times because it is a very rewarding object to see with a telescope. Also, it is at the end of Kemble's Cascade which gives a nice view in the finder 'scope as I make my way to NGC 1501. Its neighbour is NGC 1502 and is a rewarding open cluster for a telescope with a wide field view.

I was out for a few hours and for once the clouds had the decency to delay their appearance until the moon was up at around 23:00 UT. I was using my 600mm f4.5 Dob and the thin high cloud meant that it was not a night for the faint stuff. My Sky Quality Meter L read about 20.72 and the air temperature at -2C, and I judged the seeing to be 'average'. One of the objects I observed was NGC 1501 in Camelopardalis, which shows some nice detail to medium sized telescopes and above. With an 8mm Ethos eyepiece and [OIII] filter (x370) I recorded the following in my notes:- Circular, large, central hole slightly oval in the NE-SW direction, brighter arc on the E edge of the PN extending about one-sixth of the circumference which appeared to 'shimmer' or glitter! The best view was with AV1 (averted vision level 1). No sign of central star, no colour noted. Using the same eyepiece but without the [OIII] filter, the PN was more easily seen. The central star was bright and obvious, mottling within the nebulosity with brighter patches to the N and W of the CS. No colour seen. In the eyepiece, the PN is flanked by three brighter field stars spread symmetrically around the planetary, with the slightly nearer one being SSE.

Most observers see this planetary as being blue, but I saw no colour and this is probably due to the relatively high magnification that I was using. It appears that colour is best seen with low power, perhaps because the object appears smaller in the eyepiece and the colour is concentrated into that smaller area and therefore appears denser..

Andrew Robertson

My most recent observation of NGC 1501, observed from South Norfolk with my 18-inch Dobsonian, 9th Dec 2015 0225hrs: It was a claggy night which slowly improved as the night wore on with a NELM of about m5.2 and a SQM-L reading of 20.95 at the time of this observation. I used an 8mm Ethos giving x 257 and a 4.7 mm Ethos giving x438, no filter used (I've found from previous observations that a filter doesn't help much on this one). Its oval shaped, thin ring with a faint CS. Best description for me is a thin oval ring that extends towards the centre but as it does so it gets fainter and is patchy.

Observation 18th Feb 2015 2325hrs, 600 mm (24-inch) Dobsonian, South Norfolk: It was an excellent night for this location reaching NELM of m5.75 with an SQM of 21.3. At the time of observing NGC 1501 it was SQM of 21.2.

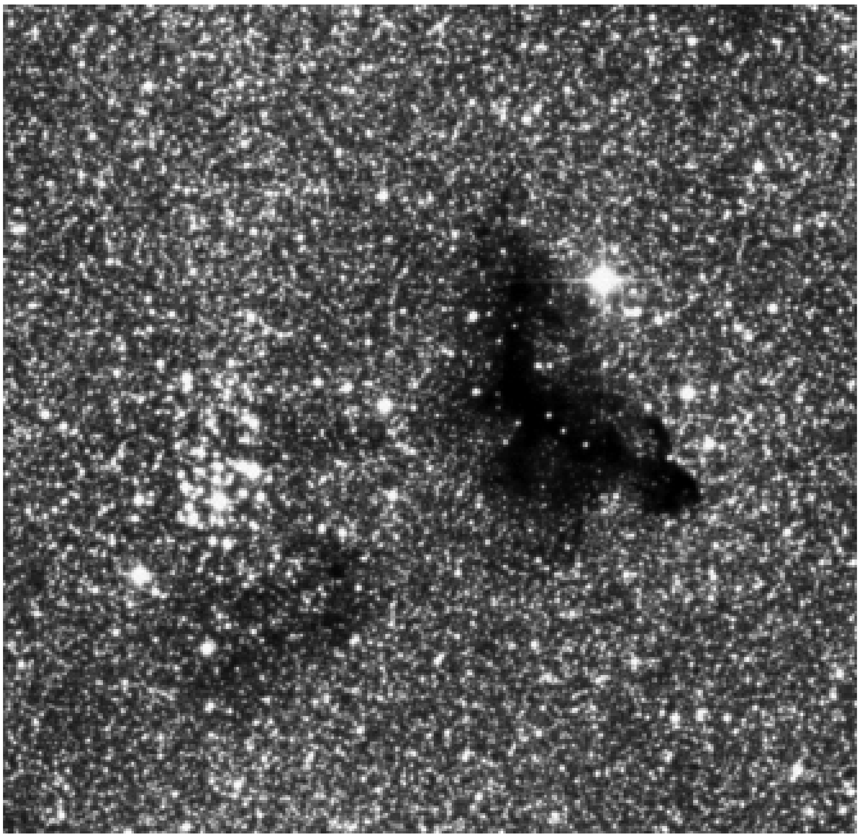
Notes; 13E (x208) quite large, thin annulus - a prominent thin ring with darkening in the middle and a prominent central star. UHC helped annularity ever so slightly. Superb with 8E (x340), very thin large annular ring, dark patch, CS.

