GNOMON

Newsletter of the Association for Astronomy Education

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A grant from The Royal Astronomical Society enables "The Universe in the Classroom", the Newsletter of The Astronomical Society of the Pacific, to be sent to members with issues of "GNOMON".

EDITORIAL COMMENT

AAE members regularly receive copies of "The Universe in the Classroom", the quarterly newsletter of the *Astronomical Society of the Pacific* (ASP). The Society also publishes a catalogue of videos, films, posters, etc., which are on sale at reasonable prices. We recommend that interested persons contact the ASP directly, requesting copies of the catalogue. The address of the ASP is 390 Ashton Avenue, San Francisco, California, USA, CA 94112.

Charitable Status - Update

I am delighted to be able to announce that the AAE now has its charitable status.

Our registered number is: 1046041

Bob Kibble, *AAE Treasurer.*

OBITUARY

We regret to announce the death, at the age of 67, of Tony Lawton. Tony represented the British Interplanetary Society (BIS) on the AAE Council. He also represented the BIS on National Astronomy Week 96 (NAW) Committee, where he co-operated with AAE members. AAE members may not have been aware of his other activities - for instance, he was (twice) President of the BIS. He contributed to Project Daedalus; he presided at the Diamond Jubilee of the BIS meeting in 1993 at Hastings; he wrote profusely for various organisations; he carried out original research on long delayed echoes, which proved they were of terrestrial origin, and was honoured as an Academician by the International Astronomical Union.

Tony worked for some time at Vickers; at what was then Kingston Polytechnic; was a member of the Barnes Wallis team on the "bouncing bomb". He was a well-known lecturer in Southern England.

He will be sorely missed by a wide range of organisations.

MEMBERSHIP of the AAE costs £7.50 a year for individual members, £15 for corporate membership and £5 for retired persons. For more information, contact Nik Steggall (address letters to: AAE, Royal Astronomical Society, Burlington House, Piccadilly, London W1V 0NL). Members receive 4 issues of GNOMON a year.

GNOMON - definition from the **Concise Oxford Dictionary:**
Pillar, rod, pin or plate of sundial, showing time by its shadow on marked surface; column, etc. used in observing sun's meridian altitude

Subscription Rates:

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Corporate Members will receive three copies of *Gnomon*.

Extra Copies:

0-10 .... £1.00 per copy
11-50 .... £0.75 per copy
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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.

All communications (except those to the Editor) should be addressed to:

The Association for Astronomy Education, The Royal Astronomical Society, Burlington House, Piccadilly, LONDON. W1V 0NL.

Editor: Eric Zucker, 35 Gundreda Road, Lewes, East Sussex BN7 1PT - for all enquiries concerning the Newsletter. (Tel 01273 474347)

Advertising Charges:

Whole page £120
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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.

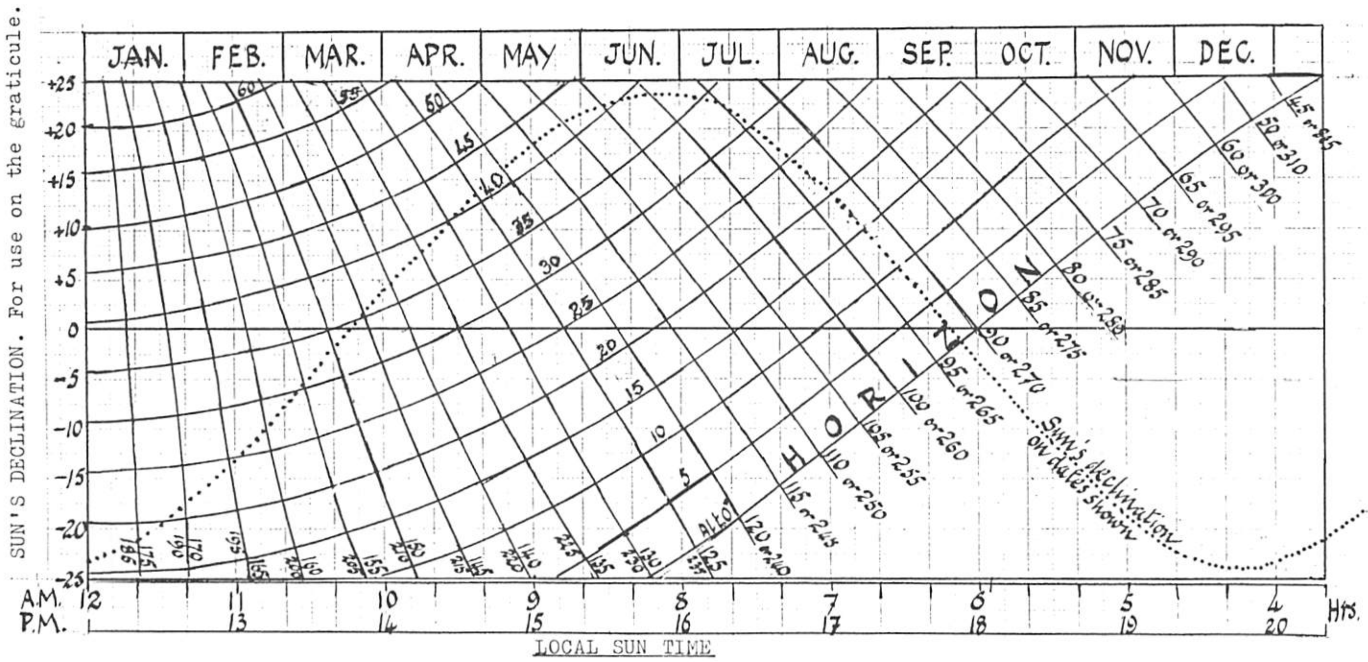
Publication Dates:

