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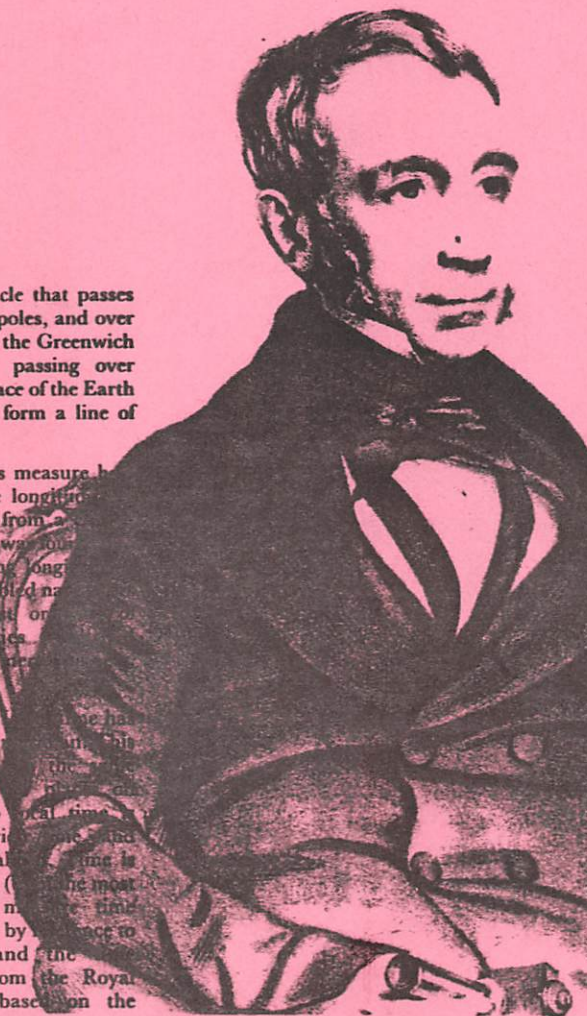
NEWSLETTER

of the

Association for Astronomy Education

Vol.3, No.3 April, 1984



Sir George Biddell Airy,
Astronomer Royal
1835-1881.

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Spacecharts

A WIDELY ACCLAIMED SERIES OF SPACE WALL CHARTS

"Attractive ... well printed ... very inexpensive ... highly recommended." BAA Journal

These new charts present up-to-date information on astronomy and astronautics in an attractive format. The meticulously researched text is by Robin Kerrod, FRAS, FBIS, author of many books on science for children and the general reader. SPACECHARTS are illustrated by superb artwork and brilliant colour photographs. Measuring some 900 x 600mm - about 3 feet x 2 feet - they are printed on artpaper for the best possible reproduction.

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Send your orders, or write for further information to:

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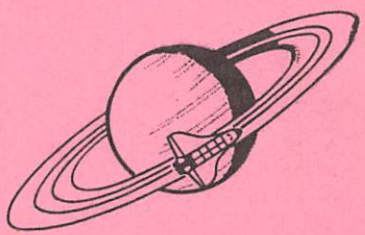

Contents

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EDITORIAL

Most readers of this Newsletter are, in some way or other, involved in furthering the cause of Astronomy Education. I hope that, whilst reading the following pages, they will find much to encourage them. On reading through the final draft I was heartened to discover so many indications that we are making headway.

There is, for instance, our Secretary's report stating that for the first time Astronomy has been included in the programme of the Association for Science Education.

There is H.M.I. Philip Smith's timely summary of the "New Curriculum", in which he offers all our readers a rare chance to influence the whole course of Secondary Science Education.

Then there is Martin Ratcliffe's (recently appointed Secretary of the J.A.S. - Congratulations!), account of his four week tour of local schools with an inflatable Planetarium from Armagh. No less than 2,000 pupils benefited from this demonstration. I both applaud his industry and agree with his judgement. The Planetarium offers an exciting change in lesson routine, a unique educational experience, and makes excellent propaganda for our cause. I, myself, hired it for one week last year, took it to eight local schools, and received a similar enthusiastic response, not only from the pupils, but from all concerned. I am hoping to be able to demonstrate this Planetarium, yet again, at our Teachers' Course at Alston Hall (November 23rd - 25th).

Finally, there is Colin Jack's informative article on the use of the computer in School Astronomy Clubs, admirably complemented both by Dr. Paul Marchant's comprehensive list of available software and Colin Jack's own programmes.

On pages 85, 86 and 87 you will find details of some of the many activities being organised by the National Maritime Museum to celebrate the Centenary of the Prime Meridian at Greenwich. These activities emphasise the vital role played by astronomy in the history of navigation and will serve to arouse further interest amongst pupils and teachers alike.

In addition to all this I am receiving a steady flow of articles and letters, to which the size of this issue bears witness. This not only indicates a growing involvement by members, it also makes life much easier for me near publication time!

The "O" level question on the Doppler effect triggered off an avalanche of comment, both written and verbal - many teachers deploring the use of Angstrom units in the calculation. This concern was echoed at a recent AAE Council meeting. As teachers in all other Science subjects are now strongly recommended to use only S.I. units it was felt, by many, that the Astronomy Examination Board should "fall into line", not only for the sake of consistency but also for the greater benefit of the students. Inexplicably they seem reluctant to do so.

An even more serious question was posed by some Physics teachers. Should problems on the Doppler effect be set at all at "O" level? Their reasoning is admirably set out in two letters which I have chosen for publication under the new heading "Letters to the Editor". I hope that these pages will now become a permanent feature of our Newsletter. My thanks are due to Mr. H. Tripp and Mr. T. K. Creamer for "starting this particular ball rolling" as well as for their valuable comments.

C. S. Goodman

* * *

ASSOCIATION NEWS - FROM THE SECRETARY

From the 3rd to 5th January, 1984, I once again mounted a small exhibition on the AAE at the Annual Meeting, in Exeter, of the Association for Science Education. This time, however, we were able to make more progress, since Doug Clish, one of our Exeter members, and myself were able to organise a talk-discussion on "Astronomy in the Middle and Secondary School". Doug tells me that he has been attending ASE Annual Meetings for several years now, and this is the first time, in his memory, that astronomy has been included in the programme.

More than forty people attended the session and it was followed by a lively discussion with some of the people who stayed behind after the meeting. Doug himself

mounted a very comprehensive exhibition on astronomy in schools. He has also written an excellent book "Exploring the Heavens with Pupils aged 9 to 13" which I will be reviewing in a future issue of AAE News. This book is available at £1.99 direct from Doug Clish (2 Woodland Road, Exeter, EX1 3PL) and there is also an activity pack at £2.50 to accompany the book.

In the last newsletter there was advance notice of a course to be held at Alston Hall, near Preston, on 23rd - 25th November, 1984. No doubt more details of this course will appear in future issues of AAE News. However, at the last Council meeting, Mr. David Harris, who now has the designation of Courses Officer, suggested that we should have a rolling programme of courses covering the country. This idea was warmly welcomed by Council and steps are already being taken to put this into effect. It was suggested that an annual course should alternate between the north and south of England, with an additional course, in some years, to cover Scotland. Details of these courses will appear in future issues of the AAE News.

The next Annual General Meeting will take place on the 11th and 12th April, 1984 at the Polytechnic of North London. The provisional programme on the 12th is as follows:- 9.45 to 10.15 Reception and Coffee

10.15 to 11.15 Education Programme - This will consist of several short contributions from people who run resource centres in different parts of the country.

11.15 to 2.00 Lunch, followed by visits to exhibitions.

2.00 to 3.00 Celebrity Lecture. It is hoped that someone from the Royal Greenwich Observatory will talk about the New Observatory at La Palma.

