Teaching of Astronomy in Asian-Pacific Region

Bulletin No. 7

The 2nd Part of Special Issue of Teaching Astronomy Meeting in the Asian-Pacific Region

Mitaka Tokyo Japan
1993. 10. 1 --600--

If you have sent this format already, you do not need to send it again and will receive further bulletin automatically except having the further notion from us.

Dear Reader of This Bulletin:

Please send this format to

Syuzo Isobe
National Astronomical Observatory
2-21-1, Osawa, Mitaka, Tokyo, Japan

after filling up using type-writer.

Name _____
first middle family

Affiliation _____

Postal Address _____

_____

_____

Fax number _____ Tel number _____

I (want, don't want) to receive this Bulletin.

I (will, will not) contribute to present paper(s) to our Bulletin.

Title of paper(s) _____

_____

If someones are interested in our Bulletin, please make copies of this sheet and give them copies. Thank you for your collaboration.

Syuzo Isobe

Syuzo Isobe.

Preface

This is one of two special issues relating to the first meeting of Teaching of Astronomy in the Asian-Pacific region held in Beijing in October, 1992.

5 years ago in Beijing, we had the 4th Asian-Pacific regional meeting of the IAU which was much successful one. At a session during that meeting, Dr. Il-Sen Nha made a proporsal for us to have a Working Committee of Teaching of Astronomy of the Asian-Pacific region under the IAU. This proporsal was accepted by all the attendances, and accidentaly I was pointed out as its chairman.

In these 5 years, we published 5 issues of our Bulletin to which about 30 authors contributed, and we had two sessions on teachiong of astronomy during the 5th Asian-Pacific regional meeting of the IAU in Sydney in 1990.

Astronomy is the oldest science. China has a long histry over 5000 years in studying astronomy. However, in an ancient time only small fraction of people worked in this field. Nowaday, after develoment of astronomy and astrophysics, many people are interested in astronomy, but it is not well developed how to teach astronomy because of very quick development of astronomical research. In each country, teachers of astronomy have tried their own efforts.

Especially, since public interest in astronomy in the Asian-Pacific region becomes higher and higher, much more activities have been expected. Now it is very happy for us to have holded this meeting just before the 70 year anniversary of the Chinese Astronomical Society which was the most memorable time.

To have a good way in teaching of astronomy, it is very important for us to exchange ideas of people who are working as astronomers, school teachers, staffs in science museum, and leaders of amateur groups.

I believe this meeting made the first step to this direction, and I hope the 2nd, 3rd, 4th, and the further meetings will be held with many supports of people in each country.

Finally, I as a representative of all the attendances would like to express our thanks to the SOC co-chairman, Dr. Li Zongei, the LOC chairman, Dr. Lin Yuangzhang, and their colleagues to bring this meeting into reality and successful. We express also our thanks to the Chinese academy of science, the Chinese astronomical society, the Beijing astronomical observatory, and the Dynic Co.Ltd of Japan for their different kinds of supports.

1993, October 1

Syuzo Isobe
Chairman of Teaching of Astronomy
in Asian-Pacific Region.

Contents

A flower and a star
-An importamt aspect of human-being-

Syuzo Isobe
National Astronomical Observatory,
Mitaka, Tokyo, Japan

Abstract

Many people who engage actively in teaching and popularization of astronomy say that one should look at celestial objects such as stars, nebulae, and galaxies, since they are very beautiful. Is this statement true? One can also say a flower is much beautiful. Astronomy has a possibility to show what is a human-being since most of the astronomical phenomenon are written with rather simple physical principles and mathematical caluculations. Then, we found our universe as well as human-being is finite in time.
In order to understand a human-being, it is also important to study a flower, that is, biology. However, we have not succeeded to show it since biological processes are too complicate to give a final idea for the existense of human-being. Therefore, I believe we should prepare teaching package to people with different levels of astronomical interest, in schools, in planetariums, and in public education circles to follow this direction. Then, we can safely say researching and teachig of astronomy are more important than those of the other fields.

1. A flower and a star.

Twinkling stars under dark night sky are much beautiful. Many active amateur astronomers claims that one should watch a star because of its beauty. Is this totally true? A flower in an open field is also beautiful. One can occasionally get pleasant atmosphere just by looking at a flower. It is an obvious matter that a flower is as beautiful as a star is. Then, why don't amateur astronomers, who claim that one should watch a star because of its beauty, say that one should watch a flower because of its beauty? They are certainly intending to insist the other people to share their own hobby.

