TRANSIT

The February 2012 Newsletter of

Cleveland & Darlington Astronomical Society

NEXT TWO MEETINGS at Wynyard Planetarium

Friday 10 February 2012, *7.15 for 7.30 pm*

Members' Night + AGM

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Friday 9 March 2012, *7.15 for 7.30 pm*

How the outer planets were NOT discovered

Dr Colin Steele, *Manchester University*

Contents

Editorial

Rod Cuff

Welcome to new members Mervyn & Jacob Wright, Emma Chapman, Mark & Steph Wilson and Philip Gaines. We hope you enjoy not only your first issue of *Transit*, but also many years of interest and involvement with CaDAS and astronomy in general.

This issue is dominated by two articles from seasoned and appreciated contributors. Neil Haggath has written a pair of articles about the Transit of Venus, which event will engage us and no doubt the media in June this year. The second of them, on the history of observations of the transit, will appear in mext month's issue, but this first article explains in depth why the transits occur when they do, and I must say it taught me a lot.

Ray Worthy takes an iconoclastic view of the semi-deification of Edwin Hubble, and an intriguing tale it is, too – not at all the story most of thought we knew …

I seem to have done very little observing this season so far. It seems that if it's not cloudy, then it will soon be, or it's close to Full Moon, or it's several degrees below freezing, or I'm out somewhere else for the evening. My partner and I escaped the British winter for two weeks recently in Tenerife, where we enjoyed (for the 15 minutes we could all tolerate the bitter temperature at 8,500 ft up) the pitch-black night skies as seen from the slopes of Mount Teide, the world's fourth-highest volcano. Arrogantly believing I wouldn't learn anything new about the sky from our excellent guide, I was chastened to fail the challenge of more or less his first question: 'Can you find the Pole Star?'. Where on earth was the Plough and its pointer stars?? It turns out that, despite the Canaries being comfortably north of thte Tropic of Cancer, Ursa Major is not circumpolar there, and in this case was below the northern horizon!

A few days later, back at our hotel, I was looking at Jupiter (virtually overhead – altitude 87°) when a satellite came swiftly in from the left of my field of view. In what felt a very weird experience, it either crossed or very nearly crossed the face of the planet – I wish I'd been recording that! Using the Heavens Above website, I found it to be the Russian Cosmo 1300 satellite, which has been up there for over 30 years. I wonder how many other observers have ever been lucky enough to see it pass in front of a major planet?

I also had a best-ever view of the Green Flash as the Sun set over the Atlantic – in fact, a double sequence, each of several seconds duration, the first being as the Sun passed behind a very low, perfectly horizontal band of cloud. Perhaps I should just move to the Canaries …

I understand there are some good talks from experienced members lined up for our next meeting – Members' Night on 10 February, immediately after the AGM. The evening should be well worth attending, though alas I can't be there, as I'm going to Astrofest in London that weekend.

The deadline for *Transit*'s March edition is **Sunday 26 February**.

Rod Cuff, info@cadas-astro.org. uk*,1 Farndale Drive, Guisborough TS14 8JD (01287 638154)*

Letters

Hooray for Brian Cox

from Neil Haggath

These days, we hear a lot of garbage in the media about 'balance', 'presenting both sides', etc. – which basically means giving airtime to conspiracy theorists and other nutcases.

If only more TV presenters would have the sense and/or the bottle to speak their minds like Prof. Brian Cox!

During the first programme of the BBC's *Stargazing Live*, he spoke to Gene Cernan, the last man on the Moon. Inevitably, this led to people e-mailing stupid 'conspiracy' questions, like 'Why does the flag appear to be waving?'

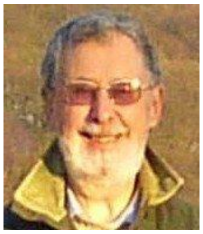
At the start of the second programme, Brian gave the obvious answer to that question, then said, 'If you think we didn't go to the Moon, then switch over to ITV – I don't want you here!'

Later in the same programme, he was debunking UFOs. He showed a typical 'UFO' photo, which had a simple explanation, and said, 'If you think this is an alien spaceship, then it's time you switched over to *Celebrity Big Brother*!'. We need more like him!

Best wishes – Neil

The Drake equation

from Ray Brown



The Drake equation was the subject of one of those drawn-out TV documentaries we have to be grateful for nowadays. From the title, I didn't expect much and so was not disappointed.

Drake did recognise what is possibly the most elementary rule in statistics, namely that the probability of several independent events all occurring is the product of their individual probabilities. However, that realisation does not get us far when we have practically no means of realistically estimating most of those individual probabilities. Drake's guesses were wild over-estimates.

The programme ignored the very special, if not unique, conditions that allow our planet to host multicellular life; viz, a suitable rotation frequency (which maintains surface temperatures in a suitable range) and a rotation axis largely stabilised by an unusually relatively large satellite (our Moon), not to mention a nearly optimised level of volcanic activity and sufficiently infrequent bombardment by large meteors etc.

Fermi thought that Drake's estimate (tens of thousands of years) for the longevity of a hi-tech species was probably optimistic (the steam engine is barely a couple of centuries old, radio roughly half of that and nuclear weapons roughly half of that again, while the US of A is now planning to mass its armed forces in the Pacific, looking for a new bogey-man adversary in China). Meanwhile, old man Drake complains that investment in ET-searching has been inadequately funded hitherto.

Kind regards – Ray

Skylights – February 2012

Rob Peeling

The Moon

7 February	14 February	21 February
Full Moon	Last Quarter	New Moon

The planets

Venus is very bright and obvious to the west as it gets dark. The planet's gibbous phase is obvious with a telescope and medium power. It is moving swiftly towards Jupiter. In the early evening of 25 February it will be close to Jupiter but the waxing crescent Moon will be very close indeed. If you're out early enough on the same evening, you may just catch **Mercury** above the western horizon.

Jupiter is almost as prominent as Venus. I have been trying coloured filters to see if they help pick out detail in the planet's clouds. I find that with my 12", a dark blue filter really picks out the two equatorial belts. For general use a lighter blue (for the bands) and an orange for the bright, white zones seem to work well. Two nights ago I caught the Great Red Spot right in the middle of the South Equatorial Belt. The orange filter showed it as a bright pool in the belt. The light blue filter showed how the darker belt seems to wrap around the northern side of the Great Red Spot.