3.00 to 3.30 Tea

3.30 to 4.30 Annual General Meeting

On the evening of the 11th April there will be an informal discussion, and demonstrations, on the Use of Microprocessers in Astronomy Education.

Arrangements for this section, and for exhibition space, are being handled by Mr. Eric Zuckner, Physics Department, Polytechnic of North London, Holloway Road, London.

* * *

From the Treasurer

SUBSCRIPTIONS - 1984/85

Members are reminded that this is the last copy of AAE News to be covered by the 1983/84 subscription, and they are reminded to renew their subscription using the enclosed form.

The cost of producing AAE News has risen steeply during the past year, so much so that, combined with the cost of producing the Association's new brochure for prospective members, it is likely that there will be a small deficit on the year's accounts. Nevertheless, Council has decided to keep subscriptions at the same rate as for 1983/84, but I must warn members now that subscriptions will almost certainly have to rise in 1985/86 unless many more prospective members can be introduced to the Association. If every existing member were to introduce one person to the Association, then, if only 20% of such persons were to join the Association it is probable that any increase in subscription could be deferred until 1986 or beyond.

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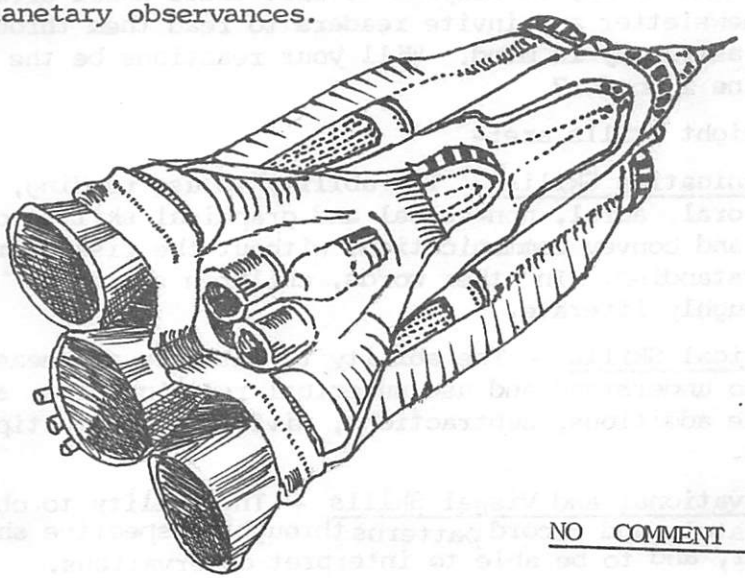
Space Shuttle "Intrepid" used from main space ship for short interplanetary observances.



NO COMMENT !

ASTRONOMY AND THE "NEW" CURRICULUM

On 5th December, 1983, a major report entitled "Curriculum 11 - 16: Towards a Statement of Entitlement" was published by the Department of Education and Science. The report lists eight basic skills which the authors believe every child has a right to be taught and challenges fundamentals of the traditional school timetable such as the number of periods to be allocated to subjects, the length of periods and even the whole concept of specific periods for particular subjects.

The report was drawn up following six years of intensive discussions involving H.M. Inspectorate, advisers and head teachers from five big local authorities. Judging from the press reports of comments from participants in the discussions and from early readers of the report, the implications are exciting indeed and may possibly result in a complete revision of the 11 - 16 curriculum.

There have been a number of articles published in AAE newsletters drawing attention to ways in which astronomy might be introduced into the curriculum via the traditional subject areas, but I was particularly excited to see this "new" curriculum because it seemed to me to place astronomy, not as just a possible topic in various subjects, but as an obvious one in many of the new skill areas. I believe that it may be helpful to list these skill areas in the newsletter and invite readers to read them through with astronomy in mind. Will your reactions be the same as mine I wonder?

The eight skills are:-

Communication Skills - The ability to use reading, writing, oral, aural, non-verbal and graphical skills to receive and convey communications without the risk of misunderstanding. In other words, children should be thoroughly literate.

Numerical Skills - The ability to estimate and measure and to understand and use numerical relationships, such as simple additions, subtractions, divisions and multiplications.

Observational and Visual Skills - The ability to observe accurately and record patterns through perspective shape, colour, and to be able to interpret observations.

Imaginative Skills - The ability to put oneself in other situations and experiences, discipline one's imagination and reshape those experiences.

Organisational and Study Skills - The ability to extract information, to arrange things in sequence, to classify, to weigh and interpret evidence and draw conclusions; the ability to make the best use of time.

Physical and Practical Skills - The ability to develop manual dexterity and body movements; the ability to select appropriate tools and equipment and use them effectively.

Social Skills - The ability to co-operate, negotiate and express ideas in a variety of contexts, as well as being able to consider other points of view.

Problem-solving and Creative Skills - The ability to diagnose the features of problems, design experiments to test hypotheses and evaluate their results; the ability to draw on relevant ideas and use materials inventively.

When starting to write this article, I had intended to relate each skill to some astronomy topic or project, etc. which I thought would be particularly appropriate. However, on second thoughts, I decided to take the easy way out for ME and get YOU to do the work. I therefore issue this challenge:-

Nearly every reader of this newsletter will have had experience of schools between the ages of 11 and 16, and is therefore qualified to comment from his or her own background. Even the under 11 readers will have some ideas of what secondary schooling should contain. Therefore let every one of you consider each skill area and write down, very briefly, one or two projects or themes in astronomy which could be matched to it.

Send the list in to me and I will collate them for advice to the AAE Council and for publication in a subsequent issue of the newsletter. Indeed, I suspect that, if you play your part, I will have so much material that an extra long issue will be required! Please do not be constrained by traditional subject demarcations or by the usual structure of the school day; be as innovative as you wish! (For those of you who wrote following Derek

McNally's request concerning science topics in the September 1983 newsletter, rest assured that I will contact him to ensure that my material is included with his and his with mine).

This could be your chance to have a real influence on the whole secondary school curriculum . . .

DO NOT DELAY - WRITE TODAY to

HMI Philip Smith
The Cottage, Baker Street, Appleton Wiske,
Northallerton, N. Yorkshire, DL6 2AQ

* * *

NEWS FROM THE SOCIETIES

The Newbury Amateur Astronomical Society is now nearly three years old, and from its beginnings had its foundations in education. It began when frequent requests to form a society came my way from a teacher running an adult 'O' level group, and also an extracurricular course for pupils at her secondary school. We all worked together to form the society, and quickly reached a stable membership of thirty - forty.

The main purpose of this article is to tell you of our efforts in November 1983. We had planned to hire a portable planetarium for a month from the Armagh Planetarium. We aimed to take it around the schools in our area, concentrating our efforts at Primary level. Each school was to be charged a small fee to cover our costs, and to test the temperature as it were, we contacted seven schools. All were very keen to have the planetarium for an afternoon, so we went ahead with the plan. We called a halt when we had twenty-one bookings.

Organisation was quite a problem - trying to find society members able to take an afternoon off work in order to operate the planetarium. Mr. Tom Smyth, our Education Officer, however, undertook this task with great efficiency, and managed to timetable all twenty-one schools into four weeks. He also organised transport.

Three members of the society wrote a half-hour programme and recorded this on cassette, (programmes are

provided, but none were available at the time). It consisted of two parts: The first part was concerned with constellation recognition. The second part was a tour of our solar system, and a recognition of its place in the galaxy.

By the end of November, approximately two thousand children had been in the planetarium, which was enthusiastically received by both them and their teachers. One or two schools arranged the visit to coincide with a parents' evening, enabling them also to see the programme.