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

A SUN COMPASS AND SUN CLOCK FOR LATITUDE 51°N

1. Read the Sun's declination for the date from the dotted curve.
2. Enter this declination on the Y axis.
3. Read the Sun's altitude and azimuth from the graticule.
4. Read the Local Sun Time along the X axis.

Note: GMT = Local SUN Time — E + Long West or — Long East. See Equation of Time graph. Atmospheric refraction causes the Sun to rise about 5 minutes earlier and to set 5 minutes later than the times for the theoretical Sun.



Example: On May 1st the Sun's declination is 14°, from the dotted graph. Observed altitude of Sun 30°. From the graphs the Sun Time is 0805 and its Az. 106° or Sun Time 1555 and Az. 254°. The 14° declination line intersects the horizon curve showing sunrise at 0450, Az. 68°, and sunset at 1910 hrs. Az. 292°.

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Cluster of Galaxies in Corona Borealis.

Palomar Observatory Photograph
Photo supplied by Nik Steggall

THE MIDLANDS SPACEFLIGHT SOCIETY

by Andy Salmon

MSS is a group of about 40 space enthusiasts who keep in touch by means of a bimonthly magazine "Capcom", by phone or by attending meetings in the Midlands.

Activities in 1994 were dominated by the Apollo 11 anniversary and Comet Shoemaker-Levy-9 impacts on Jupiter. There were public talks at Birmingham Science & Industry Museum and at a local library - with space artist David A Hardy, space author Dave Shayler and space educator Andy Salmon contributing. There were also children's events at two Solihull libraries around the theme of "The Moon" - with a simulated rocket launch, impact cratering, demonstrations and Moon legends included.

The evening of July 20 was marked by an Apollo/SL9 members party. Apollo videos, music from 1969, telescopes to observe Jupiter and plenty of drinks were combined in an evening enjoyed by all. A hardy few even stayed awake until 0356 the following morning - to toast the exact moment of Neil Armstrong's "small step".

MSS members were present as a group to both welcome and interview visiting space travellers in 1994. Ex-NASA astronaut Joe Allen visited the UK to promote a new book written by MSS member Dave Shayler. UK astronaut Helen Sharman was encountered at Chesterfield library and on a visit to a local chemical company (arranged by an MSS member). Ex-cosmonaut Georgi Grechko and astronaut Claude Nicollier were interviewed during their visits to Jodrell Bank - thanks to Sylvia Chaplin at the Science Centre there.

The MSS "Race to the Moon" game was created by members Dave Evetts and Andy Salmon for an Apollo 8 anniversary exhibition at Birmingham Science & Industry Museum at the end of 1993. It proved so popular with children and families that it was present at several other (local astronomy) events in 1994.