Mars is prominent below the tail of Leo and the star Denebola. The orange colour is unmistakeable. I haven't yet had a telescope on Mars this apparition because it is too far east in the evening for me to pick up around the edge of our house.

Saturn is still an early morning object if you want it high in the sky to see well.

Deep sky

Last month I recommended the **Christmas Tree Cluster, NGC 2264**. Close by to the south is **NGC 2261, Hubble's Variable Nebula** (*photo on next page*). This is a tiny, arrow-shaped wisp apparently emerging from the star R Monocerotis. Regular observations of this object are encouraged by the BAA or SPA in order to provide a record of the light variations from the nebula. Variations occur on a timescale of a few weeks. I re-discovered NGC 2261 for myself on 22 January at 21:46 UT with my 12" Dobsonian:

"*Clear view of Hubble's Variable Nebula, NGC 2261, with 15mm lens and CLS filter. Examined with 2× ED Barlow and 4.9 mm without filter. Object appears to be a faint star of magnitude 11 or maybe 12 with a definite fan of emerging nebulosity pointing almost due north of star (slightly preceding). The leading edge is the brighter and the size (leading edge) is ~ 2 arc min (10% of field of view). Easy to find. Nebula is brighter closer to the associate star.*"

Also try **β Monocerotis**, which is a lovely triple of white stars (use high power).

ε (epsilon) Aur is one member of an obvious triangular asterism called the **Haedi** or **Kids**, which lies close-by to the south-west of bright Capella. The Kids looks like a dart, with ε Aur marking the thin pointy end nearest to Capella. The other two stars are η (eta) to the left and ζ (zeta) to the right. I have talked about ε Aur in February *Skylights* for the past two years because of its long, slow eclipse, which is now over. Compare the brightness of ε Aur with η (magnitude 3.1) and ζ (magnitude 3.8) and you should be able to see that ε is very slightly brighter than η – this is ε Aur's normal state.

Twice in a lifetime – Part 1

Neil Haggath

On 6 June this year, we have our second and last opportunity to observe one of the rarest of astronomical phenomena – a **transit of Venus**. While this one will be partially visible from the UK, it won't be seen very well, even if the weather cooperates. It will be well underway before sunrise, and we'll only see the last quarter of its six-hour duration. To see it in its entirety, you have to go to the Far East, Australia or New Zealand, or any of the islands of the Pacific. I plan to be somewhere in the Far East, though I'm not yet sure exactly where.

Transits of Venus aren't anything very spectacular to see. Nor are they of any scientific importance now – though they were in the past, as I'll explain next month. But the reason they are still considered so exciting is simply because of their extreme rarity. Before the last one, on 8 June 2004, there wasn't a single human being alive who had seen one, since none had occurred since 1882. In fact, that was only the sixth transit ever to be observed.

After this transit, there won't be another in any of our lifetimes – or indeed, in the lifetime of almost any human being now alive, apart from a few who are now very young children, and will live to well over 100! The next one doesn't occur until 11 December 2117.

Both Mercury and Venus, being closer to the Sun than Earth, can undergo transits, i.e. pass directly between us and the Sun, so that we see them silhouetted against the Sun's face. Transits of Mercury occur every few years – about 13 times per century on average – so there are several of them during any average person's lifetime. There have already been seven of them during my lifetime, though I've only observed one, in 2003.

But transits of Venus are *much* rarer – so rare that a large fraction of the human race never have the chance to see one. They always occur in pairs, eight years apart, but the intervals between the pairs alternate between 105.5 years and 121.5 years. They always recur in this sequence, so the whole cycle repeats, with four transits, every 243 years.

This year's transit of Venus will be only the eighth to occur since the invention of the telescope, These were the dates:

6 December 1631 (26 November O.S.)

4 December 1639 (24 November O.S.)

6 June 1761

3 June 1769

9 December 1874

6 December 1882

8 June 2004

6 June 2012

But nobody saw the first one in 1631 – although it *had* been predicted. That's because, like this year's, it was mainly visible from the Far East and Pacific – and there weren't many telescopes in that part of the world then! The reason I've listed two dates for each of the first two is because Britain, at that time, hadn't yet adopted the Gregorian Calendar, though most of Europe had. So the first date for each one is the Gregorian Calendar date; the date in brackets is the date according to the 'Old Style' calendar, which was still in use in Britain. I've listed the Old Style dates because the first observation of a transit of Venus, in 1639, was made in Britain.

Now lots of popular-level astronomy books tell you that the transits recur in that strange sequence, but none of them ever tells you *why*! Early in 2004, when I was planning to travel to observe that year's transit (although it would potentially have been entirely visible from the UK, Don and I decided not to gamble on the British weather, and went to Turkey), I realised that I had never actually seen, in any book, an explanation of the sequence. A lengthy exchange of e-mails followed with my good friend Dr John McCue, and between us we worked it out for ourselves, starting with just the knowledge of Venus' orbital and synodic periods. In the month of the transit, the explanation appeared in *Sky and Telescope*, so we had the satisfaction of confirming that we had got it right!

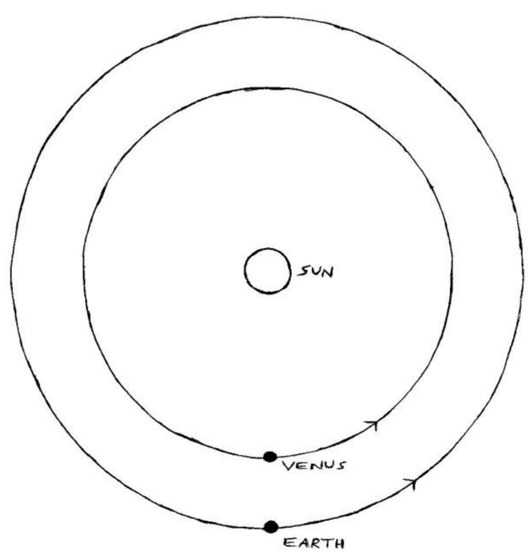


Fig. 1

Obviously, a transit can only occur when Venus is at its **inferior conjunction**, i.e. when Earth, Venus and the Sun form a straight line, with the two planets on the same side of the Sun (Fig.1). This happens about once every 19 months.

