GNOMON

Newsletter of the Association for Astronomy Education

Vol. 10 No. 1 **ISSN 0952-326X** **AUTUMN 1990**

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

The Universe in the Classroom

The four centre pages of this issue are reproduced from 'the Universe in the Classroom', the newsletter of the Astronomical Society of the Pacific. Page 3 is an extract from an issue on Pluto (1988); pages 4, 5 and 6 contain lists of books on astronomy from the Spring 1990 issue. Many of these books are available in the UK, sometimes from different publishers.

GCSE Astronomy

by Frank Flynn

This new examination has now been running for three years. In the summer of 1988 the old O level, administered by London University, was replaced by GCSE, with a provisional syllabus, and I became Chief Examiner at that time. The comments which follow are my private opinions, and not an official statement from the London and East Anglian Group (LEAG) who now run the examination.

The provisional syllabus ran for two years, as one of the Nautical Studies group of subjects, but it did not meet the stringent requirements of a Science course under the new National Criteria, and a major rewrite was undertaken.

There were several reasons for the revision. Firstly, to be sure that the course did indeed reach a much wider range of potential candidates than did the former O level and the provisional GCSE and also to ensure that the questions were designed to get away from an excess of factual recall, and test a wider range of skills such as perceiving connections between phenomena, drawing conclusions from data presented in a variety of ways, and imaginative reasoning around a particular topic. It was agreed, in common with the other subjects in the Science group, differentiated papers would be needed to cater for the full ability range, and that coursework would be made a prominent feature.

The first examination under the new syllabus was taken in Summer 1990. It is important to stress that this examination now carries the full status of an approved GCSE science examination, under National Criteria, and will be accepted as such by bodies looking for a science element in a group of GCSE results from a particular candidate.

The new exam contains the following elements:

Paper 1 is taken by all candidates. It is designed to reach the whole range, answers are written on the question paper itself, and this counts for 30% of the whole assessment.

Papers 2 and 3 are options. Paper 2 is targeted at grade D/E level, and those who take this option have access to grades C to G. Answers are written on the paper, which carries 40% of the total. Paper 3 is a considerably harder paper targeted at grades B/C, and those who take this option have access to grades A to E. Answers are written on a separate paper, and this paper also carries 40% of the total. The remaining 30% of the assessment is coursework.

As with all examinations which have a system of differentiated papers, it becomes very important for candidates to make a careful choice of the most suitable options for them. One apparent difficulty is that a lot of our candidates are individuals who may be self-taught, or receiving only light guidance from a friendly teacher in a different sphere. These candidates lack the close guidance they would be receiving in a conventional science class, and may find it very difficult to assess their own standard. It is perfectly possible for a 'middle of the road' candidate to choose either option and do equally well, but the really able candidate is certainly better advised to attempt paper 3, and hopefully obtain a B or A grade, not available via paper 2, which has a grade C ceiling. Conversely a less experienced candidate will not succeed well on paper 3, and may even fall below grade E level, and so be ungraded, whereas he or she will certainly experience a much greater degree of success and satisfaction on the easier paper 2, and achieve a realistic grade.

On the basis of three years' experience, we seem to have three populations taking the course – the potentially able scientist, typically in the lower sixth, and doing science A levels, 'throwing in' Astronomy as an extra (this was the traditional O level Astronomy population) – some isolated but highly motivated adult students (these are often identifiable from the maturity and exceptional quality of their coursework), and the third population which is largely new, and very welcome, is groups of younger students probably in 4th and 5th year science courses in school. These tend to show a wide spread of ability, but have the advantage of being taught as a group by a teacher who is obviously an enthusiast in the subject.

Finally, a word about coursework. On the new structure five pieces of work are required, to be presented in May of the examination year. At least two must be taken from the list headed 'Observations – naked eye, telescopic, photographic' and at least one from 'Constructional, Graphical, Computational'. Other individual projects in the same spirit as those on the list may be submitted. Each is assessed under a variety of different criteria, and the five together constitute the remaining 30% of the total. Coursework has generally been of a very good standard, and there have been some particularly impressive contributions. Work is initially marked by local teacher assessors, and then moderated by the Board on a sampling basis, to ensure comparable standards between Centres.

At present we have about 60 Centres entering for the examination, spread all over the country, and a few overseas Centres. Entries vary from only one or two candidates, to sizeable groups.

