GNOMON

Newsletter of the Association for Astronomy Education

Vol. 23 No. 4 ISSN 0952-326X SUMMER 2004

Prizes for students and schools for the defense of learning science and maths

The Faulkes Telescope Project has announced a competition for students to express their ideas of how they would like science and maths lessons to be carried out. Students are requested to write a letter (maximum of one side A4) to Dr. Dill Faulkes, founder of the Project, outlining a project idea that will make studying science and maths more fun and exciting. The letter can be accompanied by one A4 picture illustrating the idea, if needed. Any ideas are welcome and the theme does not have to be based around astronomy. It could be a practical experiment or a game... whatever you find fun!

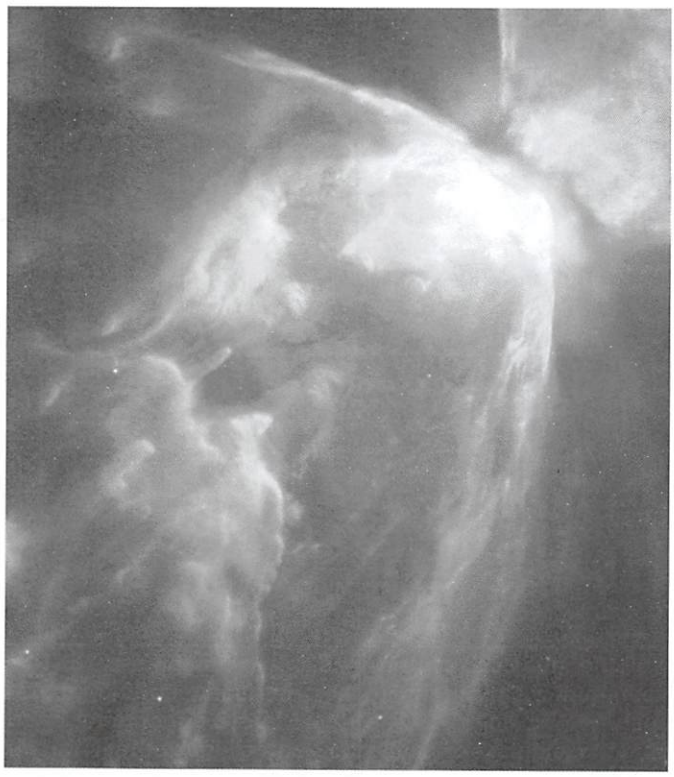
The competition is open to three age groups: Key Stage 3, 4 and post-16. The closing date for the competition is 16th July 2004 and a prize of £300 will be awarded in each age group to the winning student, with the school winning a free Faulkes Telescope Project subscription. The entries should be marked 'science competition' and sent to the Faulkes Telescope Operations Centre, Cardiff University, 5 The Parade, Cardiff, CF24 3YB.

For guidelines please visit
faulkes1.astro.cf.ac.uk/competition.htm

The scientific grade CCD has been successfully installed on FT North (previous images have been taken with the engineering grade chip), and test images show a clear improvement in quality. The Robotic control system ☞

Bugged by ice and fire

The Bug Nebula, NGC 6302, is one of the brightest and most extreme planetary nebulae known.This NASA/ESA Hubble Space Telescope image shows walls of compressed gas, laced with trailing strands and bubbling outflows. A dark, dusty torus surrounds the inner nebula (seen at the upper right). At the heart of the turmoil is one of the hottest stars known. Despite its temperature of at least 250,000K, the star itself is hidden by the blanket of icy dust and shines most brightly in the ultraviolet.The dusty torus contains hydrocarbons, carbonates such as calcite, as well as water ice and iron. The presence of carbonates in the Solar System has in the past been taken as evidence for liquid water in the past.Their detection in nebulae such as this, where no liquid water has existed, shows that other formation processes cannot be excluded. The Bug Nebula lies in Scorpius and its distance is estimated to be about 4000 light-years. - ESA/NASA and Albert Zijlstra



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The Royal Astronomical Society,
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Advertising Charges:

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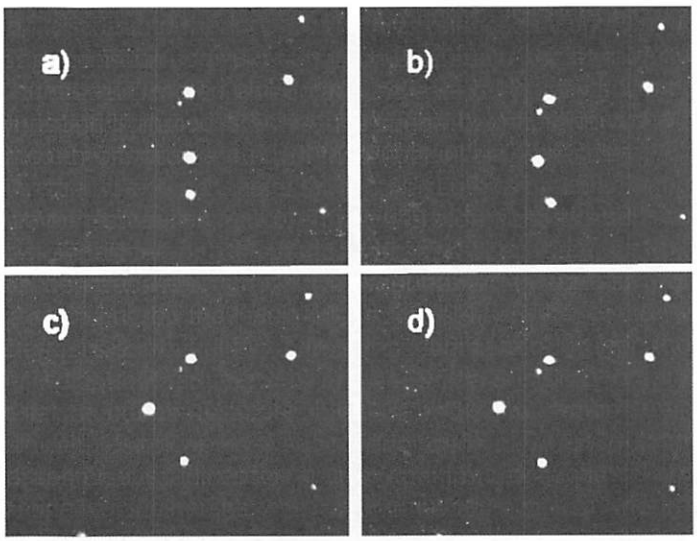
Publication Dates:

These are at the equinoxes and the solstices, that is four times a year. Copy deadlines are six weeks before these dates,

☞.was being commissioned during May, meaning that the telescope was due be able to operate autonomously towards the end of the month (it previously requires the Telescope Management Centre in Liverpool to open and close the enclosure, and monitor conditions through the night).