OK, so why don't we see a transit at every inferior conjunction? That's because the orbits of Earth and Venus aren't in the same plane; they are inclined at an angle of about 3.4° to each other (Fig. 2). So at most inferior conjunctions, Venus passes slightly above or below the Sun, rather than directly in front of it.

A transit only occurs if an inferior conjunction happens to coincide with one of the **nodes** of Venus' orbit – one of the two points at which it passes through the plane of the Earth's orbit. Fig. 2 shows what we mean by the nodes; the **ascending node** is where Venus passes through the Earth's orbital plane from south to north, and the **descending node** is where it passes through from north to south.

Naturally, if inferior conjunction happens when Venus is at a node, this also means that Earth is passing through the plane of Venus' orbit. This happens at two points in Earth's orbit, six months apart. At the moment, these two dates are 7 June and 8 December. So now we see why, as we saw in the list of dates, transits can only occur in June or December. December transits occur at Venus' ascending node, June ones at the descending node.

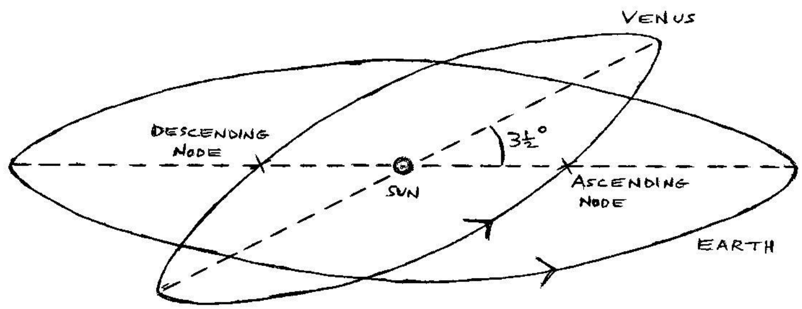


Fig. 2

Owing to the finite size of the Sun, the conjunction doesn't have to line up *exactly* with the node; it can be out by a day or so either side of it.

Now let's look at some numbers. Venus' **orbital period** – its 'year' – is 224.7 days. Its **synodic period** – the interval between successive inferior conjunctions – is 583.9 days.

Venus passes through each node once per Venus year, as does the Earth once per Earth year. So the interval between successive transits has to be an exact multiple – or very close to it – of the synodic period, of half a Venus year, *and* of half an Earth year!

If you care to do the arithmetic, you find that 5 synodic periods are almost equal to 13 Venus years. Almost, but not quite; it's actually 1.6 days short of 13 Venus years – and that difference is vitally important. This period is also almost equal to 8 Earth years – 8 years minus 2.5 days, to be exact. The half-day in that figure shows us why the two transits of a pair are visible from roughly opposite hemispheres of Earth.

So, starting from any given transit, you would expect to see another one 5 synodic periods later, when the inferior conjunction again occurs close to the same node. And transits do indeed occur in pairs, separated by this interval. But then, why don't we see a transit *every* 5 synodic periods, or every 8 Earth years?

The key is that 'shortfall' of 1.6 days. Starting from a given transit, the conjunction that occurs 8 years later is still close enough to the node for another transit to take place – but after another 8 years, when the shortfall has doubled to 3.2 days, it has moved far enough away from the node to make Venus miss the Sun from our point of view, and therefore we don't get another transit. In fact, for each pair of transits, the first occurs slightly *after* the node, and the second slightly *before* the node (Fig. 3).

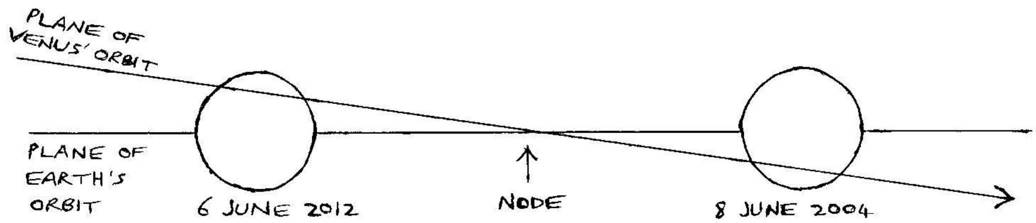


Fig. 3

Fig. 4 shows the tracks across the Sun of the 2004 and 2012 transits; it demonstrates quite clearly why they occur in 8-year pairs. If a transit took place exactly at the node, we would see Venus pass right across the centre of the Sun; if it isn't quite aligned with the node, then we see it cross the Sun above or below centre. This pair take place at the descending node; we can see that the 2004 transit happened just after the node, while this year's, because of that 1.6-day shift, happens just before the node. By extrapolating the shift in position, it should be clear that 16 years ago, at the inferior conjunction of 1996, Venus made a near miss just below the Sun, while in 2020 it will pass just above.

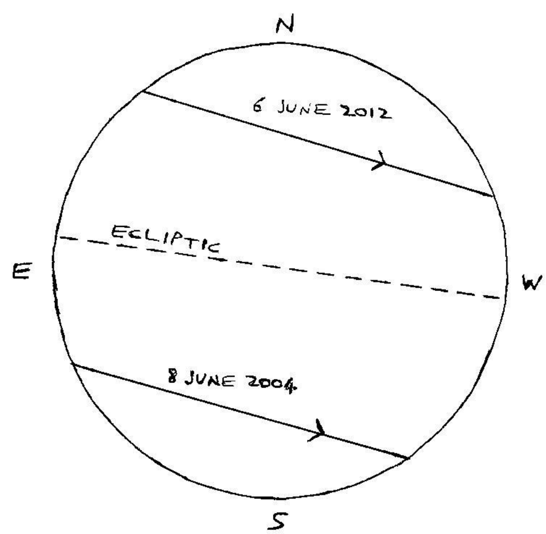


Fig. 4

This is why we get transits in 8-year pairs, but not at continuing 8-year intervals.