Reading these two observations I clearly should have used more power with the 600 mm Dobsonian especially as that one is driven and easier to use high power but I was mainly on a Galaxy hunt that night and would have been mainly using just the 13mm and 8mm Ethos e/p's (easy to keep them in the pocket and quickly swap). I'd just been looking at IC 342 and my following target was NGC 2841, a GX in UMa so it was clear that I was just having a 'look' whilst I was in the area. I notice with the 600 mm a UHC filter had a slight effect but that was at low power, I find filters have less effect as you push the power up, so must re-visit with the 600mm at high power on a good night (the latter being the big issue in the UK at present).

Object of the Season New Target B86 / NGC 6520

This is a spectacular combination of a dark nebula (B 86) and an open cluster (NGC 6520), located in Sagittarius Milky Way. The cluster was found by William Herschel on 24 May 1784. He did not notice the black spot 10' northwest. It was discovered by Angelo Secchi in 1857 with the 10-inch Merz refractor at the Collegio Romano (Rome). It was also seen by Edward E. Barnard in July 1883, using his private 5-inch Byrne refractor in Nashville. He later catalogued the object as no. 86 in his catalogue of dark nebulae.

Image of B86
© Digitised Sky Survey



DATA

NGC 6520

Position (2000):	18h 03m 25.0s -27° 53' 28" (Sgr)
Visual brightness:	7.6 mag
Type:	Open Cluster (12m)
Diameter:	5'
Other designations:	VII 7, h 3721, GC 4386, OCL 10, ESO 456-SC42

B 86

Position (2000):	18h 02m 58.0s -27° 52' 06" (Sgr)
Type:	Dark Nebula
Distance:	1950 ly
Other designations:	LDN 93

Observing and Humidity

Ronald J Morales

I have observed faint deep-sky objects for a number of years and had noticed early on that the level of the Relative Humidity, henceforth known only as "humidity", in the atmosphere seemed to be a factor in my ability to see faint details while observing faint to very faint galaxies. In the early 1990's, while observing faint deep-sky objects, I began to sporadically include in my observing notes, the current levels of humidity in the night sky air. During this earlier time my results were scattered and inconclusive, but I still felt that the humidity was an important factor in my observing. During the years from 2013 to the middle of 2015, I began anew to see what effect humidity has on the faint objects as seen within my telescope's field of view. This time I listed the level of the humidity for each and every observing session.

Let me state one important factor here. I have been observing in the southern Arizona desert for over 43 years and because of this I have become used to observing in this very low humidity. My eyes have become used to this particular low humidity "condition" and therefore I tend to notice any slight increases in the humidity level while I am observing. In fact, I can walk outside and "feel" the humidity when it is much above average for my location; in this case the atmosphere feels "heavy" to me.

Now an observer routinely accustomed to observing in higher levels of humidity might not notice the differences as readily as a desert observer might. This is something to consider when reading my results. The results listed below are derived from my particular observing site which is located behind my house in the Sonoran Desert and concerns how humidity effects what I see within my telescope's field of view. I would be very interested in reading a similar study made by an experienced observer, who routinely observes in a much higher humidity atmosphere.

