Gnomon

Newsletter of the Association of Astronomy Education

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Where do we go from here? Moving AAE into the 21st century

In many ways this is a golden age for astronomy education. The last few years have seen public participation in events ranging from the opposition of Mars to the transit of Venus. For the first time, the National Schools' Observatory and Faulkes Telescopes give schoolchildren direct access to the data from large telescopes overseas. The press, broadcast and online media have a seemingly insatiable appetite for space and astronomy features. New science centres and planetaria have been built across the UK. And more students than ever are enrolled on "non-advanced" courses like the excellent GCSE Astronomy.

AAE members have been at the heart of many of these initiatives and can be justly proud of their efforts. The Association was set up almost a quarter of a century ago with the remit of helping teachers teach astronomy and this should remain the central focus of our work.

However we also need to look more widely. One of the best things about the recent Annual Business Meeting was the number of new members and the real enthusiasm they brought. Astronomy education and engagement is taking place in venues from community centres to shopping malls and embraced by everyone from practising research scientists to amateur astronomy societies. And yet the Association still has a low membership. Most classroom teachers (and educators in the wider sense) have not even have heard of the AAE, let alone considered joining. So how can we reinvigorate our organisation?

The AAE has an important function. It remains the only UK astronomy education body that anyone can join – irrespective of their affiliation to a planetarium, science centre, school or university. Our members are dedicated to inspiring young and old to take a deeper interest in the wider Universe, something that captivates us all. From missions to Mars to the James Webb Space Telescope, the continuing and exponential growth in astronomical discovery will give us plenty of material for the future. All this gives us an opportunity - even a responsibility - to develop our role.

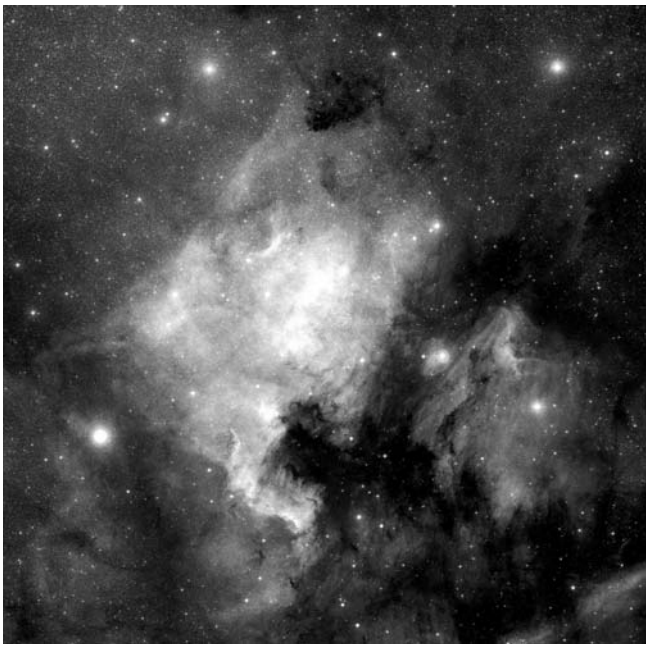
As a starting point, we should all work to encourage new members. Fees of £12 a year are excellent value for money. Why not ask educators in science centres and the many portable planetaria that travel around the UK? Or perhaps astronomical societies could be encouraged to affiliate – after all most of them serve to educate their own membership? A broader base will make us an even more attractive organisation for future recruits.

Secondly, our annual general joint meeting with BAP needs more time for AAE members to contribute. The most successful meetings encourage everyone to take part – why not have a whole morning where we can present and demonstrate good ideas that work in and out of the classroom? For many of us the sharing of good practice is the reason we joined the Association in the first place – let's make this happen more!

Finally, we need to cherish and build our external links. Our connections with the RAS, PPARC and others give us a voice in shaping astronomy education in the years ahead. Let's make the most of it.

Robert Massey

Robert Massey is Public Astronomer at the Royal Observatory, Greenwich and newly elected AAE President. He writes here in a personal capacity.



FITS creates spectacular pictures in minutes

With the release of version 2 of the popular ESA/ESO/NASA Photoshop FITS Liberator image processing software, it is now easier and faster than ever before to create colour images from raw observations. These could be from, for instance, the NASA/ESA Hubble Space Telescope, ESA's XMM-Newton and the NASA Spitzer Space Telescope.

In July 2004 imaging scientists at the European Southern Observatory and NASA released a free plug-in called the ESA/ESO/NASA Photoshop FITS Liberator. (Flexible Image Transport System). This single file format archives nearly all images of stars, nebulae and galaxies produced by major telescopes around the world. Until July 2004, this file format was accessible only to very few people ☞

You can produce stunning photographs like this, of the North America nebula, but in full colour, using FITS software from ESA/NASA.

☞ other than the scientists themselves, using specialised image processing techniques.

With the release of version 2 of the FITS Liberator it has become even easier to create colour images from raw observations. You can literally create spectacular pictures like the iconic Hubble image "Pillars of Creation" in a matter of minutes.

Version 2 of the FITS Liberator has been improved in several areas. Images with up to 4 billion greyscales (32 bit) and with up to 500 million pixels or more can be processed (100 times larger than standard images from a digital camera).

The ESA/ESO/NASA Photoshop FITS Liberator v.2 is now freely available for download from

💻 **www.spacetelescope.org/projects/fits liberator.**

Any old Gnomons?