So, after each cycle of 5 synodic periods, the position of the inferior conjunction moves a little way backwards along Venus' orbit, further away from the node. Naturally, after some long period of time, this backward regression will take it halfway around the orbit, so that a conjunction will line up with the opposite node – so then we get another pair of transits, again eight years apart.

This explains those two century-plus intervals between the transit pairs. 105.5 Earth years is almost equal to 171.5 Venus years, and to 66 synodic periods. This is the interval between the second transit of a pair at the descending node and the first of a pair at the ascending node. 121.5 Earth years is almost equal to 197.5 Venus years, and to 76 synodic periods.

This is the interval between the second transit of a pair at the ascending node and the first of a pair at the descending node.

The reason that those two periods are unequal is simply a consequence of the orbits of Earth and Venus being elliptical instead of circular. The nodes don't quite divide the orbit into equal halves; the distance along Venus' orbit from the ascending to the descending node is greater than that from the descending to the ascending node.

Actually, adding up that backward regression gives us intervals between transit pairs that are five times longer than the actual periods; that is, we get four transits every (5 × 243) years. But so far, we have only considered what happens every five synodic periods.

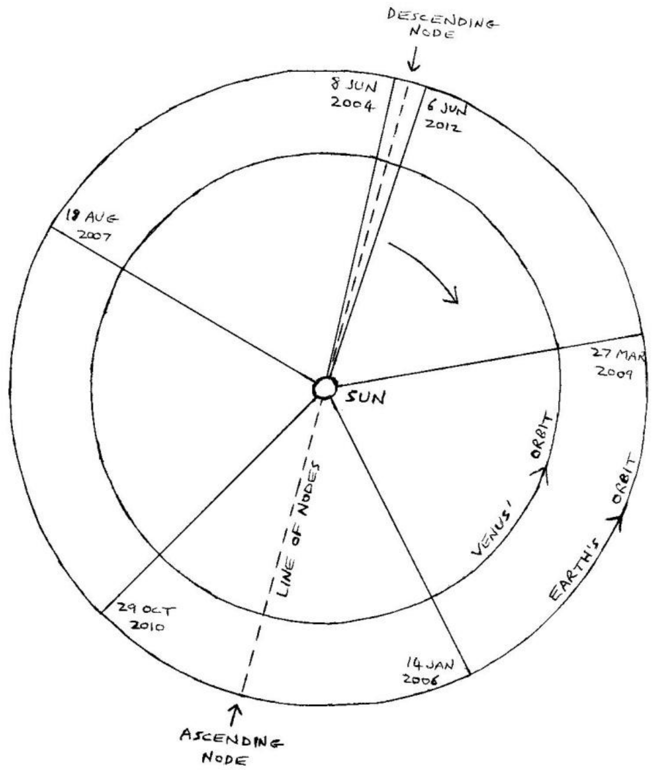


Fig. 5

Within each sequence of five consecutive inferior conjunctions, the conjunctions occur at five different points in the orbits, 72° apart. Owing to the aforementioned 'shortfall', each of those points slowly moves clockwise around the orbits, periodically lining up with the nodes. If we picture the radii from the Sun to these five points, as shown in Fig. 5, the entire pattern slowly rotates, like the spokes of a turning wheel. So there are five interleaved sequences of transits, giving us that sequence of intervals.

So far, for the sake of simplicity (!), I've assumed that transits of Venus *always* follow this same sequence of eight-year pairs – but that isn't quite true. While this *is* the case for many centuries either side of the current epoch, it doesn't apply on very long timescales.

Looking at Fig. 4, you may have realised that it's also possible for transits to occur singly, instead of in pairs. If an inferior conjunction lines up almost exactly with the node, then a transit will occur in which Venus passes almost across the centre of the Sun. The conjunctions eight years before and after that one will both be near misses. The last single transit occurred in 1396, and the next won't occur until 3089.

In fact, there are periods of several centuries, during which *only* single transits can occur, separated by 121.5 years – because several successive transits all occur very close to the nodes. The last such period lasted from 427 BCE to 424 CE. (BCE and CE, meaning 'Before the Common Era' and 'Common Era', are the non-religious equivalents of BC and AD.)

Either side of one of these periods, as the transits move a little further away from the nodes, there is a period, again of several centuries, during which the transits alternate between singles and pairs. After the single transit of 424 CE came a pair in 546 and 554, then a single in 667, then a pair in 789 and 797, and so on, until the last single in 1396. The reason for this becomes clear with a little thought; if the second transit of a pair only just 'grazes' the Sun, then the next one will be a single, followed by a pair in which the first just 'grazes', and so on.

We then have an even longer period, in which all transits occur in pairs. We are now in such a period, which began with a pair in 1518 and 1526, and will end with a pair in 2976 and 2984.

Then it will be back to alternating singles and pairs, then back to singles only – and so the cycle repeats, in a period of about 4200 years.

So there you have it, folks; that's why many people never have a transit of Venus during their lifetime, but the lucky ones among us have the chance to see two!

***Next month:** Part 2 – the history of transit observations.*

The Hubble juggernaut

Ray Worthy

This last Halloween, rather surprisingly, I found myself with family, visiting the United States. Because of my eyesight problems, I had thought that I would never go there again, but, happily, that proved not to be the case. It was while I was there, in the company of some planetarian friends, that they informed me that they had been surprised to hear that Edwin Hubble may not have been the first to discover that the universe was expanding. They had just been made aware that the famous Mr Hubble had been rather remiss in not acknowledging his debt to others in the field and that he had garnered all the laurels into his own bosom, as it were. I laughed at this and told them that I had known this for many years. My friends scoffed at me then, expecting me to launch into the claims of some British astronomer, but when I told them that most of those whom Hubble should have acknowledged came from his own country, they began to listen and take note.

In this article, I want to develop this theme and paint a few broad brush-strokes over this particular bit of history.