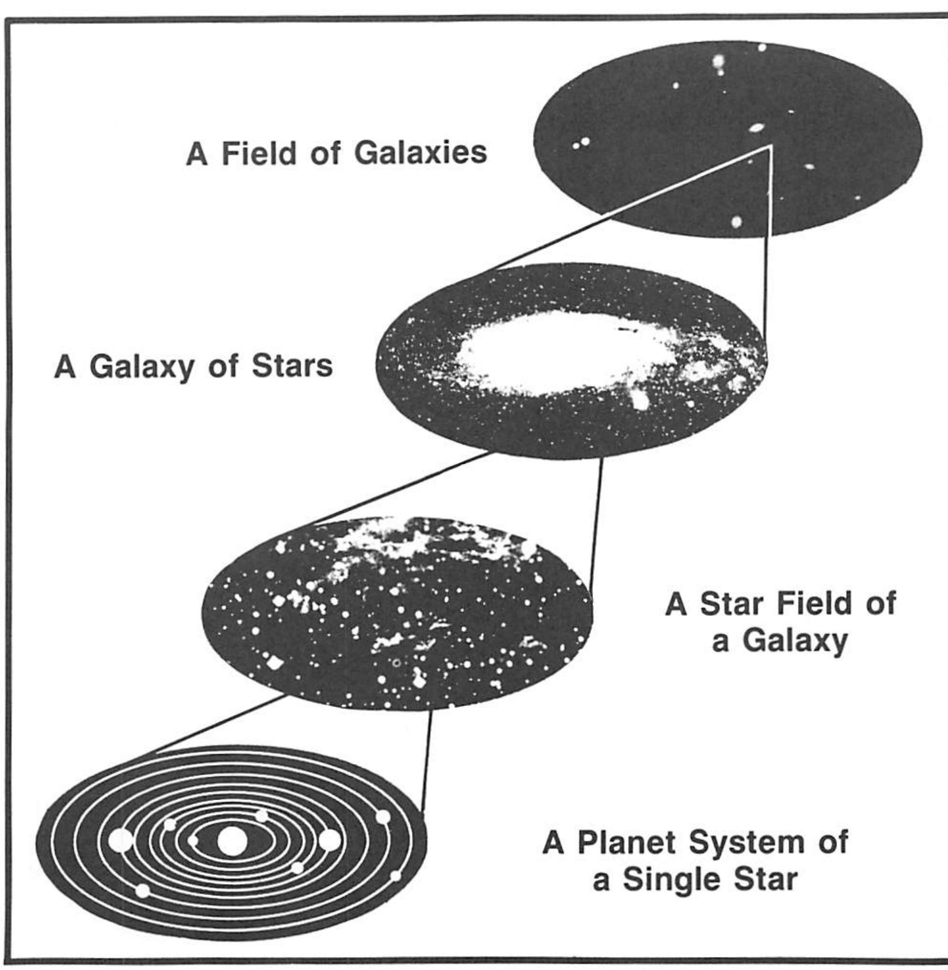
An exhibition of model spacecraft in Birmingham Central Library and an open evening in the centre of Birmingham were MSS contributions to Midlands Space Week (organised by Walsall Astronomical Society). MSS' Andy Salmon gave a "Space news" update at the start of each talk in a series by The Planetary Society/Walsall Astronomical Society at Birmingham Science & Industry Museum in 1994.

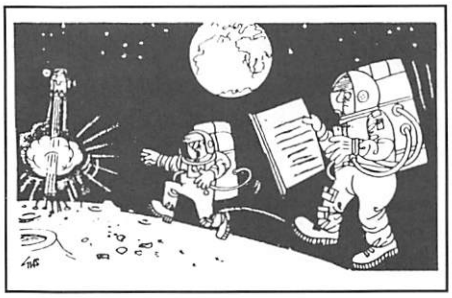
MSS now has a small range of educational and promotional items for sale. It is hoped to expand sales items in 1995.

To receive a sample issue of "Capcom" and for more information about MSS, please send an A4-sized, stamped, addressed envelope to: Andy Salmon, "Olympus Mons", 13 Jacmar Crescent, Smethwick, Warley, West Midlands B67 7LF.

An MSS "Space Mission" prepares for launch. There have been many talks and demonstrations by the team of Andy Salmon, Dave Evetts and J. Dawson.

HOW BIG IS THE UNIVERSE? (From NASA)





SPACE - LINK

These articles have been compiled by Nik Steggall

ESA'S LONGEST SPACEFLIGHT

The European EUROMIR 94 spaceflight to the Russian space station MIR achieved a major milestone when ESA astronaut, Ulf Merbold, landed aboard the Soyuz TM-19 spacecraft on November 4. It was the longest European spaceflight to date lasting one month.

Ulf Merbold was launched into space aboard the Soyuz TM-20 spacecraft on October 3 and arrived at the space station two days later. During the flight, he had taken numerous biological samples which will give European scientists a new insight into the effects of the space environment on the human body. He also conducted technological experiments that will help ESA develop new equipment for space missions and took hundreds of photographs of the Earth's surface.

On board the returning Soyuz TM-19 spacecraft with Merbold were Russian cosmonauts Yuri Malechenko and Kazakh Talgat Musabyev. Their descent through the Earth's atmosphere, which eventually touched down in Kazakhstan, took one hour. It started with the firing of the Soyuz engine to slow the spacecraft. The craft endured extreme temperatures as it entered the atmosphere before landing under parachutes. All the cosmonauts were reported as being well after their mission.

