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NGC3628 (THE HAMBURGER GALAXY)

By Chris Longthorn

This image of NGC3628 (The Hamburger Galaxy, or Sarah's Galaxy) was taken in May in New Mexico and I have just managed to get the file processed (it has been troublesome). NGC3628 is an unbarred spiral galaxy lying about 35 million light years away in the constellation of Leo. It was discovered by Sir William Herschel in 1784 and process a 300,000 light years long tidal tail, and is notable for the thick dust lanes transecting the core.This galaxy along with M65 and M66 form the famous Leo Triplet small group of galaxies. If you recall, on my 2010 visit to New Mexico Skies, I failed to get this object due to bad weather, so it was the first thing I did this time. But I was plagued by high winds so the data was a bit compromised. Anyway... I made this from 6 out of 9 off 5 minute exposures, giving a total of 30 minutes.

Taken with a 16" Meade LX200 SCT at F5, the camera was a SBIG ST2000 XCM colour camera. The image was taken on 28th May with the final exposure at 22:58 local time. It was stacked using SBIG CCDOPS and saved as R/G/B channels (FITs files). The individual RGB channels were then re-combined in Photoshop CS3 using Noel Carboni's RGB combine action, followed by the usual Levels/Curves/various other wonderful actions to get to what you see. Chris Longthorn

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The Dumfries and Maxwelltown Camera Obscura

By Mike Frost

Late last year, I was asked to give my first ever talk in Scotland, by Mike Alexander, who with his wife Helen runs the Galloway Astronomy Centre, near Wigtown, in south-west Scotland; you might have seen their adverts in Astronomy Now and Sky at Night. Mike and Steve Rose were running a five-day "star camp" in early November, and wanted to put on a series of talks on the Saturday. Galloway has recently been in the news for becoming Britain's first "Dark Sky Park" and so local businesses and the National Lottery were willing to sponsor the event, meaning that they could put me and another speaker, Dr Joachim Rose of Leeds University, up in the local hotel for the week-end. I felt that my talk on "The Green Flash" had enough Scottish connections to keep my audience happy, and so I was delighted to accept.

So I traveled up to Scotland on the morning of Friday November 5th. I crossed the border at late lunch-time, and although I still had nearly 100 miles to go to Wigtown, I had enough time to stop en route. This was great, because between me and my destination was a venue I have long wanted to visit – the Dumfries camera obscura.

Regular readers of this journal will know about my enthusiasm for this deceptively simple piece of optical apparatus. A camera obscura – literally, a "dark chamber" – projects the outside world onto a screen in a darkened room. This might not sound very exciting, but there is something very appealing about a projected image; my theory is that in a darkened room the pupils of your eyes can open wider, allowing you to see colours more vividly. In our digital world an analogue image, infinitely magnifiable, is fascinating. And of course there is a voyeuristic element – you can watch the outdoor world going about its business, without anyone in view realizing that you are observing them.

I have visited many camera obscuras around Britain (and one in Pretoria, South Africa) but I was well aware that one of the oldest, which I had never had chance to visit before, was in Maxwelltown, a suburb of Dumfries. How could I drive past it?

The camera obscura is part of a museum on a small hill on a street corner in a quiet residential part of town. The museum is built behind and adjacent to an old windmill, which houses the camera obscura. The museum is a local museum for Dumfries and Galloway, featuring galleries on the history and natural history of the region. There are dinosaur footprints, preserved in long-fossilised mud, a large display on the wading birds of the Solway Firth, and a room full of ancient holy crosses from across southern Scotland.

The camera obscura has been observing Dumfries and surrounding countryside since 1836, the longest continuous duty of any such instrument; there are other sites established earlier, such as Edinburgh or Bristol, but the camera obscuras in these locations are not the originals. And the camera has always been the centerpiece. In autumn 1834, Robert Thomson called a meeting to establish an astronomical society for Dumfries. Right from the start the old windmill (a working mill in the early 1800s, but by 1834 not in use) was earmarked as the location for an observatory.

There was considerable discussion as to what to put into the observatory. Both a camera obscura, for solar observing, and a telescope were suggested, and a number of optical manufacturers in Scotland were approached. Eventually Mr. Morton of Kilmarnock was asked to provide a Gregorian Telescope "the speculum of which is to be 8 inches in diameter" and a camera obscura "of the description approved by Mr. Morton when here". Mr. Morton designed a camera obscura with a lens of 7.5 inches diameter; although by the time of installation the lens was 9 inches in diameter (it isn't clear from my notes when the change happened).

The observatory opened on 1st August 1836. Thomas Carlyle, the famous historian and essayist, was one of the first visitors to sign on the book. The running costs of the observatory were funded by the entrance fees paid by visitors, which enabled a program of astronomical and meteorological observations which lasted for over three decades – the museum contains drawings and sketches of the Sun and planets, and a variety of interesting meteorological phenomena such as solar halos and "The Merry Dancers" or Northern Lights. Regular observations ceased in 1872, although the camera obscura and telescopes remained in place. The corporation took over the building in 1934 and turned it into a museum, which is how it remains today.

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The museum was pretty good. But of course there was really only one thing that I wanted to see. Unfortunately, there was a problem. The camera obscura requires an operator. And there was only one attendant in the museum – who was operating the till by the front door. "Sorry – the camera obscura is closed from October to April" she said. I explained that I had driven all the way up from Rugby, just to see this one instrument, which would complete my collection of camera obscuras of the world (I may exaggerate a little). She began to realize that I was not going to be fobbed off easily. Eventually she rang through to the back office, and asked the other member of staff, who was doing some administration, to come and cover for her. And we set off up the stairs of the windmill to the camera obscura.

The camera shares features with other camera obscuras I have visited. There is a plaster viewing screen, which can be raised or lowered to the focal point of objects which are nearby or at a distance. In the roof, twelve feet above the viewing screen is a wooden turret containing a metal mirror, to reflect the outside view downwards, and the f16 9" inch lens to focus the image. The mirror can be rotated to vary the view in different directions. The Dumfries camera obscura very rarely operates during the winter; in part because hours of sunlight are shorter, but mostly because the weather is worse and more likely to affect the optics of the camera.

The view is of course splendid, with a fine prospect over the centre of Dumfries, town and river, and a distant view of the Galloway hills; unfortunately there was no clear view to the south towards Lakeland (on the Sunday I had a wonderful view south to the Cumbrian Fells as I drove back towards Dumfries, but the camera obscura was closed that day). The curator did a familiar demonstration for camera obscuras, bringing out a little "road hump", over which the images of cars and buses appear to travel. It was only a quick demonstration, and the light was hardly ideal, but I didn't mind.