We, astronomers, observe and analyse stars. Some astronomers were amateur astronomers at their young age and have been enjoying to watch stars, but its fraction in number is not very large. Most astronomers as well as I are interested in data obtained through observational and/or theoretical analysis. I personally can not enjoy to watch a star all over the night during a cold night with a temperature below zero degree without sleeping under a telescope. Therefore, to escape from this uncomfortable

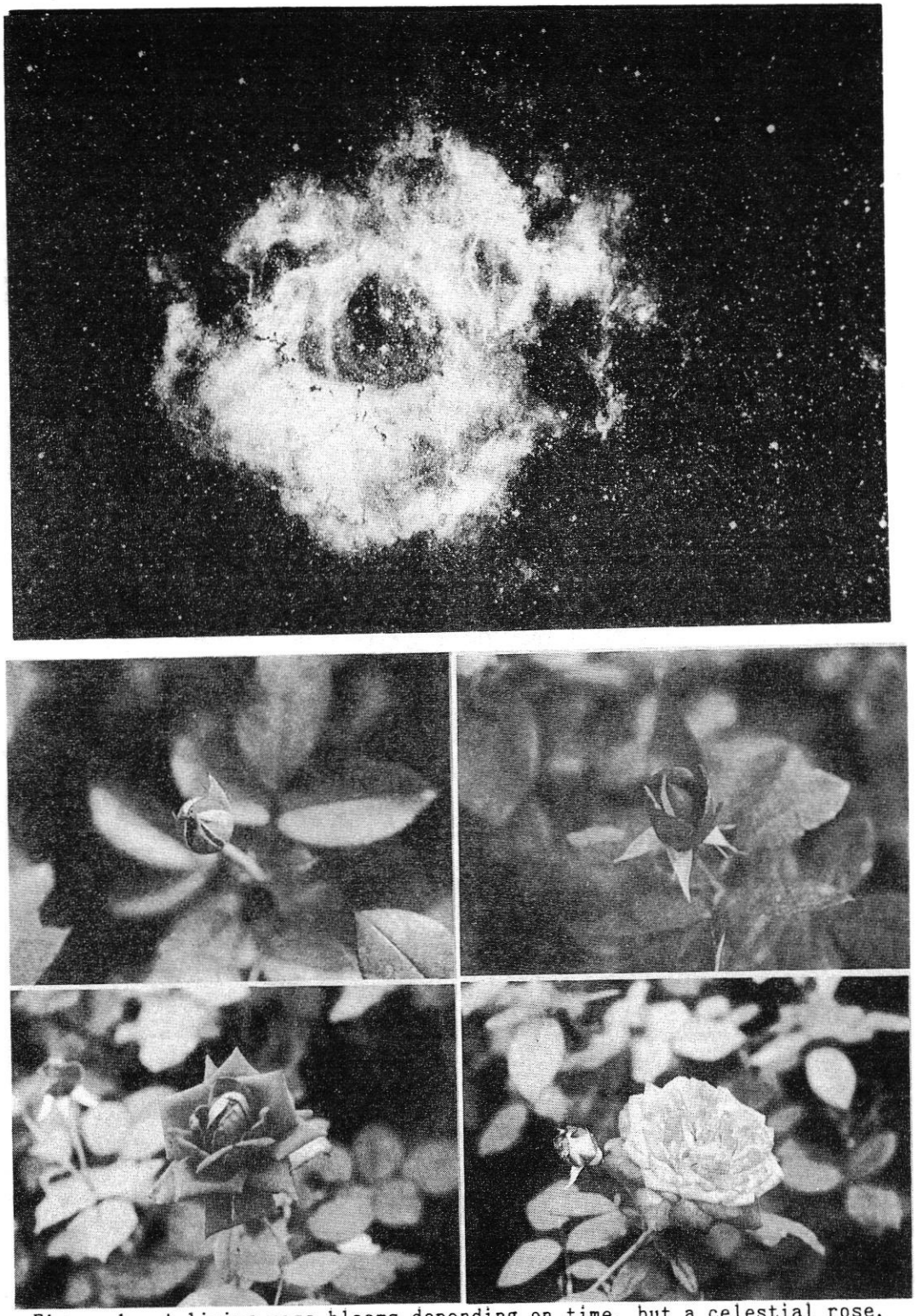


Figure 1. A living rose blooms depending on time, but a celestial rose, Rosette Nebula does not change in life-time of a human-being.

condition, I introduced a TV guide system, by which we can guide a star in a warm observing room. This was the first trial in Japan.