Pupils at Kings School in Canterbury have been studying the aptly named Canterbury Asteroid. Can you spot it in the images above? They also form wonderful examples of stereo pairs, allowing you to see the asteroid in paerspective with the naked eye- if you know how: see page 5.

(c) Faulkes Telescope LLC

FT South continues to make good progress, and is on schedule to start commissioning in the late summer. Dr. Richard Cole (FT Project Manager) is currently visiting both sites in yet another round-the-world tour, to monitor progress and liaise with local staff.

Over the last month, Faulkes Telescope North on Hawaii has been used by a small selection of schools and other institutions to test the use of the telescope and the educational materials, such as described above

Just time to get to Boston

A three-day hands-on symposium on teaching introductory astronomy at the college level will be held on July 16 - 18 on the campus of Tufts University near Boston, Massachusetts. The meeting is sponsored by the Astronomical Society of the Pacific and NASA's New England Space Science Initiative in Education, with co-sponsorship from the American Astronomical Society. The program includes components for veteran as well as for new instructors.For more information and registration instructions, see the meeting web site

www.astrosociety.org/events/cosmos.html

John Thompson

John Thompson, a member of the Association of long standing, who had taken over from Mike Dworetsky the task of answering the questions sent to the Association's "Query" service, died recently. The ASE President writes:

He was always there, telling of the beauty and mystery of the sky to little eager minds, reporting of his school adventures at our meetings, and helping in whatever was necessary at our busy stand at the ASE conferences. Most recently, he was answering in his unique and loving way, the questions of many children and teachers through our *Query* line, a task that he gladly accepted only a few weeks ago, and carried out to the very last minute.

I include one of his detailed answers on why lunar last longer than solar eclipses, which tell us, teaches us, about searching for examples, analogies, even for the simplest concepts, so that the idea becomes clearer.

Dear Dotty: Thank you for your question.

The duration of an eclipse depends mainly on two factors. Firstly the speed at which the Moon moves along its orbit around the Earth, which is the same for both types of eclipse, and secondly the sizes of the Earth and the Moon.

The Earth is about four times the diameter of the Moon and so it casts a much larger shadow at the distance of the Moon when it passes in front of the Sun. This means that it takes longer for the Moon to pass through the Earth's shadow in a lunar eclipse than for a point on the Earth to pass through the Moon's shadow during a Solar eclipse.

The distance between the Earth and Moon affects both eclipses in the same way. If you watched a long truck pass along a road in front of a street lamp at 60 mile/h, it would hide the light longer than a car travelling at the same speed along the same road. I hope this answers your question.

Best of luck: John Thompson (Query)

In another example, we find his delicate handling of the difficult topic concerning the influence of religion in the progress of our knowledge of nature.

Question: How have religious values impacted on our understanding of the universe throughout the ages, please give two examples such as Galileo and someone else. Thank you - Roisin

Dear Roisin: Thank you for your interesting query. Galileo is certainly a good example, and you should be able to find out about his confrontation with the Church of Rome through the internet or from a library or bookshop.

Another example is the influence which creationists are having on the teaching of astronomy and the evolution of life on Earth, especially in the Bible States of the USA and in Australia. They want schools to teach literally the Biblical account of creation, and largely to ignore the enormous mass of scientific evidence for the Earth having formed 4.5 billion years ago, and life having evolved for a large part of that time.

This can have a bad effect on the scientific training of large numbers of potential future astronomers. There is a large number of references on the internet: just do a search for "creationism". Or you can look in your library. Admittedly these deal more with creationism versus Darwinism, ie the origins of life, but the creation of the Earth is also covered.

I hope this is of some use. Let me know how you get on. Best wishes: John Thompson (Query)

This evoked the response:

Hi John, I would just like to thank you sooo much for your help. You are probably the only one that actually replied to me, not to mention the short amount of time it took. You are a brilliant man and a great help to all students. Once again, thank you so much, as you have helped me (an accelerated year 9 science student) greatly. Yours thankfully: Roisin

Thank you John. Your insight and love for those young minds will remain an inspiration and example for all of us, who had the privilege of working with you.

We send our deep sympathy to John's family and friends.

Francisco Diego

Observations

The first news page leads with the Faulkes telescope project again: and why not - it is better than a blank space? This project is going to be an important developing story until both telescopes are in service. This issue shows some of the initial results of the first telescope being used by a school in a trial run as part of the commissioning procedure. It represents a rare and valuable opportunity to stimulate the interest of young people in science, a need that the government and the educational establishment has identified, and which is causing a real worry.

We have received several items of interest announcing events that took place in May, which should have been sent by February 20 if they were to have any hope of appearing in Gnomon in time for any reader to take advantage of it. The Faulkes Telescope competition announced in our lead news item in this issue may even get to you a whole 26 days before the deadline for entries: not a lot of time for taking advantage of it!

