TRANSIT

The Newsletter of

Cleveland & Darlington Astronomical Society

11th April 2003. Julian Day 2452741

Editorial

March meeting Nigel Bannister, formerly from the North East but now at the University of Leicester, held us spellbound with his description of the x-ray camera he and his colleagues are developing. His description of the analogy with the actual lobster eye and the forthcoming ability to see "The Universe in the Eyes of a Lobster" were truly at the forefront of science and technology. It was a pleasure to see last month's lecturer, Jurgen Schmoll, at the meeting. Nigel sent us this message after the meeting : - *Many thanks for your emails and your hospitality on Friday night despite my tardy arrival - thanks for your patience! I remain extremely impressed with your setup - a very*

nice piece of work all-round, and I hope the planetarium continues to be a success - I'm sure it will. I'd be grateful if, at your next meeting, you would pass on my thanks to the other members of CDAS for the great welcome they gave me - it was a pleasure and made the journey worth every mile! Best Regards, Nigel.

Scarborough Star Party. Neil reminded us that the dates are August 1st to 4th, 2003. Application should be made to Scarborough AS or enquiries to Neil or myself.

Light pollution. Discussion after the last meeting made it clear that some of our members have been taking an active interest in this subject for some time. Pat Duggan has been engaged in talks with her local authority to keep the Osmotherley sky as dark as possible. Mike Gregory had already written a very cogent letter to the Science and Technology Select Committee. Please do what you can, locally and nationally, to bring the problem – and the usually easy solutions – to the attention of those who can do something about it.

The Society Book Project. Developing the subject a bit further is discussed in a following article. It seems that the next thing is to encourage pens to burn the paper and hope that articles will be received soon.

Next meeting will be held on 11th April 2003, in Thorpe Thewles village hall, when our own David Graham, FRAS, will give us a talk on "Cassini's Planet"

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Light Pollution Issues

May I remind you that The Science and Technology Select Committee is due to consider the following questions:

1. What has been the impact of light pollution on UK astronomy?
2. Are current planning guidelines strong enough to protect against light pollution?
3. Are planning guidelines being applied and enforced effectively?
4. Is light measurable in such a way as to make legally enforceable regulatory controls feasible?
5. Are further controls on the design of lighting necessary?

Submissions are wanted by Wednesday, 30 April 2003. Oral evidence will be heard in May. Evidence should be sent in hard copy to the Clerk of the Science and Technology Committee, 7 Millbank, London SW1P 3JA. Please send an electronic version also, in Word format, via e-mail to *scitechcom@parliament.uk* or on disk.
Guidance on the submission of evidence can be found at :-
www.parliament.uk/commons/selcom/witguide.htm
Further information on the work of the Committee can be obtained from Committee staff on telephone number 020 7219 2793/4.
Previous press notices and publications are available on the Committee's homepage: *www.parliament.uk/parliamentary_committees/science_and_technology_committee.cfm*

I am sure Mike Gregory will be pleased to tell you his experiences in writing his submission and to advise you how to go about it. I have the "Guide for Witnesses to Select Committees" if anyone wants a copy.
If anyone would like to take on the job of "Light Pollution" for the Society, please make contact. We need to know of developments both local and National.

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The Society Book Project

Further to last month's proposed Objectives and Contents for "The CaDAS Book of Amateur Astronomy", here are some more suggestions to answer the questions some members have been asking. This is an addition to last month's ideas, not a replacement.

1. Content and Headings, in addition to the list already published in March edition
   - Astronomy on TV and Radio
   - Astronomy on the Internet
   - Telescopes, binoculars, instruments owned by members
   - Telescopes owned by Society for loan
   - Recommended telescopes for various uses
   - Member's Nights, subjects covered
   - Words and Music of "The Galaxy Song"
   - Poetry and Music as well as prose
   - The sheer enjoyment of Astronomy
   - short notes from those who do not want to write a lot
   - Experiences with Astronomy
   - Why I became interested in Astronomy
   - Jokes and Cartoons
   - Interesting characters I have met

2. Subjects Generally
   - anything, all contributions welcome
   - several contributions by one person is ok
   - chapters to be of a similar length and balance
   - the key is Interest and Entertainment

3. Time Scale
   - suggested deadline for manuscripts, end September
   - suggested publish date by the end of the year (Xmas presents?)

4. Size and Cost
   - are there any publishing experts in the Society, please?
   - decision needed on whether to photocopy or print
   - decisions needed on fonts and type of print
   - (100 pages is about 50,000 words)

5. Target Audience
   - Society Members
   - Other Astronomy Societies

- British Astronomical Association
- Astronomy popularisers?
- University Departments?

6. Editorial Board
- Suggest 4 or 5 people to decide details and vet articles
- need proof readers and layout suggestions
- need computer format expert

7. Pictures and Drawings
- need to convert articles to computer format
- may need to use drawing programs

8. Authors - members of the Society with known expertise and experience will be "commissioned" to write articles for the book, individually or as a group. The idea would be to bring out the wide range of interests the Society has and the contribution we make to amateur astronomy. However, as we have said on a few occasions, everyone in the Society will be encouraged to make a contribution of some kind.

Letter from Stromlo March 2003

Hi Guys,

I thought I would put fingers to keyboard and send you all an email about what's happening on Stromlo these days. We have now returned to the site, which is gradually being cleared up and sorted out. Most of the gutted buildings are currently being demolished, which makes a lot of noise when you're trying to work! The historic admin building (very historic for Australia, built in the 1920's!) is being cleared up and shall be rebuilt in the existing footprint. It rained the other day, the first time for about 9 months. The grass has gone green again, I hadn't realised how much I'd missed the greenery.

Our house is back to normal; we had to spend a week with friends until the power was reconnected. We've had our carpets cleaned and the garden is living again. Only the destroyed fence to be replaced now... Actually, most of you probably saw our house on the telly over there; the footage was always on here, showing our garden ablaze. Quite exciting stuff to see your house on international telly.

Work is going well. I have completed my analysis of 1/8th of 47 Tucanae, looking for variable stars and planetary transits. I have found 18 variables, most of which are new, and seem to be mostly Small Magellanic Cloud RR Lyraes, with a few short period W-UMa type eclipsing binaries. Such stars are important for studying the dynamical history and structure of the cluster. The SMC stars will eventually be used to make a map of the structure of the Galactic Halo behind the cluster. I'll present them at the IAU in July.

