GNOMON

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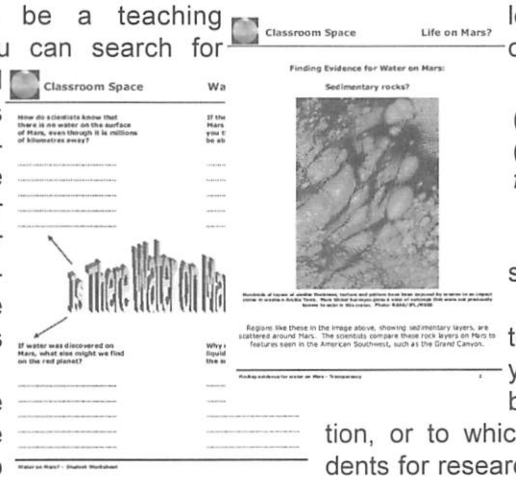
Professional astronomy data for schools

Classroom Space is a national project for Key Stage 3 and 4 that aims to revitalise science education in the UK using space science and astronomy. This is available on a website, designed to be a teaching resource. You can search for space-related activities under the various module headings, or look under the appropriate Key Stage to find what is available.

These resources are all linked to the Science National Curriculum, with some also incorporating the mathematics, ICT and geography curricula.

In each activity, teacher guides are provided, together with answer sheets and overheads; student worksheets, and real space data - either in hard copy (tables you can print out), or electronic format (files which can be downloaded and used with computer packages such as Excel).



(Left) woksheet and (right) data sheet from the new website

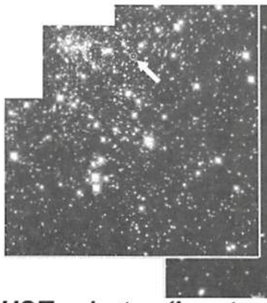
There are also links to other resources that you may find useful for background information, or to which you can direct students for research purposes.

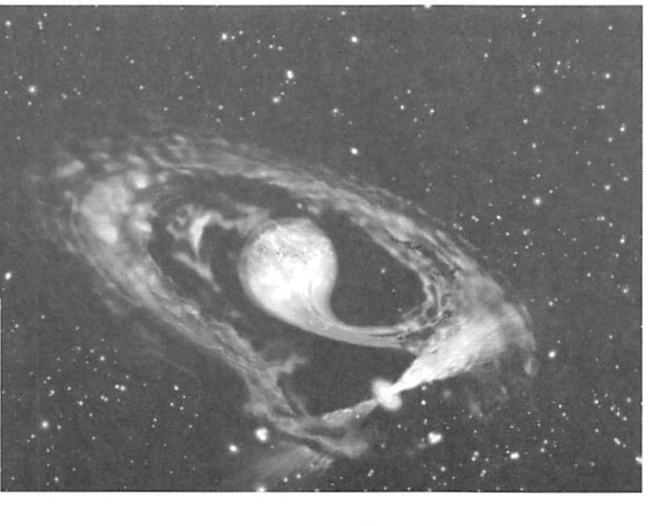
The project is funded by PPARC, and developed by Martin Barlow of the University of Leicester.

💻 **www.classroomspace.org.uk**

Hubble shows birth of millisecond pulsar?

The most favoured theory of how a pulsar attains such high revolutionary speeds, hundreds of times per second, is that the additional rotational energy is imparted to an old, slowly rotating neutron star in the neighbourhood of a red giant, from which it draws matter and transfers energy until stripping the giant star and leaving a white dwarf. HST observations, combined with the Parkes radio telescope, indicated that pulsar PSR 31740-5340, which rotates at 274 times per second in the globular cluster NGC 6397, close to a red giant star. If the theory outlined above is correct, this would indicate that the super dense object has recently speeded up to become a millisecond pulsar.





HST photo (inset, top left) and artist's impression of the pulsar and its red giant neighbour. (European Space Agency News Release)

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Publication Dates:

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

News from Down Under

Despite the wealth of excellent astronomical facilities available here in Australia, sometimes we have no choice but to apply to use telescopes elsewhere that are better located, or just better suited to observing our favourite objects.

One such example is in the so-called "millimetre" region of the electromagnetic spectrum (frequencies near 100GHz), which is where emission from a veritable zoo of molecules can be detected, among them SiO, HCN, and CO. Although Australia has the largest radio antenna in the southern hemisphere for observing at these wavelengths, it is hampered by being situated in a relatively humid environment (actually, the same humid environment that most of our optical telescopes suffer from). Water vapour is the arch-enemy of millimetre waves, absorbing most of them before they can reach the telescope.

This is why most millimetre-wave radio telescopes are located on high, dry sites, but unfortunately none exist on the Australian continent. The only other major millimetre-wave telescope in the southern hemisphere is run jointly by Sweden and the European Southern Observatory (ESO) at ESO's La Silla Observatory in Chile. The Swedish-ESO Submillimetre Telescope (SEST) is a 15m diameter antenna, whose surface is so smooth that it makes a pretty good optical reflector as well. This point was brought home in dramatic fashion during SEST's construction, when it was left pointed straight up as the mid-summer Chilean sun reached its zenith, and the result was great clouds of smoke billowing from the focus cabin. To this day, there are all sorts of dire warnings about observing anywhere close to the Sun, and indeed there are software and hardware mechanisms in place to prevent just this occurrence.

In February this year I travelled to Chile to carry out my own observations with SEST. Australia has an agreement with Sweden whereby it gets 10% of the Swedish time (5% of the total) in exchange for providing some hardware and personnel support. First stop was the ESO Guesthouse in Santiago, which provides food and lodging to astronomers in transit to either La Silla, or Paranal (home of the Very Large Telescope, or VLT). Amongst the many comforts provided to visiting astronomers, perhaps the most anticipated are the pre-dinner Pisco Sours!