So if you are a recipient of this newsletter, and find it interesting or useful, then let us know by sending in your news, comments, accounts of experience in astronomy education, and full details of practical work that can usefully be applied by others. The address is prominently shown on the front page. If you do not find this newsletter interesting or useful, please let us know that also - as long as you explain why you are dissatisfied. But again, if you let us have any of the articles described, in the form and at the level you would like to meet your criteria, then we can do something about it.

The Association of Astronomy Education subscription rate is among the lowest you can find for a professional or even leisure-oriented association of any kind. Its newsletter production is of high quality, whether or not the content matches up to your expectations, and accounts for most of that subscription.

Changing the subject, you probably noticed the press getting excited about some UFO sightings recently. I offer two contrasting, exclusive, reproductions of sensational observations of my own dating back, respectively, to (top photograph) about 1951, and (below) about 1994. The oldest was taken on a box camera (2¼ X 3½ format, 1/25s, f8, or thereabouts) well before the personal computer and Photoshop even existed, and the second was an Ektachrome slide which I have taken liberties with the contrast in a rather desparate hope that the impressive fleet of six UFOs (in the centre at the extreme top edge, and another to the left of Venus) can be seen when printed in *Gnomon*. This was taken as a photograph of a rather "old" Moon rising, with Venus close by. I did not spot the UFOs till I saw them on the slide

I'll leave you in suspense till the next issue for you to decide what they actually were.

Richard Knox
Editor

FOR YOUR LIBRARY

Exploring the Starry Sky. Robert Burnham and Wil Tirion. Cambridge University Press. 24pp. Diagrams (full colour). ISBN 0 – 521 80251 2 (paperback). £7.99 (US$12.0)

This book is eminently suitable for the young, first-time observer, even though the price is rather high per page!

The maps are designed to be held over one's head and oriented against the observer's sky. They show the aspect of the night sky through the year with eight chronologically arranged 19cm diameter circular maps, in the incomparable Wil Tirion style. Each of the four seasons is represented twice (early and late in the season) and each is marked with the time during the evening that the aspect shows on five dates spread throughout the period. The sky is expanded to over 180° in diameter to cover the stars that can be seen from latitudes north of about 40°

As an example, an appropriate one for this issue of Gnomon, the late summer, is used in greyscale and reduced in size for the "Sky Diary" map on the last page of this issue.

Each map is faced by a page of descriptive commentary highlighting what is prominent, or of particular interest in the illustrated night sky. In addition, a larger scale detail map features a part of the sky well placed for viewing

The book is a spiral bound paperback, which some potential users may also rather resent considering the price of the book. But the days of stitched binding that allowed spreads to lay flat (such as vintage editions of Norton's) are long gone, and the spiral binding and very heavy high-quality paper do allow the pages to be doubled backwards for ease of use outdoors, without destroying the book!

The presentation is non-technical. Times are given as by one's watch (even the effect of daylight saving time does not have to be remembered by the user). So, as explained in the caption to the map on Gnomon's back page, the chart is applicable from 30 minutes after midnight at the beginning of the two-monthly period, to 8.30p.m. (including daylight saving time) at the end.

To cater for the changing aspects of planets, the book concludes with tables of planetary positions in terms of the constellations where they will be found for each month during 2004 to 2006 (A brief moan here, why not start at 2005? It certainly limits the life of the book.) Astonishingly, for an observer's book, this also includes the positions of Neptune and Pluto!

In the same vein, one can also be critical of including faint telescopic objects shown in the charts. Most of the Virgo and Coma clusters of galaxies are shown, for example, although the text makes quite clear that these are telescopic objects. Another curious feature is the glow around the whole horizon throughout the year. An indication of twilight might have been more helpful (although it would conflict with the times given for the star charts, or course). Was it a sign of surrender to the inevitability of light pollution, or merely artist's licence?

Other "end-pieces" include a list of lunar and solar eclipses for 2004 through 2006, and a summary table of the best meteor showers.

Richard Knox

News from Down Under

The Anglo-Australian Telescope is now in its 30th year of operation, and like any facility approaching middle age, needs more and more TLC (Tender Loving Care) to keep it running smoothly. With the exception of four nights near Full Moon each February, when the main mirror is removed for washing and re-aluminising, the AAT is scheduled for use by visiting observers every night of the year. Unlike a lot of other telescopes of its size around the world, the AAT does not have a scheduled period of several weeks each year for preventative maintenance and upgrades. Instead, any major work has to take place in and around the aluminising period. In those 30 years, we have seldom lost more than one whole night to equipment failure (though on average one night in three is lost to bad weather). But just recently, our luck finally ran out.

On the evening of Saturday 24 April, the normally whisper-quiet system of electric drive motor, gearbox, and chains which haul the 17t shutter open each sunset, and closed each sunrise, was heard to emit some "unusual noises". Upon closer examination by the night assistant, it was discovered that the dome shutter had opened to beyond its normal opening limit, as a result of one of the chains stretching, and damage to one of the gearboxes. Although the shutter would still be able to close most of the way, and protect the telescope from the worst of the weather, it would not be safe to open it again until the damage could be repaired. The whole system had been inspected just six months ago, but clearly the strain of more than 20,000 openings and closings had finally taken its toll.