I have one transit candidate, and am crosschecking the star in my old data to see if I can see the transit there too. If so, I shall put in a proposal to use Keck to get high-resolution spectra and see if it's Planet-mass. I need a fairly large scope to do that, as the star is mag +17. It would be very good if it were, as there are no planets known in a Globular up to now.

Anyway, to other things. I am planning to come back to England for 3 weeks in August, to see my parents and visit as many people as I can while over there. I thought I would come over in August to avoid the cold in both respective winters! So it would be great to catch up with as many of you as possible - the 14th onwards is the date up to now. The IAU is on in Sydney Harbour a couple of weeks before, and hopefully nothing will crop up to stop me coming over.

I don't know when the next time will be after that. Definitely after graduating, and also depending on where in the world I get a job (if I get one!)

OK, better go, lots to do as usual. Keep up the excellent job with the meetings and transit magazine etc, very impressive stuff.

Dave.....
David T.F Weldrake

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Musical Comet

From John Crowther

A page from "Halley's Comet, 1910: Fire in the Sky". It seems the popular music composers of the day found inspiration from the sky when Halley's Comet appeared. From left to right, the comments in the book were:-

1. Bold print and a large comet with "Rag" in its tail make for a jazzy piece and complements the up-beat, bouncy cartoon guy and Gal (unfortunately obscured. Ed) and bubbly heavens.
2. Similar elements appear in a staid and stately depiction of a Merlin-like astronomer studying the comet while standing on an Earth dramatically reduced in size.
3. This fanciful sheet music cover for "The Comet March and Two-Step" pictures the comet faintly visible behind an Arab astride a camel. The cover seems to be saying "An oasis, a camel, Halley's comet and you". But why? Lost to the memory is the reason for the publisher's choice of image to represent William Leander Sheetz's Lively music.

As John said, surely the allusion is to a "wanderer across the wide open spaces".

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Astronomy and the Internet

by Rod Cuff

We start with a few websites that tell you more about X-ray astronomy and the LOBSTER project, following the talk by Dr Nigel Bannister at our March meeting; then some on light pollution and the BAA's campaign about it (will CaDAS appoint a light-pollution officer?). Neil Haggath's tutorial on H-R diagrams in the last *Transit* is illustrated by an animated whiz through a few billion years of stellar evolution, before a section of astronomical news more or less rounds things off.

By the way, last month's *Transit* included a review of *The Life and Death of Planet Earth*, by Peter D. Ward and Donald Brownlee. Alex said he'd lost the name of the reviewer: it was Fraser Cain, and the review itself is at www.universetoday.com <http://www.universetoday.com> ("Space News from Around the Internet Updated Every Weekday").

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 <mailto:rod@wordandweb.co.uk>).

X-ray astronomy

- "X-ray Astronomy Home Page" is at www.xray.mpe.mpg.de<http://www.xray.mpe.mpg.de>
- There's a well-structured tutorial from NASA at <http://imagine.gsfc.nasa.gov/docs/introduction/xray_information.html>
- The University of Leicester Space Research Centre's site, which includes information on the LOBSTER project, is at www.src.le.ac.uk <http://www.src.le.ac.uk>

Visible stars and light pollution

- "The Night Sky in the World" site (www.lightpollution.it/dmsp <http://www.lightpollution.it/dmsp>) shows satellite monitoring of night-sky brightness and stellar visibility around the world. As well as being interesting in its own right, it can show you what to expect when you go off on holiday. In recent years I've been to some amazingly dark sites, notably Malawi, scores of miles from a town in all directions - the Milky Way knocks you sideways …
- The British Astronomical Association's "Campaign for Dark Skies" site is at www.dark-skies.org/introq.htm <http://www.dark-skies.org/introq.htm>

Hertzsprung-Russell diagrams

- Appetite whetted by Neil's article last month on H-R diagrams? Want to see stars evolve across an H-R diagram on your screen? Knew you would - visit <http://instruct1.cit.cornell.edu/courses/astro101/java/evolve/evolve.htm>

News

- "The most comprehensive measurement of the cosmic microwave background - the faint afterglow of the Big Bang - has been revealed by NASA. The results, billed by astronomers as the biggest scientific breakthrough of the year, turn cosmology into

precision science for the first time" - see www.newscientist.com/news/news.jsp?id=ns99993375 <http://www.newscientist.com/news/news.jsp?id=ns99993375>

- Astronomers have found the first object apart from Venus and Mercury that has an orbit entirely within that of Earth - it's an asteroid currently known as 2003 CP20 - see <http://skyandtelescope.com/news/current/article_879_1.asp> …
- … and have also found the coolest star ever observed, with a surface temperature of 410° Celsius - cooler than a glowing coal. See <http://skyandtelescope.com/news/current/article_834_1.asp>
- The Solar System still continues to produce real surprises: for half a century, people have thought that the light 'zones' on Jupiter are formed by upwelling gases, while the darker 'belts' are formed by descending gas. The Cassini spacecraft (<http://saturn.jpl.nasa.gov/index.cfm>), on its way to Saturn, has shown that the reverse is true. See <http://spaceflightnow.com/news/n0303/09jupiter/>
- There's a truly stunning sequence of pictures at <http://spaceflightnow.com/news/n0303/26hubble/> that show a developing "light echo" of a stellar explosion in our Galaxy that was visible a year ago. If you click on no other link, do try that one.

General

- Want to buy or sell something astronomical? Try the Astro Ads page at <http://easyweb.easynet.co.uk/~chrish/aa-ads.htm> - ads are free.
- You can get free software to help plan and document your astronomical observations at www.davidpaulgreen.com <http://www.davidpaulgreen.com>

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Oceanus Procellarum. The Moon's Largest Impact

Text and drawings by Michael Roe

Oceanus Procellarum is the official Latin name of the Ocean of storms, actually the largest expanse of dark, frozen lava on the Moon. It is easily visible to the naked eye, dominating the last quarter phase of the Moon, with only a thin border to it. The origin of Oceanus Procellarum is in the earliest period of the Moons existence. The Moon itself is believed to have formed about 4,600 million years ago by the incredible collision of a Mars-sized object with the newly formed Earth, then a red-hot molten globe only a few million years old. The debris of this collision, gathered together by gravity, became our Moon – at least, that's the best theory we have at present.