From Santiago, it is a one hour flight to the nearest large town of La Serena, then a further 2½ hours north and east by bus to La Silla Observatory. La Silla is home to a large number of telescopes, including a 3.6m and the silver barn-like 3.5m "New Technology Telescope". Each telescope is supported by a team of astronomers which spends roughly one week a month at La Silla, with the rest of the time at ESO's Santiago headquarters.

Observing with SEST is relatively straightforward. Because the sky is so much brighter at these wavelengths than most sources, all observations start by looking at an adjacent "blank" position on the sky, then subtracting this from observations of the target. In addition, because the sky brightness changes so quickly, the telescope's secondary mirror "nods" 6 times every second between these two positions, so as to cancel out these changes.

For my own observations, I was interested in finding out how much molecular gas is contained in a huge cloud of intergalactic hydrogen which I discovered in 2001 using the Parkes multibeam (see my earlier Letters). At the end of four nights observing this cloud, I had detected absolutely nothing! While this was not the most personally-fulfilling outcome, considering how far I had travelled, it does throw up the more astrophysically-interesting possibility that this cloud is made up of primordial hydrogen created in the Big Bang, and so it has never been "polluted" by heavy elements produced in stars, as would happen had it once been part of a galaxy. So sometimes a null result can be the most interesting of all!

Stuart Ryder
sdr@aaoepp.aao.gov.au

Hands-on astronomy demo

Last year I was asked to help at a science fair for primary schools in north-east Hampshire. It was to be held on several dates between last November and this March. The organisers had found my name in the BAAS Speakers Database. I volunteered my services for one day, the venue being at Aldershot. The aims of the event were to enable local businesses and organisations to support KS 2 science and technology projects through "hands-on" activities and to offer Y6 pupils a glimpse of the World of Work.

The children would be in groups of six to eight and would spend 30 minutes at each station. I would have to repeat my presentation eight times in the course of the day. After canvassing the AAE Council Members, perusing the Earth and Space workpack, and thumbing through some back issues of Gnomon for ideas, I decided that the most suitable approach would be to concentrate on the Sun, Earth and Moon, with plenty of hands-on and interaction.

I turned up on the day and was shown to the separate room that I had asked for, because I wanted a dark room for the use of a projector. The other 12 or so organisations were spread out in a large hall. Their emphasis was on conservation and wildlife. Mine was the only exhibit dealing with a physical science. Macdonalds had a stand, though where this fitted in I have no idea, except perhaps representing a potential employer!

Although I had rehearsed at home, my presentation developed and improved throughout the day. I started with four slides of the Earth and Moon, including the Galileo photo of them together. Then I demonstrated the relative sizes and distances, with one child holding a small football (the Sun), and two others holding the Earth and Moon represented by tiny blobs of Blutac on the end of cocktail sticks.

I asked the children holding the Earth and Moon to stand at what they thought was the right distance away from the Sun. This usually got one or two metres in reply. Then I made them walk across the room, through the door, and down the corridor until they were the correct 19m away, with the Earth and Moon 5cm apart. This never failed to amaze them.

To demonstrate seasonal variations in the hours of daylight, the Moon's phases and eclipses, I used a child's Earth globe, a Blutac ball on a stick for the Moon, my projector with a blank slide in it, and a sheet of black paper over the screen to cut out reflection back onto the night side of the Earth and Moon. Although the Earth/ Moon separation was correct, the nearness of the projector "Sun" gave a diverging beam and hence an excessively large umbra, so that the total eclipse covered too large an area of the Earth. However the principle seemed to get through to the children, and I let them all have turns with the Earth and Moon(s), even though some of them were more interested in making shadowgraphs on the screen.

I also included a bit about how gravity controls orbits,

Astronomy Day in Rezh

Astronomy Day is already a tradition in the town of Rezh and its surroundings, in the Sverdlovsk region of Russia. In 2000, the association won third place in a nation-wide competition for such an event, called "Astronomy Day - our day", run by the astronomical magazine *Zvezdochet* (*Stargazer*).

The programme of events, displays and demonstrations making up Astronomy Days, became very popular as an annual event. The events are spread over a few days, even up to a week. Each year, the members and organisers try to introduce new and varied items to cover a range of interests for all ages, a tough assignment for an annual event.

Studying the Sun is an ideal activity when the weather permits, and attracts quite a crowd.

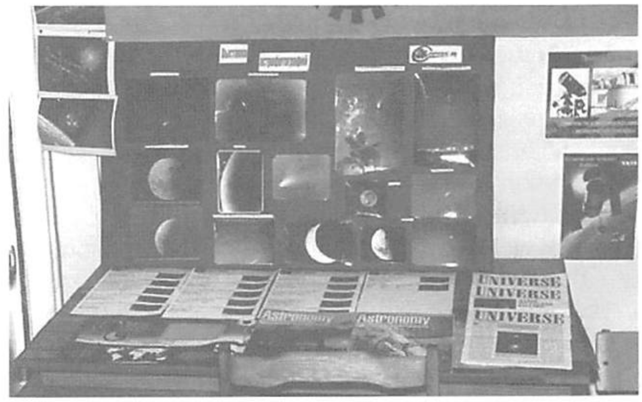
The programme usually includes a number of items such as:

- video and slides, which generally relate to modern knowledge about the universe;
- the latest astronomical news;
- virtual journeys around the Solar system using computers and the Internet;

Computer simulations and video displays back up talks on any aspect of astronomy.

