TRANSIT

The November 2009 Newsletter of

Cleveland & Darlington Astronomical Society

NEXT MEETING	
13 November 2009, *7.15 pm for a 7.30 pm start* Wynyard Woodland Park Planetarium **Strings in the sky** Professor Ruth Gregory (Durham University)	

Contents

EDITORIAL & LETTERS TO THE EDITOR

Editorial

Rod Cuff

Almost everything in this issue is more or less a follow-up from an item in October's issue. North Polar Expedition (NPE) observations are in full spate (Rob and Alex); a spin-off from a casual remark in my article in the previous issue led to a letter from Mike Gregory and some interesting research from Rob and Barry; Dave Weldrake continues with another fine article on his Lupus project; part 4 of Keith's webcam imaging tutorial is full of (believe me!) useful practical detail. We reveal the results of the recent Astromind and Thomas Wright Trophy competitions plus answers to the October quiz, and of course there's a new quiz (though slightly different this time). As a bit of variety, Ian sorts us out on matters of insurance.

Many thanks again to all contributors to this issue. I've had to hold over more good stuff until next month – but don't let that stop you sending things in, especially NPE-related articles. The copy deadline for the next issue is **Thursday 26 November**.

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Letters to the Editor

From Mike Gregory:

The SHJ catalogue

Dear Editor –

You mention 'SHJ' in your October *Transit* article on multiple stars. This is the joint 1824 catalogue of James South and John Herschel, the 'J' being added to differentiate from Herschel senior, William (whose catalogue designation was 'H'), and this catalogue was normally written 'S,h', though modern computer systems prefer 'SHJ'. About the same time, the real 'father' of multiple-star measuring, FGW von Struve, was observing at Dorpat in Russia, and later James South lamented that Struve had 'reaped a golden harvest' of all the best doubles for his own catalogues. Of course, as we now know, there were (and still will be) many more systems out there for advanced technology to discover.

The CaDAS library contains a copy of *Sky Catalogue 2000.0, Volume 2*. On page x of the introduction there is a comprehensive list of Double Star Designation Codes, and on adjacent pages there is much information on James South and the Herschels plus many other 'fathers' of multiple-star measuring who may be of interest to you.

[*Many thanks for that, Mike. In parallel, Rob Peeling was tracking 'SHJ' down too, which led to some interesting byways – see his article starting on p.19. – Ed.*]

From Keith Johnson:

DIY dew heater and a free magazine

Dear Editor –

Some members have probably already visited www.dewbuster.com/heaters/heaters.html – for those who have not, it shows how to make your own dew heater strap with very simple instructions.

On another topic: Jürgen has pointed out that you can subscribe free of charge to a new downloadable magazine, *Practical Astronomy*, at http://practicalastronomy.com. This isn't to be confused with *Practical Astronomer*, the magazine you had to pay for and that disappeared under strange circumstances.

From Neil Haggath:

General knowledge??

Dear Editor –
This will horrify you... A Gallup poll was recently conducted, in both the UK and the US, to determine levels of general knowledge – asking general knowledge questions to a random sample of people.

One of the questions was what they called a 'basic science' question, though I wouldn't even call it that; it's just a really basic 'general knowledge about the world' question. Namely: Does the Earth move around the Sun, or the Sun move around the Earth?

Can you guess what percentage of British adults got that right? Brace yourself, and make sure you're sitting down …

It was just 67% !! Of the rest, 19% got it wrong, and 14% said they didn't know!

****** ****!!

OBSERVATION REPORTS AND PLANNING

Skylights – November 2009

Rob Peeling

The Moon

2 Nov	9 Nov	16 Nov	24 Nov
Full Moon	Last Quarter	New Moon	First Quarter

In the morning of 4 November the Moon will pass south of the Pleiades, occulting some of the outer stars of the cluster. On 8–9 November it will be near Mars, followed by Saturn on the 13th and finally (and closest) to Jupiter on the 23rd.

The Sun

The Sun is showing some signs of returning to its proper duty, which is clearly to provide us with spots to look at. I saw a couple on 26 September and there were some coming around the limb on 17 October. The daily image from the MDI instrument on the SOHO spacecraft (http://sohowww.nascom.nasa.gov/sunspots) is my preferred place to check whether there are any sunspots to see.

Planets

Jupiter still dominates the south-western sky. On 13 November at 22:20, Ganymede will totally occult Io. The event will be over at 22:46. A half-hour break in the seemingly continuous cloud would be perfect.

Neptune is getting easier to pick up because Jupiter is getting closer to it again after its retrograde loop. Sweep to the east and slightly upwards along the ecliptic from Jupiter with binoculars or your telescope finder and look for the obvious row of the three 6^{th}-magnitude stars 42, 44 and 45 Capricornii (the brighter, 5^{th}-magnitude μ Cap is a bit further east in the same binocular field). Neptune will look like an 8^{th}-mag. star.

Uranus is beneath the circlet asterism of Pisces and is an easy binocular object. Once again a medium-power lens in any telescope should show the disk. It appears as an isolated 5.7-mag. object to the east of φ Aquarii.

Mars will start to be conveniently observable towards the end of November, when it rises at around 21:00.

Meteors

There are two showers to look out for in November. The **Taurids** peak on 4–7 November; they're slow and bright and derived from Comet Encke. This year, however, the Moon will be uncooperative.

The **Leonids** reach maximum on 17/18 November, and with the Moon safely out of the way there are predictions that there will be a good show.

Minor planets

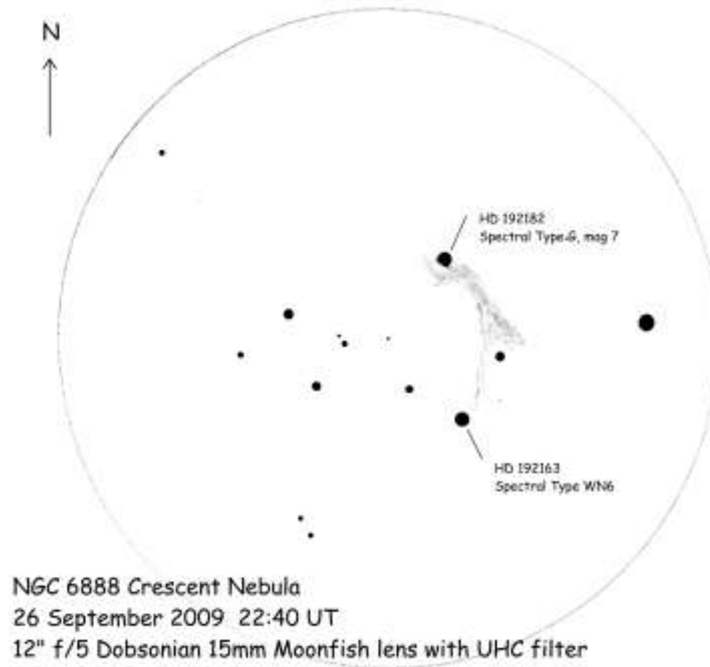
Apologies are in order. The positions I've been giving for **Juno** are very inaccurate. On 26 September, I found Juno nearly one degree from the position given by the software I've been using. Various people have asked why I hadn't updated the ephemerides for Juno within the program, but why would the predictions be so far out for such a well-defined object, even if the data is old? If the orbit of something as big as Juno isn't accurately known, then heaven help us with Near Earth Objects! Perhaps the calculation routines in the software are flawed.

Deep sky

If you happen to be at a dark site, have a go at spotting and recording the faintest objects seen with your **naked eye**. Dr Mike Inglis has been writing letters to all the major amateur astronomy societies and magazines inviting observation reports, to be publish on his project website at http://web.me.com/mdiastro/faintestobject. Can you see M33 with the naked eye? Andy Fleming (*left*) reported doing so in *Transit* last year.

Another possible target is **Uranus**. Mike Inglis's rules allow looking through filters (though I've noticed this seems to blur the image) but NO magnification at all.

Last month, I recommended taking a look at ***NGC 6888*** *in Cygnus. Here's a sketch I made of this object as viewed from my back garden.*



This month, the **Pleiades** and **Hyades** will be grabbing your attention. Also, try to find **M33**, the Triangulum galaxy. It's a bit elusive with light pollution but the core can be quite bright. At a dark site see if you can spot the nebulosity to the north-east of the core. This is **NGC 604** and is a star formation nebula like the region around M42 in Orion. The picture on the next page shows NGC 604 to the upper right of M33. However, to adjust your perspective, consider that while M42 is ~1300 light-years away, NGC 604 is 2.8 million light-years away, so in reality it is far grander than M42.