EUROMIR 94 was the first of two ESA manned missions with the Russians. The next, scheduled for August 1995, will be even more ambitious, lasting 135 days and including the first spacewalk by an ESA astronaut. Currently training for this flight are Christer Fuglesang and Thomas Reiter.

* * * *

RUSSIA JOINS INTERNATIONAL SPACE STATION

The United States, Canada, Japan and the member states of the European Space Agency (ESA) have been working together, on the basis of the Intergovernmental Agreement of 29 September 1988 on the Permanently Manned Civil Space Station, to design and develop a space station as the next milestone in the exploration of space.

A dramatically changed international situation, in which Russia continues to play a constructive and responsible role in the international community, has created the opportunity to consider a landmark undertaking . . . the inclusion of Russia in the building of the International Space Station.

At a meeting in Paris on 16th October 1993, the representatives of the governments participating in the co-operative partnership to build and operate an international space station considered a proposal by the United States that Russia be invited to join in this endeavour. The international partners recognised that Russia, with its impressive record of achievements in space, including its wealth of experience in human space flight activities, could make considerable contributions to this programme. The international partners also recognised that Russian involvement in this programme would represent important progress toward their shared objective of building co-operative relationships with Russia.

ON VISITS TO SCHOOLS!

by J. E. Thompson

"I learnt a lot, I had know idea that there were so many galaxies in the Universe or so many stars - R Horrocks."

"I am glad that you have visited our school because you have fed my hungry brain, and now I will be able to fill up my science book. Science is my favourite topic and now even more so, thank you very much - T Moloney."

"Please come and see us again. I liked the bit about Saturn because its my favourite planet. I hoped you liked our class and our school - Vicky."

"Can I first say what a delight it was to listen to your highly interesting speech. I found it most wonderfully exciting - Ryan." (Ryan should go far!)

The next ones are from 7-9 year olds in a junior school, and each of them asked me two questions, which I tried to answer in a communal letter to the class.

"How fast can a meteorology go? I liked satin and all the other Plants they were very interesting - Lee."

"Miss Benge said that you were an Astronomer but I thought at first that you was an spaceman. But now I think that you are an Astronomer. Please answer back. What are you an Astronomer or an Astronaut? - Marian."

"I really really wanted to know why planets are always round? I was the one that sat in the corner near Mrs Haji. I have forgot to tell you what my name is my name is Louise I am 9 years old." (Louise then tells me the names and ages of her sisters, about her parents, how funny her teacher is and lot of other non-astronomical news. She ends:-_ "Got to go, Your little friend Louise. P.S. Please please write back soon."

"How did Saturn's rings become a smooth circle? Are there more planets beyond Smiley? - Nicholas." (Smiley is the temporary name given to the first of a new class of objects beyond the orbit of Pluto, which had captured the children's interest, as they thought it might be a new planet.)

"Thank you for showing us the slides and telling us about space and especially about Smiley's mite only be a comet - Bradley."

"The week after you came to our school we saw a Zig Zag programme and it told us about the moon buggy and we saw the men in the space craft doing acrobatics in it and lot's of little bubbel's and how they wash eat and drink by pushing straw's through the water bubbles - Katie."

I hope you have enjoyed reading these as much as I did.

Helius Io CCD Imaging System

The quality of any astronomy can be judged almost exclusively on the quality of the images you are able to produce, be they photographic or electronic. It is from these images that astronomical data is derived.

The purchase of a CCD system has in the past also been coupled with the technological problem of inbuilt obsolescence. We have overcome this by offering a modular system the basic camera is of outstanding quality using the EEV range of slow scan scientific CCD sensor found in many of the world's major observatories. As the user's ability allows, accessories may be added ranging from a high speed shutter to 3 colour filter wheel and even a diffraction grating for basic spectroscopy. Other ancillaries range from a motorised focusing tube, controllable from the imaging program, to a high speed data link allowing a full 16-bit image to go from CCD to screen in less than 5 seconds. The CCD sensor may be upgraded to a back-illuminated device, or even opt for special coatings like the UV enhancing coat.

From the beginner just wanting basic facilities for imaging, to the demands of the professional, the Helius Io CCD camera and imaging software offer no compromise to performance.

There are three principal aspects of designing a good CCD camera, the first of which is resolution, the target object must be spread over as many pixels as possible. Whilst magnification is a key point in determining image scale, equally important is the number of pixels available to spread the image over. The standard sensor we offer has 585 x 385 pixels, giving twice the resolution of a normal television set. We can obtain and use CCDs up to 2100 x 2100 pixels for professional applications. The digital dynamic range we offer is either 12-bit or 16-bit, these giving over 4000 and 64,000 grey scales respectively. In terms of intensity resolution, the 16-bit camera offers 3 photons per bit.

