# Teaching of Astronomy in Asian-Pacific Region

*Bulletin No. 13*

Contents




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# Preface

There is one year gap between Bulletin No.12 and No.13 In this period we had the 23rd IAU General Assembly in Kyoto, Japan in August. We also had a traditional local teachers' meeting with members of IAU Commission 46 at the Kyoto Computer school on August 28. There are three invited speakers from the commission members and three from the local teachers. Poster papers were also displayed. Nearly 200 audiences enjoyed the talks and the exhibition. At a small reception party after the meeting, there were many direct talks each other. In this Bulletin, I will take three invited papers by Dr. Percy ,Dr. Pickwick and Mr. Adachi, and the others will be published in the next bulletin.

I am sorry for a long waiting of this bulletin to authors who present their paper at the first fourth of 1997. I hope to have enough number of papers to make regular publication ( once a half year ) possible.

Syuzo Isobe
Chairman of Teaching of Astronomy in
Asian-Pacific Region
National Astronomical Observatory
Mitaka, Tokyo, Japan

# Teaching Astronomy: A Brief Review

John R. Percy

*Erindale Campus, University of Toronto*
*Mississauga, Ontario, Canada L5L 1C6*
*e-mail: jpercy@erin.utoronto.ca*

## 1. Introduction

This paper is based on a presentation which I gave at the Joint International Forum on Teaching Astronomy, held in Kyoto, Japan, on August 28, 1997, as part of the 23rd General Assembly (GA) of the International Astronomical Union (IAU). It was attended by about 150 science teachers from Japan, and several interested astronomers from around the world. As President of IAU Commission 46 (Teaching of Astronomy), I am deeply indebted to the organizers - Drs. Syuzo Isobe and Takao Mizuno - and their colleagues, for arranging this important and successful workshop. Such teachers' workshops are a traditional part of IAU GA's, and they are one way in which the IAU can leave its "imprint" on education around the world. For a comprehensive overview of astronomy education, particularly in North America, see Percy (1996). The introductory paper in that book contains a more complete account of international astronomy education issues. There are also two comprehensive conference proceedings mentioned in Section 6.

## 2. Why Teach Astronomy in the Schools?

As Fraknoi (1996) has eloquently pointed out, astronomy education takes place in many settings outside the classroom, but these settings are voluntary for both students and the public. Teachers are the primary means by which children learn astronomy and, if the students are well taught, they will retain their enthusiasm and knowledge for a lifetime. In the oral and poster papers at this workshop, Japanese astronomers and teachers demonstrated their educational creativity and dedication.

There are many reasons why astronomy is important to our education system, and our culture - even though it has no apparent economic benefit.

- Astronomy has influenced our history and culture, through its practical applications, and its philosophical and religious implications. This is reflected in calendars, mythology, and a variety of art forms. Astronomy figures prominently in Japanese history and culture, as Emperor Akihito of Japan pointed out at the opening of the IAU GA.

- Astronomy still has practical applications to navigation; timekeeping; calendars; daily, seasonal, and long-term changes in climate; and other external influences on our terrestrial environment.

- Astronomy has advanced mathematics, science, and technology, and is a dynamic science in its own right. Japan is a major participant in modern astronomy, through its ground-based optical and radio telescopes, space astronomy satellites, and through its contributions to theoretical astrophysics.

- Astronomy deals with our place in time and space, and with our cosmic roots: the origin of our star, our planet, the elements in our bodies, and life itself. Is our planet the only one in the universe which sustains life? As Henri Poincaré said, "astronomy is useful ... because it shows how small our bodies, how large our minds".

- Astronomy reveals a universe which is vast, varied, and beautiful. The beauty of the night sky, the spectacle of a comet or eclipse, a color image of a nebula or galaxy - all of these have aesthetic appeal. Our appreciation of the night sky should move us to fight "light pollution" which deprives so many people of this beauty, and wastes billions of dollars around the world.

- Astronomy harnesses curiosity, imagination, and a sense of shared exploration and discovery. [These feelings are also expressed through science fiction which - in its better forms - provides a wonderful partner to science fact].

- In the classroom, astronomy provides an important alternative to the experimental mode in the scientific method - namely, the observational mode - and provides many examples of the use of simulation and modelling as a process in science.

- Astronomy can be used to illustrate many concepts of physics: gravitation and relativity, light and spectra. Methods of determining distance by parallax, apparent brightness, and apparent size are essential to astronomy, but rarely taught in physics courses.

- In schools which are suitably equipped, astronomy provides excellent examples of the use of modern information technology in education: accessing information, data, and images, from archives or even in real time from satellites or ground-based telescopes. The European Association of Astronomy Educators' *Astronomy On-Line* project is an excellent example.

- Astronomy is the ultimate interdisciplinary subject, and "integrative approach" and "cross-curricular connections" are increasingly important concepts in modern curriculum development.

- Astronomy attracts young people to science and technology, and research shows that students learn more effectively if they are interested in the material being taught.

- Astronomy can increase public awareness, understanding, and appreciation of science and technology, for all the reasons which are mentioned above. This is important in all countries - particularly the developing ones.

- Unlike most sciences, astronomy can be enjoyed as a hobby. Amateur astronomers can continue to enjoy and to do science beyond school, and make important contributions to astronomical education and research. This is especially true in Japan, where amateur astronomers are noted for their discoveries of comets, novae and supernovae, observations of variable stars, as well as for their support for school and public education.

## 3. Teaching Astronomy in Schools: Problems and Solutions

Having read the above, one might wonder: why is astronomy not a compulsory subject in every country? At best, it might be a "unit" in another science course. At worst, there may be no astronomy in the curriculum at all.

Several problems and issues have been identified in many countries around the world, in studies of astronomy learning and teaching:

- Teachers, especially at the elementary level, have little or no background in astronomy or astronomy teaching. Astronomers and astronomy educators must therefore arrange for pre-service or in-service workshops - like this one - for teachers. French astronomers and teachers have been the leaders in working together to develop workshops and other resources.

- Students have misconceptions about astronomical topics, such as the cause of seasons, and moon phases. Many of these misconceptions are based on even more fundamental misconceptions about gravity, and light. These misconceptions must be identified, and overcome, as part of the teaching process.

- Astronomical concepts must be matched to the students' levels of intellectual development. For instance, the explanation for three-dimensional concepts such as moon phases can rarely be appreciated by students younger than about 10.

- *Inquiry-based* (or activity-based, or hands-on) teaching and learning is more effective than the classical lecture-textbook approach. This applies to all levels from elementary school to university!

- Practical work is a problem; "the stars come out at night; the students don't". It is possible (though difficult) to arrange for evening star-gazing sessions; local amateur astronomers may be able to help. A planetarium is sometimes available as a simulation of the night sky, and Japan is well endowed with planetariums, but the planetarium sky isn't the real thing. Daytime observing of the sun and moon is possible. For night sky viewing, students can construct their own star charts or planispheres from templates, as were distributed at this workshop by the Nishiharima Astronomical Observatory; they can learn how to use these in class, and then put them to use in the evening.

- Teachers believe that telescopes, computers, and the Internet are essential to teach astronomy. They are certainly useful if available, but the unaided eye or binoculars are perfectly acceptable. Simple refracting telescope kits are available, from which students can learn how a telescope works by investigating and assembling one.

- Astronomy is often considered irrelevant by education authorities, because it has no apparent economic value (despite the reasons given above).

- In many countries - Japan included - there are very few women in astronomy and other physical sciences. This indicates that there are reasons why women are not attracted to or retained in science in these countries - probably beginning at the school level. We can double the "pool" of potential scientists, and science teachers, by ensuring that both girls and boys feel welcome in science, at every level.

- In many parts of the world, students' interest in science is less than it was a generation ago. There are many reasons for this. In countries such as China and Russia, business and economics offer much higher salaries. In some countries, science is perceived as being unduly difficult, or irrelevant; science is simply not part of the "culture". Astronomy appears to be a significant part of a wider "science culture" in Japan, as evidenced by the large number of planetariums and public observatories. Perhaps astronomy can rekindle students' interest in science.

## 4. Informal Education

Astronomy education takes place, not only in classrooms, but in a variety of other places: on radio and TV; in newspapers, magazines, and books; in planetariums, science centres, and public observatories; in astronomy clubs and youth groups; in camps and parks; and on the Internet. These sources of "informal education" have a strong influence on students, as well as on the general public. Astronomers and teachers must work together with the staff of these facilities. I am glad that the organization which is sponsoring this workshop - The Society for Teaching and Popularization of Astronomy - includes both formal and informal education in its mandate, membership and activities.

## 5. International Perspective

The school science curriculum is normally a national, provincial, or local responsibility. Still, it is important for teachers to have an international perspective - at least occasionally. Astronomy is an international science, involving international collaboration. Astronomy has deep cultural roots, and it is interesting to see how astronomy has been absorbed and interpreted in different cultures.

We can learn from astronomy educators elsewhere. In almost every country, astronomy educators have developed unique and/or innovative facilities, projects, programs, or approaches. At workshops such as this one, I have the pleasure of meeting teachers from other countries, and learning about their accomplishments.

In the developing countries, astronomy educators face many problems which those of us in the industrialized world do not. That makes their achievements even more impressive. We should find ways to assist them: by supporting programs to provide them with books, journals, equipment, and data; by communicating with and visiting them; by learning more about their situation and needs; and by supporting the work of the IAU, and other organizations which promote astronomical development. The Ministry of Culture of Japan has generously provided planetariums, telescopes, and computers to several developing countries around the world, and this will have a significant effect on their astronomical education and research.

## 6. The Educational Programs of the IAU

Since this workshop is being held on the occasion of the 23rd IAU GA, it is appropriate to end with an overview of the educational programs and projects of the world organization of astronomers.

The IAU was founded in 1922 to "promote and safeguard astronomy ..... and to develop it through international co-operation". There are currently about 60 adhering countries, and almost 10,000 individual members in 77 countries. The IAU is funded through the adhering countries, and is administratively "lean": almost all of the funds are used for the development of astronomy.

One of the 40 IAU *commissions* or interest groups is Commission 46: The Teaching of Astronomy. This is the only commission which deals exclusively with astronomy education (though there is a Commission 38 (Exchange of Astronomers) which allocates travel grants to astronomers who need them, and a Working Group on the Worldwide Development of Astronomy). The Commission's mandate is "to further the development and improvement of astronomy education at all levels, throughout the world." In general, the Commission works with other scientific and educational organizations to promote astronomy education and development; through the National Representatives to the Commission, it promotes astronomy education in the countries which adhere to the IAU; and it encourages all programs and projects which can help to fulfil its mandate. Dr. Syuzo Isobe has been an effective National Representative for Japan for many years, and is now the Vice-President of Commission 46.

The Commission holds business sessions at each IAU GA. Within the format of the IAU GA's, the Commission organizes or co-sponsors major sessions on education-related topics. At the 23rd GA, these included an important discussion on the educational and research needs of the developing countries. The Commission has also organized two major international conferences on astronomy education - in the US in 1988 (Pasachoff & Percy 1990), and in the UK (McNally et al 1997); another conference is being planned. I hope that many of you will attend this conference, which is scheduled to be held near Sydney, Australia, in July 1999. For many years, the Commission has sponsored one-day workshops, like this one, for local schoolteachers, as part of every IAU GA, and as part of several IAU regional meetings. In 1995, a very successful workshop was held as part of an IAU scientific conference in South Africa.

For over 20 years, the Commission has sponsored the International Schools for Young Astronomers (ISYA) - intensive three-week schools attracting 20 to 50 young astronomers. These are held approximately once a year, in different parts of the developing world. In July 1997, a very successful ISYA was held in Iran. A handful of carefully-chosen faculty members give mini-courses on topics chosen by the host institution, in consulation with the ISYA secretaries. The ISYA students also give informal talks on their research interests, and on astronomy at their home institution, and in their country. Informality and interactive discussion is strongly encouraged.

The Commission also sponsors Teaching for Astronomical Development (TAD), a flexible program designed to develop astronomy in a few selected countries. It replaces the Visiting Lecturers Program, a less flexible program which did, however, succeed in developing new generations of astronomers in Paraguay and Peru. The TAD program is presently active in Central America and Vietnam, and may be active in Morocco and Sri Lanka in the near future. The Commission also maintains a Travelling Telescope (and instruments) for use in countries without telescopic facilities, a program to provide surplus books and journals to countries which need them, and a committee to advise countries on how to use solar eclipses, safely and successfully, to cultivate interest in astronomy.

