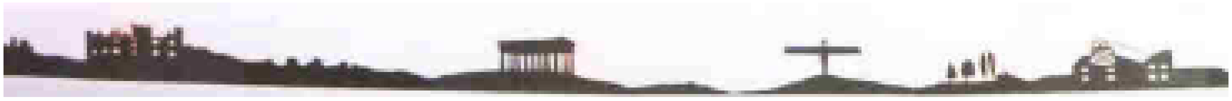

TRANSIT

The Newsletter of

Cleveland & Darlington Astronomical Society

14th February 2003. Julian Day 2452685

Editorial

February Edition Another bumper edition - 24 pages this month. You are keeping the contributions coming in, making my job very easy. I know that to send something each month requires quite an effort. Please keep them coming, and I hope you will bear with a delay in publishing – they will all be used in the fullness of time.

January 2003 meeting. Our Member's Night in the Planetarium was as entertaining as ever. Chris Newman gave us an account of his telescopes, astro-photography, his SETI work and how he built his observatory in the garden. As an icing on the cake, he also gave us a slide show of his three exciting Atlantic crossings – in very small boats**.** John McCue deployed the latest technical resources of the Planetarium to take us through a typical night's viewing at this time of the year. Neil Haggath rounded off with a combination of Monty Python's Galaxy Song and co-ordinated slides. Wonderful!

CaDAS Book of Astronomy President Jack Youdale proposed that, with all the talent in the Society, we should produce such a book, written by members. If you have any suggestions, please let us hear them. An article next month will develop the idea.

Mount Stromlo Disaster Many of you will already have read of the destruction of the Mount Stromlo Observatory by the Canberra bush fires. Dave Weldrake, who is working for his PhD there, has sent us a message and there is a press release from the Director.

Experiment I hope you approve of our trial of coloured pictures on front and back pages. If you don't, it was John McCue's idea. If you do, it was mine. The front is a satellite picture from the web of the line dividing night from day. The back page is just one of a number of stunning pictures taken by Keith Johnson with his TV camera. There will be more!

Next Meeting. 14th February, 2003 at Grindon Parish Hall, Thorpe Thewles. "Astro-photography" by Jurgen Schmoll of Durham University.

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A Message from Dave Weldrake at Mount Stromlo

Hi Everyone. As you have no doubt heard on the news, Canberra has been ravaged by the worst bushfires in a century. Stromlo has been destroyed, although the offices remain intact. Ours looks just like it did on Friday night.

We are all safe, we saved our house (we live in Duffy) by fighting the fires in the garden, the flames in the next street were 100ft high, that street has gone completely, and our garden is now totally black, and the house scorched but safe. We had 10 mins warning to grab our stuff and evacuate. We saw houses over the road explode with the gas lines, the sky was black, it was 40 degrees and ash was raining down. It was like the end of the world.

I went to Stromlo yesterday, all the domes are gone; the workshop and admin buildings are gutted out completely. We are now working on the main ANU campus, and I can be contacted via email as normal. If you could forward this mail around to the CaDAS people that would be great. We are all safe here, a little singed but OK.

Dave........

David T.F Weldrake
Research School of Astronomy & Astrophysics.
Mount Stromlo Observatory,
Cotter Road,
Weston Creek.
ACT 2611 AUSTRALIA.

Press release from The Australian National University
www.anu.edu.au/mac/media
Sunday, 19 January 2003

MOUNT STROMLO OBSERVATORY DESTROYED BY FIRE

The Australian National University expresses concern and sympathy to those who have lost so much in the Canberra fires. In particular, our thoughts are with the families of those that died in the fires. The Mount Stromlo Observatory has been largely destroyed by the bushfires which have ravaged Canberra. "We are thankful that no staff or students were injured in the Mount Stromlo fire", ANU Vice-Chancellor Professor Ian Chubb said today.

The Observatory, operated by the ANU Research School of Astronomy and Astrophysics, is one of Australia's leading centres of Astronomical research. The fires destroyed four telescopes, the equipment workshop, eight houses which had been occupied by staff and an administration building. Preliminary estimates have valued the losses at more than $20 million. Two office buildings and the visitor's centre were spared - importantly, preserving most of the computer data generated on site in recent years.

Professor Chubb emphasised that the work of the Research School would continue. "The loss of Mount Stromlo is a devastating blow to Australian research and in particular to the 60 staff and 20 students who made it their workplace. To those staff who also lost homes on Mount Stromlo, these fires have delivered a double blow. It is vital to emphasise that the work of the Research School of Astronomy and Astrophysics will continue, however. The University has adequate workshop and laboratory facilities to accommodate the valuable equipment contracts which are being fulfilled by the school - including the $6.3 million contract to build a sharp-eyed imager for the Gemini South Telescope in Chile".

"Other research projects have been undeniably set back by this loss, although we are still evaluating the full extent of the damage. Plans are already being put in place to rebuild at Mount Stromlo and restore the Research School to its full capacity. The fires have been a devastating blow to Canberra and the ANU is committed to helping rebuild the lives of those affected."

The Director of the Research School, Professor Penny Sackett, said, "Our losses are presently overwhelming and the scene of Mount Stromlo is one of devastation. However, we have retained our most valuable asset, our staff, 100 per cent intact and we are extremely grateful for their safety. We have also saved our computer database and many of us will be back at work tomorrow."

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Twinkle, twinkle, now we know just what you are

A cutting from the Times sent by John Crowther

It was a sign in the heavens – a strange star circling beyond Pluto.
Astronomers with a ground-based telescope spotted the small dot of light far away, then aimed the Hubble Telescope at it for a better view. The result was the largest heavenly body to be discovered in the Solar System since Pluto, 72 years ago. Not even a planet in fact but a lump of rock and ice in orbit four billion miles from Earth.
It was found by Michael Brown and Chadwick Trujillo of the California Institute of Technology in Pasadena, who presented their findings yesterday at the American Astronomical Society meeting in Alabama. Known simply as 2002 LM60, it has been nicknamed Quaoar ("kwa-whar") after the creation force of the Tongva tribe, the native inhabitants of the Los Angeles basin.
The object, whose 800-mile diameter is about half the size of Pluto, and about a tenth that of the Earth, is in a mysterious region known as the Kuiper belt, an icy layer of debris beyond Pluto, which holds many other large bodies too small to be planets. Quaoar does not reflect as much light as Pluto, so is much harder to see.
The discovery adds to controversy over whether Pluto is a true planet. Its status is disputed by many astronomers. "Quaoar" definitely hurts the case for Pluto being a planet" Dr Brown said. "If Pluto were discovered today, no one would even consider calling it a planet because it is clearly a Kuiper Belt object".
By Mark Henderson, Science Correspondent.