By around 4,400 million years ago, the Earth and Moon were beginning to develop crust although each world was still hot and as sterile as the Moon today, constantly bombarded by asteroids of all sizes. A few gigantic impacts may have slightly exceeded the one forming Oceanus Procellarum but not much bigger, as the Moon would have been destroyed. No doubt several miles of surface thickness were added to the Moon at this time from the ferocious pounding.

At about 4,200 million years ago, the impact causing the Procellarum Basin hit the Moon, a huge asteroid about 100 miles across. It must have been an awesome event lasting

several minutes. The violence of the impact would be completely beyond imagination. The material flung out would have scattered all over the Moon and into space. Some would have collided with Earth, causing large craters here. Some of the ejected material eventually re-collided with the Moon itself, long after the event.

The gigantic crater or impact basin was a third of the Moon's surface in area, about 2,000 miles across and momentarily 200 miles deep. It must have damaged the new, thin crust and lava must have welled up, though later impacts and lava flows covered this up. The Procellarum Basin, also called the Gargantuan Basin, has an impressive series of concentric mountain ranges now, the outermost over 40,000 feet high originally.

Later, the Procellarum Basin was joined by a slightly smaller basin, the South Pole-Aitken Basin. Over millions of years, more impacts still occurring at many times today's rate battered the Procellarum Basin, smoothing and obscuring its surface. But it was still an impressive structure until 3,900 million years ago. Then the IB was formed, near the centre of the Procellarum Basin, leaving only faint traces on the far western face of our Moon. The main remains of the Procellarum Basin were a slight but wide depression. About 3,200 million years ago the Earth-facing hemisphere of the Moon began to be covered by new lava flows, mostly in the large, old impact basins. Some covered the Procellarum, outlining its western edge, though the Mare Orientale Basin covered some of this area. But, despite this, the Oceanus Procellarum is the largest mare lava area on the Moon and the only area called Ocean, rather than Sea.

It is likely that the reason the Earth-facing side of the Moon has so much lava covering is that the Procellarum Basin thinned and cracked the lunar crust so that later basins, such as Imbrium or Serenetus were filled with lava. Far side basins older and smaller have only a little lava.

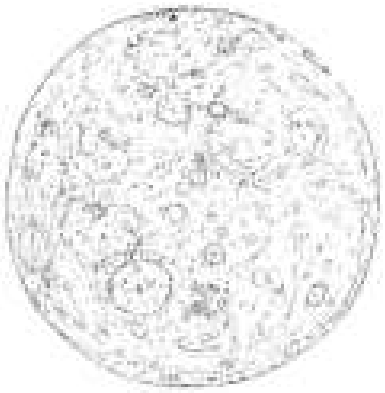

Fig 2.

The western edges of the Mare reveal a mass of flooded craters showing how battered the Procellarum Basin was across the whole face. In fact the various ghost craters on the Mare surface reveal this. These large craters are barely visible and smoothed over by lava.

Since then, a few smaller lava flows and features have appeared on Oceanus Procellarum , including the volcanic Marius Hills, Rumker Plateau and Aristarchus Plateau. Some lava flows were melted by long, sinuous rills. More recently, about 200 million years ago, the bright crater Aristarchus was formed on MP and since then many smaller craters. This huge cataclysmic event has seen all this happen but another important thing also happened. Much more recently, visitors arrived. First the Surveyor 3 robot spacecraft landed in 1967. Then in November 1969 it had two human visitors, Alan bean and Charles Conrad, the landing crew of Apollo 12, the second manned landing on the Moon. The samples brought back to Earth have revealed a great deal of knowledge about Oceanus Procellarum .

A recent spacecraft, Clementine, surveyed the Moon from orbit and its findings suggested some doubt on the Procellarum Basin but it seems real enough - a large part-circular basin of lava with a faint outer rim, just what would be expected from the largest and oldest known lunar basin. Only future exploration and deep drilling could reveal more about Oceanus Procellarum, the Ocean of Storms, and that is very unlikely in our lifetime.

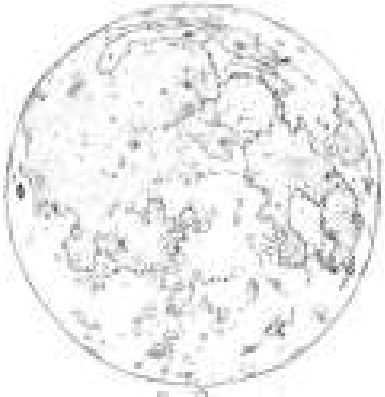

Fig 3

Astronomy Basics

by Neil Haggath

No. 11: The Life and Death of Stars – Part 1

In last month's article on the Hertzsprung-Russell diagram, I explained that the Diagram is intimately related to the evolution of stars, and that the different regions in which stars are located on it represent different stages in the life cycle of a star. In this article and the next, I'll describe the birth, life and death of stars, and how they evolve through those stages. This month, I'll concentrate on the life cycle of an "average" star like the Sun; next month, I'll describe the more exotic fates which befall its bigger and more extravagant cousins.

First, we need to consider how stars are formed. We usually think of space as being a vacuum, and by most practical standards, it's a pretty good one. But it isn't *completely* empty; even interstellar space contains some matter. This matter is incredibly tenuous – its average density is about one atom per cubic centimetre – but if you consider it spread throughout a volume of space the size of a galaxy, it still adds up to a vast amount – enough to make several million Suns, in fact!

A number of effects, such as density waves moving through the spiral arms of a galaxy, cause some of this interstellar matter to "clump", or collect into regions of slightly higher density than average. And then gravity comes into play. Very slowly at first, the mutual gravitational attraction of the matter in a denser-than-average region draws the matter towards the region's centre; it begins to condense and increase further in density. Gradually, over many millions of years, a cloud of gas and dust accumulates, several light years across, which is significantly denser than the surrounding interstellar medium.

Naturally, the denser the cloud becomes, the more quickly it condenses. Typically, the cloud contains a few thousand solar masses of matter, but gravitational instabilities eventually cause it to fragment into many smaller clumps, each a fraction of a light year across and containing just a few solar masses of material. It's these smaller clumps which will eventually condense into stars; stars are invariably born in clusters, with dozens or hundreds of stars packed into a relatively small volume of space.