You can find out more about IAU Commission 46 through our free electronic newsletter - contact Armando Arellano Ferro at armando@astroscu.unam.mx - or by visiting the WWW site at http://physics.open.ac.uk/IAU46/. I especially recommend the triennial reports on astronomy education in the various countries around the world. They testify to the creativity and dedication of astronomy educators worldwide.

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# Teaching of Astronomy in Elementary and High Schools in the UK

by Alan C Pickwick (Alan_C_Pickwick@compuserve.com)

All the children I have ever talked to have an interest in "Astronomy and Space". I propose that our job as science teachers is to develop that interest into an understanding of the underlying science. However, we must be careful not to remove the "delight and wonder" of the subject in the process! Using the UK as an example, I will explore how "Astronomy and Space" has entered the lives of both children and their teachers and how it has been used to encourage children to maintain an interest in science studies. Some children will continue their interest even as far as university where they will follow Physics and Astrophysics courses.

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## Compulsory Education - 5 to 16 years old

In England and Wales, science is taught to all pupils of ages 5 to 16 years. Schools follow the National Curriculum which defines in some detail what topics must be taught. I intend to outline the strengths and weaknesses of this policy in respect of astronomy education in particular and physics education as a whole.

## History

In the 1970s and 1980s politicians were increasingly conscious of the importance of a more educated society. The days of the old smoke-stack industries were drawing to a close and the new technically-based industries were taking over.

When the Thatcher government came to power in 1979 there a great deal of tension between the government and the labour organisations (unions). Over the next few years the teachers' unions had several confrontations over 'pay and conditions' with the government. In addition, the newspapers highlighted a number of primary (elementary) schools that were not following satisfactory curricula. The scene was set for change.

The government took control and introduced legislation for a National Curriculum for England and Wales. Since 1989, state schools have been required to follow this curriculum. There are new national tests for 7, 11 and 14 year olds. The traditional examinations for 16 year olds have been revised to fit in with the system.

The original 1989 curriculum was to have covered only English, Mathematics and Science but was extended to cover all subjects. That version contained rather too much material and did not allow the schools enough freedom. In 1993 the government started to revise the content of some areas and to reduce the content of others to a more manageable level. These changes are now working their way through the schools.

The National Curriculum presented science as one integrated subject and was given the teaching time of two normal subjects. By merging physics, chemistry and biology it ensured that all pupils had to study a balanced science course. It also made it easier to address a continuing problem, that of the shortage of physics teachers. It became possible, but perhaps not desirable, for non-physicists to teach the material since the complexity was not too great and the content was well defined.

## The Importance of Being Prepared

When the science section of the National Curriculum was being designed, many groups wrote to the government to express their views on the content. Over 2000 submissions were received and considered but the major influence was from the small team of school inspectors and curriculum developers who were already working to make astronomy more prominent in teaching. The astronomy community was lucky that these members of the team felt strongly that Astronomy and Space must be part of a child's education. I am told that the syllabus for this topic was written one Thursday afternoon in the small English town of Hexham by just one person!

Up to that time, Primary (Elementary) School children might have worked on class projects about the Seasons and perhaps Space Travel. However, there was no mention of the subject in the examination syllabuses for 16 year olds. These syllabuses covered the traditional physics topics of heat, light, sound, mechanics, electricity and magnetism. They also had more modern sections on the electron, radioactivity and electronics.

The effect of introducing the new teaching topic of Earth and Space has been that every child must now study the material. The problem that should have been obvious but was not considered initially was that every primary (elementary) school teacher would have to be trained to teach the material!!

Here is a summary of the astronomy related sections of the National Curriculum. At the end of each Key Stage pupils must take a compulsory national test. As you will see, some of the later material is quite difficult and only the brighter pupils would study it in any depth.

## National Curriculum - Astronomy Related Sections

## Key Stage One - 5 to 7 years old

- Light comes from a variety of sources, including the Sun
- Darkness is the absence of light

## Key Stage Two - 7 to 11 years old

- Objects have weight because of the gravitational attraction between them and the Earth
- Light travels from a source and we see light sources because light from them enters our eyes
- Light cannot travel through some materials, and that leads to the formation of shadows
- The Sun, Moon and Earth are approximately spherical

- The position of the Sun appears to change during the day and how this changes shadows
- The Earth spins on its own axis, and how day and night are related to this spin
- The Earth orbits the Sun once a year and the Moon takes about 28 days to orbit the Earth

## Key Stage Three - 11 to 14 years old

- In a uniform medium, light travels in straight lines at a finite speed
- Light travelling in straight lines as the explanation of shadows
- Non-luminous objects are seen because light scattered from them enters the eye
- White light can be dispersed to give a range of colours
- Apparent daily and annual movement of the Sun and stars is caused by the Earth's movement
- The relative position of the Earth, Sun and planets in the Solar System
- Gravitational forces determine the movements of the planets around the Sun
- The Sun and other stars are light sources whereas the planets are seen by reflected light
- Artificial satellites can be used to observe the Earth and to explore the Solar System
- The Sun is the ultimate source of most of the Earth's energy resources

## Key Stage Four - 14 to 16 years old

- How the atmosphere and oceans evolved to their present form
- Plate tectonic processes are involved in the evolution of the Earth's surface
- Longitudinal and transverse Earthquake waves probe the Earth's layered structure
- Use of radio-activity to date rocks
- The electromagnetic spectrum from radio to gamma-rays
- Uses of radio waves, microwaves, infra-red and visible light in communications
- The relative positions of the Earth, Sun, Moon, planets and others bodies in the Universe
- Gravitational forces determine the movements of planets, moons, comets and satellites
- How stars evolve over a long time-scale
- Some ideas used to explain the evolution of the Universe into its present state

*Abstracted from Science in the National Curriculum ISBN 0-11-270884-6*

## Problems and Solutions

The biggest problem was that most primary (elementary) school teachers had little or no training in science. When they saw the National Curriculum for Science they felt deeply threatened. I have only discussed the astronomy related topics here but there was a whole range of new science and technology topics to be taught. Many teachers pressed for all the primary (elementary) science materials to be removed from the curriculum.

At the same time the people responsible for placing the Earth and Space topics in the curriculum set about writing teaching materials and running workshops to help the worried teachers. The Royal Astronomical Society and The Association for Astronomy Education (AAE) ran workshops. The AAE and The Association for Science Education jointly published a simple but comprehensive guide to the Earth and Space topic.

Slowly but surely, the teachers came to see that the new material was of great interest to their pupils. It was up-to-date and often in the news. It motivated the children and could be developed in many ways. Not only could the underlying science be taught using the Earth and Space but it could be extended to creative subjects such as Art and Drama. As they became more familiar with the topic, the teachers realised that it could be used at many levels of sophistication. There were entertaining videos as well as demanding study projects.

Now, if you ask primary school teachers if they want to drop the Earth and Space topic from the syllabus the answer is 'No'. Quite a change over just a few years!!

Acceptance of the curriculum in the Secondary (High) Schools was rather less traumatic as the material was more familiar to the existing science teachers. However there was a strong demand for training workshops in the first few years.

## Advanced Level Education - 16 to 18 years old

Pupils who continue with their education beyond the age of 16 years usually study three main subjects. The most common science combinations are Mathematics, Physics and Chemistry (MPC) or Biology, Chemistry and Physics (BPC). The pupils studying MPC usually go on to read mathematics, science or engineering at university. Those studying BPC go on to study bio-sciences or medicine. There is no restriction as to the number or combination of subjects studied, but university entrance requirements are the major determining factor.

Now that over 80% of all pupils study all three sciences to the age of 16 years, has this helped to improve the take-up of science at Advanced Level and subsequently at university?

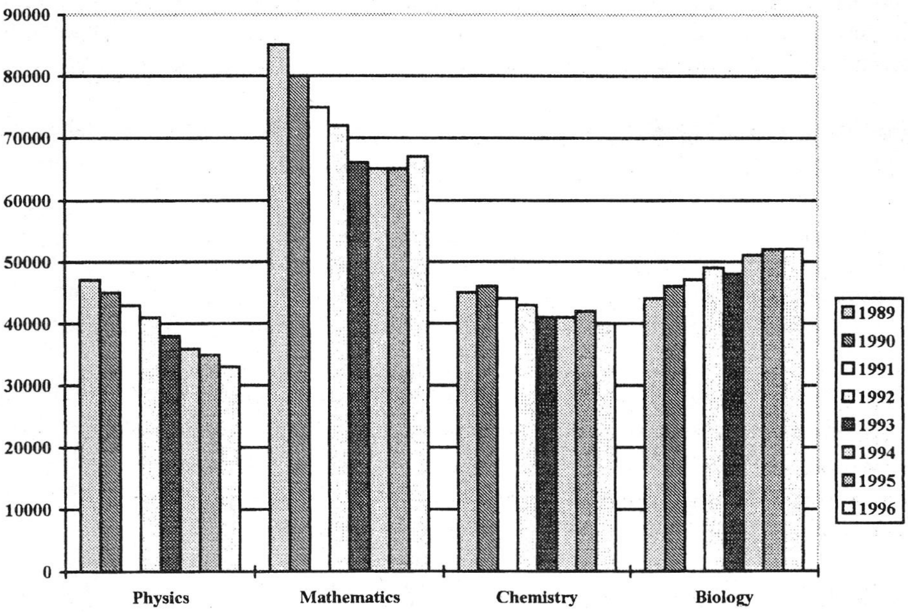
For Advanced Level, the answer is shown in the chart. There has been a slight fall in the population of 16 year olds over the period shown so the fall in the Chemistry entries could be said to marginal. However the fall in the Physics and Mathematics entries cannot be explained away so easily. The Biologists must be very happy with the increased response to their subject.

There have been many theories advanced for the fall in the numbers taking Mathematics and Physics at Advanced Level but none have been proved conclusively. The most likely is that the universities have widened the range of subjects on offer and so the traditional restrictions on choice have been lifted. Perhaps the hard core of physics students remains the same but those traditionally pressed into the subject have looked for easier options.

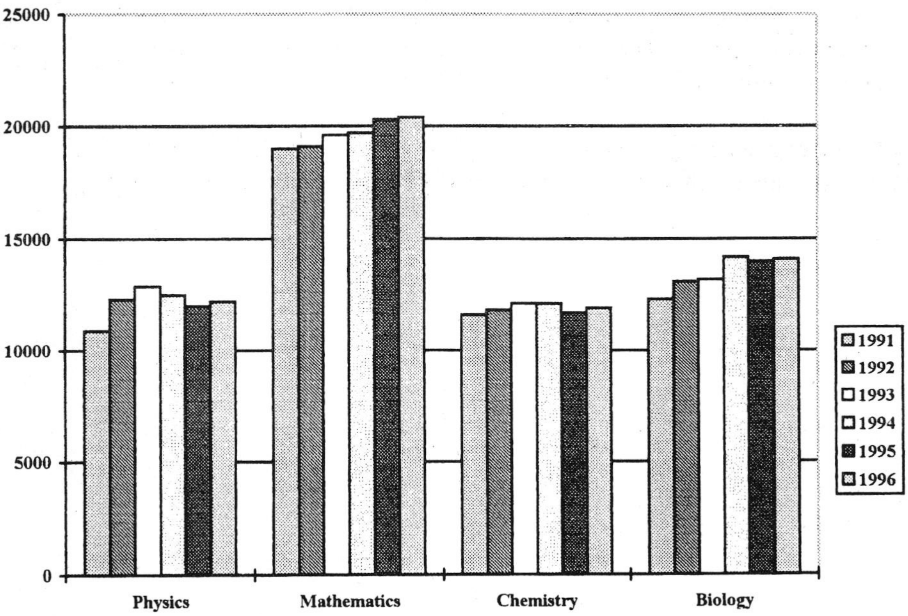
The system in Scotland is slight different. They do not follow the National Curriculum but have a more broadly based curriculum with less specialisation and with little or no astronomy related material. Perhaps only Biology and Mathematics can claim worthwhile increases in numbers with the other subjects remaining fairly static. It is a matter of some debate as to what causes the difference between the English and Scottish results. Is it the broader curriculum with its absence of Astronomy or is it the Malt Whiskey - for the teachers of course!!!! I don't think anybody really knows. The English system is likely to offer broader choices to 16 year olds in 1999 but the effect will be difficult to gauge for some years.