I do sometimes voluntary work for an event of star watching to public people. We prepare telescope to show celestial objects to them. However, there is a strict restriction that only one person can watch an object at once with a telescope. Although it is possible for us to prepare some number of telescopes with small apertures, only one telescope with an aperture larger than some tens in cm is able to be there, because of its high cost. Therefore, if we have more than several tens of visitors, only half or one minute is allocated for each one to watch a celestial object. To make many people watch clestial objects simultaneously, I tried to introduced a high-sensitive TV system about ten years ago. This was a completely unsuccessful effort. People get exciting by watching light from celestial object directly but do not enjoy those images obtained after transferring into electric signal.

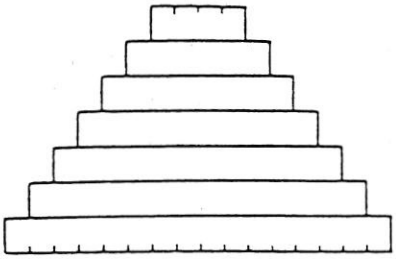
In a TV program, a flower of rose is displayed and we feel it very beautiful. Then, a series of time-leap images shows a delicate change of its pedals, which is an impressive scene. Such a photo of celestial object as Pleiades cluster and Andromeda galaxy is also beautiful, but it is not so impressive as different kinds of flowers showing much delicate variations. There is no restriction for each person to enjoy beauty of stars. However, if one works to popularize astronomy only because of the beauty of stars, we may think that he is egoistic.

2. Degree of astronomy interest

I showed figure 2 in some of my papers. This diagram was firstly present at the IAU colloquim No.105 held in Massachusetts (Isobe 1988). Fortunately, the diagram has been referred in many papers of astronomical education. Figure 2 is a schematic diagram for number of people in each categories depending on their interest in astronomy. Given numbers are nearly for a case in Japan. However, this pyramid structure can be applied for some other countries if some factor depending on population in each country is multiplied.

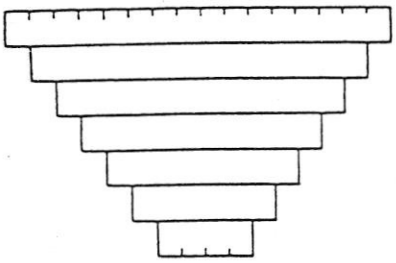
Figure 2a says: 1) nearly 100 amateur astronomers have a capability to produce astronomically meaningful data and this number is gradually increasing in this half decade, 2) nearly 10^3 amateur astronomers observe intensively, 3) nearly 10^4 people observe and/or watch celestial objects several times per year, 4) nearly 10^5 people regularly read astronomical magazines, 5) nearly 10^6 people read general scientific journals, and 6) nearly 10^7 people sometimes read scientific articles appearing in newspapers. However, nearly 10^8 people, about 90% of the whole population have no interest in astronomy.

This is a roughly correct structure in Japan. When one uses a word of teaching of astronomy or popularization of astronomy, what structure does he intend to bring in? There are fairly large numbers of active amateur astronomers even in developing countries. Those structures are not a pyramid one, but one with a shape of long tower as shown in figure 2c. Even if one works actively to popularize astronomy, it is certain that he



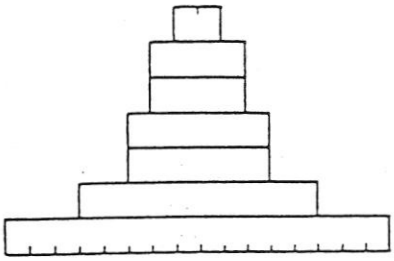
10^2	A	produce useful observational data
10^3	B	observe frequently
10^4	C	observe several times per year
10^5	D	read astronomical magazines
10^6	E	read general science magazines
10^7	F	read scientific articles in newspapers
10^8	G	no interest in science

Figure 2a. One example in a structure of education in astronomy. Here people are divided into 7 categories, A to G, depending on their interests in astronomy. This figure shows a structure in the shape of a pyramid, and is nearly the case in Japan.



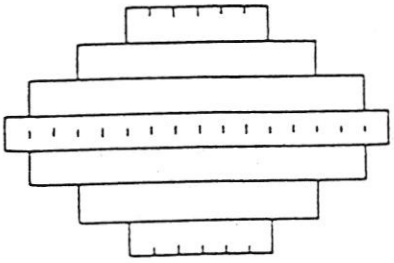
10^8	A	produce useful observational data
10^7	B	observe frequently
10^6	C	observe several times per year
10^5	D	read astronomical magazines
10^4	E	read general science magazines
10^3	F	read scientific articles in newspapers
10^2	G	no interest in science

Figure 2b. Same as for Figure 2a, but with a different structure. This is not a realistic case.



