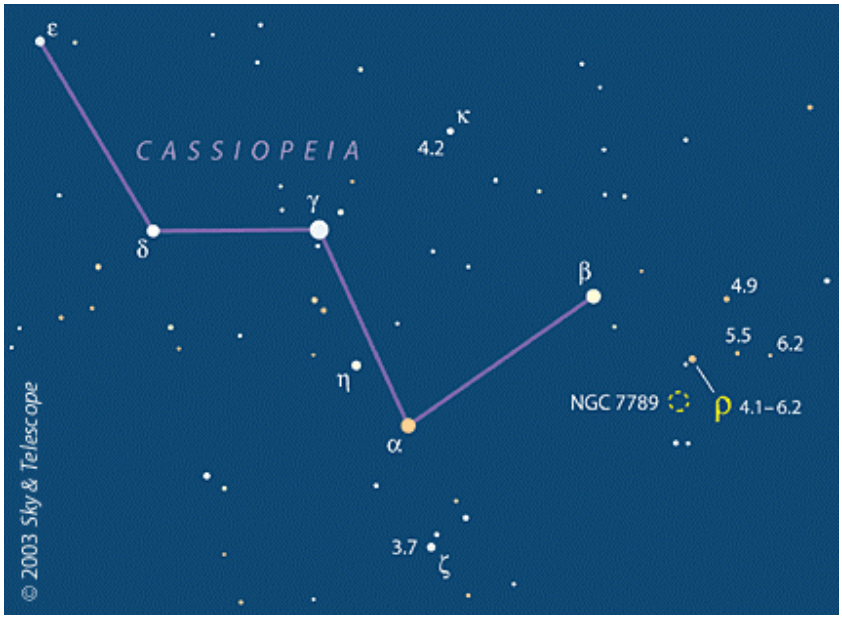
TRANSIT

The Newsletter of

Cleveland & Darlington Astronomical Society

11th October, 2003. Julian Day 2452924



Front page picture

To complement part of our new logo – Cassiopeia.

Editorial

The Society Book Project. Please let me have your articles for the book as soon as possible now. Yes, it really is the end of September!! If we are to publish next year, we need to collect things together and do all the editorial and production work necessary. Only 5 authors have turned up with the goods so far.

Keith's Video. We are looking for a member who has video editing capability and skills. Keith Johnson has offered to put his and maybe other members' images on a video. This is a wonderful opportunity for us all to tap into the Society expertise and have a really worthwhile collection of astronomy pictures.

Boulby Deep Mine Eight Society members visited the mine on the 4th of September, to see the Dark Matter Laboratories. There is a report later.

September meeting Dr Fred Stevenson's talk on "Recent Developments in Cosmology" was attended by the usual good turn-out of members.

October meeting. Please note that the meeting is on a Saturday, 11th October at 2pm in the Planetarium. Admission is by ticket only, available from John McCue before-hand. The former cosmonaut Alexander Alexandrov is visiting.

Chairman's History of the Society. The concluding Section of Barry's history is in this edition. Comments and corrections, please.

Neil's Basics Articles. The 15th and final article, on eclipses, appears this month. Transit won't be the same without them. I'm sure Neil will go on contributing on all sorts of interesting subjects.

Society Web Site. I hope you all visited the Society website following the article by Ed Restall last month. We have what must be one of the best Astronomical Society websites in the country. There is a new area for buying and selling equipment and suggestions for changes. Opinions, please.

New Logo. You may have noticed the changed logo at the head of the newsletter. The colours may be adjusted but the idea will remain. Ed Restall has put a lot of time into this and has produced an excellent result – evolution, not revolution, and Locomotion and colour! Note Cassiopeia in the stars from the chimney. CAS – Cleveland Astronomical Society, of course.

Member's Night. Now is the time to be getting together your Member's Night Talk for January 9th, 2004. Please contact Neil and tell him what you are going to talk about for 20 or 30 minutes.