Record Binary Stars

Two stars in the constellation of Cancer dance round one another every 5.3 minutes. No other pair rotate so fast, the previous shortest orbit time observed being 9.5 minutes. They are white dwarfs, separated by less than 100,000 kilometres. The system is a good candidate for those trying to detect gravity waves.
Press release from Gavin Ramsay, Mullard Space Station, Dorking.

Email from Pat Duggan

Hello Alex, I was amazed to read *(Dec, 2002, Transit, piece by John Crowther – Ed)* that rainbows were called "dogs". Then I got to thinking that Sirius is the brightest star and always sparkles like a rainbow to look at, so I wonder if, in an ancient language, the word "rainbow" was pronounced "dog" and that was when Sirius, "the Dog Star" got it's name? Just a thought,
Regards, Pat Duggan.

Last month, Rod Cuff gave us some fascinating web sites to visit and learn more on this subject. I hope you visited them, Pat. Thanks for the email, Alex.
If anyone has discovered how these phenomena were named, please let me know.
Further comments welcome.

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A Busy Night Around Jupiter

From Neil Haggath

Observations of the Jovian triple transit, plus mutual satellite occultation, 2003 Jan 17-18.
Observing site: my home in Shelton Lock, Derby.
Telescope: 8-inch f/10 Schmidt-Cassegrain, using 165x and 220x magnification.

Now here's a novelty, folks… *me* sending an observation report!

First, a bit of background. We are currently experiencing a season of "mutual events" of Jupiter's Galilean satellites. Many of us are familiar with transits and shadow transits of the satellites, which can be observed whenever Jupiter is in your sky. Observing them is a popular project for amateur observers; I used to do so frequently, when I was young and keen. Every issue of *Sky and Telescope* includes a list of timings of these events for that month.

Usually, the orbital planes of the satellites are tilted a few degrees from our line of sight, so when they overtake each other in their orbits, they pass slightly above or below each other. But twice per Jupiter year – i.e. about once every six years – for a period of a few months, we see their orbital planes almost edge-on, so we can see the satellites occulting and eclipsing *each other*. A series of such events is happening now; a complete list of timings can be found on the *Sky and Telescope* web site, at
http://skyandtelescope.com/observing/objects/planets/article_771_1.asp

The night of 17-18 January was a very busy one for Jupiter observers; it included one mutual event, interspersed with a whole series of "conventional" transits and shadow transits, all within a few hours.

During the evening and the early hours of the morning, there occurred successive shadow transits and transits of Callisto, Io and Europa (the shadows preceded the satellites). In fact, for a period from 23h52m to 00h48m, all those three satellites, and the shadows of Io and Europa, were in transit simultaneously. The sequence lasted from 17h04m (ingress of Callisto's shadow) to 02h46m (egress of Europa). (All times UT.)

But the night's mutual event, which occurred between 00h51m and 01h05m, was a particularly rare and interesting one. Callisto partially occulted Io, with 62% coverage (in fact, Io passed behind Callisto, as it overtook it in its faster orbit), while they were both in transit across the face of Jupiter!

That night, I experienced a phenomenon which is depressingly rare in this country… the sky was actually clear, at the right time for a specific event! I spent a marathon session with my telescope, from about 20h15m to 03h00m, and observed the entire sequence of events, except for the start of Callisto's shadow transit, which occurred before Jupiter came into view. I was ready in time for the ingress of Callisto itself at 20h38m.

Because the orbital planes were edge-on, all the transits took place in front of Jupiter's light-coloured Equatorial Zone (EZ). (Sometimes, the satellites pass in front of the dark North or South Equatorial Belts (NEB or SEB)). I didn't bother trying to observe any detail on Jupiter itself; I was only concerned with the progress of the satellites and their shadows. But the SEB was noticeably broader and darker than the NEB.

All three satellite shadows were easily visible against the EZ, as inky black round spots. Of the satellites themselves, Callisto was easily visible while in transit (at 220x magnification), but Io and Europa were not. From past experience, I know that those two, which are bright and quite light in colour, are quite easy to see, if they happen to pass in front of the NEB or SEB, but difficult when in front of the EZ. For Callisto, which is dark brown in colour, the situation is reversed.

Had the seeing been better, Io and Europa might have been discernible while in transit, but it was only Antoniadi III, occasionally bordering on II. Throughout the times that they were fully in transit, I couldn't discern them against the EZ. But it was a different matter during the few minutes which each one took to ingress and egress; then they were easily visible as tiny whitish discs, against Jupiter's limb. When a satellite was halfway ingressed, its un-ingressed half stood out clearly, as a tiny, but distinct, semicircular "bump" on Jupiter's limb. (See Sketch 1.)

Io's shadow began to transit at 22h31m, followed by Io itself 23 minutes later. During the next two hours, its shadow could be seen noticeably gaining on Callisto. Europa's shadow, and Europa itself, followed at 23h05m and 23h52m respectively; Io's faster-moving shadow gradually drew noticeably further ahead of Europa's.

The non-visibility of Io meant that I didn't do very well with the mutual occultation! About half an hour earlier, Io's shadow caught up with and overtook Callisto, but didn't actually pass behind it; instead, it passed just to the south of it (see Sketch 2), appearing almost merged at the time of closest approach. The shadow egressed three minutes before Io itself caught up with Callisto.

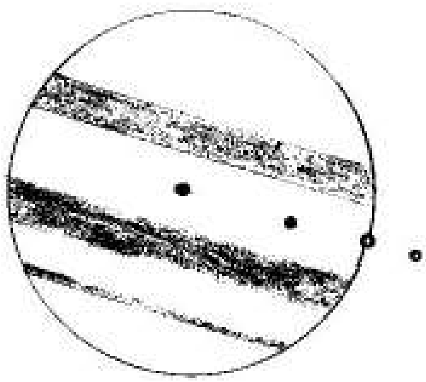
At the time of the occultation itself (00h51m-01h05m), Io was still not discernible, even though I knew *exactly* where it was, passing behind Callisto! So though I observed this rare event in progress, I can't strictly say that I *saw* it! (See Sketch 3.)

I continued observing as the satellites egressed from their transits. Io and Callisto, now in the reverse order, egressed soon after their mutual event, at 01h11m and 01h24m respectively. Europa, bringing up the rear, followed at 02h46m. I called it a night just before 03h00m, with the three satellites closely lined up on the opposite side of Jupiter from a few hours earlier. Ganymede, which was close to its greatest angular distance from the planet, had been somewhat neglected all night!

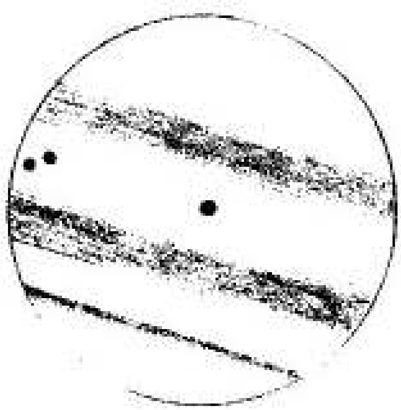
This has been the account of a lousy observer. I know that Jack and the Durham lads also observed the triple transit; I'm sure they, and probably a few others, produced observations far superior to mine!

