GNOMON

Newsletter of the Association for Astronomy Education

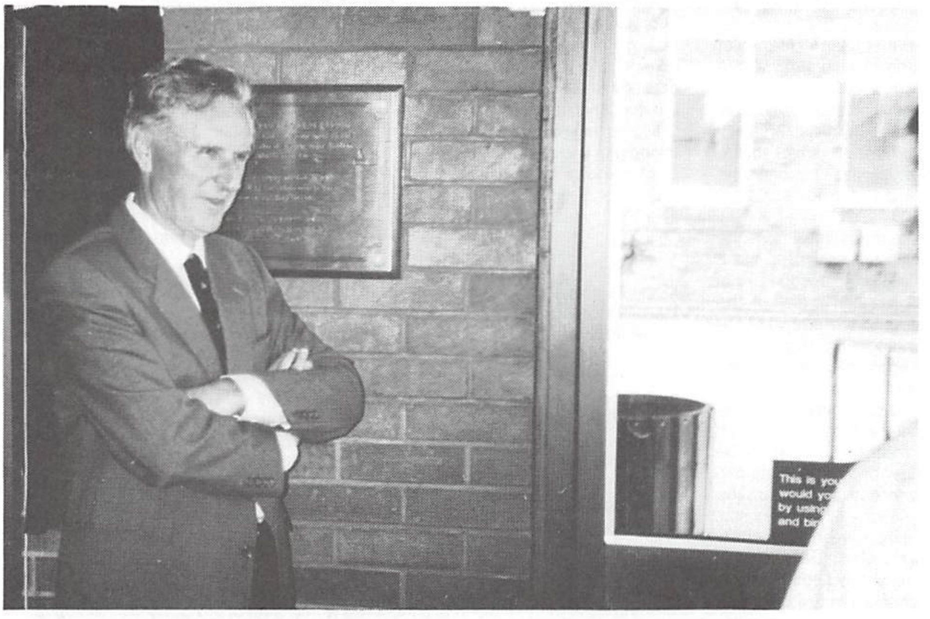
Vol. 12 No.1 | **ISSN 0952-326X** | **AUTUMN 1992**

EDITORIAL COMMENT

Shoot the Editor!! Abject apologies to Eva Hans for misrepresenting her remarks on the instant of sunset/sunrise, and the instants of the equinoxes, spring and autumnal. For a true account, see the LETTER from Dr Andrews and the article by Dr McNally in this issue. Apologies once again!

* * *

THE PIT AND THE PENDULUM



Airy centenary celebrated at South Tyneside College. The photograph shows the Astronomer Royal unveiling the commemorative plaque. The inscription reads: In October 1854 George Biddell Airy (1801-92), the seventh Astronomer royal, measured the mass of the earth by pendulum experiments at the top and bottom of the nearby Harton Pit. This plaque was set up by the Rotary Club of Harton in 1992 to commemorate the centenary of Airy's death. Unveiled 14th July 1992 by Professor Arnold Wolfendale, FRS, 14th Astronomer Royal.

ASSOCIATION FOR ASTRONOMY EDUCATION

REGIONAL MEETING

30th SEPTEMBER, 1992

6.00 pm - 9.00 pm

SOUTH TYNESIDE COLLEGE PLANETARIUM

For details please contact: The Planetarium,
South Tyneside College,
St George's Avenue,
South Shields,
Tyne and Wear
NE34 6ET
Telephone: (091) 4560403 Ext. 477

All AAE members are invited to attend free of charge. Anyone joining the AAE at the meeting will also be admitted free but non-members will be subject to a small admission fee.
Places must be reserved as accommodation in the Planetarium and Observatory is limited.

This issue of 'Gnomon' has been sponsored by The Royal Astronomical Society

This enables the newsletter of the Astronomical Society of the Pacific, 'The Universe in the Classroom', to be included as pages 5-8 of this issue.

Subscription Rates:

Individual Members	£7.50
Retired Members	£5.00
Corporate Members (e.g. schools, colleges etc.)	£15.00

Corporate Members will receive three copies of *Gnomon.*

Extra Copies:

0-10	£1.00 per copy
11-50	£0.75 per copy
51-	£0.50 per copy

Back numbers, not less than one year old, half these prices.

There will generally be a 10% discount to AAE members on all publications and advertising rates.

Practising teachers may claim their subscriptions as an allowance against income tax, thereby effectively reducing their contributions.

Addresses for Correspondence:

Secretary: Eva Hans, The Planetarium, South Tyneside College, St. George's Avenue, South Shields, Tyne and Wear NE34 6ET - for all general enquiries. (Tel: 091 4560403, ext. 477)

Treasurer: John Flynn, Armagh Planetarium, College Hill, Armagh, Northern Ireland BT61 9DB - for all financial and subscription enquiries. (Tel: 0861 524725)

Editor: Eric Zucker, 35 Gundreda Road, Lewes, East Sussex BN7 1PT - for all enquiries concerning the Newsletter. (Tel 0273 474347)

Advertising Charges:

Whole page	£120
Half page	£60
Quarter page	£30
Inserts	£75*

* These may be of any size which may conveniently be inserted into the newsletter. There may also be an additional charge for posting if the inserts are heavy.

The prices are for *one* issue.
A 25% reduction is made for advertising in all four issues.

SPACE COMPETITION: The Winning Essays

Congratulations again to our three winners; the essays are printed in full below.

Man has always looked to the skies and been transfixed by what he has seen in the heavens. Up until about four hundred years ago they could only dream about the stars and strive to understand them. One man who was inspired by this dream was Galileo Galilei who revolutionized the way in which everybody views our cosmos. He began with a telescope no more powerful than a pair of modern day binoculars, and made the discovery that the moon has craters on it. It had previously been suggested by Greek philosophers that all planets and moons were perfect. With better and more powerful telescopes he made many more observations including the discovery of four moons around Jupiter.

Over the years telescopes have been developed, unlike the ones that Galileo had used with lenses; now mirrors are used instead, these give a higher definition and clearer images. Telescopes have increased in size and become more powerful over the centuries and have become one of the most important aids to astronomers throughout the world. There are many different types of telescopes. There are solar telescopes of which there are many orbiting the Earth, and a few such as The Big Bear Solar Observatory in California. There are also telescopes that can pick up radio waves from galaxies. These can be picked up by large dishes such as the one at Jodrell Bank in Cheshire.

There are telescopes that can pick up electro-magnetic waves outside the visible spectrum; many of these can only be picked up from beyond the Earth's atmosphere such as gamma rays, X-rays and ultraviolet waves. However some infra-red waves can pass through the atmosphere and can be picked up at high altitudes like that of the observatory on Mauna Kea in Hawaii or from aircraft. The Earth's atmosphere is almost opaque to infra-red so the best way to observe infra-red waves is from beyond the Earth's atmosphere. This can be done with IRAS, Infra-red Astronomical Satellite. Launched in 1983, in a polar orbit 900km above the Earth, it gives a view of the sky with infra-red wavelengths. With the observatory astronomers can see what the sky looks like from the "far infra-red" spectrum.

Ultraviolet and gamma rays must be observed from space because of the opaque nature of our Earth's atmosphere. One of the observatories that can observe the ultraviolet waves is the Hubble Space Telescope. The Astra-1 mission in 1990 was another chance to view the cosmos through ultraviolet eyes. Containing the UIT Ultraviolet Imaging Telescope and the Hopkins Ultraviolet Telescope, it gave pictures of hot stars and found the image of a supernova that exploded about 20,000 years ago.

Lenses and mirrors are useless when scanning for gamma rays because they pass right through them so with telescopes such as the Compton Observatory and the Gamma Ray Observatory more effective equipment sensitive to the different wavelengths are used instead. Using these observatories, astronomers hope to unravel some of the mysteries of quasars, white dwarfs, neutron stars and interstellar clouds in the Milky Way.