The planetarium itself arrives in a large holdall, and is inflated by a large fan to about twenty feet in diameter. Two large packing cases (2ft x 2ft x 2ft approx) carry the projector and accessories, with the fan in a smaller case. After practice it can be made operational within fifteen minutes. For one month's hire, the cost is in the order of £200 plus cost of transportation.

Undertakings of this scale are ideally suited to local societies, who have resources that few individuals have. I would thoroughly recommend the project to any society. The hard work will be amply rewarded by the sight of young children with eyes wide, and the sound of "Cor!". The best description of our Universe I've heard.

We intend to repeat the venture in late 1985 in order to benefit a new generation of children.

Martin Ratcliffe

* * *

We do not ask for what useful purpose the birds do sing, for song is their pleasure since they were created for singing. Similarly, we ought not to ask why the human mind troubles to fathom the secrets of the heavens..... the diversity of the phenomena of Nature is so great, and the treasures hidden in the heavens so rich, precisely in order that the human mind shall never be lacking in fresh nourishment.

(Johannes Kepler
Mysterum Cosmographicum)

* * *

TEACHING ASTRONOMY TO ADULT CLASSES

by J. HEDLEY ROBINSON

The presentation of the science of Astronomy to a group of newcomers to the subject may easily encourage or discourage them, depending upon the breadth and depth of its content.

It would obviously be unwise to indulge in mathematics or say, the structure of the celestial sphere in the first lesson. Something to capture imagination and to awaken a general interest will offer a much greater appeal.

It is with this in mind that the following suggestions are made in the hope that they will prove helpful.

Experience over forty years of teaching for the Workers' Educational Association has taught me some effective and useful methods of approaching the problem of instilling some appreciation of the Universe in the minds of people of various ages, who have no previous ideas of the subject.

The first essential is to establish rapport with your students. Tell the class: "This is our class, not my class. You will not just sit and listen, and probably forget, talks on the subject. We shall together study and explore together topics that will be of interest to us all. So, please feel free to stop me talking at any time and ask questions as we go along. Be assured that I shall never laugh at you or your ideas if you express something foolish. I shall however be pleased to laugh with you. Also remember this: The question or statement that makes you feel foolish, or bothers you, is probably the one that your neighbour is longing to bring up, but feels too shy to mention. You can do it for him, and so cement a close relationship within the class." A selection of slides is helpful at this stage.

Next comes the problem of keeping all levels of students interested. One may have in the class someone already deeply involved in Astronomy, a university graduate, a bright sixth former, a housewife, a business man, and even a youngster still at school. To find out the average standard of the class it is helpful to ask for a

show of hands at the very beginning: Those who have never read a book on Astronomy; those who have studied the subject at a popular level; those who may be actively engaged in astronomical projects and perhaps own and use telescopes, etc.

Start your talk at an elementary level and as it progresses go deeper into the subject as far as you judge the class can follow you. How deeply you can go will depend on the average ability of the class as a whole. Try not to exclude those unable to go very far. Your aim should be to present a homogeneous picture of the Universe that can be assimilated and retained by students of all levels. For this purpose a simple and easily envisaged system of measurement of distances and dimensions must be evolved.

First introduce your students to the appreciation of a million. Say perhaps: a million inches equals 15.7 miles. For a middle aged audience miles are better than kilometres for they can envisage a mile, whereas a kilometre may be unfamiliar. Younger students may prefer kilometres. Let the class decide their preference, but, whatever unit you adopt, let it be retained throughout the course. Next, establish the idea of the Astronomical Unit - 93 million miles - and use this for your description of the solar system throughout, and illustrate it as the equivalent of 8 minutes 20 seconds light travel time at 186,000 miles per second: seven times round the earth per second. Using light travel time as a measure of distance, then proceed to a light year unit. Let the class do the multiplying as an exercise to establish in their minds the immensity of the distance of one light year, expressed in miles.

Now lead your class outwards from the sun to the earth, moon, planets and comets with full descriptions of each to the appropriate standard. Then, make the jump from the solar system to the stars, remembering that the average star is situated some million times further away than the sun, but still using light travel time as a measure of distance, i.e. the light year. This establishes a relationship between the Astronomical Unit and the light year. But remember to use the A.U. for the solar system; it is easier to visualise the radius of the orbit of Mars

as 1.5 A.U. than as so many millions of miles, for instance.

By comparing the 8 minutes 20 seconds light travel time of one AU with a whole year, the distance proportions are fixed in the minds of students.

Continue to use light years for the Milky Way and galactic distances, introducing the Doppler Shift when appropriate. Parsecs should not be used in this connection. Once having established a picture of the Universe, it becomes possible to deal with the celestial sphere together with Right Ascension and Declination, and later Galactic Latitude and Longitude.

Now, and not before this stage has been reached, arrange, if possible, a visit to an observatory to let students see for themselves the objects they have been discussing. It will be found that a talk of about half an hour's duration is enough. After this period concentration tends to falter. This is the time to recapitulate by showing slides and/or models and allowing free and easy conversation to develop. This gives members a chance to discuss their difficulties in a relaxed atmosphere.

If students can be persuaded to take notes as the course proceeds, let them use ordinary school exercise books, and guide them (especially at the beginning of the course) in heading up pages for each subject: Sun, Moon, each major planet, stars, etc. If you suggest they write down the salient points and dimensions and distances of the various objects under consideration at each session, they will provide themselves with a valuable reference system which they can use to answer the many questions that may arise.

In any case, this system will provide a permanent record which they can consult in private after the course is finished. It also encourages a team spirit in class.

If opportunity has not already arisen, it is advisable finally, to introduce students to a local astronomical society for the encouragement of a continuing hobby and the making of friends who are similarly interested.

Over many years, this method has been found to work well, and it is recommended herein as a helpful suggestion.

* * *

Twinkle, twinkle little star,
I don't wonder what you are.
I surmised your spot in space
When you left your missile base.
Any wond'ring that I do
Centres on the price of you,
And I shudder when I think
What you're costing us per twink.

(Source not traced - Apologies to the author)

* * *

INTRODUCING ASTRONOMY TO SCHOOLS III

USING A COMPUTER IN THE SCHOOL ASTRONOMY CLUB

One of the problems in running as Astronomy Club at school is the inherent limitation of blackboard or paper in demonstrating astronomical phenomena. Many of the most important and interesting topics deal with movement. Typical examples are the planetary orbits, lunar phases, the diurnal and annual cycles of the celestial sphere.

These are difficult to explain without the use of complicated and expensive models, some of which may even hinder rather than help understanding. Another problem is showing, in a daytime club, how astronomical objects look as seen through binoculars or telescope.

I have gone some way towards solving these difficulties in recent months by using a microcomputer (Sinclair Spectrum), which most schools now possess as standard equipment. There are a few relevant programs available - Dr. Marchant at Leeds Polytechnic has been investigating astronomical software for the AAE - and some of these are especially useful. For example: 'The Night Sky' by Bridge Software is an excellent star atlas which shows the night sky for any time and date.

It is also not particularly difficult, with a little computing experience, to write your own astro-software, tailored to your own needs. To give several examples: I can demonstrate the orbiting planets, to scale (relatively!) in space and time. This allows me to explain oppositions, conjunctions, synodic periods, etc. Any

number of planets may be input, with a chosen 'time jump' for the orbital motion.

Another two programs (advertised in this newsletter) simulate the appearance of astronomical objects in any telescope or photographic system. The minimum instrument data are input, together with the type and angular size of the object being viewed or photographed. This is particularly useful for any pupils who own or are intending to buy a telescope.