Transit Photo-copying As many of you who receive Transit by post saw last month, we are having problems with copying Transit. We are having to change our printing method and hence this reduced, 12-page version for October. Apologies to John Crowther and Barry Hetherington for having to leave out your articles. I will explain in more detail at the next meeting and in future editions.

Astronomy Not-So-Basics
No. 15: Lunar and Solar Eclipses – Part 2
(or Why I'm Looking Forward to 22 July 2009!)

by Neil Haggath

OK – daft title again! Once again, this article goes a little beyond what can really be classed as "basics", but it follows on from the last one.

Last month, I explained the causes and properties of the different types of eclipses. This time, I'll explain why similar eclipses recur at regular intervals – and the meaning of my strange subtitle will become clear!

As I explained last month, due to the inclination of the Moon's orbit, an eclipse can only occur when New Moon or Full Moon happens to coincide with one of the nodes of its orbit – the two points at which it crosses the plane of the Earth's orbit (the Ecliptic Plane). So how often does this happen?

If the *line of nodes* of the Moon's orbit – the line between the two nodes – always pointed in the same direction in space, then it would line up with the direction of the Sun once every six months; each node would line up with the Sun at the same time each year. But this isn't quite what happens. Due to an effect of the Sun's gravity, the line of nodes rotates at a rate of about 19^{o} per year; each node moves around the Moon's orbit once every 18.6 years. Because of this *regression of the nodes*, the alignments of the nodes with the Sun occur slightly more than twice per year; in fact, the interval between successive alignments of the Sun with the same node is 346.6 days – 18.6 days short of a year. We call this period the *draconic year* or *eclipse year*; this is very important, as it determines when eclipses can take place. It's also important for another reason, as we'll see later.

So we can see that every half an eclipse year, it's possible for an eclipse to take place, *if* New Moon (for a solar eclipse) or Full Moon (for a lunar eclipse) happens to coincide with the alignment of the node with the Sun. Fortunately, this isn't as much of a restriction as you might think! Because the Sun, Moon and Earth have appreciable angular sizes, the alignment of the Sun with a node doesn't need to be exact for an eclipse to occur; one can still occur if the alignment is out by a few degrees either side.

In fact, a solar eclipse can occur if the Sun is within 18.5^{o} of a node. The calculations to prove this are a little beyond the scope of this article (Translation: they are a little beyond me!); parallax due to the observer's position on the Earth also plays a part. Since the Sun appears to move along the Ecliptic at very nearly one degree per day (You don't say!), this means there is a period of 37 days, centred on the Sun-node alignment, during which it's possible for a solar eclipse to occur. We call this period an *eclipse season*; there are of course two eclipse seasons per year.

Now this is interesting. As we all know, the interval between successive New Moons is about 29.5 days. (This is two days longer than the Moon's orbital period, due to the Earth's orbital motion.) As this is less than the length of the eclipse season, it follows that at least one solar eclipse *must* occur during every eclipse season – and it's possible to have two during a single season. It should be obvious that total and annular eclipses occur near the middle of the eclipse season, and partial ones near the beginning or end of it – so in any eclipse season, we get either one total or annular eclipse, or two partial ones.

So this explains why, as I stated last month, there are always at least two eclipses in any given calendar year, and often more.

For lunar eclipses, each eclipse season is somewhat shorter – only about 22 days; this is determined by the width of the Earth's shadow at the Moon's distance. As this is less than the interval between Full Moons, it follows that there can be no more than one lunar eclipse during an eclipse season, and sometimes none. So it's possible not to have a lunar eclipse at all in a given year.

In fact, one eclipse season can contain *three* eclipses – two solar and one lunar!

So we can see that solar eclipses are actually more common than lunar ones, in the ratio of about five to three – though of course, lunar ones are much more common from any given location, as each one is visible over a much bigger area of the Earth.

So the minimum possible number of eclipses in a calendar year is two – both of which must be solar. The maximum possible, due to various subtleties of eclipse seasons, is seven – which must consist of either five solar (all of which must be partial) and two lunar, or four solar and three lunar.