An expedition to the North Pole

A CaDAS project to celebrate the International Year of Astronomy 2009
by collecting observations, sketches, images and *any* kind of information about any object with a J2000 declination ≥70 degrees.

Send your reports, lists, or whatever to Rod, Alex or Rob (contact info for all three is at www.cadas-astro.org.uk/contacts.html) or, if you prefer, bring them along to a CaDAS meeting.

REPORT 1 — *Alex Menarry, 20 Oct 2009*

Only seven observing nights to report in the six-week period between 9 September and 19 October.

i) *9 September*: Patchy, drifting cloud, making things difficult and the atmosphere 'thick', as they used to say. Limit of naked-eye visibility from my back garden is about magnitude 3 tonight, with only the brighter stars visible. In the binocs, RZ Cas is visible and not in eclipse. µ Cep is bright, too – if I've identified it correctly!

Some wonderful general views, e.g. the star field in Perseus. Clouded out by 2150.

ii) *12 September*: Better seeing than last time. Spent some time exploring the area for the North Pole Project. Some data:

- **Named stars** are Polaris, Yildun, Kochab, Pherkab, Er Rai, Alfirk, Tyl.
- **Constellations** are Cepheus (part, including β, π, γ, $ρ^1$ and $ρ^2$); Camelopardalis (part, including ρ and δ); Draco, which goes almost to the North Pole (part, including ψ, χ, φ, ν, τ and ε); Ursa Major (part); and Cassiopeia (part).
- **Messier objects** – none, but M81 and M82 are on the borderline, so I'm going to include them as targets.
- **NGC/IC objects** – there are ten on Norton maps 1 and 2 – must cross-check these with Rob's list. There is also some cross-checking to do on the Norton double stars and variables.

Observations, other than naked-eye tonight, were with my new, lightweight 15×70 super-duper binoculars. This project is costing me a fortune. The binocs bring out Neptune, M13, µ Cep (found [?] after a lot of effort with the BAAVSS charts) and RZ Cas very well.

iii) *17 September*: High, thin cloud and naked-eye limit about 2.5. Struggling. Not much joy.

iv) *25 September*: A public viewing night at the Planetarium. Looking at all sorts of things, not just in the North. RZ Cas bright, µ Cep bright (I think I'm finding it now), M92 and M13, Neptune and Kemble's Cascade in binocs.

v) *4 October*: Setting up new Celestron 8" Schmidt–Cass on the post in the back garden. Trying out the 'Eclipse' GoToStar equipment for accuracy. Everything within 0.5°, but I've yet to set up the backlash settings as advised by Mike Gregory (*right*), my mentor with this gear. Reminder from tonight's experience; always check the time, date and location settings (don't ask!).

vi) *8 October*: A good night, with naked-eye visibility of about magnitude 4.5. C8 set up with three-star alignment. Having a go at some of the double stars from the North Pole lists – κ Cep, ∑2675 found OK but not resolved with 25mm eyepiece; 40/41 Dra, ∑ 2308 found and easily separated (200 arc secs); O∑28/14 Cep found but not confidently; 75 Dra doubtful, should have been able to resolve. Other objects were IC 1454 in Cep found as a fuzzy blob; RZ Cas (eclipsing binary) in eclipse and hard to see (checked later and confirmed that the time was right for an eclipse on this star). The Moon in the C8 is just great! A new pollution hazard then appeared, as a neighbour started up his illegal coal fire and blotted out the sky!

vii) *11 October*: Up at 0530 to see the line of four planets – Mars (high up), Venus, Saturn and Mercury. Only one planet to find now (Uranus is easy, they tell me). Planets twinkling like mad were very puzzling at first because my understanding was that planets do not twinkle, since the images are finite in size and bigger than the atmospheric disturbances. Conclusion – the air was very disturbed over industrial Teesside.

1922 hours. Generally having a good time instead of getting down to work on the North Pole Objects. M13 resolved into stars by 9mm eyepiece – wonderful sight and an ambition for a long time! Albireo just sensational. M57 seen as a clear ring in 9mm. Naked-eye visibility about magnitude 4.5 tonight.

The new Celestron 8" telescope is a mixed blessing. Wonderful views are in prospect and there's the chance to set up in imaging competition with Keith and Jürgen (fat chance!). I probably need to spend lots of money on web cameras and filters and stuff, as well as more eyepieces. There are an awful lot of things to do in the North Pole area, which will keep me occupied for ages. There are rumours that others are finding yet more interesting objects to chase.

My back garden is an observer's nightmare, which I will describe in detail one day, but this project has got me out there again and making the best of it. Where will it all end?

REPORT 2 — *Rob Peeling, 18 Oct 2009*

[*This is Part 1 of a comprehensive report by Rob on NPE observations from the past couple of years. Attempting the objects yourself with a telescope would make a worthwhile and varied NPE project over the next few months. More in later issues of* Transit*. – Ed*.]

Collinder (Cr) 463 – **an open cluster** in northern Cassiopeia at >70° declination.

- 23:05 UT 29 September 2007, from Eaglescliffe with 12" f/5 Newtonian. Easily found in triangle bounded by 42, 48 and 50 Cas. Cr 463 is large and obvious using 50mm lens.

An old observation from long before IYA, but is this a binocular object? This description suggests it just might be.

- 20:37 UT 17 September 2009, from Eaglescliffe with 150mm f/5 Newtonian, 12" f/5 Dobsonian, 8×40 binoculars. From γ Cep, work east to find a wide pair 21, 23 Cep which points straight to a wide triangle formed by 40, 48 & 50 Cep with the cluster in the centre. Clearly seen with 32mm, and CLS [*light pollution*] filter shows it to be richer than the light pollution makes easily apparent. With present observing conditions I can't spot much in the location of Cr 463 with 8×40 bins; a couple of the brighter stars can be seen in the 8×50 finder but not really a detection of the cluster. Cr 463 can be seen using a 25mm lens in the 150mm scope.

- 20:37 UT 26 September 2009, from Eaglescliffe with 12" f/5 Dobsonian, 15×70 ½-binocular. With 32mm it is a large, lovely, rich cluster. Marginally visible with the ½-bin.

NGC 188 – **an open cluster** in Cepheus near Polaris.

- 21:47 UT 30 September 2007, from Eaglescliffe with 12" f/5 Newtonian. Apart from the high northern declination it is visually not special. It appears slightly cloudy with a 15mm lens, so perhaps is richer than it seems if viewed under a darker sky.

Another old observation. With greater experience I now realise that the cloudiness is the cluster.

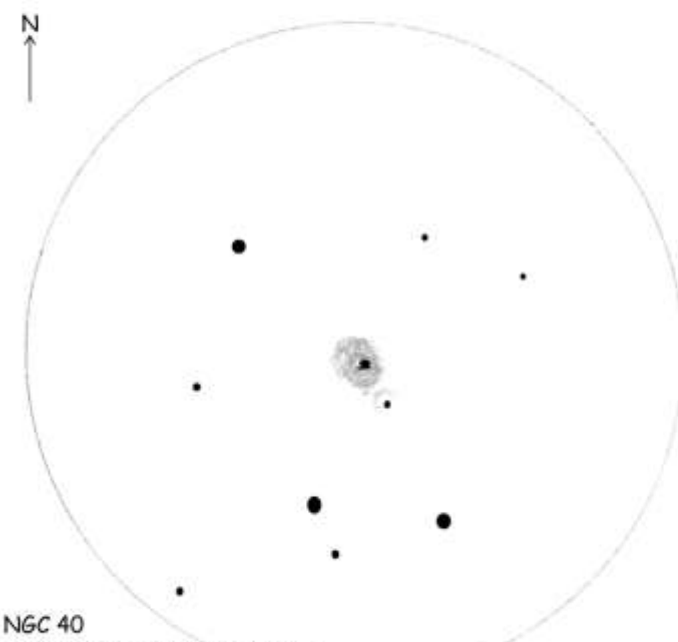
- 30 July 2009, from Eaglescliffe with 12" f/5 Newtonian. Polaris was seen with 15mm lens first quite close to a double star – headlight pair (not quite in same FOV – identified as 0Σ482). The CLS filter helps the contrast a little. NGC 188 is an averted-vision object with 32mm lens. What you see in the 15mm lens is a fairly large milky or nebulous field filling maybe half the FOV with a few stars scattered through it. Nothing very bright. The main impression is of a thin, skinny nebula over quite a wide extent. Easier to see this nebulous effect without the CLS filter.