Over the years, when visiting some of my numerous American relatives and being interested in education, I would examine the books on their shelves. I was struck by the attitude shown in their school history books. The authors seemed to encourage a cult of hero worship. They would take one of their historically prominent men or women and paint such a picture that their subject would emerge as pure as pure could be, without any blemishes. They did not write history, but developed legends. I believe this sort of thing happened to the story of Edwin Hubble. The historians put him on a pedestal that grew higher and higher, and when the Space Telescope took his name, the image on its pedestal soared out of sight. It was as though there were no other astronomers around at the time. I hope this piece may do something to rectify the situation.

In the first decade of the twentieth century, astronomers had plenty of detailed photographs of the night sky. They could see the stars of the Milky Way, they could see the globular clusters, they could see an increasing number of spiral nebulae, but all their attempts at learning about the spatial relationships of these objects failed because, apart from the parallax measurements of our closest neighbours, there was no definitive guide to their distances. What was needed was a reliable distance candle.

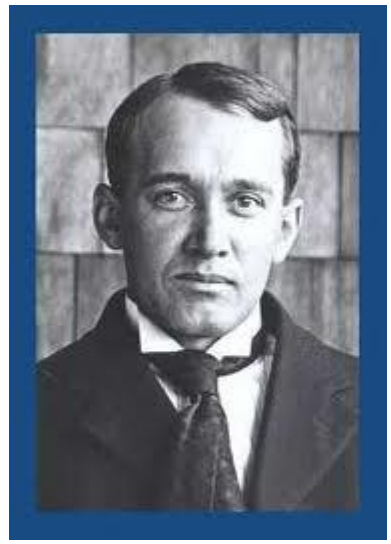
It was a young woman who cracked this problem. Her name was **Henrietta Leavitt** (*left)*. At the time, in the first decade of the twentieth century, one of the leading astronomical institutions was Harvard Observatory in Massachusetts. The observatory possessed a vast collection of photographic plates of the night sky. Valuable though these plates were, they were useless until someone examined them with a magnifying glass and extracted all the information they possessed. This was arduous and tedious work. Intelligent and educated young women were employed because they were cheap. These ladies were called 'computers', and amongst their number was Henrietta. She developed her talent at this work until she became outstandingly competent.

One of her tasks was the study of a certain type of variable star called 'Cepheids'. These stars showed a sharp rise in brightness followed by a slow decline. There were many of these variables showing different periods, and Henrietta got the idea that the brighter ones had longer periods of variation. However, there was no way to prove it because she did not know how far away the stars were. Then she hit upon her crucial idea. She reasoned that all the stars in one of the Magellanic Clouds could be regarded as being more or less the same distance away from the Earth.

If she could find Cepheid variables in one of these clouds, then the distance problem could be ignored. It was a long way from having that idea and achieving a result, but with diligence and patience she persisted and finally arrived at a graph showing a definite correlation. There was a relationship between the periodicity and the brightness of the star. Miss Henrietta Leavitt had provided the astronomers of the world with a reliable distance candle that reached outside the Milky Way. Unfortunately Henrietta died in 1921, not very long after her triumph. In her lifetime, Henrietta hardly got a mention in the scientific press. Only later did it become apparent that she had provided the astronomical world with the key to unlocking the true scale of the universe. Not bad going for ten dollars fifty a week.

Round about the time of the lead up to the First World War in Europe, astronomers began to realise that the new generation of large telescopes would have to be sited at high altitude in clean and dry air. The new frontier of astronomy would henceforth be in the Californian mountains. Mount Wilson Observatory, under the directorship of **Ellery Hale**, was gifted a sixty-inch and later a hundred-inch telescope. These instruments, better than any other in the world, were inevitably used in the front line of discovery.

Meanwhile (back at the ranch), a young man was making a name for himself in an observatory at Flagstaff, Arizona. The millionaire **Percival Lowell** had a bee in his bonnet. He was obsessed with Mars. He had caused the observatory to be built with the expressed intention of proving that there was life on the Red Planet. Yes, this is the place where the young **Clyde Tombaugh** discovered Pluto in 1930, but that is not part of this tale. The person central to my story here is a man who spent all his working life in Flagstaff but did not become Director until 1926.



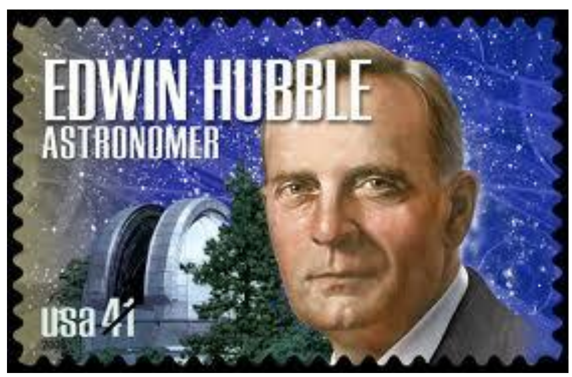
The young **Vesto Slipher** (*right)* was given the task of working with spectroscopes. He found that the instruments then available were not very good, so he did what he could to improve their efficiency. Over the years, he improved the instrument out of all recognition. I seem to remember that he improved the efficiency of his spectroscopes by a factor of two hundred, which is absolutely astonishing if my memory is correct.

Before the First World War, one of the problems of astronomy was the true nature of what were known as the spiral nebulae. The point I wish to make here is that, as early as 1912, the young Vesto Slipher was examining some of the brighter spiral nebulae and, with the aid of his improved spectroscope and long and tedious exposures with the twenty-four-inch reflector, had come up with radial velocities never before measured in the annals of science. He did not know how far away these nebulae were, but he knew how fast they were travelling with respect to Earth. The displacement of the Fraunhofer lines enabled him to see that the Andromeda Nebula was shooting towards us, but most of the others were racing away from us at tremendous speeds. These speeds were so high that he and others realised that these nebulae could not be part of the Milky Way assembly. They had to be somewhere else in space. Slipher was just a starter at this time, but he was supported in his endeavours by two more senior astronomers, James Keeler and William Wallace Campell, both at Lick Observatory. Bearing in mind the main contention of this article, the reader has to realise that Edwin Hubble in 1912 was in Cambridge studying law and even Spanish. He was not even a practising astronomer.