The number entering university physics courses is more or less constant at about 2000 per year but the average examination grade on entry has fallen a little in recent years.

## Advanced Level Examination Entries (Age 18) - England and Wales




## Higher Level Examination Entries (Age 18) - Scotland



## Astrophysics in Advanced Level Physics Examinations

There are a number of examination boards that have the authority to set Advanced Level examinations. For some years now, the three most popular ones have had an Astrophysics section in their syllabuses. It is one of a number of options topics which also include Particle Physics, Medical Physics and Physics of Materials.

On the bright side, demand for the Astrophysics option is strong and is growing. It is usually second to the most popular option - Particle Physics. This is good news for the cosmologists studying the Big Bang!! Here is a typical syllabus.

## Advanced Level Astronomy and Optics Option

### Lenses

- Principle focus, focal length, lens formula

### Optical fibres

- Qualitative treatment of fibre optics

### Detectors

- The eye
- Simple variable focus single lens camera
- Photographic emulsion
- Charge coupled device

### Optical Telescopes

- Astronomical telescope consisting of two converging lenses
- Reflecting telescopes

### Applications of diffraction and interference

- Resolving power

## Radiation

- Black body radiation
- The optical window
- The radio window
- The full electromagnetic spectrum
- Radio astronomy
- Single dish radio telescopes, general principles and resolving power
- The Milky Way

## Classification of stars

- Classification by luminosity, apparent and absolute magnitude
- Classification by temperature, use of Wien's law
- Principles of the use of stellar spectral classes
- The Hertzsprung Russell diagram
- Black holes

## Distances to the stars

- Trigonometrical parallax
- Spectroscopic parallax
- Cepheid variables

## Doppler effect

- Red shift
- Binary stars

## Radar astronomy

- Distance of planets
- Doppler shift

## Quasars

- Estimation of distance - problems with dust
- Use in cosmology

There are now a number of good text books and I provide copyright-free notes and worksheets to help improve teacher confidence and increase the amount of pupil participation in the course.

## Astronomy Education in England and Wales

## Strengths

## Primary (Elementary) Schools

- ♦ Earth in Space is flourishing
  - ◊ Applicable at many levels
  - ◊ There is enthusiasm from the pupils
  - ◊ The subject teaches itself
  - ◊ The AAE's book, Earth and Beyond, has reached over half of all Primary (Elementary) Schools
- ♦ Practical work in Science is the best by international measures

## Secondary (High) Schools

- ♦ Over 80% of pupils take Balanced Science - Biology, Chemistry and Physics
- ♦ There is a general acceptance of the Astronomy topics
- ♦ Boosting Teacher Confidence
  - ◊ In-service training for teachers in Astronomy topics by RAS and AAE
  - ◊ Distance learning for teachers from the Open University and the University of Central Lancashire
- ♦ Books, videos and worksheets
  - ◊ Good provision now
  - ◊ Long diffusion time for resources
- ♦ Young teachers are arriving in the profession who have been taught the material at school or university

## Advanced Level Studies

- ♦ The demand has been strong for Physics courses with an Astrophysics content
- ♦ Many university Physics Departments are renaming themselves Departments of Physics and Astronomy to attract more and better qualified undergraduates

## Weaknesses

- Falling numbers choosing Physics at 16 years
    - Wider choice now available
    - Increasingly perceptive pupils and parents
    - Physics is harder by a few percentage points in examination results
    - Biology, Chemistry and Mathematics now allowed for Medicine
- Flat numbers in university courses
    - About 2000 Physics undergraduates per year - fairly constant
    - Fall in grades achieved by entrants
    - Wider spread of ability and motivation
    - However it no harder to do a PhD in Astrophysics than in any other science
- Curriculum Development has been frozen out
    - Loss of variety: Rural Studies, Car Maintenance, Home Economics
- Curriculum Change - Always possible for Astronomy to lose out
    - Disappearance of Electronics from Science is a warning
    - Careful presentation of arguments for retention
    - Not a fate suffered by Earth and Space

**If you want to promote the Teaching of Astronomy**

**BE NICE TO:**

- Science Teachers' Organisation
  - Help Teachers
  - Publishing
  - Lobbying
- Planetarium Administrators
  - Encourage Pupils
  - Help Teachers
- Scientific Societies
  - Support in Curriculum Development
- Curriculum Developers
- Inspectors of Schools
- Teacher Trainers
- Librarians

- New Teachers
- Old Teachers

- Organisers of Education Days at the IAU

- Individual Efforts

The author holds a Master's degree in radio-astronomy from Jodrell Bank and teaches physics to 13 to 18 year olds at Manchester Grammar School which is a selective independent day school with 1440 boys on roll. Almost all the pupils go on to university with just under a quarter securing places at Oxford or Cambridge. This year the author is President of the Association for Astronomy Education and is also Chair of the Education Committee of the Royal Astronomical Society.

## Appendix of Typical Questions

### Question for 11 year olds

A class of children investigated the Sun's movement. They used a stick to make a shadow. They found that when the sun was higher in the sky, the shadow was shorter.

On May 1st last year they measured the length of the shadow at midday. It was 60 cm long.

Use one of the following to complete each sentence: longer, shorter, the same.

a) Early in the day the shadow was ...........

b) Later, at 3 o'clock in the afternoon, the shadow was .............

c) At midday, four weeks later, the shadow was .............

### Question for 14 year olds

Arrange the following objects in order of size from smallest to largest: Earth, Galaxy, Moon, Solar System, Sun.

Complete the following sentences using words from this list:

Universe, Sun, satellite, planets, Moon, gravity, and galaxy.

a) The Solar System contains a number of ............. which orbit the .............

b) Our Sun is one of many millions of stars the from the swirling group called a .............

c) These swirling groups of stars are held together by .............

d) There are millions of swirling groups of stars, which all together form the .............

### Question for 16 year olds

As the Sun grows old it will first become a Red Giant and then eventually a White Dwarf.

a) What major forces are considered to be in equilibrium inside the Sun at present?

b) Explain what will happen to the Sun as it becomes a Red Giant.

c) How does this differ from the White Dwarf stage that follows?

d) Name the process by which energy is produced inside the Sun and give a brief account of this process.

The Sun loses approximately 4 million tonnes of mass each second. Using the equation $E=mc^2$, calculate the amount of energy, in joules, that is released by the Sun each second. (Speed of light = $3x10^8$ m/s. 1 tonne = 1000 kg)

e) Explain what is meant by the term 'Red Shift' and discuss the possible implications its discovery has for the nature of the Universe.

## Question for 18 year olds

a) Explain what is meant by the apparent and the absolute magnitude of a star.

b) In the Hertzsprung-Russell diagram, stars are grouped according to their spectral class. State what you understand by the term spectral class and give the prime reason for the range of spectral classes that occur.

c) Outline the method of spectroscopic parallax for determining the distance of a main sequence star from the Earth.

d) Explain why this method can lead to a considerable error in the calculated distance of the star.

e) The distances to some stars are measured by trigonometric parallax whereas the distances to other stars are measured by spectroscopic parallax. What determines which of these methods is more appropriate for a particular star?

f) The star Polaris is a Cepheid Variable. Outline a method for determining the distance to Polaris using a property of Cepheid Variable stars.

# Fun astronomy for elementary pupils


Makoto Adachi

**Kujo-Tonan Erementary School**
**Kyoto Japan**


I've been teaching astronomy as an elementary school teacher for 20 years and two years previously at a planetarium. Also I've been a coordinator of star-watching evevts for nealy 30 years as an amateur astronomer. As a result, I've experienced teaching astronomy to many pupils. I have learned from my carreer that it is the best for the pupil to start studying astronomy in elementary school at the age of about 10.

Very few of my peers have any interest in astronomy. I'm afraid very few elementary school teachers have any interest in astronomy. I've met only one teacher in my 20 years of elementary education who can properly identify constellations. those who can't find constellations in the starry night aren't able to teach astronomy so well. Most teachers cover only astronomical concepts dictated from textbooks. Such a learning environment actually takes away from a children's interest in astronomy.

The elementary school curriculum in Japan is controllded by the Ministry of Education's educational guideline known as "gakushu sidou yoryo". But, the educational guideline has been reformed over the past 20 years. Now, it's going to be reformed again.

Twenty years ago, pupils observed the moon and the sun, and studied color and brightness of stars from the 4th grade. In the 5th grade, they studied constellations and the motion of stars.The 6th grade covered the motion of the sun and the seasonal changes in the positions of the sunrise and sunset. However, this curriculum was too difficult to understand for 12-year old children. It was evident for 12-year-old children to understand the seasonal changes of the motion of the sun thoughout a year.

The Ministry of Education has revised the educational guideline. The new guideline states that astronomy study should begin in the 5th grade. The content of this study was for the former 4th grade. Now 5th graders observe the motion of the moon and the sun; and 6th graders study the seasonal motion of stars and constellations.

In Japan, elementary school teachers superficially teach all subjects rather than any one or two subjects in great detail. Therefore, they hardly teach any subject in detail except for what they specialized in university. That is why I have asked other teachers to allow me to instruct astronomy in their classes.

I also do this on behalf of my own research. I have been doing research on astronomy teaching materials based on children's interest per age group. My ultimate goal has always been to determine how children find interest in astronomy.

I have found that in general, children start to show their curiosity of natural phenomena at about 10 years of age. I'll give you an example. My 5th graders have kept fish and turtles in an aquarium. They have been keeping many kinds of creatures in the classroom for 2 years since they were 3th graders. So they are very curious about the fauna. They don't only keep, but voluntarily look up how to cure fish, even if it's too difficult for their age. They voluntarily came to school, even during summer holidays to look after them. The interest that one had at the age of around 10 never fades.

It was 10 years ago. By the 5th grade their interests included astronomy and hence, I introduced basic solar and lunar phenomena. I often talked about astronomy during a school day. These children of whom I was in charge were greatly interested in astronomy. As a result of my efforts, some of pupils became amateur astronomers. At present they, as I, are very active as instructors at astronomical meetings around Japan.

The first step to teach astronomy should begin in the 4th grade with simple activities such as finding bright stars with the naked eye and observing the shape of the moon. The motion of nearby planetary bodies should be covered in the 5th grade. I believe this plan matches the average child's development.

My experience as a profesional planetarium has given me the desire to construct my own planetarium. Unfortunately most schools don't have desirable planetarium. Unfortunately most schools don't have desirable planetarium equipment. My school is no exception so I had to improvise. I used a midget lamp and dry-cell battery as a light source. I also used a motor to demonstrate how the sun appears on the horizon.

I had to cover four corners of the room with white sheets to simulate a dome in a rectangular classroom. This is not a round dome, and not used for the simulation of the motion of stars because of its irregular shape. We were able to see the sunrise and sunset on the walls and the constellations on the ceiling. Obviously the shape of the makeshift 'dome' was far from perfect. But the children seemed very excited to see stars appearing from the horizon at sunrise. I took the children out to see the real stars that night. And the observation begins with their high tension. This way produced wonderful effects by using a dome.

We have seen stars silently passing ever-so slowly through the dead branches above us. It is the same excitement you feel when watching the sun slowly disappear sunset.

I want children to experience this excitement. I did this by having the kids lie beneath horizontally-positioned parallel ropes. We should use pillows in order to be comfortable. They can actually see stars slowly passing through the ropes, fostering their curiosity of the firmament. They need to experience for themselves watching moving stars in order to learn motion of stars. They could find real moving stars in the sky above us, not in the planatarium. I will continue my astronomy work which pupils are greatly interested in.

**Star Parties held at special settings**

Julieta Fierro
Instituto de Astronomía, UNAM

## I- Introduction

In the following article we describe two star parties that were organized in Mexico at archeological and cultural sites.

Star parties have been held all over the world for many years; several have put forward innovations which make them a memorable experience, such as those in New Zealand, where children observe the stars, the glow worms, and then spend the evening sleeping in a planetarium under the star covered dome (Orchiston, in Batten 1998).

We shall describe a star party held at the archeological site of Monte Albán in the southern state of Oaxaca in Mexico for 1 000 people, and another at a monumental sculpture for over 3000 participants at Mexico's National University main campus. We think these star parties were particularly successful due to the magnificent setting where they were placed.