The Hubble Space Telescope, built by NASA and with contributions from the European Space Agency is the only visible light observatory in space. It has a 2.4m mirror and has several advantages over the Earth based telescopes. It is able to pick up ultraviolet radiation and does not fall prey to many of the earthbound disturbances. Unfortunately because of a defect in the shape of the mirror, images that had been hoped for have not been forthcoming. Hopefully in 1993 when the corrections are made by the astronauts on board the NASA Space Shuttle, it will produce the pictures that we have been expecting since it went into orbit in 1989. The Hubble Space Telescope even in its present condition is far better than any ground based telescope. It is estimated that it will be about seven times more effective when repaired next year. Although fainter objects cannot be focused upon properly at the moment, the distortion on other brighter objects can be overcome with the aid of computer enhancement and can correct for the shape of the mirror.

With innovations such as the Hubble Space Telescope we have a new perspective into the exploration of space; it means that quasars can be studied in greater detail and may even lead to new planets being found around other stars in our own galaxy. The atmosphere around Mars can be monitored in greater detail and hopefully we might be able to detect infra-red bands around any planets orbiting the closest star Alpha Centauri. As the Hubble Space Telescope and other space observatories like it will help to answer astronomers' questions, it will no doubt leave us with more questions waiting to be answered.

On Thursday 23rd April 1992 findings from COBE (Cosmic Background Explorer) were made public, supporting the Big Bang theory to be correct as to how the Universe began. COBE, launched in 1989, detects deviations from a perfect blackbody spectrum. It monitors the glow after the Big Bang by examining the cosmic microwave background. Before, the Universe was observed to be uniform in every direction, COBE has now detected slight abnormalities which condensed into galaxies supporting the Big Bang theory. This discovery could be the biggest breakthrough this century in space exploration. Many measurements at a variety of different wavelengths were taken of the cosmic radiation left over from the Big Bang. The results strongly support that the Big Bang did take place billions of years ago. At present the Universe is still expanding. If or even when it ceases to expand the Universe may contract and lead to the Big Crunch. The space observatories that are in operation at the moment may eventually give the observations that we need to tell us whether there will ever be a Big Crunch, or whether the Universe will continue to expand forever!

Debra Morris (Age 17)
Dane Valley High School,
Congleton, Cheshire.

Astronomy is a subject in which I have always been interested. Observing the heavens on a clear night always leaves me with a sense of wonder and awe. Astronomy is, after all, a pursuit of the imagination. We can only wonder about the size of the Universe and the phenomena which we may never see.

In the last twenty-five years many breakthroughs have been made. Man can travel to space again and again and can live there for lengthy periods of time. This enables us to explore and learn about the Universe in which we live. Before, we could only view our solar system and the Universe from the Earth but now we can get a much clearer view from above the Earth's obscuring atmosphere and without the limitations of view. For example, observing from the northern hemisphere we cannot see the Southern Cross. This enables us to observe further into the realms of space, further than we could every have imagined before.

Spacelab is one way in which we can observe the Universe. In Spacelab, many experiments are undertaken but in addition many astronomical observations can be made, observations of such transient events as a comet passage, aurora borealis and novae as well as a more refined study of our solar system. Perhaps we could observe our own planet too, to find out such happenings as the depletion of the ozone layer which is a major concern.

An astronomical observatory in space can extend man's vision of the Universe. The largest one ever to be built was the forty-three foot Hubble Space Telescope. It enables us to have a picture window view of the Universe. It can see planets, stars and other celestial objects much, much better than any telescope would on Earth. It can observe much further into the Universe. For example it could give us detailed views of the outermost planets of the solar system. It could possibly detect planets revolving around other stars, other galaxies. It can make many observations enabling astronomers to determine the distances of stars from each other and from the Earth as well as other celestial bodies. An astronomical observation is a great achievement. With the naked eye we can only see a small fraction of the vast numbers of stars in the Universe which can be compared to a grain of sand on a beach. There are billions of galaxies in the Universe each with billions of stars. To be able to observe them all would certainly give a great sense of fulfilment! Indeed we are observing what has happened in the past in our Universe as the light which has travelled from distant objects to reach us has taken a vast amount of time, up to may billions of years in fact. By studying what happened in the Universe billions of years ago it can help us establish or try to predict how the Universe began and exactly how our own solar system came into being which has had many theories.

None can see what exactly the future holds but hopefully with the improvement of technology we may be able to further our study even more. Will we be able to determine exactly how big the Universe is? Will we be able to observe celestial objects of great interest, such as quasars, in depth and find out more about them or study such curiosities as black holes in more detail? Will we be able to prove the existence of other planets in other galaxies, and possibly other life forms? The Universe is expanding at a rapid rate. Will we be able to observe the changes taking place in more depth?

Who knows what man will achieve? I know I would certainly like to be part of it.

Liese Marks (Age 17)
Ballyclare High School,
Co. Antrim, Northern Ireland.

Man has always gazed at the celestial heavens, even from his earliest existence. He probably thought that each star was a worshipful god and may have even contemplated the existence of other civilisations. In doing so astronomy was created and hence remains to be the most ancient of sciences, even though one might consider it to be one of the most advanced. Astronomy has since then steadily progressed over the ages from being purely observational, as in the case of the Babylonians, Egyptians and Chinese, to a balanced theoretical and empirical practice, as introduced by the Greeks. However, most progress made in astronomy is quite recent as it has all taken place this century.

The 20th century has brought about a revolution in astronomy. Most importantly it has seen the birth of cosmology and radio astronomy, the introduction of the photometer and CCD (charge-coupled device) silicon chip, and most important of all the dawning of a new era - the Space Age.

Scientifically, the Space Age has dragged astronomy out of the cobwebs and has placed it in the spotlight at the forefront of modern science and technology. Astronomy is today's world is concerned with the mapping out of Mankind's future amongst our neighbouring planets, solving the genesis problem, discovering what our distant future may hold, unravelling the mysteries of the universe, and searching the galaxies for extraterrestrial intelligence (SETI).

The golden age of space exploration officially commenced on 4th October 1957 when the Russians launched the first artificial satellite *Sputnik 1* into orbit around the Earth. It was about the size of a football and only carried a radio transmitter. since then, however, rocket and satellite technology has progressed rapidly. On the 20 July 1969 the *Eagle* lunar module carrying the American astronauts Neil Armstrong and Edwin "Buzz" Aldrin descended to the surface of the Moon to land on the bleak rocks of the lunar Sea of Tranquility. Armstrong's first step on to the Moon signified the coming of a new age in which humans would someday colonise the planets and satellites in the solar system.

Astronomy today is not confined to ground based observatories but is branching out into orbiting space observatories. Observatories in space have more advantages than those on Earth as they are not affected by any atmospheric or light pollution which would result in light loss and weakening of radio waves to both conventional optical and radio observatories. The Earth's atmosphere effectively absorbs most kinds of electromagnetic radiation from the heavens so that the images received by ground based observatories do not give us a complete picture of the universe. Hence, if working in space, we would be able to see X-rays, Gamma-rays, Microwaves, Ultraviolet and infra-red light which would form a different picture of the universe.

Since 1957, Man has constructed many satellite observatories dealing with the previously unattainable electromagnetic radiation that would bring another dimension to the observable universe. for example, X-ray astronomy officially began with the launch of the first X-ray astronomy satellite *Uhuru* on 12 December 1970 off the Kenyan coast and since then we have seen the launch of others such as *Ariel V*, October 1974, *The Einstein Observatory* satellite, 1978, ESA's *Exosat* satellite, 26 May 1983, and most recently *Rosat*, a joint British, German and American venture. The first real Gamma-ray telescopes were launched in the 1970s like the US *SAS-2* satellite, 1972, the European *COS-B* satellite, 1975, and more recently NASA's *Gamma-ray Observatory* (GRO). The first infra-red satellite was launched in January 1983 known as *IRAS*. The first ultra-violet satellites, launched in the 1960s, were replaced by NASA's *Orbiting Solar Observatory*. Other satellites have been launched since like the European *TD-1* satellite, 1972, and the *IUE* satellite, 1978.