Checking 16/09/09: double is NOT 0Σ482 because the two stars are not well matched in brightness. Perhaps someone can identify whether there is a catalogued double actually fitting this description. I think I meant the finder's field of view here.

- 23:45 UT 15 August 2009, from Eaglescliffe with 12" f/5 Newtonian. Found without any difficulty with 32mm lens. 15mm gives a better view.
- 21:20 UT 24 August 2009, from Eaglescliffe with 12" f/5 Newtonian. Found with 32mm lens. Possibly just on the edge of visibility in the 50mm finder, but I might be kidding myself and really detecting one of the nearby stars. Faint, ghostly stars clearly seen with 15mm lens.
- 28 August 2009, from Wynyard Planetarium with 12" f/5 Newtonian. With 15mm and 32mm. Considerably more stars visible in the darker sky at the planetarium than at home. The cluster seems to have two levels of stars, with sparse brighter ones and many more cluster stars several mags fainter, making it almost a milky object. Thought: are the bright stars the giants and the rest the main sequence in this old cluster?
- 17 September 2009, from Eaglescliffe with 12" f/5 Newtonian. The double reported on 30 July was indeed in the same finder field as suspected. However, it's not actually such a good double. It's a wide optical pair and not particularly well matched.

NGC 40 – **a planetary nebula** in Cepheus.

- 21:17 UT 1 October 2007, from Eaglescliffe with 12" f/5 Newtonian. Switched to this after a fruitless search for another planetary nebula, NGC 7139 near to VV Cephei. Working down from γ Cep this was easily spotted in the 50mm lens and takes 15mm and 10mm well, clearly showing nebulosity around the brighter central star. Nicely framed by two ordinary stars to either side. View is not much improved by using an OIII filter, although the central star faded out with this. This result is perhaps to be expected for a low-excitation planetary nebula, since the central star is cooler and therefore emitting less UV light than most central stars in planetary nebulae.



NGC 40
26 September 2009 23:37 UT
12" f/5 Dobsonian 15mm Moonfish lens with 2X ED Barlow

An old observation from when I was chasing Herschel 400 objects. This is number 1 in that list.

- 21:38 UT 24 August 2009, from Eaglescliffe with 12” f/5 Newtonian. Found by starting from γ Cep, then κ Cep and star hopping from there. Found with 15mm lens. Added the 2× Barlow to obtain the following description. Bright central star of probably mag 12, I think surrounded by nebulosity that is brighter in the centre and gradually fades outwards. A nearby star also appears to be involved in nebulosity. Returning to 15mm leads to no further observations. SkyMap Pro gives mag 11.5 for the central star.
- 28 August 2009, from Wynyard Planetarium with 12” f/5 Newtonian. Found eventually using *Uranometria* in 15mm lens. Shown to the others at the planetarium site.
- 23:37 UT 26 September 2009, from Eaglescliffe with 12” f/5 Newtonian. Found with 32mm, confirmed with 15mm and sketched with Barlow and 15mm (*see previous page*).

NGC 6217 – **a galaxy** in Ursa Minor.

- 16 November 2007, from Wynyard Planetarium with 12” f/5 Newtonian. Very faint. Asked Dave Blenkinsop to confirm detection, which he did. No one else could see it!

Not far from η and 19 Ursae Minoris. There is a ‘face’ asterism close by that marks the area well. I think it’s very difficult to see. No chance at all from anywhere with light pollution like in my garden in Eaglescliffe. This is another old record from when I was chasing Herschel 400 objects. How did William Herschel spot this one!?

Polaris, α Ursae Minoris, Σ93 – **a double star** with a 9^{th}-mag companion.

- 21:12 UT 24 August 2009, from Eaglescliffe with 12” f/5 Newtonian. With 15mm and 2× Barlow. Seeing is moderate or else my telescope is poorly collimated. I see a colour difference between Polaris (yellowish) and the companion (bluish).
- 4 October 2009, from Eaglescliffe with 150mm f/5 Newtonian. Observed with Celestron Microguide lens and 2× Barlow to measure separation: A–B = 20.6". Washington Double Star catalogue gives the separation as 18.4".

NGC 6503 – **a nice edge-on galaxy** in Draco.

- 20:28 UT 11 October 2009, from Eaglescliffe with 12” f/5 Newtonian. Initially seen with 32mm and then 15mm. Washed out/poor contrast with 15mm and Barlow. 15mm with CLS filter was effective.

S Cephei – **a carbon star.**

- 23:29 UT 15 August 2009, from Eaglescliffe with 12” f/5 Newtonian. S Cephei located using 32mm lens – possibly glimpsed in the finder – not confirmed, but certainly something in the finder with averted vision that seems to correspond to S Cephei in the 12". Long time since I last looked at this star, so I needed to check the star field in Sky Atlas 2000 first, but then it was easy to find. Sketched S Cephei and the brighter stars nearby using 15mm + 2× view.
- 28 August 2009, from Wynyard Planetarium with 12” f/5 Newtonian. 32mm and 15mm lens. Clear and deep red colour but faint – close to minimum?
- 25 September 2009, from Wynyard Planetarium with 12” f/5 Newtonian. Very faint and difficult to find. Only seen with 32mm.
- 23:24 UT 26 September 2009, from Eaglescliffe with 12” f/5 Newtonian. Found quite quickly in the 32mm lens, and this time I could find it with the 15mm lens. Colour is as vivid as ever, but faint.

A beginner's guide to imaging solar system objects

Keith Johnson

Part three: Capture settings

This month's edition focuses on camera settings

The best laid plans…

To enable me to set out this part of the tutorial correctly it was important to take screen images of the camera settings when I was actually imaging with the telescope – and guess what? The seeing was terrible! However, this illustrates a point that I put across at the very beginning of these tutorials and will repeat once more.

No matter how good the focus, collimation and camera settings, if the seeing is poor then I'm afraid you're going to achieve poor results.

So, how do you set up the camera settings? Well, it's a bit of a chicken-and-egg thing; to achieve the correct settings, you must have the telescope in focus, but how do you get the camera image into focus if the camera settings aren't correct?

My answer to this would be to practise in the daytime on a distant building: adjusting the focus, then adjusting the shutter speed, then the focus again and so on. Gradually you'll get a sharp image of the building on the camera. Practising as often as possible is the key here! Once you're confident about using the telescope and camera plus settings together, it's time to move on to imaging the planets and the Moon.

The very first thing you should do before you attach your camera to the telescope for any imaging session is to align your finder scope so that the object being imaged is centred in the finder scope cross-hairs as accurately as possible when the object is centred in the eyepiece. Start off with an eyepiece that gives a nice wide field of view and adjust the finder accordingly, gradually increasing the magnification until you have the finder set as accurately as possible.

A few tips

To help me seek out the planet whose image I'm about to capture, I always set my camera to be over-exposed. By doing this, even if I haven't yet managed to get the planet on the CCD I may instead be able to see one or two of its moons and so will know that I'm somewhere near.

To assist me in achieving good focus, at this stage I always set the capture rate to 30 frames per second. This fast frame-rate allows me to get an instant update on the screen after any adjustment I make with the focusing knob.

I always advise anyone starting out on webcam imaging to begin by imaging the Moon. First of all, it's big – in fact it's very big – so you will find it much easier than trying to place a planet on the CCD chip.

It's also very bright, so you will probably see the Moon on the chip, albeit out of focus and with incorrect camera settings.

As the ToUcam Pro web camera is the most popular one for planetary imaging, I'm going to assume its use in the rest of this part of the tutorial. The screen shots of the camera driver software may well be familiar to you; but if you're using the camera for the first time, just simply go with the settings shown. They may not be exactly appropriate but they will hopefully help to get you somewhere near what you're after.

In this tutorial I'm using the AVI–IO capture software (www.avi-io.com). All capture programs differ in appearance and some allow the user to do more than others, but the camera screen pages will be the same. I used Jupiter for my capture session, and thus the settings here are different from what they would be if I were capturing the Moon.

Capture settings

Select "Video settings" then "Capture settings" (Figure 1).