"Hang on a minute!" I hear you say, "How can there be *five* solar eclipses in a year, if there are no more than two in an eclipse season, and two seasons per year?" Well, remember that the eclipse year – the cycle of eclipse seasons – is 18.6 days less than a calendar year. So if one eclipse season begins within the first few days of January, then the *next but one* season will begin in late December of the same year, and overlap into the following January. While we can't have three complete eclipse seasons in the same calendar year, we can have "two and a half"; hence we can have five solar eclipses, but not six.

Similarly, if an eclipse season begins in late December of the previous year, then we can have three lunar eclipses in one year. It's obvious from the above that years with seven eclipses are quite rare; the last one was 1982. So we now see how it's possible to predict the dates of future eclipses, by calculating the dates of eclipse seasons and New and Full Moons. But there's another subtlety of eclipses, which is much more interesting. As I said at the beginning of this article, *similar* eclipses recur at regular intervals.

To be precise, starting from *any* given eclipse, we know that another will occur, *in almost identical circumstances*, after an interval of 6585.32 days. (e.g. following a total solar eclipse, another of almost equal duration will occur after this interval.) This period works out as 18 years and either 10.32 or 11.32 days, depending on how the leap years fall. This interval is known as the *Saros*; it's a Greek word, as the Saros was known to the classical Greeks. In fact, it was discovered even earlier, by the Babylonians, around 600 BC, and they learned to use it to make the first predictions of future eclipses. The first known prediction was by the Greek philosopher Thales, who is often regarded as the world's first scientist; he correctly predicted the eclipse of 25 May 585 BC.

A series of eclipses, each separated by one Saros, is predictably known as a *Saros series*. Since eclipses occur much more frequently than once every 18 years, we can see that there must be many different Saros series interleaved with each other; in fact, at the present time, there are 42 different Saros series underway.

From now on, I'll talk only about solar eclipses, though everything I'll say also applies to lunar ones. Lunar eclipses also occur in Saros series, but since they are much easier to observe than solar ones, without having to travel to exotic parts of the world, that fact is of little interest to us.

So how does the Saros come about? It's a coincidence of three different periodicities in the motions of the Earth and Moon; one Saros is almost an exact multiple of each of the three periods. The first period we need to consider is the interval between successive New Moons, which we call the *synodic month*. This is equal to 29.5306 days. As a solar eclipse can only occur at New Moon, it's obvious that the interval between any two of them must be an exact multiple of this period; the Saros is equal to exactly 223 synodic months.

The next period is the draconic or eclipse year, the interval between successive passages of the Sun through the same node of the Moon's orbit. To be precise, this is equal to 346.6201 days. A Saros is *almost* exactly equal to 19 eclipse years, but for a few hours; 19 eclipse years is actually equal to 6585.78 days.

The alignment of these two periods is enough to ensure that another eclipse will occur one Saros after any given one. However, by a remarkable coincidence, a Saros is also almost an exact multiple of a third period – and it's this coincidence which leads to the successive eclipses in a Saros series being almost identical to each other. This third period is the Moon's orbital period – to be precise, the interval between successive perihelia, which we call the *anomalistic month*. This is equal to 27.5546 days. And 239 anomalistic months equals 6585.54 days; again, within a few hours of a Saros!

So we now see why the eclipses in a given Saros cycle occur in very similar circumstances. At each one, the Moon is at very nearly the same position in its orbit, and therefore at the same distance from Earth. And since successive ones occur at almost the same time of year – only 10 or 11 days different – it follows that the Earth is also at almost the same position in *its* orbit. Therefore, each eclipse in a series is almost identical to the previous one – e.g. if it's a total, then the duration of totality will differ by only a few seconds.

Almost identical, that is, but not quite. Since the three periods don't quite match up exactly, each eclipse is very slightly different from the last; those slight differences add up over time to produce major differences over a long period.

Though successive eclipses of a Saros series are so very similar, they are *not* visible from the same part of the Earth. The reason for this should be obvious, since the Saros is not equal to an integer number of days. Remember, it's 6585.*32* days; in that third of a day, the Earth makes a third of a rotation, so each eclipse occurs 120^{o} further west in longitude than its predecessor.