So – mission accomplished. I headed off west towards Wigtown with a smile on my face. Next year San Francisco…

I'm grateful to the staff of the museum for providing me with "Notes on the camera obscura" written by A.E.Truckell in 1859; another source was Mike Feist's "Pocket Guide to Camera Obscuras of Britain and the World".

I'll finish with a plug for the Galloway Astronomy Centre, run by Mike and Helen Alexander from Cragiemine Cottage, Glasserton, Wigtownshire. They have a variety of telescopes, up to 400mm in aperture, and are happy to offer assistance, and a variety of courses and guided tours of the sky. There is B&B accommodation on site and a campsite nearby for star parties. Galloway is the UK's only Dark Sky Park, and the weather is surprisingly mild (look at the weather map the next time Scotland has snow). Wigtown is Scotland's book town, with twenty-four second-hand book stores, and is next to one of Scotland's largest Nature reserves, which comprises flood meadows on the edge of Wigtown Bay. It's a great place for a holiday!

When Planets Merge

By Mark Edwards

Some years ago I came across a curious book, *"The Astronomical Scrapbook"*. The book was written by Joseph Ashbrook, one-time editor of *Sky and Telescope* magazine, who took an interest in collecting anecdotes from the history of astronomy. These had such titles as "Some invisible astronomers", "A Hole in the Sky" and "Darkness at Noon", but the one that caught my attention was "The first Observed Occultation of One Planet by Another".

This observation we are told was made by an amateur astronomer, John Bevis, from Greenwich Observatory on May 28 (May 17 OS) 1737 and was of Venus passing in front of Mercury. Curiously, the circumstances were very similar to those of the first observation of the transit of Venus by Jeremiah Horrocks in that the planets were at a very low altitude and clouds obscured the view just at the critical moment.Bevis reported his observations to the Royal Society as follows:-

XII. Mercurius *a* Venere *occultatus* Maii 17. 1737. *in Obſervatorio Regio* Grenovici, *ab* J. Bevis, *M. D. obſervatus.*

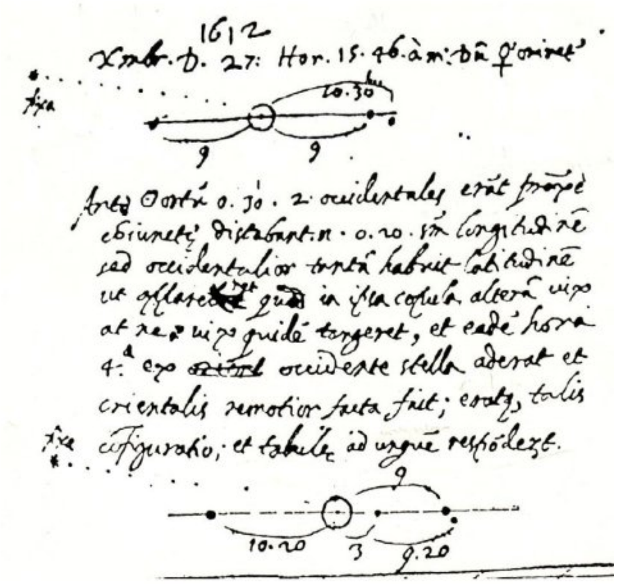
Tem. Appar. P.M. H.	M.	S.	
1	37	03	PRæcedens Limbus Veneris Meridianum tranſit, centro a Vertice 25° 46′ 35″. Mercurium vero intra teleſcopium nequaquam conſpiciebam.
9	04	09	Centrum Mercurii Limbum Veneris præcedentem præcedebat 12″ Temporis.
	06	20	Repetit. eodem tempore præcedebat, quo prius.
	28	00	Mercurio Filum parallelum Micrometri decurrente, Cuſpis Veneris auſtrina ab eodem Filo reſcinditur, unde Venerem Mercurium obtecturam, vel faltem ſtricturam colligebam; Micrometrum itaque extrahebam, quo melius inſtantem Contactum diſcernerem Tubo 24 Pedum.
	43	04	Mercurius haud plus diſtat a Venere quam decima vel duodecima parte Diametri Veneris: Deinde inimicæ Nubes.
	51	10	Venus iterum clariſſime effulget, Mercurius vero totus ſub Venere latet. Nubes jam Venerem rurſus excipiunt, ulteriorem tam rari ſpectaculi contemplationem prohibentes.

Maii

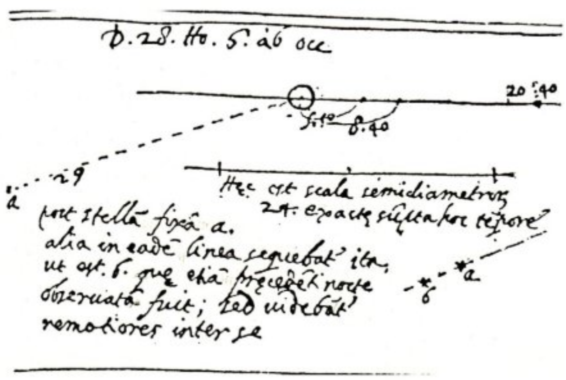
In this report he says that *"at 9:43:04 pm Mercury was very close to Venus, being only about 1/10 to 1/12 of the diameter of Venus away. Unfortunately at this point clouds intervened to obscure his view. Eight minutes later Venus reappeared, but Mercury was invisible, being totally obscured by Venus, at which point yet more clouds intervened."*

However, was Ashbrook correct in saying that this was the first observed occultation? 146 years earlier Johannes Kepler thought he saw one on January 9th 1591. On that day Jupiter and Mars rose shortly after midnight, but Jupiter seemed to him to have vanished, the red colour of the only planet visible convincing him that Jupiter was hidden behind Mars. In fact they were separated by about 3 minutes of arc. Without the aid of a telescope he can be forgiven for his mistake. A much better candidate for the first astronomer to see a planetary occultation is no less than Galileo himself.

In the early hours of 28th December 1612 he was making observations of Jupiter's moons when he noticed a fixed star near the planet. He saw another fixed star near the planet again a month later on 28th January 1613, drew it in his logbook and noted that it had appeared to move from the previous night. However he investigated it no further, if he had, he would have discovered that both "fixed" stars were in fact the planet Neptune!