A more complex program shows the reference points on the celestial sphere, and demonstrates the rising and setting of astronomical objects from any latitude. A 'moon' program shows the phases, orbits and eclipses of the system. Smaller programs include the Galilean satellites (allowing an Earth - or 'God's'-eye view), meteor showers and, a very popular one, a program which plots an input number of random stars to magnitude 5, allowing pupils to imitate the imaginary adventures of the early astronomers and find their own constellations.

I have mentioned my own programs, and members could undoubtedly think of more applications. The introduction of the computer has revolutionised the Club, to the extent that I have had to play down my advertising, as I have more than enough enthusiasts already!

Apart from anything else, it allows pupils to see a genuine application of a computer, other than the endless games for which it is so often used.

Colin Jack
(February 1984)

COMPUTER PROGRAMS FOR ASTRONOMY EDUCATION

1 - ASTRO is an Orrery program, demonstrating the motion of the planets around the Sun. It runs on an RML 380Z (disc or cassette based with 32K memory). It was written in RML BASIC V5 by A. King, a teacher at Bengamin Gott School in Leeds, and is available from me at Leeds Polytechnic by sending a suitable cassette or disc onto which to copy the program.

2 - CONSTELLATION plots a section of the sky for different

dates for different azimuths and elevations. The stars of a constellation are coded by unique letters. It runs on a BBC model B (cassette based) and is written in BBC BASIC. It is available from Program Power, 8/8A Regent Street, Leeds, LS7 4PE and costs about £6.50.

3 - CONSTELLATION plots the night sky for various dates with a 'zoom' facility available. It runs on a ZX81 with 16K RAM and is available on cassette from Bug-Byte, 98-100 The Albany, Old Hall Street, Liverpool, L3 9EP. Cost unknown.

4 - ORBIT 1 and 2 concerns planetary motion and analyses real and generated orbit data to demonstrate the laws of planetary motion. It will run on any of: Apple, RML 380Z with high resolution graphics, PET or disc based BBC machines. It is available, as part of the Computers in the Curriculum Project. from Longman Micro Software, Longman Group Resources Unit, 33-35 Tanner Row, York, YO1 1JP, telephone 0904-20801. The cost is around £13.50, which includes documentation.

5 - Four programs written in BASIC for a BBC model B machine by Dr. I. W. Rogers, The School of Applied Physics, The Polytechnic of North London, Holloway, N7 8DB; telephone 01-607 6289.

a) STARCLAC - This is a calculation program which determines the altitude and azimuth of any star (defined in terms of the RA and Dec) at any time in the period 1975-1999.

b) STARPLOT - A modification of STARCLAC in which the stars are plotted on a skymap along with 46 stars, the data for which is held in the program. The star of interest flashes.

c) PSPHERE - Shows the movement of the 46 stars over a full day from 12 noon to 12 noon at one hour intervals.

d) STARTRACK - a modification of PSPHERE which plots at ten minute intervals and simulates a time exposure photograph.

In the latter three programs the projection used is one with the zenith at the centre, and with the position as the cosine of the altitude. This leads to some distortion but even so the constellations are recognisable. In terms of the azimuth, this goes anticlockwise from the top i.e. NESWN.

6 - NIGHT SKY PATTERNS - Plots the stars for a given time looking North for latitude 10°N - 90°N, labels major stars and includes a table of RA and dec. It runs in BASIC on a 32K BBC Model B using OS1.0 and later (unless *FX21.0 is removed). It comes on cassette and costs £5 from Mr. P.L. Wearn, 15 Mountfield Avenue, Sandiacre.

7 - Seven separate programs are available at no cost by sending a cassette to Colin Jack, 38 Grange Drive, Penketh, Warrington, Cheshire. They cover (1) The Solar System; (2) Moon; (3) Proper Motion; (4) Galilean Satellites; (5) Random Constellations; (6) Meteors; (7) Celestial Sphere; they run on a 16K Spectrum.

8 - Two programs are available on cassette from Bridge Software, 36 Fernwood, Marple Bridge, Stockport, SK6 5BE.

a) NIGHT SKY creates high resolution starcharts using a 16K Spectrum (cost £8.90) or BBC Model B (cost £9.90).

b) EPHEMERIS computes observational data for the Sun, Moon and planets for any date time and point of observation between 66°N and 66°S and runs on a 16K ZX81 (cost £6.90) or a Spectrum (cost £7.90).

9 - Bretmain Ltd. of 99B Hamilton Road, Felixstowe, Suffolk, IP11 7BL market the following astronomical software. More details are given in the firm's catalogue.

a) PLANET FINDER generates the ephemeris of the major planets (to the end of the century) and calculates the altitude and azimuth for a given latitude, longitude and time. It runs on a 16K ZX81 and costs £10.

b) MOON FINDER generates the parallax corrected ephemeris in the Northern hemisphere to the end of the century. The Moon's position and appearance may be calculated for any date and time along with the altitude and azimuth. It runs on a 16K ZX81 and costs £15.

c) TC SOLAR is a comprehensive Time and Co-ordinate manipulation program costing £40 which runs on a Commodore PET. For further details see the Bretmain catalogue.

10 - SKY shows N or S sky at any time/date for the UK. It runs on a 16K ZX81 and costs £3.50 from MUSE (Microcomputer Users in Secondary Education), c/o 5 Ways School, Scotland Lane, Bartley Green, Birmingham, B32 4BT.

11 - SKY-BABY includes:-

a) Colour and brightness coded display of stars, planets, sun and moon.

b) View from any position on earth, any date and time specified by the user.

c) A library of all stars down to magnitude 4.0 including co-ordinates, magnitudes and names.

d) Orbital parameters of planets: sun and moon positional formulae.

e) Star sizes plotted to indicate brightness; sun and moon and planets colour coded.

f) Moveable 'space probe' to identify name and details of any object displayed on the screen.

g) Details of current position, rising and setting times of any selected objects.

h) 35 page User Guide.

Runs on a BBC model B and available on cassette (cost £12.50 inclusive) from Stellar Enterprise, 84 Dudsbury Road, Ferndown, Wimborne, Dorset, BH22 8RG. Tel: (0202) 575234.

*

Last year it was suggested that I compile a catalogue of computer programs for astronomy education for the Association. Unfortunately the response to my article in the Newsletter was disappointing but I have managed to compile the foregoing catalogue. Now the field seems to be opening up, however, with more commercially available software appearing. I understand too that a microcomputer section of the BAA has been set-up.

Books are now beginning to be produced on the subject - see for example Astromedia adverts in Astronomy magazine. Recently Sunshine books have published a very useful and comprehensive book of programs for the Sinclair Spectrum called ZX Spectrum Astronomy by Maurice Gavin (229 pp) at £6.95.

Paul Marchant

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ASSOCIATION FOR ASTRONOMY EDUCATION present . .

CLASSROOM ASTRONOMY

A COURSE FOR TEACHERS AT ALL LEVELS

23rd - 25th November, 1984

A WEEKEND WORKSHOP in conjunction with the Department of Education and Science

at Alston Hall Residential College of Further Education, Longridge, Nr. Preston, Lancs.

This course is open to teachers in Primary and Secondary Schools and Colleges, to provide an introduction to Astronomical topics as an up to date vehicle for classroom science, in addition to a study of the subject.

There will be a series of lectures and workshop sessions where course members may study topics at their desired level. In structuring the course this way we are able to provide a low cost course designed to give personal satisfaction at any academic standard required.

Topics to be covered include: The Sun; Methods of Observation; Instruments and Biology and Space.

It is hoped that opportunity will also be given for practical observations and a visit to the Observatory on site (by kind permission of the Director of the Observatories, Preston Polytechnic).