N.B. In the following sketches, I have simply drawn the positions of Jupiter's belts, without attempting to show any detail in them. I was concerned only with the positions of the satellites and their shadows.

Sketch 1. 22h55m, 220x.
Callisto and Io's shadow in transit, Io just beginning transit, half-ingressed.
Left to right: Callisto, Io's shadow, Io, Europa.

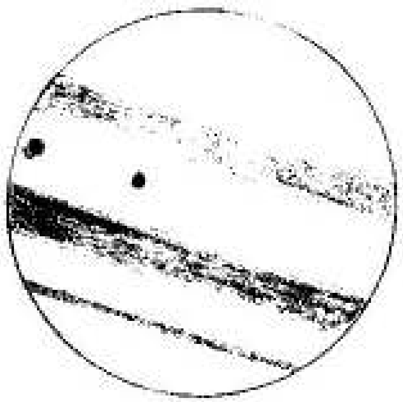


Sketch 2. 00h42m, 220x.
Callisto, Io, Europa and shadows of Io and Europa all in transit, but Io and Europa not discernible. Io's shadow has just overtaken Callisto.
Left to right: Io's shadow, Callisto, Europa's shadow.



Sketch 3. 00h59m, 220x.

Callisto, Io, Europa and Europa's shadow in transit, but Io and Europa not discernible. Io is being partially occulted by Callisto. Arc below Callisto indicates position of Io, but it could not actually be seen.
Left to right: Callisto (with Io behind it), Europa's shadow.



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Astronomy and the Internet

from Rod Cuff

A downbeat start this month: all the bad space/astronomy-related news in one section. But things look up after that, so read on …

If you have any particular areas that you'd like me to tackle for a future issue, please e-mail me (rod@wordandweb.co.uk).

Bad news

- I'm writing this the day after the Columbia disaster, when the unexpected costs of advancing astronomy through tools like the Hubble Space Telescope (HST) (http://hubblesite.org/) become very hard to come to terms with. The suspension, perhaps permanently, of the Shuttle programme is bound to affect the planned course of astronomical research, but it's too early to stand back from the human cost and see what the scientific effect may be. Today it seems a relief that the HST's planned successor to be launched in 2010, the James Webb Space Telescope (www.astronomy.com/Content/Dynamic/Articles/000/000/001/011emmvi.asp), won't require astronauts to deploy or service it.
- In a very bad month for rocketry and space exploration, another failure of the European Space Agency's Ariane rocket caused a complete temporary suspension of planned launches; so the Rosetta spacecraft will no longer go out to meet (and land a probe on) Comet Wirtanen (www.estec.esa.nl/spdwww/rosetta/html/main.html). However, the probe will be retargeted to investigate some other comet in the next few years (http://spaceflightnow.com/news/n0301/22rosetta/).
- Sigh … and there's the Mt Stromlo fire (http://msowww.anu.edu.au/) ….

- To complete the gloom (or, in some ways, its opposite), there's a fascinating Italian site (in English) that gives full data and many different kinds of maps showing how light pollution affects the visibility of stars at places around the world – www.lightpollution.it/dmsp

Thanks to telescopes in space …

- One of a Columbia crew's triumphs on a flight last year was to add to the HST a new super-instrument, the Advanced Camera for Surveys (ACS). Last month NASA released "an image nothing short of breathtaking – the best-ever view of a distant, massive galaxy cluster and what lies behind it" (http://skyandtelescope.com/news/current/article_838_1.asp). There's another astonishing set of images from the ACS – "the most spectacular light echoes ever seen" – at http://skyandtelescope.com/news/current/article_840_1.asp
- It turns out that the supermassive black hole at the centre of our galaxy produces X-ray flares almost daily (well, it did 26,000 years ago, when the radiation we see today started on its journey), and there are signs of tumultuous activity in the past. See http://spaceflightnow.com/news/n0301/07chandra/

Galactic images

- The NGC and IC Images Archive at www.ngcic.com/dss/dss_images.htm is planned to contain a complete set of images of all the deep-space objects listed in the New General Catalogue and Index Catalogue produced by the Royal Astronomical Society (www.ras.org.uk) roughly 100 years ago. Hundreds of images are there already.
- Moreover, from elsewhere on the site (www.ngcic.com/oblstgen.htm) you can generate a personalised list of NGC and IC objects to look for, in a constellation of your choice.

And finally …

- I'm told that Neil's slideshow to Monty Python's *Galaxy Song* was the highlight of the January meeting. Read/sing along with it all over again (without the slides, alas) at www.humorlinks.com/python/songs.html

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Astronomy Basics

by Neil Haggath

No. 9: Stellar Spectra and Spectral Classes

In the 1830's, the philosopher Auguste Comte made one of the most spectacular blunders in the history of science. He said that there were some things which would be forever beyond human knowledge, and cited as an example "the chemical composition of distant stars". In fact, it was to be a mere three decades before he was proved wrong; in 1863, William Huggins identified spectral lines in the spectra of Betelgeuse and Aldebaran, and consequently identified some of the elements of which those stars are made.

Huggins was a pioneer of what is now one of the most important tools in astrophysics – spectroscopy. Today, we can obtain a huge amount of information from a star's spectrum

– its mass, temperature, chemical composition, speed of motion – and even deduce whether it has planets!

An object's *spectrum* is defined, in the broadest sense, as the distribution of intensity of the electromagnetic radiation emitted from it, with wavelength or frequency. As we learned last month, the electromagnetic spectrum covers an enormous range of wavelengths and frequencies – but in this article, we're concerned only with the spectra of stars, which emit mainly within the range of visible light.

A spectrum can be obtained and displayed in various ways. It can be obtained by measuring the intensity of light at different wavelengths with electronic instruments, and plotting a graph of intensity against wavelength. But the form of spectrum with which we are most familiar is the kind produced by splitting light into its constituent wavelengths – which we perceive as colours – with a prism or diffraction grating, and photographing the resultant "rainbow" pattern (Fig. 1). Of course, one form of spectrum which is familiar to everyone *is* a rainbow – a spectrum of the Sun, formed by water droplets in the atmosphere acting as tiny prisms.