The next parameter that determines the quality of performance is noise, thermal noise associated with the CCD, and electronic noise associated with the drive circuits. Most of the objects to be observed are by their nature very faint, if the noise threshold of the system is higher than the intensity of the incoming starlight, then it becomes impossible to discern an object. We have incorporated many precautions against noise, at the camera head, for instance, we use 2 Peltier devices, each removing 25 degrees C of heat. The third cooling stage is liquid cooling, a small water pump is provided as part of the package, so if ice water is used, the sensor temperature will drop to -45/-50°C.

A more adventurous alternative is to use glycerine glycol instead of water, and feed it through dry-ice. This provides a coolant temperature of -35°C; when coupled with the 2 Peltier devices this puts temperatures of -85°C well within the grasp of amateurs not able to use liquid nitrogen, whilst offering a thermal noise performance better than 0.1 e-/pixel/seconds.

For the occasional user, or those using portable instruments, wanting convenience rather than performance, a radiating heat shrink can be used instead of liquid cooling. Whilst limiting the sensor temperature to -20°C the thermal noise is still extremely low at 5 e-/pixel/sec, and offers the ease and speed of use.

Attention to detail in a design such as this is important, for instance we have our CCD sensor directly coupled to the Peltiers, and not to the circuit board. This is mounted at the base of the camera head with fine wires running to the sensor. The reason for doing this is simply to prevent heat flowing back into the CCD via the fibreglass circuit board. Another feature to low noise and reliability is a military-style connector that screw locks the cables to the camera and electronics; this cable is a metre long, and screened signal cables are used.

At the electronics end, the circuit board is fully ground planed, with all the sensitive components canned and screened. This is of special importance to the 16-bit version since dividing a 5 volt signal into 64,000 levels means that circuit sensitivity lies in the micro-volt region. Any stray noise will adversely affect the signal.

The third major part of the system is the imaging and control software. For the newcomer to CCD imaging, it has many helpful features like the optional auto-exposure time setting. To avoid over-exposure, or saturation of pixels, the program can shorten the exposure time to optimise the image, likewise exposures that are too short do not make the best advantage of the integrating ability of the CCD, and it will equally compensate by lengthening the exposure time. For the more adventurous, images may be aligned and butting together, giving an effective image as large as the computer can handle.

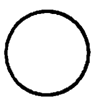
A full range of imaging enhancement and analysis routines are supplied by operating through *Microsoft Windows*, offering both frequency and spatial analysis. Any palette can be selected, including negative display. Histogram equalisation is available at image display level, there are many high pass, low pass, median, gauze and unsharp filters can be used. The frequency analysis routines include Maximum-Entropy deconvolution, a relatively new but very powerful image reconstruction technique.

General manipulation routines range from zooming and panning through to mirror image, full file handling facilities for reading and saving image files in any directory or drive. Comparative work can be done through anything up to 50 operational buffers; these buffers can be added, subtracted, divided and multiplied together for more sophisticated manipulation. Each or any image may be manipulated as an entity in its own right, or combined with any other image held in a separate buffer.

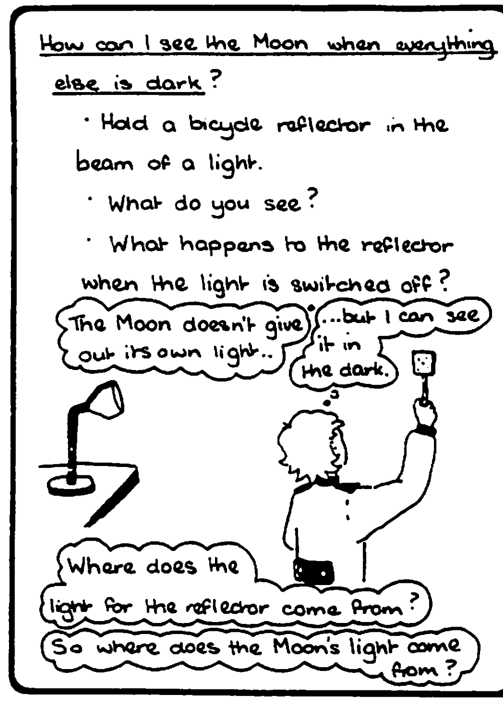
Dark-frame and flat-field subtraction are provided for, and can be done automatically. Any software setting can apply to incoming images, so histogram equalisation can automatically cut off background light pollution and just display a filtered image direct from the camera head.