Speakers will include:-

Mr. P. J. C. Smith, HMI
Mr. J. Ravest, Liverpool Planetarium
Prof. V. Barocas
Mr. C. Goodman, Teacher, Hinckley
Mr. P. Drew, Director Amateur Astronomy Centre
Dr. P. A. H. Seymour, Plymouth Polytechnic

The cost of the course (inclusive of board and tuition) will be approximately £35.00.

Accommodation in single and double rooms, also cubicled dormitories. A bar is available.

Please complete the enclosed form.

* * *

THE ROYAL OBSERVATORY, EDINBURGH

The Origin of the Observatory

Plans for an Observatory on Calton Hill were formulated in 1736. However, it was not until 1776 that sufficient funds were raised to build an Observatory to the design of J. Craig, the architect of Edinburgh's New Town. The Observatory was completed in 1792 but it soon became a ruin. In 1812 the Astronomical Institution founded a new Observatory to the design of W. H. Playfair. During the visit of King George IV in August 1822, His Majesty agreed to the Observatory being called 'The Royal Observatory of King George IV'. The government became responsible for the Observatory in 1834 and the first Astronomer Royal for Scotland was appointed. A proposal in 1876 to re-site the Observatory resulted in the present Observatory which was designed and specified by W. W. Robertson of H.M. Office of Works. Building started on Blackford Hill in 1894.

Scotland's Royal Observatory stands on Blackford Hill on the southern fringe of Edinburgh, less than three miles from the city centre and with an unsurpassed view of the magnificent Capital. Within its four acre walled boundary well over 100 people are actively engaged in the pursuit of astronomy at various levels and from various directions. There are first of all the professional astronomers and a large technical staff who are responsible for maintaining the UK Schmidt Telescope in Australia; the UK Infrared Telescope in Hawaii and the UK Millimetre Wave Telescope being installed at the present time, also in Hawaii.

The Observatory contains the UKST photographic plate library, a priceless store of many thousands of original photographs which are available on loan to research workers worldwide, and has also its own photographic laboratories where these and other photographs are copied and printed. There is the Data Processing Unit, the members of which maintain the famous COSMOS automatic plate measuring machine which is capable of tackling stars and galaxies by the million!

Within the Observatory precincts is also the

Department of Astronomy of the University of Edinburgh, consisting of teaching staff, undergraduate and post-graduate students and research fellows. The Observatory, an establishment of the Science and Engineering Research Council, and the University are traditionally linked, with the Astronomer Royal for Scotland combining the responsibilities of Director of the Royal Observatory Edinburgh and Regius Professor of Astronomy at the University.

The Observatory also houses a Visitor Centre which plays an important and popular educational function locally, organising visits from school parties as well as sending lecturers to schools.

Though the Observatory's research material is mostly acquired with the large instruments overseas or from satellites, there are still telescopes in active use in Edinburgh. The largest, a 36-inch Cassegrain, installed in 1928, is now mostly used for testing equipment. Two others, a 20-inch reflector and a 10-inch astrograph are dedicated to undergraduate instruction. Students at Edinburgh University have their own flourishing amateur Astronomical Society and observe regularly from Blackford Hill.

Contemplative scientists, lively students, enthusiastic amateurs, excited visiting children, all are to be encountered at Edinburgh's Royal Observatory. Whether you are involved in Astronomy or in Education or are just in the role of a passing tourist, the ROE is well worth a visit.

Mary T. Brück

* * *

Twinkle, twinkle little star,
I don't wonder what you are,
For by spectroscopic ken
I know that you are hydrogen.

Anon. Quoted in D. Bush, Science and English poetry, 1950. O.U.P.

Twinkle, twinkle quasi-star,
Now I wonder what you are.
Pulsating light! 'pon my soul,
Could it be a big black hole?

Anon.

BOOK REVIEWS

'HOW WE FOUND OUT ABOUT' Series: No.1 Outer Space; No.8 Black Holes; No.15 Comets. I. ASIMOV. 50 pp. Text with line drawings. LONGMAN 1982. £2.95 each - hardback.

These books are a selection (astronomical) from a series by this well known author, describing the history of scientific discovery in a variety of areas. Written for the younger readers?

The format is unfortunately a somewhat 'old fashioned' one and therefore looks a little uninteresting at first glance. However, the contents belie this. The books are exceptionally well structured containing a logical and systematic description of the processes involved in the advance of scientific knowledge. They will be very useful in Primary schools for the more highly motivated children around 9-11 years old, and in Secondary schools for the average child, 11-13 years old.

'Outer Space' describes man's efforts to conquer the air, from the first rocket to the modern shuttle, including spaceships, the Apollo lunar landings and Skylab on the way.

'Black Holes' is the most challenging of the trio and well worth the effort (for young readers) of following the author's simple unravelling of this cosmic detective story.

'Comets' - With the return of Halley's comet eagerly awaited, this book is invaluable as a concise and comprehensive discourse on the nature and history of comets, with a little tit-bit about meteors thrown in.

The author has managed successfully to make these books both fascinating and challenging, and they therefore warrant a place on both Primary and Secondary school bookshelves. Teachers will find them an inexhaustible source for references, at a nominal price.

Judith Turpin

'ADVENTURES WITH ASTRONOMY'. PERCY SEYMOUR. 69 pp incl. appendices. JOHN MURRAY 1983; hard or soft cover. ISBN 0-7195-3945-5 Hard: £5.95; 0-7195-3931-5 P/back: £3.50.

This is a book which should be welcomed by all teachers right across the board. It is chock full of

practical classroom projects and abounds with illustrations. The format is bold and easy to read and the author has chosen projects which lend themselves (in the main) to experiment by both Primary and Secondary pupils.

Whilst these projects are devised for construction in the classroom, most of them use some form of instrumentation which is readily available elsewhere. Here are two examples of classic type projects:

(i) A simple sun-dial. This constitutes useful knowledge for all ages and demands a variety of skills both in its construction and application.

(ii) Construction of a nocturnal dial - a thingummy for telling the time by the motion of stars. Once again useful for all ages, notwithstanding parental constraint when put in use in the dark hours. However, it's all good stuff, well tried and ideal for the classroom.

For the real enthusiastic, one is shown step by step (and measurement by measurement) how to make a cheap home-made astronomical telescope which is capable of allowing observation of the rings around Saturn. You don't need to know a thing to begin with! It's all made so easy!

There are, of course, mistakes in this book, several in fact, but it would be nit-picking to make an example of such minor errors, especially in a practical book where they become self evident once you embark on the chosen project. In a text book it might be a different matter. However, I did find calling the last quarter of the Moon the third quarter rather irritating. I felt like asking "Where's the second quarter?"

I can recommend this book on three counts: Firstly, it's ideal for the Primary school teacher who wants his class to "make and investigate" an astronomical topic. Secondly for the first and second year general science pupils in secondary schools it is also ideal. Finally, it would make an excellent book by providing suitable material for candidates submitting practical work at 'O' level.

My congratulations to the Author, a good, practical cheap book with no glossy pictures of cosmological phenomena. A really 'down to earth' book for teachers!

P.R.J.

GREENWICH MERIDIAN CENTENARY

In 1984 it will be 100 years since the world's adoption of the Greenwich Meridian - the line of longitude passing through Greenwich - as the Prime Meridian dividing East from West. Subsequently it became the basis of the world's Time Zones via Greenwich Mean Time.

A full programme is in preparation and plans include a set of four special stamps to be issued by the Post Office: (a) Prime Meridian encircling the globe; (b) Greenwich Observatory; (c) Navigational map; (d) antique telescope. Meridian Day will be on Tuesday, 26th June, when it is hoped there will be bonfires and fireworks, music and dancing, fairs and fetes and "fun" activities along the line of 0 degrees longitude through England. Greenwich events that day will be planned mainly for the children.