The exploration of microwave radiation is being undertaken by NASA's *Cosmic Background Explorer* satellite (COBE) which recently discovered the expansion ripples in the cosmic background microwave radiation remaining from the Big Bang. Observations with conventional astronomical instruments also benefit enormously from being made above the obscuring mantle of the Earth's atmosphere. The recently developed *Hubble Space Telescope* (HST), a conventional Gregorian reflector telescope with unconventional capabilities was launched by NASA in the early 1990s but developed a distortion owing to a fault in the mirror testing apparatus.

Other astronomical satellites are concerned with the exploration of the solar system, e.g. the Soviet *Luna* probes, the American *Pioneer* and *Ranger* series as well as the *Surveyor* and *Orbiter* probes. Other planetary probes include the Soviet *Venera* and the American *Mariner*, *Viking* and *Voyager* series. More modern probes consist of the Soviet probes, *Vega (1&2)* and *Phobos (1&2)*, the Japanese probes, *Sakigake* and *Siusei*, the European *Giotto* and *Ulysses* solar probe, and NASA's *Magellan* and *Galileo* craft.

Astronomy from space does not necessarily have to consist of computer controlled orbiting observatories. It is now quite common to put astronomers into orbit around the Earth who would conduct their experiments and observations in special laboratories aboard orbiting space stations. The first successful space station was *Salyut 6*, one of the Soviet Salyut series incorporated with 3 telescopes. Other space stations include the Soviet *Mir* spacecraft, the American *Skylab* craft, and ESA's *Spacelab (1&2)*.

Astronomy from space has become an important everyday issue with each new discovery being widely publicised. What with recent developments in science it is quite likely that Man will set foot on Mars shortly after the year 2000, begin the inhabitation of the Moon, and through cosmology even determine the fate of the Universe. It appears, from the happenings over the last 30 years, that astronomy is guaranteed a place at the forefront on Mankind's mission to colonise Earth's neighbouring planets in the solar system (and possibly beyond) and also to fulfil his quest for knowledge formulated with the existence of the universe - and all this can only be done by astronomy from space.

David D. Feinstein (Age 15)
St. Paul's School,
Barnes, London.

The Star System of Regulus - α Leonis : HR 3982, HD 87901

Notes by Tony Lawton, President of the British Interplanetary Society

Leonis, a B type Main Sequence star with an apparent magnitude of 1.35

Data from HR Catalogue

Spectrum B7V	- Main Sequence
Colour Excess	(B-V) +0.01
Parallax	0.045
Distance	22.2 parsecs or 72.5 light-years
Apparent Magnitude	+ 1.35
Companions	4
Class of companions :	spectral binary or eclipsing binary
Separation	A-B 177.6 arc-sec
Separation	B-C 4.3 arc-sec
Apparent magnitude of B	= + 8.13
Apparent magnitude of C	= + 13.1
Spectral Class of B	= KIV, i.e. a Main Sequence Orange Dwarf
Spectral Class of C	- not quoted but assumed M class
Red Dwarf (see Derived Data)	

Derived Data from above

A - Spectrum and Colour Excess

The spectrum of A is B7V but is quoted as having discontinuities in the UV and a considerable excess in IR. The figure for colour excess (+0.01) is more in line with a straightforward cooler star of A1V classification. Further, the note 'SB' is added which indicates that the primary A is a spectral binary, and this could explain the duality of some of the temperatures quoted by different sources.

A single B7V star has a spectral temperature of about 23 000 K.

A single A1V star has a spectral temperature of about 15 000 K.

Therefore a "mean" of the two could well be 20 000 K with the spectrum showing the duality of the SB pair by fluctuating between A1 (15 000 K) and B7 (23 000 K).

As far as I know, no fully substantiated figures have been published for the periodicity of this spectral binary, but it probably lies between 1 and 10 days.

Companion B

This lies at a distance of 177.6 arc-sec from A. Derived from the parallax this corresponds to a present distance of 3 950 AU (say) to 4 000 AU, so it is well and truly spaced from the primary.

The period of B about A can be indirectly derived by determining absolute magnitude of A and B and using Eddington's Modulus of $B = M^{3.5}$ where B = brightness, M = mass. This assumption is linearly valid for Main Sequence stars 05 to M5.

The Absolute Magnitude of the primary A is -0.7, which gives a mass of 4.3 solar masses.

The Absolute Magnitude of B is 6.4, which gives a mass of 0.85 to 0.9 solar masses.

Therefore the combined mass A + B = 5.2 solar masses approximately.

Equating Kepler's Law $P = D^{23}$ we get a period of about 48 000 years for B about A.

Now this interests me personally, for it shows that Regulus B is a Sun-like star which could support a life-bearing planet. From previous work done I would guess it would orbit about 0.7 AU from B with a period of some 280 days (very roughly). But any life-bearing developments will be brought to a premature halt by the Main Sequence evolution of A which cannot last much beyond 500-800 million years before going to the planetary nebula/white dwarf phase.

Since planetary nebula rings extend over several light years, B will get swamped with undesirable radiation.

Companion C

This lies at a distance of 4.163 arc-sec from B and orbits it with a quoted period of approximately 2 000 years at a distance of approximately 90 AU. These figures together with the low luminosity 5 magnitudes below B or less than 0.5% of our Sun indicates a mid-class M (say M4-M6) Red Dwarf - an often encountered parasite in such multiple star systems.

To sum up, Regulus is a complex of 4 stars (although quoted as A, B, C).

A is a B7V spectral binary with possibly an A1 very close companion - an item not yet settled. Both stars are Main Sequence.

B is a K1V main sequence Orange Dwarf Sun-like star orbiting some 4 000 AU from the primary A with a period of about 48 500 years. This isolation is sufficient for B to have its own planetary system without being perturbed by A.

A hypothetical "Earth" planet could orbit B at a distance of about 0.7 AU and with a period of approximately 280 days - similar to the orbital elements of our planet Venus.

C is an M type Main Sequence Red Dwarf orbiting B at a distance of about 90 AU with a period of 2 000 years. It would appear in the skies of B's hypothetical "Earth" as a brilliant red point of light slowly drifting through the constellations.

Other Items

There is an excess of infra-red from the total emission of Regulus which is over and above that expected for the minute Red Dwarf C (0.5% Solar radiation or 0.03% of the radiation from A). The recorded infra-red fraction is much larger, and can only come from a ring of dust surrounding A.

Presumably a similar ring surrounds B and again both rings would be mutually non-interfering. This could lend further support to the theory of Regulus B having a primordial solar system.

The diameter of Regulus A has been recorded as between 0.029AU and 0.030AU, or 4.4 million km to 4.56 million km. For comparison the Sun has a diameter of about 0.7 million km.

Whether this is just experimental error or a real expansion/contraction phenomenon is not explained. If the latter, then this lends further support to the possible very close binary nature of A.

In short, Regulus is a much more interesting star group than appears at first sight.

REGULUS - THE TRUE STORY

by Dr. M. Dworetsky, University of London Observatory (Dept. of Physics and Astronomy, UCL.)

I have read the article of Regulus provided by Tony Lawton and would like to comment as follows.

First, it is absolutely obvious from the quoted typical value of "23 000 K" for a B7V star that the numerical value is actually in Fahrenheit. The correct value for the average of B7V star is around 13 000 K, which on conversion gives 22 940 F ($F = 9/5C + 32$; $C = K - 273$), close enough to verify completely my suspicion of such a confusion. The most fundamental temperature determination available for Regulus is that by Arthur Code and collaborators (1976), 12 210 K (± 310 K).

It is unfortunate that Mr. Lawson chose to rely on the Bright Star Catalogue's notes and comments, because they are frequently wholly wrong or based on untrustworthy opinions. I can find no data in the published literature to confirm that Regulus is a spectroscopic binary, and no orbit has ever been published. The published radial velocities scatter a bit, but this is typical of random errors for a star with such a rapid rotational velocity ($v \sin i$ = 330 km/s). Accurate measurements are very difficult in such cases.