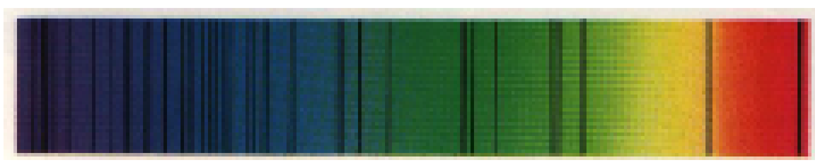

Fig. 1

The study of spectra began with Sir Isaac Newton in 1666, who first showed that sunlight, passing through a prism, was split into the colours of the rainbow. He correctly deduced that light of different colours was refracted through different angles, but as the wave nature of light wasn't known then, he didn't know that colour was related to wavelength. Later, as the quality of optics improved, people were able to see much more detail in the Sun's spectrum. In 1814, Joseph von Fraunhofer discovered that the band of colours wasn't quite continuous; superimposed on it were a great number of narrow dark lines (Fig. 1), indicating that the intensity of light was considerably reduced at certain specific wavelengths. He recorded the positions of about 500 *Fraunhofer lines*, as they are still known; today, we know that there are over 25000 of them.

The Fraunhofer lines were explained, at least partly, by Gustav Kirchoff and Robert Bunsen in 1859. They found that many chemical elements, when heated to incandescence, imparted characteristic colours to the flame. (It was the need for a suitable heat source for these experiments, which led Bunsen to invent the Bunsen burner.) They then passed the light through a prism, and found that, for any given element, the resultant spectrum consisted not of a continuous rainbow, but of a number of narrow bright lines, indicating that light was only being emitted at certain discrete wavelengths. Each element emitted its own characteristic set of lines, which we now call *emission lines*. And what's more, each of those emission lines corresponded exactly to the position of one of Fraunhofer's dark lines in the solar spectrum.

Kirchoff and Bunsen then discovered something remarkable. If the light from an incandescent source was passed through some cooler material, containing the same elements, before reaching the prism, then the emission lines disappeared. They deduced that when light from an incandescent source passed through cooler material, the elements in that material somehow absorbed light at the same wavelengths at which emission lines were produced when those elements were heated.

We can now explain the Fraunhofer lines, which are more correctly called *absorption lines*. The Sun's light is produced in its intensely hot core, and initially consists of a continuous spectrum of all wavelengths, known as a *continuum*. This light then passes through its outer layers, which are (relatively!) cool; elements in those layers absorb light at characteristic wavelengths, resulting in the dark lines in the spectrum.

By comparing the Fraunhofer lines with emission lines produced in the laboratory, Kirchoff and Bunsen were able to identify many of the elements which make up the outer layers of the Sun. Then in 1863, William Huggins, using a spectrograph attached to a telescope, identified a number of Fraunhofer lines in the spectra of Betelgeuse and Aldebaran – thereby disproving Comte's assumption about "things which we could never know"!

In 1868, Norman Lockyer discovered a set of Fraunhofer lines in the solar spectrum, which didn't correspond to any known laboratory reference lines. He correctly deduced that these were due to the presence in the Sun of a "new" element, which wasn't known on Earth; quite predictably, he called it helium! Today, of course, we know that helium *does* exist on Earth, and we use it for such mundane applications as filling balloons – but it was discovered in the Sun first.

Understanding exactly *why* elements emit and absorb light at specific wavelengths had to wait until the 20th Century, and the development of quantum physics. (Don't worry; I'm only going to touch on the absolute basics of that. Anything more is beyond me!) To explain spectral lines, we need to consider the structure of atoms.

An atom consists of a nucleus, made up of protons and neutrons, with a number of electrons "orbiting" around it. The number of electrons is equal to the number of protons in the nucleus; each element has a different number. The simplest way to think of an atom is to picture the electrons as orbiting in a number of concentric spherical "shells" around the nucleus; this view is greatly over-simplified, but it will do for the purpose of this explanation. Each shell corresponds to the electrons having a certain amount of energy.

Quantum physics says that the energy of an electron is *quantized*; that is, it can only take certain discrete values. In an atom of a given element, the electrons can only exist within shells corresponding to discrete energy levels. An electron can "jump" from a "lower" shell to a "higher" one, if it gains precisely the right amount of energy, or it can "fall" from a higher shell to a lower one, if it loses precisely the right amount of energy.

So how do electrons gain or lose energy? Well, as we learned last month, the energy of light, and other electromagnetic radiation, is also quantized. An electromagnetic wave consists of discrete "packets", or quanta, of energy, called photons, and the energy of each photon is related to the frequency and wavelength of the wave. For radiation of frequency f and wavelength λ, the energy E of a photon is given by

$$E = hf$$

or

$E = hc / \lambda$

Where h is Planck's Constant and c the velocity of light.

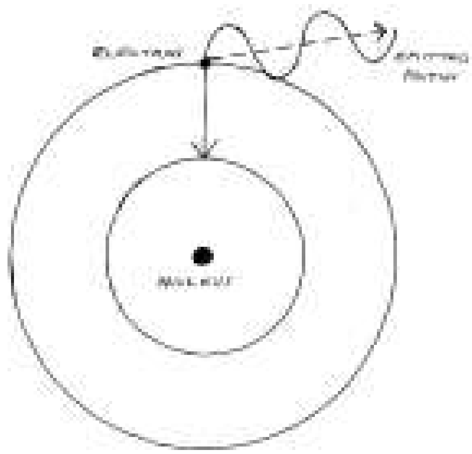

Fig. 2

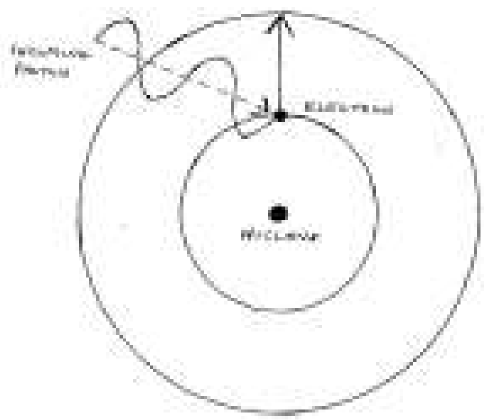

Fig. 3

So when an electron falls from a higher to a lower energy level, it emits a photon whose energy is exactly equal to the difference in energy between the two levels – which means that the photon has to have a specific wavelength (Fig. 2). This explains emission lines; heating an element "excites" its atoms, i.e. raises some of their electrons to higher energy levels, then they emit photons of those specific wavelengths, as the electrons fall back.

And for an electron to jump from a lower to a higher energy level, it needs to absorb a photon with exactly the right amount of energy (Fig. 3). This explains absorption lines; as light passes through cool material, some of the photons are absorbed by atoms, to excite their electrons to higher energy levels.

So now we see why each element has characteristic spectral lines associated with it; each line corresponds to a particular transition between electron energy states in the atoms of a particular element. For elements of higher atomic numbers, there are many different energy levels within the atom, and hundreds of possible transitions; hence hundreds of spectral lines. Just to complicate matters, there are also absorption “bands”, caused by transitions within molecules, which appear in the spectra of cool red stars – but not in those of hotter stars, as molecules can’t exist at their temperatures.