The actual centenary date will be Saturday, 13th October, 1984, which the Museum will mark with a reception for distinguished, specially invited guests.

At the National Maritime Museum and in Greenwich Park on Meridian Day the following events will take place:-

Crossing the Line Ceremonies, organised by sailors in the way they do in ships at sea.

Posting a giant letter with the four Special Meridian Stamps issued by the Post Office.

An All London Schools' Tournament to be organised by the ILEA.

Young astronomers cycling along the Longitude Zero will be welcomed at the Old Royal Observatory.

continued...

Helium filled balloons will be flown off East or West of the Meridian Line.

Demonstrations of the Airy Transit Circle will take place.

Patrick Moore will be a star guest.

Children are invited to wear their National Costume.

The G.L.C. is providing entertainment in the Cutty Sark Gardens - near the Clipper Ship.

We invite you to bring your children along on 26th June to join in or watch the fun, and a programme of events will be issued in the near future.

+

To celebrate the CENTENARY OF THE PRIME MERIDIAN this year - 1984 - the Education Section of the National Maritime Museum is offering the following programmes and facilities to schools.

PROGRAMMES:-

1 - A slide lecture in the Lecture Theatre of the National Maritime Museum on the History of the Old Royal Observatory and the establishment of the Prime Meridian and the use of longitude by mariners and astronomers. This talk is suitable for all ages and can be followed up by visits to the Museum's Navigation Gallery and to the Old Royal Observatory.

2 - A special Planetarium demonstration is available titled, "Why the Greenwich Meridian?" The demonstration will explain the movement of the Earth in relation to other celestial bodies, how time is determined and how astronomers use the Prime Meridian. (Suitable for all ages).

3 - Children can study chronometers, used for the finding of longitude, and other related exhibits in the Navigation Gallery. They will be told of the importance of chronometers in relation to the Prime Meridian and can record their visit through sketching in the Galleries and more detailed art work in the Education Section's Art Studio. Studio sessions can be of half-day or whole day duration. (Suitable for junior and middle school ages).

4 - FILMS: Two films can be shown in the Lecture Theatre of the National Maritime Museum for schools studying the Prime Meridian.

a) "The Discovery of Longitude - A History of the Marine Chronometer" (Black and white - 25 minutes)
A comprehensive documentary covering the history behind the establishment of longitude starting with Queen Anne's Act of 1714; the Board of Longitude; Harrison's achievements and Kendall's compact chronometer which Capt. Cook took on his second voyage. The film ends with the decision to make Greenwich the Prime Meridian in 1884. (Suitable for eleven years old and over)

b) "Understanding Longitude" (Colour - 11 minutes)
A straightforward and simple explanation of longitude - the need for it, its historical evolution and how it works geographically and mathematically.
(Suitable for young children).

5 - Worksheets and Information Sheets
Worksheets and information sheets are available from the School's Liaison Office at a minimal charge. The sheets deal directly with the Old Royal Observatory, Chronometers, Longitude and Time. There is no copyright, so teachers can use them as they wish. Buy one set and copy them at school.

6 - Teachers' Seminar
A Teachers' Seminar is planned at the Museum to take place in early May. This will include a tour of the relevant areas of the Museum, talks by Curators and Education Staff on longitude, the Old Royal Observatory, the Prime Meridian and there will also be a Planetarium demonstration. A date has not yet been decided but interested teachers can contact the School's Liaison Officer for further information - (01 858 4422, ext. 208).

7 - An Exhibition
The Education Section is mounting an exhibition in the Half-Deck of the East Wing to illustrate the History of the Old Royal Observatory, the Establishment of the Prime Meridian at Greenwich and uses of the Prime Meridian, Latitude and Longitude to Mariners and

Astronomers. The Exhibition will be opened to coincide with the Teachers' Seminar in early May.

8 - For further information on Education activities, please contact the School's Liaison Officer at the address below:

Sheila Acers
School's Liaison Officer
National Maritime Museum
Greenwich
London, SE10 9NF
(01 858 4422 ext. 208)

* * *

What is a meridian? It is a circle that passes over the Earth's north and south poles, and over the place to which it refers. Thus, the Greenwich meridian is a north-south line passing over Greenwich. The points on the surface of the earth immediately below the meridian form a line of longitude.

Why Greenwich? At the time of the conference 65% of the world's ships (72% by tonnage) were using charts based on Greenwich. Also, the U.S.A. had just adopted a time-zone system based on Greenwich Time adjusted by a whole number of hours.

Why Greenwich "Mean" Time? A day is the interval between successive crossings of the meridian by the Sun. Unfortunately, this interval varies slightly throughout the year. Rather than adjust the speed of a clock to keep in step with this, mean time is used, which goes at a uniform rate and has the average, or mean, length of day as 24 hours.

What is it used for? Navigators measure how far east or west they are by the longitude; an angular measure of the distance from a chosen meridian. The Royal Observatory was founded in 1675 to provide a means of finding longitude at sea. The tables they published enabled navigators to calculate their longitude east or west of Greenwich. (Other observatories published similar tables based on different meridians, e.g. Paris).

What has it got to do with time? Local time has midday when the Sun crosses the meridian. This will be the same for all points on the same meridian, but will be different

for places on different meridians. Thus Truro local time is about 20 minutes behind Greenwich time, and Sydney time is 10 hours 5 minutes ahead. Time is measured by reference to the stars (even the most sophisticated clocks can only measure time intervals; they have to be put right by reference to an astronomical standard), and the time measured at and distributed from the Royal Observatory was, of course, based on the Greenwich meridian.

Why choose just one meridian? Clearly, it is convenient to have all clocks in one country telling the same time. It would not be practical to have clocks all over the world telling the same time (it would be inconvenient to use Greenwich Time in Australia for example as the date would change in mid-morning), but again it would be better for zone times to differ from one another by a whole number of hours rather than have French time 9 minutes 21 seconds ahead of U.K. time, as it once was. Also it would be sensible to have all longitudes measured from the same meridian.

What was done about it? The problem became pressing in the mid-1800s when every country, and many individual towns, kept their own time, and over a dozen different lines of zero longitude were in use on charts. An international conference was held in Washington in 1884 to sort things out. They unanimously agreed "to adopt a single prime meridian for all nations" and on 13th October 1884, agreed by a majority of 22 to 1 (San Domingto), with two abstentions (France and Brazil) "the adoption of the meridian passing through the centre of the transit instrument at the Observatory at Greenwich as the initial meridian for longitude".

Why through the transit instrument? The transit instrument referred to in the resolution is the Airy Transit circle, a specialised telescope for the accurate measurement of star positions and of time. It was designed by the Astronomer Royal, Sir George Bidell Airy, and installed in 1850. It was in regular use for 100 years and is still in working order. Naturally, the time determined with this instrument refers to the meridian that passes through its centre.

* * *

METEORITES AND MIX-UPS

Meteorites, those "free" pieces of outer space, provide a definite link between astronomy and another science somewhat neglected in schools - geology. Well-preserved specimens of the three main classes of meteorite: stones, stony-irons and irons are fairly distinctive in many cases and not too easily confused with terrestrial materials. But very many meteorites need expert examination to tell them as such.

Very likely, many AAE members have had lumps of substance x brought to them with the question, "Is this a meteorite?" There are several books on the subject that may be of use to teachers wanting a basic introduction to the science of meteoritics: some are listed below. Ultimately, the arbiter on any postulated new U.K. meteorite find is the Mineralogy Department of the British Museum (Natural History) - Cromwell Road, London, SW7 5BD. The Museum has an interesting display of meteorites in a special gallery.