Full details of the syllabus and past papers may be obtained from:

East Anglian Examinations Board (for LEAG), 'The Lindens', Lexden Road, Colchester, Essex CO3 3RL

As far as books and resources are concerned, Patrick Moore's recent publication 'Astronomy for GCSE' is likely to prove very useful. It is an up-to-date and very readable text at just the right level, covering most of the essential features of the course. But it is good for candidates to dip into a wider range of sources as well, and the Board provides a reading list.

The Author, Dr Frank Flynn, is Chief Examiner for GCSE Astronomy and a member of AAE. He lives at Bury St Edmunds, but until June next year, his address is Rehovat, Jerusalem.

Editorial Comment

Loose insert haters may be annoyed with this issue of *Gnomon*, which contains (to date) three loose inserts. I know one lady who regularly shakes out all inserts in her Sunday colour supplement, never bothering to favour them with a glance. I suspect she is not alone in this.

We sincerely hope that our readers do not apply the same treatment to *Gnomon*. All our inserts are a regular part of the newsletter, being items dealing with books, conferences, museums and planetaria, subscription renewals, etc. For technical reasons these are dealt with as inserts.

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We are always pleased to mention literature provided by institutions such as Jodrell Bank, the RGO, the ROE, etc. When there are items of news of interest to our members, these are incorporated into the text; if on the other hand they may be regarded as advertising, we are happy to include them for a fee (advertising costs are given elsewhere in this newsletter).

We have received a considerable amount of material from the ROE (Royal Observatory, Edinburgh). It is lavishly illustrated with photographs. I have made a selection of this material and included it in the text. I am sure it will inspire our readers as much as it did me!

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Francophile anglophones will be saddened to learn that the circumflex accent is to be abolished from the French language. English speakers learning French have always experienced difficulty with the various accents above vowels (acute, grave and circumflex). Many French words have been imported into English *together with their accents*. To lose the circumflex is somewhat akin to losing an old friend, especially with words such as rôta, fête. As a traditionalist, part of the job of editor is to go through all the material supplied for *Gnomon* and add, where necessary, the missing circumflex (some words slip through the net, of course, despite this). Incidentally, I remember being taught at school that sometimes one could get a good idea of the meaning of a French word with a circumflex by replacing the accent with an 's' after the vowel – thus 'fête' becomes 'feste', which is close to 'feast', 'château' becomes 'chasteau', hence 'castle', and so forth. But I also well remember coming a cropper when I translated 'les bêtes sauvages' as 'the best sausages'.

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On a related topic, would any reader care to explain the origin of the curious word Boötes for the constellation of the Herdsman and comment on its pronunciation?

A SOLUTION TO GNOBLEM 10?

One reader thinks the collision of two black holes is impossible, as the two statements: A swallows B and B swallows A are logically incompatible.

Another says that if matter is falling into one black hole, producing X-rays which may be detected from outside, then it is possible that on close approach to the other black hole this falling matter would transfer to the other hole. This would give rise to X-rays of different wavelength.

Another reader says that black holes may rotate. Matter falling into the black hole could emerge into another part of the universe. But he is not sure if the same argument applies to one black hole falling into another.

The whole subject of black holes is like trying to explain a fantasy world, and is not properly understood. Readers who are interested should consult the copious literature. (One example is: Black Holes, Quasars and the Univérse, by H. Shipman.

GNOBLEM 11

Consider the revolution around the Sun of the three innermost planets Mercury, Venus and the Earth. Let us assume that at one particular instant, these planets are all lined up. What interval of time must elapse before the next lining up of these three planets takes place?

The periods for one revolution around the Sun are: Mercury 0.24 year, Venus 0.62 year and the Earth 1.00 year. Assume the orbits are circular.

We have received the following information from Professor Jay Pasachoff:

The Teaching of Astronomy
Proceedings of the 105th Colloquium of the International Astronomical Union

Edited by
Jay M. Pasachoff, Williams College
John R. Percy, University of Toronto

The Teaching of Astronomy holds lessons for teaching all sciences. This volume discusses teaching students of various levels – including schools, colleges and universities – as well as teaching the general public through public lectures, planetariums and correspondence courses. The experiences of educators from all over the world as applied to the teaching of astronomy were shared in the 105th International Astronomical Union Colloquium by 160 people from 31 different countries. Cross-cultural considerations and the needs of developing countries received careful discussion.

This book contains not only general considerations of teaching matter but also practical examples of specific courses, demonstrations, laboratories, planetarium topics and other applications. It offers a unique overview of international teaching technology and expertise that will serve as a lasting guide to astronomers involved in education.

Contents: Prologue / Curriculum / Astronomy and Culture / The Teaching Process / Student Projects / Computers / Textbooks / Teaching Aids and Resources / Conceptions and misconceptions / High-School Courses / Teacher Training / Popularization / Planetariums / Developing Countries.