So every three Saroses, or just over 54 years, another eclipse can be seen from almost the same geographical region. Again, almost, but not quite; there's another subtlety here. Within each Saros series, successive eclipses also move slightly north or south in latitude – always in the same direction within the same series, the direction being determined by which of the Moon's nodes the eclipses involve.

This is another consequence of the fact that 19 eclipse years don't quite equal 223 synodic months; there's a discrepancy of about 11 hours. So at each successive eclipse in a series, the Moon's position with respect to the actual node moves very slightly backwards – i.e. south if the eclipses occur at the ascending node, or north if they occur at the descending node.

So if the eclipses in a series occur at the ascending node, then the track of each one on the Earth's surface is slightly further south than the previous one; if they occur at the descending node, then their tracks move steadily northwards.

Fig. 1 illustrates this trend; it shows the paths of totality of six successive total eclipses in a Saros series, which occurred between 1901 and 1991.

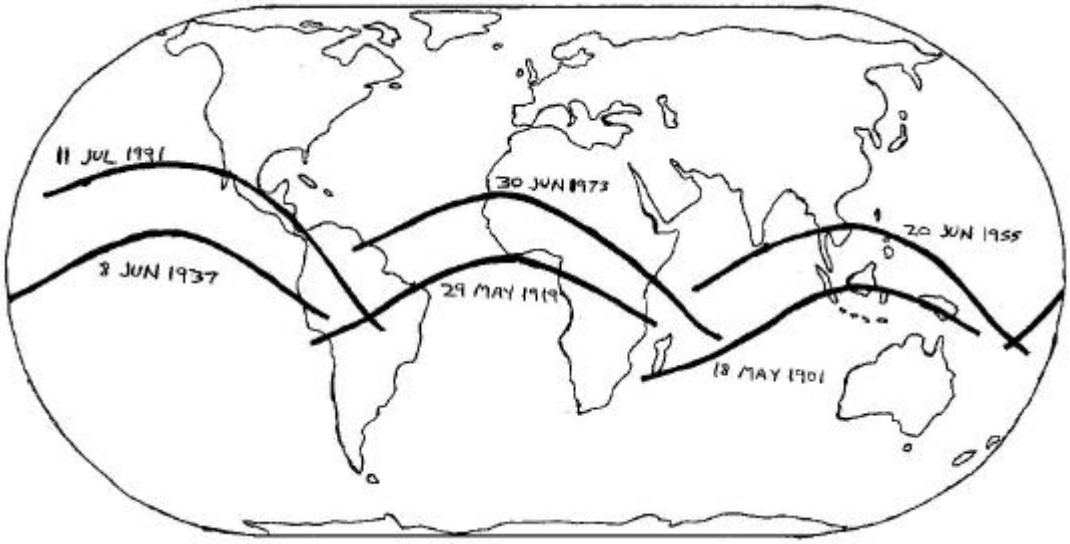


Fig. 1

It therefore follows that Saros series are finite. Each one begins with an eclipse near one of the Earth's poles, and ends with one near the opposite pole. A typical series lasts around 1300 years, and consists of around 70 eclipses; the number can actually vary between about 65 and 80.

I said earlier that there are currently 42 different Saros cycles in progress; many earlier ones have been identified from historical records. Each one is identified by a number, and the eclipses within it are numbered. For example, Fig. 1 shows part of Saros 136, which comprises 71 eclipses; the six shown in the diagram were numbers 31 to 36 of the series. The one which I've so far seen – that of 11 August 1999 – was the 21st eclipse of 77 in Saros 145.

Throughout a Saros series, the characteristics of the individual eclipses vary slightly in a systematic way. This is, of course, due to those slight misalignments of the three periods; at each successive eclipse, the Moon is at a slightly different position with respect to the node, and at a slightly different distance from Earth. Early in the series, partial eclipses steadily increase in magnitude, or total or annular ones increase in length by a few seconds each time. A maximum is reached around the middle of the series, then the trend is reversed. In fact, in a typical series, the first few and the last few eclipses are partial, and the middle 50 or so are total or annular.