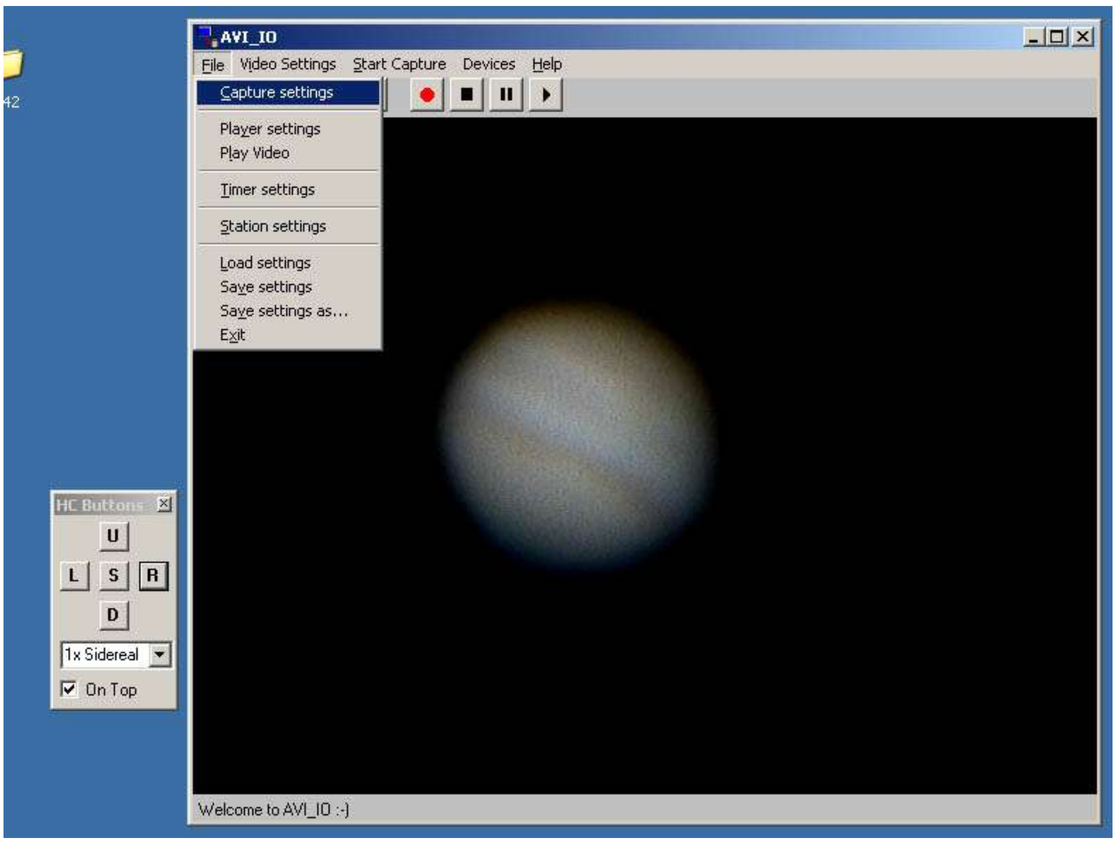


Figure 1. Selecting capture settings

Connect the camera to the computer and start up your favoured capture software. The software should detect the camera automatically; if it does not, select the "Capture Source" tab and then the video device – in our case, the Philips ToUcam Pro Camera (Figure 2).

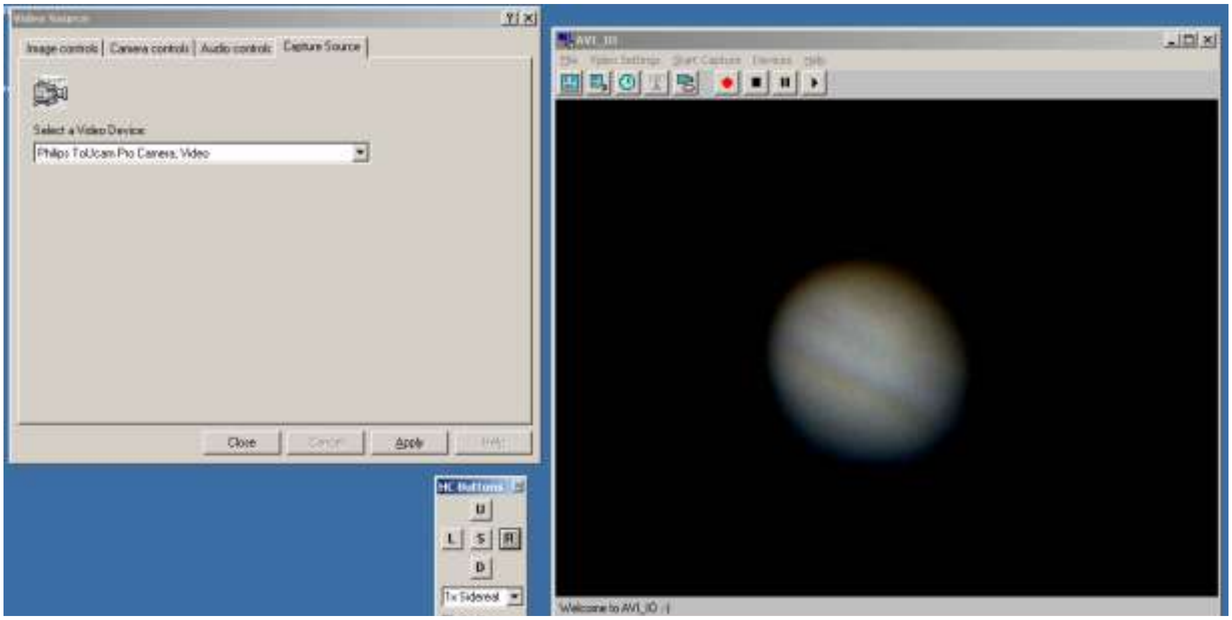


Figure 2. Selecting the camera

Click on Apply and then Close. Now select the “Video format” tab to display the Stream Settings. Specify 640 × 480 (Figure 3).

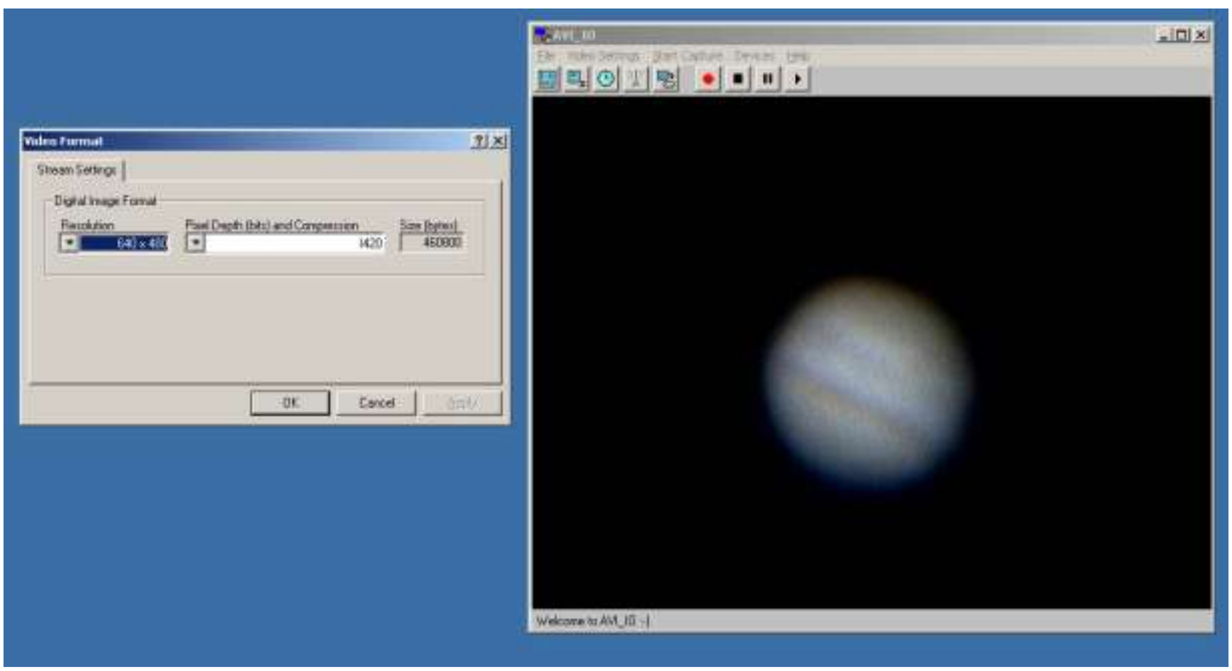


Figure 3. Selecting the image format

Click on OK. Next, select the “Video Compression” tab and choose “Full Frames (Uncompressed)” (Figure 4). This will enable you to capture more data, resulting in a better final image. Click on OK.