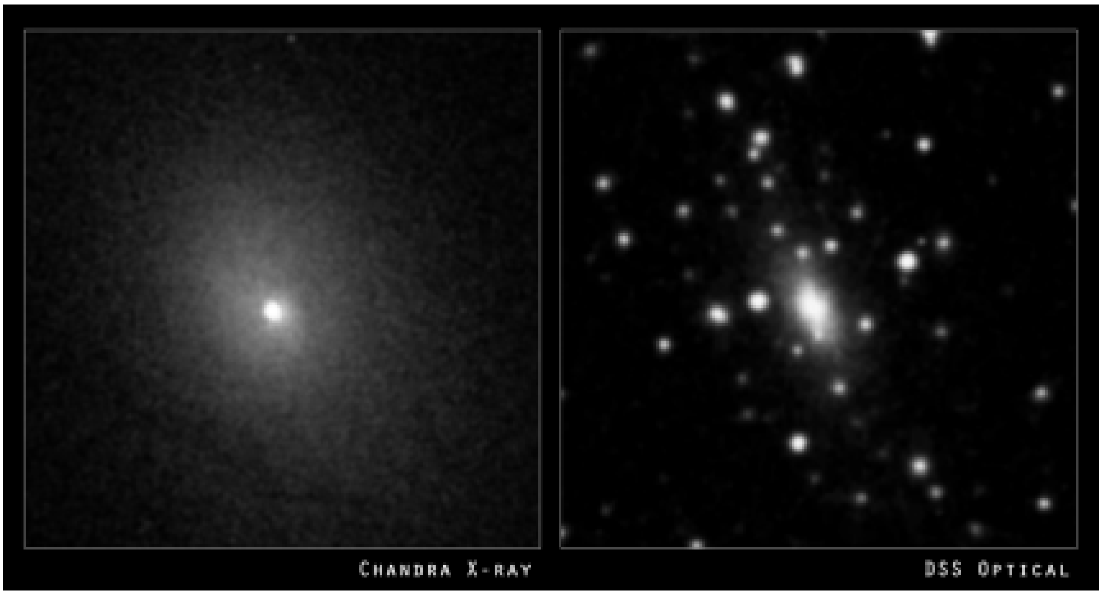
For the following results I paid particular attention to the humidity level, particularly while observing faint galaxies, where the amount of diffuseness of the outer envelope can at times be subjective at best. The main telescopes used for this project were a 12.5-inch F/7 motorized Newtonian, a 13.1-inch F/4.5 Dobsonian and a 17.5-inch F/4.5 Dobsonian. I would also take notice of the telescope's focal lengths used, i.e. F/4.5 to F/7; as this might also affect the results as given in Table #1. The eyepieces used consisted of a 20mm Clave, 16mm Konig, 12mm Konig, 10mm Orthoscopic and an 8mm orthoscopic ocular. These telescopes were used either within or just outside of my Sonoran Desert Observatory, which is at an elevation of 3500 feet. A black cloth was used to cover the head and focuser during these observations. The objects viewed were on or in the immediate region of my local meridian. To keep these results as accurate as possible I would observe a particular faint galaxy or galaxy group on at least two separate observing sessions, each one having a different humidity level. I would then compare one observation with another of the same faint galaxy. During the course of this project, many faint to very faint galaxies, and galaxy groups, were observed. While comparing these observations I would adjust (if necessary) for my Naked Eye Limiting Magnitude (NELM). My humidity levels for these particular observations ranged from a low of 9% to a high of 70% [during my monsoon season]. Looking at all of my observing sessions, over the many years, where my humidity has been listed, it appears that my "usual" humidity levels for my observations in this desert region, ranges from between 23% to 35%. I then used this level of humidity as my "reference point" for completing the following list of "Humidity Levels" as given in Table #1. These should only be used as a guide and not considered to be an absolute, as the results may differ for your particular location.