Why do the durations of totality peak in the middle of the series, and then decrease again? This is for two reasons. The first is because, again due to the slight mismatch of the periods, successive eclipses occur at different times within their eclipse seasons; the first and last few occur near the start or end of the season, and those in the middle of the series occur near the middle of the season. The second is due to the changing latitudes of the eclipse tracks on the Earth; after all, an observer on the Equator is 6000 km closer to the Moon than one in the Arctic or Antarctic, so the longest eclipses are the ones whose tracks lie near the Equator.

Well, that's all I have to say about eclipse seasons and Saroses – but I'd like to end on a personal note. Now it's time to explain my strange subtitle – "Why I'm Looking Forward to 22 July 2009!"

Of the 42 Saros series which are currently underway, there is one particular one which is near its middle, and whose eclipses occur in particularly favourable circumstances, resulting in durations of totality which are nearly as long as you can get. This is in fact Saros 136, part of which is shown in Fig. 1. The last eclipse of this series was the one of 11 July 1991, whose path crossed Hawaii, Mexico and part of South America. Its maximum length of totality, in Mexico, was 6 minutes 54 seconds.

The previous one in the series, on 30 June 1973 in the Sahara Desert, was a few seconds longer. And the one before *that*, on 20 June 1955, had a maximum duration, in the Philippines, of 7 minutes 8 seconds. This was the longest totality in recorded history, and only 23 seconds short of the maximum possible!

The 1991 event was my first attempt at a total eclipse; I and four CaDAS friends travelled all the way to Hawaii (where totality lasted a little over four minutes) – only to be completely clouded out! I couldn't possibly describe how we felt on that day – at least, not in print…

As you should now be able to work out for yourself, the next eclipse in this series occurs on 22 July 2009, and its track crosses India and China. This will be our next opportunity to experience a "really long" totality – 6 minutes 39 seconds at maximum – and I want to be there!

Finally, another very important date in my long-term calendar is 21 August 2017. "Why?" you may well ask. Well, the only total eclipse which I've actually *seen* so far was the one of 11 August 1999. I'm sure I don't need to tell you now, that that date in 2017 is the next eclipse of *that* Saros series. It's also a nice accessible one, as it crosses the mainland United States.

In the last couple of decades, as worldwide eclipse chasing has become a popular activity among us astronomers, some have begun "Saros chasing" – setting themselves the goal of "completing a Saros", or seeing two successive eclipses of the same Saros series. That's why I've set myself that particular ambition.

Leif Robinson, the former Editor of *Sky and Telescope*, has gone one better; he has actually seen *three* successive eclipses of a Saros series, in 1963, 1981 and 1999! Whether I can equal that achievement remains to be seen; I'll be 73 years old in 2035!

Author's note: This brings us to the end of my Astronomy basics series. I've enjoyed writing the articles, and I hope some readers have found them useful. Of course, those of you who have joined the Society within the last 18 months will have missed the earlier articles in the series; if anyone would like to read any which you have missed, please e-mail me at neil.haggath@ntlworld.com, and I'll gladly e-mail you copies of any which you request.

Giving credit where it's due, my thanks to John McCue, for his considerable assistance in writing these articles. Though he will probably modestly deny it, John has contributed a lot, by reviewing my writing and keeping me right, and helping me with some awkward explanations. There have been a couple of articles which I really couldn't have written without his help. Thanks a lot, John!

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The CaDAS Interview – Don Martin

Several people had said that it was about time our Society eclipse expert was interviewed. Don was having problems with his internet service provider and he is ex-directory but eventually we arranged to meet in Darlington. He found me ok, although, from the eastern approach, my house isn't the easiest to find. We settled down in the front room bay on another wall-to-wall sunny day. This is largely the story of a man searching for the perfect eclipse.

The obvious opening subject with you is Eclipses – how many have you seen?
Well, I've travelled to five and seen four. The missing one was Hawaii, 1991, when a few of us from the Society went there. *But more of that later, Don, when we come to it.*

By the way, do you prefer Don or Donald. I notice your email address is "Donald"
I don't mind, really. Everyone calls me Don.