As frustrating as the loss of observing capability is for the AAO, it can be even more so for the visiting observers, most of whom had been planning their trip to the AAT for months (not to mention the poor chap who had just arrived, only to have to turn around and fly all the way back to the UK). Our current estimate is that the AAT will re-open in early June, meaning a total loss of some 6 weeks of observing time. We are being assisted by the superb efforts of a local engineering company, for whom our gearboxes are tiny compared with the sort normally serviced for the mining industry. We have been extremely fortunate in securing replacement chains from a supplier who just happened to have some of the right gauge and length, since the company from which it had been ordered originally had since collapsed. Nevertheless, this type of urgent repair is not something that has been budgeted for, and will require the AAO to make savings elsewhere to ensure our number one priority: collecting photons.

But as they say, every cloud has a silver lining, and six weeks gives the local observatory staff a rare opportunity to carry out all those jobs they had been putting off, for fear they may not be completed the same day, and risk jeopardising that night's observing. Such apparently trivial tasks as upgrading all our computer operating systems (Unix for the most part) to the latest version, and then thoroughly testing that all dependent systems still function reliably, can now be done in a less-frantic environment. Even the astronomers who would normally be spending their days and nights at the observatory helping the visiting observers, now get to spend time in the office instead, and have found themselves getting a lot more science done lately!

One job that sadly won't be able to be done in this time is the replacement of the AAT's computer control system, which has been in use almost unchanged from day one. The AAT was one of the first telescopes built with the expectation that it could be fully computer-controlled. Of course, many of the engineers were sceptical, and equipped it with all the usual dials, knobs, and pushbuttons. Although this made for quite an impressive console desk, most of them have never been used. The staff who designed the computer control system, and its software in particular, made such a good job of it that until now, there has been no scientific need to replace it. At its heart is an Interdata (later Perkin-Elmer) Model 70 microcomputer with a grand total of 64 kilobytes of memory (half of which is taken up by the operating system!). Yet this humble computer is able to drive the AAT in quite complex raster and spiral patterns, and keep the dome and windscreen aligned with it at all times. The programmers must have had a sense of humour though; the task for controlling the dome is called CONDOM, while the task for applying a focus offset is, of course, called [CENSORED]!

In the coming months, once the dome shutter problem has been resolved, we will be replacing a lot more of the aging infrastructure at the AAT, to make sure that it continues to perform reliably for the next 30 years, and hopefully beyond.

Stuart Ryder
sdr@aaoepp.aao.gov.au

Dotting t's and crossing eyes

Three-D images have been around since before photography was invented. If you want to know more about its fascinating history, look up the Stereographic Society's information. Earlier in the year I was lucky enough to be able to visit New Orleans. Among its many attractions was a magnificent aquarium and an adjoining I Max cinema, which was showing a new feature about undersea life on the Great Barrier Reef in 3D.

My wife and I felt doubly lucky because it was a Tuesday in term-time, so there were relatively few folk around, and no prospect of lots of noisy children in the middle of the day. We got our come-uppance for such uncharitable thoughts when we turned up with our pre-booked and paid tickets just before the next showing to find that an entire New Orleans school had also booked, and the auditorium was completely full! However, when the film started, and we all sat there wearing our left and right-polarised glasses, looking like a mass meeting of the Short-Sighted Society of the USA (President George W. Bush?) the cinema fell totally silent. We had never experienced such a vast array of children so totally engrossed, and my wife's a retired teacher! The stereo effect was completely magic. The depth of focus and perspective was so great that, at times, the fish appeared almost to be swimming out of your mouth! And when they did, most of the kids (and us!) were grouping in the air in front of them, trying to touch one of the fish!

It occurred to me then that it was a pity nobody publishes stereo films or photos for the enjoyment of those of us who have taken the trouble to learn naked-eye stereo viewing. There is enormous scope for using stereo-effect photographs in astronomy books too. There have been some very effective attempts, using different dates for taking photographs of the Moon, for example, against the starry backdrop, so that seen in stereo, the Moon swims out in front of the stars.

On the front page of this issue, there is a quartet of photographs taken by the New Faulkes Telescope North in Hawaii, by pupils at Kings School in Canterbury, of the coincidentally-named Canterbury asteroid as it moved against the background stars. These are presented in two pairs of photographs, and make perfect astronomical stereo pairs. Unfortunately, because of the relative positions of the photographs (they are swapped left and right for true stereo) the stars appear in front of the asteroid, so you need frame b) on the left of frame a), for example.

However, these simple examples may open to door to naked eye stereo viewing, if you try the following. Place the page in front of you at your normal reading distance (with your spectacles on if you need such things – like me). Concentrate on, say, the top two pictures a) and b) only. If you gradually start to cross your eyes, as if you were actually trying to focus on something nearer your eyes than the page, but without allowing your eyes to re-focus at that distance (and that's the hard part), then you will see two of everything on the page – i.e. four small frames of asteroid pictures.

As you adjust the degree to which your eyes are crossing, so the four pictures appear to move together and overlap. Now we are getting somewhere. If you are still in focus with each eye, even though they are not co-ordinated, the nearest two of each image will overlap until, with a bit of luck, they suddenly merge into one. You can now see three frames: a) on the left, b) on the right (both of which can be ignored) and the merged pair in the middle in stereo. There is the asteroid, clearly floating "behind" the stars. You will have to cut the pictures out and transpose them left and right if you want the asteroid to appear in front, because a) (and c) in the row below) are right eye views, and so it is no good simply turning the page upside down, since that also reverses the parallax effect.