- an exhibition of astronomical photographs;
- astronomical publications;
- observations in a telescope of the Moon and other celestial objects;
- audio-visual lectures on the basic directions of astronomy.

In addition, the Astronomy Day programme includes an exhibition of astronomical software for computers, so that anyone who wishes to can get acquainted with opportunities with programs such as "Red Shift ". Another feature has been the exhibition of materials demonstrating the activity of foreign astronomical societies and organisations. For the first time Sirius 86 members were able to show visitors a sample of the activities of the Mid Kent astronomical society



Part of the photographic exhibition, with some familiar reading on the table in front!

from England, with which Sirius 86 has been successfully cooperating for several years now.

The final day traditionally includes competitions and the Sky-Quiz, for which winners are awarded appropriate prizes

A group of keen young astronomers enjoy the special "library".

such as astronomical books, visual aids and so on. The most significant result of these events is the enlargement of the association by people with a new-found interest in astronomy. This year, the astronomical week will be held from April 15 to April 21.

Vladimir Golendukhin
President, Astrocosmic ssociation *Sirius-86*

☞(from p.2) using the stretch in a bicycle inner tube held by two children to represent gravity. A tennis ball on a string held in one hand, and whirled around above my head, also demonstrated how gravity (the tension in the string) is balanced by the centrifugal force on the planet (ball). As an engineer, I know that centrifugal force works and people understand it more easily than centripetal acceleration even though it is not rigorously correct!

At the end I asked for questions, and asked what had they learnt that was new. The Sun/Earth distance generally cropped up, and questions were, not surprisingly, more often about aliens, asteroid collisions, and how long does it take to fly to another galaxy?

I enjoyed the day very much, and volunteered my services for next year.

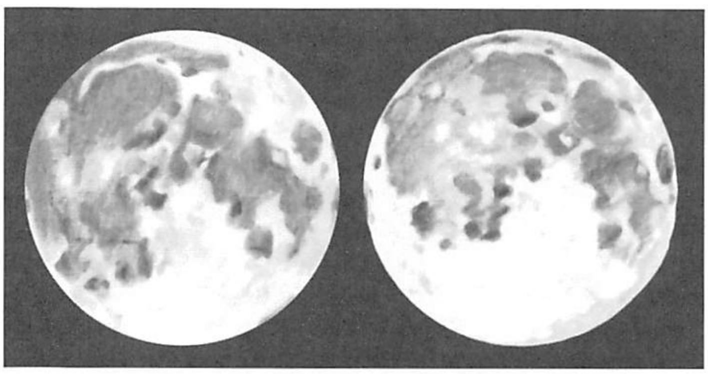
John Thompson

Lunar librations reveal the Moon's behind

The Moon always keeps the same sphinx-like face turned in the Earth's direction. As it orbits us every 29 days, 12 hours and 44 minutes, the Moon turns once on its own axis. This is known as synchronous rotation, a phenomenon displayed by various other of the solar system's planetary satellites. But the terrestrial observer is able to chart a little more than half of the Moon's surface. An apparent rocking motion of the Moon's globe called libration (Latin: *librare*, to balance), means that from the Earth a total of 59% of the Moon can theoretically be observed over a period of time. The remaining 41% constitutes the permanent lunar far-side that can never be seen from the Earth.

The process of libration is too slow to be noticeable in real time, but is evident when the Moon is inspected over days. Libration has two causes - optical and physical. Optical libration results from the Moon's ever-changing presentation to the terrestrial observer, combined with the position from which the Moon is viewed. Physical libration is an actual wobble of the Moon around its own centre of gravity - a real, though exceedingly small oscillation rather than an apparent one.

In fact, the Moon's physical libration is so tiny that it need not bother us in this discussion, for it never amounts to an angular displacement of under a second of arc at the centre of the Moon's disc. Because their magnitude is so tiny,



Sketches of the lunar disc, showing the effects of a maximum east and west libration. *(Sketches by Peter Grego).*

physical librations do not have any appreciable impact upon the observability of lunar features. Though Newton predicted this phenomenon in 1686, it had to wait over 150 years to be first detected by Friedrich Bessel who secured accurate astrometric measurements with a special telescope (which he designed himself) called a helimeter. On the other hand, optical libration - a term first applied by Isaac Newton - brings about obvious effects on the apparent position of features in the libration zones around the edge of the lunar disc, and there are three kinds - libration in longitude, libration in latitude and diurnal libration.