International Astronomical Union Colloquium 105
Cambridge University Press 1990 445 pp. 35331-9 Hardcover $54.50

Professor Pasachoff, who was formerly at the Institute of Advanced Study, Princeton, NJ, and is now at Williams College, Hopkins Observatory, Williamstown MA, is a member of the Association for Astronomy Education.

Astronomy Essay Competition

A Young People's essay competition on the subject 'Our Place in The Universe' is being organised by the Royal Astronomical Society and American Express as a contribution to National Astronomy week in late November 1990.

The first prize will be a week's holiday in Tenerife and a night-time visit to Britain's major telescopes in the Canarian island of La Palma. There are over 20 other prizes including a pair of binoculars with a book on binocular astronomy, lucite-mounted meteorites, books and planispheres.

Michael Penston, Chair of the Royal Astronomical Society's Education Committee said "We are extremely grateful to the generosity of American Express and our other donors who have made the prize list so attractive. Astronomy is a popular science which is just now taking its proper place in education as part of the new National Curriculum. As a result, we look forward to an excellent entry to this competition."

Entrants should be 13–17 on 1st September 1990 and entries should be submitted by 22nd October. Entry forms and full details are included with this newsletter (*Gnomon*, Autumn 1990). Further copies may be obtained from the Royal Astronomical Society, Burlington House, Piccadilly, London W1V 0NL);

Royal Observatory, Edinburgh, and Visitor Centre

Please note that the telephone number has been changed to 031–688–8100.
There is a direct line to the Visitor Centre: 031–668–8405.
The Visitor Centre is open to the public from 10.00–16.00 Monday to Friday, and 12.00–17.00 at weekends.
On public holidays the centre is open from 12.00–17.00; it is closed on Christmas Day and New Year's Day.
A winter series of lectures starts on 12 October, and these are on the second and fourth Friday of every month between October and March.

The following brief items have been selected from a number of leaflets supplied by the ROE, and will be of interest to readers:

The James Clerk Maxwell Telescope

The James Clerk Maxwell Telescope is the largest of a new generation of radio telescopes designed to work at submillimetre wavelengths. Located at the Mauna Kea observatory on the island of Hawaii, by arrangement with the University of Hawaii, the telescope was designed and built jointly by the United Kingdom and the Netherlands.

The telescope has been named after the Scottish physicist James Clerk Maxwell who was born in Edinburgh in 1831 and educated at that University. As one of his major contributions to physics he discovered the laws of electromagnetism, which are also of great importance for astronomy.

Now, more than 150 years later, the James Clerk Maxwell Telescope is operated by the Royal Observatory Edinburgh on behalf of the scientific communities in the United Kingdom, Canada, the Netherlands, and at the University of Hawaii.

The day to day running of the James Clerk Maxwell Telescope is managed and carried out by a resident support group at the Joint Astronomy Centre in Hilo on the island of Hawaii. This group maintains the telescope and its instruments and provides technical and scientific assistance to visiting astronomers.

What is submillimetre astronomy?

The submillimetre and millimetre waveband spans a region of the spectrum between infrared radiation and radio waves (roughly between 0.3 and 3 millimetre or 100 and 1000 gigahertz). Until recently this band was one of the few spectral regions not fully opened up for astronomers, because of the special conditions required. Submillimetre observations have to be done from carefully chosen high sites with specially designed instruments that combine the bolometric techniques used at infrared wavelengths and the heterodyne techniques used in radio astronomy. In addition to this, submillimetre radiation from astronomical objects is weak, providing an even bigger challenge to the submillimetre instrument builder.

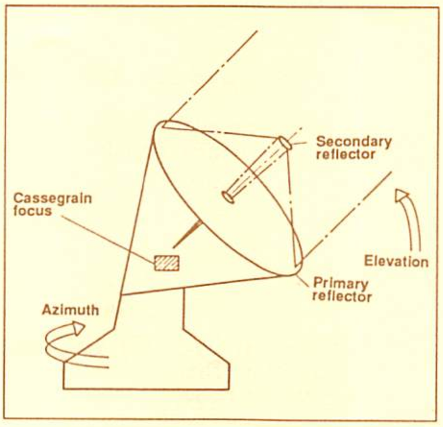
On the other hand the submillimetre band is a crucial one for astronomy, because it contains spectral and spatial information on very different classes of celestial objects.