As a cloud of gas and dust collapses inwards under its own gravity, increasing in density, its temperature also increases. (A little basic physics here, folks. As a given particle of matter "falls" towards the cloud's centre of gravity, it loses gravitational potential energy and gains kinetic energy. Temperature is simply a measure of the kinetic energy of atoms or molecules.) When it reaches a temperature at which it begins to emit a significant level of infrared radiation, we call the object a *protostar*. So the protostar becomes steadily smaller, denser and hotter, until something happens which prevents it collapsing any further.

That "something" occurs when the core of the collapsing protostar reaches a temperature of about ten million degrees; that's the temperature required to enable the thermonuclear fusion of hydrogen into helium. Hydrogen fusion is an exothermic reaction; though it requires a huge amount of energy to trigger it, it releases an even greater amount. Once fusion has begun, the matter in the protostar is heated to a greater degree than it could have been by gravitational collapse alone, and acquires enough

kinetic energy to counteract gravity and resist any further collapse. So from then on, the protostar becomes a stable sphere of constant size; as long as fusion continues in the core, there will be a continuous supply of energy to maintain the equilibrium.

The thermonuclear "ignition" of its core is the point at which a protostar becomes a true star – and the delicate balance between gravity and outward energy flow is what governs the remainder of its life.

At this point, we can't yet see the new star, as it's embedded within an obscuring cloud of debris, left over from the original cloud from which it was born. This surrounding gas and dust is heated by the star and begins to glow, forming an *emission nebula*. Some of these nebulae are among the amateur astronomer's favourite deep sky objects, such as the Lagoon Nebula, the North America Nebula and the magnificent Orion Nebula. These are "stellar nurseries", with entire clusters of very young stars hidden within them.

After a few million years, the stellar wind from the young stars disperses the nebula, and they become visible as an *open cluster*, or *galactic cluster*, such as the Pleiades. The Pleiades are a fine example of a very young cluster; the stars are still surrounded by wisps of nebulosity, the last remnants of the nebula in which they were born. In fact, they are estimated to be only about 50 million years old.

While stars are always born in clusters, they don't stay together forever. Over many millions of years, the random motions of the stars in a cluster eventually cause them to drift apart, and the cluster disperses. The closer together the stars in a cluster, the younger they are likely to be. (I'm talking about open clusters here. Globular clusters, with many thousands of stars, are something else entirely; their mutual gravitational attraction is strong enough to keep them permanently bound together.)

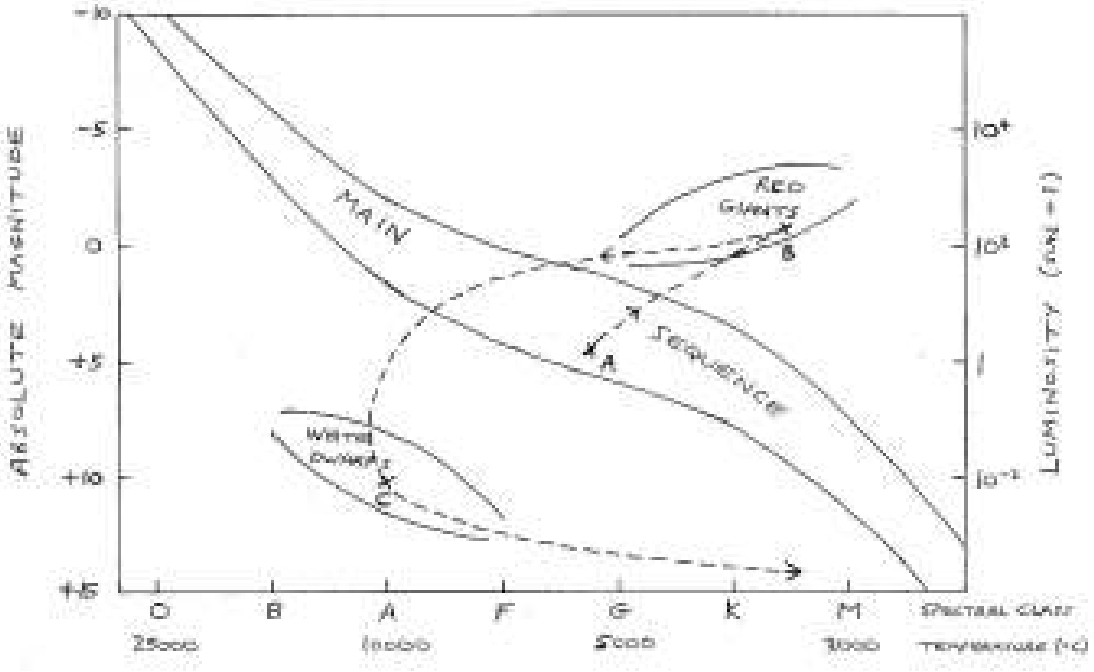

Fig. 1

Fig. 1 shows the Hertzsprung-Russell Diagram, with its three main regions which I identified last month. Since about 90% of stars are found on the Main Sequence, it's clear that this is where they spend most of their lifetimes. Red giants and white dwarfs represent stages in a star's old age, as we'll see later.

Once a star begins its hydrogen "burning", it settles into its position on the Main Sequence. In Fig. 1, A denotes this position for our Sun-like star – right in the middle of the Main Sequence. The Sun is about as "average" a star as you can get! The dashed line shows the future evolutionary path of our star – how it will progress through the various stages in its old age – but we'll come to that later.

How long a star spends on the Main Sequence is heavily dependent on its mass; the smaller the star, the longer its life. This might not seem to make sense at first; don't smaller stars run out of fuel sooner? No, because bigger stars need to generate energy at a far higher rate to balance their gravity. A star with ten times the Sun's mass needs to burn its fuel at *a thousand times* the Sun's rate; therefore it will exhaust its fuel in a hundredth of the time!

The biggest and hottest stars – those of spectral classes O and B (see Astronomy Basics No. 8) live for only a few tens, or at most hundreds, of millions of years. Sun-like stars live for around ten thousand million years; the Sun itself is currently about halfway through its Main Sequence lifetime. And the smallest and coolest M-type red dwarfs live for much longer still; many are still around now, which were among the first stars to be formed in the early Universe.