Helius Io is the only CCD camera to offer such extensive and professional imaging software as part of the basic package, any free updates to software are available for 12 months, and other optional software like colour imaging is supplied with the appropriate accessory. As a system it is a complete and comprehensive system easy enough for the newcomer whilst offering the highest performance for professional users. The Io can be upgraded, and parts added as time and funds allow, so it will never become obsolete.

For further details, contact Helius Designs, The White House, Aldington, Evesham, Worcs WR11 5UB.

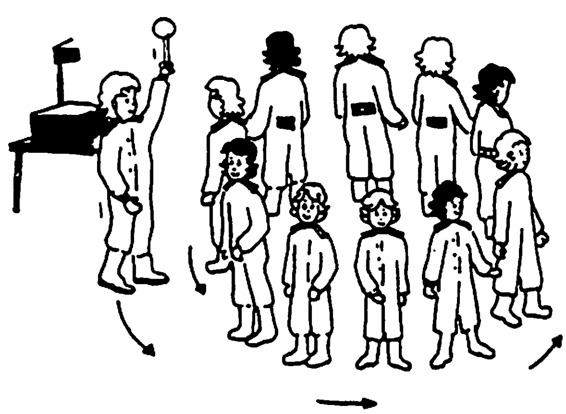
PHASE	APPEAR-ANCE	WHEN SEEN	WHERE SEEN DURING DAYTIME
new		not visible	
waxing crescent		afternoon and evening	southern and western sky
first quarter		afternoon and evening	eastern sky
waxing gibbous		evening and night	eastern sky
full		night	
waning gibbous		night and morning	western sky
third quarter		morning	western sky
waning crescent		morning	eastern and southern sky

We see the Moon because it reflects the Sun's light



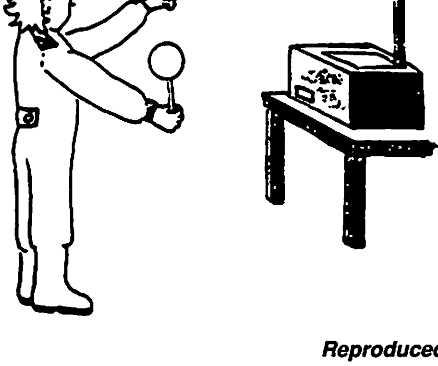
A cycle reflector (preferably circular) makes a good model Moon. Try linking this to work on mirrors.

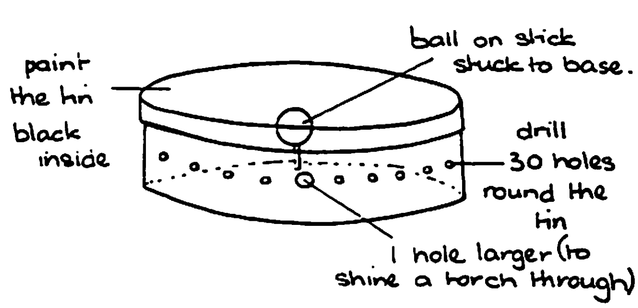
The Moon orbits the Earth approximately every 28 days



To teach about the movement of the Moon around the Earth an excellent method is to cluster the children as a central Earth and orbit them with a polystyrene ball on a stick. If you can do this in a darkened hall with an OHP Sun the children will be able to see the appearance of the Moon go through its phases.

There are several good board games, models and mobiles which can be used to teach about the orbit of the Moon around the Earth.





In a dim classroom children can use polystyrene sphere Moons and a lamp or OHP to show the Moon's phases.

Reproduced by permission of the Earth Science Teachers' Association

GRAVITATIONAL LENSES

One of the major problems with cosmology is that all the important things you want to study are a very long way away and, therefore, faint. Obviously, faint things are harder to find and identify and they may be so faint you can't see any detail or get more than a very rough spectrum. What the diligent observer needs is more light.

At this point, the diligent observer runs into serious problems. Consulting the experienced telescope constructor and his colleague the expert telescope designer reveals that building a bigger telescope on the ground tends only to give a better view of the rapidly changing defects in our atmosphere. Adaptive and active optics make quite a big difference, under the right conditions, which tend to be the best viewing conditions anyway. So these new systems are found on telescopes situated on Mauna Kea, La Palma or mountains in the Chilean deserts. These are also, generally, the sites of new even larger telescopes, but only the Keck is working yet.

Another solution is to lift the telescope above the atmosphere. This, of course, is one of the major justifications for launching the Hubble Space Telescope (HST). Now that it has corrected optics, this telescope has proved to be capable of producing the most amazing pictures of distant objects. Unfortunately, the HST is not a particularly large telescope (2.4 metre aperture) and, although it sees with exquisite clarity, its penetration is limited by its light-grasp.