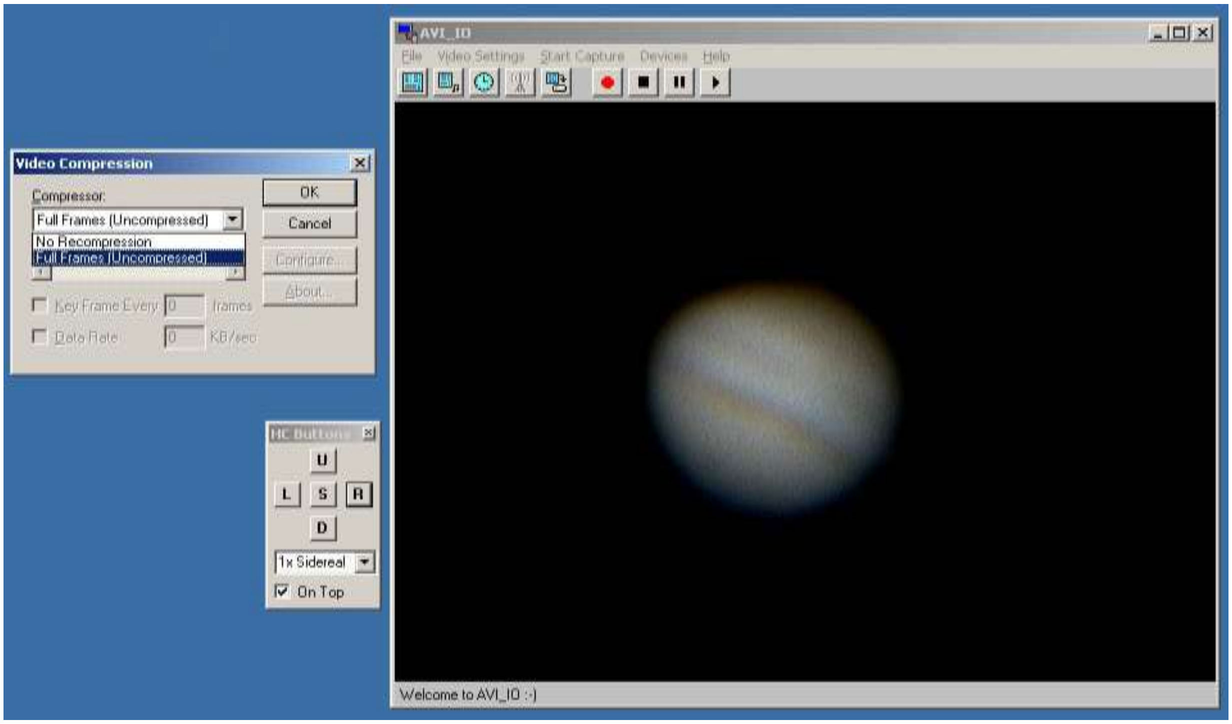


Figure 4. Ensuring that data is uncompressed

You may notice that within most of the screen shots there is a small box titled "HC Buttons". This is not part of the image capture settings but is in fact the SkyMap Pro telescope control box that I use at the computer to control the movement of my telescope (www.skymap.com).

You can adjust the following **image control settings** (Figure 5):

Frame rate: Any higher than 10 frames per second will cause the downloaded data to be compressed, resulting in less information within each frame of the AVI and thus a poorer-quality image.

Brightness: I always have the slider control no further to the right than in the middle position.

Gamma: Using this function will result in a washed-out image. Leave the slider to the far left.

Saturation: This can be increased when you process the image at a later stage, so I always leave this slider slightly below halfway.

Leave any Auto functions disabled (unticked). As a consequence, the Contrast function is not available, but that does not interfere with our capturing process.

Leave the Black and white box unticked unless you wish to capture in black and white mode.

The Mirror Image box may or may not be ticked, according to your fancy.

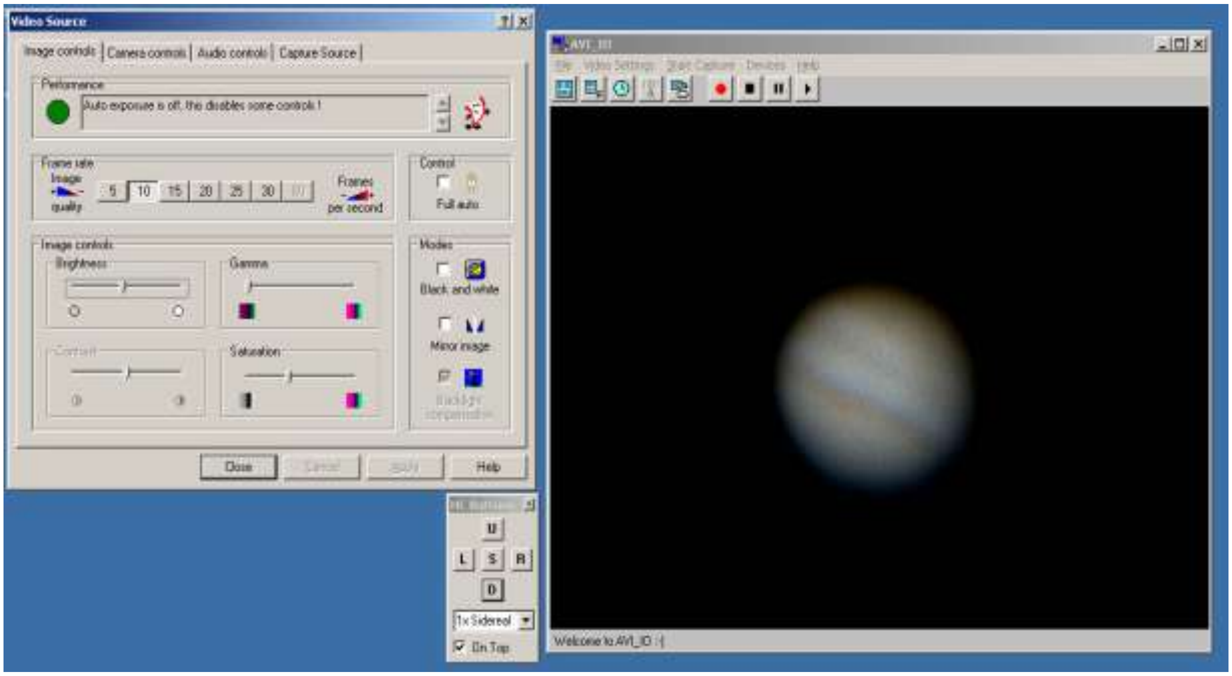


Figure 5. Setting image controls

You can adjust the following **camera controls** (Figure 6):

Shutter speed: No matter what object you are about to image, it is important that no part of it is over-exposed; so we first alter the Shutter speed slider control to give a slight visible over-exposure as seen on the computer screen…

Gain: … then use the gain slider to remove the over-exposure.

Leave the Auto exposure box unticked.

White balance: Finally, we need to set the correct white balance. How to do this is not obvious! Leave the Indoor, FL, and Outdoor boxes unticked, but instead click in (tick) the “Auto” white balance box. After about 30–45 seconds, the white balance will have had time to re-adjust; then click in the Auto box once more to disable the automatic white balance function.

Remember – These settings are only a guide. Depending on the object you’re imaging and the telescope you’re using, most settings will have to be altered slightly. Experiment!

Good luck, and I hope to see your efforts published in* Transit*!