This may have little to do with astronomy – but it provides a good opportunity for learning this skill, and who knows, if all *Gnomon* readers become boss-eyed, we can become the first magazine to publish everything in stereo (*pace* the Stereo Society!)

Richard Knox

Night falls on the triple-mooned planet

Peter Ford sends some interesting astronomy-related photographs to *Gnomon*. It would have been nice to be able to include the picture of ice crystals at sunset in the upper atmosphere above Askham Bryan, near York, taken by his daughter Bekki in 1995., but, as he pointed out, it depends on the colour to be appreciated.

So instead here is his shot of the full Moon through glass with a deliberately induced double image. This gives a feel for what lovers would spoon to on a triple-mooned world. Thanks Peter.

CURRICULUM CORNER

Spaced Out, the educational and public outreach project to create the World's largest scale model of our Solar System, had its media launch at the Jodrell Bank Visitors' Centre on Friday 12th March, the first day of National Science Week 2004.

This ambitious project aims to install eighteen sculptures, or "artistic installations" representing the planets, Halley's Comet, asteroids, centaurs and Kuiper Belt objects. These are situated in the grounds of schools and sites of astronomical interest (including Armagh Planetarium and the National Space Centre) at scaled distances from a central Sun that is in the grounds of the Jodrell Bank Observatory. The scale of the model is 1:15 million. On this scale, Mercury will be sited in Holmes Chapel in Cheshire, the Earth in Macclesfield, Saturn in Lancaster and Pluto in Fort William. By coincidence, the planet Uranus will be hosted by the William Herschel Museum in Bath.

Site Designer Ann Picot shows the site layout to pupils from Lancaster Girls' Grammar School at the launch of* Spaced Out *(Photograph: Chris Cartwright)

The Spaced Out team was led by Dr Nigel Marshall, Science teacher, author and proponent of GCSE Astronomy. The team comprises astronomers, teachers, designers and artists, who will oversee the design, construction and realisation of the project. The project's Patron is Professor Sir Francis Graham-Smith FRS, who describes Spaced Out as "a brilliant idea". The hardware will be supported by an dedicated interactive website, and it is envisaged that the individual models will be installed by the Spring of next year.

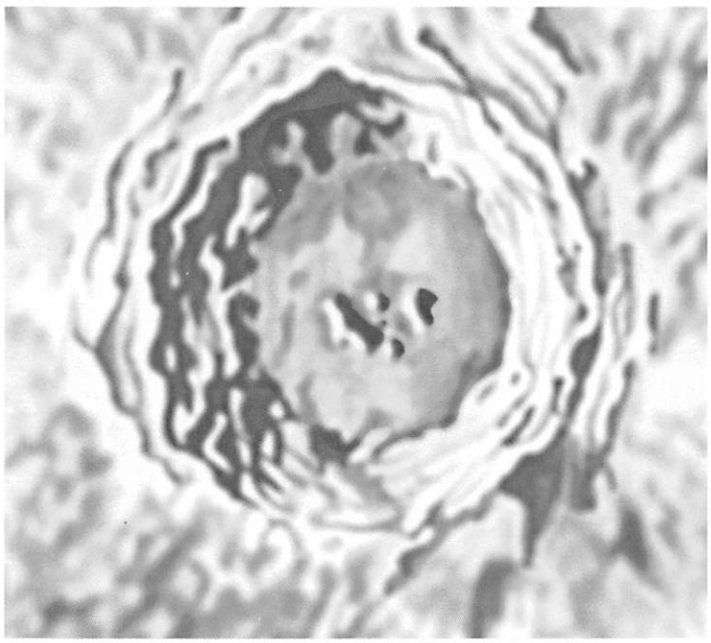
The project launch, supported by the Northwest Development Agency and G-MEX/Manchester International Convention Centre, was chaired by Jodrell Bank's Ian Morison and attended by astronomers, school pupils, media reporters and members of the general public The event was featured on the lunchtime and evening editions of BBC's Northwest Tonight, in a wide range of local and national newspapers and in Astronomy Now. A report on the BBC News website attracted over 3000 visitors in just two days.

Space exploration and astronomy now form major themes in primary and secondary school curricula. The Spaced Out team hope that the model will become a major national teaching resource that is accessible to all students in all schools. "It will show the scale and content of our Solar System. It is, no doubt, going to inspire, captivate and stimulate. We hope to encourage more young people to consider science-based careers," said Dr Marshall. The project can be monitored at **www.spacedout-uk.com**. Nigel Marshall will be more than pleased to give further information via e-mail on: **spacedoutuk@postmaster.co.uk**, or by telephone at: 01663 740 070.

Lunar vulcanism, and cosmic impact

In his book 'Micrographia' (1667) the English scientist Robert Hooke (1635 - 1703) explained how he boiled pots of alabaster and water, concluding from his observations that the Moon's craters might actually represent the solidified rims of bursting bubbles. Hooke also threw pellets into mixtures of clay and water to produce features which resembled impact craters surrounded by ejecta systems. The scientist, however, came to reject the impact (exogenic) theory of crater formation because he lived in an era long before the extra-terrestrial origin of meteorites was acknowledged. For the next two centuries the volcanic (endogenic) theory, and numerous variations upon the theme, were to dominate the thoughts of selenologists.