Ok. Start with your first eclipse.
That was in 1983, in Java. I travelled with a travel company called "Explorers", who arrange everything to give the very best chance of seeing the eclipse *Ah, yes. Julia McBride did a talk at a Member's Night on an eclipse she saw in Africa.* I was just getting really interested in astronomy at the time, saw an advert and decided to further my enthusiasm in this way. I took two cameras and telephoto lenses to see the eclipse and record it. Patrick Moore is usually on these trips, along with about 200 other people on this occasion. We flew to Jakarta and then took another plane to the south-east of the island. It is an enormous place, without roads or railways, so flying in rather ancient aircraft is the only practicable way of getting there.
The holiday and the travelling was as interesting and exciting as the eclipse itself. We spent two weeks out there and went to Hong Kong and other places. I sat in the next seat to Patrick and we conversed for 4 or 5 hours. Of course, people kept coming to talk to him and interview him as well.

The eclipse itself was tremendous. For my first one it was sensational. A duration of six minutes of total eclipse. There are long waits, while the first contact comes along, then when second contact comes it is all chaos, everything happening at once and trying not to make silly mistakes. In the last ten minutes of the Sun being covered, it goes very cold and quite dark. The wild life goes quiet, the birds roost and the night animals start to come out. It's amazing.
The locals had all sorts of different reactions to the event. There were drums being beaten and whistles blown. Some were worried about evil spirits, some were praying and not looking at the event. It depended on their religion. Others were cheering.
We also had a military escort because the President and his entourage of important government officials had to be protected.
Half an hour after the eclipse the clouds covered the sky! It may be that the local weather effects of the darkening of the Sun brings this on. It seems to happen a lot.

How did you get started in Astronomy?
Oh, it was when the Society got started. John McCue and John Nichol were doing their night class lectures and the Society was formed. On the first night 150 people turned up! I met Neil Haggath and we have been firm friends ever since. I bought a telescope and gradually improved my knowledge. Sold one to a Durham chap who later appeared a lot on "The Sky at Night". It must have been about 1983-ish. *Good heavens, that's 20 years ago!* So it is.
We were very enthusiastic in those days, travelling all over the country to other venues and Astronomy Societies, to meetings in London, to Bacup AAC to help them out.
I'm still very interested but more as an armchair enthusiast. Read all the magazines. I find the conditions in this country, with the weather and the light pollution, makes practical astronomy and astro-photography very hard work.

So 1983 was number one eclipse. It sounds difficult to top that one.
The following year, 1984, there was an annular eclipse to be seen in Washington DC, on the east coast of the USA. Once again, I went out with Explorers. This time there were about 50 people in the party but no Patrick this time. The trip was to include a space shuttle launch as well as the eclipse. We went to Chesapeake Bay in a bus but the weather was bad – there was no chance of seeing anything. So the bus driver took us south and we chased the eclipse into South Carolina. When the clouds cleared we stopped and did our observing. It was quite difficult technically, being an annular.
We went to see the maiden launch of Discovery but when we got there, it was engine testing only that we saw – and heard! 200 decibels near the launch, with toxic hydrochloric acid clouds near the launch pad. We were about 3 miles away, luckily. There were 5 shuttles then. Another one was built and they have lost two, so there are 4 left now.

What was the next trip?
The next time I went with Explorers was not for an eclipse but for Halley's Comet. We went to Australia for a general holiday, including Siding Springs and the Parkes radio telescope. Patrick Moore was there and a lot of eminent people from Universities etc. This helped when we were touring the Observatory. We were admitted to all sorts of

places the general public never see, such as the Schmidt telescope doing the full survey of the southern sky.
We stayed about 100 miles from Siding Springs and travelled across miles and miles of uninhabited country. The skies were pitch black. No Moon. You couldn't see your hand in front of your face. The stars were sensational. We thought it was cloudy, then realised there were so many stars it just looked that way. It was very difficult to make out the constellations – too many stars! I estimate I could see down to about 7th magnitude. Never seen anything like it in this country.
I guess this was the high point of my enthusiasm for astronomy. The weather was good night after night. Since I was doing scientific work for "Comet Watch", there was no rush or panic, like an eclipse. I saw Mercury rising for the first time and Venus.