- *The microwave background radiation* spreads throughout all space and is the cool relic of the hot early phase of the Universe. There are many reasons why there should be small ripples in this radiation related to the origin and evolution of galaxies. Some of these effects can be studied only in the submillimetre waveband.
- *Very distant newly formed galaxies like quasars* are relatively strong sources in the submillimetre waveband. The determination of their spectra and time variability is very important for understanding the total energy content of the active nuclei.
- *Early stages of star formation* take place in clouds of gas and dust. The large number of dust particles in these clouds dims the visible light of stars now being born. At submillimetre wavelengths, however, we can look into these stellar nurseries and identify the regions where the youngest stars and their precursors, the protostars, are forming.
- *Evolved stars* hide themselves in very thick expanding shells due to ejection of large amounts of material caused by instabilities in their atmosphere. At submillimetre wavelengths we can look into these deathbeds of stars and discover how stars breathe their last.
- *The chemical evolution of galaxies* can be studied. Here molecular line radiation is used to measure different chemicals in various parts of the galaxies. The submillimetre band is rich in these molecular lines and provides us with an extra-terrestrial laboratory in which many rare molecules can survive.

The Telescope

The telescope is a classical *Cassegrain* type. Radiation is collected by a 15 metre diameter paraboloidal reflector that directs the light towards a 75 centimetre hyperboloidal *secondary* reflector. The secondary reflector in turn directs the light through a hole in the primary reflector to the *Cassegrain focus,* where the instruments are located.

The reflector system is supported on an *altazimuth* mount. Movements in *elevation* and *azimuth* are made using direct current torque motors acting through frictional contact.



The secondary mirror is adjustable in three mutually perpendicular directions and can be vibrated in the plane perpendicular to the *optical axis* to allow background subtractions by on- and off-source measurements.

The primary surface is produced by supporting 276 lightweight panels on a mild steel space frame which deforms uniformly as the elevation changes to maintain a paraboloidal shape.

To operate efficiently at submillimetre wavelengths the telescope must retain its paraboloidal shape to a very high accuracy. At present the surface accuracy is better than 38 microns (as thick as a thin piece of paper) under all operating conditions, which makes this telescope unique. It is expected that the accuracy can be further improved to 20 microns in the near future, guaranteeing efficient operation at wavelengths down to 0.3 millimetre.

It is important that a telescope can be pointed at a given position in the sky with a very high accuracy. At present the pointing accuracy is about 1/200 degree, about 1/1000 times the size of the full moon.

Mauna Kea, the White Mountain

At submillimetre wavelengths, atmospheric water vapour strongly absorbs radiation from astronomical objects. So the telescope needs to be at a high altitude site to be above as much of the water vapour as possible. Isolated high mountains on islands make particularly good sites because the absence of large land masses reduces convection which lifts water vapour to higher altitudes. The volcanic mountain of Mauna Kea (altitude 4,200 metres) on the island of Hawaii, is the best site in the world where there is an established observatory. The James Clerk Maxwell Telescope is located in 'Millimetre Valley' about 100 metres below the main ridge where the optical and infrared telescopes are situated.

Although it is in the tropics, the summit of Mauna Kea experiences on occasion severe weather conditions with winds over 150 km/h (95 mph) and heavy snow which is the origin of the mountain's name: Mauna Kea, the White Mountain. To protect the telescope it is built inside an enclosure which rotates with it. During observations, the viewing aperture is covered with a membrane of woven polytetrafluorethylene (teflon) to protect the telescope surface from wind and sun, both of which would affect the surface and pointing accuracy. The membrane shields winds up to 80 km/h (50 mph) wind speed; for higher wind speeds, the doors and roof shutters have to be closed.

BOOKS

The Fundamentals of Stellar Astrophysics, by George W. Collins II, W.H. Freeman and Company, New York 1989. £44.75, hardback, 494 pages. ISBN 0–71–67–1993–2.

This is a textbook. In American terms it is aimed primarily at first-year graduate students; in Britain, this means that it is suitable for second- and third-year specialist courses for students taking three-year honours degrees in Astronomy or Astrophysics. For this purpose it appears to be very well suited; it is however somewhat too detailed to be the ideal text for a general Astrophysics course taken as one of the final-year options in a Physics degree.

The subject of stellar astrophysics is concerned with an essentially theoretical discussion of the properties of stars: there is nothing here at all closely related to observational matters such as spectral classification or photometry. The background knowledge assumed is therefore rather beyond that of the general reader with an interest in Astronomy. It is assumed that the reader is already familiar with concepts such as the HR diagram (which appears here purely in the form used by theorists as a plot of luminosity against surface effective temperature), the curve of growth, quantum mechanics and differential equations. On the other hand, the level of treatment quite consistently stops just a little way short of the most advanced research topics in each subject considered; that is, this is a genuine textbook rather than a research monograph.