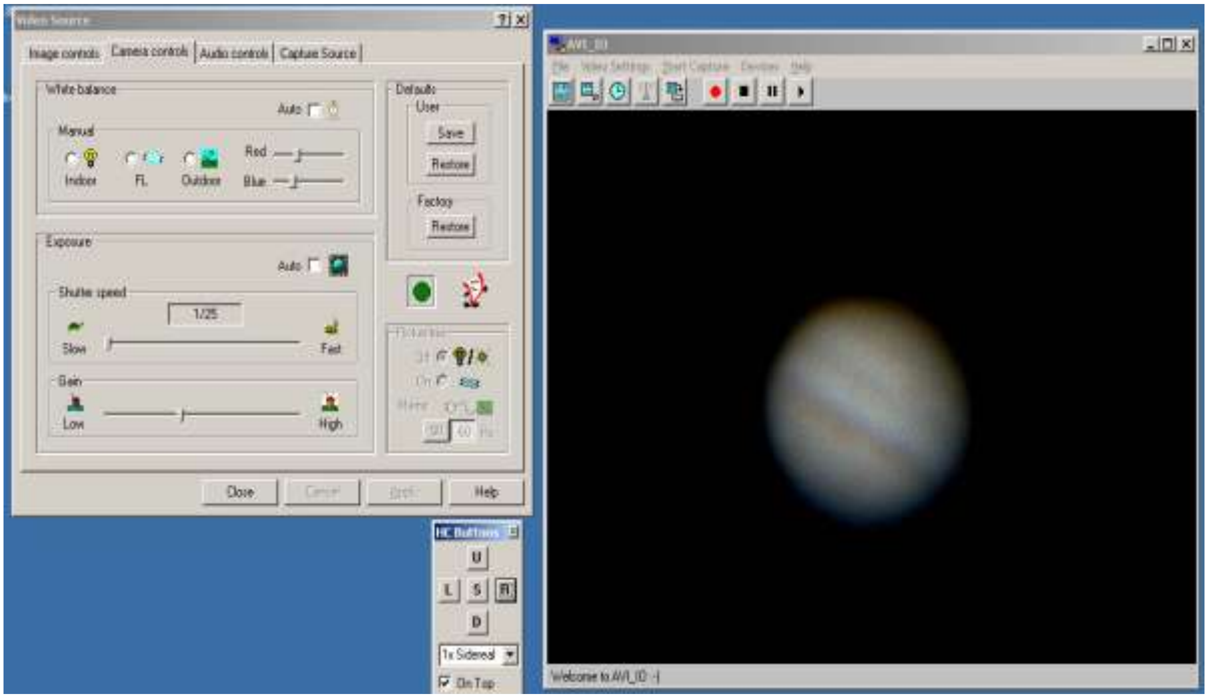


Figure 6. Adjusting camera controls

Next month's tutorial

Processing your AVI using (free) Registax software.

GENERAL ARTICLES

The Lupus Project: Looking for transiting Hot Jupiter planets

Dave Weldrake

Part 2: Data reduction and analysis

Last month, I described the typical process of preparing and carrying out the observations for a large-scale search for transiting planets, using the 40-inch telescope at Siding Spring. This month, I'll describe the next stage of the process: what kind of initial image-reduction analysis has to be performed on the data, why we should do this and the resulting image quality. I'll then describe how we produced the brightness measurements we needed. Next month, I'll describe how we performed a search through the data for the signals of transiting planets and variable stars and exactly what we found in our 0.66 square-degree patch of sky.

Data reduction

Firstly, the raw data taken at the telescope (about a thousand images of the same field of view) have to be corrected for the inaccuracies inherent in the telescope's CCD. Performed in several key steps, this is called **image reduction**. We first need to **trim and overscan-correct** the images, which essentially means that we chop off those small parts of the edges of each frame that were added by the CCD software and which contain specific information about the performance of the camera, yet are not needed when we move on to analyse the frames. Next we need to **flatfield** our data, typically automatically with software called 'ccdproc' within a suite of programs called 'IRAF'.

Flatfield images are images of the twilight sky, which we take just after sunset and just before sunrise each night, preferably with the sky clear. The result is an accurate map of the brightness variations inherent in the CCD itself, which inevitably also project onto the data images. These brightness variations have to be removed before analysis can begin. We choose the best flatfield images and combine them all to make a **master flat** (one for every couple of days of the observing run, as the brightness variations slowly change with time). We need to do this for each filter with which we observe, as each has a unique pattern of variations – similar to how each window in a house has unique optical properties. For the Lupus project, we used only one filter (V+R), which simplified the image-reduction process considerably. Once we have the final master flat, we subtract it from each data image.

As the aim of the project is to gather ultra-precise brightness measurements of all the stars we observed, further image reduction is needed, which ordinarily would not make enough difference to the result to be warranted. The next stage is therefore to produce a **dark frame**, which is an image revealing the tiny light leakage of the CCD camera onto each image, caused by the presence of so-called 'guide cameras' and other secondary instruments. The light can affect the results of our brightness measurements, so should be removed in order to get optimal data. We take several images at the telescope with the same exposure time as for the data images, but with the CCD shutter closed. This allows us to measure the light leakage or **dark current** of the camera. We then combine the images into one master dark frame, and subtract that from the data images as we did for the flatfields.

After all this is done, we perform some tests to see if the reduction process was successful, and then carry on with the main parts of the image analysis, uncovering our project results.

Data analysis

Making **light curves** is a very involved process. Now that we have our thousands of reduced images, we can start actually producing the brightness measurements of all the stars visible on the images, collectively called **photometry**. If we plot the brightness of each star against the time at which the measurement was taken, we've made ourselves a light curve.

We can choose from three ways of doing this: aperture photometry, profile photometry and image subtraction photometry. Each has its own pros and cons, but only one can produce photometry of sufficient quality to find planets – image subtraction. This is also the hardest to do, and this stage constituted the longest time to produce, deserving a whole section of this report to describe it.

Aperture photometry is the simplest method. We place a circular aperture of known radius over a star, and measure the amount of light contained within it, after subtracting the brightness of the background sky. This can be converted from a raw flux to a magnitude unit. As the simplest method, it is also the most inaccurate. Although perfectly fine for measuring the differences in the brightness of various stars in the image (for example in making rudimentary colour–magnitude diagrams), it is not suitable for precise measurements.

Profile (or PSF) photometry is one step up from aperture photometry. We first model the shape of the star (its so-called **point spread function**) and then use that model to calculate its brightness (after subtracting the background sky brightness). This method is much more accurate than simple aperture photometry, as we now take into account the observing conditions, but it still cannot produce consistently accurate measurements when processing data taken over many different nights with differing observing conditions. To find a planet, we need our photometry to be as stable as possible.

The method of choice here is called **image subtraction photometry**. It's relatively new (because high-end computers are needed to get it to work quickly enough to be usable) and highly complex, but it's a very precise way to measure the brightness of the stars in our images. Trying to tell the computer to perform subtraction photometry took up a great deal of my time as a thesis student. It made a thick chapter. The method is also very interesting, so I'll go into it here in a bit more detail.

The first step in the method is to produce a very accurate map of the star positions in the field of view, taken from a master image (usually the one with the highest quality). A program then goes through all the images in the dataset, finding the same stars in each image, and shifting the images slightly in translation and rotation until all the stars **overlay** each other exactly throughout the dataset (typically to an accuracy of $1/10^{th}$ of a pixel). This guarantees that each star is in exactly the same position on all the images.

We then make a very high-quality image of the field by **stacking** and combining dozens of the best-quality individual images; we call this image the **template**. The profile of each individual star in the template image is then measured and recorded (for more than 110,000 stars, this takes a little while). Each individual dataset image (reduced, as described earlier in this article) is then compared to the template image, and the profile of each star on each image changed so it matches that which we measured on the template. This sounds complex, and it is. It took a long time to get this to work properly, but the net result is that we essentially remove the effects of the varying observing conditions, by producing a dataset that does not change unless there is an inherent change in the star itself. It's equivalent to taking our measurements from above the Earth's atmosphere. By performing these complex processes on the data, we can in effect make a dataset as good as if it had been taken by the Hubble Space Telescope.

The penultimate stage of this process is that we subtract each individual image from the template. As the stars now match between image and template, it follows that the subtracted frame should be totally flat and featureless. If any star has changed in brightness from what it was on the template, then it will be immediately visible on the subtracted frame as a conspicuous bright or dark spot.

The final part of this process is to make the actual light curves that we will analyse to look for our planets. Each image has a time associated with it, accurate to a second, which corresponds to the time when the image was taken at the telescope. We convert all these times into a **heliocentric Julian date**, that is, the corresponding time as if measured at the centre of the Sun. This might sound a bit crazy, but it's very important to place the timings of our images on a common reference system. The speed of light is fast, but not infinitely fast, and the position of the Earth in its orbit with respect to the direction we are observing can introduce timing errors that can make time measurements less accurate. By converting the times so that they are as if we were at the centre of the Sun, we remove this effect.

As we know the positions of the stars in our images very accurately, we can use good old aperture photometry to derive the brightness measurements on our subtracted frames at those positions. Aperture photometry can now give us excellent results when applied to the subtracted frames. As the subtracted frames have an average of zero, we measure a **difference flux**, which we then convert to magnitudes using standard equations. For each flux (brightness) measurement, we have its associated time. By plotting both on one graph for each star, we can see how the brightness has changed over the course of a month. We've finally made our light curves, and the analysis can begin in earnest.