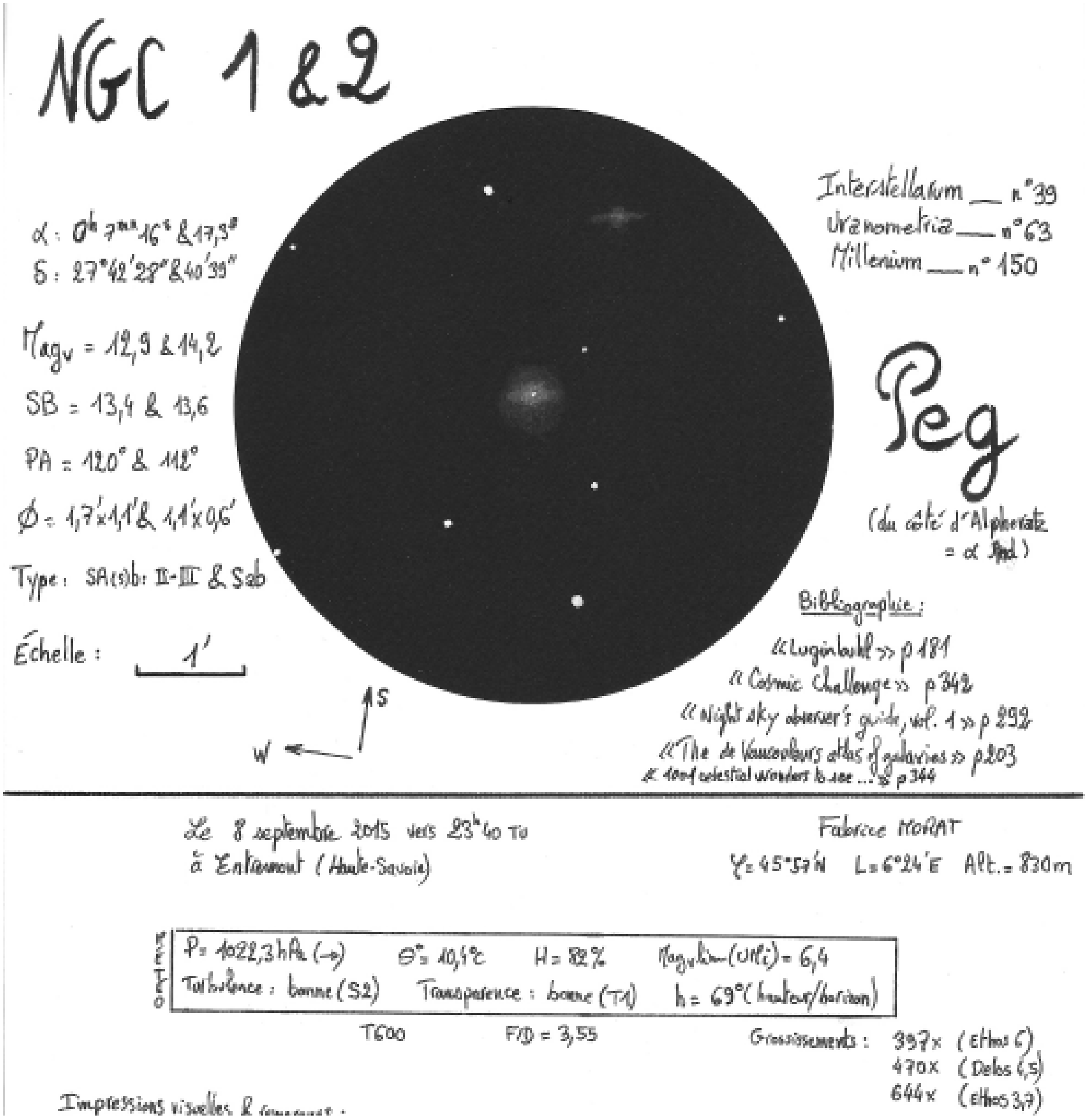
Humidity is not the only meteorological factor which effects the atmosphere which we must look through to see our deep-sky object. Other factors affecting the atmosphere include the temperature, the dew point, the wind speed and direction, the location of Jet Stream, the barometric pressure, sky cover [clouds] and I am sure there are others. For those of you who are wondering about the "steadiness" of the atmosphere; this can be composed of one or more of the meteorological factors previously mentioned. One of these factors which greatly effects my location is the wind. Due to the extreme dryness of the atmosphere here, a wind with a speed as low as 10 miles per hour places large quantities of "dust" into the lower levels of the atmosphere. This is enough to cause some low level pollution which effects what I see (or do not see) through my eyepiece. This is particularly apparent with faint galaxies. What I am trying to say here is that there is no one observing location which should be considered as being "perfect". If you enjoy observing deep-sky objects, then it is best to learn to live with what we have to work with and enjoy the wonders of the universe.