We consider that in developing countries science is still far from being incorporated into the local culture, as for most people culture includes only fine arts. Holding a star party at an archeological site is a wonderful opportunity to unite history, art and science. We strongly recommend such activities.

## II- Monte Albán

The ruins of Monte Albán are built on the top of an plaza measuring roughly 2 km across. On its surface are located more than ten large constructions. The star party was held at the main plaza and it included public lectures during which the participants sat on the steps of the highest pyramid.

The star party started during the afternoon and concluded after midnight. The astronomical talks were given after sun set so that slides were clearly visible as well as the star-cluttered sky. During the entire program telescopes were set up so that people could walk up to them and watch the Moon or the prehispanic constructions during the afternoon and astronomical objects during the night.

When people arrived at the site they could walk amongst the ruins and visit the museum or else take a guided tour of the Monte Albán site. Professional archaeologists conducted 45 minute presentations.

When the sun set, attendees were seated on the steps of one of the major pyramids and two public lectures were given by professional astronomers, one on general astronomy and the other on the archeoastronomy of Monte Albán. An electricity plant had to be taken to the site, as well as sound and projector equipment.

The astronomy talk was about the kind of observations the Zapotec people could have made with an non aided eye: Sun, Moon, Planets, Comets Stars. Demonstrations were carried out during the lecture in order to have people get a feeling about the understanding of the physical principles that govern astronomy. For instance, for phases of the moon the demonstrations suggested in *Les Cahiers Clairaut*, a simple astrolabe was build to explain how Asian people measured angles and a comparison was carried out with the local instrument, a hair drier was used to blow air on a ***ball with a tail*** in order to explain why a comet's tail always points away from the sun, etc. The seasonal changes of the sun's apparent position in the sky and the experiment of Eratosthenes to measure the circumference of the Earth were explained so that people could understand the different directions of sun rays during the year at different locations.

The archeoastronomy talk made emphasis on alignments, sunrise and settings, and the zenital pass of the sun, on the 8th of May and August the 5th, and the way it illuminates a chamber on these two special days.

After the lectures the attendees were invited to look through ten telescopes that were placed on the site. During the talks many of the people gathered around the telescopes, specially children, so that the waiting lines did not get too long.

Since this activity was held during October one could observe: Jupiter, Saturn, Andromeda Galaxy, and the crescent moon amongst other objects.

## III- Espacio Escultórico

The Star Party organized at the *Espacio Escultórico* was aimed at observing comet Hale-Bopp. The setting is a 500 meter diameter monument that surrounds a 3 000 year old lava flow. The telescopes were set in a semicircle surrounding the monument. In the middle of the flow we installed projection and sound facilities in order to give lectures. In the access to the monument we placed: information area, portable sanitary facilities, video projectors, exhibit on Mexican astronomy, computers with astronomical software, workshops on comet building and a small souvenir shop.

In order to carry out such an event we had the help of 30 graduate students, several groups of amateur astronomers, and the department of community services of Mexico's National University. We shall describe in more detail some of the activities that were held during the event.

### 1- Written materials

We produced a small pamphlet describing the outstanding properties of comets in general and comet Hale-Bopp in particular that was given to people that came to the star party. We also gave out a few copies, mainly to teachers, of a 40 page document on comets, that included simple experiments that can be carried out in the classroom such as the ones that have been published in the *Asian Pacific Teaching of Astronomy, Mercury*, and *The Universe in the Classroom*. We think written materials are important for teachers since they have a hard time getting up to date scientific information.

### 2- Computers

Very few schools in Mexico have computer facilities. Placing 6 computers with astronomical software at the star party gave visitors a chance to get acquainted with them. For trained users it was a chance to have them know about astronomy programs.

3- Amateurs

Since the Instituto de Astronomía has only four small telescopes and we expected thousands of people we invited all the amateur groups in Mexico City to help us with the observations. All the telescopes were placed in a semicircle on the eastern side of the *Espacio Escultórico* so that there would be enough space for people to stand in line in order to observe the comet and other objects. Of course, this represents the prime event of a star party since for most people looking through a telescope is a breathtaking experience.

It is good to get amateurs involved in star parties since they are well acquainted with the sky and know how to handle large groups of people.

4- Dance performance

A dance group gave a performance during the event. Ten ballerinas dressed in frail gowns frolicked about with a musical background carrying a large ball with a tail. They concluded the performance in the middle of the *Espacio Escultórico* while an actor recited astronomical poems.

5- Public Lectures

Projection equipment and loudspeakers were installed in the middle of the *Espacio Escultórico*; two astronomers gave a public lecture on comet's general features, and on comet Hale Bopp in particular. Most of the audience sat on the lava flow, once in a while all the lights were turned off in order to have a better visibility of the comet. While people stood in line to watch trough one of the telescopes they could listen to the lectures.

6- Videos

Several monitors were place on the isles conducting to the observation site where astronomical videos made in Mexico by the National University were shown. They were on archeoastronomy, the National Observatory that is located in Baja California, astronomy in Mexico and comets.

Since there are only 100 astronomers in Mexico this was a good way for the more than 3000 visitors to learn about astronomical activities in our country.

7- Workshop

A workshop for building a comet using mainly ground dry ice and water was carried out *(The Universe in the Classroom)*. Teams of graduate students explained how to make them and talked about general properties of comets in the mean time. They had people participate in the construction and subsequent discussion that included topics such as the presence of organic compounds in comets.

We think hands-on activities are the most proficient way of conveying science to general public, since they have a greater retention span than other activities.

**IV- Conclusion**

Star parties that take place in a monumental environment can be a breathtaking experience. If they are held at ruins they can include archeoastronomy and astronomical talks. When organizing such events it is important to give people certain instructions such as to remind them to wear proper clothes, hand out enough flashlights to go around, or offer warm drinks.

Astronomy is an excellent way to convey scientific knowledge and when it is combined with other forms of culture it turns out to be very appealing.

Amateurs offer an excellent help during star parties; they own portable telescopes which they manipulate skillfully, know what objects are easy to observe, and like to be around people.

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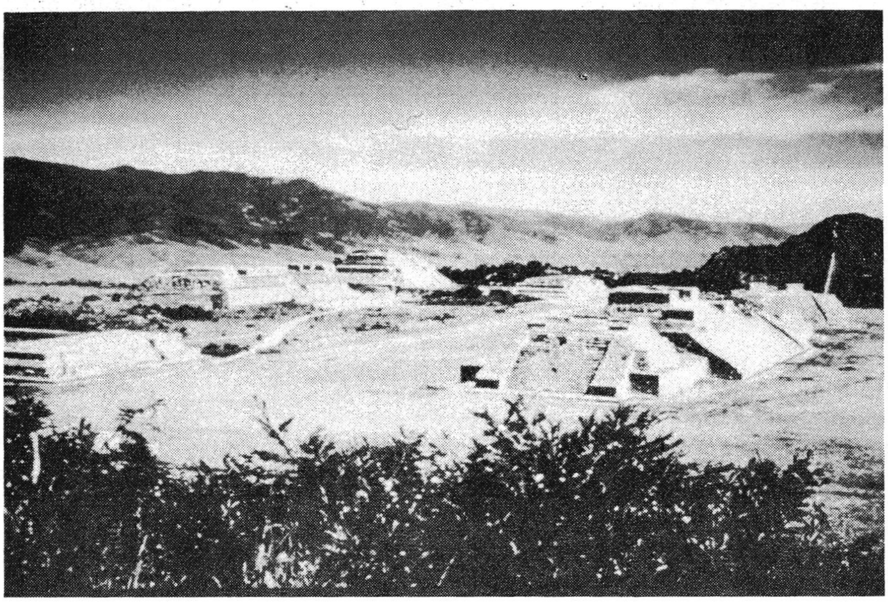
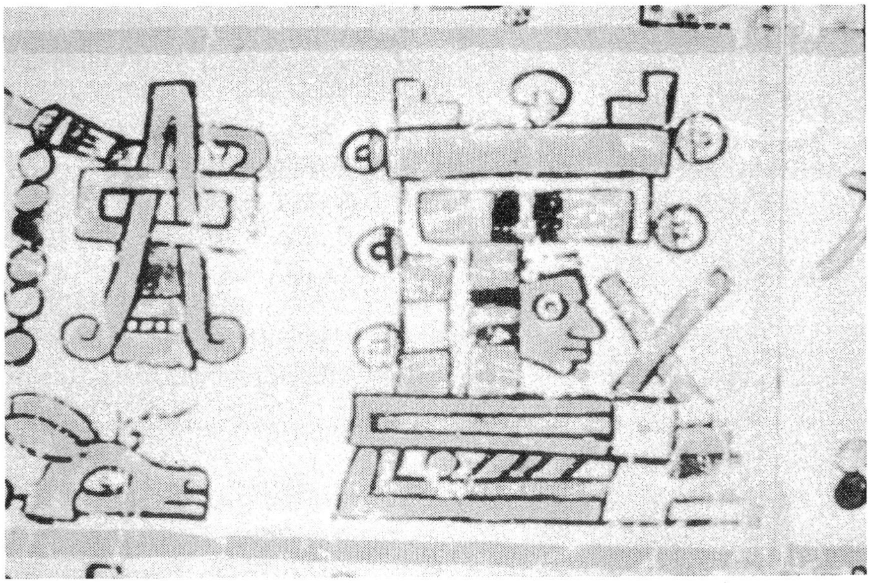
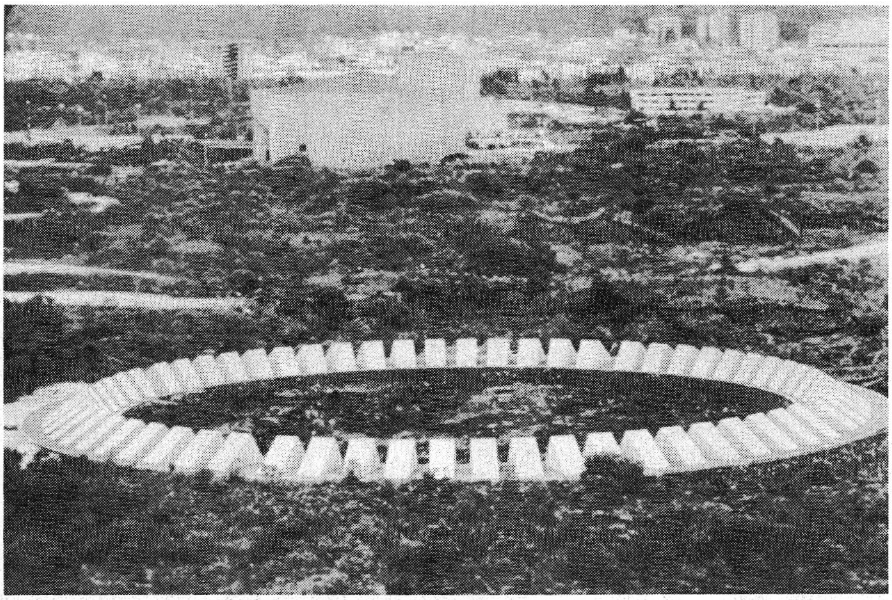


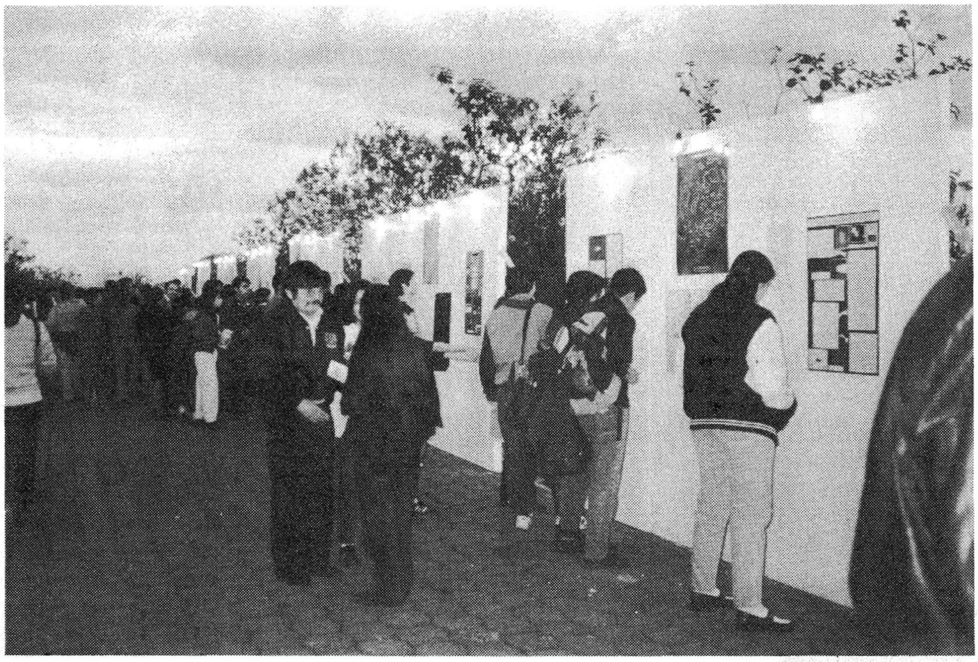
1- The Archeological site of Monte Albán where one of the star parties was carried out.