Watch out for the rare attempted hoax, though. A few years ago I was handed a piece of rusty metal by an amateur astronomer who said he'd found it several kilometres from his home. It turned out to be grey cast iron. Not to be outdone, the same chap turned up with a piece of iron meteorite that he said he had found in the same location. This turned out to be rather like an iron meteorite that fell in Texas many thousands of years ago. He tried to bolster his allegedly new British meteorite find with a lump of metal that seemed superficially to have nickel-iron crystal boundaries typical of some iron meteorites. On close examination by experts this pattern was shown to have been made on what was probably grey cast iron, by an engraving tool. So, beware, it's not just UFOs that we have hoaxes about.

Brief Bibliography

"Comets, Meteorites and Men", P. Lancaster Brown, Robert Hale, London, 1973.

"Meteorites", F. Heide (translated by E. Anders and E.R. DuFresne), University of Chicago Press, Chicago, 1964.

"Catalogue of Meteorites" (third edition), M.H. Hey, Trustees of the British Museum (Natural History), London, 1966.

"Appendix to the Catalogue of Meteorites", R. Hutchison, A.W.R. Bevan and J.M. Hall, British Museum (Natural History), London, 1977.

"Meteorites and Their Origins", G.J.H. McCall, David & Charles, Newton Abbot, 1973.

"Meteorites" (third edition), A.A. Moss, Trustees of the British Museum (Natural History), London, 1975.

"The Nature and Origin of Meteorites", D. W. Sears, Adam Hilger, Bristol, 1978.

"Meteorites", J.T. Wasson, Springer-Verlag, Berlin, 1974 (in English).

"Meteorites and the Origin of Planets", J. A. Wood, McGraw-Hill, New York, 1968.

The Natural History Museum's catalogues are essential reference books for brief details on many hundreds of known meteorites. The Museum's booklet by Moss is a fine introduction to the subject, presented briefly.

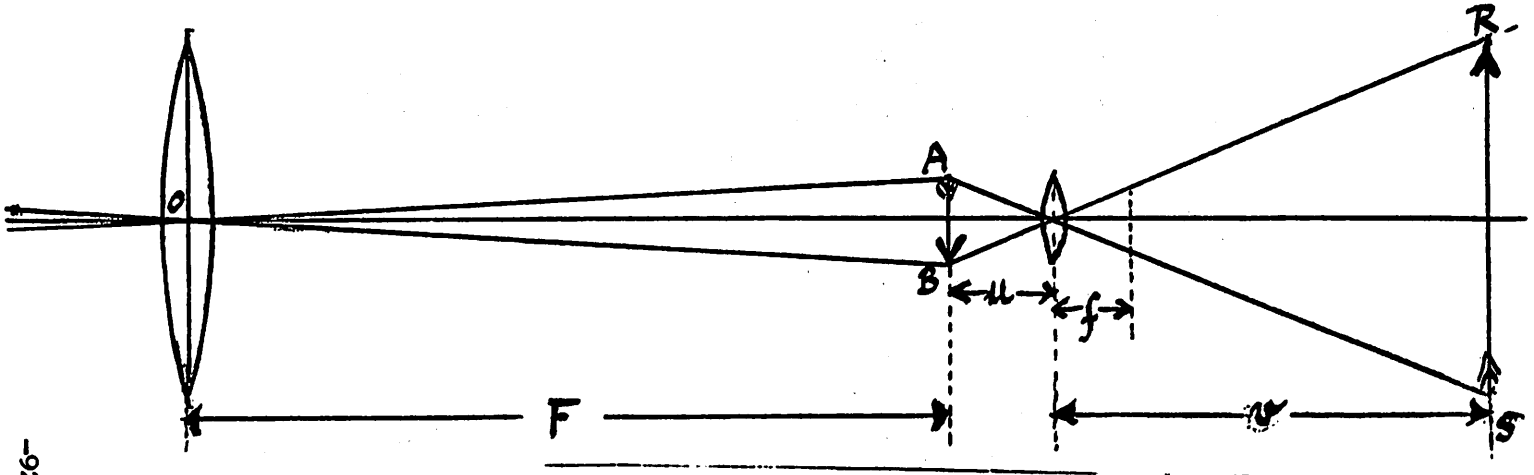
In meteorite literature there are many terms used from geology and mineralogy, so it can be useful to have hold of a geological dictionary such as that published by Penguin Books.

Geraint Day
7 Poulton Street, Swindon, Wiltshire, SN2 1BH

EYEPIECE PROJECTION AND PHOTOGRAPHY

One of the more impressive and instructive uses of a small telescope in schools is to produce a well defined large image of the sun on a white screen by the eyepiece projection method. The screen should be so placed to form an image of the sun which will just fit into a standard solar disc of the recommended size, 150mm diameter.

This exercise in projection can be usefully correlated with the physics syllabus dealing with the basic relations between F the focal length of the objective lens, f the focal length of the eyepiece, v the distance of the screen from the eyepiece, and u the distance between the primary image formed by the objective lens and the eyepiece. In some standard and authoritative books



on astronomy the simple relations connecting these quantities are often avoided or are wrongly used, and if quoted in an examination would score less than 3/10.

In the figure above the size of the primary image of the sun at AB is directly proportional to F. The angle AOB = 32' which is approximately the angle that the sun's diameter subtends at the observer on earth. AB = Fxarc 32'. Using a scientific calsulator arc 32' = 0.00931. Let the focal length of the objective lens be 1000mm, the diameter of the image at AB is 9.31mm. Let f be 20mm. The image of diameter 9.31mm has to be enlarged to 150mm diameter.

By similar triangles $150 / 9.31 = v/u$ ..... (1)
v, u and f are connected by the basic relation $1/v + 1/u = 1/f$ using relation (1) $1/v + 150/9.31\,v = 1/20$ giving v = 342.23mm. Substituting this value in (1) we have u = 21.24mm.

Thus u must be greater than f to produce a real image on the screen.

The image of the sun by projection is quite safe to carry out, and it can be photographed by a camera, suitably mounted so that it is pointing to the image as nearly as possible perpendicularly to the plane of the screen.

The diagram also illustrates the principle of using a telescope eyepiece as a short focus camera lens, for photographing such objects as the moon, as in the following example.

A camera such as a 35mm S.L.R. (minus the camera lens) is mounted in position so that the eyepiece is at a distance v from RS which is now the focal plane of the camera. The eyepiece forms an image of AB on the camera film at RS. The distance v and the size of the image on the film can be varied by the use of extension tubes.

The requirement now is, for example, to select v so that the image of the moon at the film will just fill the 35x25mm film.

The primary image AB, diameter 9.31mm, must be enlarged to 25mm diameter. The magnification is 25/9.31 = v/u = (v/f - 1). i.e. v/20 -1 = 25/9.31 giving v = 73.7mm and u = 27.45mm.

The value for u shows that the eyepiece must be racked out a distance of 7.45mm from its "Normal" position i.e. from 20mm from AB to 27.45mm.