The next individual I wish to mention was ten years junior to Vesto Slipher (how I like rolling that name about my tongue). This rumbustious fellow dropped out of school early and began his working life as a crime reporter in Missouri. Educationally speaking, he pulled himself up by his own bootlaces and ended up as a Professor of Astronomy in Harvard. His name was **Harlow Shapley** (*left*). I include Shapley in the list of astronomers germane to my theme because he was the first to take up the tool provided so cheaply by Henrietta Leavitt and do something meaningful with it. Oh, how I wish she had survived to see what a difference she made to the world of science.

Early in his career, Shapley took up a junior post at Mount Wilson and began studying globular clusters. As he became more familiar with them, he realised that he could discern a number of Cepheid variables. Using these as distance candles, he worked out the spatial disposition of the clusters. To cut a long story short, what he discovered was that the globular clusters were definitely associated with the centre of the Milky Way Galaxy. They existed in a sort of sphere centred around the middle point of the Milky Way. Once he had constructed a model of the Milky Way, and knowing the distance to some of the globular clusters, he could fairly accurately estimate the size of the Galaxy. It turned out to be much larger than astronomers had previously thought. Furthermore, his model showed that the Earth was not at the centre of the Galaxy, but was relegated to a position in one of the outer spiral arms. These radical discoveries were not accepted by many diehards, but in essence Shapley was right. This work was done whilst Hubble was in the Army in France.

So many times in the history of science, some brilliant individual makes a radical breakthrough and, when it becomes associated with his name, he sticks with it through thick or thin, even when subsequent work shows that a new step has been taken. Thus it was with Harlow Shapley. This new enlarged Milky Way was his baby and the spiral nebulae could not possibly be more examples of the same kind, but must be much smaller and be located within his Milky Way. He seems to have ignored the opinions of the professors I have already mentioned.



Now, at last, we come to the star of the show, or the villain of the piece. **Edwin Powell Hubble** (*right – he got a US stamp all of his own*) was born in 1889 in Missouri near where Harlow Shapley had been born four years earlier. But this boy was born with a proverbial silver spoon in his mouth. From the word 'go', everything seemed to progress smoothly. He was brilliant and acknowledged to be so. His dominant father was a rich lawyer running the family insurance company. The young Edwin had a sparkling education and, if this were not enough, he was a marvellous athlete as well. He studied at Chicago University and, while there, was selected to be a Rhodes Scholar in Oxford. He had everything going for him and was even described as an 'Adonis', as handsome as a film star.

There is no shadow of doubt that this man was talented. His brain was outstanding. It was with the way in which his character developed that his contemporaries found fault. At Oxford, the young Hubble adopted the dress and mannerisms of the English upper class, and this never left him for the rest of his life. He later joined the Army with the rank of Captain, something I did not realise was even possible. He emerged with the rank of Major. As far as is known, he saw no action, though he claimed he did. This was a trait that others did not care for. Brilliant though he was acknowledged to be, he added items to his résumé, to his CV, that were not merited.

He finally took up his delayed position as a junior astronomer at Mount Wilson Observatory where, at that time, Harlow Shapley was making the news. Soon, however, Shapley left to take up a post at the Harvard Observatory.

The key player in the next few years was not a person, but the new 100-inch reflector, which saw 'first light' in 1917. Now astronomers could see further into space than ever before.

One day, or one night, rather, Hubble was visiting various parts of the sky and noticed a bright spot in the Andromeda nebula which had not been there before. He took a half-hour exposure to confirm the nova. Later, upon examining the plate in his office, he noticed a couple of other stars brighter than they should have been. Comparing that plate with others taken previously, he realised that he had found some Cepheids as well as the nova. He then worked hard and long, calculating the light curves to establish their periodicities. He had these figures a long time before publishing them in the New Year of 1925. Shapley acknowledged that he had been wrong. Andromeda was a galaxy in its own right and was composed of hundreds of millions of stars. Furthermore, Hubble established that it was at least a million light years away (we now know that it is 2.5 million). The enormity of this distance, calculated and not guessed, was enough to wake up the astronomical world to the fact that our galaxy, the Milky Way, was but one of many others in the Universe.

When reading this, one has to appreciate that we view all these goings-on with the perspective of ninety years of hindsight. We know who was right and who was wrong, but it is worth considering that, at the time, these astronomers were working at the very limits of the current technology. For example, there was an older and much respected astronomer at Mount Wilson called Van Maanen, who, examining plates of some spiral nebulae with the aid of a blink comparator, was convinced that he had discerned some rotation of the spiral. This respected man was taken seriously. The import of this was that, if his observation were true, the spiral nebulae could not be far outside of the Milky Way. It was this as much as anything that caused Hubble to hold back on the publication of his discovery.

Consider the conditions at the top of this mountain, where a group of intelligent men and women had, perforce, to work and eat in close proximity and harmony. It must have been something like being on a remote island. Think of the impact on this group when a young man presented himself posturing as an upper-class English aristocrat, a man, moreover, whom they knew to have been born in Missouri only a few miles from where Shapley came from. I'll bet that he alienated himself from them at the start. Add to this a driving ambition to be famous, the top of the tree. Edwin Hubble did not want to share his glory.

In 1925, after he had made his great breakthrough, the Director of the Observatory, Ellery Hale, wanted Hubble to concentrate on expanding his work on the distance and radial velocities of the galaxies. Unfortunately, either none of the other qualified scientists would work with him, or he himself refused to work with one of them. Someone was needed to work alongside this 'English toff', and, by using the spectroscope, calculate the radial velocities of the galaxies in question. Ellery Hale solved this dilemma in a most peculiar and unique way. He promoted the janitor of the establishment to be an assistant astronomer.

In all the annals of astronomy, there is no story so riveting as the life story of Milton Humason (pronounced Hummason) (*left*). It is so unique that someone based a musical on it.

As a young man with little education, he worked in a hotel for tourists on Mount Wilson. When construction started on the summit, he ran a mule train for supplies, up and down the mountain. He hung about the observatory so much that Ellery Hale asked him to become the janitor. He did more than that, much more. He helped with the instruments and, over the years, it became obvious that Milton Humason could operate the telescopes as well as any man there. He was dedicated, patient and thorough, so he was promoted to work alongside Hubble. It was said that Hubble accepted Humason because he knew the ex-janitor could never be a rival for honours.