2- The prehispanic glyph for astronomer, the cross in front of the human face has been interpreted as being an astronomical instrument.

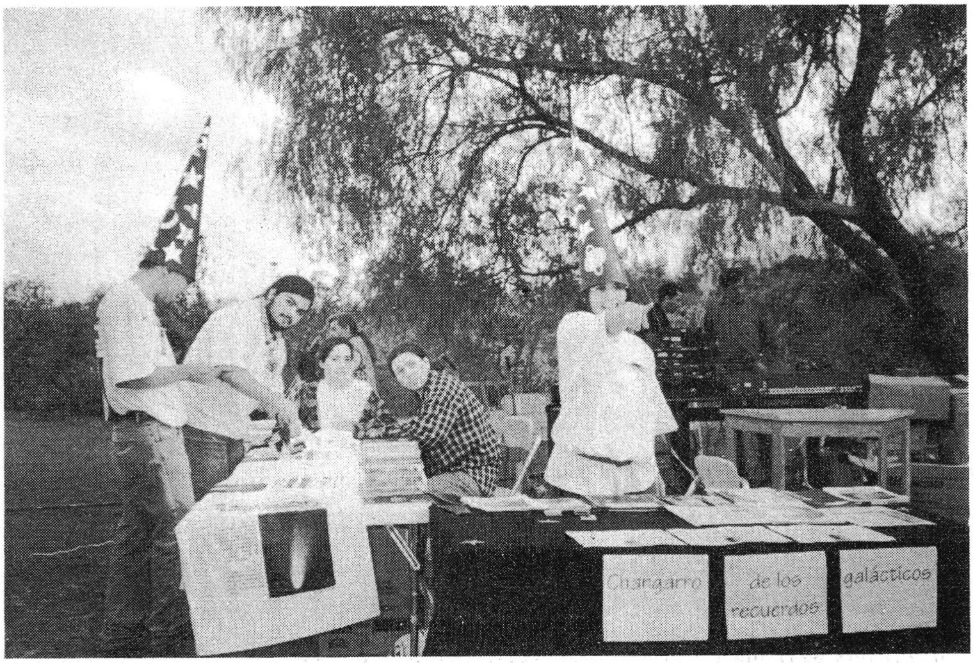


3- General view of the *Espacio Escultórico* where the star party took place.



4- Posters were placed along the access so that public could get a general idea of the astronomical research that is carried out in Mexico.

5- The equipment for the public lecture was placed in the middle of the hardened lava flow.




6- Students sold astronomical books, cups, T-shirts and postcards during the event.

7- Graduate students held workshops on dry ice construction of "comet nuclei".

8- The telescopes were placed in a semi circle and were widely spaced in order to allow viewers to have enough room to stand in line.

# 1819: a curious manuscript

**T.Cadefau-Surroca and M.A.Català-Poch**

The idea of this essay appears as a result of the finding of a manuscript dated in 1819. It provides an approximate and simple way to calculate the phase in which the Moon appears in a particular day, that is to say *"To deduce the day and the hours we are in relationship to the Moon , and the amount of light given to our hemisphere, any day of the year"*

This document, which we consider as very curious, shows the need anybody had to know the astronomy's phenomenons and how they determined daily life.

Its analysis implies a Knowledge over the motion of the Sun, the Moon and the Earth, and that of the calendar, of course. It's for this reason that we propose an activity based on this document, because it enables us to work with these concepts in a natural way in order to be able to judge and value its contents.

We study the Earth's motion to better understand the apparent motion of the Sun and the Moon, because most calendars are based on that. A little bit of history will help to know the origin of our calendar and its peculiarities, in special, the determination of some mobile festive days. Some concepts as epacta, gold's number and dominical letter must be known to estimate Easter date.

The essay is organised in three parts: the first one is an introduction which translates the contents of the document, the second one seeks to give a schematic picture of basic knowledge to analyse the document - motions of the Earth, the Sun and the Moon, calendar's history, definition of any concepts that appear in the manuscript and how to estimate Easter date -, in the third and last one we propose the activity to do with students.

With this we hope to have a complete picture of the activity. Depending on the students,. the teacher will decide the level and aims to be taught . Although we think it's probably suitable for 16 years old.

## CONTENTS OF THE DOCUMENT

The document is written in Catalan, we translate its content to English:

*"To deduce the day and the hours we are in relationship to the Moon , and the amount of light given to our hemisphere, any day of the year, we suppose these principles:*
*1- That the lunar year begins in March and finishes in February.*
*2- That the Epacta, which is the clock of the Moon, increases or advances eleven days every year. This is because in this year 1819, the Epacta is four, the next year will be fifteen, et sic in perseum, and at thirty it goes back to one, two, three...*
*3- That the Moon recedes three-quarters of an hour every day, and when it's in crescent, at sunset it's in west wind, and when it is full moon it's sunset, in Orient.*
*4- That in the months with thirty-one days the Moon has thirty and in the months with thirty days the Moon has only twenty-nine.*

*Bearing these principles in mind, to deduce the day of the Moon (in every day of the year), we must count the days that the Epacta has, the days of the month we are in, and the months that have passed from March on (March included) , and finally how the Moon is: and all these days summed, we can say the day the Moon is and its situation.*

*Example:*

*I want to know what the Moon is like on 20th of May, how the Moon is. I computer: Epacta 4, day of the month 20 th and the third month, that is March, April and May: I deduce clearly and with calculus most clearly than Mister N's. (I talk to Mr. Valentin Torres) that the Moon has twenty days.*

*Another Example:*

*I want to know what the Moon is like and if I can go to " matines de Nadal" (Mass of Christmas Eve) with no lantern, or if there is Moon on that eve. I must computer: Epacta 4, 24 of the month, and ten months from March to December inclusive I will find 38 days. Here I'll deduce: nine days ago the Moon of November finished because it only had 29 days: and these nine remaining days belong to the Moon of December, and in consequence, I will conclude that I'll go to "Matines" with no lantern, because the Moon has quarter crescent, and it will shine enough; but as it sets between eleven and twelve a.m. it will be useful to carry a light went I go out from "Misa del Gall" if I don't want to move in the dark.*

*et sic in infinium* N.F.

**BASIC CONTENTS**

Study of the motion of the Earth, the Sun and the Moon.

**Earth:**

Evidence of its motion of revolution and rotation: annual parallax, aberration of light (annual and diurnal), Foucault's experiment.

Inclination of the axis of rotation: seasons

Motions of precession and nutation

**Sun:**

Sun's motion

Annual displacement of Sun in the Celestial Sphere or annual motion of Sun: ecliptic, the vernal and the autumnal equinox, summer and winter solstice

Units of time: true solar day, mean solar day. Sidereal year and tropical year.

**Moon:**

Orbit of the Moon already of Earth

Periods of revolution: sidereal month, synodic month or lunar month, draconitic month and anomalistic month.

Geometrical librations in longitude and latitude, diurnal or paralactic libration and physical libration.

**History of our calendar**

Our calendar comes from the solar calendar of ancient Egypt (4000 BC), This was appropriately modified in the year 46 BC, giving rise to the Julian calendar , until Pope Gregory XXIII reformed it in 1582 giving rise to our Gregorian calendar.

In our liturgical calendar we find fixed festive days, for example Christmas Day, other festive days change, some of them depend on the situation of Sundays during the year and others on Easter.

Easter is celebrated on the following Sunday after the first full moon that has risen in the vernal equinox or immediately after. Therefore, Easter is linked to lunar cycle and this is why it won't ever be a f xed date in our solar calendar as both, lunar and solar cycles, are incompatible. Its determination is one of the main problems of the calendar, in the Gregorian calendar it's determined by the dominical letter and the Epacta.

For this reason we are interested in explaining it for a better understanding of the utility of the Epacta, and how the solar and lunar cycles relate making clear the existing complexity if we want to relate one and the other.

In text books it's not common to find an explanation to these concepts apart from its simple definition, it's for this reason that we explain them:

**Dominical letter**

If we associate the days 1, 2, ...and 7 of January to letters A, B,.... and G, the dominical letter is the letter that corresponds to the first Sunday of the year. For example, if the 1st day of January is on Wednesday, the dominical letter of the year is E, because:

| Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| A | B | C | D | E |

If the year is a leap year, the dominical letter changes the 1st. of March. As in the previous example, the letter D corresponds to 29th February, the process being repead, so, there will be two dominical letters. The dominical letter will change from year to year decreasinly, because the year has 52 weeks and 1 day.

| | |
|---|---|
| If in the year 1995 the dominical letter is | A |
| the letter dominical of 1997 is | GF |
| and the letter dominical of 1997 is | E |

For a particular year we can estimate the dominical letter in the Gregorian calendar with the expression:

$$L=\{2c + 1 - (c/4) -u - (u/4)\}_7$$

where: L is the order number of dominical letter
c is the number of hundreds of the year, and
u is the number formed by the two last numbers of the year.

Besides: of the fraction in parenthesis we take the enter quotient; of the bracket with subindex we take the rest of division for the subindex, if it's nought, we take L=7; and if the year is a leap one we obtain the second dominical letter.

**Gold's number**

Each 19 Julian years the phases of the Moon are approximately in the same dates of the Julian year (this periodicity is also called cycle of Meton, in honour to the Greek Meton, 432 BC, who discovered this relate luni-solar). Therefore:

235 lunations = 29'530580 x 235 = 6939'6882 days
19 Julian' years = 365'25 x 19 = 6939'7500 days

In 19 years the mistakes aren't over 0'0618 days, which approximately represents a delay of 1 day every 300 years or 8 days every 2500 years. We call gold's number of a determinate year, the place it occupies in the period to which it belongs. It's disposed that the year 1 of our age has the number 2 for gold's number, resulting in:

$$n = \{m+1\}_{19}$$

where: n is the gold's number of year m, and of the bracket with subindex we take the rest of division fc r the subindex

**Epacta**

The Epacta of any year is the age of the Moon the first day of January diminished in one or days passed from the last new moon of the year to the 1st. day of the following January. In a common year, we will have 12 lunation and 11 days, because a sinodic revolution of the Moon approximately lasts 29'5 days and 12 lunations 12 x 29'5 = 354 days. In the Julian calendar to pass from a year to the next one, a particular phase of the Moon is late in 11 days or the first of January or the Epacta increases in 11 days. Taking into account the previous year of our era, the first lunar cycle of 19 years began, that is, the new moon happened the first of January, the epacta of year m, with gold's number n, we can obtain it by:

$$E = \{n+10 \{n\}_3 -3- c + (c/4) + ( (8c+13)/25 ) \}_{30}$$

where: n is the gold's number, and
c is the number of the hundreds of the year.

**Estimation of Easter**

To estimate Easter we must know:

The place of Sundays in the year
The calendar of the phases of the Moon
The first Moon following 21 March
The first Sunday following this date.

So, Easter will just depend on the dominical letter L and the Epacta E in the Gregorian calendar. Days counted from first March, are derived from:

$$P= 45 -E + \{E+ L + 1\}_7$$

We realise that if P>31 Easter is in April and if E> 23 the full moon takes place before 21 st. March (44-23), and it isn't the Moon of Easter. We will have to take the following Moon, 30 days later. By agreement and to preserve the same formula, we will use E-30 instead of E when E> 23. In the leap years we must take the second dominical letter and it has to be taken into account that if the Epacta is 24 it has to be taken as if it was 25, and if it's 25 as if it was 26.