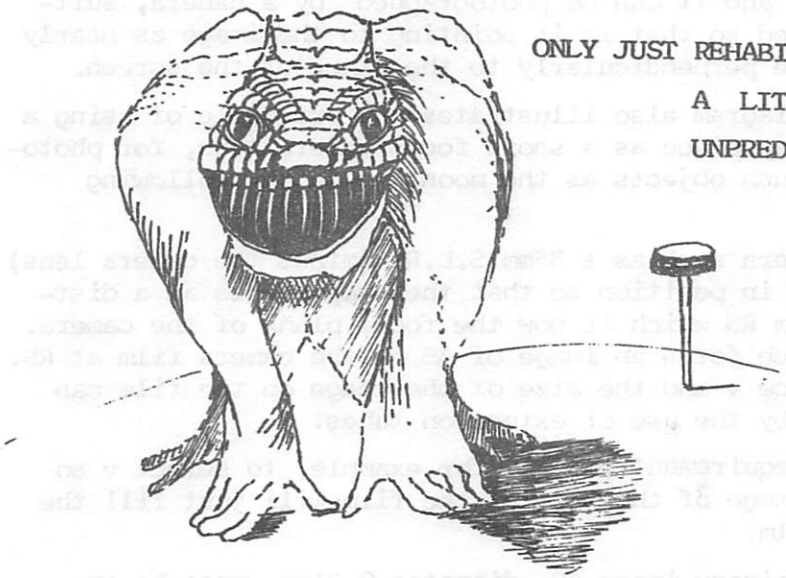
It is interesting to note that from the magnification relation v/u = (v/f -1) when:

v = 2f there is no magnification (It is <u>one</u>)
v = 3f the magnification is 2
v = 4f the magnification is 3 and
when v = nf the magnification is (n-1).

In the example the magnification is 25/9.31 or (v/20 -1) and v = (25/9.31 +1) 20 giving v = 3.685 x 20 = 73.7mm as a check.

<u>NOTE</u>: Great care must be exercised when forming images of the sun. Looking directly at it through any telescope should never be allowed. The moon in any of its phases will provide useful experience in eyepiece photography for keen photographers. This note is mainly concerned with the optical principles and not with the important general subject of photographic techniques.

83 Firs Road, Winterslow, Salisbury. H. R. MILLS



* * *

How vast those orbs must be, and how inconsiderable this earth, the theatre upon which all our mighty designs, all our navigations, and all our wars are transacted, is when compared to them. A very fit consideration, and matter of reflection, for those Kings and Princes who sacrifice the lives of so many people, only to flatter their ambition in being masters of some pitiful corner of this small spot.

(Christian Huygens,
New Conjectures Concerning the Planetary Worlds c. 1690)

* * *

To what purpose should I trouble myself in searching out the secrets of the stars, having death or slavery continually before my eyes?

(A question put to Pythagoras by Anaximenes)

* * *

LETTERS TO THE EDITOR

Dear Sir,

The Examination Type Question (page 52, Vol.3, No.2) poses some important questions on the teaching of Astronomy. At the risk of being thought pedantic, I would point out the formula used for calculating the Doppler effect is the approximate form. I accept that provided V is much smaller than C then the approximate formula is applicable, but here is the rub.

As scientists we owe it to our History/Geography colleagues, as well as the pupils, to explain that although the analagous effect in acoustics has a similar equation, it does not hold for electro-magnetic waves. The principles involved are very different and are given by the special theory of relativity. This is expressed by the formula:-

$$\lambda = \frac{\lambda o\ (1 + Vr/C)}{\sqrt{1 - V2/C2}}$$

where λo is the wavelength and Vr the velocity as determined by the observer.

I feel sure most of us would agree this topic is too advanced for 'O' level work. Yet many numerical problems are set on it. We are left with the choice of over simplification and the real risk of misunderstanding - especially at a later stage, or of giving a straightforward idea a complicated explanation that would probably not be understood. Either way does not recommend itself to the writer.

Provided the conditions stated earlier are satisfied, the approximate equation can be used with confidence to measure say, the speed of cars by radar. Most of the problems are set on astronomical motion where if such assumptions are made they are not necessarily valid.

I would suggest there are many physics 'A' level students that have got confused ideas on this and I question whether "a little study of spectra in general and the manner in which the Doppler effect works" (Acoustic or Relativistic?) is enough.

T. K. C.
23 Hemington Avenue, Friern Barnet, London, N11 3LR

* * *

The worked example on the Doppler Effect (Vol.3, No. 2, page 52) reminded me of some of the difficulties which pupils face when applying, to astronomical problems, the equation:-

$\frac{\delta\lambda}{\lambda} = \frac{v}{c}$ for a change (shift) in wavelength $\delta\lambda$ of a spectral line of wavelength λ when the source has a recessional velocity (usually) of v and c is the speed of light.

(i) It is worth pointing out that $\frac{v}{c}$ is a constant for a given source, then $\delta\lambda \propto \lambda$.

i.e. the size of the shift depends upon the wavelength of the line which is shifted. I have found many pupils think that all lines in the spectrum of the moving source are shifted by the same amount.

(ii) Since $\delta\lambda$ is measured and λ and c are known, the equation is used to calculate v. This should be referred to as the line-of-sight velocity and not merely the velocity. Somewhere else in the syllabus we teach that velocity is a vector quantity, so direction should be specified. (By the way, I wonder why we refer usually to the velocity of light rather that to the speed of light?)

(iii) $\frac{\delta\lambda}{\lambda}$ is usually represented by the symbol z and called the value of the red-shift of the source. Since v is always <u>less</u> than c, the equation suggests that z is always <u>less</u> than unity. Sooner or later a pupil will read of values of z which are <u>greater</u> than unity, and ask "How can this be? Do sources recede faster than the speed of light?" The quasar with $z = 3.53$ was discovered in 1973. (Is there a red-shift limit? This remains an unanswered question, I think). In fact, the recessional velocity (v) is given by the relation:-

$$v = \frac{cz}{\sqrt{1 + z^2}} \quad \text{or} \quad \frac{v}{c} = \frac{z}{\sqrt{1 + z^2}}$$

Having calculated z from $z = \frac{\delta\lambda}{\lambda}$ we can go on to calculate v.

For $z = 3.53$ we have $\frac{v}{c} = \frac{3.53}{\sqrt{1 + 3.53^2}} = 0.96$

We have a source receding at 96% the speed of light (if the red-shift is due entirely to the Doppler Effect). Conversely, as an exercise, we can calculate what the red-shift should be for a source receding at 50% (say) the speed of light, etc.

If z is very small, then $\sqrt{1 + z^2}$ is very nearly unity and we use the equation given in the introduction.

(iv) What we choose to infer from these high values of z and the part played by non-Doppler Effects is another story. (See "Scientific American" Feb. 1982 on Quasars).

H. TRIPP
Read School, Drax, Selby, North Yorkshire, YO8 8NL

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OPEN UNIVERSITY TELEVISION PROGRAMMES ABOUT ASTRONOMY, 1984

	07.20 BBC2 Tuesday	08.30 BBC2 Sunday
Steel Stars and Spectra	Apr 17th	Apr 22nd
	06.25 BBC2 Saturday	**07.20 BBC2 Monday**
Shooting the Moon	-	Aug 13th
	06.20 BBC1 Saturday	**07.45 BBC2 Tuesday**
Special Relativity	Jul 28th	Jul 31st
Absurd Stars - The Physics of White Dwarfs	Sep 22nd	Sep 25th
	06.50 BBC2 Sunday	**06.55 BBC2 Friday**
The Crab Nebula	Jul 15th	Jul 20th
The Surface of Mars	Jul 29th	Aug 2nd

	07.15 BBC2 Sunday	07.20 BBC2 Friday
A Conflict Brought to Light	Apr 8th	Apr 13th
Marking Time	Apr 29th	May 4th
$E = mc^2$	May 13th	May 18th
An Isolated Fact	Jun 24th	Jun 29th
A Matter of Geometry	Jul 8th	Jul 13th
At the Frontier	Jul 22nd	Jul 27th
Measuring Shadows: (The Universe Today)	Aug 5th	Aug 10th
A Note of Uncertainty: (The Universe Tomorrow)	Aug 19th	Aug 24th
Vanished Brilliance (The Universe Yesterday)	Sep 2nd	Sep 7th
Shades of Black	Sep 16th	Sep 21st

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