Light curves

Before we actually look at the light curves, we need to do one more thing: we need to measure their accuracy. If a planetary transit is 1% deep, then clearly we need to at least reach this level of accuracy to be able to see it. If the newly made light curves are not accurate enough, we must tweak our computer programs and repeat the whole process described above until they are.

We can determine via online catalogues the actual measured brightness of our stars. Typically in Lupus our brightest stars were magnitude 15, going down to 22.5 or so. As we go fainter, the quality of our data decreases. How faint can we go before we cannot detect a planet? By measuring the standard deviation of the light curves and plotting that as a function of magnitude, we can determine how accurate our light curves are and to what magnitude limit they reach. For Lupus, we found that we could detect a 1% transiting planet (corresponding to a ~Jupiter-sized planet) down to a magnitude of 18 or so. This gives us tens of thousands of stars to search and huge discovery potential.

For planets, we can search only those stars for which we have sufficient quality in our data, but we can search all of them for variable stars. No one had ever looked in this part of the sky for either before.

Next month

I'll describe how we performed our search, and what we found in our Lupus field.

'SHJ' – the start of a chain of discoveries …

Rob Peeling

In October's *Transit* Rod Cuff told us of his observation of the double star **SHJ 136** (SAO 1991) and commented that I'd used 'SH 136' as its label in the list of doubles for the North Pole Expedition.

First things first. This pair is a really wide one, with a separation of 71", and has a nice contrast between the brighter yellow star and the fainter blue, rather like Albireo. SHJ 136 is easily found by first finding the double 32 Camelopardalis from Polaris and then moving to SHJ 136.

Using the parallax (distance of) the yellow star and proper motions of both stars from the Hipparcos mission (http://archive.ast.cam.ac.uk/hipp/hipparcos.html) plus some other data on spectral types, I think I can show that this pair is an optical double rather than a true binary. If my calculations are correct, then the blue star B is much closer to the Sun than the yellow A.

Back to Rod's comment. The SH 136 designation I used is non-standard and came from the *Cambridge Double Star Atlas* from which I compiled the list of target doubles. The correct discoverer's designation as used in the Washington Double Star (WDS – see http://ad.usno.navy.mil/wds) catalogue is SHJ 136 (the formal designation in the WDS is **WDS 12110+8143,** which is actually the star's J2000 coordinates).

So who or what was SHJ? **John Herschel's** first major task in astronomy was the re-observation of the double stars catalogued by his father. John collaborated with James South, who was able to afford the refined instruments best suited for this work. The catalogue that they compiled in 1821–23 and published in the *Philosophical Transactions* in 1824 earned them the Gold Medal of the Royal Astronomical Society and the Lalande Prize in 1825 from the Paris Academy of Sciences. This work was their only joint undertaking (source: Encyclopaedia Britannica on-line at http://www.britannica.com). Both men later became knights. The code SHJ in the WDS refers to this 1824 catalogue, which contains 380 double stars.

Presumably the actual discoverer of this pair of stars was **Sir William Herschel**. It is also interesting to note that the WDS does **not** include the Herschel/South measurements in its records, because the first 'satisfactory' observation is dated 1876. The work of the two Herschels and South is evidently not considered satisfactory!

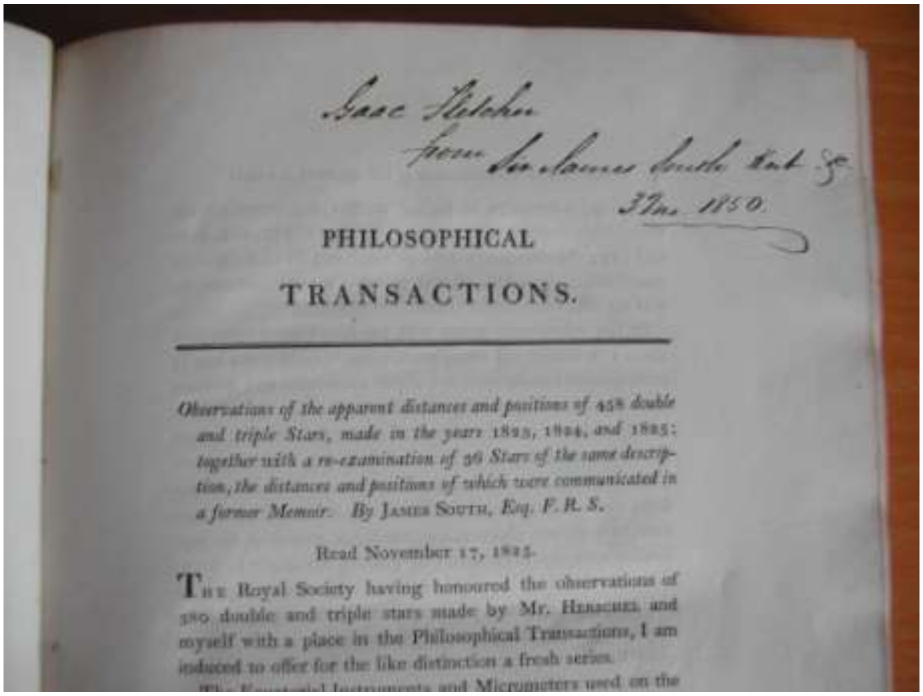
Sir James South (1785–1867) helped found the Astronomical Society of London, and it was under his name that a petition was successfully submitted to obtain a royal charter in 1831, whereupon it became the Royal Astronomical Society.

After his collaboration with Herschel, South then continued and observed another 458 double stars over the following year. He won the Copley Medal in 1826 and the Gold Medal of the Royal Astronomical Society in that same year and was knighted in 1831. Craters on Mars and the Moon are named in his honour.

South was involved in a notorious lawsuit brought against him by the instrument maker **Edward Troughton** over an equatorial-mount telescope that the latter had constructed for him, and which South considered defective. Troughton sued him for payment and won. South promptly demolished the telescope (and auctioned off the pieces); the lens, which had been purchased separately, was preserved and was presented to the Dublin Observatory in 1862. (source: http://en.wikipedia.org/wiki/James_South).

At this point in my research, Barry Hetherington (*right*) produced an original copy of South's work on the additional 458 double stars and presented in *Philosophical Transactions* in 1826. The copy of South's work that Barry gave me is dedicated to Isaac Fletcher (*see the next page*).

A little bit of searching on Google found **Isaac Fletcher** (1827–79), MP for Cockermouth. Sir James South was also an MP, so the two men probably met each other at the House of Commons. A bit more digging confirmed that this Isaac Fletcher is our man, because he was involved with double-star observations and had his own observatory at his house at Tarn Bank in the Lake District. In fact I found a photo of the outside of the observatory taken as recently as 1997. Whether any astronomical equipment remains, I don't know. He was a Quaker and seems to have been part



PHILOSOPHICAL

TRANSACTIONS.

Observations of the apparent distances and positions of 458 double and triple Stars, made in the years 1823, 1824, and 1825; together with a re-examination of 36 Stars of the same description, the distances and positions of which were communicated in a former Memoir. By James South, *Esq. F. R. S.*

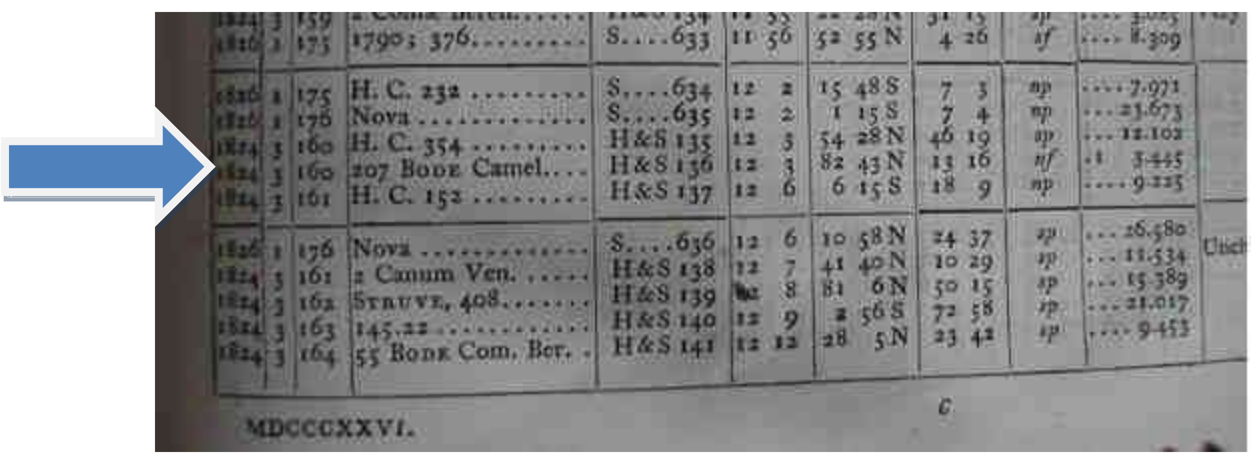
Read November 17, 1825.