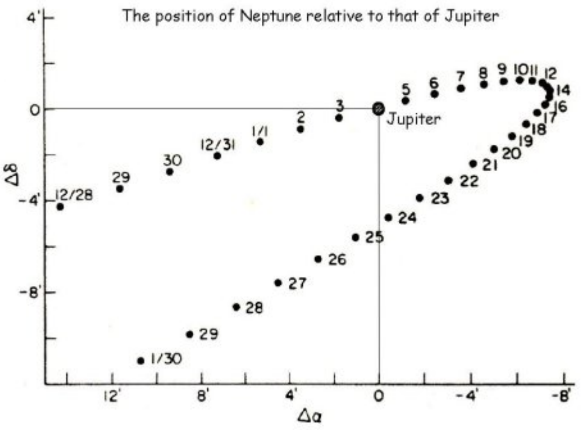
Galileo's observation on 28th December 1612 showing Neptune as the fixed star to the upper-left of Jupiter.



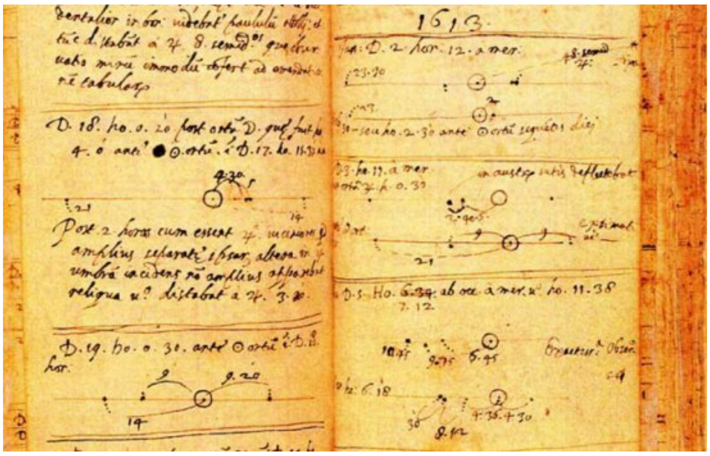
Galileo's observation on 28th January 1613 showing Neptune as the fixed star 'b' to the lower-left of Jupiter.

His note reads: "after fixed star 'a' another followed in the same line, thus that is 'b' which was also observed in the preceding night; but they seemed more remote from each other.

A more surprising fact reveals itself if we plot the relative positions of Jupiter and Neptune between these two observations:-



Neptune appears to orbit Jupiter as at the time both planets were executing their retrograde loops as seen from Earth, but note what happens on 4th January, Neptune goes behind Jupiter! So did Galileo observe this momentous event? If we take a look at his logbook for the start of 1613:-



The second entry has the heading "D3 Ho 11 a mer post orta J h 0.30" translated as "Day 3, 11 hours after noon, after the rising of Jupiter 30 minutes" The figure 11 does look like 17 in the log book, but using a Jovian moon simulator shows that indeed the positions of the moons in the first diagram for that day match those of the simulation for 11pm. (Jupiter also rose shortly after 11pm.):-

The time of the second diagram is also unclear as it is just given as "anti O ort h 0", or "before sunrise hour 0". However, it seems to match the position of the satellites for 5:30 am on January 4th with sunrise

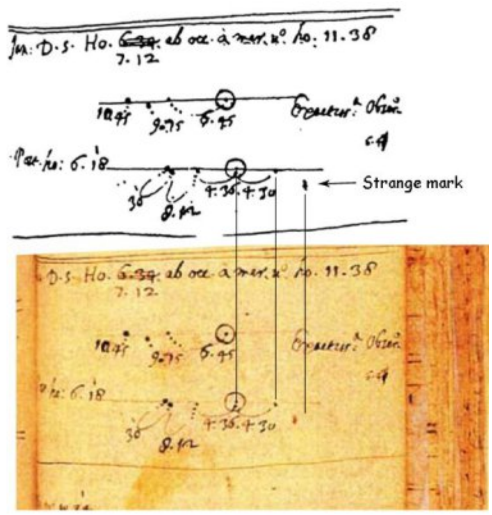
not being for another two hours:-

So when was the occultation? It would appear that it lasted from about 7pm on 3rd January till 4am on the 4th. So at the time of Galileo's first observation for the night, Neptune was occulted and was just visible again at the time of the second observation.

It could be argued then that indeed Galileo was the first astronomer and not Bevis to see an occultation of one planet by another, in that his observation was similar to that of Bevis's. He saw a planet near another before it was occulted and did not see it when it was behind the planet. Neither of them saw the planet disappear. Okay, Galileo did not recognise that it was a planet, but does that make the observation any less valid?

There is a curious epilogue to this tale, as Myles Standish and Anna Nobili in 1996 made a claim that Galileo had seen Neptune for a third time on January 6th and made a deliberate mark in his logbook to show its position. In their paper to Baltic Astronomy they showed an extract of Galileo's logbook for that date that appears to show the said mark.

In May 2009 Anna Nobili again presented this claim at a conference in Pisa and luckily put her presentation on the web. This presentation not only included the same extract from the logbook, but also showed a photograph of the logbook itself. Comparing the two reveals a curious difference:-



The upper picture is the copy of Galileo's logbook as reproduced in Standish and Nobili's 1996 paper as a high contrast image, the lower one is a photograph of the logbook itself. I have drawn lines between the two to show how the drawings of Jupiter and the satellites line up, but the supposed marking of Neptune does not.

In the photograph of the logbook the mark looks like many others on the same page, which have the appearance of stains, or soak through from the other side of the page. So to my mind it looks as though the supposed copy of the logbook has been "doctored" to make the mark look like a deliberate drawing to support their claim.

Pre-Discovery

By Mike Frost

I hope that you managed to catch an excellent series called *"Beautiful Minds"* which aired on BBC4 last year. What I liked about Beautiful Minds was that it spurned many of the tricks which have spoilt Horizon and other science programs in recent years. There were no rapid cuts between talking heads, crazy camera angles, nonsensical camera shots. There were no celebrities being guided step-by-step through basic physics. Just three of the greatest British scientists of recent years, given an hour each to talk about their discoveries.

My favourite subject, needless to say, was Dame Jocelyn Bell-Burnell, the discoverer of pulsars. Jocelyn Bell was a PhD student at Cambridge University during the late 1960s. Her PhD supervisor, Anthony Hewish, devised an experiment to use interplanetary scintillation to map quasars. As Bell examined the ticker-tape output from the experiment, she noticed an occasional, very short-lived buzz in the data. Bell carefully investigated to see if this was due to experimental noise, or terrestrial interference, but soon decided that the signal was astronomical in origin. Something out in deep-space was pulsating once a second (actually once every 1.337 sec).