By the late 19^{th} Century, as many stellar spectra were photographed, it was realised that stars of different colours had very different spectra. A star’s colour indicates its surface temperature; blue stars are the hottest and red the coolest, with white, yellow and orange in between. Stars of different temperatures have noticeably different patterns of absorption lines in their spectra; generally speaking, the cooler the star, the more numerous and prominent are the absorption lines. (The spectrum shown in Fig. 1 is that of a yellow star similar to the Sun.)

Between the 1890’s and 1920’s, a team of astronomers at Harvard produced the *Henry Draper Catalogue*, an immense photographic catalogue of the spectra of over 225000 stars. They realised that stars of similar colour – and therefore similar temperature – had similar spectra, and that stars could be classified according to their spectra. They grouped stars into a number of *spectral classes*, based on the characteristics of their spectra. At first, these classes were denoted by an alphabetical sequence from A to P, in decreasing order of temperature, each class being identified by the relative strengths of various absorption lines.

As work progressed on the catalogue, the sequence of spectral classes evolved through numerous versions, as some of the classes were found to be unnecessary, and others found to be in the wrong order. As a result, the final version of the *Harvard Classification*, defined by Annie Jump Cannon in the 1920’s, uses a rather peculiar sequence of letters; in decreasing order of temperature, the spectral classes are:
O, B, A, F, G, K, M.
Astronomers throughout the English-speaking world remember this sequence by the silly but effective mnemonic, “Oh be a fine girl; kiss me!” (Believe it or not, some female students in the USA are now campaigning to ban the use of that harmless phrase, because it’s “sexist”!)

In terms of colour, O and B stars are the hottest blue ones; A and F range from blue-white through white to yellow-white. G stars are yellow, K orange and M the coolest red. In terms of spectral characteristics, the seven classes can be described as follows:

O: Ionised helium (HeII) lines dominant, strong ultraviolet continuum
B: Neutral helium (HeI) lines dominant, no HeII lines
A: Hydrogen lines dominant, ionised metal lines present
F: Metallic lines strengthen, hydrogen lines weaken
G: Ionised calcium lines dominant, metallic lines strengthen
K: Neutral metal lines dominant, molecular bands appear
M: Molecular bands dominant, neutral metal lines strong

Several extra “fringe” classes have since been added to the Harvard Classification. Type W, placed before O, denotes Wolf-Rayet stars, a rare class of extremely hot blue stars. Types R, N and S are now placed after M, to denote various classes of very cool and dim red dwarfs.

Obviously, dividing all the stars in the sky into just seven (or eleven) classes is far too simple an approach, so the system has been refined by subdividing each of the Harvard classes into ten subclasses, denoted by the numbers 0 to 9 placed after the class letter. For example, within class G, a G0 star is the hottest, just slightly cooler than an F9; G5 is in the middle of the range, and G9 is the coolest and yellowest, just slightly hotter than a K0. The Sun's spectral type, by the way, is G2.

To complicate matters further, some stars exhibit certain "non-standard" spectral features, which are identified by the addition of lowercase letters as suffixes; the suffix e, for example, indicates the presence of emission lines in the spectrum. And the suffix v indicates that the star is variable.

Finally, stars within the same spectral class can have a huge range of intrinsic brightness, or luminosity. Consider, for example, a red giant star like Betelgeuse. Its core is intensely hot, and it's several thousand times more luminous than the Sun, but because it's swollen to a huge size – 800 times the Sun's diameter – its surface temperature and colour are similar to that of a tiny red dwarf. Both are of spectral type M, despite being vastly different kinds of stars.

So yet another refinement to the Harvard Classification is to follow the spectral class with a *luminosity class*. This is denoted by a Roman numeral, from I for the brightest supergiants to VII for the dimmest subdwarfs. The Sun's type thus becomes G2 V, the V denoting that it's a decidedly "average" main sequence star. (The meaning of "main sequence" will be revealed next month.)

As if learning what a star is made of isn't enough, we can also learn much more from its spectrum. In my third article, we learned about the Doppler Effect, which shifts the wavelength of light, due to the relative motion of the source and the observer. Spectral lines provide us with a simple way of measuring a star's Doppler shift, by accurately measuring their positions and comparing them with reference lines produced in the laboratory; hence we can measure a star's velocity of motion – or rather the component of its velocity along our line of sight, towards or away from us. The first person to measure a star's Doppler shift was none other than Huggins, who measured the speed of recession of Sirius in 1868.

Stellar Doppler shifts have enabled us to map the structure of our Galaxy, while measurements of the redshifts of galaxies led to the discovery of the expansion of the Universe, and still play a vital part in cosmology. But on a smaller scale, we can also learn other things about individual stars.

There are some binary stars whose components are too close together to be resolved optically, even with the biggest telescopes – but they can be identified by their spectra. The Doppler shifts of their spectral lines change periodically, as the stars move alternately towards and away from us in their orbits. We call these stars *spectroscopic binaries*, for obvious reasons. In recent years, similar measurements, but with even greater precision – it's now possible to measure velocity changes of just a few metres per second – have enabled astronomers to detect the presence of planets orbiting many nearby stars.

It's quite remarkable to think that such a simple concept as splitting light into its constituent wavelengths has taught us so much about the Universe. I wonder what Sir Isaac, who first experimented with prisms over three centuries ago, would make of it all!

Next month, we'll look at another of the most important tools of the modern astrophysicist – the Hertzsprung-Russell Diagram.

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<u>The CaDAS Interview – John Crowther</u>

John has always been a dependable contributor to Transit, providing interesting items most months. His membership of the Society goes back a long way, to the original Cleveland Club for Schools almost 20 years ago. He lives in Redcar, quite near to the Recreation Centre at Coatham, where my wife and I go dancing a lot. It was easy to park there and take a short stroll to John's house. His sitting room has photographs of old Whitby, one of the (reproduction) Endeavour sailing into the harbour, about ten years ago. There are models of ships of all kinds, too. The reason for this nautical connection became clear as we talked.

John opened the conversation straight away – I copy Transit each month and send it to my son and a few friends. *Perhaps if I sent you a couple of extra copies it would save you the trouble of copying it?* That would be handy. They all find it very interesting. (One goes to my cousin's husband in Tunbridge. He is a clever fellow, an artist. He's doing up an old MG. It was driven by an uncle until he was 90). Here's an article I may send you for the magazine, from an old friend, David Bayliss. You should interview him; I'll introduce you on Friday.