10	A	produce useful observational data
10^2	B	observe frequently
10^2	C	observe several times per year
10^3	D	read astronomical magazines
10^3	E	read general science magazines
10^5	F	read scientific articles in newspapers
10^8	G	no interest in science

Figure 2c. Same as for Figure 2a, but with a different structure. This case is frequently seen in developing countries.



10^3	A	produce useful observational data
10^5	B	observe frequently
10^7	C	observe several times per year
10^8	D	read astronomical magazines
10^7	E	read general science magazines
10^5	F	read scientific articles in newspapers
10^3	G	no interest in science

Figure 2d. Same as for Figure 2a, but with a different structure. This is the ideal one.

does not intend to change the structure into that of inverse pyramid shown in figure 2b. I believe that an ideal structure is probably that shown in figure 2d. In this case, most of the people are interested in science, read astronomical magazines, and watch celestial objects several times per year with enough scientific and astronomical knowledges.

When we, human-beings, spend their daily-life, we need few astronomical knowledges. One may say that astronomy contributes much to build a calendar and other several items, but even if we have no knowledge on them we can live without any difficulty. A shift of calendar days in several ten days per year may make much trouble for daily-living, but a shift of it in a few days per year does not produce any difficulty for us. If we had only this reason for people to be interested in astronomy, we could not expect that the structure should be that shown in 2d. We need much essential reasoning to popularize astronomy.

3. Astronomy without mathematical equations

Most of the pupils at the lower grades in an elementary school are certainly interested in astronomy. They have a variety of questions; How did the universe formed? Is there the edge of the universe? How did the solar system formed? Then, their questions extend further: Do UFOs exist? Do ETs (extraterrestrial intelligence) come to our Earth? Unfortunately, a degree in their interest in astronomy decrease depending on time in most cases, when they are proceeding to the higher grade. What is a reason for their loss of its interest?

In the Japanese educational system, a pupil should use many hours to prepare for entrance examination to a junior high school, a senior high school, and university, and looses time to enjoy celestial objects. It is said that this is one of the main reasons for their loss. However, I believe there is another strong reason; that is, many teachers in a elementary school do not like science. To become a teacher in Japan, it is not necessary for him/her to study all the scientific courses. Then, one, who can not enjoy to use mathematical equations, does not study courses of physics and geoscience including astronomy. We have several evidences showing that this is true situation. In our observatory, there is a section of amateur astronomer education, the head of which is myself, and which carries several programs as for public service. One of the main programs is to answer astronomical questions from public people through telephone lines. At the end of summer and winter vacation periods, school pupils often ask us that they could not find the moon in night sky although their teachers gave them a home work relating to change of the lunar shape night by night. We could easily find that the period which the teachers chose was just before the new moon and that one could only see the moon in early morning. Their teachers probably had a knowledge from only a text book that the moon changes its phase day by day but had never tried to watch the moon by themselves and to check the lunar phase at that period in a calendar. Since this type of teachers' misunderstanding occurs often, it is certain that school pupils are gradually loosing theirinterest in astronomy.

It is very difficult to understand astronomy without mathematical equations. When I am asked to write an astronomical book to public people, its editor always claims me not to use mathematical equations. Its reason is that a reader feels the book is difficult when he picked out it from a bookshelf and found many mathematical equations in it. Then, he does not buy it. It is very difficult to explain the Kepler's law without mathematical equation. If one use a^3/P^2=constant where a and P are a semi-major axis and an orbital period, respectively, then pupils in the elementary school can calculate it for each planet. If one can not use the equation, it is clear that one needs too long complicate explanation. Further, if one can not use mathematical equation for a distance of celestial objects, it is impossible for him to have any idea on its accuracy. An expression of $r=1/\theta$, where r and θ are distance in a unit of parsec and annual parallax in a unit of arc second, respectively, shows clearly how an error of θ propagates to that of r. This question can also be managed by pupils in the elementary school. Pupils in the senior high school are able to introduce a distance modulus of $m-M = 5 \log r - 5$, where m and M are visual and absolute magnitude, respectively. Then, it becomes clear how observational errors of m and M propagate to the error of r.

A question raised by many pupils in the elementary school is what our universe is. They knew a word of big-bang. An important first step to answer it is the Hubble's law of $v= Hr$ where v, H, and r are radial velocity in a unit of km/s, the Hubble constant, and distance in a unit of mega-parsec. Pupils in the elementary school can probably understand that our universe is expanding if they are given a knowledge that many cosmological objects follow the Hubble's law. And then, running back to the past, a curious idea, that our universe was once so small as a pinpoint, is coming up to them. It is a starting point in studying science for them to have a question.