This explains why, while Sun-like stars and cool red ones are usually found either solitary or in binary pairs, hot blue and white ones are found almost exclusively in open clusters. Any newly formed cluster contains stars of all sizes, but by the time those stars have drifted apart, the most massive ones will be already nearing the end of their lives.

Now, how exactly does a star generate its energy during its life on the Main Sequence? It is initially made mostly of hydrogen, which it fuses into helium, in the same reaction which powers hydrogen bombs. The process is known as the *proton-proton cycle*; for those interested in the details, it works as follows:

Two hydrogen nuclei (which are simply protons) fuse together to form a nucleus of deuterium, or heavy hydrogen, which contains a proton and a neutron. One of the protons actually turns into a neutron, by emitting a positron (or antielectron) and a massless neutrino. The deuterium then captures another proton, to become a nucleus of helium-3 (two protons and one neutron). Finally, two helium-3 nuclei combine to form a single nucleus of helium-4 (two protons and two neutrons), with the two excess protons being released.

In equation form, the reaction looks like this:

$$p + p \Rightarrow D + e^+ + \nu$$

$$D + p \Rightarrow {}^3He$$

$${}^3He + {}^3He \Rightarrow {}^4He + p + p$$

where p denotes a proton, D deuterium, e^+ a positron and ν a neutrino.

The net result is that four hydrogen nuclei are combined into one helium-4 nucleus. But the mass of the end product is very slightly less than that of the initial protons – even accounting for the positron. So where has that "missing" bit of mass gone? It has been converted into energy, in accordance with Einstein's Principle of Equivalence, $E = mc^2$. In a star's core, hydrogen nuclei are being fused in immense numbers; that's where the constant supply of energy comes from, which "holds the star up" against gravitational collapse, and causes it to emit copious amounts of light and other radiation. The Sun, in fact, is losing mass at the rate of four million tons per second – but don't worry; it still has enough fuel left to sustain it for a long time yet!

There's also another reaction, which takes place in the cores of solar-mass or bigger stars, called the *carbon-nitrogen-oxygen cycle*, or simply the *CNO cycle*. This also fuses hydrogen to helium, but also involves atoms of carbon, nitrogen and oxygen as catalysts; I won't go into the details here.

Now let's look at what happens in a star's old age, as it begins to exhaust its supply of hydrogen fuel. You might think that it would simply keep on shining until the last of its hydrogen is used up, and then finally fizzle out, succumb to gravity and squash itself into some kind of dense, dead state – but that isn't quite the case. In fact, a star's death throes begin long before it actually runs out of hydrogen.

Fusion reactions only occur in the star's central core; its outer regions aren't hot enough. (Remember that the temperature at its centre is measured in millions of degrees, but that of its surface in mere thousands. Energy is carried from the core to the outer layers by means of both radiation and convection). The helium produced by fusion is denser than hydrogen, so it naturally sinks towards the star's centre. So the very centre of the core becomes a "dead" sphere of pure helium, with the hydrogen fusion taking place in a "shell" a little further out. This helium core produces no energy of its own, though initially it's hot enough to resist gravitational collapse.

Slowly but surely, the helium core grows ever bigger, as more helium, produced in the hydrogen-burning shell, falls into it. Eventually, it reaches a certain critical mass, at which it can no longer support its weight – and then the star is doomed. The helium core begins to collapse under gravity, while the outer layers swell up and are thrown off into space. When a star has recently undergone this process, we see it as what we call a *planetary nebula* (a ridiculous name, as it isn't really a nebula, and certainly has nothing to do with planets!). The best known example is the Ring Nebula in Lyra; the "smoke ring" is the shell of still-glowing gas which was thrown off from the star.

Then something happens which halts the collapse of the core. The collapse heats it to even higher temperatures; eventually, it reaches a temperature at which helium can itself begin fusion reactions, to form heavier elements. (In fact, it's believed that the only elements initially produced in the Big Bang were hydrogen and helium, and that all other elements which now exist have been produced in the cores of stars.)

At this point, the star enters the next stage of its evolution. This new phase of helium burning causes its outer layers to swell to an enormous size – its radius increases about a hundredfold - while its surface cools and reddens. On the H-R Diagram, it moves away from the Main Sequence, where it has resided happily for the last ten billion years, and within a very short time – a mere couple of million years – moves to point B in Fig. 1. It has become a *red giant*.

This, of course, spells disaster for any planets orbiting the star! When the Sun becomes a red giant, five billion years from now, its surface will be somewhere near the orbit of the Earth; the three inner planets will be completely destroyed.

The red giant phase is relatively short lived; it lasts just a few tens of millions of years. Of course, it now has a new core, composed of the denser products of the helium burning, and surrounded by concentric shells of helium and hydrogen burning. When *this* core reaches a critical mass, the star finally loses the long battle against gravity. The core collapses, the tenuous outer layers are thrown off, and what remains of the star, with nothing left to support it, shrinks inexorably. In Fig. 1, it moves across the H-R Diagram to point C, and becomes a *white dwarf*.

A white dwarf is a very strange object. With no energy source to resist gravity, it collapses into an extremely compact and dense state, with the mass of the Sun compressed into a sphere about the size of the Earth! It's now composed of a bizarre kind of matter, which is found nowhere else in the Universe, with a staggering density of around a million tons per cubic metre. A piece the size of a sugar lump would weigh a ton!

At such a density, the familiar laws of classical physics break down; the behaviour of white dwarf matter is governed by the laws of quantum mechanics. The more massive a white dwarf, the smaller its radius – which doesn't appear to make sense! This is because the forces between atoms try to resist further compression, but the stronger the object's gravity, the more easily these forces can be overcome, and the closer the atoms can be squashed.

But there *is* still a limit to how far a white dwarf can be compressed. There's a quantum effect which halts the collapse, and causes the white dwarf to stabilise at a particular size; it's called *electron degeneracy pressure*. As I explained in Astronomy Basics No. 8, quantum theory says that the electrons in an atom are only allowed to occupy certain discrete energy levels – like pegs placed in holes on a board. No two electrons can occupy the same level; that would be like trying to put two pegs into the same hole.