Have you any suggestions for Transit? It's very good. One thing I would like to say about the Society is that it is very well run, with good lectures and meetings. However, we don't really get to know one another very well. We attend the meetings and then go home. We should sit in a ring and say who we are, perhaps, have a social evening occasionally. Michael Roe has mentioned he would like a social gathering now and then. I take him from Redcar to Thorpe Thewles and it's very difficult getting him to leave after the meetings. He wants to talk. When I drop him off for the bus his mother says 'watch out for the ladies of the night'!! *One thing I would like to do is buy a digital camera and include a photograph of the person being interviewed each time.*

Your son is a museum curator in Canterbury – I remember you sent a newspaper cutting for Transit when he organised an Astronomy event. What about the rest of your family? My wife and I have been married for 40 years – we were married in St Hilda's and recently renewed our marriage vows there. We have three children. Our eldest daughter is in Sheffield now, after graduating in American Studies. Martin is the middle one and a museum curator in Canterbury. Our youngest daughter is a teacher; she is to be married in August and lives here with us.

Have you always lived in Redcar? I was brought up in Whitby, with a background of the merchant navy. My father was a Chief Engineer and my grandfather was a Master Mariner. My grandfather had two terrestrial telescopes, which he gave to me. There is a great naval tradition in Whitby, of course, and close connections to fishing and whaling in the past. I can remember you could walk across the harbour on the herring fishing boats moored up. The herring were over-fished and are no longer around. I was in the Sea Scouts. My father sailed to and from the USA and Canada – he was torpedoed in the war. He used to bring home nylons and American things. I had the first coca cola and the first transistor radio in Whitby, which amazed my friends. I can remember going with him across the Atlantic to Montreal and from there to Boston. We flew in a rattling, old Dakota at 150 mph to Boston from Montreal, where we were given hospitality by friends from the English Speaking Union. That was in 1949.

How did you come to live in Redcar, then? I was a primary school teacher and taught in the Middlesbrough area. My last post was in Dormanstown, which was a model town built on a semicircle. The houses had steel beams in their roofs. The church was built to be extended but never was. Living here means everything is local. The school was near and the Church and the park. Coming from Whitby, living near the sea is quite important. I'm not sure if I would want to be a teacher nowadays. There seems to be so many assessments and paperwork generally, interfering with the business of actually teaching things.

You are a religious man, with close connections in the Church. Yes, I am a Lay Reader in the local Church and at Dormanstown. The two churches are to be merged very shortly. I preach and take confirmation classes and services. Here's a picture of me with the new Bishop of Whitby. I spend a lot of time working with the Church and it means a great deal to my wife and myself. The Church magazine is very well produced and I am able to send you a relevant article from it every so often. Like the ones on sundials.

When did your astronomy begin? The school I attended in Whitby, the Grammar School, had an observatory and a thriving astronomy club. It had several very good instruments, a transit telescope and a sidereal clock. We used the school lecture theatre for the meetings and lectures and I remember a lecture by a pupil on "Does Vulcan, the supposed planet nearer to the Sun than Mercury, exist"? *Was there a master who ran the club, then?* I seem to remember the 6th form pupils ran it themselves. The physics master, Mr Preston, took an overall interest, I think. The observatory is now used by the Whitby Astronomical Society. It has a conical roof, which opens with a rope to rotate it inside. The observatory was privately owned and was given to the School, being rebuilt on the other side of the railway in the 1920's. A plaque gives the details.

Do you make telescopes? The first one I made was from a kit, which included a 4-inch mirror, and I assembled the telescope. Before I joined the Society I went to John Morley's classes in Eston on telescope making. We also ground mirrors from scratch, 4½ inches in diameter and about 3 feet in focal length. John figured them for us and tested them. One was mounted on a post in the garden. This homemade 'scope is now with my son in Canterbury. I use a monocular and binoculars for observing now. I bought an elbow telescope, a gun sight, from an ex-WD shop in Guisborough. I also have a 60mm refractor, which I had to remount to make it balance properly. I don't use it much. The light pollution round here makes observing quite difficult.

What about computers? You are not on email. No. Computers are not my thing at all. I don't have one and don't intend to get one. I'm a Luddite as far as computers are concerned. My daughter uses one at school, which takes images from drawings on a white board.

When did you join the Society? I joined soon after making the telescopes with John Morley. John McCue and John Nichol, who live next door to one another, were running the Society then. It was then the original Society for Schools. We met in different places, Marton Road, Harrow Road, the Sixth Form College Stockton, the Scientific Institute in Middlesbrough. At one place the karate class kept running through in their fighting gear. Darren Summerfield came with his Dad. Darren gave a lecture to the Society when he was about 10.

Do you travel abroad much nowadays? We mostly spend holidays with the family, in Canterbury. I've been to Canada and Switzerland. I went to France in 1990 to see the eclipse. We had a wonderful view of the full eclipse. Our technique was to use Pringle tubes to project the image from binoculars on to the plastic end, to get the image bigger. The French papers spoke of "the Moon dancing with the Sun". Then we went to do some champagne tasting.
I would like to go to the Scilly Isles, Greece for the history, Italy for the Roman history. I've made a model of a Greek trireme and one of a Roman galley.

I see you have a number of models around. I make a lot of models of ships and then give them away, as presents, mostly. I must have given about 40 away. The cases cost a lot of money. I get the Hobbies catalogue from Norfolk. It used to be Hobbies weekly. I made all six of their big galleon models, including one of the Endeavour, of course. Whitby is steeped in history, from the wooden Saxon Abbey and St Hilda in the 8th century, the Synod of Whitby, up to Cook's voyages in the 18th Century. There are a lot of odd legends in Whitby about the fossil ammonites being snakes with the heads missing. You could get ammonites with a snake's head added in Victorian times to prove that St Hilda performed a miracle!

What are you reading at the moment? I usually read factual stuff. As a Christmas present, I was given "Galileo's Daughter", which is a wonderful read. I recommend it to everyone. The tragedy is that Galileo's letters were destroyed. Arthur C. Clarke's "3001", which I came across recently, was very enjoyable – a sequel to "2001, A Space Odyssey". In Pickering, opposite the railway station, there is a wonderful shop full of second-hand paperbacks, very cheap. It's worth a visit. Biographies interest me, too. "Longitude" by Dava Sobell was another memorable read. Authors like Clarke, Asimov, John Wyndham I read a lot. Another one I enjoyed was "Canticle for Lebowitz" and "The Voyage of the Beagle, in which you can see Darwin's evolution theories developing and coming through. Reading and the radio stimulate the imagination so much. There is too much given to you nowadays, as on children's TV, which does not do much for their imaginations.

Any other interests? Well, I keep fish. Not the fancy, tropical species, just the ordinary goldfish. They are very restful to watch.