Hewish and his colleague Martin Ryle then took interest. Famously, one theory given serious consideration was the LGM or Little Green Man theory, although the signal turned out to be too regular to be an alien broadcast. Bell, Burnell and Ryle published a paper, detailing the mysterious observations, but drawing no conclusion as to their cause. The correct interpretation for Bell's observation was suggested shortly afterwards by Thomas Gold and Franco Pacini. Pulsars turned out to be Neutron Stars, which had been proposed by Walter Baade and Fritz Zwicky in the 1930s as the final state of evolution for massive stars. When a star of up to 10 solar masses exhausts its nuclear fuel, there is nothing to prevent the collapse of its core under gravity. A supernova results, where the outer layers of the star are completely blown off, but what remains is an incredibly compact object, barely a mile across, where atoms have collapsed into a dense sea of neutrons. Bell's pulsar is now known as CP 1919.

Anthony Hewish and Martin Ryle received the 1974 Nobel Prize for Physics for their work in radio astronomy, in particular the discovery of pulsars. Notoriously, Jocelyn Bell did not get the prize, despite being first to spot the signal, and her failure to receive the prize has been widely criticized ever since. She has received many other awards, including being made a Dame, and a fellow of the Royal Society: she has been President of both the Institute of Physics and the Royal Astronomical Society, also an academic at the Open University. On camera she was gracious and self-deprecating about not receiving the Nobel Prize – *"a lot of people have got annoyed on my behalf"* – and pointed out that a PhD supervisor takes responsibility for their student's research, whether successful or not.

At the end of Bell-Burnell's episode, she related an anecdote which I had never previously heard. Apparently there were several pre-discoveries of pulsars prior to her first observations in 1967.

I'll repeat that: – several people had observed pulsars prior to the original discovery! The earliest such observation was in the 1950s, at a public star-gazing evening at one of the American universities. The telescope was trained on the Crab Nebula, and one member of the public told the telescope curator that *"one of the stars is flickering"*.

The astronomer patiently explained that the flickering was actually twinkling, or scintillation of starlight as it passed through Earth's turbulent atmosphere. But the observer wasn't put off. *"I'm a pilot",* she said, *"I know what twinkling is. And that isn't twinkling. That star is flickering".*

She was correct. The pulsar at the heart of the Crab nebula flickers at a frequency of 30 Hz, because it is rotating at thirty times a second. This is just below the threshold at which most humans can detect flickering. Most of us cannot see the flickering of cinema film frames, at twenty four times a second, for example. But the pilot observer must have had unusually acute vision (I suspect movie-going was uncomfortable for her).

Should we regard this unknown observer as the discoverer of pulsars? No, of course not. We should give her credit for saying exactly what she saw, but she made no known effort to follow it up. Should we regard the astronomer as the discoverer? I don't think many people would give him that much credit – though he did at least eventually report what had happened, even if he had not thought to do anything with the observation reported to him at the time. Observers at star parties report some very peculiar things, almost none of which turn out to be true.

Many other astronomical discoveries were also pre-discovered. You might remember me writing before in MIRA 71 about the astonishing pre-discovery of Neptune by Galileo, in some of his earliest drawings of Jupiter and its moons. Galileo recorded Neptune as a background star, and even noticed that it had moved between observations. Unfortunately his telescope was not remotely good enough to record Neptune as a disk rather than as a point, or to follow the star once Jupiter had moved out of the narrow field of view.

Uranus was pre-discovered on many occasions, first of all by John Flamsteed and then on several occasions by Pierre Charles Le Monnier. Flamsteed and Le Monnier were simply cataloguing the skies, and weren't looking for stars which moved night-on-night. William Herschel wasn't looking for a moving star either, but he was in the habit of repeating his observations, and so he spotted that there was a star which moved from night to night.

Yet Herschel initially thought he had discovered a comet. It wasn't until Anders Lexell computed the orbit, and discovered it to be nearly circular, and far beyond the orbit of Saturn, that the true nature of Herschel's object was understood. So should we regard Lexell as the true discoverer of Uranus? I think not. Herschel knew he had discovered something of importance, and made sure people knew about his discovery. The computation of the orbit was almost a follow-up chore. Sure, the results weren't what were expected – and Lexell deserves credit for spotting this, perhaps more than is usually given to him – but the significant step was the discovery of Herschel's comet, not its classification.

The protocols of pre-discovery are thrown into sharp relief by Neptune's eventual discovery in 1846, which I have also written about in MIRA 75. Two separate theorists – Urbain Le Verrier in Paris and John Couch Adams in Cambridge – suspected that unexplained motions in Uranus's orbit were due to the perturbing influence of an outer planet. Both theorists made calculations and predictions of where to find this outer planet. Adams was first to make the calculations, but his predictions were not clear and never formally published. Le Verrier's predictions were much more precise, and he sent them to European observatories, including Berlin, where Johan Galle and Heinrich D'Arrest, in possession of a new, accurate star map, were able to locate Neptune in an evening's search.

After Galle's announcement of the discovery of a new planet, English astronomers made a desperate attempt to claim the credit for discovery. James Challis, who had been making a desultory search based on Adams's predictions, pointed out that he had seen Neptune before Galle, but failed to realize it was not on his star charts. Supported by George Biddell Airy, the Astronomer Royal, Challis argued that he would have recognized Neptune when he came to analyze his notes - and he had therefore successfully pre-discovered the planet.

Do Adams and Challis deserve recognition as the discoverers of Neptune? Modern scholarship has not been kind to them. In an article in *Scientific American*, "The Case of the Pilfered Planet", William Sheehan, Nicholas Kollerstrom and Craig Waff were scathing *"… Adams utterly failed to communicate his results forcefully to his colleagues and to the world. A discovery does not consist merely of launching a tentative exploration of an interesting problem and producing some calculations; it also involves realizing that one has made a discovery and conveying it effectively to the scientific world".*

In this view of history, Le Verrier deserves the bulk of the credit for his predictions, and Galle and D'Arrest substantial credit for actually making the required observations. Challis gets no credit at all, Airy's reputation is stained, and Adams deserves at best a footnote, acknowledging his precedence in making first predictions, but pointing out firmly that they were not as accurate as Le Verrier's. In this reading of history John Couch Adams becomes Scott of the Antarctic to Le Verrier's Amundsen – a heroic British failure.

So, with these case studies to guide us, how should we assess Jocelyn Bell-Burnell's discovery?

Did she spot something unusual? Yes.

Did she announce her discovery? Yes, to her supervisors.

Did she follow up her discovery? Yes, when her supervisors seemed, initially, not to be interested.

Did she publish up her discovery? Yes, as promptly as possible.

Did she come up with an explanation for what she had found? No.

To my mind, Jocelyn Bell-Burnell's discovery of pulsars was closely analogous to Herschel's discovery of Uranus. Anthony Hewish deserves great credit for designing an observational experiment which uncovered something completely new and unexpected. Gold and Pacini deserve credit for understanding that Bell-Burnell's discovery could be the long-predicted neutron star. But the critical factor was that first recognition that there was something there in the signal. And that was purely down to one person's intuition, persistence and bloody-mindedness.