When matter is compressed to an extreme density, as in a white dwarf, all the electrons in each atom are forced into the lowest energy levels; after that, no amount of further compression can force the atoms closer together, as the electrons stubbornly refuse to budge from their places. This effect, called *electron degeneracy,* effectively exerts an outward pressure, which resists gravity and prevents the star being squashed any smaller.

Of course, the compression of matter to this dense state has made it very hot. The surface temperature of a white dwarf is around 10000^{o}C; that's why it glows white! The light it emits no longer comes from nuclear fusion; it has a thin gaseous atmosphere, which is heated to incandescence by the heat from the star's interior, generated by its collapse.

But after the collapse has been halted by electron degeneracy pressure, there's no longer any source of heating, so the star gradually begins to cool again. Very slowly, over billions of years, it becomes steadily cooler and dimmer, fading from white to red, and tailing off towards the lower right of the H-R diagram. Eventually, it ceases to shine at all, and ends its days as a *black dwarf* - cold, dark and thoroughly dead.

That concludes the story of the birth, life and death of a Sun-like star. Apart from a brief blaze of glory in its red giant phase, it's fair to say that it finally goes out "not with a

bang, but a whimper". But the same isn't true of those massive, short-lived O and B stars; they end their brief lives in much more spectacular fashion – as we'll see next month.

My thanks to John McCue, for his assistance in writing this article.

The CaDAS Interview – Pat Duggan

A substantial proportion of CaDAS membership are ladies, so the interviewer considered it was high time one of our ladies was interviewed. Pat had responded to some of the things in the Newsletter, so she seemed a likely candidate to agree to be interviewed. She has done a lot of work in her local area, Osmotherley, to keep the skies dark there. Her comments later play down the efforts she has made. I am sorry I don't have a digital camera (yet) to be able to include a photograph.

Where were you born and brought up? Croydon Surrey then Horsham Sussex. *Did you have brothers and sisters?* No, I am an only child.

Have you moved around the country a lot? Yes loads. London to train as a State Registered Nurse and take an OND. After qualifying, I lived in Southampton for a while. Jobs came up abroad and I fancied the idea of travelling the World. I have worked as a nurse in The Pacific, Liberia and Nigeria. At the present I am living in Osmotherley.

Do you like travelling? Yes. We went to Nova Scotia last fall. *Have you a favourite place?* Yes, the brook in the valley east of us here and the Pacific Ocean

Tell me about your own family. We have a son, who is an electrical engineer, our daughter is a robotics engineer and our younger son is still at Oxford, reading History.

How did you first get interested in Astronomy? I think I would have to thank my Gran for that. She used to tell me all the constellations when I was very young. Also my father was a radio ham and the squeaks and whistles his equipment made off station were always "interference in the airwaves", which made me want to know about these waves and where they were.

Where is most of your observing done? In the back garden, with my 4.5 inch reflector. We are lucky to have dark skies in Osmotherley and a group of people who want to keep it that way. *Do you specialise?* Not really. I just like dreaming that one day I will witness a supernova, preferably the first to see it.

Have you done any mirror grinding? Not for telescopes. The nearest I got was when I managed to make a plastic contact lens on a lathe once, as part of my ophthalmic nursing training

What do you like about the Society? I really enjoy the lectures.

What was your educational route? I missed a lot of primary school, so never got the chance to study astronomy. I was sent to a convent, where the nuns thought girls had to wear their gloves and hats correctly in order to get husbands or become nuns. They did not think we needed exams and gave the impression that science was not a good thing for us! I got my sense of humour there and enjoyed it tremendously. I was (and am) awful at maths but I love sciences and computing (especially the spellcheck).

Do you worry about asteroid strikes? I am much more troubled that the Yellowstone magma bubble will make the crops fail World-wide and we'll all end up fighting over the last tomato or something as sordid.

Do quantum theory and super massive black holes excite you Oh, yes, because they are so deep. However, I will have to read all about it, not do the research work. Unless I can arrange to be born again somehow.

In this Society, and in astronomy generally, I find people are life-long learners. Do you study with the OU or other distance learning courses? I always enjoy reading about advances in the understanding of these things. The course given by Fred Stephens at Harrow Road last winter was very much enjoyed.

What is the essence of astronomy for you? I think it is re-assuring that mankind is so insignificant. "Creation" is quite happily progressing with such infinite complexity and beauty and all we humans have to do is sit back and admire it.

Tell me about the memorable characters you have met in the astronomical world. As a child my mother used to work as secretary in the "Flash and Bang Joint" where some of the 1950-60s boffins worked for Royal Aeronautics Defence Establishment. She mentioned names like Hoyle and Horace Dall, who was so workaholic but married when he was really quite old. (He met Edna watching the eclipse at sea, I think). We went to their wedding and Patrick Moore was there with his telescopes set up on the roof of the Dorchester.

Have you any heroes? People who work to reduce the suffering of animals

Have you "done" all the Messier objects? No. I would be content to find the ones visible from here. I simply point my telescope and find a smudge in approximately the right place and look at a picture of what I should be able to see. If only I had more skill!

Are you a member of any of the National astronomy organisations? Yes, I joined the SPA and learn a lot from their magazine.

Do you have time for any other interests and hobbies? Well, I write as much as I can. Another interest I have is our family roots and researching the family tree. I spend a lot of time enjoying my home and garden. I love going to car boot sales and jumble sales and auctions. There is always the dream that I'll find a gem and sell it for a fortune!

People have always been my best hobby. Can I tell you about our mice? We have some tiny harvest mice (Britain's smallest mammal) to look after as part of a breeding for re-introduction program on Teesside and we saw the first babies of the year today. The adults only weigh 6 grams. One still hadn't got its eyes open. They are so pretty. We have them in large fish tanks in our dining room! We have three ducks, two geese, one dog, one rabbit, all rescues, so I am kept quite busy apart from the sky watching.
There doesn't seem to be time to read much at the moment, either.

What about the theatre, films, ballet. Yes, I like them all but there is not much opportunity in Osmotherley – well, not yet

What is your most satisfying astronomical achievement to date? Just being able to absorb the beauty of the night over the Pacific Ocean and to relate it to pictures seen in books.