The author has confused *colour index* (B-V) with *colour excess* E (B-V); the latter is due to reddening by interstellar dust. The quoted colour excess of + 0.01 is so small as to be consistent with no reddening at all. The published colour index, -0.11, is typical of a B7V star.

I have checked Regulus in the IRAS Catalogue of Point Sources for infra-red data. The fluxes at 12 μm and 25 μm are typical of those for B7 stars and I can find no evidence to confirm the claim of an infra-red excess. In particular, there is no sign of a dust cloud such as that around Vega. I do not know of any discontinuities in the ultraviolet spectrum which set Regulus apart from other B7 stars and I can find no evidence of such by examining published spectra. The one odd thing about Regulus is that it is extremely deficient in Carbon according to Johannes Hardorp and co-workers (1986). A few other stars share this characteristic, which is still the subject of debate by theorists, but may be connected with rapid rotation. The angular diameter of Regulus was measured in the early 1970s with a special type of interferometer. The "range" 0.00132 to 0.00137 arc-sec refers to analyses of the data for various assumptions about the *limb darkening*: the first value assumes a uniform disk (a physical impossibility) and the second is the value assuming the limb-darkening of Regulus to be the same as that for the best available theoretical model of the star; it is probably reasonably close to the truth.

Mr. Lawton's summary of the distant companion system α Leo BC is essentially correct as presented. It is definitely gravitationally bound to Regulus as it shares its proper motion and radial velocity to within errors of measurement.

Mr. Lawton is most enthusiastic and I would not wish to dampen this at all, but it is to be hoped that he will be very cautious in accepting at face value the comments in the BSC, which are, unfortunately, often remarkably speculative - or just plain wrong.

"Can we have Central Heating next time Miss?

by Miss Alex Lovell, University of Leicester

Since October 1991, I have been running the Planetarium of Leicester University. Never heard of it? I'm not surprised. We don't publicize as we simply couldn't cope with the demand!

Leicester has owned a projector for some twenty-five years, a GOTO ES, which used to inhabit a high ceilinged room in the Physics building. However, when the room was required to build a tall satellite in, the Planetarium was removed.

A new building was built for the projector and dome, and a seminar room was added next door. The new premises were opened in October by Patrick Moore - then the enquiries started!

Previously the Planetarium was not open to schools because it was used by undergraduates during term-time. However, now it was housed in a separate building, arrangements were made to allow schools in on Wednesday afternoons.

Since October we have had over 1200 people through the door - not bad for a 22 seater dome! I have put on shows for ages 5 to senior citizens!

However, as the title indicates, life with an overworked, 26 year old projector is far from peaceful!

The children as always are perfectly frank in their letters. I love receiving their comments on the Great Bear that isn't really, the sky that the Eskimos would see, and the sky from the Sahara.

Unfortunately though comments like "I hope the pointer didn't break for the next group" and "The best bit was when all the stars went out" are not uncommon!

We have got stuck at the equator, jammed at the North Pole, lost the summer sky and had Jupiter blow up in front of our eyes! Did you know that Mercury's orbit goes out past Mars? It does if the cog wheel is missing a few teeth!

Astronomy inside the Leicester Planetarium is a unique experience in every way - you never know what's going to happen next! However although we'll be open for business from the end of September, our future is somewhat uncertain. The projector can't last forever and we can't afford to replace it. Demonstrators are equally hard to come by, especially those that can fix loose connections and replace bulbs in the middle of a show!

Over the past year I would like to think that we have helped some Leicestershire schools (and Guides, Cubs, Scouts . . .!) cope with astronomy. Judging by the enquiries we receive, we are certainly needed as a resource.

We find teachers enjoy the intimacy of a small teaching group and all the children get to ask questions and have a go at finding patterns in the night sky. Large classes are split and one half is occupied by activities in the seminar room.

My life has changed drastically since I became involved with the Planetarium. With an observatory and portable telescope as well, I often go from teaching under a fake sky to teaching under the real thing!

I hope I have given you a little insight into the work that is being done - against many odds! - in a small part of the country. We may not be up to London's standard, but our motto is *"small is beautiful"*!

For anyone who would like more information, either contact me, or, for bookings see below.

Oh, and if anyone can supply me with suitable answers to the following questions from eight year olds I would be grateful!

i) "Who found space?"

ii) "Is there any money in space?"

iii) "Does my hamster become a star when it dies?"

[Bookings (about 1 hour a show) cost about £10.]

The Secretary, Astronomy Group, University of Leicester, University Road, Leicester LE1 7RH. (0533) 522073.

STARGAZING WITH THE NAKED EYE

by Roger O'Brien

For most of us astronomy is about eyes. The Mark 1 eyeball is a remarkable instrument, capable of detecting faint light, identifying patterns and distinguishing objects and backgrounds. When it is not cloudy, the sky is up there, overhead, for free (not much else is, these days!). There is no better way to get a feel for the basics of astronomy than just to look up. Try reclining in a deckchair to save your neck.

The Earth rotates about its axis once a day. It revolves about the Sun once a year. These motions are reflected in the apparent movements of the night sky. From Britain, a distinctive group of constellations is circumpolar: in other words, they never set, but circle above the horizon. Apart from these, the sky changes. At each season, there are different stars on view. The clearest skies are usually round the zenith, directly above your head, and down near the horizons the sky gets murkier and you see a lot less.

I always feel that the northern constellations are the place to start. You may not be sure of north, but there are several tips: street layouts are often north-south and east-west; a magnetic compass points near enough to north and you can always try remembering where the sun was around mid-day and look in the opposite direction. The northern sky is dominated by two groups of bright stars and the more famous of these is "The Plough" - seven bright stars in a fairly empty part of the sky. The formal name is 'Ursa Major'. In late summer, the Plough is low on the northern horizon and looks larger and somewhat flattened compared with when it is high up. Patrick Moore made the idea of signposts popular years ago, but there is no simpler way to find your way around. The famous "pointers" are the first lesson in signposting. Follow the line from Merak through Dubhe and on upwards until you see a lone bright star. This is Polaris, the Pole Star. It is almost over the Earth's north pole and, in consequence, seems scarcely to move while the rest of the sky rotates around it.

If you extend the line a bit further and veer over to the right or east a little, you will come to Cassiopeia. This is a tight group of five stars in the form of an "M" or "W" according to the season. The Milky Way runs right through Cassiopeia and, if you are lucky with the seeing conditions, you can see a faint stippling of light - the gleam of thousands of the more distant stars in our Galaxy. Heading southeast from Cassiopeia you may just be able to pick out the Double Cluster in Perseus. In binoculars it is a marvellous sight - two dense groupings of hundreds of faint stars all in the same field of view. Also in Perseus, you can find Algol, whose name means "Demon". This star changes in brightness (it is actually two stars eclipsing one another) and you can monitor and record those changes, if you have the patience and good weather. Still further down near the horizon you will see bright Capella. This yellowish star is the herald of a large group of bright winter constellations.

On the other side of Cassiopeia you can find Cepheus and a try a true variable star - delta Cepheii - which I have monitored with my eyes. It is not as easy to find as Algol, but interesting none the less.

In the angle between Perseus and Cassiopeia is Andromeda. Two lines of stars converging on the north west point of the Square of Pegasus. Higher up the sky than the middle stars of the lines you can find the Andromeda galaxy. It is called M31, because Messier so numbered it in his catalogue. It is an independent galaxy and larger than our own Milky Way. In one way it is the most exciting object in the sky: the most distant thing the unaided eye can glimpse. If conditions are right - clear weather, no street lights, dark-adapted eyes - you may just pick out a misty oval against the darkness. That light, which you can only just see, has been travelling for more than two million years to reach your eye. By contrast, most ordinary stars are no more than a few hundred light-years away.

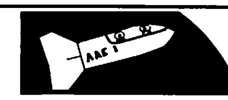
If you are interested in the Zodiac, it is down in this portion of the sky, squashed between the Perseus-Andromeda-Pegasus arc and the horizon. Taurus is just beginning to rise, but the other zodiacal constellations - Aries, Pisces, Aquarius and Capricornus are dim and disappointing. Sagittarius is setting and you really need to be further south than Britain to see it at its best.