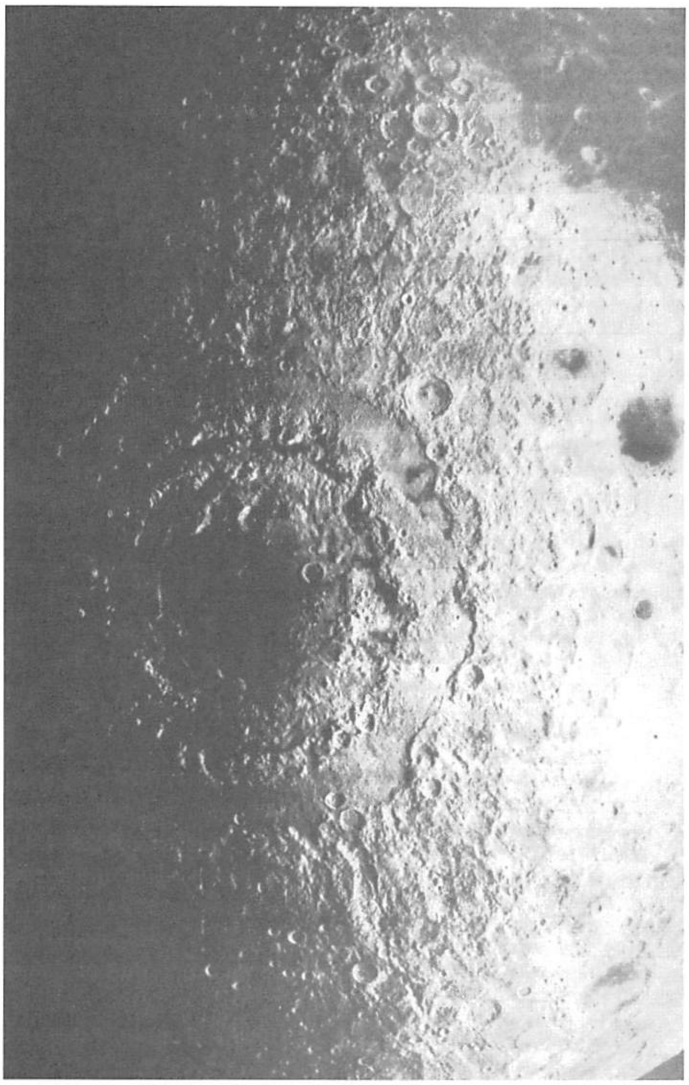
Libration in longitude, affecting the "sides" of the Moon, was described by Galileo in 1637. It is produced because the Moon's angular velocity varies as it orbits the Earth in an ellipse, accelerating on its way towards perigee (closest point in its orbit to the Earth) and slowing down on its outward leg to apogee (furthest point from Earth), whilst at all times maintaining a constant rate of rotation upon its own axis. Take the Moon as it completes a "fast" quarter section of its orbit after perigee; it will have covered this distance in less time than it took to make a quarter of a turn on its own axis. The Moon's axial rotation is at this point lagging behind, so to speak, and the mean centre of the Moon's disc appears displaced towards the west limb; far-side features on the east limb will have been brought onto the Earth-facing hemisphere, and if the illumination is right their favourable aspect will be viewed by telescopic observers eager to take advantage of this presentation. Half an orbit later, when the Moon is moving away from apogee in a slower section of its orbit, the opposite situation occurs. The Moon has made a quarter of a turn on its axis before it has made a quarter of an orbit around the Earth; the apparent displacement of the Moon's surface features will be towards the east, and features which are normally on the far-side make their appearance on the Moon's western limb. Twice every anomalistic month libration in longitude creates an east-west displacement of ± 7° 54'.

The Moon's "top and bottom" areas are brought into view by libration in latitude because the Moon's axis of rotation is not perpendicular to its orbital plane around the Earth. The lunar poles are tilted slightly and remain fixed in one direction in space, a fact which enables the observer each month to peer a little over the mean northern limb, and a fortnight later to view under the mean southern limb of the Moon. Libration in latitude was described by Hevelius in his *Selenographia* (1647). The phenomenon displaces the mean centre of the Moon north-south by ± 6° 51'.

On top of these two kinds of optical libration, the observer's view of the Moon changes because the Earth is revolving, carrying the observer around with it. The extent of this so-called "diurnal libration" is dependant upon the observer's terrestrial location. It is restricted by the Earth's apparent diameter of some 2° as seen from the Moon, but it can appear something like the parallax effect produced by an alternate left and right eye view of a tennis ball placed ten metres away - just under a degree in lunar longitude.

The Moon's libration zones lie around the edge of the lunar disc on either side of longitude 90°E and 90°W. Over time, all the features within these zones (amounting to 18% of the surface of the near-side) eventually make an appearance on the lunar limb. Whenever the Moon is observed, a narrow crescent of the Moon's far-side (ie., that which is further than the 90°E or 90°W line) is at all times being presented to the observer to some extent, though this region is not always visible because it might be on the limb of the unilluminated hemisphere. Strange to think that the "mean" Moon - one which has the 90° longitude line positioned exactly on the visible limb, as depicted on most lunar charts and atlases - has probably never been observed!

Lunar observers take optical librations into account because they determine the practical visibility of the Moon's limb features to a great extent; foreshortening effects can favour or disfavour useful observation. For example, it is no good planning in advance to observe Mare Orientale, which lies largely past the 90°W line near the Moon's south-western limb, without knowing whether libration will have brought it onto the Moon's near-side. Similarly, it is best to plan to observe near-side limb features when they are presented favourably. There isn't much point, for example, in attempting to observe the floor of the walled plain Gauss, near the north-eastern near-side limb, when there is a strong libration favouring the south-west. Features closer to



The Mare Orientale as can never be seen from the Earth with its amazing concentric rings of crater walls, the remains of a huge impact early in the history of the Solar System. Part of the Oceanus Procellarum can be seen in the top right corner and the dark-floored crater Grimaldi is on the right. Virtually all the unilluminated surface in this photograph is also on the lunar "far side". *(Photograph 1967 from an altitude of 2721km by Orbiter 4: NASA-Langley & Boeing Co.)*

the centre of the lunar disc are affected not so much by alteration in apparent shape, but by their proximity to the Moon's terminator, hence their individual times of emergence from and immersion into the lunar night.

Mare Orientale

A splendid lunar feature named Mare Orientale (the Eastern Sea) is perhaps the most famous of the Moon's libration features. At a favourable libration the formation may be discerned in binoculars, making a recognisable "dent" on the edge of the Moon.

Orientale lies on the "near-far-side", as it is situated beyond the mean western lunar limb (the whole of the 300 km diameter sea being past 90° west) and therefore a good libration is needed to bring it sensibly onto the visible hemisphere. Mare Orientale, along with other near-limb features, was recognised and named by Julius Franz at the turn of the century. The feature was not discovered by Percy Wilkins and his friend Patrick Moore in the 1950s - contrary to the claims of Moore himself!