Do we do enough as individuals, or as a Society, to combat light pollution? I think there is a great deal more we could do. Firstly, over the past 30 years, there have been huge advances in affordable night security surveillance systems. This means that floodlighting, which is expensive as well, can be replaced if an alternative can be suggested as desirable. Local Parish Councils do have an influence against private houses with obtrusive lighting. Local businesses can be approached for a statement of their company policy on light pollution. North Yorkshire County Council is aware of our feelings in the area because we have clearly told them we like it dark. They also see planning applications, so a friend there would be useful. Strangely, the Environment Agency at present does not have light pollution under its remit but if there were enough people to ask loudly "Why Not?" that could change. I have an encouraging letter from the woman at the top of the Environment Agency that says she has sorted out her local area as far as light pollution is concerned, with her Parish Council.

What should we do to protect the Observatory for example There must be a good way to approach this. I think a little research about sky observation sites worldwide would not go amiss. The legislation that other places use would be a "tool" when approaching the council for the creation or maintenance of a "blackout" ring.

Where does your motivation and enthusiasm come from? My theory is that it comes from an interest in difficult puzzle solving. *Do you worry about it going away? It* can't go away, it's in my brain.

Who has influenced you the most? Probably my uncle who gave us a set of children's encyclopedias when I was young. Other books were never as interesting after that!.

Do you consider yourself to be computer literate? It's a lifelong learning process!

If you were World dictator, what measure would you introduce? One language, so that we would all have to call the creator God the same name.

In a short sentence, what is your definition of a civilised society. A world where every individual takes responsibility for the well-being of their own next door neighbours, regardless of political or geographical frontiers.

Are there any questions you expected which I haven't asked? No. You have really had me brain bashing!!

Whom should I interview next. Someone involved in the setting up of the observatory and planetarium, after all it has become bricks and mortar only because several members had "the dream".

♑ ♑

The Apollo Hoax 4

Extracts from the website article continue to give you a flavour of the sort of arguments which are used in the "hoax" argument. Some of the points may well give pause for thought if you have never come across the physics or engineering before. Any reactions you have to this series is welcome, of course. Neil has sent a few comments, which I will include when all the article has been presented.

(13) Laser ranging reflectors on the Moon are proof right?

No, they are not proof that astronauts put them there. NASA and its believers claim that astronauts placed a reflector on the surface of the Moon so that astronomers may bounce laser beams off of them in order to better determine various lunar parameters, distance from Earth, period and so on. That fact is often incorrectly cited as a proof. There may well be reflectors on the lunar surface but that doesn't prove anyone set foot on the Moon. The Russians deposited a reflector during their Luna (Lunakhod) series of unmanned missions to the Moon some time in the early nineteen seventies. In fact the Russians were first with the ability to "soft land" instrument packages on the Moon in February 1966 with the Luna 9 mission. The Soviet success was closely followed by the American Surveyor missions which also "soft landed" instrument packages.
No proof of a manned Moon landing there then.

(14) Why don't they point the HST at the landing sites?

Even today, the largest telescopes in the world and the Hubble space telescope (HST) do not have the resolving power to identify the LM or what would be left of it on the Moon's surface. The smallest object they can discern is something about the size of a football pitch at the distance of the Moon and even then it would be hard to tell exactly what it was they were looking at. In order to make a specific determination they will need more information than size alone. A blob the size of a football pitch could be anything, a crater, a patch of ground or anything. The LM is of course much smaller than a football pitch.

(15) The Russians had to be in on it, right?

No, the Russians would have exposed the Missions if they could have. The 60's was the peak of the propaganda wars between the US and the USSR as it was known then. There was no known technology available that could detect the presence of humans aboard a capsule from a distance. The only means of detecting a fraud would have been from the "leakage" that may have resulted in relaying communications from the Earth to the capsule in order to make it appear to originate from the capsule or from the lunar surface. That would not have proven a problem, however, as microwave links are highly directional and thus inherently very "leak proof" and when that is coupled with secure communications methods such as frequency hopping, spread spectrum techniques, encryption and any other unusual modulation methods it's virtually certain that an outsider would not have detected it.

(16) What about Apollo 8, 9 and 10?

Apollo 8 orbited the Moon and returned to Earth. Apollo 9 never left Earth orbit. The astronauts allegedly practised deploying and docking with the LM. Apollo 10 practiced everything but the landing itself. Lunar orbit, deployment and docking with the lunar module. If they were "real" then there's no technical reason we could not have gone on to land astronauts on the Moon is how the argument goes. The answer to that is, why should the deployment and docking trials of the LM be any more real than the Moon landings? If the LM wasn't fit to land on and take off from the Moon, then why would anyone risk any space maneuvers with it? It would have been illogical to do so. Apollo 8, 9 and 10 don't prove astronauts landed on the Moon.

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A History of the Cleveland and Darlington Astronomical Society

Part 4

Barry's history of the Society continues, describing the activities of members up to the end of 2001. 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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The eagerly awaited event of a total solar eclipse observable from Britain proved to be a mixed blessing. This occurred just before noon on the 11th August 1999. From Cleveland the event was a major partial eclipse, with about 86% of the sun being obscured at maximum. As it turned out the weather was kind to David Blenkinsop, Charles Rees and John Fadian, together with about three hundred members of the public who congregated at the observatory at the Castle Eden Walkway Country Park. A variety of equipment was assembled, including 8-inch and 12-inch reflectors, with the public bringing pinhole cameras, and milar filters for direct viewing.

Jack Youdale, with thousands of others, decided to observe from Penzance, Cornwall, where an incoming weather front, with rain, blocked out the event; the sun only appearing some half hour later through breaks in the cloud.

David Graham went to Truro, in Cornwall, to observe totality but he, together with members of the British Astronomical Association eclipse expedition and about 500 other eclipse watchers, was clouded out at the appropriate time. The glimpse of a thin crescent sun just after totality was his best result.

John and Elaine McCue, Neil Haggath and Don Martin travelled to Bulgaria where they observed totality in a clear sky some two kilometres from the centreline. John observed Venus quite close to the sun but was unable to see any other celestial object, putting this down to the brightness of the corona. The corona was symmetrical and through binoculars showed fine structure, while pink prominences were seen dotted around the black edge.