However, there is a summer and autumn plum for everyone. Patrick Moore dubbed it "The Summer Triangle", marked by the starts Deneb, Vega and Altair. You can't easily miss these three bright starts and their attendant constellations high up in the summer evenings. They enclose a rich area of the Milky Way. When you have the chance, sweep the area with binoculars and see even more.

Finally, try another bit of signposting, if you read this before the autumn. Follow the curve of the handle of the Plough anti-clockwise away from the constellation until you find a bright, yellowish star. Arcturus is the brightest star in the northern half of the sky and by far the most prominent in Boötes, otherwise not a well-marked constellation. I mention this to emphasise the movement of the sky - Boötes is setting for this year.

(Roger O'Brien is a regular contributor to the Journal of the BAA. It is hoped that this article is the first of a regular series.)

SPACE-LINK



A new series compiled by Nik Steggall, FBIS

Space Shuttle Mission STS-46 tests Feasibility of Tethered Satellite

Launched on 31 July 1992, the orbiter Atlantis conducted experiments involving a 12.5 mile long tether connecting a satellite to Atlantis. This was to demonstrate the feasibility of the technology for a variety of uses ranging from generating electrical power to researching the upper atmosphere. The Tethered Satellite System-1 (TSS-1), a 1,139 pound satellite, was developed by the Italian Space Agency (ASI) with NASA developing the tether and deployer system.

When the tether was fully extended to its 12.5 mile length, the combination of the orbiter, tether and satellite was the longest structure ever flown in space. The crew also deployed into orbit the European Retrievable Carrier (EURECA-1) platform, which contains a series of experiments dealing with materials sciences, life sciences and radiobiology. The EURECA platform will remain in orbit for about 9 months before it will be retrieved during a later Shuttle mission.

On-board the Atlantis, the crew of seven will include Franco Malerba from the Italian Space Agency and Claude Nicollier, a Swiss national from the European Space Agency.

Atlantis's next flight, STS-57, is planned for next year with the first flight of the Spacehab payload and the retrieval of the EURECA payload deployed on the STS-46 mission.

UPCOMING SPACE SHUTTLE FLIGHTS

STS-47 ENDEAVOUR

Launch is targeted for September 1992 with the payload of Spacelab-J, a microgravity material science and processing mission. This seven day mission will be launched into an orbit with an inclination of 57 degrees and an altitude of 187 statute miles. The crew consists of Robert L. Gibson, Curtis L. Brown, Mark C. Lee, Jay Apt, N. Jan Davis, Mae C. Jemison and Mamoru Mohri (Japan).

STS-52 COLUMBIA

Launch is targeted for September 1992. Among the payloads are LAGEOS-11, USMP-01, CANEX-02, ASP and IRIS. This nine day mission will be launched into an orbit with an inclination of 28.5 degrees and an altitude of 185 statute miles. The crew members are James D. Wetherbee, Michael A. Baker, William M. Shepherd, Tamara E. Jernigan, Charles L. Veach and Steve MacLean (Canada).

STS-53 DISCOVERY

Launch is targeted for December 1992 with DOD dedicated mission. This four day mission will be launched into an orbit with an inclination of 57 degrees and an altitude of 230 statute miles. The crew consists of David M. Walker, Robert D. Cabana, Guion S. Bluford, James S. Voss and Michael R.U. Clifford.

The Giotto Extended Mission

On 10 July 1992, at 15h30 UTC, the Giotto spacecraft passed within approximately 200km of the nucleus of comet Grigg-Skjellerup. Eight out of the original eleven experiments were operated providing a wealth of data.

At about 600,000 km from the nucleus (12 hours before closest approach), the Johnstone Plasma Analyser (JPA) detected the first presence of cometary ions. At a distance of 18-15,000km both the JPA and the Reme Plasma Analyser reported what looked like a bow shock or a bow wave, much more distinct than had been predicted for such a weak comet.

The Optical Probe Experiment got the first indication of entering the dust coma at around 20,000 km. At 15:30:56, the Dust Impact Detectors reported the first impact of a fairly large particle, followed by two smaller ones.

At 15:31:02, shortly after the first impact, the High Gain Antenna appeared to be oscillating slightly around its normal value. An increase of the spin rate by .003 RPM was also observed while the Solar Aspect Angle readings were fluctuating between 89.26 and 89.45 degrees, pointing out a nutation of about 0.1 degrees.

A thorough test of the camera on-board Giotto on 7 July 1992 could only confirm that the optical path was very effectively blocked. However on 12 July, a number of tests were performed with the detectors of the Halley Multicolour Camera, which provided very valuable engineering and calibration data on the long term behaviour of CCD's in space.

(Continued on page 9)

(Continued from page 4)

On 23 July 1992, the Giotto spacecraft was put into hibernation for a third time. Before hibernation a final orbit correction manoeuvre was made which was designed to bring Giotto back to Earth at an estimated distance of 220,000km on 1 July 1999.

Will there be a third mission of Giotto? At present, no further activities are foreseen. The fuel left on-board the spacecraft for attitude and any further orbit correction manoeuvres is only 4 kg limiting activities in 1999.

TIMES OF SUNSET AND SUNRISE

by Dr D McNally, Director of the University of London Observatory

In GNOMON recently, there has been a discussion of the manner in which the times of sunset/rise are determined. In conversation with members of the public, surprise is often expressed at an apparent lack of precision in such times being given in the Almanacs to the nearest minute.

Sunset/rise times are not predictions of actual times but are a convention to give an indication of the time. Hence quotation to the nearest minute. The need for a convention comes about because of the need to allow for refraction and to a lesser extent because the apparent diameter of the Sun varies throughout the year. Refraction in the Earth's atmosphere is continuously variable as observers will know because of "seeing". The convention is to fix the refraction of 34'. The convention is to take the angular semi-diameter of the sun to be 16'. The time of sunset/rise is therefore conventionally defined to be the instant when the Sun's centre has a zenith distance of 90° 50'. Sunset is therefore when the Sun's upper limb disappears, sunrise is when the sun's upper limb reappears. The actual time of sunset/rise is likely to be different from the conventional predicted times of sunset/rise.

Twilight is also determined by a convention as follows. If the zenith distance of the Sun's centre is z, then

Civil twilight is the period when $90° 50' < z \leq 96°$,
Nautical Twilight is the period when $96° < z \leq 102°$,
Astronomical Twilight is the period when $102° < z \leq 108°$.

For the moon, lunar parallax must also be considered and the conventional times of moonrise/set lie between zenith distances of 89° 49' and 89° 55' - i.e. for zenith distances less than 90°! If the observer is located above the Geoid (effectively sea level), rising will occur earlier and setting, later, than the conventional values. Times may be computed by adding $2'.12h^{1/2}$ to the conventional zenith distance for setting/rising where h is the height in metres above sea level of the observer (or $1'.17h^{1/2}$ where h is the height in feet above sea level).

LIVING IN SPACE

(Reproduced by permission of NASA)

Concept: The size of the middeck and payload bay areas of the Shuttle helps determine the crew's activities and the payload.

• Ask students to imagine that they have been chosen for a space mission. Have them list items they would take as mementoes.Then inform them that their Personal Preference Kits must be limited to 20 separate items weighing a combined total of 680 grams (1.5 pounds). Ask them to eliminate all overweight articles and list only the items they consider most important.

Have students suggest some familiar large payload objects for the cargo bay to gain an idea of comparative size, i.e. a trailer truck (18-wheeler), a railroad boxcar, a tank car, or a bowling alley.

• Obtain large discarded cardboard boxes used to ship appliances to build a model of the middeck. Let students measure, cut, tape and build a walk-in model of the middeck. Invite other classes to see these examples of "cardboard carpentry".

Many teachers are using a process approach to writing with their students. In one of its earliest stages students prepare to write by charting words and relationships on paper. Given the topic "Everyday Life on Mission 51-L," build a "word web" or idea chart on the chalkboard. Assign students to choose the best ideas to write a paragraph on the topic.