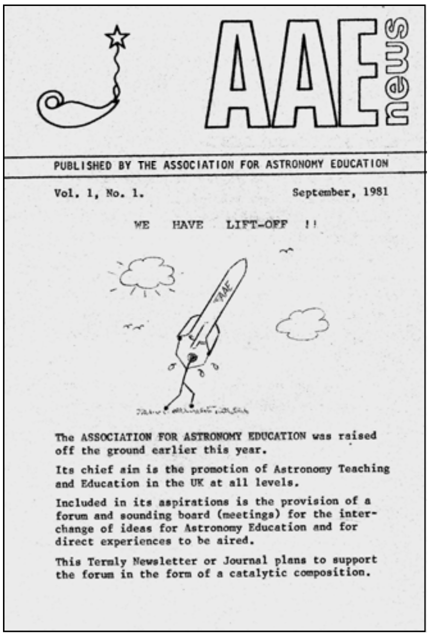
This issue marks the beginning of Volume 25 of *Gnomon*.The Editor of even a humble publication such as *Gnomon* has a duty to try to maintain a complete archive of previous issues, and recent contributions have highlighted the fact that our memories play us falsely as time goes by.

Coincidentally, just as I had decided to attempt the daunting task of collecting a complete set as a start, I had a very helpful offer from Teresa Grafton of the London Planetarium to send me their set of back numbers, with apologies that it was not a complete collection!

In the event it was not far short, and I was able to make up some of the missing issues. This is due to a squirreling habit that I seem to have, but it served me well for many of the years before I took over the Editor's chair.

As a result, the AAE is now short of only eight issues of the newsletter! The Association would be very grateful is any members have copies of the missing issues that they could lend to the Editor for scanning and completing the archive. Peer in your deepest cupboards, cellars, grandparent's trunks, or anywhere where these precious eight issues might be hiding. The missing issues are (expressed in volume/issue numbers) 2/1; 3/2; 5/1; 7/1; 13/2; 13/3;16/2; and 16/4. These are all between September 1982 and September 1997. (See the reproduction of the cover of the very first issue, to remind yourself what the oldest missing issues look like).

It should be explained that originally, the AAE newsletter was published three times a year to correspond with the three academic terms. The first issue was published in September 1981, and the start of new volumes has remained with the start of the academic year ever since. Originally an A5 format, and called "*AAE news*", the first Editor was Dr. David Clarke of Glasgow University Observatory. The occupant of the Editor's chair changed in September 1983 to Colin Goodman of Hastings High School, when the publication was renamed the *AAE Newsletter* for September and had the AAE logo as today on the top of the title page. Colin's place was then taken for the April 1986 issue by recently deceased Dr. Eric Zucker, on his retirement from the Polytechnic of North London. The title "*Gnomon"* was introduced by Eric when the format changed to A4 and the publication frequency changed to four per year in 1988 for Volume 7 number 1 (a missing issue). Eric's tremendous 10-year stint as Editor lasted until the end of 1995, when my predecessor Alex Lovell – later Barnett – took over and ran the publication until the Summer 1998 issue.


AAE news

PUBLISHED BY THE ASSOCIATION FOR ASTRONOMY EDUCATION

Vol. 1, No. 1. September, 1981

WE HAVE LIFT-OFF !!

The ASSOCIATION FOR ASTRONOMY EDUCATION was raised off the ground earlier this year.

Its chief aim is the promotion of Astronomy Teaching and Education in the UK at all levels.

Included in its aspirations is the provision of a forum and sounding board (meetings) for the interchange of ideas for Astronomy Education and for direct experiences to be aired.

This Termly Newsletter or Journal plans to support the forum in the form of a catalytic composition.

The first issue of the AAE newsletter, September 1981

Richard Knox

Astronomy weekend in the Wirral

You can just make it, if there are any places left, to go to the Burton Manor, Burton, South Wirral, for the weekend of Friday 21 to Sunday 23 October, for a residential course (or day visitor if you are near enough) on practical astronomy. The course tutors, Ian Morison and Dr. Tim O'Brien, will show you how to use small telescopes, star charts etc. And the course also includes a visit to the Jodrell Bank Observatory. Prices for the weekend are from £155 (residential) and £111 for day visitors.

Contacts for more information and booking are:

💻 **www.burtonmanor.com**

🖮 **enquiry#burtonmanor.com**

☎ **0151 336 5172**

Sorry about this

I have had to change my e.mail address as part of a struggle with an over-zealous spam filter. The whole story is too long! Please use the following address from now on for material intended for *Gnomon*

🖮 **gnomon_editor@onetel.com**

Please note that the hyphen of old has become an underscore, and the service provider has changed (and does not like hyphens!). **Richard Knox**

Subscription Rates:
Individual Members............. £12.00
Retired Members £10.00
Corporate Members
(e.g. schools, colleges etc.) £24.00
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Extra Copies:
0 - 10....................... £1.00per 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, effectively reducing their contributions.

All communications (except those to the Editor) should be addressed to:
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Any photographs sent to the Editor by email (preferred) should be sent in a common format (TIF or JPEG) with resolution not less than 300 dpi

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

For your library

Eclipses 2005 – 2017. A handbook of solar and lunar eclipses and other rare astronomical events. Wolfgang Held. £9.99 paperback. ISBN 0-86315-478-6.Floris Books.

All eclipse junkies (I am one!) will find this amazing little book invaluable. It is both practical but poetical, succinct but thorough. For the new recruit or aspiring eclipse observer it will be a goldmine.

The last thorough coverage of eclipses which has come *Gnomon*'s way was the splendid Brunier/Luminet *Glorious Eclipses,* but it was definitely a coffee table book. This one is perfect for putting in your pocket and taking to Antarctica, Easter Island, Celebes, or any of the many exotic destinations to which solar eclipses drag you so willingly.