The Orientale basin consists of several fractured mountain rings, and it was formed 3.8 thousand million years ago by a huge asteroidal impact. It is the youngest of the Moon's maria. Unlike the near-side basins, which have all been filled with lava, the Orientale basin is only partly flooded. Mare Orientale itself is only 300 km diameter. The basin's outer regions are stained by lava flows, and of these Lacus Veris and Lacus Autumni (Lakes of Spring and Autumn) are situated just on the near-side and may be seen whilst Mare Orientale is not on the disc. The true majesty of the whole formation only came to light when space probes photographed the area.

Orientale is captured on a plate in Pickering's 1904 lunar photographic atlas. When the feature was named Mare Orientale (Latin for Eastern Sea), the nomenclature was correct at the time since the system of lunar co-ordinates then in use meant that all features on the left hand side of the Moon were deemed to be in the east. The old classical system had lunar east and west pointing towards east and west on the celestial sphere, thus favouring telescopic observers. In 1961 the International Astronomical Union (IAU) chose to reverse east and west on the Moon to favour "astronautical" convention where an observer on the Moon would see the sun rise in the east and set in the west, as it does on Earth.

Seas on the Moon's eastern limb

Mare Humboldtianum, on the north-eastern limb, is a small crescent-shaped sea some 300 km across, situated wholly on the near-side from 90°E to 70°E longitude. Humboldtianum occupies the central part of a larger impact basin 650km diameter which extends onto the far-side. Like all near-limb features its visibility is affected by libration. At a good libration the whole of the mare and the mountains beyond can be discerned.

East of Mare Crisium lie two small irregular-shaped seas, Mare Marginis and Mare Smythii, both of which extend onto the far-side. Mare Smythii is one of only six lunar maria known to possess a central mascon - a concentration of mass beneath the surface whose gravitational pull is enough to make Moon-orbiting spacecraft deviate slightly from their orbit.

Mare Australe at the south-east limb is a circular sea of about 1000 km diameter which is composed of a network of flooded dark-floored craters and plains. It is probably a very ancient impact basin which experienced volcanism after subsequent meteoritic bombardment breached the pre-fractured crust in the basin's interior. Australe sits more-or-less squarely on the 90°E line, half on the near-side and half on the far-side.

Observing near-limb and true far-side lunar features is a challenge which appeals to those interested in taking their astronomical studies into places rarely viewed by human eyes. Even if the chances of new discoveries are very unlikely (now that intensive Moon-mapping has been completed by space probes) those who make this area of research their speciality will gain a great insight into the near-limb topography and librational behaviour of our satellite.

Peter Grego

Editor, *Popular Astronomy*

Director, SPA Lunar Section

(A simple observation of east west libration is possible with the naked eye when the Moon is around in the evening by looking at the Mare Crisium, the pom pom on the "Poodle's" tail. As shown in Peter's sketch, the difference in the separation between the Mare Crisium and the eastern limb is easy to make out. Check it out on photographs too, such as Peter's photo on page 6 of Gnomon *Vol.21 No.1.-* Ed.)

THE THINGS PEOPLE ASK!

Sarah Appleton and several others in January wrote: **What is the big bang? What is dark and anti-matter? How long will the universe last?**

The Big Bang is the name given to the cosmological model currently accepted by most astronomers and physicists as the best explanation of the evolution of the Universe from its beginnings until the present day. The model uses Einstein's General Theory of Relativity and is supported by several observations that agree with the predictions of the model. These include the expansion of the universe (Hubble red shift of distant galaxies), the cosmic microwave background radiation (the 3K background), the abundance of the light elements (hydrogen, helium, lithium, beryllium and their isotopes), the degree of clumpiness in the early universe, and the clumping of galaxies into clusters.

In this model all matter and space was once contained in an extremely tiny hot region that suddenly began a rapid expansion and cooling that eventually produced the Universe we see today. This happened about 14,000 million years ago. This is an oversimplified answer and you should try to find some astronomy books in your library that might explain the details a bit more.

No one knows what dark matter is, but there is a lot of evidence that it exists. As the name implies, it is matter that exerts a gravitational force but is not observed to radiate or reflect any light. One example of this evidence is the rotation of our own Galaxy. If there were only the matter we can see (stars, dust, gas) stars far out from the centre should orbit slowly. In fact they orbit nearly as fast as stars close to the centre. So there must be a lot of matter in a form that is just not visible.

Anti-matter is something else! This is "negative" matter. Every subatomic particle (e.g., electron, proton, neutrino) has an anti-particle. If a particle and its anti-particle happen to meet, they combine to yield all their mass-energy (as predicted by Einstein's equation $E = M C^2$) as a great flash of light (usually X rays and gamma rays). But this is not the same as dark matter; anti-matter would be very visible and cannot account for the "dark matter".

How long will the universe last? No one knows, but to judge from current observations, the expansion could go on for so long that all the stars would burn out long before the expansion slowed down to a stop.

There are some theories that the very nature of time itself would be altered by the vast epochs needed so that such a question would be meaningless. *Query* has no idea whether any of these ideas is correct.

I would like to become an astronomer. I'm doing a school project on the world of work and I was wondering if you could be tell me what being an astronomer is like and whether it is difficult and what it involves *wrote Elspeth Nuttall*

The best advice I can give to anyone who wants to be an astronomer is to do it because you love the subject, and be prepared to work very hard. There is little point in doing it for the money because most astronomers are either academics or employed by government bodies and the scope for earning high salaries is not very good. The other advice is to get as much education in mathematics and physics as you can absorb because it is essential to be good at both subjects in order to do astronomy.