Objectives:

1. To simulate the amount of space available to the crew on a Shuttle mission by measuring and laying out the dimensions of the middeck and payload bay
2. To physically experience the amount of space available in the middeck and payload bay areas.

1. Remind students of the Teacher in Space's tour of the Shuttle. Explain that they will be laying out the size and shape of the Shuttle on a parking lot or blacktop area (chalk), playing field (lime or mowing), snowy field (dye). Middeck dimensions may be laid out in the classroom; payload bay, in the school hallway.

2. Assign groups to make specific measurements of the following interior dimensions of the Shuttle on the surface you have selected:

a. Overall length of the middeck, 4.00m (13.1ft.) plus the payload bay, 19.7m (60.00 ft.), totals a continuous length of these two working interiors of 23.7m (73.1ft.).

b. At right angles to the length, beginning at the front end, mark off the height of the middeck, 2.1m (6.89ft.).

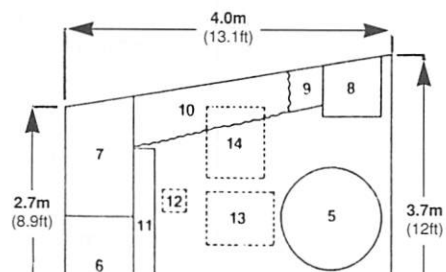
c. At the terminal end of the middeck (which has an airtight structural wall), measure the height of the payload bay 4.56m (15.0ft.). The increase in height of the payload bay should rise above the middeck height since the commander/pilot flight deck is on top of the middeck. (See illustration below.) Measure and mark this height, 4.56m (15.0ft.), at intervals along the entire length of the payload bay.

d. Use some technique to outline the length and height of the middeck and payload bay. You now have the crew's working area (middeck) and the payload bay.

e. To show the trapezoidal-shaped floor space available to the crew when the Shuttle is on the ground, use the same 4.00m middeck length and mark off these widths for the floor plan: 2.7m (8.9ft.) at the front, expanding to 3.7m (12ft.) at the rear. This floor plan area is filled with hundreds of items precisely arranged to maximize efficiency and minimize discomfort for the crew. (See illustration below).

f. The payload bay's floor plan is the same as that laid out in 2.c above because the height of the bay, 4.56m (15.0ft.), is also its width.

3. Have seven students stand on the floor plan of the middeck and see how much area each student has. How does this area compare with rooms in a home? Tell students to imagine this middeck floor plan area also holding large equipment (see illustration below). Have students now estimate the available space for crew members with equipment in place. Could microgravity during orbit increase their options? How? Have students calculate the volume of the middeck. Does the manoeuvrability of weightlessness make the middeck quarters seem less confining?



MIDDECK FLOOR PLAN

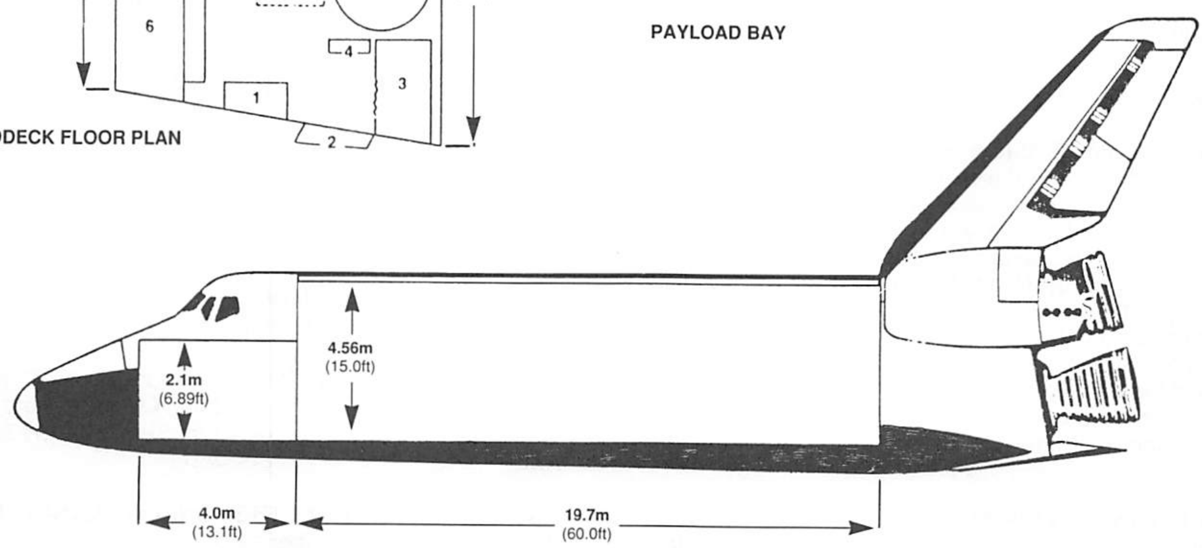
1 Galley
2 Hatch
3 Toilet
4 Ladder to flight deck
5 Airlock
6 Avionics bay 1
7 Avionics bay 2
8 Avionics bay 3
9 Lockers
10 Sleep station
11 Wall of lockers

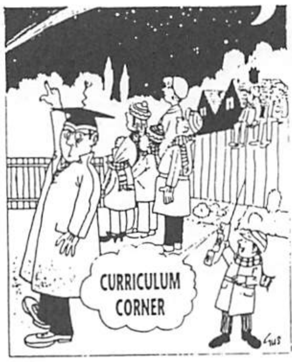
Floor hatches

12 Lithium hydroxide changeout
13 Lithium hydroxide storage
14 Wet trash storage

MIDDECK

PAYLOAD BAY





OLD WIVES' TALE?

Why can't you see stars in the daytime? Because of the Sun's glare, we know. To illustrate this, direct an overhead projector on to a screen to produce a bright rectangle of light. At the same time, shine a torch on to the bright area of light. If the torch is not too bright, its light will be swamped by the glare of the projector. When you switch off the projector, the torch-light will be seen. To make it look more realistic, you can place a piece of cardboard pierced with holes (to represent stars) over the end of the torch.

TRUE OR FALSE - The old story that you can see stars in the daytime (no clouds, of course) if you look up a straight chimney, or a deep pit, or even a long cardboard tube. Is this an old wives' tale? Let's test this by doing some experiments: some stately homes are a good source of long chimneys. Please send in your findings to *Simplicimus*, c/o The Editor, 35 Gundreda Road, Lewes, East Sussex BN7 1PT. Results will appear in a future *Gnomon*.

Simplicimus.

Sky Diary Autumn 1992

Equinox :	Sept	22^d	18^h	43^m
Solstice :	Dec	21^d	14^h	43^m

MOON

New Moon	First Quarter	Full Moon	Last Quarter
Sept 26^d 10^h 40^m	Oct 3^d 14^h 12^m	Oct 11^d 18^h 03^m	Oct 19^d 04^h 12^m
Oct 25^d 20^h 34^m	Nov 2^d 09^h 11^m	Nov 10^d 09^h 20^m	Nov 17^d 11^h 39^m
Nov 24^d 09^h 11^m	Dec 2^d 06^h 17^m	Dec 09^d 23^h 41^m	Dec 16^d 19^h 13^m

MERCURY Mercury is an evening object from Sept 27th to Nov 16th but it is very low in the west at sunset and virtually impossible to see. It is in the morning sky from Nov 28th but again is difficult to observe.

VENUS Venus is in the evening sky in the west after sunset. It is very noticeable after mid-November.

MARS Mars is prominent throughout the autumn, rising in mid-evening. It moves from Taurus into Gemini, into Cancer, then back to Gemini in mid-December. The retrograde loop should be easy to observe. The magnitude of Mars will be -1.3 by the end of December.

JUPITER Jupiter is in the morning sky in Virgo from the beginning of October.

SATURN Saturn is a prominent evening object in Capricornus.

METEORS The Geminid meteors should be visible around December 13th. However a waning gibbous moon will hamper observations.