This sounds like a tale of woe: it isn't. Einstein's General Theory of Relativity suggested that light would be bent as it passed through a strong gravitational field. This effect was amply demonstrated at the 1919 total solar eclipse, when a team under Sir Arthur Eddington measured the deflection of light due to the Sun's gravity. Since then, General Relativity has passed every test scientists have been able to devise. If a massive body can bend the path of light, there is a chance that, given suitable conditions, the light from a distant source might be focused by an intervening massive body.

It may be difficult to envisage this. The detailed maths is hard to grasp, but the idea is really quite simple. The intervening mass (it can be a star, a galaxy or a whole group of galaxies) acts like a lens. It is not, generally, a nice simple lens, but more like the 'bottle glass' window panes in 'Olde Tea Shoppes' in picturesque places. The 'image' is not simple either. The observer may see the distant source as a ring or an arc or arcs or there may be multiple images of point sources.

It may be worth making a few terms clear. The distant source is very often a quasar and, since these enigmatic objects look like stars, they make excellent point sources. However, there are plenty of cases where the distant source is a galaxy or, even, a whole group of galaxies. The whole thing, distant source and intervening mass, is known as a 'lensing system'. The mass that bends the light is the 'lensing mass' or, in some cases, the lensing galaxy. The most common name for the effect is 'gravitational lensing'.

So, a gravitational lens is a system in space where the deep gravitation field of a large mass acts like a convergent lens and gathers more light for us. There are other interesting cases where a smaller object is responsible. This is called 'microlensing'. The effect has already been seen in observations of the Large Magellanic Cloud. Observers monitor individual bright stars in the LMC and watch for sudden, brief, otherwise inexplicable brightenings. The name of the project is MACHO, which refers to the search for Massive Compact Halo Objects. Quite a number of probable microlensing events have been seen, but alternative explanations have been put forward and there is no consensus yet.

Meanwhile, on the massive gravitational lens front, there is almost an embarrassment of riches. We have examples of near perfect alignments where the distant source, the lensing mass and the Earth are in a straight line and the source appears to us as a ring surrounding the lensing mass - usually a large galaxy and not always visible to us. The discovery of 8C1435+635 last year probably owes something to an intervening gravitational lens. This galaxy is so distant that it would probably be undetectable but for the magnification of a lens. There are other beautiful examples where a large cluster of galaxies is the lensing mass and a more distant cluster forms a set of blue arcs - blue because young galaxies have proportionately more young stars. Double images of quasars and Einstein crosses, where there are four separate images of the distant source, are now, if not common, at least not rare.

This leads me to a very exciting discovery, made by a group of Cambridge astronomers using the WHT. One of the Einstein crosses is known as the Huchra Lens. In this case, a comparatively nearby spiral galaxy with a redshift of only 0.04 provides the gravitational lens and makes four images of a quasar with a redshift of 1.7 (redshift gives a crude measure of distance). The crucial point is that the lensing mass is a spiral galaxy. Spiral galaxies contain massive stars quite far out along their spiral arms. There is a small chance that a star will drift through the line of sight to a lensed image. This has in fact happened. The effect is similar to a telescope. The microlensing event magnifies a small portion of the already lensed image. It will probably enable scientists to watch the detail as the star passes across. Astronomers will be able to obtain sequences of spectra of different parts of the quasar's structure. Much more accurate models of quasars may result. In addition, the gravitational field of the spiral galaxy may be defined to an unprecedented accuracy.

HOW LONG DOES IT TAKE TO GET TO THE STARS?

Destination	*Jet, 600 mi/hr*	*Rocket, 25,000 mi/hr*	*Sunbeam, 186,000 mi/sec*
Moon	16.5 days	9.4 hr	1.2 sec
Sun	17 years 8 months	4 months	8.5 min
Mercury	10 years 10 months	3 months	5 min
Venus	5 years 5 months	1.5 months	2.5 min
Mars	8 years 10 months	2.5 months	4 min
Jupiter	74 years 3 months	1 year 9 months	35 min
Saturn	150 years 3 months	3 years 7 months	1 hr 11 min
Uranus	318 years 6 months	7 years 7 months	2 hr 30 min
Neptune	5 13 years 2 months	12 years 3 months	4 hr 2 min
Pluto	690 years 1 month	16 years 5 months	5 hr 25 min
Alpha Centauri (nearest star)	4.8 million years	114,155.2 years	4.2 years
Sirius (Dog Star)	9.6 million years	228,310.4 years	8.4 years
Pleiades Cluster (The Seven Sisters)	———	———	400 years

CURRICULUM CORNER

UNDERSTANDING TELESCOPES - IN TWO PARTS

by Bob Kibble

(The second part of this useful guide will be published in the September edition of Gnomon.)