The best preparation is to do a University degree in Astronomy, Astrophysics, or Physics. It normally takes several years of study and research after a first degree before the aspiring astronomer can be awarded a doctorate (PhD) which is the entry level qualification for research.

However a possible alternative, if you think you might like teaching rather than research, is to look into training as a planetarium lecturer or educator. There is an American Web Site at Lick Observatory where some students have set up an "Ask an Astronomer" service; they have links to careers questions: 🖳 **//www.ucolick.org**

Go to the Public Outreach link and look for the next link to "Ask an Astronomer", where you will find two links relevant to your question, "All about Astronomers" and "How Do I Become an Astronomer?".This will give you several related answers they have given to similar questions. Except for the obvious American orientation, the answers I read are not very different from those we would give in Britain.

Best wishes for success in making your dreams come true!

Lesley walker from Dundee asked **I'm looking for the correct name and spelling of a 3D model that shows our planets' position in the solar system. I believe it's called an "orary". Can you confirm and do you know where I could buy one?**

"Orrery" is the generic name of a mechanical clockwork device that shows the positions of planets (and the Earth's moon, usually), named for the Earl of Orrery, Charles Boyle, who commissioned the first one to be made for him by John Rowley in about 1712. The painter Joseph Wright of Derby depicted the use of an orrery in one of his most famous "scientific" paintings.

There is an American company that makes fairly expensive orrerys: 🖳 **//www.vancort.com/orrery.htm**

Another American maker, with lower prices, is found at 🖳 **//www.scienceartco.com/Products.htm**

Now that you have the right spelling perhaps you could try a search on the Internet. There are relatively cheap orrery kits that are sold through science museums and planetariums; you might ask their gift shops.

Antique orrerys are sometimes found in sale catalogues and at auctions; they usually command high prices.

What is the next planet after Pluto and is it true that Pluto will one day crash into Neptune? *asked Simeon Wells*

There are no planets known outside the distance of Pluto. It is unlikely, by current thinking, that such a planet exists. The region beyond Pluto is populated by thousands or millions of large "dirty icebergs" that may be up to more than 1200km across, though most are much smaller. The name of this region is the Kuiper Belt. Pluto will definitely never collide with Neptune. Very detailed calculations have shown that Neptune and Pluto are in a stable relationship and that the existing (very complicated in detail) gravitational interactions have been unchanged for the age of the solar system. Every time Pluto's orbit alters to bring Pluto closer to Neptune, Neptune sort of pushes it away!

Query

Ask an Astronomer

"The Things People Ask!" is selected, and edited, from the many questions received, and answers given by the Association of Astronomy Education's "Ask and Astronomer" Service conducted by Dr. Mike Dworetsky, University College, London. *Query* reminds senders of e.mail that plain text format is preferred, not Microsoft Word documents which can transmit computer viruses. The service is available to members of the AAE by e.mail:
🖮 **query@ulo.ucl.ac.uk,** or via the AAE home page:
🖳 **www.aae.org.uk**

CURRICULUM CORNER

A shadow measuring activity that I have done several times works well with children from about 9 year olds upwards. By having several students in the same class doing shadow records at the same time it give good comparisons. Much discussion arises as the records progress and in the end they have a pretty good understanding of the relationship between the length of the days and why the seasons change.

The following instructions can be added to the standard form illustrated.

The aim of this activity is to relate a series of shadow records of a student to the changing season.

This activity is best done recording the shadow of the same person on a length of paper at solar noon on the same day each week for 5 or 6 weeks. Have a student stand with their shadow lying along a 3m length of paper (3). Draw around the shadow outline, including their shoes. Record the student's name (1) their actual height (2) and date of recording. Measure the length of the shadow from heels to top of head (4) and record date and shadow length. Find and list the time of sunrise (5) and sunset (6) for each recording day and work out the length of daylight (7) and the time of solar noon (8).

What is revealed about the time of solar noon when compared with the changing length of daylight? Depending on the time of the year the shadow will be either lengthening or shortening. Can the students work out the correlation between the length of daylight and shadow length? Can they predict what next week's shadow length will be?

Stretch a length of string from the top of the student's head to the end of their shadow's head and measure the angle where the string meets the ground (measuring the altitude of the Sun). Is there any correlation between the changing length of the shadow, the Sun's altitude and what is happening to the season? What is the explanation? What has happened to the student's actual height over the time of the activity? From measurements made, can it be predicted if the length of the shadow will be the same as the student's height?

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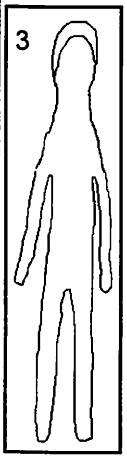
WHAT'S HAPPENING TO THESE SHADOWS? WHY?

1. NAME ____________________

2. HEIGHT start________ Date__________
end ________ Date__________

3



4.Date/Length	SUN 5.RISE	6.SET	7. DAYLIGHT	8. NOON
25/7 3010mm	7.25	17.30	10h 05m	12.27
1/8 3970mm	7.19	17.35	10h 16m	12.27
	7.13	17,41		
	7.05	17.47		
	6.56	17.52		
	6.47	17.58		

KEY
1.Name of the person who's shadow is being recorded.
2. Actual height of person recorded at the start and end.
3. Length of paper for recording person's shadow.
4. The length of the shadow at each recording date.
5. Sunrise times for each recording day.
6. Sunset times for each recording day.
7. Length of daylight for each recording day.
8. Time of solar noon on each recording day.