**ACTIVITIES**

We can specify the outline of the activities in the following items:

- Explain the manuscript to pupils, comment it establish general analysis:
. Look for the meaning of some concepts, for example Epacta.
. General observation of Moon's motion. Is it really delayed 45 minutes every day?
. Duration of the lunar month.
. Why does the lunar year begin in March?
. Relationship between man and astronomic phenomenon.
. Prove if the reasoning of the document is correct. For example: If we know this year's Epacta which will be the phase of the Moon tomorrow?

- For a more definite criteria, to analyse the document more accurately:
. Motions of the Sun, the Earth and the Moon, study and observation.
. Brief history and study of our calendar

- As exercise
Estimate the date of some local mobile festive days depending on Easter. For example: In Berga (latitude 42°5′, longitude 1° 49′ W.), the "Patum"(Popular holiday celebrated in Corpus, it dates from 14th century)
. Verification of the bases and the values (Epacta) which appear in the document: *"To deduce in that day we are of the Moon, and witch hours, and quantity illuminate our hemisphere, in any day of year".* How we look at the Moon? How can we plan an evening observation of the sky?

- Finally give an opinion of the document ,and be able to explain the basis of the document, and give bibliography.

The activity can interest the pupil easily. This experience enlarges their knowledge, They value it and they are conscious of the difficulties that a good measure of timeimplies: theirs basis and the determination the most important dates respecting traditions. Finally he provides to realise big research , to be able to judge and explain their opinion.

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# The Present Situation of Astronomy Education in Secondary Schools and High-Schools in Romania

**Anamaria RUSU teacher at "Gheorghe Şincai" High-School**
**Cluj-Napoca, Romania**

The organization of education of young people in Romania may be presented as follows:

| Age | Type of education |
|---|---|
| 3 - 7 | nursery school, kindergarten |
| 7 - 11 | four class elementary school |
| 11 - 15 | four class secondary school |
| 15 - 19 | for class lycee or high-school ending with high-school certificate |
| 19 - 24/25 | four, five or six years of university studies, ending with Master's Degree |

Astronomical elements are introduced in the elementary school while teaching Geography and Physics. Geography in the 5-th class comprises a chapter on the "*Earth as a Cosmic Body*" explaining the solar system, the shape and size of the Earth, the terrestrial orientation. The second chapter entitled "*Earth's Motions*" explains the rotation and the revolution of the Earth and their consequences.

While teaching Physics in the 6-th class one mentions the gravitational force of the Earth and on other celestial bodies, and the Earth's gravitational field in the chapter "*Magnetism*". In the chapter on "*Optics*" in the 8-th class the teacher introduces various optical instruments, the notion of difraction of light, the solar spectrum and on "*Geometrical Optics*" are presented the eclipses of the Moon and the Sun. In high school, in the 9-th class in "*kinematics*" the heliocentric and geocentric systems are presented. The chapter "*Gravitation*" is about the motions of the Moon and of artificial satellites round the Earth, about the Solar System, Newton gravitatial law, the importance of gravitation in the Universe. In the 11-th class in the chapter "*Geometric Optics*" the reflection and some optical instruments (the reflector, the refractor) are prsented. In the 12-th class the students are taught about the nuclear reactions as sources of stellar energy.

In Romanian high-schools astronomy was taught for many years as a separate subject. But after the 1978 reform of the educational system, astronomy was eliminated from school programes. In 1990 astronomy was introduced again - one hour per week for a year in the 12-th class but only for mathematics - physics profile (Maybe it would be necessary to explain that in Romania there are four types of lycee where one of the following subject groups is taught in a more detailed way: mathematics-physics, informatics, biology-chemistry and humanities).

The Astronomy curriculum consists of an introductory chapter where the structure of the Universe is presented. The second one named "*The Celestial Sphere and its Rotation*" introduces the main celestial coordinates systems. The third chapter deals with the Earth as a planet - its shape and size, geographical coordinates and their determination and the Earth rotation. The following chapter is about the Earth's revolution and its consequences.
The fifth chapter is about time and its measurements, the next one deals with the determination of the celestial distances. The seventh chapter deals with some elements of celestial mechanics like the apparent and the real movement of the planets, Kepler's laws, the law of the universal attraction, the movement of the Moon, its phases, eclipses. The eight chapter is about methods and instruments for the studying the Universe. The ninth chapter is about the Sun (dimensions, methods of observation, energy and temperature, the Sun's constitution, Solar atmosphere, the origin of the Sun's energy). The following chapter is about the solar system (major planets, satellites, minor planets, comets, meteorites). The eleventh chapter deals with stars: magnitudes, temperatures, the spectral classification of the stars, double and variable stars. Stellar systems is the name of the twelfth chapter. It deals with stelar clusters, nebulas, galaxies and clusters of galaxies. The last two chapters deal with the origin

and the evolution of celestial bodies and the direct research of the cosmic space.

By tradition the Maths teachers teach Astronomy in Romania because Astronomy is studied in the third year at Faculty of Mathematics. Teachers, however have often found explaining astronomical concepts difficult because of the complexe nature of the material and the difficulty is keeping face with new discoveries. One main problem is the textbook which needs to be modernised and uptodated. Adding furthermore that most of the observations must be done outside the classroom, in the evening and away from city lights.

It's difficult to write in general about methods and materials that Romanian teachers use in teaching Astronomy. I'm not in a position to have that kind of information! But I can surely write about the materials that exist in my school. I teach at "Gheorghe Şincai" high School in Cluj-Napoca, which is one of the most important universitary centre of Romania. The local University has a Faculty of Mathematics and an Astronomical Observatory. Keeping in touch with the local astronomers my school receive a set of 175 slides named "*The Colours of the Universe*" (elaborated by NASA), videotapes containing Carl Sagan's TV serial "*The Cosmos*" and "*The Planets*". We can also use the computer for illustrating the astronomy lessons (using the Cosmos programme).

The intent of this presentation has been to provide a few brief information about the teaching of Astronomy in schools of Romania. Request for details of astronomical education in Romania from readers is welcomed.

## About the Centenary of a Cultural Magazine

Elvira BOTEZ
Cluj-Napoca, ROMANIA

"The culture and the civilization of a country is judged not only by the peaks achieved by the great cities but also by the level of culture and the extension of civilization into the broad masses of the people". This truth, set forth by a Romanian scientist in the inter-war period, was well understood by *Spiru Haret*[1] as far back as in his professorship at the University in Bucharest, so that, being at the leadership of the Ministry of Education at the end of the last century he undertook its most important and radical reform, at all levels.

But, finding that the results of primary school to remove illiteracy couldn't produce any result because after leaving it the young country people would not read anything and at the age of recruiting they did not know even to read, Haret drew up a written statement concerning "The foundation of a magazine for the rural classes", taking counsel with a group of men of culture with a view to set up a popularization magazine which "through content and price could be at hand for the countryside population".

The magazine, with a popularization and encyclopedic character, in which the reader, mostly a peasant, could find in an easy language everything that could contribute to the cultivation of his mind and spirit was called *ALBINA* (The Bee) and in its first number issued on the 5th of October 1897 announced its programme, synthetized in 21 branches aiming at national education, practical activities and general knowledge (which included popularization of science as well). The appeal of the editorial staff to specialists in different branches to support the success of the magazine, involved personalities of the Romanian culture, their articles and advice being a reliable pattern for the way in which one should write for the peasants. *Albina* with its character of a cultural popular primer has developed many people's taste for reading. Therefore, it has been widely spread, loved an appreciated, being awarded golden and silver medals on the occasion of three national exhibitions during the pre-war period.

Even if unfavourable circumstances twice determined the interruption of the publication of *Albina* for more years and sometimes its irregular publication, mostly of the time its publication was weekly, becoming monthly only in 1974. With different enunciations

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[1] (1851-1912) astronomer with important contributions to the mechanics of the solar system and whose name was assigned to an crater on the reverse side of the Moon.

of the subtitle, it has permanently been defined as a magazine for the countryside till 1991 when it became "a monthly magazine edited by the Ministry of Culture".

Running through the collection of this magazine one is surprised by the richness of astronomical information, a fact which has lead the author to the drawing up of a bibliographic index of these themes which comprise no less than 1000 titles; this fact situates *Albina* on the third place among the periodicals which have had this aim (popularization of Astronomy) as an objective after the semi-centenary magazines *The Newspaper of Sciences /and of Travelling/* (1897-1948) and *Science and Technique* (1949- ) specialized only in science. Under these circumstances it proves to be very interesting to research the subjects and the contents of the astronomic materials published by *Albina* throughout one century, a fact that would add a page to the history of astronomic culture in Romania, particularly through the fact that the magazine speaks to a specific category of readers.

In the first period of appearance the reader of *Albina* - the Romanian farmer or shepherd, onlooker at the celestial vault was afraid of the heaven, ignorant and dominated by superstitions; under those circumstances the astronomic articles also had an important role in the struggle against the superstitions. Themes about the mechanism of eclipses, the occurrence of comets, "meteor shower", earthquakes, "the end of the world" needed such an approach. For example, explaining the mechanism of eclipses, proving that they are predictable has succeeded in scattering off the reader's mind the superstitions about these phenomena.

In the same way, in the case of the reform of the calendar, *Albina* has had an important role, because the Romanian peasant, preserver of the tradition of religious holidays, could not easily accept, according to his understanding, a change of their dates. Through the presentation of the history of this problem, through the permanent improvement of the agreement of the calendar with the astronomic phenomenon on the basis of which it had been made up, the magazine points out the superiority of the Gregorian calendar (new style) to the Julian Calendar (old style) which was used at us, and hence the necessity of a natural acceptance of the first one, as a form of social progress and agreement with the majority of the European countries.

But these remarks should not turn away our attention from the diversity of the topics which *Albina* has dealt with through the long period of its issuing, most of them transmitting the reader the scientific knowledge about the cosmic world, showing a certain preference to "the near cosmos" - the solar system. And because research has always enriched knowledge, the same themes referring for example to the Moon, Venus, Mars, Jupiter etc., are taken now and again, synthetizing the knowledge about them through the interpretation of the new observations and discoveries. Until four decades before these had been made from terrestrial astronomical observatories. With the beginning of the cosmic era, the observation of the near cosmos has become much better, the data obtained with the help of artificial cosmic bodies or the space missions to the Moon, Venus, Mars and to the other planets of the solar system enlarging and deepening knowledge about them. All these special programmes, as they took place, have been presented in the pages of *Albina*, together with their decennial reckoning as well as with future perspectives of astronautics. But the cosmic flight is itself an epochal achievement so that it has made account of both its technical performances and the flight of cosmonauts, their lunar landing in the Apollo mission being amply treated.

Wide information has been provided about the central heaven body of the solar system, information obtained especially in the last four decades. It is about the active Sun, the calm Sun, the sunspots and the solar flares, their influence on the Earth, the solar wind, the age of the Sun (and of the Earth).

Keeping inside the solar system, let us bring in our objective the Halley comet, seen twice in the last century. Comparing the way in which it was presented in 1910 when there was a struggle against the "fear of the comet" and that of 1986 when it published large information about its constitution and chemical composition provided by the spacecrafts launched into its direction, we can notice the cultural progress achieved by *Albina's* reader in the course of this time.

If the remote sidereal world remained for the reader of the twenties only through the knowledge of constellations, during the last decades *Albina*, quitting its "contemplation" concentrates on its aspects which are in the objective of research, regarding the stellar evolution (the birth, the life and the death of stars) and in its context the diversity of the stellar structure, shown by the discovery of the pulsars, neutronic stars, magnetic stars, hypermagnetic stars, black holes.

Beside the vast informational material about astronomical knowledge, in the pages of *Albina* incursions are made in the past of Astronomy, some well-known personalities being presented (Copernic, Kepler, Galilei) on the occasion of certain anniversaries.

As autochthonous element *Albina* publishes (rather irregularly) an astronomical ephemeris and articles about the achievement of the Romanian astronomy in the context of the international collaboration, about the Romanian space exploration, the flight of the Romanian cosmonaut *D. Prunariu*, and about the planetariums in Constanţa and Baia-Mare.

Many materials are better picked up because of the illustrations which accompany them and which complete the written word, but the great merit belongs to their authors, among whom many astronomers have also enlisted their names.