Not many astronomy books mention one of the most amazing, but impossible to explain and difficult to describe aspects of a total eclipse of the Sun: the tremendous emotional effect it has on all who witness one. Almost the whole gamut of human emotion is seen, from grief to joy, from tears to laughter, from depression to elation. Not only does the author of this book describe this effect, but he includes some memorable accounts by observers of historic eclipses, including a long poem by Wordsworth!

The causes and details of solar eclipses are described, making sure that all readers know what to look for, and what to expect at different moments during the Moon's transit of the Sun's disc. And the book even includes a Sun filter in the form of aluminised Mylar spectacles.

The solar eclipses from 2005 October 3 (see Sky Diary in this issue) to 2017 August 21 are listed, and those either total, hybrid or annular are described in detail. Each eclipse is described in full, with maps of the track of the Moon's shadow across the globe, and in detail on a larger scale across the most important locations (i.e. mostly leaving out the high seas!).

A table of principle data along and either side of the eclipse track lists magnitude of the eclipse, times, or beginning maxima and end of the event, duration and altitude of the Sun. A whole sky map at the eclipse centre shows the position of the Sun and any bright planets and stars in the sky, and finally an assessment of the weather and chances of seeing the eclipse is given for all the central eclipse path.

Total lunar eclipses are described for the same period of time. There will be ten: the first is in March 2007, and the last listed in September of 2015. The various stages of a lunar eclipse are described in the introduction to this section, then each eclipse is covered in full.

If that were not enough, the book concludes with a selection of the most interesting (or photogenic) conjunctions and other planetary phenomena over the same period. These include, for example, the opposition of Saturn in Cancer in 2005/06, when the planet will make its retrograde loop just south of the naked eye Præsepe star cluster. Another unusual line up is the proximity of Regulus, Saturn, Mars, Venus, Mercury and the very Old Moon in Leo in the morning sky of 2015 October 9.

A few minor quibbles cannot detract from the excellent value for money of this book. But a "pinhole camera" is not usually what is meant by a "camera obscura". Neither does a pinhole need focussing. The two telescoping boxes of the model pinhole camera described will merely change the size (and brightness) of the image on the screen. Two annular eclipses (one in 2006 and one in 2008) are indexed as "total" on page 33.

Richard Knox

Is light pollution now against the law?

Yes. It may be against the civil law (i.e. where the complainant sues: there have been successful cases) and as of April 2005 intrusive nuisance lighting is against the criminal law. Common law private nuisance actions have been successfully brought against nuisance lights in several cases. It must be noted that none of the complainants in these cases were astronomers.

However, such an action requires the complainant to sue the party responsible, although the cases above show that bad lighting is becoming increasingly unacceptable. Exterior lighting has now become subject to the criminal law of statutory nuisance, where the State may prosecute a party for a nuisance light. The change in the law was introduced by sect. 102 of the Clean Neighbourhoods and Environment Act 2005. However, the provision will not be up and running until April 2006. Then, a complainant will be able to take the matter up with the Environmental Protection Unit of their local council, who in turn may initiate proceedings in the Magistrate's Court.

The issue of whether street lights are covered by this new law is a vexed one, which remains to be tested. Transport-related premises, e.g. docks, railway stations and bus depots, are (for no good reason this writer can fathom) exempted.

This Act does not specifically protect the night sky, but any adaptation or removal of poorly directed lamps is good news for astronomers. The Campaign for Dark Skies continues to fight for all lighting to be controlled, and for the starry sky to have as much protection as any other part of the environment.

Bob Mizon
BAA Campaign for Dark Skies

UK Solar System model website is "Go"

As readers of *Gnomon* (Vol.23 no.4) will no doubt be aware, Spaced Out is the national project to create the world's largest scale model of our Solar System. There are 18 artistic installations representing the Sun, planets, asteroids, Halley's Comet etc., all located at scaled distances from the Sun, which is at Jodrell Bank in Cheshire. The Spaced Out team have announced that the website is now fully functional with five major areas.

The Virtual Tour of the Solar System allows visitors to access the 18 planets, asteroids etc. from the Spaced Out map of the UK. Each sub-page gives images of the sculpture, key facts about the planet, information on the artist and development work where partnerships with pupils was involved, corporate sponsorship details, and links to other major UK-websites. ☞ (**cont. col. 1, page 5**)

Andrew Loudon's slate sculpture of Saturn is at Lancaster Girls' Grammar School. The distance between the school and Jodrell Bank (The Sun) was the basis for determining the scale of the Spaced Out project.

Curriculum Corner

GCSE Astronomy makes new advances

Although there has been a qualification at this level in Astronomy since the days of O-level, the number of secondary school students taking the GCSE course has risen dramatically in the last few years. Over 700 candidates took this summer's examination – the highest in the history of the qualification, with 75% gaining an A*-C grade. Adults and Sixth Form students continue to be a sizeable part of the entry but it now seems that many schools are finding GCSE Astronomy to be a popular option as part of their Specialist College or Gifted and Talented provision. Key Stage 4 students now represent an increasing fraction of the entry and with three-quarters of candidates gaining an A*-C grade, it's not hard to see why!

The GCSE astronomy course

Many schools and colleges teach this as a one year GCSE course, combining teaching time in the classroom with coursework which students can complete in their own time. A full specification can be downloaded from the Edexcel website but the main areas to be studied are:

Planet Earth – the Earth and its place in the Solar System

The Moon and the Sun – covering lunar phases and eclipses as well as the study of these two astronomical bodies.