ECLIPSE There is a total eclipse of the moon on the night of December 9th-10th. It is visible from the UK, weather permitting:-

First contact	Dec 09^d 21^h 59^m GMT
Totality starts	Dec 09^d 23^h 03^m GMT
Totality ends	Dec 10^d 00^h 22^m GMT
Last contact	Dec 10^d 01^h 29^m GMT

NEWS FROM THE LONDON PLANETARIUM *(SPECIAL SESSIONS 1992/93)*

CUB SCOUTS ASTRONOMER'S BADGE

Candidates should be able to answer these questions :

- ★ What is the difference between a STAR and a PLANET?
- ★ Which is the NORTH POLE STAR?
- ★ How do I find ORION THE HUNTER and TAURUS THE BULL?
- ★ What other CONSTELLATIONS can I see?
- ★ Why does the MOON appear to change shape and where are its SEAS?
- ★ When will I see METEORS (SHOOTING STARS)?
- ★ What is the SOLAR SYSTEM and where is its ASTEROID BELT?
- ★ What is an ECLIPSE?

THE PLANETARIUM SESSION will concentrate on the night sky and what can be seen there around the time of the visit - i.e. the stars and constellations of winter, together with any planets on view. The emphasis will be on learning to find your way about the sky using certain stars as "signposts". The fact that we see different stars as the seasons change will be explained, as will the behaviour of the planets, which appear to wander against a starry background.

We shall also look at the Moon, our nearest neighbour in Space, and at the Sun, our own Star.

Finally, we shall view Earth as it would be seen from "outside" the Solar System - as one of a family of planets orbiting a central star.

THE SPACE TRAIL EXHIBITION contains much that is of interest and has relevance to topics associated with this badge, e.g. comets, meteorites, sun spots, black holes and space exploration.

INFORMATION PACK - on booking, each group will receive a pack of material (most of it photocopiable) for use in activities related to badge work.

PROGRAMME DETAILS - Badge Sessions will take place from November to February on Saturday/Sunday a.m. There will be seven sessions in all. These will start at 10.00 a.m. and last 40 mins.

Please note - sessions are identical.

As before, it will be possible for groups to include the 30 mins. General Starshow - "Starburst" - and Madame Tussaud's Exhibition in their visit.

Details of dates, costs and booking information are :

SESSION DATES

1992	November	*Sun* 15th	*Sat* 21st	*Sun* 29th
1993	January	*Sat* 23rd	*Sun* 31st	
	February	*Sat* 6th		
	March	*Sun* 7th		

COSTS OF VISIT

Special Session only	£1.95
Special Session + General Starshow	£3.70
Madam Tussaud's + TWO shows	£5.70

NB 1 adult FREE per 10 Cubscouts

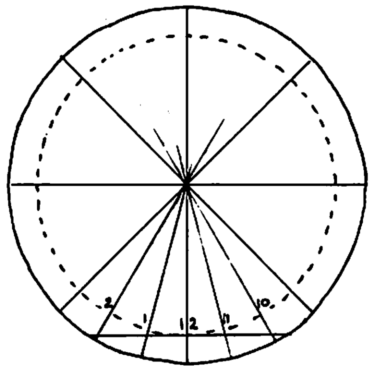
BOOKING INFORMATION - Please contact Debbie Marrable (Tel. 071 486 1121) in the Group Booking Office for more information and to make bookings - from SEPTEMBER 7th PLEASE.

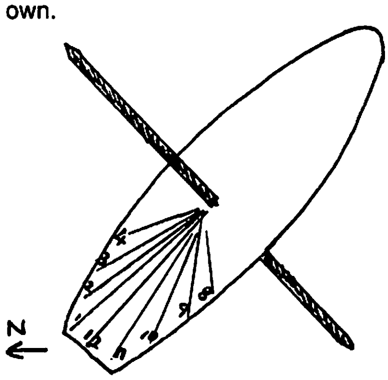
SIR ISAAC NEWTON VISITS THE LONDON PLANETARIUM
30th November - 5th December 1992
Telephone Teresa Grafton or Undine Concannon on 071 486 1121 for details.

THE COCKTAIL STICK SUNDIAL - *By Bob Kibble*

Here is a simple sundial which is portable and can be adjusted for observers at most latitudes. It is based on a cocktail stick which my measurements have shown is 80mm long. (The pointed ends can be shortened should your stick be a little over 80mm). You will need a pair of scissors, some card, a protractor and a compass to draw the circles. The drawings here are not to scale.

Draw two concentric circles on the card at radii 40mm and 50mm. Draw diameter lines at 15° intervals, mark them out first. There will be 12 diameters altogether. Mark a cord which just touches the smaller circle and which is centred on one of your lines. Cut this off. This will enable your sundial to stand on its own.

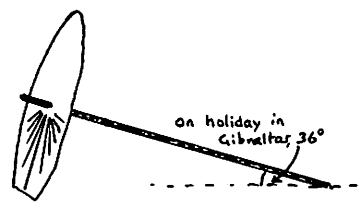


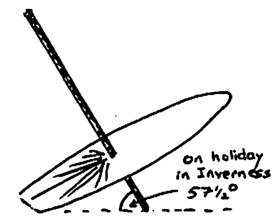


Mark the line in the centre of your cord '12'. Label the remaining lines with their hours, increasing clockwise as you look at the dial. Finally push the cocktail stick through the centre of the card. The dial will now be free-standing. If you mark the hours on both sides of the card you will have a summer and a winter dial.

The cocktail stick must point to north. A compass will give you this direction. To adjust the dial for your latitude you simply move the stick so that it points up from the horizontal at an angle equal to the latitude of the observer. For observers in the London area this angle is about 51 degrees. (Ensure that 32mm of stick lie below the card). Observers in Edinburgh, latitude 56 degrees, should move the stick so that 27mm lie below the card.

(The general rule is: tan (latitude) = radius of inner circle / length of stick below the card.)

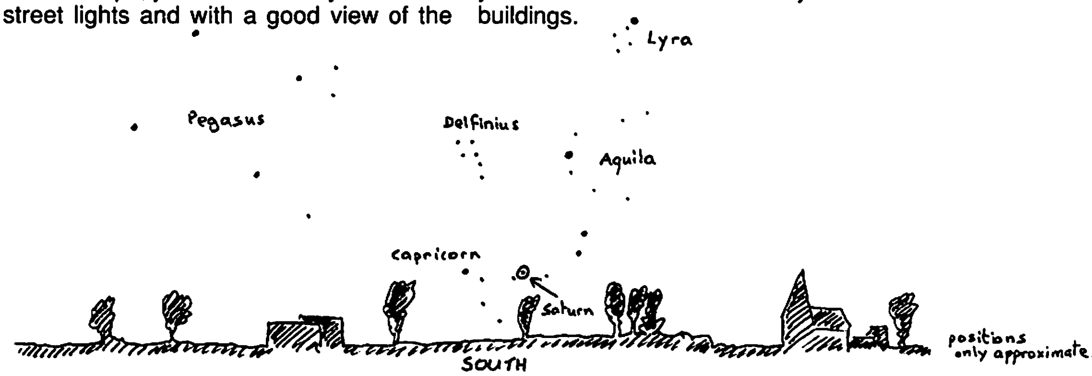




You don't have to be limited to a cocktail stick. Try a wooden knitting needle or a barbecue stick and scale up the dimensions accordingly. Remember that in the summer months British Summer Time will mean that your dial will read 1 hour behind your watch time. Also note that your longitude will made a difference. Dials in Cornwall will appear 'slower' than dials in Kent. Finally the uneven motion of the Sun will introduce an error. This can be corrected for with the Equation of time. But this must be left for another day.