David Weldrake, together with fifteen other astronomy students from the University of Hertfordshire, decided on Mt. Paringul (6,000ft), in Romania, as their preferred site, being only 1,500 meters from the point of maximum totality (2 minutes 20 seconds) on the centreline. They stayed up all night prior to eclipse day and enjoyed spectacular observing conditions, seeing stars down to 7th magnitude with the naked eye, observing many Perseid meteors, and listening to nearby wolves howling! Totality was observed from a clear sky in the company of about 100 locals. Like John McCue, David was surprised by the brightness of the corona.

John Crowther successfully observed the eclipse from Reims where he was able to see Venus and some bright stars.

Barry Hetherington and Geoff Hoddy journeyed to Ulm, in Germany, where the day started mainly overcast. This developed into total cloud and heavy rain. By the time of totality they were desperately trying to get under the only small break in the clouds. They succeeded with only seconds to spare and observed the event until a few seconds before totality ended, when the clouds obscured the sun once again.

The South Tynside College, South Shields, was the venue for the Northern Area Group of Astronomical Society's meeting in September 1999. Talks were given by John McCue – *Royal Observatory, Edinburgh*, Neil Haggath – *Total Eclipse*, and Daren Bushnall – *Deep Sky Observing Techniques*. The competition for the Thomas Wright Trophy was held with our society being victorious.

This year the Leonids meteor shower was predicted to be a storm so many people observed well into the night of the 17th/18th November, despite poor weather conditions. Cloud cover was total and in varying thickness. Chris Newman, observing from our observatory, reported that by 1am the occasional meteor was glimpsed through thin cloud but clearing skies at 3am produced a rate of two meteors a minute. There was a noticeable drop in sightings by 5am. Shortly before giving up, at 6am, there was a brilliant flash from directly above which left 'the most fantastic meteor train' some 20º in length and lasting for three minutes.

Ian Miles, John McCue and Neil Haggath went onto the moors where they experienced the same conditions. Observing between 1:40am and 3am they counted 177 meteors but could only see down to magnitude 2 at the best of times.

The 20th anniversary meeting of the society was held on the 18th December 1999 on H.M. Bark Endeavour where our speaker, Dr. David Hughes of Sheffield University, addressed the meeting on *The Star of Bethlehem*.

Many society members witnessed a fantastic aurora on the night of the 6th/7th April 2000 between 22:30 and 0:30 GMT. Vivid shafts of light blue, green and blood red colour lit up the night sky.

After midnight on the 22nd July 2000 David Weldrake and Darren Bushnall observed comet Linear S4, predicted to be a spectacular sight. They were not impressed with its magnitude of 7 with a bright coma. It had a stellar nucleus and a broad fan tail around 20 arcminutes in length.

Visitors to the observatory on the 6th October 2000 were viewing the first quarter moon when, at 20:39, an aurora appeared. It covered an area of about two-eighths of the sky, was greenish in colour, and was visible until the sky clouded over about half-an-hour later.

Cosmos IV moved to a new venue, the Pursglove Centre, adjacent to Prior Pursglove College, Guisborough. The convention, held on the 7th October 2000, featured Dr. Paul Murdin, Science Director of the British National Space Centre, and former Director of the Roque de los Muchachos Observatory on La Palma – *Black Holes are Real*; Dr. Carole Haswell (former society member) – *Searching for Black Holes*; Dr. Alan Chapman – *Giovanni Domenico Cassini, Pioneer of Planetary Astronomy*; Peter Rea – *Passage to a Ringed World*; and Paul Money – *2MASS: A New View of the Universe*. Neil made a profit of £65.15 which he donated to the society.

The competition for the Thomas Wright Trophy was held at Thorpe Thewles on the 8th December 2000. Teams from Durham, South Shields and York, as well as ourselves, took part with the winner being Durham Astronomical Society.

Observing from the observatory on the 2nd March 2001, Charles Rees, David Weldrake and Darren Bushnell observed a fireball heading from the constellation of Ursa Major towards Coma Berenices and then into Virgo, disappearing between the stars Arcturus and β Leo Minoris. The yellowish/orange fireball was as bright as the planet Venus and was seen breaking up as it descended. There was no sonic boom and the event, which occurred at 21:32 hours, lasted for about ten seconds.

On the 11th April 2001 an aurora was seen independently by Charles Rees and David Graham. At David's site, at 22h UT, the event developed into definite auroral rays filling the circumference of the northern sky. The rays stretched as far north as the bowl of Ursa Major and took on a distinct red colour. At 1:15 moonlight overpowered the event.

In June 2001 John McCue received an e-mail from David Weldrake to say that he had arrived safely in Australia to begin his Ph.D. work at Siding Spring Observatory.

The Leonids on the 19th November 2001 proved to be a spectacular sight for Darren Summerfield. He popped over to Australia where he observed the event from Alice Springs. He saw his first Leonid at 1:24 am (Australia time). From then on the number of meteors increased and peaked between 3:30 and 4:00. During one 2-minute period he counted at least 50 meteors. After 4:00 twilight began to interfere and at 4:45 he stopped recording. In just over 3 hours he had seen well over 1250 meteors, and he estimated that at maximum, just before 4:00 am, they were coming at the rate of 4000 an hour.

David Weldrake, working on his Ph.D. thesis in Australia, went up to Mount Clear, where his party observed heavy thundery rain – and snow! They moved off to Stromlo, to be followed by the rain. The event was a disaster – not one meteor was seen.

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Do you recognise anyone?

This black-and-white picture was given to me by a long-standing member of the Society. There are at least two people in the shot who are current members. For this month the questions are 1) What year was the picture taken? 2) Where was it taken ? 3) How many can you name? and 4) What caption would you add to the picture?". Answers to me by May 1st, please.

Transit Tailpiece

Quote/Unquote

I believe a leaf of grass is no less than the journey-work of the stars.
Walt Whitman

The Universe may
Be as large as they say.
But it wouldn't be missed
If it didn't exist
Piet Hein

The Universe was brought into being in a less than fully formed state, but was gifted with the capacity to transform itself from unformed matter into a truly marvellous array of structure and life forms.
St Augustine.

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

The Back Page Picture

The front page and the back page pictures seem to form a pair. I came across them on the NASA website, where there are masses of wonderful astronomical images available for downloading. The one on the front page always intrigues me. I don't know how or when it was taken – it can only have been from one of the shuttles, one supposes. Note that the dustbin lid is open. To see such an object suspended in space is counter-intuitive, somehow. Oh yes, and what is the big round thing hanging down under the telescope?