Besides relying on my "visual descriptions" (observations) of faint galaxies, I also compared my "Naked Eye Limting Magnitude" [NELM] when comparing observations of the same galaxy made on different nights having different levels of humidity. It turns out that the NELM stars seen on lower humidity nights were almost consistently fainter than those NELM stars seen on higher humidity nights. I hope the experienced deep-sky observers find Table #1 useful.

TABLE #1	**Humidity Levels**
H 1 = 0% -30% =	No ill effects seen in my telescope's field of view.
H 2 =31%- 40% =	Using the 8mm ocular I now begin to see some slight deterioration in my field of view. The stars are not quite as sharp and I now suspect some brightening of my background sky. The lower magnifications (10mm, 12mm, 16mm, 20mm) are not affected.
H 3 =41%- 50%=	There is now noticeable deterioration seen in the field of the 10mm ocular. The stars are now less sharp and the background sky is now noticeably brighter than when viewed with less humidity. This deterioration is even more noticeable with the 8mm ocular. The 12mm ocular now begins to show a little brighter background sky in my field. The 16mm & 20mm oculars are not effected.
H 4 = 51% - 70% =	Using the 8mm ocular the field of view deterioration is now *quite* noticeable, having both "soft" stars and a brighter background sky". The 8mm ocular cannot now be used to make reliable observations and the 10mm ocular is not much better for seeing any new details, although it can still be used. This is especially true when viewing very faint galaxies, their diffuse outer envelopes begin to gradually deteriorate and it becomes a little more difficult to accurately determine any faint to very faint stars which may be involved within the diffuseness of the galaxy. Using the 12mm ocular I now notice a brighter background sky and although the stars now appear to be a little "soft" they are still considered to be "relatively" sharp, and can still be used for observing faint details in my field. The 20mm & 16mm oculars are not affected.
H 5 = 71% & up =	The 10mm & 8 mm oculars are now considered "useless" for any "accurate" observing. The 12mm ocular is now becoming less useful as my stars are now soft and the "background sky" is definitely brighter. The 12mm ocular can still be used but the field has deteriorated significantly. The 16mm & 20mm oculars are still relatively "sharp & crisp" but the background sky is noticeably brighter in both oculars. This is a negative factor when attempting to view the outer envelope of faint galaxies; or trying to detect a possible very faint star [supernovae] involved within the galaxies diffuseness.

Errata for DSO 170





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New Members

At a recent committee meeting it was suggested that we should mention new members in the DSO and so we would like to welcome the following to the Society.

Axtell	John	Pyrford, Surrey, U.K.	27-Feb-16
Broad	Tony	Haveloc, New Zealand	9-Sep-15
Buckley	D.	U.K.	2-Oct-15
Burns	Andy	U.K.	3-Oct-15
Chaplin	Geoff	U.K.	19-Sep-15
Dantnall	Cliff	Beckenham, Kent, U.K.	2-Oct-15
Frost	Robert	Ludlow, Shropshire, U.K.	8-Oct-15
Gurney	Kevin	U.K.	27-Feb-16
Heijen	Math	Landgraaf, The Netherlands	14-Mar-16
Jenkins	D. A.	Spring, Texas, U.S.A.	1-Sep-15
Knight	Brent	U.S.A.	23-Jan-16
Lane	Dave	Wimslow, Cheshire, U.K.	12-Mar-16
Liston	Scott	Rugby, Warwickshire, U.K.	2-Oct-15
Loose	John	U.K.	19-Oct-15
Marchesi	Luis	Spain	22-Feb-16
Meal	Mike	Torpoint, Cornwall, U.K.	17-Oct-15
Moseley	Robert	Earlsdon, Coventry, U.K.	12-Mar-16
Paul	David	Shalford, Essex, U.K.	2-Oct-15
Pistrittio	David	Bitonto, Italy	30-Nov-15
Powell	Simon	Colchester, Essex, U.K.	24-Mar-16
Smith	Ian	U.K.	2-Oct-15
Startup	Jim	Lampeter, Wales, U.K.	2-Oct-15
Stuart	Mark	U.K.	21-Sep-15
Trenchard	Richard	Dulverton, Somerset, U.K.	2-Oct-15
Ward	Anthony	U.K.	21-Oct-15
Weakley	Ken	Bloomington, Indiana, U.S.A.	13-Nov-15