In the mid 19th century French astronomer Jean



Copernicus (93 km dia.) one of the Moon's best-known impact craters. [Observational drawing by Peter Grego]

Chacornac envisaged a lunar crust which often succumbed to violent underground explosions which tore out the lunar craters in a series of mighty upheavals - much like the Mount St. Helens disaster in 1980, where an entire mountain blew its top with a force 500 times more powerful than the Hiroshima atomic bomb. In 1874 the British astronomers James Nasmyth and James Carpenter had a vision of a slightly quieter Moon whose craters (including their terraced walls and central peaks) were formed by benign volcanic 'fountains'. The ray systems, they hypothesised, were large radial cracks in the crust through which lighter coloured lava had flowed.

One of the earliest attempts to introduce the impact theory of crater formation was made in 1829 by Franz von Gruithuisen. Though an excellent observer, the German astronomer was a rather eccentric character who believed that he had discovered firm telescopic evidence of intelligent life on the Moon, including a splendid lunar city near the Sinus Medii. It is unfortunate that Gruithuisen's ideas about lunar cratering were considered odd by many of his contemporaries.

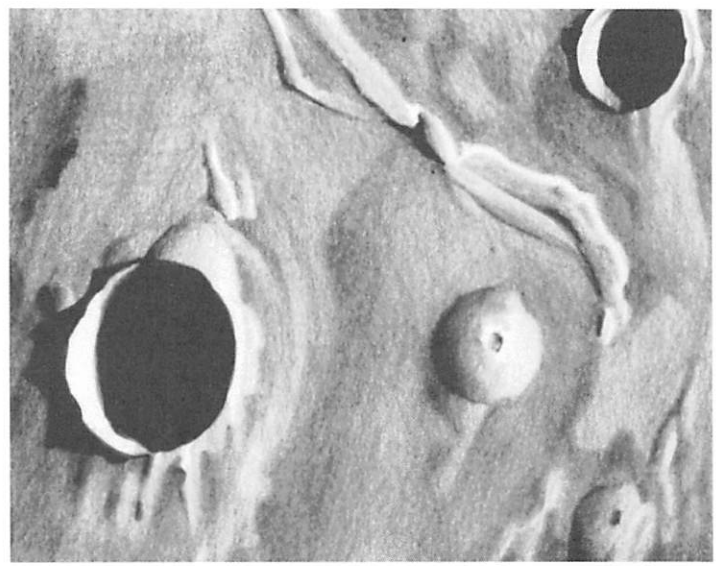
Support for lunar impact began to build after the realisation that Arizona's Barringer Crater, discovered in the 1870s, was a 1.3 km diameter scar produced by the prehistoric impact of a large iron-nickel meteoroid weighing two million tonnes. The first credible assault upon the views of volcanic proponents was launched in 1893 by the US geologist Grove Gilbert. After an extensive comparative analysis of the Moon's craters and the Earth's volcanoes, Gilbert firmly concluded that their differences ruled-out large-scale lunar volcanic cratering, claiming that the large craters were far too big to have been formed by any known volcanic processes. The geologist expanded upon his impact hypothesis by making systematic telescopic observations and laboratory experiments.

Today, bolstered by the mass of evidence gathered from Moon-orbiting and surface sampling probes - not to mention the rocks brought back by the Apollo missions - most lunar authorities are in no doubt that most of the Moon's craters were formed as a consequence of impact. Vulcanism has produced numerous very small craters, such as those that adorn the summits of some lunar domes, but most of these can only be discerned by amateurs through large telescopes under good conditions of seeing and illumination.

A notable American exception, the geologist and selenologist Josiah Spurr (1870 - 1950) was an extreme pro-vulcanist. In his 'Geology Applied to Selenology' (1944) he wrote "I have encountered nothing that would lead me to interpret any (lunar) feature as the result of meteoric infall....The sculpture of Moon features in general is quite sharp. Indubitable eruptive craters....are unmarked by evidence of any later catastrophe, such as pelting by celestial missiles." Somewhat ironically, the 13km lunar crater in the Marsh of Decay named in Spurr's honour is probably a meteoritic impact feature which was later modified by vulcanism and flooded with lava!

Around three trillion ($3X10^{12}$) craters over a metre diameter dot the lunar surface. From the very smallest pits to the largest enclosures, a survey of them all reveals an unbroken pattern in the relation between size and type. Were the craters volcanic, it would be reasonable to expect to see some of these features frozen in various stages of formation. But the telescopic observer will be disappointed to discover that there are no large laccolithic shields with peripheral faulting and on the verge of collapse, nor are there any semi-formed volcanic 'fountain' remnants. On the contrary, the majority of lunar craters, large and small, show the undeniable stigmata of impact origin.

Further endorsement of the impact theory was given by



Summit crater on the dome Milichius Pi (diameter 2 km), lying a short distance west of Copernicus. [Observational drawing by Peter Grego]

the nature of the lunar rocks themselves, for most of the metamorphic melts and hastily-assembled breccias could have been formed only by the tremendous instantaneous energies released by sudden meteoroidal impacts. Today the arguments have toned-down. Most accept that vulcanism and impact have jointly sculpted the Moon. What most well-informed authorities now find untenable is the suggestion that most of the craters are volcanic features.