Jocelyn Bell Burnell was the discoverer of pulsars. And she should have got the Nobel Prize for that discovery.

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Exosolar Planets

By Paritosh Maulik

If a main sequence star like the Sun can have a planetary system, it is just as possible that other stars have planets as well. Let us stay near to home, the Milkyway. To look for a planet may sound simple; as the planet orbits or transits the star, there is a drop in the starlight. But in reality the drop in starlight is insignificantly small. So we have to try some indirect methods to look out for the dimming of the star. When we talk about dimming of starlight we must not forget the variable stars and other phenomenon as well. To date, the presence of over five hundred planets has been reported. We shall briefly look at the methods applied for detection of planets outside our Solar system and how the material might have gathered to form planets.

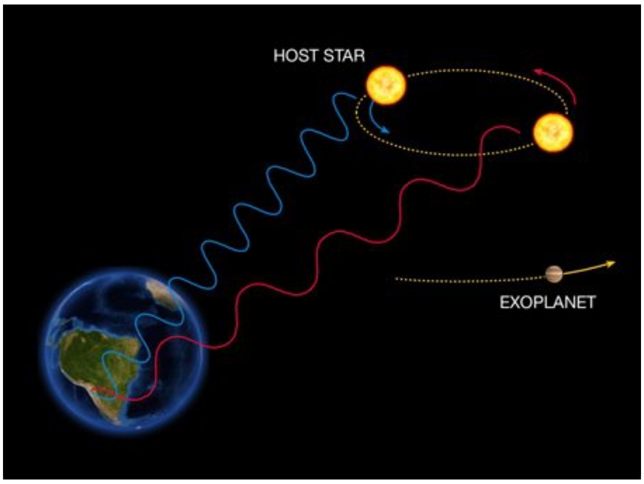
Let's not get into the debate over the definition of a planet and follow the guideline of the International Astronomical Union (IAU), issued in 2006, for the Solar System. A planet should

i) go round the Sun,
ii) have enough mass, so as to make itself round under its own gravity and
iii) clear its neighbourhood of any smaller objects.

This definition excluded objects like Pluto, Makemake and Eris; the exclusion, especially of Pluto, made a lot of people unhappy.

The above guideline also applies to the extrasolar planets, that is, the planets going round some of the other stars in our galaxy. The report of the first possible detection of an exoplanet was in 1988. But the detection methods were not accurate enough and the final confirmation came in 2003. An exoplanet around a pulsar was detected by radio astronomy in 1992. In 1995 Michael Mayor and Didier Queloz of Geneva observatory reported the presence of a planet around a main sequence star. According to the last count in May 2011, there are 552 exoplanets.

Let us see how to detect the far away planets in other solar systems. A planet is always small compared to the star, but as it goes round the star, it affects the star light and thus we deuced the possible presence of a planet. In reality the planets are very small compared to the star and hence their effects are very small; this requires precision measurement. Coupled with this, there is the added problem of observation from the Earth. The atmosphere of the Earth blurs the image of the star, but space based observation can overcome the problem of image distortion. Basically there are three methods to detect the possible presence of planets.



Gravitational effect of the planet causes the star to wobble and as the star approaches the Earth the light is blue shifted and then red shifted when the star is going away from the Earth.

The Measurement of Radial Velocity, Astrometry and Observation of transit of the planet

Measurement of Radial Velocity

The spectrum of a star carries a lot of information about the star. It contains dark absorption lines and these absorption lines are due the elements and molecules present on the surface of the star absorbing the light. These lines are used for the determination of the chemical composition of the star and also other parameters like temperature and pressure.

Now, if another body orbits the star, it creates a gravitational influence on the star and the star wobbles; it appears to gyrate or pirouette around a point in space. The star moves towards the Earth and then moves away in a periodic fashion. This movement of the star causes a Doppler shift in the spectrum and the Doppler shift occurs in a periodic manner; from this data, the mass of the planet and the orbit is determined.

The HARPS (High Accuracy Radial Velocity for Planetary Searcher) instrument at the 3.6 m telescope at the European Southern Observatory La Silla, Chile, is perhaps the most precision spectrograph attached to a telescope to measure such Doppler shifts. Two optical fibres feed the spectrometer; one is from the object and the other is either from a reference source or from the sky. For stability, the spectrometer is mounted on a stable platform and is housed in a vacuum. This instrument is designed to measure radial velocity of the order of about 1 m/sec.

Astrometry

This is a more direct method to measure the wobble of the star than the previous method. In this method the position of the star is directly measured. But Earth's atmosphere puts a serious limitation on the measurement and therefore space based instruments are best suited for this method. The Hubble telescope has been successful in detecting 2 – 3 exoplanets.

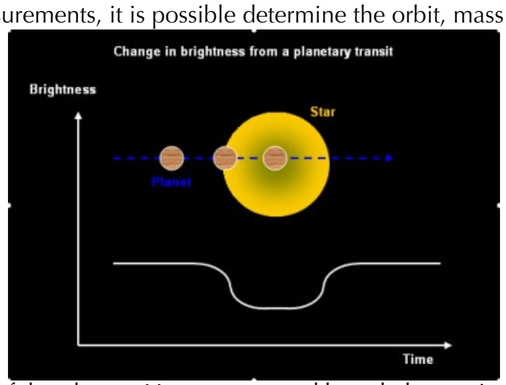
The Gaia mission of European Space Agency, scheduled for launch around 2011, is expected to be the most precise astrometric satellite to date. In this mission, the target stars would be monitored about 70 times over a five year period to determine their position, distance, movement and brightness. It may find between 10,000 and 50,000 gas giant planets beyond the Solar system. In this space based system there will be two optical telescopes with 1.45 m rectangular mirror. Light from both of the telescopes would focus to a common focal plane. The signal would be processed for astrometric, photometric and spectroscopic studies. In the photometric instrument, prisms will split the light, and will provide information on the colour and brightness of the star. In the spectroscopic instrument, a grating and prisms will carry out the spectral analysis. This will provide the information, if the star is moving towards or away from us. The precise location and the brightness of the star will come from the astrometric instrument. Stellar light becomes polarized when it interacts with atmospheric molecules present in a planet; this could be detected with a polarimeter.

At the end of May 2009, a group from Jet Propulsion Laboratory reported a cold Jupiter like planet detected by astrometry. This work is a culmination of 12 year of work at the Palomar Observatory. The group has been observing 30 stars. The planet is 6 times the mass of Jupiter and is orbiting a M dwarf star of mass one twelfth of the Sun. The star – planet distance is about the same as that of the Sun – Mercury distance, but comparing to the Solar system, this distance works out to be similar as the Sun – Jupiter distance. It is a cold Jupiter and the temperature of the planet is not dissimilar to the Earth. The star is the perhaps smallest star to harbour a planet. It may be possible that there are other rocky planets close to the star.