Recently, many books relating to the Hawking's universe have been sold, but only a few public people understand its contents. University students have possibility to understand it with a knowledge of complex wave-function. Our universe is not expressed by complex wave-function in only space but also in time. Even for university students, it is much difficult to have a correct concept of imaginary time, but a symmetrical formula expressed in complex wave-function can give a clear idea to imaginary time.

I do not intend to say that all the public people should know mathematics to catch an idea of astronomy, but I do that at least teachers and instructors in astronomy should have enough knowledge of astronomy and then teach astronomy to school pupils without missing essential points. If teachers do not understand essential points, they may make such mistakes as that they give school pupils a home work to watch the moon at the period of new moon.

4. A role of planetarium in teaching of astronomy

A planetarium has an important role in teaching of astronomy. It

shows that all the celestial objects move in the sky. Ancient people felt these motions in their daily life. However, there are a fraction of people who have opportunities to watch celestial objects, and therefore most people have never watch celestial objects so long hours to feel their movement in the sky. Because of outdoor-lighting in a big city, night sky can not be enough dark but whitish, and therefore we can only see moon, planets, and several bright stars.

In the last section, I showed how important to introduce mathematical equations in understanding astronomy. However, to understand the daily motion of celestial objects correctly, one should have a knowledge of spherical triangle. In this case, not only school pupils but also university students studying in non-scientific faculties are not able to understand it. I believe that it seems essentially impossible to teach complicated diurnal motion of celestial objects to school pupils. We should abandon to teach their exact motions, but it is just enough to make them feel that celestial objects are continuously moving in the sky.

Recently in Japan, many planetariums with an inclined floor, in which so-called auto-programs are projected, have been built. The main reason of this tendency is not based on a point of teaching of astronomy but on a governmental point of view. The planetariums with an inclined floor can be used for the other shows or lectures, which are multi-purpose theaters. By introducing auto-program, local governments have a tendency to stop in employing staffs with good astronomical knowledges. Moreover, since celestial objects under horizon are projected on this type of dome, school pupils may have mis-conception. Although there are some number of good auto-programs, those production cost is high. Especially, it is too much high for programs using the whole dome as a projection screen. These expensive programs would be acceptable if we assumed them to be as a movie theater. However, a movie with a good story is certainly much better than those auto-programs.

People visit a planetarium with different purposes. Some people visit to see stellar constellations, some others visit to watch stellar diurnal motions, and the others visit to study stellar characters and then astronomy itself. It is very difficult to make all different people satisfy by a single auto-program. Only staffs with wide-range of astronomical knowledges can provide informations matching to each level of visitors. It is necessary condition for a good planetarium to have staffs with this ability. To achieve this, we should start to give good education to presently working staffs, and therefore we need long constant efforts. We should make number of people supporting popularization of astronomy increase one by one to figure planetarium in a good shape.

5. Astronomy for human-being

Coming back to the first section, we will again think how astronomy is important for human-being. We spend daily-life without thinking about astronomy. However, when one gets some period of free time, he may think why he is there and why human-being is alive. There are people saying that these types of questions seem to belong philosophy and religion.

Then, one may have a possibility to solve these questions by deeply thinkig. Is this only a way? Is there no way to answer this question scientifically.

To think why human-being is alive, one should study living species by bio-physics; how does a flower live, how does a flower grow, and what environmental conditions does a flower need to survive? Further questions follow one by one. In these years, researches of bio-physics have been progressed, but what we have to study remains much and its mechanisms are too complicated to discuss meaning of human-being or life itself.

On what stage is astronomy relating to the above-mentioned point? Astronomical phenomena are relatively simple and are able to be solved by physical law. We now know that our Sun will stop to shine about 5 billion years later and that our universe itself has its end. In the shorter time scale, the human will be extinct by a collision of asteroid to the Earth. An answer given by astronomy is that the human can survive within a finite time period.

We often think that the human will survive forever even if each individual person certainly dies. Astronomy destroyed completely this concept. Moreover, following to the recent theory of inflation universe, our universe seems to be one of many bubbles appearing and disappearing. Then, questions what a human-being in this universe is and why a human-being is alive in this universe is coming out.