The Royal Society having honoured the observations of 380 double and triple stars made by Mr. Herschel and myself with a place in the Philosophical Transactions, I am induced to offer for the like distinction a fresh series.

of a family circle of people interested in natural philosophy or science in the Cockermouth area at that time.

Given James South's bizarre behaviour over his telescope, it is perhaps a little disturbing to find that Isaac Fletcher committed suicide by shooting himself in the head at a hotel on Trafalgar Square. The *New York Times* commented that it caused 'some excitement' amongst MPs at the time.

At the back of South's *Double Stars 1826* is an appendix listing all 838 of the double stars covered by Herschel and South in 1824 and South alone in 1826. SHJ 136 appears in this appendix as 'H&S 136' (see below for the page in the 1824 paper). It gives the position angle in an unfamiliar form: 13^{o}16' *north following* and the separation as 1' 3.445", i.e. 63.445".



1826	1	175	1790; 376.	S....633	11 56	52 55 N	4 26	sf	....8.309
1826	1	175	H. C. 232	S....634	12 2	15 48 S	7 3	np	....7.971
1826	1	176	Nova	S....635	12 2	1 15 S	7 4	np	...23.673
1824	3	160	H. C. 354	H&S 135	12 3	54 28 N	46 19	sp	...12.102
1824	3	160	207 Bode Camel.	H&S 136	12 3	82 43 N	13 16	nf	.1 3.445
1824	3	161	H. C. 152	H&S 137	12 6	6 15 S	18 9	np	....9.225
1826	1	176	Nova	S....636	12 6	10 58 N	24 37	sp	...26.580
1824	3	161	2 Canum Ven.	H&S 138	12 7	41 40 N	10 29	sp	...11.534
1824	3	162	Struve, 408	H&S 139	12 8	81 6 N	50 15	sp	...15.389
1824	3	163	145.22	H&S 140	12 9	2 56 S	72 58	sp	...21.017
1824	3	164	55 Bode Com. Ber.	H&S 141	12 12	28 5 N	23 42	sp	....9.453

MDCCCXXVI. c

What interested me was the designation '207 BODE Camel.' given as the star's name. Camel is obviously Camelopardalis, in which SHJ 136 lies. I think this can only be a reference to

Johann Bode's star atlas *Uranographia* published in 1801, or more exactly to the star's entry in Bode's accompanying catalogue with the catchy title *Allgemeine Beschreibung und Nachweisung der Gestirne nebst Verzeichniss der geraden Aufsteigung und Abweichung von 17240 Sternen, Doppelsternen, Nebelflecken und Sternhaufen. Von J. E. Bode*. Given that this catalogued 17,240 stars, it was probably one of the most comprehensive references available in 1826. What seems arcane to us nearly 200 years later was probably crystal clear in its time.

COMMITTEE NEWS AND INFORMATION

Thomas Wright Trophy *and* Yorkshire Astromind

A CaDAS team (Rob Peeling, Alex Menarry and Rod Cuff) retained the Thomas Wright Trophy on 16 October, with the lead switching round by round with the Durham A.S. team, all of whom are also CaDAS members (Jürgen Schmoll and George & John Gargett). A team of Durham astronomy students came third, standing in creditably when York A.S. had to withdraw. Many thanks to them and also especially to Alex, who was arm-twisted into the CaDAS team only that afternoon, after Michael Roe had to withdraw through illness. Neil's questions were as tricky as ever, naturally.

From Neil Haggath

Despite a gallant effort, Rob failed to defend his Yorkshire Astromind title on 10 October. He finished in a highly creditable third place, in another very tightly fought contest, in which only five points separated the first three contestants.

Marcus Armitage, of Huddersfield A.S., won the title for the third time, pipping his rivals at the post with a truly remarkable performance on the speed round. Second was Gary Gawthrope of Mexborough and Swinton. Darren Swindells of Sheffield finished last, with a still respectable performance.

[*Rob added:* At Astromind I was sat next to a magnificent model of a Dalek. It was built to climb into and rumble about shouting, '*Exterminate!*'. Bradford A.S. denies responsibility for it.]

CaDAS insurance briefing

Ian Miles (Treasurer)

This short note is to clarify the insurance position of the Society.

Public liability insurance

The Society does not hold public liability insurance, as public observing is only undertaken as part of the official Planetarium programme of events and so is a Council-led event. It is therefore not worth the expenditure to hold our own insurance. As a result, a number of points are worth noting:

- Only people registered as volunteer wardens at the Council's

Wynyard Woodland Park are covered on the Council's public liability insurance when causing injuries by their negligence, and then only when undertaking duties on behalf of the Planetarium Director (whether he is present or not).

- With regard to the Wynyard Woodland Park site, anyone can make a claim against the Council – e.g. when visiting the park, using the Planetarium or visiting the observatory – if the Council is proven negligent.

- Because the Society does not hold public liability insurance, the Society does not hold its own organised observing activities, involving the public or its members.

- As a consequence of the above, should a member be using the observatory independently, i.e. not as part of an official Council Planetarium event, then they have no obligation to assist the public, as they are not insured to do so.

In summary, only registered Council volunteer wardens are insured to assist the public.

CaDAS asset insurance

The Society's assets are covered by the Council's insurance while they are in the Planetarium and for limited perils such as fire, lightning and storm. There is no cover for theft or accidental damage. Excess is set at £500 per incident.

There is no cover for the Society’s assets once they are outside the Planetarium.

THE *TRANSIT* QUIZ

Quiz questions for November

As a variant from the usual convolutions this month, here are some definitions from the glossary of a standard reference book. What terms are being defined?

Q1. Any star on the main sequence of the Hertzsprung–Russell diagram.

Q2. The centre of mass, or balance point, of a pair of bodies such as a double star or a moon and planet, around which the bodies orbit.

Q3. The dividing line between the illuminated and dark portions of a planet or satellite, particularly the Moon.

Q4. The occasion on which a star or planet first appears in the dawn sky, after having been too close to the Sun to be visible.

Q5. Two doughnut-shaped zones of atomic particles around the Earth.

Q6. In astronomy, either a difference between two values or a correction.

Q7. The period of 19 calendar years (6939.6 days) after which the Moon’s phases recur on the same day of the year.

Q8. The splitting of spectral lines into two or more parts by a magnetic field.

Q9. The dimming of starlight by dust in space or by the Earth’s atmosphere.

Q10. A band of young, brilliant stars at an angle of between 15° and 20° to the plane of our Galaxy, stretching around the sky from Perseus, Taurus and Orion, via Carina, to Centaurus and Scorpio. [It] is believed to be a spur on the local spiral arm of our Galaxy.

Answers in next month's issue

Answers to October's quiz

Q1. Where/what are Chara and Asterion? (*Hint: together they make up a constellation.)*

A1. Canes Venatici -- the Hunting Dogs, hunting companions of Boötes.

Q2. If Amalthea is V, what are I–IV?

A2. Amalthea is the fifth in the conventional listing of Jupiter's satellites, so I–IV are the Galilean moons -- respectively Io, Europa, Ganymede and Callisto. At the moment we also know of LVII others (all the varieties ...).

Q3. If Astraea is 5, what are 1–4?

A3. Astraea is the fifth in the international Astronomical Union's standard numbering for asteroids, so 1–4 are respectively Ceres, Pallas, Juno and Vesta.

Q4. (a) Which is the least dense solar system planet, the only one less dense than water?
(b) Which are the other two planets that are less dense than the Sun?
(c) Which is the densest planet?

A4. (a) Saturn (0.69). The Sun's average density is 1.41 (pure water is 1.0).
(b) Uranus (1.27) and Jupiter (1.33).
(c) Earth (5.52). Venus runs it close at 5.24. (Figures are from the BAA Handbook *for 2010, which got them from http://nssdc.gsfc.nasa.gov/planetary/factsheet/fact_notes.html)*

Q5. Which Messier object was described by Messier himself on discovery in 1773 as 'very faint nebula without stars', yet by his collaborator Pierre Méchain eight years later as 'double, each one with a brilliant centre, separated from each other 4' 35"'?

A5. M51, the Whirlpool Galaxy (pictured here).

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