Transit of a planet

As a planet passes in front of its parent star, the brightness of the star drops, but again this drop is very small. There are examples of possible detection of a planet by the radial velocity method and later it was confirmed that the transit of planets caused the dimming of the star light. The planets have to be sufficiently large to cause sufficient the dimming of the star light. Such transits last for 2 to 16 hours and both the duration and the amount of the drop of the star light should be periodic. In order to get a good estimation of possible number of planets, one must observe thousands of stars.

Results combined from the transit and radial velocity measurements, it is possible determine the orbit, mass and



size of the planet. However ground based observations can only detect large gas giants of about ten times the size of the Earth. Often these planets are too close to the parent star and hence hot, these and are called hot Jupiters.

For the detection of smaller Earth like rocky planets, space based instrumentation is needed. The French COROT (Convection, Rotation and Transit) mission is the first attempt for such a space based observation. It was launched in December 2006.

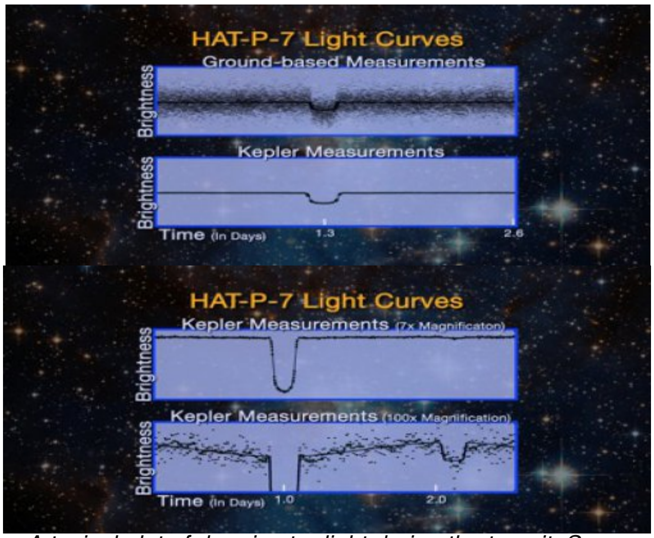
The telescope in the COROT satellite monitors the changes in the brightness of the star as a planet transits the star. This telescope also detects starquakes. This is the science of asteroseismology. These are acoustic waves generated deep inside the star and travel to the surface, this gives information on the mass, age and the chemical composition of the star. The joint ESA – NASA mission SOHO, is collecting similar information on the Sun; with the COROT data, now it will be possible to compare other stars with the Sun.

In the COROT system, there is one telescope and it feeds information to two cameras, one for the transit observation and the other is for the asteroseismology study. The satellite is placed in a circular polar orbit and observation is carried out on two opposite regions of the sky for 150 days. During this 150 day period, a selected star field is monitored. The opposite ends of the sky are selected so as to avoid interference from the Sun. After 150 days a new star field is scanned.

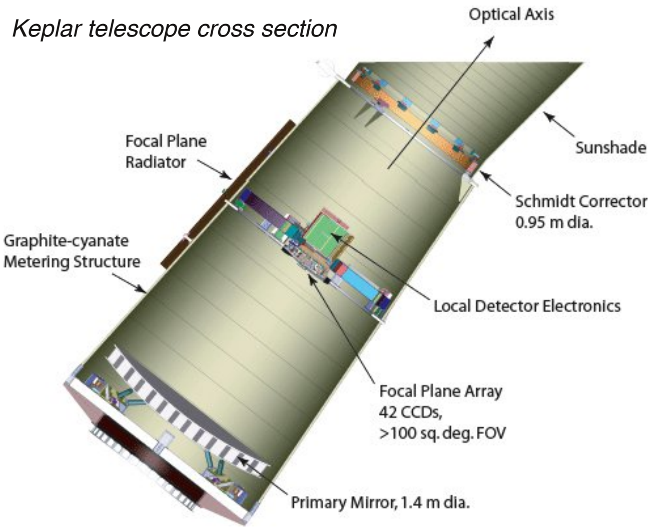
Some of the early COROT information has started a detailed study of internal properties of stars from asteroseismology. There was some uncertainty, if the oscillation i.e. expansion and contraction of stars are in radial direction or in the non-radial direction. If the oscillation is non-radial it tells a lot more about the star. COROT data suggest the oscillation of the red giants stars (stars nearing the end of their life) is non-radial. The COROT telescope has detected the largest known so far, a planet of a size similar to Jupiter, but about 20 times the mass. It takes only 4 days and 6 hours to go round the parent star. From its size, it can be asked, if its a brown dwarf, but unlike a brown dwarf this object does not shows any stellar activity. It is interesting to note that a lot of supporting data for this planet has come from ground based observations. Early this year COROT has detected the smallest planet, about twice the size of the Earth and its temperature is between 1000° – 1500°C. At such temperatures, the surface is expected to be covered with liquid lava. It has been predicted that planets with equal portion of rock and water may exist; details are still being worked out.

NASA Keplar Mission

The primary aim of the Keplar mission is to search for terrestrial and larger planets near the habitable zone of different types of stars. It will also look for a number of planets in multiple star systems and will study the properties of the stars which harbour planets. The Keplar telescope would not image the planets directly, but will monitor transit events. If we are to look for planets in the habitable zone, the time to transit is around one year. In order to get a reliable data, we have to look for three to four transits. This works out a time period of at least three and half years. The telescope of the Keplar mission is essentially a big wide field photometer. The diameter of the primary mirror is 1.4m. Its field of view of

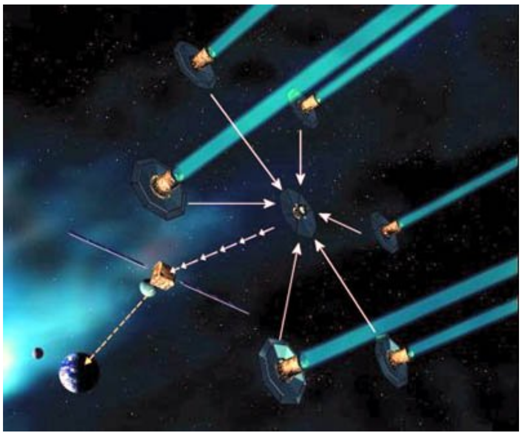


A typical plot of drop in star light during the transit. Space based instrument in Keplar can resolve two dips, where as the Earth based instrument show only one dip. (Top)



105° square degrees, allows it to observe about 100,000 stars in its three and half years life time (may be extended). In general most of the telescopes have a field of view of the order of 1° square degree. The light from the photometer is collected by a 0.95m aperture photometer with 95 mega pixel CCD camera. The Hubble telescope rarely looks at one star field, whereas the Keplar mission will observe the variation of the brightness of 100,000 stars at every 30 minutes. This mission was launched in March 2009. In August NASA published some early results. It monitored a planet, the light curve of which was established from ground based observation. Keplar data showed that the day side temperature is 2300°C. The light curve showed the dip from the transit of the planet. Soon after this event there was another dip in the light curve, this second dip was due to the occultation of the planet behind the star.