Both the flower and star are beautiful. They are presenting important materials to give some answer(s) to the above-mentioned questions. From a side of star, that is, astronomical side, an outer frame to answer them is nearly settled. The next step will be forwarded from a side of flower, that is, bio-physical side. There are so many people who love a flower, but only few people who watch a flower on this standpoint. A star is beautiful. Fortunately by studying astronomy we are nearly reaching to find some degree of answers to those questions. Therefore, in these years it is essential to draw people's interest in astronomy, to teach astronomy and to give them some concept on our universe. I stress that one engaging to popularize astronomy should definitely keep this concept in their mind. Certainly in the next step, bio-physics will play more important role than astronomy.

A flower and a star are not only beautiful but also have a possibility to give an answer for a meaning in existence of human-being.

References

Isobe, S. 1990, in The Teaching of Astronomy, IAU Colloq. No. 105 (Massachusetts, 1988), ed. J. M. Pasachoff and J. R. Percy (Cambridge University Press, Cambridge), p. 109.

Astronomy —— The Front of Basic Physics Education

ABSTRACT

Jianhu Zeng
Department of Physics
Huazhong Normal University
The People's Republic of China

With the development of observation technique, a new astronomica observation age has been opened with γ—ray, X—ray, ultraviolet ray, infrared ray and total—wave, ect. advanced technique. New celestial bodies have been found, also some astronomica phenomenon difficult to be explained. All of these wealthy phenomenon and procedue deeply reveal the mysterious of the universe. Making correctly and clearly explaination to these phenomenon impels us to develop the theory of nature science furtherly, especially, Physics.

I. Basic Physics Educaion Must Be Closely Integrated With The Front of Physical Research.

It is generally considered that basic content is comparatively basic and fixed. The front is probale and mutable. Not all the content in basic physics education is absolutely correct or have been strictly proved. Newton said "• • • I have infered that force keeping the planet on its orbit must be inversely proportional to the distance between the planet and the center of the orbit. After that, I compared the force keeping the moon on its orbit with the gravity on the surface of the earth, both are almost equivalent • • • " Several centuries passed, in textbooks or in the classes, the question we discussed above is indecated as absolutely correct or equivalent. In the research of modern astrophysics, whether r^{-2} law has been strictly proved? Whether approximate equivalent means absolutely equivalent?

$$F \propto \frac{1}{r^2}$$

$$V=-\frac{GMm}{r}(1+\alpha r^{-r/\lambda})$$

α and λ can be neglected only when r is extremly large. The test is: When $r=1$ AU r^{-2} law fits best

When $r\geqslant 10$ KM r^{-2} law fits very well

When $r\leqslant 15$ CM r^{-2} law fits well

When $1\text{M}\leqslant r\leqslant n\text{KM}(n\leqslant 10)$ r^{-2} law fits bad

But in the class, we seldom introduce the provement, only indicate that gravitation is universal.

In twentyth century, there are many new finds in astronomica field:

1963	quasar, 3K microwave backround radiation
1967	pulsar
1970	X—ray binary
1971	the expand of superlight velocity of radio source
1977	solar neutrino stream abnormal
1978	the gravitation radiation damp of binary system
1979	gravitation lens
1982	magnetic monopole

Especially, the four important finds in the 1960's, quasistellar, pulsating star, 3K microwave background radiation interstellar particles. Among which, the finds of pulsating star and 3K microwave background radiation got Nobel Prize.

II. Achivement of Astronomy Should Become the Front of Basic Physics Education.

1. The finds of PSR 1913+16 radio binary and orbit periodic change first time proved the existence of gravitation wave. According to the general theory of relativity, gravitation radiation reduces PSR 1913+16 orbit period with rate 2.6×10^{-12} the observation result is 3.2×10^{-12}, both accord with each other very well.
2. Celestial body evolation is one of the three front of nature science. What mass of celestial body will evolve to fixed star, white dwarf, neutron star or black hole? Why different star has different end—re-

sult after nuclear reaction?

Caculate the procedue of star from cold to hot, and then from hot to balance. Deducte with the theory of gravitation, statistical physics and quantum mechanics according to equilibrium condition of fixed star, white dwarf, neutron star and black hole.