Not only did Humason succeed, but he improved the efficiency of the spectrometer and, because some of his cumulative exposures lasted as long as thirty hours, he persuaded the photographic companies to invent faster plates. In reality, Humason took over where Vesto Slipher had left off. Slipher never left Flagstaff, but he had reached the limit of what could be done with his twenty-four-inch reflector. For four years, the two of them slaved away, Hubble at his desk minutely examining his plates for Cepheids to calculate distances, and Humason perched all night at the top of the telescope staring through the cross-hairs to keep the telescope pointed correctly, gathering photons. Humason was a dab hand at recognising the relevant displaced lines, but he had to have the help of a young lady 'computer' because his maths was hardly of the standard needed.

Came the day in 1929 when the famous 'Discovery' was announced. When the parallel results of the two men were matched up, a graph with a beautiful correlation resulted. The galaxies were apparently moving away from Earth with an acceleration proportional to their distance. On the day, Humason was allowed to present his paper first, but no one paid much attention to 'the janitor'. The proportionality became known as 'Hubble's Law' and the acceleration became known as the 'Hubble Constant.' Even though Hubble had actually used and included Slipher's figures, the man from Flagstaff received no mention (not for the next twenty years, at least).

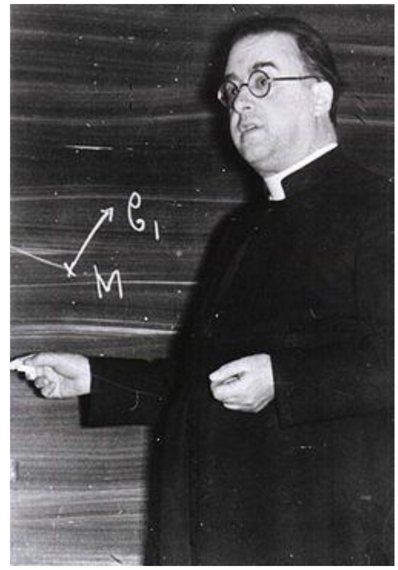
The Hubble juggernaut took over. During this period, Hubble met and married a rich widow who became the Boswell to his Dr Johnson. She thought the sun shone out of him, and became his publicist. She saw to it that the world knew all about her hero. The world accepted at face value that Edwin Hubble had done all the work. Humason was relegated to the shadows, whereas in reality he carried on and recorded the speeds of many hundreds of faint galaxies.

When Isaac Newton was asked how he had managed to achieve his miracles, he modestly said that he had stood on the shoulders of giants. The Hubble juggernaut just rolled over everybody who had gone before as though they had not existed.

So, back to the conversation with my American friends last November. The juggernaut had done its work well, and even the Space Telescope had taken the name of this illustrious astronomer. School textbooks can be found that extol Hubble, standing alone as though he had existed in a vacuum. My friends had been fully convinced that Hubble had discovered that the universe was expanding, and now they were brought up sharp. They had been informed that someone had pre-empted their hero by two years.

'Who was this man called Lemaître?', they asked me.[1]

'Well,' I answered carefully, 'he was very different in character from our friend Edwin Hubble. First of all, he was a priest. He had served in the Belgian Army and been awarded medals for bravery. Then he took up the study of engineering, then physics and finally mathematics. When the faculty at Louvain University realised they had a genius on their hands, they sent him off to Cambridge to study under Eddington and then to Harvard to work under Shapley.



'At the time, the new theories of Einstein's relativity were all the rage. Even though practically unknown to the scientific community, Georges Lemaître (*right*) was confident enough to argue with the master – and not only that, he came out on top. Einstein, we now know, genius though he was, made a fundamental error. He assumed, as everyone else did at the time, that the Universe was in a steady equilibrium. When all Einstein's calculations were finally worked out, indicating that the Universe was either expanding or contracting, he considered this answer wrong and introduced a constant to rectify the situation and to bring his results in line with generally accepted ideas. This young priest argued with Einstein, trying to persuade him that the use of the constant was wrong, but Einstein was not convinced, He told the newcomer that, although his mathematics was first class, his appreciation of physics was misguided.

'How wrong he was. This newcomer went on to show that the relativity equations indicated that the Universe's matrix of space-time was expanding. He calculated the rate that later became known to the world as 'Hubble's Constant' (two years ahead of Hubble). He was brave enough to postulate that this concept could be reversed, with the conclusion that the Universe had begun from a single point. Lemaître called this the 'primeval atom'. A brave young man indeed. Lemaître published his paper in 1927, but unfortunately in an obscure Belgian science journal, which was entirely ignored by mainstream astronomers. The world did not even blink.

It was only later in 1931, when, at a public meeting, Eddington (*left*) bemoaned the lack of a proper mathematical basis to explain the expansion of the Universe, that Lemaître wrote to Eddington, reminding him that he had sent him a copy of the 1927 article.'

'Who was this Eddington? Why was he so important?', one of my friends asked.

'Well,' I said, 'Eddington was the Professor of Astronomy at Cambridge. He was the one who made Einstein famous. In 1919, he took an expedition to the island of Principe off the west coast of Africa to photograph the sky around a total eclipse. Basically, he showed that Einstein's prediction was correct; starlight could be

[1] *[Lemaître is currently eighth on the list of most famous Belgians at www.famousbelgians.net, although sadly three places behind Plastic Bertrand. – Ed.]*

bent by the gravity of the Sun. The world's press listened to everything he said.'

'I see,' said my friend. 'I understand.'

'Eddington apologised,' I went on. 'He rectified the situation and made the Belgian priest famous.'

'Not famous enough to enter our textbooks', said one of my companions.

'Yup!' I agreed. 'You can say that again!'

"We wouldn't like to play Scrabble with this bloke!"

John Crowther

If you get the free local lifestyle magazine *The Eye* through your letter box, the title above will be familiar, as it's from the current issue.

I've managed to use ten out of the fifteen 'absolutely fantastic anagrams' from the magazine in an astronomer's tale. Can you fill in the blanks, each of which is an anagram of what follows or precedes it in capital letters in the same sentence? You can find the answers after the *Transit* quiz, on page 20.