Reaching the age of a century issuing, *Albina* continues to be a real encyclopedic primer, Astronomy being well represented in the framework of popularization of science. On the whole, it acquaints the reader with information in a wide range of fields aiming to enrich his general knowledge, an aim which was established at its setting up. For the countryside readers and even for those in town, it has been a time saving means of information, bringing in few pages extensive and varied information.

Taking into consideration the large number of periodicals which have appeared in our country (and the *Dictionary of the Romanian Press* records more than 7000 titles till 1918) a great number of them being ephemeral and with limited address, *Albina* reaching its centenary with its large address and with its encyclopedic character best suits the reader eager to inform himself in the rushing epoch we are going through, fully deserves the underlining of the anniversary event. It is the triumph of a so solid idea of its founder.

# MUKTA-BENI BYARTHA TARAYE LOTE

## ( The 'String of Pearls' falls on the surface of 'Failed Star')

RABINDRANATH CHATTOPADHYAY

Haripal G.D.Institution,Khamarchandi,712405,Hooghly,WB,INDIA

Introduction:

The first headline,written in Bengali pronounciation with its immediately following bracketted meaning is in analogy with the famous line "Mukto Beni Pither Pare Lote" of a famous poem by Nobel poet Sri Rabindranath Tagore,which according to the present author should be the transliteration of the recently held cosmic collision of comet Shoemaker-Levvy-9 with the planet Jupiter. In Tagore's poem 'Mukto Beni' refers to the fastened loose open hair-bundle of a lady while 'Pither Pare Lote' means fly over the back (of her). But here 'Mukto Beni' that is a 'Beni'(String) made of 'Mukto'(Pearls) falls on the surface of 'Byartha Tara' meaning 'Failed Star'. The prefragmented parts of the comet Shoemaker-Levvy-9 is usually described as the 'String of Pearls' while the planet Jupiter is described as the 'Failed Star'. The mass of the planet Jupiter is so large compared to the masses of other planetary member of our Solar System that sometimes the astronomers make fun by saying that 'In its course of being a star Jupiter has transformed into a planet'. That's why they call Jupiter a 'Failed Star'.

A brief historical perspective of the planet Jupiter:

Described as the king of the Gods or heaven in Greek Purana and as the master or preceptor of Gods in Hindu Purana the Brihaspati(Hindu Purana) or Jupiter(Greek Purana) has wife named Juno(Greek Purana) or Tara (Hindu Purana). According to Hindu Purana 'Angira'the most renowned of the group of seven monks ( whose names were given respectively to the seven stars of the group known as 'Great Bear' constellation) was the father of 'Brihaspati' or Jupiter. According to Hindu Purana,the two famous sons of Tara and Brihaspati,the author of 'Brihaspati Samhita' were 'Kauch' and 'Bharadwaj'. The name of one of the four largest asteroids within the asteroid-belt that exists between the orbits of Mars and Jupiter has been given after the name of 'Juno' the Greeks-described wife of 'Jupiter'. Bold,civalrious and cognizant this Brihaspati(Jupiter),the great master of Gods and Godesses is described in the Puranas as the father of the Gods and the human beings.

The history of astronomy and astrophysics can not give any decisive answer to the question 'who discovered the planet Jupiter for the first time?' The only information that one can obtain from all puranas that the existence of the planet Jupiter was known to ones who predated old Babilonian civilisation or pre-vedic age. Many pre-Aristotlian philosopher scientists had occasionally tried to know in details about all the planetary members of our Solar System. At last it was the discovery of Galileo the telescope,which made it possible for human being to collect many real scientific datas about the planet Jupiter.

## Scientific theories about the creation of Jupiter:

Although scientists agree that the creation of the planet Jupiter did not happen only singularly scientists have still not been able to reach an unambiguous conclusion about the creation of the whole planetary system. There are approximately nine different theories of nine schools of thought about the creation of the whole solar system which ofcourse include the three most favoured ones. Among all those theories the mostly accepted and established,the most modern theory,which was originated from Swedish scientist Emanuel Swedenborg and then presented in a scientific jesture by Ger an philoshoper Immanuel Kant and lastly modified and perfected by German scientist Weizsacker is the 'Nebular Theory'. According to this theory the major portion of gaseous material bulk in a diffused rotating nebula in a state of gradually decreasing temperature underwent condensation and thereafter centralised to produce the 'Sun'. The minor portion of the bulk in the rear part of the nebula became gravitationally unstable and regained stability by centralising discretely in a number of smaller bulks which eventually turned into being the planetary members of our solar system. The material bulk between the orbits of planets Mars and Jupiter were gravitationally torne out into pieces to form a huge accumulation of a very very large number (almost uncountable) of small subplanetary spinning bodies placed into an orbit of rotation. This, in the form of a belt around the Sun in between the orbits of Mars and Jupiter is known as the famous 'Asteroid Belt'. All the members of this newly formed solar family including the Sun and the planets, obeying the principle of conservation of total angular momentum by retaining the total angular momentum of the mother nebula and being at a particular distance rom the centre in a centrosymmetric system sustained dynamical equillibrium and thus was created the whole solar system in its present form. In the first phase of this theory there was dispute regarding the distribution of total angular momentum which in its finally modified form was corrected. Thus the modern scientific belief is that the planet Jupiter was formed simultaneously with the creation of the whole solar system.

Scientific theory about the creation of comets:

According to the hypothesis of Jan Oort, at a distance of about 750000 crores of kilometers in the farthest part of the solar exosphere there exist condensed cloud comprising of millions of cosmic objects ranging from a tinniest to a largest within which there lies the 'seeds' of comets. Assumingly the total mass of this Oort's cloud is almost equal to the mass of the Earth and therefore the mass of each 'cometoid' or the embryo comet is negligible compared to that of the Earth. In astronomically remote past, while passing by the side of the solar system this Oort's cloud lost some such cometary 'seeds' due to gravitational instability which was caused by the strong and complex gravitational pull of massive solar system. The ones of such torne out cometoids which came towards the Sun-centred family, became, by the combined gravitational pull of all members of the solar system, permanent or temporary member of the solar family. Some of these cometoids or thereafter fully grown up comets do follow elliptical trajectory of very very large major axis while some other such cosmic bodies follow parabolic or hyperbolic trajectory both keeping the Sun at one of the focie of corresponding trajectories. The comets with closed orbits around the Sun are the permanent members of the solar system while the comets with open orbits are the temporary members of the solar family. While staying in the remotest distance from the Sun the cometary constituents such as methane, ammonia, carbon dioxide etc. remains frozen within the comets as ice and stone. As the comets approach the neighbourhood of the Sun they receive more and more solar thermal energy flux per unit time and consequently their material constituents gradually melt and finally evaporate to produce solid-nucleus-bound gaseous envelopes. The gaseous part, being more and more heated expands and internal pressure within it becomes so low that the solar radiation pressure shapes the gaseous envelope of a comet like an elongated and outwardly widened diffused beam of light known as the tail of the comet which is directed away from the Sun. Eventually in cases of some comets another tail like part extends right from the nuclei of the comets towards the Sun and these tails have been found mainly to comprise solar magnetically influenced swarm of charged particles. Most of the com tary mass is centralised within the nucleus at the centre of a comet around which there exists an opaque or semitransparent envelope consisting of aerosols and vapours. This semitransparent or opaque gaseous envelope is called the 'coma'. uter part of the 'coma', thrusted by solar radiation pressure from one side extends locally on the other side to produce the tail of a comet. The comet Shoemaker-Levvy 9 is such a comet as described above.

Space technological probes meant mainly for the observation of Jupiter:

The major space-technological ventures that have still been performed to unleash the mystery about 'Jupiter' are sequentially given below;

| Year(AD) | Name of Space-vehicle/project | Concerned space agency |
|---|---|---|
| 1973 | Pioneer-10 & 11 | NASA |
| 1975 | Jupiter Orbiter and Probe Mission | Jet Propulsion Laboratory & Ames Research Centre |
| 1981 | Voyger 1 & 2 | NASA |
| 1986 | Galileo | Jet Propulsion Lab. & Ames Research Centre |
| 1989 | ( A Space Craft) ? | NASA |

Among the other space crafts, sent to space, which have helped collecting many important informations about the planet Jupiter are the Hubble Space Telescope (HST) of NASA and MIR-Space Station of Soviet Russia. Pioneer-10 & 11 have helped in knowing many things about the atmoshphere and dynamics of the planet Jupiter. Voyger 1 & 2 have still sent us more than 36000 photographs of planet Jupiter with the help of which many important information about the atmospheric dynamics, rings and natural satellites of the planet have been collected. Space-craft Galileo and the Hubble Space Telescope have witnessed a large number of jovian and extra-jovian phenomena providing us many important datas. Most of the scientists believe that the space station MIR too will supply us with many more important informations about Jupiter.
Besides that particular range of wavelength of em waves which help

us visualising the world with our naked eyes (that we call light) there are a large number of em waves such as Infra-Red(IR),millimeter and radio waves which help us collecting innumerable important information about various physical conditions that prevail on Jupiter. The most ingenuous way which the cameras within the aforementioned space-crafts will photograph accurately the main body and the planetosphere of Jupiter in,is known in the language of science, as CCD Imaging(Charge Coupled Device-Imaging).

Important features about Jupiter:

From the viewpoints of structure and planetary nature there occur mainly the following extraordinarily significant features on the body of Jupiter;

1) 'Great Red Spot' is an elliptical area on the jovian surface which has an average major-axial length of 50,000 kms and minor-axial length 16,000 kms. This 'spot' continuously radiate red light wave with an unaltered brightness. Telescopically viewed from the Earth this spot appears as an eye-shaped reddish fire-ball and that's why it is transliterated in Bengali as the 'Red Eye of Jupiter'. Relevant to mention that although the real cause behind the formation of 'Great Red Spot' is still unknown scientists surmise that a collision of some very large cosmic body with Jupiter in remote past,very similar to the collision of Shoemaker-Levvy 9 fragments,produced the spot there.

2) Inspite of having both diurnal and annual motion like the Earth, Jupiter does not show change of season on its surface. The main reason behind it is that the Earth's diurnal motion is directionally much apart from its annual motion while the plane or the direction of diurnal rotation(axial rotation)of planet Jupiter is hardly different from that of its annual rotation(orbital rotation) (Approximately 3° only). That's why on jovian surface a particular season persists eternally at a particular latitude of it.

3) The relative abundances of materials such as $H_2$ ,He,$CO_2$, $O_2$, $N_2$ etc. which have been observed to exist in the jovian atmosphere have been found to be exactly same as that found in solar chromosphere. That's why scientists do believe that the Sun was created simultaneously alongwith its other family members due to a single cause.

4) It has been observed that the time rate of absorption of extra-jovian thermal radiation and emission of heat(thermal em waves) by the jovian atmosphere are almost equal to each other and that's why there exist a thermal equillibrium in the jovian atmosphere(Isothermal)

5) Scientists presume that a dense cloud consisting of huge amount of water vapour and the vapour of ammonium hydrogen sulphide ($NH_4HS$) persists in the outer part of the jovian atmosphere.

6) The maximum speed of flow of stormy wind amidst the jovian atmosphere is approximately 430 kms/hr.

7) The diurnal motion of Jupiter at its equator is a few minutes' different from the same at its pole which in turn, irrefutably proves that the planetosphere of Jupiter comprises mostly semiliquid or gaseous matter. The Jupiter surface is covered with so thick and dense cloud and atmosphere that even with the help of most powerful telescope on the Earth one cannot observe the hard surface of Jupiter.

8) A horse-shoe-shaped zone has been discovered on the surface of Jupiter where there is a large quantity of ionised sulphur. Scientists do believe that the natural satellite 'Io' of Jupiter, which contains some of the still known most powerful volcano, is the source of that sulphur which being ejected with a tremendous speed and thereafter carried by fluid flow, has reached the jovian surface.

9) Radio waves of wavelength ranging from one to a few decameter are spontaneously and continuously being emitted by the planetospheric gaseous envelope of Jupiter and those radio waves are most powerful

means of acquiring knowledge and many important informations about the structure and formational mechanism of Jupiter. But Jupiter's natural satellite 'Io' being electromagnetically conducting, does eventually influence those radio waves from jovian surface and makes them appear to us in altered form.