The condition what the celestial body starts to contract is:

$$T_c < \frac{2GMm_N}{3Kr}$$

m_N —— Mass of particle M —— Total mass

When pressure balance with gravitaion

$$P \approx \frac{GM}{r}\rho$$

$$nKT \approx \frac{GM}{r} \cdot m_N \cdot n$$

$$T_B \approx \frac{GM}{Kr} m_N$$

$$M_\odot \sim 10^{33}\text{g}$$

$$r_\odot \sim 10^5\text{KM}$$

$$T_\odot \sim 10^7\text{K}$$

When the nuclear reaction stop, there is a balamce between self-gravitaion of celestial body and degenerate pressoure such as white dwarf and neutron star.

$$\rho_{WD} \approx 10^4\text{g/cm}^3$$

$$r_{WD} \approx 10^4\text{KM}$$

$$\rho_{NB} \approx 10^{15}\text{g/cm}^3$$

$$r_{NB} \approx 10\text{KM}$$

When cold degenerate pressure still fail to contend with self-gravitation the celestial body

$$r = \frac{2GM}{C^2}$$

The celestial body becomes "Black Hole" for the observer.

$$M = M_\odot$$

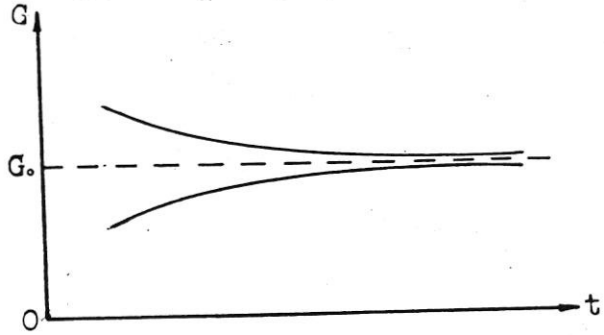
$$r = 3\text{KM}.$$

3. Whether gravitational constant G will change with time?

Based on

$$T_B \sim \frac{GM}{Kr} m_N$$

Observation result of ancient organism traces in remote antiquity illustrates no changes of G.



Solareclipseis a astronomical phenomenert closely related with gravitation, according to observation data of solar eclipse

$$\frac{\dot{G}}{G} < 10^{-11} \qquad yr^{-1}$$

So G is a constant, at least it is a constart of little changes.

4. The Problem of Solar Neutrino Missing

The sun is the source of life on the earth. It is the issue of common interest about energical internal structure and evolution problem of the sun. Not untill 1960's that people basicly considered there were definite conclusion, the source of solar comes form $\frac{1}{4}$ $R_\odot$ area of the solar centre (energy-producing area). The thermo-nuclear-fusion reaction is four Hydrogen nucleons chemical combinate to a Helium nucleon, losing quanity changes to energy and released. In the abouv enuclear reation procedue, there are proton — proton reaction and Carbon-Nitrogen-Oxygen cycle. The nuclear reactions are as following:

$$^1H + {}^1H \rightarrow {}^2D + e^+ + \nu + 1.44\text{Mev.}$$

$$^2D + {}^1H \rightarrow {}^3He + \gamma + 5.49\text{Mev.}$$

$$^3He + {}^3He \rightarrow {}^4He + {}^1H + {}^1H + 12.85\text{Mev.}$$

$$\text{Sum} \quad 4\,{}^1H + 2e^- \rightarrow {}^4He + 2\nu + 26.67\text{Mev.}$$

Every neutrino takes 0.26Mev energy. In C-N-O cycle, every neutrino takes 1.7Mevenergy. In the energy-producing area, there are still some other junior reactions producing meautrino. Physicists believe that the

action area of neutrino and other material is so small, about $10^{-42} \sim 10^{-46} cm^2$, that neutrino can escape from solar center without any hindrance, and the probility neutrino absorbed by other material can be negligible. So, determing solar neutrino emission is the only way to directly "observe" the solar interal structure and energy-producing mechanism at present.

The solar standerd model prophetics that are two neutrinos released in the H→He reaction procedue. So, the neutrino flow on the earth should be

$$I_{(\nu)} = \frac{2L_{\odot}}{25(\text{Mev}) \times 4\pi(A)^2}$$

$$= 3.5 \times {}^{1}0\ 12 \quad \text{neutrino} \cdot cm^{-2}S^{-1}$$

In order to "catch" neutrino, Davise, an America scientist, and his cooperators put a very big jar containing 390,000 kl C_2Cl_4 solution in a 1,500 metres deep abandoned gold mine in ; used it as a trap of neutrino. When neutrino passing through, the reaction will happen:

$$\nu + Cl^{37} \rightarrow Ar^{37} + e^-$$

Cl^{37} changes to Ar^{37}, release a electron e^-. Ar is a radioactive element, the amount of neutrino ν can be got by counting Ar atoms with counter. In terms of theory, it needs 1.8×10^{35}Cl atoms per second to catch an netrino. There were 2.2×10^{30}Cl atoms in the big trap, so 1.1 neutrino would be caught per day. Acturally, there was very little chance to catch one neutrino even per five days according to the reports from 1968. Davise and his menanalysed the measuring instrument again and again, and considered it was reliable. This was "Neutrino Missing" case. The Energy—Producing Mechanism became critical.