To be sure, vulcanism has played a part in flooding many crater floors and producing features such as domes and their tiny summit craterlets. It is, however, unreasonable to suggest that internal mechanisms produced features like Plato, Copernicus, or the marial basins. We have now seen the mass of cratering evidence on the Solar System's other solid worlds, especially icy bodies and a myriad of objects far too small to have experienced any kind of conventional volcanic activity. This testimony, carved in solid rock and ice, has reinforced the impact scenario beyond measure.

Moon probes and discarded rocket stages thrown at our satellite have produced many sizeable craters which have been photographed from lunar orbit. A Moon-impacting spaceprobe, meteoroid or asteroid with a velocity of just 11,000km/h - rather a low speed on an interplanetary scale - will release an explosive energy equivalent to its own mass in TNT and carve out a crater at least ten times its own diameter. The missile would be totally shattered, some of the fragments buried beneath the lunar surface and some distributed around the impact site among a blanket of debris excavated from the Moon's surface.

The size and shape of impact craters depends on the composition of the missile, its size, mass and velocity. A non-compact icy cometary nucleus will hardly make a dent in the lunar crust, whilst a solid meteoroid of the same mass will produce a definite crater. Take a meteoroid of one million tonnes travelling through space with a velocity of 30km/s, a velocity equal to the Earth's orbital speed around the Sun, or ten times the speed of the low-energy impact outlined above. This meteoroid will have a kinetic energy of a quintillion (a million million million) joules. If this object hit the Moon then it would slice into the lunar crust like a hot knife through butter and tunnel a considerable distance into the Moon (several times the meteoroid's own diameter) before stopping. During this process, its kinetic energy would be converted to other forms, such as the mechanical energy of shock and fracture, heat energy and seismic waves transferred into the local lunar rocks. During the impact process, the temperature of the meteoroid would rise to several million degrees - enough to utterly vaporise it. Temperatures of a few hundred thousand degrees would be experienced by the rocks surrounding an ultra-hot bubble of gas, but the sheer weight of the lunar rock would not be enough to entomb the gas bubble for more than a fraction of a second. A violent explosion would occur as the local rocks rapidly heated and expanded, affecting a zone many times the diameter of the original meteoroid. The main effect of this frenetic event would be akin to a point charge under the Moon's surface. Because the explosion has such a concentrated focus deep within the lunar crust, it follows that the angle at which the meteoroid originally approached would be irrelevant to the resulting crater shape. Of greater significance to the form of the crater would be the nature and composition of the rocks at the impact site: the higher the amount of volatile material (substances which vaporise at relatively low temperatures), the greater the explosion will be.

When, in July 1994, the fragments of comet Shoemaker-Levy 9 slammed one-by-one into Jupiter's atmosphere, they created long-lived disturbances in the Jovian clouds which could easily be seen in a small telescope. For the first time in recorded history, we were all made aware of the undeniable power of major cosmic impact.

Peter Grego
Director, SPA Lunar section

Sky Diary Spring 2004

The perpetual astronomical twilight during the summer nights of the first half of this quarter makes serious observation somewhat difficult. The definition of twilight depends on who you are. If you are a council officer and have to decide when "lighting up time" is due you need to work with civil twilight. If you are a master and commander of one of HM fighting ships then you need to know nautical twilight, and if you read Gnomon, you are interested in astronomical twilight (I tell you!).

Each of the three definitions is based on "negative" altitudes of the Sun, or the angle of the Sun below the horizon, in 6° increments. Thus as the Sun sinks lower below the horizon, twilight ends when the Sun is at angles of 6°, 12°, and 18° below the horizon for the three definitions listed above, respectively. Similarly, the morning twilight begins as the Sun climbs higher towards the horizon and reaches each of the same angles. When the Sun reaches a maximum northerly declination of 23½°N at the northern Summer Solstice, it is at an angle of 66½° from the pole (polar distance or codeclination). In the case of mainland Britain, which covers latitudes of about 50° N to 59°N, its altitude when due north (latitude -polar distance) will be -16½° from the Lizard Point, and only -7° from northern Scotland. So from the extreme north, only civil twilight has finished before midnight. We may not have midnight Sun in the UK, but we certainly have a midnight twilight. Even from the Lizard, one can watch the nimbus of light above the Sun move round the horizon all through the night till it begins to brighten, and dawn breaks.

The critical declination for the Sun to achieve a momentary end of astronomical twilight must be when (transposing the relationships explained above) codeclination = latitude + 18°. So dark night draws nigh from the Lizard on about July 15, but at John O'Groats it not until a month later.

One of the practical results of this is to confuse the logic about the best time to observe southern objects, for example the most southerly zodiacal constellations. Any object should be best observed when due south (pace southern-hemisphere observers) at midnight, meaning highest n the darkest sky. The midnight twilight, and even more the early evening twilight when the casual observer is most likely to be looking, spoils such observations of objects with celestial longitudes of around 18h since these are culminating at midnight at the Summer Solstice. So, if you want to see Scorpius or Sagittarius, for example, during an evening star-gazing session, then early August permits a much better view (see the chart overleaf).

This quarter, the five naked eye planets are all fairly close to the Sun for most of the time. Mercury, of course, always suffers this fate. The planet will be at its best for the year in the morning sky during September. A maximum westery elongation of 18° (it could do better, as elongations ☞

☞ go) is on September 9. The favourable angle of the ecliptic across the eastern horizon in the late summer provides the best opportunity for spotting this elusive planet. Even though bright at magnitude 0.1, it is still in a bright twilight sky. Maximum magnitude does not coincide with maximum elongation, but rises as the planet closes with the Sun. By the end of September it will be about -1.2magnitude, but only 12° from the Sun.