Stellar astrophysics is clearly divided into two distinct parts – the study of stellar interiors and atmospheres. Studies of the interior are concerned with the large-scale structure, the nuclear processes of energy generation, and the evolution of the star through its lifetime. The atmosphere of a star is the region where the detailed form of the emitted spectrum is established; the essential atmosphere problem is, given a flux of energy from below, to consider how it is redistributed in wavelength, mainly through the process of radiative transfer, to produce the continuum and line spectrum emerging from the surface. The two subjects of interiors and atmospheres involve distinctly different physical and mathematical problems, and they are studies by distinct groups of researchers. Many textbooks are devoted to only one or the other of them. In the present case, the book is actually divided into two almost equal halves. They are not altogether independent and in the second part on atmosphere it is often necessary to refer back to the first half for definitions and explanations of concepts. On the whole this works well although it would obviously have disadvantages for a course on atmospheres alone.

Overall, I think that this book succeeds pretty well in its aim to be an advanced textbook covering both halves of its field. As such, it is to be welcomed, for genuine textbooks at this level are rare. It would also be useful as an introduction to the subject for new research students.

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UNDERSTANDING THE UNIVERSE: Instructor's Manual with Test Bank, by Philip Flower and T.F. Collins, West Publishing Co., St Paul, MN, USA. Softback, pp.296, 1990. ISBN 0–314–57880–3. $46.50.

UNDERSTANDING THE UNIVERSE: Observer's Handbook, to accompany the above text, by Philip Flower. Softback, pp.30, 1990. ISBN 0–314–73281–0. £5.00.

These books may be obtained from the publisher's representatives in the UK:

Graham Pickup, 26 Parkhurst Road, Wood Green, London N22 4JQ, for the South of England, Wales and Ireland, or

Patrick Cullen, 8 Edge End, Great Harwood, Lancs BB6 7UZ, for the rest of the UK.

As the title of these volumes states, they are *instructive manuals*, and the main text is set out rather in the same way as a manual is designed for a motor car. It is certainly not a textbook, and it is not a book which can be read to glean some knowledge of astronomy.

The publishers provided these two books for review, but on reading an accompanying letter describing the books, it appears that there is yet a third volume, which forms part of the trilogy, called the Study Guide. This was not provided.

I found the introductions (to the instructor) on how to use the books extremely confusing. Thus on page 1:

Introduction

How to Read a Science Textbook

Introduction

Outline. of introduction: How to read a science textbook

Introduction

After many attempts to understand these instructions, I gave up and concentrated on the content. A table of contents describes 19 chapters and 2 modules. The chapters deal with the solar system, the stars, galaxies and the expanding universe. But on reading a typical chapter, it appeared that this was set out in the same confusing style. It was as though all the footnotes from a good book on astronomy were collected together and placed in some kind of matrix, with constant changes in typeface, so that the end product resembled a railway timetable.

This is a great pity as a lot of hard work has obviously been put into these volumes. There must be someone out there to whom this work appeals, but he or she is certainly not this reviewer.

Eric Zucker

LETTERS

Several readers expressed concern about the possible danger of using a 'sun filter' with the Zeiss Telementor refracting telescope, details of which were circulated with the Autumn 1989 issue of *Gnomon*. Zeiss Jena (of East Germany) were asked to comment on this, and the following reply was received, via their UK distributors.

Dear Editor,

Following your recent letter to Carl Zeiss Jena concerning the use of sun filters with the Telementor Telescope – Zeiss have asked us to convey the following reply.

"In this particular instance there is a confusion between the sunglass and the sun filter. The sun filters for our astro amateur telescopes are completely safe. There is no possibility of accident. These filters are mounted in front of the lens of the observation instrument and thermally are not subjected to any more stress than any other surface exposed to the sun.

The sunglass on the other hand does not give sufficient protection from the sun. The sunglass is mounted behind the ocular and the concentration of heat in this particular spot could lead to distortion or fracture of the sunglass."

Zeiss have also pointed out that the instruction book contains information on the use of the sunglass to avoid confusion.

I trust that this will clarify the situation and thank you for your interest in our products.

Yours sincerely
S.R. Lealand
Product Marketing Manager
CZ Scientific Instruments Ltd.

Addresses for Correspondence

Secretary: Bob Kibble, 34 Acland Crescent, Denmark Hill, London SE5 8EQ – for all general enquiries. (Tel: 071–274 0530)

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