The Solar System – the planets and their satellites, along with the smaller members such as comets, meteors and asteroids. This section also looks at the development of the heliocentric view of the Solar System, including the work of Copernicus, Galileo, Kepler and Newton.

Stars and galaxies – this includes a study of a handful of the most famous constellations, the process of stellar evolution, galaxies and an introduction to the key discoveries in cosmology

Observing techniques and space exploration – students study the principles of basic refracting and reflecting telescopes as well as radio and other forms of observation. The course also looks at some of the most important missions of space exploration such as Apollo, Voyager, Galileo and Magellan.

As readers will know, these are topics that are endlessly fascinating to almost everyone - from the youngest primary school student to the senior citizen attending adult education classes. Many institutions therefore find the GCSE an excellent way for their students to develop this interest into a qualification. It can also complement and support students' work in other scientific courses such as GCSE Science or AS/A2 Physics.

The GCSE is assessed by a written examination paper in June (75%) and a small portfolio of student coursework (25%) which is submitted in May.

The Examination

There is one written examination paper with 20 structured questions covering the complete range of topics. Each question generally has one particular theme, and candidates are asked to present their answers in spaces that follow each part of the question. The level of difficulty tends to increase through a question, and there is a general level of increasing difficulty through the paper.

Candidates are asked to respond to questions in a number of ways ranging from simply circling the correct item (as in a four-part multiple choice question) through completing a diagram to writing more open-ended prose. Questions early in the paper often require short answers or simple labelling of diagrams. The examination usually includes about five or six mathematical questions, some of which require candidates to use a formula (all required formulae are given in the examination paper) whereas others require candidates to use some degree of reasoning e.g. applying the inverse square law to an unfamiliar situation.

Student coursework

This is a popular part of the course which helps to ensure that students actually go outside and take some simple astronomical observations, as well as producing an astronomical instrument or chart.

Students complete two pieces of coursework, one observational and the second requiring the construction of an astronomical model, chart or instrument. Popular observational projects include keeping a diary of naked-eye lunar observations for a month, using a shadow stick to determine longitude or observing a meteor shower. Those students with access to optical instruments can produce drawings or photographs of the planets, the Galilean moons, smaller lunar features or sunspots etc.

For their second project, many students build a simple refracting telescope using two small lenses and a cardboard tube or construct a simple sundial and then test its accuracy. Alternatively, students can produce large lunar or star charts for display, whilst others build simple Earth-Moon-Sun models to provide a visual demonstration of eclipses and phases.

Coursework is assessed by the teacher using a simple mark scheme supplied by the Board and a sample is then submitted for moderation by Edexcel. The majority of students clearly find their coursework an interesting part of the course, obviously putting in a great deal of work in their own time. A complete list of suggested coursework project titles can be found in the Specification, which can be downloaded from the Edexcel website.

Support for GCSE Astronomy

As existing centres will know, there is a substantial amount of support for schools or colleges preparing candidates for the GCSE Astronomy examination. Choosing "astronomy" from the Subject Index on the web site allows you to download several resources. *The GCSE Astronomy Specification*, gives full details of the syllabus and its assessment. A specimen examination paper is provided, with the mark scheme. (In addition, copies of past examination papers can be obtained by contacting Edexcel). Lists are given of suggested resources to support teaching the course, places to visit as part of the course, and of astronomical organisations.

In addition, a Coursework Guide for teachers and students will be available very shortly. This gives background information to help with the completion of the coursework projects, along with some samples of fully marked and annotated coursework. This should also be available for download from the website by the end of October this year.

Each year there is also an Examiners' Feedback Day, usually held at Greenwich at which teachers of the course can get full feedback on all aspects of the previous summer's examination, followed by a coursework workshop. It also provides an opportunity to share ideas with other colleagues teaching the course and to raise any queries about the course with the examiners.

Sample examination questions

Inserted in this issue of *Gnomon* are three questions in the 2005 examination paper, with "typical" answers (added by the Chief Examiner). These questions are thought to be good illustrations of the length and style of questions contained in the examination paper. The examiners would expect Grade C candidates to score well on questions 5 and 6; question 13 is beginning to test the A/B candidates' knowledge.

Question 5 begins by testing purely factual information. Parts (a) and (b) show correct responses, but several candidates did confuse the positions of the Moon during lunar and solar eclipses.

A range of answers from 700,000 to 900,000km was accepted for (c). This candidate gives a clear indication that he or she understands that it is the relative sizes of the Earth's and Moon's shadows that are important in determining the duration of an eclipse in part (d).

Question 6 begins by testing awareness of how the stars in a constellation are formally classified. This candidate has either forgotten the Greek alphabet, or somehow believes that Andromedae is part of Pegasus (often regarded as such, but clearly labelled in the diagram).

Part (b) is numerical in nature and illustrates the type of question for which reasoning can be used. Unfortunately, the candidate has failed to square 2.5 or has given an imprecise answer.

In part (c), the candidate has correctly manipulated the data and gained full marks. The ridiculous number of significant figures was not penalised (although the examiners would hope that candidates would not write down answers that are more precise than the data given in the question!).

Question 13 is more demanding and expects candidates to express themselves more clearly than earlier in the paper. The response to (a) (i) is typical of many this summer that did not gain the mark; the examiners felt that this and similar statements were too vague, hoping for some reference to the *apparent* origin of meteors.