I'm an - - - - - - - - - - (1), so I'm a MOONSTARER. When I'm ready to observe, THE EYES must become light adapted – then - - - -   - - - (2). It's 3 a.m. and there's a lunar eclipse soon. So, earlier I set two - - - - - -   - - - - - - (3), and when I woke up it was ALAS NO MORE Z'S.

I bought a new telescope recently. To fund it, I went to the - - - -   - - - - - - - - (4) outside the bank, though at first they said CASH LOST IN ME. Was this because they were not working properly because - - -   - - - - -   - - - - - - (5), which caused THAT QUEER SHAKE? Or it might have been because -   - - - - - - -   - - - - - (6) was incorrect; so that it couldn't say, 'I'M A DOT IN PLACE' .

Before I finally got my money, I was full of - - - - - - - - - - - (7), and I even thought, "A ROPE ENDS IT!"

'Oh, my!', I exclaim, 'Clouds are blocking out the lunar eclipse!' Note that I never add the G** word to that exclamation, because I'm a - - - - - - - - - - - - (8), so I'm BEST IN PRAYER. Ah, my reward – the sky is now perfectly clear!

Back inside, I read an article about SETI, the Search for Extra-Terrestrial Intelligence. If we used - - -   - - - - -   - - - - (9) to send signals to alien civilisations, would they exclaim, 'HERE COME THE DOTS!'?

THE TRANSIT QUIZ

Neil quite properly objected to an answer to November/December's Orion-oriented quiz, 'What is IC 434 better known as?', and I'd said 'The Horsehead Nebula'. Neil pointed out:

> *IC434 is not, strictly speaking, the Horsehead Nebula! It's the red emission nebula against which the Horsehead is silhouetted. The Horsehead itself is Barnard 33.*

I've taken a new delivery of ashes to put on my sackcloth.

Answers to January's quiz

1. Which organisation operates the Very Large Telescope in Chile? **The European Southern Observatory.**

2. Visible to people in the Southern Hemisphere at the moment is C/2011 W3 or 'The Great Christmas Comet of 2011'. Who discovered it; what kind of comet is it; what was remarkable (these days) about the discovery; and what is fairly remarkable about its visibility now? **The Australian amateur astronomer Terry Lovejoy; it's one of a family known as Kreutz sungrazers; it's the first comet from that family to be discovered by ground-based observation in 40 years; and, despite passing only 140,000 kilometres above the Sun's photosphere, it survived the experience to blaze out in the pre-dawn skies as it journeys back out, to return in the 27th century.**

3. Which famous supernova remnant contains Pickering's Triangle? Which constellation is it in? **The Veil Nebula in Cygnus.**

4. Pickering directed an observatory for over 40 years, and had a famous scientific harem. Can you name the observatory and any of the women? **Harvard College Observatory (from 1877 to his death in 1919); his accomplished female workers included Henrietta Leavitt (who discovered the period–luminosity relationship for Cepheid variables) and Annie Jump Cannon (who first identified and labelled the main stellar spectral classes – O, B, A, F, G, K, M).**[2]

5. Why might you want to set your alarm for no later than 4.30 a.m. on 6 June this year? **In order to be up and about at sunrise, when the last Transit of Venus in your lifetime will be visible if the sun itself is – but only until around 5.40 a.m. There's an interactive webpage that gives more precise times, depending on your location.**[3]

6. The Orion Nebula, M42, is the second brightest diffuse nebula as seen from Earth. What's the brightest? **The Carina Nebula, NGC 3372 – its declination of –59° 52′ 04″ means you'd have to travel a long way south to see it, though.**

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[2] *[See Ray's article in this issue …]*
[3] *[… and Neil's! – Ed.]*

7. The Kepler space telescope looks for evidence of extra-solar planets – in which constellations? **Cygnus and Lyra.**

8. What constellation has Aries to the west, Gemini to the east, Perseus and Auriga to the north, Orion to the south-east, Eridanus to the south and Cetus to the southwest? **Taurus.**

9. Abbe, König and Erfle are – what? **Types of eyepiece design – the names are less well known than some others, such as Plössl or Nagler.**

10. Why is the Sagittarius A* region likely to get even more attention than usual for the next few years? **Sagittarius A* is the supermassive black hole at the centre of our galaxy; just before Christmas 2011 the ESO announced the discovery of a cloud of gas (with mass several times that of Earth) accelerating fast towards it, reaching its closest in 2013. In the process it's being stretched, and over the next few years will be twisted, broken up and transformed in ways that will be fascinating to study in detail.**

February's quiz

1. In what kind of amateur observing equipment might you find BaK-4s or BK-7s?

2. Why might an astrophysicist be interested in the proton-proton chain, the CNO cycle and the triple-alpha process?

3. Which famous 16th-century astronomer was sometimes called 'the Lord of Uraniborg'?

4. The constellation Cancer is quite faint, and is unusual in that a certain Messier object is sometimes the only part of it than can be seen with the naked eye. What's the object?

5. The Mars rover *Opportunity* recently found direct evidence of past water flow on the planet, in the form of something about 45 cm long and 2 cm wide. What is it?

6. The Gemini North telescope in Hawaii has recently found evidence for the most massive black holes known. Are they roughly (a) a million; (b) ten million; (c) a billion; or (d) ten billion solar masses?

7. What feature traditionally marks the 'Greenwich Meridian' of Mars – in other words, the zero point of longitude?

8. Before 1500 or so, the star Achernar ('End of the River') was of spectral class A2 and magnitude 3.4, but now it's B9 and magnitude 0.5. How come?

9. Because of Earth's precession, 12,000 years ago a first-magnitude star was the North Pole Star, and it will be again in about another 12,000 years. Which star?

10. Who first used the unfortunate term 'planetary nebulae' because in the telescopes of the time they looked like extended faint disks?

ANSWERS TO THE ANAGRAM PUZZLES (P. 17)

1. Astronomer. 2. They see. 3. Snooze alarms. 4. Slot machines. 5. The Earth quakes. 6. A decimal point. 7. Desperation. 8. Presbyterian. 9. The Morse code.