What keeps you interested in Astronomy? It requires such a lot of imagination, a sense of wonder, a sense of "we'll never know everything". There is so much to find out. Using a microscope gives the same feeling of discovering a Universe in a drop of water. When I'm looking at galaxies I always wonder if there is anyone looking back at us. *As a theologian, would that bother you?* No, not at all, I am not a fundamentalist in any way. On the law of averages there will be other civilisations out there, maybe more advanced than us. The history of astronomy is one of putting mankind in a more and more insignificant position - the Earth is not the centre of the planetary system, the Sun is in a backwater of the Galaxy, our Galaxy is a very average one, and so on. What does bother me is that astrology and crystal-gazing and suchlike are taking the place of organized religion. Anything with discipline required is rejected in modern society – the New Age and all that.

Do you have any heroes? My big hero is Nelson. And Queen Elizabeth the First, who dedicated her life to her responsibilities. We have Newton, of course. Then there's Cook, who was forgotten until his bicentenary. Being a lay minister, I have to consider Jesus Christ is a hero.

What makes a civilised society for you? In one word, toleration. While acknowledging that there are shortcomings to be worked at, British culture and society is among the best in the world at present.

If you were Dictator, what would you do? Going back to society and knowing people, we all seem to live in unconnected "boxes" – a family box, a work box and so on. I would like to open up society so that we are all aware of one another's problems. Communication and tolerance are the things I would concentrate on.

The Apollo Hoax 2

This second extract from the website gives the author's answers to the first six of the 26 questions listed in last month's article. The rest will follow in future editions.

(1) What does it take to prove we went to the Moon?
I would remind the reader that it's up to scientists and claimants of this or that fact to provide proof of their claims. That's how it works in science. It's called the scientific method. If we find flaws or errors in their method or in the results of their scientific work then we may call in to question the validity of their claims. NASA and many scientists provide what they claim is proof that man walked on the Moon and then we are allowed to examine that proof.

(2) The public are dumb, they'll buy into any idea.
It has been said that up to 20% of the American public believes we did not go to the Moon and that there is no idea so dumb that they will not buy it. Or something of that sort. This is a non-argument. It is neither supportive of nor detrimental to any scientific analysis of the Apollo record. It is merely an attempt at ridicule and should be ignored. Most of the NASA believers that swallow the NASA story hook line and sinker usually end up making remarks of this kind or worse.

(3) No stars are visible in the images, where are they?
In order to capture stars on film you need very long exposures in comparison to "daylight" scenes even if the sky is pitch black. Just try and take a photo of stars for yourself whilst including some brightly lit scene (say a lighted car park at night) and you should find that the car park images are "burned out" when the stars begin to show in the pictures. Though it's correct that stars will have been absent from the lunar photographic images it is strange that none of the astronauts remarked on the stars in the sky. The stars really will have been a magnificent sight at all times from the Moon.

(4) The flag waves.
The only footage I have seen where the flag waves or flaps about is when the astronaut is adjusting the flag pole. Because he had his hand on the flag pole this particular criticism of the Apollo record is invalid.

(5) There's no dust on the lander footpads
The Moon has no atmosphere in which eddies and such can cause the dust to swirl and "float around". Dust is "shot" away when there is no atmosphere. Therefore it is difficult to say whether the foot pads would have been covered in dust with any certainty. The chances are that some hollows and crevices will contain trapped dust but all of the images I have seen look remarkably clean. Nothing conclusive here in my opinion though.

(6) Why is no engine noise audible in the LM radio broadcasts?
Hmm... Your guess is as good as mine. The LM was pressurized to about 5 psi (oxygen rich atmosphere) during the landing and ascent phases of the missions. The LM cabin will have been filled with the sound from the engine and control thrusters. The following website has an account describing the noise from the engines on the space shuttle orbiter;
http://internet.ocii.com/~dpwozney/apollo1.htm>
Quote: "The forward primary thrusters sound like exploding cannons at thrust onset; and during their firing" –each primary thruster produces a thrust of only 870 pounds. The LM engine produced a 3000 pound thrust and would have made much more violent sounds and actions. "Jets of flame shoot out from the orbiter's nose. The orbiter reacts to the primaries' shove by shaking slightly and moving very noticeably. For the crew on board, a series of attitude changes using primaries resembles a World War I sea battle, with cannons and mortars firing, flashes of flame shooting in all directions, and the ship's shuddering and shaking in reaction to the salvos".
It has even been suggested that because passengers do not hear the sound of an airplanes engines over the captains loudspeaker system when he addresses them then there is no expectation that we should hear it in any of the LM radio broadcast!
The reason we can't hear the engine sound over the loudspeaker is because the passenger compartment is already filled with engine noise and there would be no way for the passenger to differentiate it. I have personally heard the engine noise during the captains air to ground radio broadcasts on many occasions. Many NASA proponents claim that the LM rocket engines never did make any noise once the flow of propellants had stabilised. They claim that the only sound it made was the sound of the propellants rushing through the tubes. Well, I have never heard of a silent rocket engine. They all

(to my knowledge) produce a roaring sound in a range from loud to deafening and there is a good reason for this, rocket propulsion is essentially a form of controlled explosion. Anything less than this and there will not be enough thrust generated to lift the rocket off the ground. Of course in a vacuum the only way the noise may reach the cabin is via the structure of the LM itself. We've all heard how much noise may be transmitted by this method every time we drive our cars. At speed road noise from the wheels becomes significant and may even interfere with conversation depending on the road surface. The ascent engine was mounted inside the cabin only inches away from the astronauts and there was no noise picked up by the microphones?

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A History of the Cleveland and Darlington Astronomical Society

Part 2

Our second extract of Barry Hetherington's history of the Society covers the formation and early years of the Darlington Astronomical Society. The Cleveland Society and the Darlington Society were then separate organisations. Any comments or additional material, which could be included in the final version, should be sent to the Editor (see Transit Tailpiece) or directly to Barry himself.

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Darlington Astronomical Society

Barry Hetherington has had a lifelong interest in astronomy, particularly with the history of the subject. He joined the British Astronomical Association in 1964.
For many years he has supported the Workers Educational Association in Darlington and when, in 1978, he asked them to provide a course on astronomy, they eventually informed him that the only way it would happen is if he taught it! This he agreed to do and after three years teaching he was running out of fresh material. A discussion with the students indicated that they wanted to continue with their interest so they decided to try and form an astronomical society in Darlington.

The Darlington Astronomical Society was founded at a meeting held in Bennet House, Market Place, Darlington, on the 5th September 1980, when 17 people met to discuss the proposal and form the society; the proposal was carried unanimously. There were two nominations for the position of President, Christopher Walker and Edward Jones; Edward Jones was elected by eight votes to seven. Barry Hetherington was appointed Secretary and Treasurer, while the position of Editor went to Paul Tate. The subscription rates were fixed at £5 ordinary member, retired members and those under 18 years of age £2.50, and a family membership of one ordinary subscription plus £1 for each additional family member. Meetings were held in Bennet House.

At the meeting of the 7th November 1980 it was announced that the new Vice-Chancellor of Durham University, Professor Fred Holliday, had agreed to become the Patron of the Society.