Mercury is always tricky to find, being close to the Sun, and the dates are critical. Amateur astronomers also have a competitive streak in trying to spot the "youngest" Moon possible. The record is far from certain, as all sorts of extravagant claims are made. Zero seconds does not count (that's an eclipse of the Sun!). But the conditions are just the same as for spotting Mercury. You need a New Moon date close to an equinox, then look for the oldest Moon in an autumn morning, or a young Moon in a spring evening. New Moon is at September 14d 14h 29m, and it is only about 5° western elongation from the Sun. It may just be possible to find it by extrapolating the line through Saturn Venus and Mercury to the horizon, if you can find a sea horizon with a clear view eastwards at soon after 5:00hr UT that day.

Venus has concluded her wonderful evening apparition of the first half of the year and is now gleaming in the morning sky, reaching an elongation of 46° by August 18. This would be a good time for watching Venus in broad daylight. Impossible to miss in the darker sky early in the twilight, one can watch its position moving as the Earth turns, relative to a familiar fixed object (tree, lamp-post, inn sign) and easily keep an eye on it until well after sunrise. There is a good deal of satisfaction from finding the planet's bright spark against the full blue of the daytime sky. Of course, as with all daytime observation, care must be taken not to look at the Sun inadvertently.

Moon phases for the third quarter of 2004

Month	New Moon	First Quarter	Full Moon	Last Quarter
July	17	25	2 & 31	9
August	16	23	30	7
September	14	21	28	6

Mars is now so distant as finally it begins to lose its race with the Sun across the celestial sphere, and by mid September is at conjunction.

Jupiter, which has also been a familiar beacon during the first half of the year, is also now closing with the Sun, reaching conjunction on September 22, virtually at the position of the Autumn Equinox which is on the same day. Now the Sun is moving south at its maximum rate, and midnight twilight is long forgotten as the days "draw in" noticeably.

Saturn begins to emerge from its July alignment with the Sun and by the end of August may be spotted in the morning sky. On September 1 the planet is about 2° to the north of Venus, which will aid finding it in the twilight at magnitude 0.2.

The Harvest Moon this year is the Full Moon of September 28. So-called because the time of moonrise around this date is much the same each night for several days. Instead of rising later due to progressing some 13° eastwards round the ecliptic, it rises earlier due to moving rapidly northwards on the ecliptic, the two effects tending to cancel each other out. So now is the time to wearily wend your homeward way by the light of the Moon after a long hard day's harvesting. Go easy on the scrumpy. The next Full Moon does much the same thing, but is high in the sky later in the evening. Ideal for a nice bit of poaching! So the so-called Hunter's Moon will be on October 27. Alas for the moonlight, but as luck would have it, there will be a lunar eclipse - but more of that next issue.

Rising and setting times (UT): lat. 52°N; long. 3°W

	July 15		August 15		September 15	
	Rise	Set	Rise	Set	Rise	Set
Sun	04h 09m	20h 25m	04h 54m	19h 37m	05h 45m	18h 28m
Mercury	06h 19m	21h 31m	06h 45m	19h 35m	04h 06m	18h 06m
Venus	01h 51m	17h 11m	01h 11m	17h 00m	01h 39m	16h 55m
Mars	06h 01m	21h 26m	05h 54m	20h 02m	05h 46m	18h 33m
Jupiter	09h 11m	22h 26m	07h 42m	20h 13m	06h 17m	18h 42m
Saturn	03h 49m	20h 05m	02h 07m	18h 16m	00h 22m	16h 24m
Uranus	22h 01m	08h 27m	19h 57m	06h 19m	17h 53m	04h 10m
Neptune	21h 13m	06h 25m	19h 09m	04h 18m	17h 05m	12h 12m

Did you know that every month's Full Moon has a "traditional" folklore style name? Some months there are even two or more names. The list probably can be extended, but to date we have: Old Moon (or Moon after Yule) (January); Snow Moon, Hunger Moon or Wolf Moon (February); Sap, Crow or Lenten (all followed by "Moon") (March); Grass or Egg (April); Planting or Milk (May); Rose, Flower, or Strawberry (June); Thunder or Hay (July); Green Corn, or Grain (August); Harvest or Fruit (September); Hunters' (October); Frosty or Beaver (November); and Moon before Yule or Long Night Moon in December. And there may be many other but they haven't been discovered! (School lesson exercise idea: name your own monthly moons. World Cup Moon? Wimbledon Men's Finals Moon?)

Comet NEAT should be found in Ursa Major. The comet will be fading as it recedes from the Sun.

The twilight may interfere with what could be (always a very risky thing to predict) a spectacularly bright Perseid meteor shower, predicted on August 11 at about 21.00hr UT. This burst of Perseid activity would be ahead of the main shower due some hours later during the daylight hours in the UK.

Richard Knox

The "late Summer" sky, as seen at "12.30 a.m. on July 15, or 8.30 p.m. on September 15, from all mid northern latitudes. [From "Exploring the Starry Sky" - see* For Your Library, *page 5]. From Britain, the "tail" of the Scorpion, for example, is never visible.