In contrast, the explanation to (a) (ii) was much more pleasing (despite the odd spelling of debris – spelling and the quality of written communication are tested only in certain indicated questions). Part (b) gained only 1 mark since no mention of meteoroids was included.

Some readers may feel that the examiners have been somewhat lenient or harsh on the candidate when marking these three questions. Although many students find it difficult to express themselves clearly, the examiners do reward candidates who show a good understanding of Astronomy.

We hope that readers have found this introduction to GCSE Astronomy useful, whether they are new to the qualification or experienced teachers. Since there are now over a hundred centres in the UK entering students for the qualification, *Curriculum Corner* would be an excellent place to share ideas and experiences relating to GCSE Astronomy. Please send in any contributions to the Editor by November 25 for the next issue of *Gnomon*.

Nigel Marshall, Chief Examiner
Julien King, Principal Moderator

☞ **(*Solar System model website:* from page 3)** *The News* page lists key items of news about the project, and is regularly and frequently updated.

Links to other astronomical resources provide a cornucopia of hyperlinks to the sponsors, and to astronomical websites (mainly in the UK). Visitors can access not only astronomical information but also suppliers of telescopes and other equipment, providers of Distance Learning Courses and access to the National Schools' Observatory.

The Gallery presents a collection of astronomy-related drawings and images submitted by the Spaced Out team, artists, pupils and astronomers.

Teaching and learning resources on the site include free downloadable Solar System learning resources and support material for teachers at Key Stages 2, 3 and 4.

We hope that all concerned with astronomy education will find the site an invaluable resource. Comments or suggestions for future of the website would be most welcome. The site has been generously supported by PPARC and CCLRC to whom the Spaced Out team express their gratitude.

Nigel Marshall
spacedoutuk#postmaster.co.uk
www.spacedout-uk.com

Free GCSE Astronomy Resources!

As part of a Gatsby Teaching Fellowship, a CD of resources for GCSE Astronomy is available freely to teachers of the subject. It contains starter and plenary activities, games and ideas for modelling, and practical activities.

The CD is organised according to the five areas of the Edexcel syllabus: planet Earth, The Moon and the Sun, the Solar System, stars and galaxies and observing techniques, and space exploration. The sample activity shown below is a song and dance (what astronomy lesson would be without music and laughter?) to the tune of *the Flintstones*. The dance allows students to model relative frequencies and wavelengths of the electromagnetic spectrum and the song mentions their use. If you would like your free copy, contact Alan Pickwick at the AAE.

(**Alan_C_Pickwick#btinternet.com**)

Lynda Dunlop

Elec-tro-mag-net-ic
We're a family of transverse waves
Gamma to Radio
We can all travel through empty space
IR shows us dust and nebulae
Also the centre of the Milky Way
Elec-tro-mag-net-ic
We're a family of transverse waves
(----musical interlude----)
Elec-tro-mag-net-ic
We're a family of transverse waves
Speeding through a vacuum
at three hundred million m per s
Pulsars and supernovae we see
Using radio astronomy
Elec-tro-mag-net-ic
We're a family of transverse
Family of transverse
Family of transverse waves!

Cut out labels of the waves in the electromagnetic spectrum, with a string so they can be placed over students heads as name labels. Ask for seven student volunteers, and ask them to arrange themselves in order of height. The tallest (longest) is a radio wave, the shortest a gamma ray.

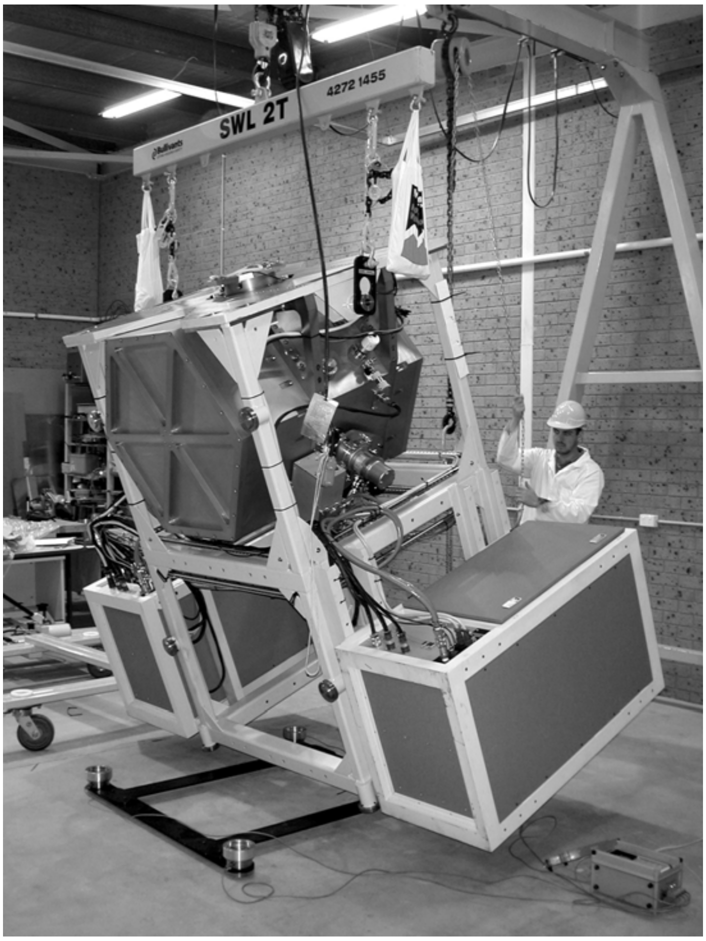
Using the Mexican wave as a model of a transverse wave, explain how waves are at the same speed but different frequency (waves per second) – students should model this by raising their hands most of they are a gamma ray and least of they are a radio wave.