On the 11th February 1981 Eddie Jones and Barry Hetherington had lunch with Professor Fred Holiday, Vice-Chancellor of Durham University, at his Home, Hollingside House, Durham City. Also present were two astronomers from the university - Drs. Scarrott and Warren-Smith - who, after lunch, walked us down to the Science Site to see the optical and radio telescopes on the Physics Department roof.

On the 4th April 1981 the society organised a coach trip to Edinburgh. Three members of the Cleveland Astronomical Society joined the party and, at 2pm, we were given a conducted tour of the Royal Observatory at Blackford Hill, and at 4pm we drove to the City Observatory on Calton Hill for another conducted tour.

Thirteen members of the society and two guests visited Durham University on the 25th September 1981. We were welcomed by Drs. Scarrott and Warren-Smith, and were shown the telescopes on the Physics Department roof. Even the weather co-operated and permitted us a glimpse of the Great Spiral Galaxy in Andromeda.

On the 5th February 1982 a joint meeting was held between the Darlington Astronomical Society and the Workers Educational Association. The guest speaker was Dr. J.B. Harding of Bishopton who gave an illustrated talk on the *Scale of the Universe*.

On the 5th March 1982 the guest speaker at the monthly meeting was Jack Youdale, FRAS, who spoke on *The Technique of Meteor Observation*.

At the meeting of the 4th June 1982 Peter Whyman and Barry Hetherington brought their PET computer systems to the meeting and demonstrated the various astronomical programs they had written.

On the 2nd July 1982 the society was very pleased to welcome to the society Dr. Fred Watson of the Royal Observatory, Edinburgh, who gave a talk entitled *Eavesdropping on the Galactic Nucleus*. He had just returned from Siding Spring Observatory in Australia, where he had been using the Anglo-Australian Telescope. Dr. Watson showed us slides of the observatory and its equipment, in particular the equipment that had been developed for his own observations - in order to observe the fluctuations in the light from particular variable stars in the galactic nucleus he had developed a method of using fibre-optics which enabled him to observe up to 25 stars at a time.

At the Annual General Meeting of the society held at Bennet House on the 3rd September 1982 Barry Hetherington was elected President; our previous president, Eddie Jones, was not standing for re-election. Mark Naisbitt was elected Secretary and Allan Day elected Treasurer. After the A.G.M. Chris Walker showed us some slides of the sky which he had recently taken, including the Ring Nebula, the Omega Nebula, the North American Nebula, and two slides of Comet Austin.

On the 4th February 1983 John Nichol of Norton gave a talk on *Telescope Making.*

The partial eclipse of the sun on the 30th May 1984 was observed by some of the members from the Darlington/Croft road, where a reporter from the Evening Despatch photographed the group and a report, together with pictures, appeared in the newspaper the following day. Observing from Brompton on Swale, David Graham had been totally clouded out.

On the 17th September 1988 David Graham wrote to Barry Hetherington about the decline of the society since the meetings were no longer minuted and had become less formal. He gave three alternatives as to the way forward. One of these was the merger of the Darlington and the Cleveland societies.

In the early hours of the 12th February 1989 David Graham and Malcolm Johnson, using a 16-inch reflector, observed the supernova (SN1989B) in M66 which had been discovered by the Australian observer Bob Evans the previous month. This was the first supernova observation by either of them.

Another first for David Graham was the display of the aurora seen from the whole country on the night of the 13th-14th March 1989. A telephone call from fellow member Chris Walker informed him that an event was in progress. Although it was raining at that time the sky began to clear shortly before 22:00 UT and thereafter he spent the next three hours watching the spectacular display.

David was later to describe the aurora on national television. On the 20th April Malcolm Johnson, Christopher Walker, David Graham, John Nichol and John McCue assembled at the Gilling observatory – next to the home of Malcolm and Pauline Johnson, where they were filmed as part of a television programme to be screened on Channel 4.

On 30th July 1989, the Channel 4 television series *Equinox* screened the programme on amateur astronomy, entitled *Earth Calling Basingstoke*, which featured the above named members; David Graham being the main contributor in our part of the story. Featured on the programme was the auroral display of the 20th April with our members giving their descriptions of the event.

A few months later, on the 21st October, David Graham and Chris Walker again observed the aurora from Hurworth on Tees.

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Transit Tailpiece

Quote/Unquote

The only means of strengthening one's intellect is to make up one's mind about nothing – to let the mind be a thoroughfare for all thoughts.
Keats

We all dance around in a ring and suppose
But the Secret sits in the middle and knows.
Robert Fox

Custom Telescopes UK. For your telescopes, binoculars and accessories of all kinds, go to Glen Oliver, a long-time member of the Society. He operates from Hartlepool and has a website www.goliver.freeserve.co.uk. Glen also supplies Astronomy and Space books of all kinds. Don't forget to visit his website soon.

CaDAS Website Now at www.planetarium.btinternet.co.uk and the society email address is planetarium@btopenworld.com . Everyone is encouraged to visit the site and tell your friends about it.

Sunderland AS Contact them at www.sunderlandastrosoc.com to see how they are progressing with the new Observatory at Washington Wildlife Centre. If you wish to attend their meetings you are assured of a friendly welcome.

York AS have a website at www.yorkastro.freeserve.co.uk and an excellent programme of lectures, if you wish to go along.

Post and Email If anyone wishes to change the way they receive their Transit, please let me know. If any member is not receiving a copy, please let me know.

Articles Please send contributions for the newsletter to Alex Menarry, 23, Abbey Road, Darlington, DL3 7RD, 01325 482597 (a.menarry@virgin.net) or to John McCue, 01642 892446 (john.mccue@ntlworld.com). Copy deadline date is the 1st of each month.

<u>A Message from Keith Johnson</u>

Hi everyone,

Orion, the Hunter, was nicely in view outside my backdoor whilst trying out the "Meteor grabber", f/1.2, 4mm camera lens with the Mintron camera and wondered how it would show up on the CCTV monitor. I was gob-smacked with the amazing result!
The light pollution in my street resulted in some of the fainter stars not being visible. However, although the true field of view of the night sky is somewhat hampered by the door and window frame, I'm sure you'll agree this lens together with the Mintron EX camera will be perfect for aurora and meteor showers.
BTW - The camera was on 68x and not at its maximum sensitivity, which is ...... 128x !!
The image was captured directly to the computer using a video capture card whilst at the same time being displayed on the 14" cctv monitor. It really was strange comparing the image on the monitor whilst looking up at the constellation thinking "where are all those stars coming from"? My eyes could barely make out the brighter stars.
It's a "raw" image , so what you are looking at is exactly how it was displayed on the monitor in real time.
For those of you with planetarium software programs, I've hi- lighted the constellations and Saturn. You may have to zoom in a little to be able to show some of the fainter stars.

Regards, Keith.