Sky Diary Spring 2002

The evening sky in the spring this year offers a very rare opportunity for making a fascinating addition to your collection of astronomical memorabilia and teaching aids. During most of the quarter, and in particular during the period April 18 to May 15, there will be a lovely line up of all the naked eye planets in the evening twilight. As always in the spring the ecliptic is most steeply inclined to the horizon in the northern hemisphere. So Mercury at its most visible evening elongation moves up the ecliptic at the southern end of the group towards Jupiter at the other. Many unique opportunities will arise as a result, and worth making a trip to where you have a very low western horizon.

On April 18, by the time the Sun has sunk to just over 5° below the western horizon, say about 19h 45m UT, Mercury will still be about 5° above the horizon, about WSW. The nearly six-day old Moon will be close to Jupiter and well up in the sky, about 47°.

The three other planets will be visible, in order from the horizon, Venus (brightest of all) Mars, faint at 1.6 magnitude compared with Mercury at about mag. -1.5, but very much higher in the sky close to the Pleiades which will not yet be visible to the unaided eye. Saturn at magnitude 0.2 will be faint but not too difficult. The total span of the five planets, Mercury to Jupiter, will be 58.5°, and, as can be seen from the first diagram, the ecliptic will conveniently lie roughly along the diagonal of your camera frame.

By April 30 Mercury has dimmed a little to magnitude 0.0, but is increasing its eastern elongation. Mars is still difficult, but with reference to the second diagram may be located between Saturn and Venus. The Jupiter-Mercury angle has now shrunk to 40.1°.

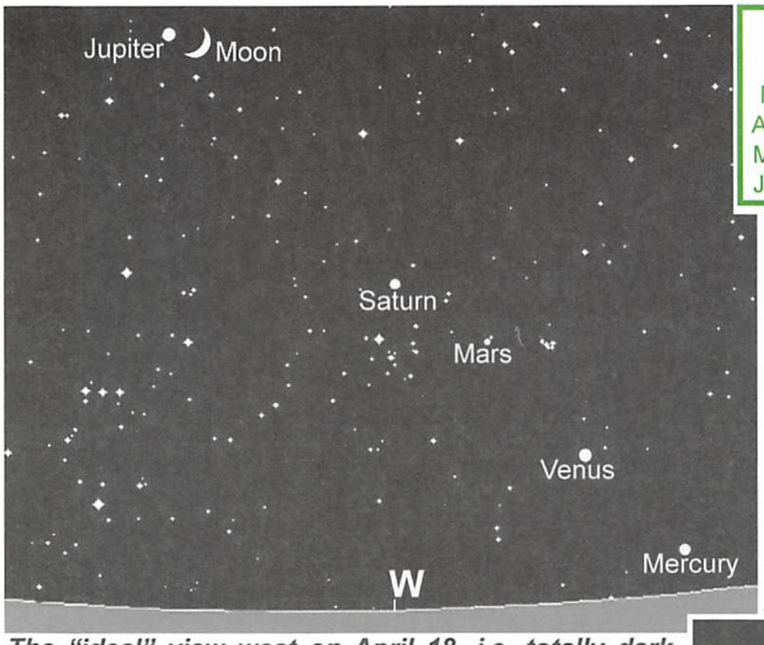
May 4 is when Mercury reaches its maximum eastern elongation of 21°, and it is at an altitude of nearly 12½° at 20h 15m UT when the Sun reaches just over 5° below the horizon.

By May 13, which possibly offers the most interesting view, although Mercury is now only 8° high when the Sun reaches the minus 5° point, the separation of the five planets is only 33.5°, and from now on it will get larger as well as increasingly difficult to see. On this evening the just over 24 hours old,1% phase, crescent Moon will joint the group as shown in the last diagram.

In addition to providing a possible record of all five naked eye planets in the same frame of film over a period of almost a month, the planets are situated in the Winter Wonderland of the sky around Taurus and Orion. The diagrams are at successively later times to allow the Sun to sink over 5° below the horizon, and Orion's Belt can be seen getting progressively lower as it nears its departure for the Summer months.

Note that the setting Belt of Orion is approximately parallel to the horizon, whereas when it rises in the eastern sky it is roughly at right angles to the horizon, showing the 90° apparent clockwise twist of bodies on the celestial equator as they traverse the heavens. At the point of reaching zero altitude, the northernmost star in the Belt, delta Orionis or Mintaka, marks almost exactly due west in these diagrams because it is at a declination close to zero, one of the most obvious stars to locate the celestial equator in the sky.

Venus and Mercury clearly move the fastest of this

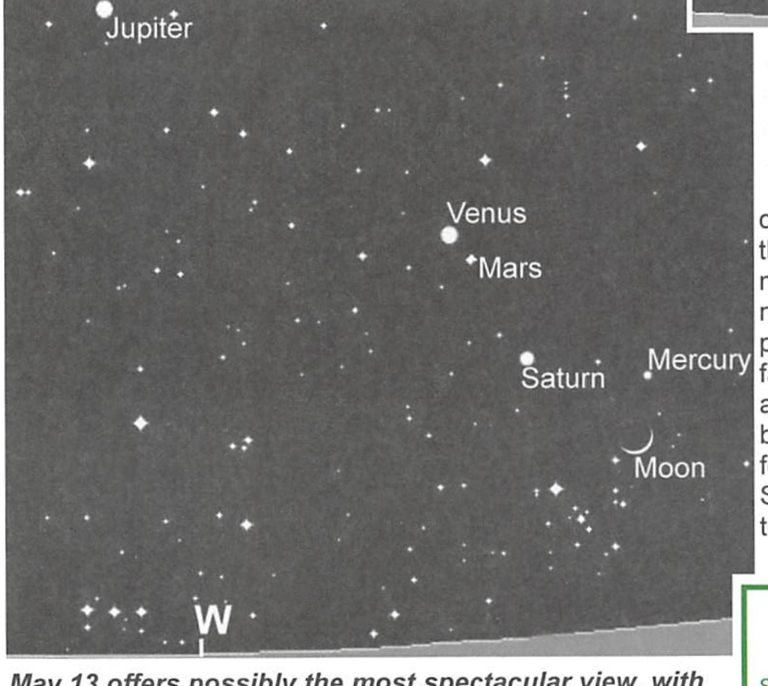


The "ideal" view west on April 18, i.e. totally dark instead of bright twilight (the Sun is 5° below the horizon in all these diagrams) and a sea horizon. Mercury is very low and difficult to find.