Flap around in time to the *Electromagnetic Song*!

Letter from Down Under

A major milestone was passed this month, with the delivery to the Gemini-North 8-metre telescope in Hawaii of the first Australian-built instrument for the Gemini Observatory. The near-infrared integral field spectrograph (NIFS) is intended primarily to study supermassive black holes at the centres of galaxies, with a resolution as good as the Hubble Space Telescope.

NIFS is a clone of the instrument destroyed in the devastating Canberra bushfires of January 18, 2003. The original NIFS was almost complete and ready for testing, when fire swept through the workshops of Mt. Stromlo Observatory. Fortunately, the most expensive component – a 2048 x 2048 pixel infrared-sensitive array from Rockwell Scientific in the USA – had not yet been integrated into NIFS, and was saved. But everything within the hexagonal "cold box" (filters, lenses, motors, etc.) was melted by the heat.



The NIFS-2 instrument shown after final assembly by AUSPACE in Canberra. The hexagonal box at the top contains the image "slicer", diffraction gratings, infrared detector, etc. and is cooled to –200 °C by a helium refrigerator. The two large boxes below it contain the control electronics. (Image: courtesy of Mt. Stromlo Observatory/Research School of Astronomy & Astrophysics/AUSPACE)

Within weeks of the disaster, Gemini gave the go-ahead to rebuild NIFS. Perhaps "Phoenix" might have been a more appropriate name than NIFS-2, were it not for the fact that an instrument on the Gemini-South telescope already has that name!

Due to the fact that Mt. Stromlo Observatory engineers and technicians were already hard at work on a different Gemini instrument, and since all the design and development work had already been done, the fabrication and assembly of NIFS was sub-contracted to a local aerospace engineering company called AUSPACE. This company had previously delivered a CCD imaging camera array for the AAT, as well as an ultraviolet telescope which flew on the space shuttle in the early 1990s.

NIFS sees only a tiny part of the sky, some 3 arcsec wide by 3 arcsec high. Using a special set of diamond-machined metallic mirrors, this field is sliced up into 30 "slitlets" each 0.1 arcsec wide and 3 arcsec long. A spectrum along each slitlet is then produced by a diffraction grating, and imaged onto the detector array, allowing astronomers to make 2-D maps of emission from hot gas as it swirls down towards the black hole.

Measuring the width and shift of these lines enables the black hole to be "weighed". Only the Space Telescope Imaging Spectrograph (STIS) on the HST could make such accurate measurements, but has only a single slit, which must be painstakingly stepped across the galaxy nucleus.

In addition, STIS works only at optical wavelengths, and dust in the central regions often obscures its view. Sadly, STIS suffered a major power supply failure a year ago, and is unlikely to be revived without a Shuttle servicing mission. So NIFS has a lot of work ahead of it!

To take full advantage of the tiny slitlets, the images delivered to NIFS must be 0.1 arcsec or less. While Gemini has an enviable reputation for superb image quality, to achieve 0.1 arcsec routinely in the near-infrared requires the help of "adaptive optics".

A Canadian-built facility called ALTAIR sits in front of NIFS, and continuously monitors any deformation in the image shape of surrounding stars. It then attempts to compensate for this using a deformable mirror, made up of 177 smaller mirrors which can be individually adjusted hundreds of times each second to remove the image distortion.

As powerful as adaptive optics is, it can only work provided there is a star bright enough and near enough to the target, which is only true for about 5% of the sky. Where no natural star exists however, powerful lasers can be used to create an "artificial star" by exciting sodium atoms 100 km up in the atmosphere.

Multiple laser guide stars, coupled with natural stars will soon enable ultra-sharp images over fields of 1arcminute or more. To take advantage of this, the contract has been awarded to Mt. Stromlo to build the Gemini South Adaptive Optics Imager (GSAOI). This will use a mosaic of four infrared detectors, each four times larger than the one in NIFS, and is due to be delivered to Chile late next year.

Following an intensive checkout and commissioning process later this year, NIFS will be offered for use by astronomers in the Gemini partnership (USA, UK, Canada, Australia, Argentina, Brazil, and Chile).

In return for all their efforts in planning, designing, building, and supporting NIFS, Australian astronomers have been guaranteed five nights of NIFS use for projects of their own choosing.

The opportunity to study up close the "monsters" that lurk at the heart of possibly every galaxy will be a richly-deserved reward for people who refused to be beaten by the flames.

Stuart Ryder
sdr#aaoepp.aao.gov.au

The Titius Bode Law

In the history of science there has been no shortage of guesses, hunches and half-baked theories that actually paid off, and one of the most amazing of these was the discovery of the minor planets.

The story begins in 1766 when Johann Titius arrived at an apparently simple mathematical formula from which could be derived the distances form the Sun of all the known planets. In addition, it later predicted the distances of yet undiscovered planets.

Titius' formula was published in a book by Johann Bode, and it is now widely known as the Titius-Bode Law. According to this formula, not only were there planets further out from the Sun than Saturn, but there was a place between Mars and Jupiter where a planet ought to be located, but had avoided detection because of its faintness.

According to the Titius-Bode Law, beginning with 0 for the innermost planet, Mercury, then 3 for Venus; each subsequent planet is double the preceding figure from the Sun: 0 - Mercury; 3 - Venus; 6 - Earth; 12 - Mars; 24 - Asteroid Belt; 48 - Jupiter; 96 - Saturn; 192 - Uranus; 384 - Neptune; 768 - Pluto.