The ESA DARWIN mission



In the Darwin system, more than one telescope will operate in interferometric mode feeding to a central receiver; this will transmit data to the Earth.

A

flotilla of 4 to 5 spacecrafts flying in formation will monitor about 1000 stars in the mid infrared region looking for small rocky planets. The reason for operating in the infrared region is in the optical wavelengths, the star to planet brightness ratio is about 10^9 to 1, where as in the mid-infrared it is about 10^6 to 1. This increases the sensitivity of detection.

The infra-red spectrometer will look for gasses like oxygen, carbon dioxide, methane and water vapour. On Earth these gases are produced by biological activities, however under certain conditions, these gases may also be produced by non-biological processes. In order to accurately determine these gases, the detector will operate at around 8°K (–265°C).

Three of the spacecrafts will act as light gathering space telescopes of 3 – 4 metre diameter and the light will be directed to the central spacecraft. The system will point to the selected star. In order to detect the faint signal from the planet, the signal from some of the telescopes will be delayed. This will cancel out the stronger star light; but since the planet is one side of the field of the view, there is an inherent built in delay of the signal reaching the telescope. This delay will in turn act in a constructive mode when the signals from the different telescopes are combined. The signal from the planet will be recorded stronger. This is called nulling interferometry. All these will require spacecrafts formation with a precision of millimetre and the light combination will require a precision of 0.1mm (100 µm). Such precision will be maintained by the GPS based guidance system. The satellites would be manoeuvred by ion propulsion engines and is expected to last for five years. Although the Darwin project was originally conceived by ESA in 1993, however it may become a joint ESA – NASA project scheduled for 2013

All the technology for this project may not be ready yet. ESA is looking for a novel way to handle the data. At present data travels at a faster speed via fibre optic at a speed of light, but once it enters the processing unit, it is converted into an electrical signal. This slows down the processing. A possible solution to this problem may be to develop chips which can handle optical signals. This will speed up the processing time and benefit computing.

SuperWASP, Wide Angle Search for Planets

This is a simple wide angle telescope and is operated by a group of eight institutions. This is an array of eight "off the shelf" wide angle telephoto lenses scaning the sky continuously, looking for transits. Each lens is connected to a high quality CCD camera. These cameras scan over a field about 2000 times wider than a conventional telescope. Each camera can observe about 100,000 stars per image.

The images are processed for removal of defects associated with the performance of CCD chips, dust and dirt etc. The stars in the processed images are identified by comparing with catalogued images of stars. Then a photometric analysis is carried out to determine the brightness of every star. After a large number of observations, say data

Super WASP is essentially a battery of digital camera with powerful telephoto lenses (Super-WASP) collection over a month, the dip in the brightness of the stars is measured. This indicates a possible transit. But there are phenomena which can also cause the variation of star light, such as binary systems and variable stars. The suitable candidate stars are spectrographically analysed in collaboration with Geneva Planet Search group, looking for wobble in the star. After this screening, selected stars are observed by Hubble or Spitzer space telescopes.

These telescopes operate robotically and are comparatively inexpensive. At present there are two set ups, SuperWASP North, in La Palma and SuperWASP South in South Africa.

Let us have a quick look at the formation of the exosolar planets around different types of stars

Planets orbiting Pulsar and Neutron stars:

Generally these stars are born out of supernova explosions. Now a question may be asked if the star has ejected material into interstellar space during the supernova explosion, where did the material for the planet formation come from. Now it seems that all the material does not leave star, some of it remains gravitational bound to the star. This material eventually begins to collapse under its own weight. Some of the material may fall back into the star, but in order to maintain the angular momentum, some of the material collapses and eventually forms planets.

Similar to the radial velocity measurement, the possible presence of planets around pulsars is detected by the delay in receiving radio signal. Such measurements around one pulsar suggest the planet is too far out to be formed out of its own dust cloud. A suggestion is that the planet has been captured from another star, by the pulsar. NASA's Spitzer Telescope has observed infrared radiation around another neutron star. The star is about 105 years old, but it may take about 106 years to form a planet. Therefore it may be possible that the infrared radiation is coming form a dust disc around the star and it is a potential future site for formation of planet.

Planets around White Dwarf stars

These stars form when the nuclear reaction in the core of the star has stopped and the outer material has been ejected as a planetary nebula. The core is still very hot from the nuclear reaction but begins to collapse, the density goes up, but at certain point, the pressure is so high that electrons cannot be packed any further and this prevents further collapse of the star.

With one white dwarf system, it was found to have a rotating body with a temperature of about 1,200°K (900°C); the temperature of the star was above 12,000°K (11000°C). It was first thought that the low temperate object is a cooler star. But the change in the temperature of the star and the object occurs at same time. The conclusion was that the object reflects infrared from the star or the infrared from the star is passing through the atmosphere of the object. These suggest the body to be a planet or a proto-planet. However the spectral signature of the star suggests that it might have caught an asteroid. The gravity of the star broke the asteroid and the material from the asteroid is now scattered in the system.

Discs around white dwarfs are about 0.1AU, much smaller than the discs around the newborn Sun like stars. The mass of such a disc is simular to an asteroid of about 30km in diameter. This also suggests that capture of an asteroid perhaps does occur. But it may also be possible that a planet was present around the original star and it did survive the explosion that formed the white dwarf. In our Solar system, an Earth like planet can survive such an explosion, if it is further than 1AU; Mars is likely to survive, but the Earth may not.

Astronomers have detected dust discs around white dwarfs at a distance of 100AU. This is too far to capture asteroids or comets. The origin of such disc is likely to be due to the collision of the asteroids or comets. If the comets and asteroids can survive the white dwarf explosion, it may be that a planet associated with the star might survive as well.

Planets around Brown Dwarf stars

A brown dwarf is not a star that exploded; the initial mass of hydrogen was not enough to generate heat to cause the fusion of hydrogen. These are objects of about 0.08 * Solar mass. Discs have been seen around brown dwarfs. These discs undergo some changes. Such changes have been explained as possible condensation of dust particles. However the discs around brown dwarfs are not big enough to form Jupiter (317.8 * Earth mass) like planets, however it can form planets like Neptune (17.2 * Earth mass) or Uranus (14.5 * Earth mass).