PART 1. DESIGN

To begin to understand telescopes you need to realise that they may look large and complex but they are basically just two parts: a large lens or mirror to collect light and form an image and a small lens to magnify this image. Let's start by looking at these two parts.

A curved mirror or a convex lens will change the direction of rays of light bringing them to a point, called the focus. If the light comes from a distant object, like a tree, you can capture the real, inverted image of the tree on a piece of card. See Fig. 1. In order to bring the light rays to a focus the mirror **reflects** the light from the tree but the lens **refracts** the light. In a reflecting telescope the mirror which does this job is called the **primary** mirror. In a refracting telescope it is done by the **objective** lens. These are just the technical names.

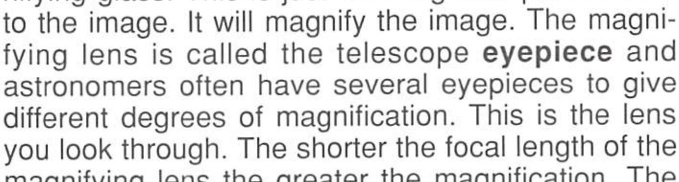


Fig. 1

Now that you have captured your image you need must make it look larger. To do this you use a magnifying glass. This is just a strong lens placed near to the image. It will magnify the image. The magnifying lens is called the telescope **eyepiece** and astronomers often have several eyepieces to give different degrees of magnification. This is the lens you look through. The shorter the focal length of the magnifying lens the greater the magnification. The views through two typical eyepieces are shown in Fig. 2.

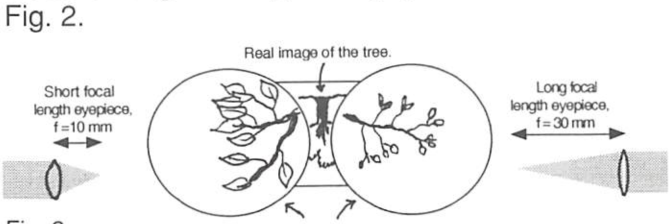


Fig. 2

Sky Diary

Eva Hans, who contributes to the Sky Diaries, has injured her arm and is unable to produce this quarter's article. We wish Eva a speedy recovery.

The smaller telescopes you see in gift shops and mail order catalogues are usually refractors. They combine the objective lens and an eyepiece at either end of a tube. The tube holds the lenses in place and keeps out any unwanted stray light. Many serious astronomers use refracting telescopes. Theirs will have very large objective lenses to capture more light from faint objects. They will also use a **star diagonal** to hold the eyepiece at a more comfortable angle. Without a star diagonal you could end up lying on your back.

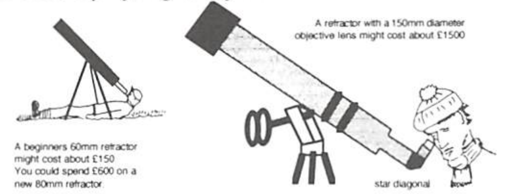


Fig. 3

The mirror in a reflecting telescope is placed at the base of the tube. A small flat secondary mirror along the tube turns the light sideways rather like a star diagonal. You look through the eyepiece from the side of the tube. Large mirrors are easier to make than large lenses and so reflecting telescopes tend to have larger diameters, or apertures. A 200mm reflector might cost from £500-£1,000 new, although there is a healthy secondhand market via the popular monthly magazines. The world's largest research telescopes are reflectors. The famous Mount Palomar telescope has a mirror 5m in diameter!

The sketches above show telescopes on tripods. Some tripods can be extremely sturdy. Cheaper instruments however often disappoint their owners not because of their lenses but because of feeble tripods which wobble about and cheap fixings which soon wear out. New buyers must beware of these problems. Reflecting telescopes tend to be mounted in a cradle, known as a Dobsonian mount. These are simple and easy to use, with no parts to wear out. My advice would be to spend £150 to £250 on a secondhand 150mm Dobsonian reflector rather than the same amount on a new 60mm refractor. For those readers keen on DIY it is possible to buy all the parts you need to make a reflecting telescope. You can even grind and figure your own mirror if you have a few dozen hours to spare. Most sane people buy the optics and build their own mount.

Important Note: For young astronomers there is no substitute for a pair of warm socks, a clear star map and a companion who knows what to look for. If the piggy bank allows then start with a modest pair of 8 x 40 or 7 x 50 binoculars which will set you back no more than £30.

See the September 1995 issue for part two of Understanding Telescopes where we explore equatorial mounts, magnification and what to look for with your 'scope.