If 4 is added to these figures and they are divided by 10, the result is that planet's distance in Astronomical Units (AU) from the Sun. One AU is the average distance between the Sun and the Earth, which is approximately 150 million kilometres.

Planet	T-B Law	T-B Law distance (AU)	Actual distance (AU)
Mercury	0	0.40	0.39
Venus	3	0.70	0.72
Earth	6	1.00	1.00
Mars	12	1.60	1.52
Asteroid belt	24	2.80	2.80
Jupiter	48	5.20	5.20
Saturn	96	10.0	9.54
Uranus	192	19.6	19.2
Neptune	384	38.8	30.1
Pluto	768	77.2	39.4

The formula works rather well out to Neptune, whose actual distance falls very short of that predicted - Pluto's actual distance is much closer to this figure. For several years following its publication, the Titius-Bode formula was regarded as a mathematical curiosity. Things changed in 1781, when William Herschel discovered Uranus; once its orbit was determined, the new planet was found to fit neatly into the Titius-Bode scheme of things, and the formula became a "law" overnight.

If the Titius-Bode Law was right and it really did have predictive properties, then there ought to be a planet orbiting the Sun between Mars and Jupiter. Convinced that there was such a planet waiting to be discovered, but it was too small and dim to be seen with the unaided eye, a number of astronomers around Europe organised themselves into the "Celestial Police" to hunt it down. Success came on 1 January 1801, the very first day of the 19th Century, when Giuseppe Piazzi discovered the first minor planet, which he later named Ceres.

Unlike Uranus, Ceres failed to be resolved into a disc through the telescope eyepiece, and it was initially thought that the new object might be an incoming comet. Once its orbit was calculated it became clear that Ceres orbited the Sun near the plane of the ecliptic in a near-circular orbit between Mars and Jupiter - just where the Titius-Bode Law predicted it ought to be.

To describe the telescopic appearance of these objects, the word "asteroid" (from the Greek, meaning "star-like") was first used by William Herschel, the discoverer of Uranus.

Reasoning that there might be yet more minor planets to be discovered, the "Celestial Police" continued their telescopic search. Minor planet 2, Pallas, was discovered in 1802, then 3, Vesta, in 1804 and 4, Juno, in 1807. There were no more discoveries for 38 years owing to the lack of detailed star charts with which to compare the view through the eyepiece. Visual discoveries picked up again in 1845 with 5, Astraea, and they continued at a steady pace. By the end of the 19th Century around 300 minor planets were known.

Peter Grego

Sky Diary Autumn

This quarter marks the start of the 25th year of the AAE, so, astrologers, what do you predict with Saturn is in Cancer, Mars is in Taurus, and so on.

Saturn has passed its furthest north point in the ecliptic and, because of its significant axial inclination (nearly 27º) it has been showing us its south pole very clearly while in that part of the sky. As it continues moving to lower declinations over the next 13 or so years, the fantastic rings will close until they become a thin, virtually invisible line, and then the planet will display its north pole Earthwards. This quarter, the rings will just fail to "engulf" the disc of the planet completely as they have done for the last four years or so.

The planet Mars is also a peculiar celestial body. Because it moves round its orbit in just under 1.9 Earth years, and is at a distance from the Sun of about 50% more than the Earth's average distance, the Earth seems to take a long time to catch up Mars after it first appears as a faint red spark in our morning skies after conjunction. Mars is a small planet, about half the diameter of the Earth, and just after conjunction with the Sun is also at five times the distance from Earth that it will be, approximately, at the next opposition. As a result it is very faint, compared with the brightness at opposition.

The interval between successive alignments such as conjunction, opposition, quadrature etc. is called the *synodic period*, roughly what a "geocentric" ancient astronomer might have called the time the planet "takes to go round the Earth". Because of their proximity, both our nearest planetary neighbours have very large synodic periods. Mars takes an average of 2.14 years between oppositions, and Venus 1.6 years (between, say, inferior conjunctions) so the casual sky watcher tends to forget just how bright Mars (and even Venus) can appear. To see Venus at its most obvious in the evening sky from the northern hemisphere (say) needs the planet to be near eastern elongation in the months around the spring equinox, when the ecliptic is most favourably inclined to the horizon. This takes over two years as well. So in 2004 during the months ☞

☞ of February to May or so people were asking “What’s that brilliant star in the evening sky?” By 2007, when it happens again, they will have forgotten once more, even though Venus is visible in the evening low in the south west towards the end of this year.

Similarly, but for slightly different reasons, Mars gets forgotten. The red planet has a highly eccentric orbit. This is clear in any scale drawing of the orbits of Earth and Mars, which shows that the orbit of Mars at perihelion is almost half the distance from Earth’s orbit as at Mars’ aphelion. The result is that whenever Mars is at opposition near its perihelion position, it is at its apparently biggest possible and brightest in the sky. This almost happened in August 2003, and was well publicised at the time (*Gnomon* Vol. 22 no. 4) when the planet was within 1º of perihelion. But for the “biggest and best” publicity, it might have gone little noticed however, because, sad to say for northern observers, Mars’ near-perihelic oppositions must occur near that same position in its orbit, which puts the planet well south in our skies.