A TARGET FOR AUTUMN SKIES: SATURN - *By Bob Kibble*

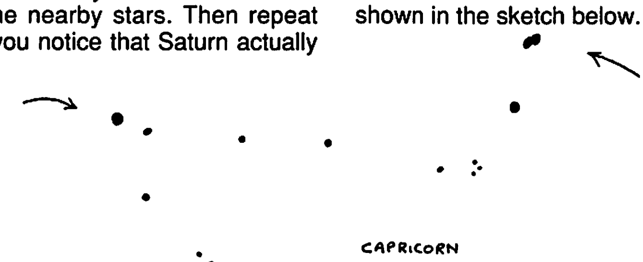
As winter draws near, dark skies occur earlier and a little night sky observing can be done before bedtime. This autumn you have a chance to see a giant of the Solar System, the planet Saturn. You don't need a telescope, just dress warmly and find a dark spot away from street lights and with a good view of the southern horizon away from tall buildings and trees. Your local park might be the place. The exact position of Saturn will depend on the date and time of your observation but in general you should look south and just above the distant trees or buildings.



A number of interesting constellations lie close to Saturn and a few are shown in the diagram below. Saturn can be found in the constellation Capricorn (The Goat). A real test of your skill at observation would be to sketch exactly where Saturn is in Capricorn, paying attention to the nearby stars. Then repeat this sketch every week to see if you notice that Saturn actually moves through the star pattern. I'll not tell you which direction it will wander in, can you detect it?

The constellation Capricorn is not particularly bright or easy to see. Two stars of interest are Gredi and Deneb Algiedi as shown in the sketch below. These stars have companions.

The brightness of Deneb Algiedi changes fractionally over a period of time. This is caused by a companion star too small to be seen which is orbiting around the main star. This is called an eclipsing binary.



Gredi, the brightest star in Capricorn, is in fact two stars. They can be seen as a pair through binoculars but in fact this is only an optical illusion. The two stars just happen to appear 'in line' as seen from the Earth. One is only 116 light years away, the other is 1100 light years away.

LUNAR PHASES BOX

by Teresa Chilton, Jodrell Bank

See the phases of the moon without having to leave the comfort of your classroom!

You will need: a shoe box, 4" nail, a ping-pong ball or a golf ball, an old biro, block of balsa (2"x2"x1"), 7 pieces of black sugar paper approx 2" x 2", glue.

A torch will be needed to illuminate the moon and see the phases.

To make the box:

Take the lid off the shoe box and glue the balsa block centrally to the base.

Invert the box and push the nail through the centre of the box via the balsa block.

Turn the box the right way up. The box should now have a nail sticking up into the middle of it. see diagram.

Remove the nib and ink apparatus from the biro.

Cut the plastic 'case' to 1.5cm shorter than the protruding nail.

Slide the biro case onto the nail.

Push the ball onto the nail (the biro case will prevent it from sliding down the nail).

You now have the moon in space.

Eight 'peep holes' now have to be positioned along the sides of the box, through which the lunar phases can be seen.

All the holes must be on a level with the ball/moon.

Make three equidistant holes along each of the long faces of the box.

Make one hole half way across one shorter side.

At the opposite end of the box, make a large hole, through which you will shine the torch (sun). Make a small viewing hole next to this.

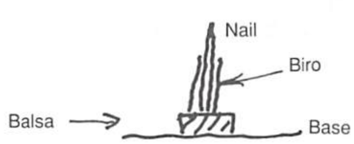
Put the lid onto the box and seal it with tape.

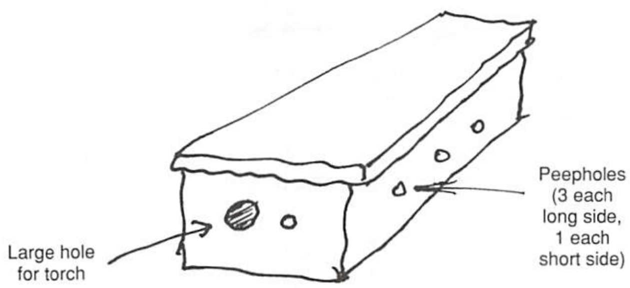
It must be light proof.

Stick a flap of black sugar paper over each hole to keep out the light and your lunar phases box is finished.

To use the box shine the torch through the large hole. Lift the flap of sugar paper covering hole 1 and 'look' at a new moon. Replace the flap, move to hole 2, lift the flap and look at the phase of the moon. By looking through each hole in turn, all the phases of the moon can be seen. If a golf ball was used then even the lunar craters are visible!

I have found that this box is simple enough for primary children to make, with direction. It also lends itself to cross-curricular work involving technology, maths (measurements to position the holes and finding the centre of the sides) and language.





LETTERS

Dear Editor,

In the latest copy of Gnomon, under the heading 'For the Newcomer', you report an answer to a query from Simplicimus concerning the rising and setting Sun. There are two errors in the answer given by Eva Hans, which states that the rise and set times are taken when the centre of the Sun's disc is on the horizon.

1. Because of refraction in the Earth's atmosphere the Sun appears to rise before, and set after, it passes the geometrical horizon. The atmosphere bends the Sun's light by 34 minutes of arc, more than the apparent diameter of the Sun.

2. The instant of Sunrise or set is defined as the instant when the refracted upper limb of the Sun is on the horizon (not the Sun's centre).

Thus sunrise or set occur when the true angular distance of the Sun below the horizon is 50 minutes of arc. The difference is made up by 34' for horizontal refraction and 16' for the semi-diameter of the Sun.

Yours sincerely,
Dr P.J. Andrews
Head of Information Services
Royal Greenwich Observatory,
Cambridge. *(A similar letter has been received from Dr D. McNally).*

Dear Editor,

The Gnomon Spring 1992 issue has a diagram on page 12 showing Jupiter's movements in Leo this year. In that diagram, the surface temperature of Regulus is quoted as 20,000 C. The correct value of T_{eff} should be 12,200 K (= 11,900 C). Incidentally, astronomers always use Kelvin temperatures for stars. It is just conceivable that the author meant 20,000 Fahrenheit, but the temperature would in fact be 22,500 F. It's all a bit confusing, and aren't we supposed to get away from the old Fahrenheit scale in schools?

Yours sincerely
Mike Dworetsky,
University of London Observatory,
Mill Hill Park,
London, NW7 2QS.

Dear Editor,

Presumably you have received your copy of *Space and Education*, the 1992 directory of UK activities published by the British National Space Centre. I am writing to draw your attention to the entry about our school on page 29.

Our Observatory is now fully operational, and available for use - while other entries in the directory describe instruments which can be seen, ours is one which visitors can use! Instrumentation consists of a 14" Schmidt-Cassegrain telescope, which is currently being upgraded to full computer control, and a four channel photometer will be installed soon. Cameras can be easily fitted, and darkroom equipment is available. Users of the Observatory currently include local primary schools, and University students undertaking research for MSc and PhD degrees.

For evenings when the weather proves difficult a range of software is provided, such as *The Sky*, and a selection of videos, and other teaching materials. We also have some 25,000 images of the outer planets and their moons taken by the Voyager probes, all stored on CD and easily used.

The Observatory is on two floors and can accommodate up to twenty adults, or a full class of school children, and is a resource which is of great educational and scientific value. If you feel that a visit could be of interest to you please do not hesitate to contact me either at school, (tel. 0227-463971) or at home (tel. 0227-470796).

Adrian Beaumont,
Observatory Director,
The Canterbury High School,
Knight Avenue,
Canterbury, Kent, CT2 8QA.

YORKSHIRE MUSEUM :

5-16 OCTOBER 1992

EARTH AND SPACE EVENT

SPONSORED BY BT, ACORN COMPUTERS, SAINSBURY'S, SONY AND McCAINS.

Talks, workshops, starlab planetaria, observatory sessions for primary school pupils.

For full details, contact Chris Edwards, Science Adviser (North Yorkshire CC) on 0904-626721 or Martin Lunn, Astronomy Curator, Yorkshire Museum (0904-629745).

ADVERTISEMENTS from members are free, as long as they are of reasonable length. *For commercial rates, see page 1.*

TELESCOPE FOR SALE : 6" Newtonian reflector (Charles Frank). Equatorial mount, RA drive to take motor, new worm and wheel, hand drive for dec., finder, camera bracket, 4 eyepieces. £495 o.n.o. Bob Renaut (091-4552219).