You should write all this up for the Society book, you know. Yes, I'm getting it together but it takes a lot of time. *Can I press you to start now and get it in as soon as possible?*

And the next eclipse?
That was in 1988, in the Philippines, for a total eclipse, with Explorers. Patrick Moore was on this trip, too. It was a disaster for all sorts of reasons. The Philippines is an archipelago of lots of small islands. We were taken to one where the rebels had agreed not to interfere with us. My suitcase and most of the gear didn't arrive, my camera drive failed and the site was clouded out. We did see it through thin cloud and experienced the temperature drop (15 centigrade degrees) and the darkness and the wildlife reactions, though. And the rest of the holiday was good.

Then came Hawaii?
Yes. 1991. Neil, John McCue, Dave Graham, Jack and me. There were lots of people on this trip, about 250. We split up into two groups. We were not allowed into the hills for some reason, so the observing site was down on the coast. A few people in the group stayed at the hotel and we went to the coast by school bus, setting off at about 2.30am. Having got set up it started to rain and we saw nothing. The group at the hotel had perfect viewing! The second part of the holiday was to go to the west coast of the USA and visit Mount Palomar and other observatories. Because Patrick was with us we were admitted to all the inner circle places. It was fascinating and wonderful.

Were you born and brought up in this area?
Yes. Lived here all my life. I have a younger sister who lives near London and my mother lives with me in Billingham. *And you work in the area?* Yes, at Wilton at the Huntsman Pu plant producing aniline. We get regular health checks, which I appreciate. They are trying to get me to lose weight at the moment – *Don patted his middle.*
Are you computer literate? Oh, yes, both at home and at work. Everything is computer controlled there.

Any more eclipses?
Yes, in 1999 Elaine and John McCue, Neil and I went to Bulgaria, to see the total eclipse. Bulgaria gave the best chance for the weather and it was on the line of totality. I took on the role of eclipse advisor and did all the car driving. We chose a place on the coast,

well away from the official site (which was packed) and did our own thing. The eclipse was clear of cloud and we had a great observing time. No matter how many you go to, they are always a surprise – the speed at which everything suddenly happens, the going cold and dark, the strange silence.

Now you're an armchair astronomer, do you have time for any other hobbies?
I've always been interested in walking and rambling. My holidays are now wild-life oriented, bird-watching and all that. I go to Scotland a lot and Norfolk and Suffolk. I've also been to the Galapagos Islands. Then there was Peru and Ecuador, condor watching. Next week I go to Brazil, to tour the Amazon basin. That will be just incredible. And of course the skies are dark in these places and perfect for astronomy.

At this point I gasped at this man's sense of adventure and wonder at the World and his determination to follow up his interests to the hilt. What else can you ask such a character?

One more question – comment on CaDAS.
The thing I like about the Society is it's informality and lack of pomposity. The lecture programme is always excellent and we can have a cup of tea and a chat afterwards. The membership numbers seem to be recovering again after a bit of a fall.

And on that note, we had a cup of tea and a chat with my wife, Nita. Very pleasant.

Transit Tailpiece

Quote/Unquote
John Crowther followed up the quote from St Augustine in a previous edition of Transit with another memorable quote of the Saint's.
When asked "What was God doing before he made the Universe", he replied "He was busy making Hell; a place for people who ask questions like yours!".

Make no little plans; they have no magic to stir men's blood and probably they will not be realized. Make big plans; aim high in hope and work . . .
Daniel H. Burnham

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(s)

Here's one I came across on some website or other. No, it's not a big Christmas cake, but a 10 metre mirror for one of the amazing big telescopes which have been coming on stream over the last few years.

And a picture from space of a hurricane approaching Florida. It must be very intimidating to see one of these things about to engulf you.

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