10) Sodium based rocky or stonny material on the surface of 'Io' being collided with high energy nuclear particles that emerge out from the radiation belt of Jupiter, produces gaseous sodium. This gaseous sodium at a temperature sufficient to exceed the escape velocity of 'Io' do escape in space and eventually, being attracted by the gravitational field of Jupiter, becomes trapped and revolves like a belt arround the Jupiter.

11) Having been surrounded by the largest possible gaseous envelope and having the highest possible speed of axial rotation among all planetary members of the solar system the Jupiter is somewhat prolate spheroidal in shape the ratio of the semiminor and the semimajor axes of which is approximately .93.

12) Jupiter as viewed from the Earth, is found to be within each one of the twelve equatorial constellations for a whole year.

Model of planet Jupiter:

Among various scientific models of Jupiter the one due to British scientist W. Ramsay is the mostly favoured and matched model of Jupiter. The characteristic features associated with the model are as follow;

Molten and vapourised materials, at a temperature of about 300000°c constitute the nucleus arround which there occurs a thick layer of metallic hydrogen in a steadily decreasing temperature. Another layer of frozen hydrogen and helium which extends, on an average, to 8000 kms of radial length, covers up the layer of metallic hydrogen. Absorption lines of methane($CH_4$) and ammonia($NH_3$) were discovered in the spectral analysis of emission from Jupiter. American scientists H. Spinnard and L.Traffon in 1963 gave, on the basis of then obtained informations, a scientifically very popular model of jovian atmosphere, which is as follows;

| | |
|---|---|
| Combined ammonia and methane | - 1% |
| Neon | - 3% |
| Helium | -36% |
| Hydrogen | -60% |

<u>Astronomical status of Jupiter compared to that of the Earth</u>:

Comparison of Jupiter with the Earth on the basis of astrophysically significant characteristic parameters.

| Planet / Parameter | The Earth | The Jupiter |
|---|---|---|
| Average distance from the Sun | 149600000 kms | 777920000 kms |
| Period of one complete orbital rotation | 365 Mean Solar Days and 6 Hrs. 14 Mins. 24 Secs. | 4331 Mean Solar Days and 23Hrs. 36 Mins. 23 Secs. |
| Mean orbital rotational speed | 29.79 kms/sec | 13.06 kms/sec |
| The angle of inclination of planetary orbital plane with solar equatorial plane | ———— | 1 .85 |
| Eccentricity of elliptical orbit | 0.017 | 0.049 |
| Mass | 5975 x $10^{24}$ Kgs. | 1899392.8 x $10^{24}$ Kgs. |

| | | |
|---|---|---|
| Equatorial radius of planet | 6378 kms. | 71398 kms. |
| Polar radius of planet | 6356 kms. | 66856 kms. |
| Average density | 5.52 gms/cc | 1.31 gms/cc |
| Volume | $1.08242 \times 10^{30}$ cc | $1.44991 \times 10^{33}$ cc |
| Time period of axial rotation | 23 Hrs. 56 Mins. | 9 Hrs. 50 Mins. |
| Angle of inclination of planet's equatorial plane with orbital plane | 23°.44 | 3°.08 |
| Numbers of natural satellite | 1 | more than 17 |
| Atmospheric pressure on the solid planetary crust (surface) | 1013216.04 Dynes/sq.cm. | 3039648.12 Dynes/sq.cm. |
| Altitudinal extent of planetary atmosphere | 300 kms. | 1000 kms. |
| Planetary magnetic field intensity at the solid planetary surface level | 1 unit (arbitrary) | 10 units (arbitrary) |
| Vertical extent of the planetary magnetic field from planet's solid crust | 1 unit (arbitrary) | 3.7 units (arbitrary) |
| Number of prominant planetary rings | 0 | 2 |
| Major atmospheric contents | $N_2$ - 78 % , $O_2$ - 21 %<br>Ar - 0.9% , $CO_2$ - 0.03%<br>(He, Ne, Kr, Xe, Ra, $O_3$) - 0.07% | ($NH_3$ , $CH_4$) - 1% , Ne - 3%<br>He - 36 % , $H_2$ - 60 %<br>(According most popularly proposed model) |
| Standard average surface-temperature | 0°c | - 105 °c |
| Mean atmospheric temperature | - 53°c | - 165°c |

Jupiter and its subfamily

As viewed from a terrestrial platform, in a clear night-sky the brightness-parameter or the optical magnitude of Jupiter is much higher than that of the brightest star Sirius (more specifically Sirius A) and at the same time much lower than that of the planet Venus which, in Bengali, is called 'Sandhya Tara' and 'Suk Tara' while appearing respectively in the East horizon at evening twilight and in the West horizon at morning twilight.

The ring of Jupiter, which is at about an average distance of 57000 kms. from the jovian expsphere has two seperate parts of its own;

i) Primary

ii) Secondary.

These two parts of the ring is found to be separated from each other by an annular ring-shaped space of an average radial length of 122800 kms. These rings are almost parallel to an equatorial circle of Jupiter. The colour of these rings are pale reddish and pale pinkish respectively. The colour of the interveining space between these two parts appears to be pale yellow. Although the different parts of the ring appear in different colour their colours in general do alter over a very long period of time. The brightness or the illumination of those rings is much feebler compared to that of the saturnian rings. There are many smaller regions on the rings which emit light of everchanging colour.

Alongwith its, still discovered sixteen natural satellites the planet Jupiter comprises its planetary system. Those satellites are respectively, Metis, Adrastea, Amalthea, Thebe, Io, Europa, Gynamede, Callisto, Leda, Himalia, Lysithea, Elara, Ananke, Carme, Pesiphae, Sinope. The most voluminous four of the above-mentioned satellites, if arranged in a decreasing order, are Gynamede $>$ Callisto $>$ Io $>$ Europa.

Entrance of Shoemaker-Levvy 9 into the jovian atmoshphere and the collision

The comet, which was discovered with the help of 46 meters Schmidt Telescope from Mount Palamor Observatory collectively by Eugene Carolyn Shoemaker, David Levvy and Philippe Bendjoya in the month of march 1993 is the famous comet Shoemaker-Levvy 9. Afetrwards scientists, by analysing a large number of photographs, radiographs and CCD images of that comet, became able to know a lot of important information about its structure and kinematics. While traversing along its own orbital trajectory within the solar system any subplanetary member of our solar system enters into the gravitational field of a planet or of a natural satellite it undergoes an extra gravitational pull and thereby suffere a perturbative change in its own trajectory. Somewhile, if such an object of subplanetary nature comes close enough to cross a particular critical distance from the perturbing planet or satellite which is technically well-known as the 'Roche-Limit' of that planet or satellite respectively, that object breaks by the planetary tidal force into smaller fragments. Being heaviest in gravitational mass Jupiter possesses the highest power of gravitational attraction among all solar planetary members and that's why its Roche-Limit too is of the greatest value. The very very strong gravitational pull of Jupiter is the most distingushing feature and is popularly known as the Jupiter-Effect by means of which it perturbs the normal trajectory of a permanent or a temporary member of solar system. According to the precise calculation made by computer the comet Shoemaker-Levvy 9 underwent accute influence of Jupiter-Effect by about 8th july , 1992 whenceafter it came down as close as about 43000 kms. from Jupiter. A very strong tidal force of Jupiter enforced the comet to fragment into approximately 22 pieces. By about 16 th July, 1993 those pieces shot out into space as far as 50000000 kms from Jupiter. Within the period of 16 th July, 1994 to 22 nd July, 1994 those cometary fragments started moving in a group directly ahead towards Jupiter. And at last, moving with a speed as high 216000 kms. per hour, they all crashed down one by one to the surface of Jupiter on 22 nd- 23 rd July, 1994. Relevant to mention is the fact that the fastest train in the world can move highest at the speed of about 500 kms/hr. According to scientists concerned the collision took place at about 45° south latitude of Jupiter. As observed, the mean life time of each collision was 30 minutes. Scientists have already discovered by analysing photographs that there exist a number of series of meteoritic craters on the surfaces of Gynamede and Callisto,the two asatellites of Jupiter. Scientists do now believe that those craters might have been created by such similar collisions of cometary fragments with those satellites in remote past.

Observations at the time of collision

The informations about the result of collision of Shoemaker Levvy 9 with Jupiter that were collected immediately after the occurence of collision are as follows;

1) The net energy that was evolved out in the great cosmic collision was almost equal to the energy release in the explosion of $4 \times 10^{10}$ atom bombs. It will not be irrelevant to mention that explosion of a single atom bomb at a place like Calcutta can cause the end of three to four crores of human lives within a zone of 20 to 30 kms. radius around the place of explosion within only three to four minutes.

2) It was observed that with each collision strong jet of very hot gas and collision-remnants speedily emerged out of the surface of Jupiter and spread out into far space within the planetosphere. At that time a big fire-ball was observed to appear at the place of collision on jovian surface. ,

3) Every collision took place on that side of Jupiter which remained in vissible from earth at the time of collision. But due to very high speed of axial rotation the places of collision become vissible from the Earth only within half an hour.

4) Energy,released in each collision directly and instantaneously was converted into a tremendous amount of heat due to which mountain of ice on the surface of Jupiter melted and thus produced a number of very large hole on it. The size of each such hole was big enough to

swallow one or two earth within.

5 The places of cometary collision on the jovian surface were all very extensively shrouded and covered out of those collisions. Even the atmosphere of jupiter was not clearly observable.

6) Astrophysicists have been able to discover the existence of $H_2S$ and $CS_2$ in gaseous state in the jovian surroundings. With the help of the discoveries about the existence of such compounds of sulphur scientists infer that as because there is no trace of sulphur in the upper atmospheric region of Jupiter the comets must have penetrated through a depth as long as 35 kms. into the jovian surface.

7) After relatively a long while from the time of collision the very specific points of collision appeared extremely dark black and the scientists expressed their surprise at the fact. A few of them surmise that carbon based compounds like methane were all burnt to produce condensed solid blocks of carbon.

8) Extremely high speed storms and vortices have evolved in the jovian atmosphere.

9) Weakly luminescent pair of rings of jupiter disappeared for the time being. Scientists surmise that either those rings have been completely destroyed or have been obscured under the thick cloud of dust and smoke created in those collisions.

10) Scientists do believe also that with each collision there must have been created pulses of shock wave which alike to the gravity wave or seismic wave of Earth may propagate through the curved paths within the Jupiter and consequently an overall vibration around the whole bulk of Jupiter will start. Change in internal temperature of the planet Jupiter will follow the gradient of which will be depicted through Infrared Imaging of the planet Jupiter.

Besides those as mentioned above there are chances that the following phenomena might have taken place as consequences of the great cosmic collision.

The change in the speed of axial rotation i,e. in diurnal motion might have caused a change in the length of a day and night on Jupiter. Moreover the extent of jovian magnetic field might have been changed correspondingly. If any change in the jovian magnetic field has really taken place which according to the oldest genius Sir Arthur C. Clarke is a very plausible fact. Then as a consequence a prolonged, though feeble, change in the terrestrial magnetic field, temperature and overall ionospheric distribution will surely take place. And such changes in extrasuperficial envelope of our Earth must have some geomorphologically connected psychopeysical influence on the life-style of human beings.

Conclusion

Tremendous amount of heat, generated in the great cosmic collision might have caused the production of highly excited rotating ionospheroid within which continuous or very frequent lightning may take place and in a naturally favourable circumstances the primordial soup ( as per scientists' view the life molecules were produced in that very way from organic compounds such as methane, ammonia etc.) and therefrom may evolve a neat ecologically balanced biosphere comprising plants full of fruits, nuts and animals from insects to mammals like man.

The role of Jupiter in this great cosmic collision of fragmented Shoemaker-Levvy 9 with itself is almost as unperturbable as the puranic preceptor of Gods. While described by means of a comparison, if the Jupiter be a football the Earth may be regarded as an ordinary glass marble ball and each cometary fragment may be regarded as a custard seed. As per the size the Jupiter is so large compared to the size of a cometary fragment that such collision can not produce appreciable changes in the kinematic condition of Jupiter although each such collision was so great in an exoergic measure as to be regarded equivalent to the one which seems to have caused the total extinction of Dinosaurus on the Earth six hundred and fifty billion years ago. Still there is no report of finding any jovian life; Yet it will not be very implausible or unrealistic to imagine that in near cosmological future there will be another 'Jurrassic Park' on the surface of Jupiter.