group, and if you allow for the fact that the Sun's apparent motion across the sky is due to the Earth's yearly orbit, you can also compare them all with the Earth (i.e. from the Sun's position).

Finally (at least as far as your Editor is going to write about it in this issue) the whole sequence shows the importance of the spring evenings, and the equivalent autumn mornings, in spotting Mercury, the very young Moon, or anything else relating to the ecliptic when at these times in the northern hemisphere, and the corresponding opposites at southern latitudes.

In addition to the two chances to watch Jupiter be occulted by the Moon, as described in the last issue of



May 13 offers possibly the most spectacular view, with the one-day old Moon joining the group. Venus has overtaken Mars, and both are east of Saturn.

Gnomon, on April 16 at 21.00h it will make a near-grazing occultation of Saturn. Of course, as the Moon makes its way along that line of planets it is not too surprising if it

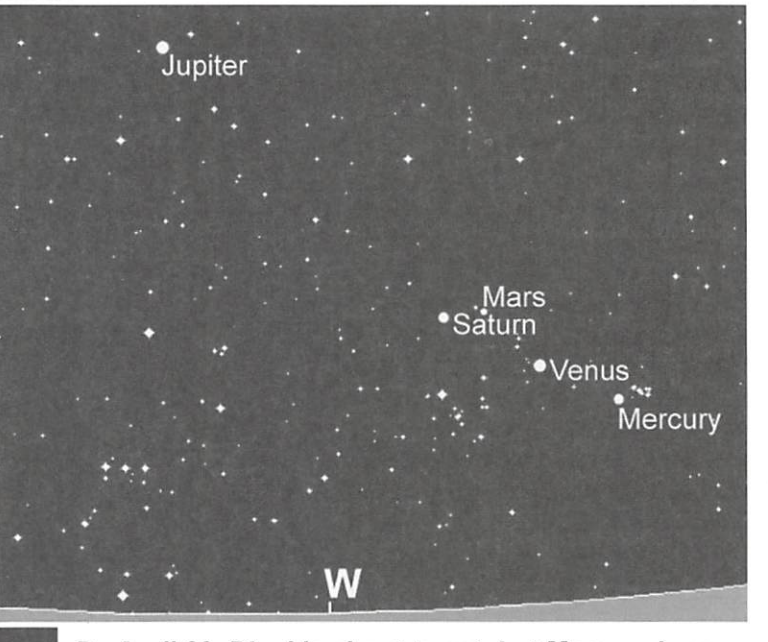
Moon phases for the second quarter of 2002

Month	New Moon	First Quarter	Full Moon	Last Quarter
April	12	20	27	4
May	12	19	26	4
June	10	18	24	3

has many close calls. Watch that space! In fact on May 14 the Moon has real fun with the planets, occulting Saturn, Mars and Venus all on the same day, but alas none of the events will be visible from the UK!

For the first week of June Jupiter and Venus will be very close together, less than 2° at the closest approach on June 3. But the planets will be bathed in twilight. It will be a valuable opportunity to see by just how much Venus outshines the biggest planet of our solar system.

By contrast Pluto reaches its closest, and therefore brightest, to the Earth on June 7. If you are not already aware, this means that it reaches magnitude 14. This is just about visible at the limit of a 10-inch telescope's



By April 30, Rigel is about to set, but Mercury is now at an altitude of about 11° when the Sun has sunk 5° below the horizon. Venus is closing on Mars and both are closing on Saturn.

capability, but even then only if you can separate it from the much greater number of faint stars by plotting it over many nights. This asteroidal object is well beyond the naked eye's capability, and was in fact discovered on a pair of photographs - two being necessary to spot that this faint dot had moved between exposures. Those of us who ask eager children of the primary ages which planet is brightest - biggest -hottest - nearest the Sun - etc. have found that almost anything other than furthest from the Sun will soon get the answer "Pluto". Uncle Walt has a lot to answer for!

Richard Knox

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

	April 15		May 15		June 15	
	Rise	Set	Rise	Set	Rise	Set
Sun	05h 15m	19h 09m	04h 18m	19h 59m	03h 51m	20h 33m
Mercury	05h 30m	20h 03m	04h 54m	21h 29m	03h 11m	18h 20m
Venus	06h 01m	21h 16m	04h 43m	22h 42m	06h 42m	22h 59m
Mars	06h 31m	22h 36m	05h 38m	22h 26m	05h 05m	21h 52m
Jupiter	08h 57m	01h 36m	07h 22m	23h 52m	05h 52m	22h 12m
Saturn	07h 19m	23h 19m	05h 33m	21h 39m	03h 45m	19h 57m
Uranus	03h 44m	13h 35m	01h 48m	11h 41m	23h 43m	09h 40m
Neptune	03h 03m	12h 00m	01h 05m	10h 03m	22h 59m	07h 59m