Are we getting carried away?

Doubts are being raised if we are too haste to identify some of the rotating bodies as the exoplanets. Some of the planets may take hundreds of years to orbit the star. From Keplar's law we can determine the mass. However we observe these for a short period and estimate mass from their age and brightness. It is assumed that the younger planets are hot, since these are still forming, and therefore brighter than the older planets. But the same condition need not apply to the star – planet system and this can lead to misinterpretation of results.

In 2008 seven planets were reported to be rotating around five starts. A member of the group who reported the original finding, now says that some of the rotating bodies may be the members of a star cluster rather than a planet.

The search for extrasolar planets although might have stared as an accidental observation, but now it has become one of the main topics of astronomy. We have detected planets not only around stars, but also around neutron stars and white dwarfs. Some of these might be captured asteroids. The compositions of these asteroids are similar to those in our Solar system.

Until recently we only had our own Solar system to study planet formation. Now as we venture out to other systems, we can see different stages of planet formation. This helps us to find out more about the past and future of our Solar system.

There are plenty of brown dwarfs close to our Solar system and it may be just be possible that some of the planets around these stars harbour life? NASA is to launch Wide field Infrared Survey Explorer satellite (WISE) at the end of this year. This survey may find new brown dwarfs close the Sun.

http://www.esa.int/science/gaia
www.esa.int/science/darwin
http://www.esa.int/science/corot
http://kepler.nasa.gov/sci/
http://www.superwasp.org/

Improbable Planets, M W Werner and M A Jura, Scientific American, June, 2009, p 26

Odds & Ends

By Ivor Clarke

At the bottom you will see a cutting from the Daily Mail a while ago, showing the dates of star signs through the year. It shows where the sun actually travels through these 13 equatorial constellations today. You can imagine the complaints from people who like to know what *their* stars tell *them* to do and how can you possible have 13 star signs?? Because the Earth wobbles in a 26,000 year circle through a 57° sweep round the sky, the north celestial pole star changes. Now we are lucky to have a near by bright star Polaris, mag 2 within ½°. But some of the ancients were not so lucky, (and folk in the future) they didn't (won't) have a pole star. In 12,000 years time α Vega in Lyra, mag 0 will be near the pole and the brightest pole star of all. Around then we will have summer on the other side of Earths orbit from now, so all of our winter constellations now, will be stars of summer then. Will future folk change the months so winter is still in December — March? On the way to Vega, γ Errai mag 3.2 in Cepheus is near the Pole in 4000AD, as well as mag 2.4 α Aderamin in 8000AD. Then nothing near until 11000AD when mag 2.9 δ Cygnus is a few degrees away. Past Vega and nothing until Thuban in the constellation Draco, much less conspicuous at mag 3.67, which was the pole star in 3000 BC, and will be 23000AD again!

So what about the list of equatorial constellations, how will they look in the future? Because the dates are now governed by the boundaries of the 88 constellations which were drawn up by the International Astronomical Union in 1930. These boundaries are not the same as seen by the Babylonian astronomers 3000 years ago, they are different. But its good fun showing folk what star sign is really theirs, some are shocked and don't want to know, and as we know most folk have only the vaguest idea of where stars are in the sky.

So we have now seen the last Space Shuttle Atlantis land on the final flight of the orbiters. After 3 decades of use and 135 missions it is the end for NASA's manned flight for at least 3 years until a replacement is deemed safe to fly. The Space Shuttle was built with a compromise to the military. They wanted to be able to fit a spy satellite in its cargo bay and early spy satellites were BIG, so NASA got the problem of making everything bigger than they really wanted or needed. The Orbiter ended up weighting in at 38 tons and needed huge lifting power to get it into orbit. Luckily for astronomers it could also carry a fairly large telescope into orbit and act as a Space AA to fix and service it.

For the future the agency is working on a four man capsule based on the Orion capsule which was cancelled. It is called a Multi-Purpose Crew Vehicle and will have a 21 day flight capacity. Along side this is a Heavy-Lift Launch System to carry up all the big bits needed for the ISS and satellites. Also four other private companies are working on developing an Earth to orbit system. One of the most advanced is called the SpaceX Falcon and it too has a four man capsule with an extended stay in orbit capacity. By 2014 this could be flying to the ISS if all the testing is complete. So what will be the legacy of the Space Shuttle? A good idea before its time? It helped build the Space Station and launch Magelian, Galileo, Hubble, Ulysses, Compton Gamma Ray Observatory, Chandra X-ray Observatory, Communication & Spy Satellites, several Space Labs, repair and replace most of the Hubble telescope science modules and keep it up-to-date and working better than ever.

It was also one of the most complex machines ever built and needed massive amounts of servicing at the end of every flight. Not many would fly around the world if every aircraft had to have a major service after each Atlantic crossing! So new spacecraft must be far more reliably and easy to service. Being smaller and lighter will bring advantages in fuel savings and lighter means less problems with re-entry temperatures. Most of the designs are similar to Apollo capsules with up-to-date materials and flight systems. I feel that these designs are a back ward step until a proper space plane is developed, using single stage to orbit technology. Work is being done on future systems, but we will have to wait for a lot more money in NASA's budget before space planes and holidays in space happen.

Our Society seems to be doing well at the moment with lots of new faces at our meetings, lots of new members. This can only be a good thing as a lively society can attract good speakers who are experts in their fields. I have been the editor of MIRA for quite a while now and I hope to continue, but I *do* need articles to make up each issue. On average each issue of MIRA has about 9000 words total in 3 to 6 articles. So what I need are stories to fill up each issue. They need not be long, as it is some times necessary to keep articles back until I can get them to fit into the issue I working on. It's not a good idea to do an article on next months eclipse, meteor shower or transit as it will be long gone by the time it gets printed! But how about a story on an interesting observation or a DIY project or a How-to-do-it article with pictures? I'm sure they are budding authors around.


HOW YOUR STARS WOULD CHANGE

Capricorn:	Jan 21 - Feb. 16	Leo:	Aug 11 - Sept. 16
Aquarius:	Feb 17 - Mar 11	Virgo:	Sept 17 - Oct. 30
Pisces:	March 12 - Apr 18	Libra:	Oct. 31 - Nov. 23
Aries:	Apr 19 - May 13	Scorpio:	Nov 24 - Nov. 29
Taurus:	May 14 - June 21	Ophiuchus:	Nov 30 - Dec. 17
Gemini:	June 22 - July 20	Sagittarius:	Dec 18 - Jan. 20
Cancer:	July 21 - Aug 10		