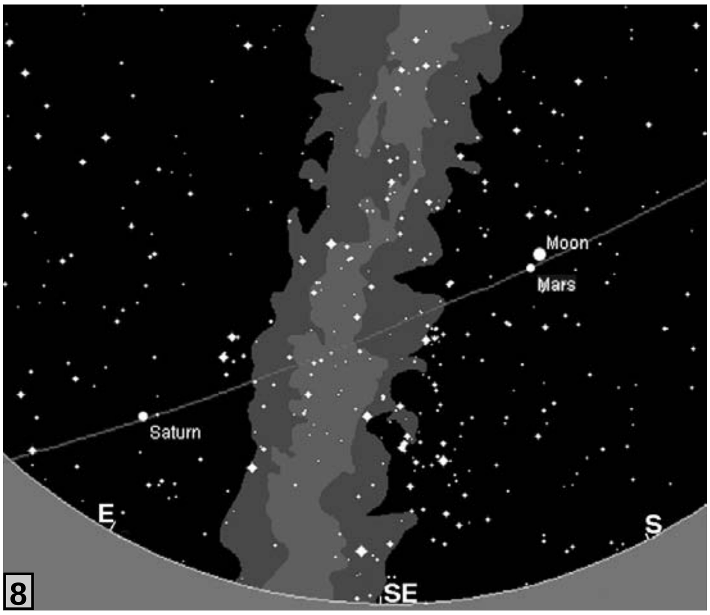
Moon phases for the fourth quarter of 2005

	New Moon	First Quarter	Full Moon	Last Quarter
October	3	10	17	25
November	2	9	16	23
December	1/31	8	15	23

This autumn, Mars will be at opposition on November 7, for the first time since that historic opposition in 2003, over two years and two months later, in Taurus, well away from its closest to the Sun, (and Earth). Even so, it will be a respectable magnitude –2.3 (see also the item at the top of the next column!)

More important is that Mars is the easiest planet to be able to observe the movement across the background of stars: its daily motion is quite clear in a small instrument, and over a few days to the unaided eye. It is a marvellous opportunity for the GCSE course work observations this autumn as the sky has plenty of easily recognised stars and star patterns in this area of sky. Observations should be carried out during the autumn as frequently as possible. A naked eye sketch of the area around the constellation of Taurus could be made, or copied from a good star map,

The south-east sector of the midnight sky on November 15, showing the ecliptic, with the planets and the Moon visible at that time.



The local paper (the Cornishman, August 25) excels itself again! The question arises, how would people have reacted to a Moon-sized Mars?


Church, Bread Street.
Everywhere: The Red Planet Is About To Become Spectacular! Earth is catching up with Mars culminating on the 27th, Mars will look as large as the Full Moon to the naked eye, No-one alive now will see this again!
Sunday, August 28
Penzance: Divine Service with

and the observed positions of Mars plotted on this. Better still, make a cross-staff for angular measurement of the stars’ positions, and plot the map from those. Then measure Mars’ positions and add to the chart.

The big special event this autumn is the annular eclipse of the Sun on October 3. To see the Sun’s ring of flame round the Moon’s disc is an interesting oddity, having little of the spectacle of a total eclipse, but in the case of the UK, not even the novelty of the annular Sun will be seen. Instead, the event will appear as a partial eclipse of reasonable magnitude: at central eclipse 66% of the Sun’s diameter will be covered by the Moon. The eclipse begins at 7h 49m UT (sunrise is at 6h 16m UT) and ends at 10h 18m. To watch a partial solar eclipse safely you must project the image of the Sun onto a screen of some kind. You can use one ocular of your binoculars by keeping the lens cap on one of the objective lens. An eyepiece cover is no good: the Sun’s focussed image will quickly drill through it!

The binoculars will need to be mounted on a tripod, and a good (and simple) accessory is an old A4 size envelope

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

	October 15		**November 15**		**December 15**	
	Rise	Set	Rise	Set	Rise	Set
Sun	06h 36m	17h 17m	07h 31m	16h 20m	08h 13m	16h 00m
Mercury	08h 26m	17h 41m	09h 23m	16h 54m	06h 18m	15h 00m
Venus	11h 17m	18h 41m	11h 51m	18h 41m	10h 40m	18h 48m
Mars	18h 20m	09h 30m	15h 44m	06h 41m	13h 30m	04h 25m
Jupiter	07h 07m	17h 32m	05h 43m	15h 43m	04h 19m	13h 58m
Saturn	23h 40m	15h 08m	21h 45m	03h 10m	19h 44m	11h 12m
Uranus	15h 58m	02h 28m	13h 55m	00h 23m	11h 57m	22h 24m
Neptune	15h 09m	00h 21m	13h 07m	22h 16m	11h 11m	20h 21m

in the centre of which you cut out a circle just a tad smaller than the diameter of the ocular. You can then point the half-binocular at the Sun by foreshortening its shadow on the screen. Place the shading envelope over the end to cast a shadow over the screen, in the middle of which the Sun’s image will appear and can be made sharp by adjusting the focus. At NO TIME should you look through the binocular – and don’t turn your back on it while someone else is tempted to! (See Peter Ford’s photographs on page 6 of the spring issue of *Gnomon,* Vol.24 no. 3)).

While partial eclipses are not a pat h on the splendour of total eclipses, they are sufficiently rare seen from the UK to be interesting. One observation worth some effort is to find a tree casting dappled shadows on the ground or on a wall. The multitude of crescents projected by the same process as in a pinhole camera is worth the trouble to see.

As can be seen from the sky map, the Milky Way is high overhead during the Autumn evenings, stretching from the so-called “Summer” Triangle in the west towards Orion in the east. This time of the year offers a good opportunity to observe the variations in the relative brightness of the axis of our galaxy as it crosses high in the early night sky.

Richard Knox