In order to solve this contradictory, Astronomers and Physicsts have given out many explainations. For example, heavey element in the solar interal was 0.1%, not 2.5%; The rotation of solar interior was much greater than its surface; There was a 10^2高斯 strong 解 field in the center of the sun; P—P reaction was not the main reaction of the solar energy—producing; Neutrino had static quanity, ect. Facing this puzzle, scientists think the best way is continuing the experiment, and plan to use $Ga^{71}$to catch neutrino.

$$Ga^{71} + \nu \rightarrow Ge^{71} + e^{-}$$

In Davise's experiment, ν could be measured only when its energy was higher than 0. 8Mev. However, in the new experment ν can be measured even when its ensergy is 0. 233Mev. Some other designed to use Li^7 to catch neutrino ν producing Be^7. The energy of neutrino which can be caught by Li is 0. 86Mev, but the rate of Li^7 catching neutrino is more than 30 times of Cl^{37}.

By using new and more effective measurer, we are expecting to get new information of neutrino.

The developmemt of ontempovary astronany is never imifed in the range of cosmo logy. From controversy of quasar red shift to probe of gravition, from 3K microwave background radiation to different theories of universal origin, from plusating star to black hole, from missing of solar neutrino to mechanism of celestial body explosion, all of these puzzle sciencists and encourage them probe further.

In brief, combination of astronomy research front and basic physics education not only enriches education content, let the students get a deeper understanding, but also enlivens students' mode of probe.

III. Facing Society, Developing Popular Science Activities, Training Astromical Science And Technology Counsellors Are Our Honour Task.

1. Offer the astronomy course in Physics, Geography and some liberal departments.

   We have compiled astronomy, astrophysics and astronomy observation, ect. textbooks. Set up astronomy education lab.

   We have three equatorial, one azimuth mounting astronomica telescopes, one Minota Mo—6 planetarium, astronomica slide, video tape, film and projector. Now, we are preparing to establish a planetarium with 8M diameter, $800m^2$ area. we have organized astronomy amateur group, persist in observation, e. g. Lunar eclipse happened on May 5, 1985, from 2^h16^m, first contact started, to 5^h36^m, last contact finished, teacher and students observed whole night and met the coming dawn.

2. Lead students to join practice of astronomica observation.

A. Nov. 1985 to May. 1986, Halley's comet regression, led a team of students to observ it in Sanya, South sea Isaned, and got a lot of vaouable photographs.

B. In Sep. 1987, observed solar annular eclipse in Hami, Xinjinag, got whole set of photograph data and photometry gradient photograph.

3. Face society, develop popular science activities.

A. Conducted Youngsters Summer Camp in 1984 and 1985 supporting Astronomy Institute of Hubei Province.

B. Nov. 1985 to Jan. 1986, Halley's comet regression, we organized more than 20,000 people to observe this rare phenomenon using our own astronomica telescopes.

C. In May, 1987, We conducted a National training class for training solar annular eclipse observation assistants. This exercice laid a foundation for the sucessful observation of solar annular eclipse on Sep. 23, 1987.

In a word, we have made some contribution to popularize astronomy-knowledge and enhance national qulity.

A "Chinese-puzzle" Method to Visualise Cosmological Evolution.

by

M. S. A. SASTROAMIDJOJO.

Solar Physics Lab. Gadjah Mada Univ.

Yogyakarta, Indonesia.

Abstract.

A "Chinese-puzzle" method to visualise cosmological evolution is proposed to help students in astronomy to connect cosmological evolution to fundamental particle physics.

Whereas the latest development in fundamental physics have made use of theory of groups, symmetry and supersymmetry backed up by megabyte computers, the "Chinese-puzzle" method makes only use of a parallel array of toothpicks which can be rotated in three dimensions.

The total cost is about one dollar (American).

Introduction.

A student in first year physics confronted by a photograph of parallel lines of different blackness in a laboratory course in optical physics is usually at a loss how to proceed to find what kind of elements make up the sample.

He is introduced to spectra by way of the Sodium double line and different other spectra caused by high voltage discharges in Geiszler-tubes.

This is to familiarize him with the Hydrogen spectrum, CO_2 spectrum and many others but when confronted with a solar spectrum for instance with hundreds of lines he is usually at a loss of how to proceed.

He is then introduced to procedures using tables and is

given some formulas, demonstrating the Balmer, Paschen series and so on.

He is also told in a course of atomic physics about the different models of atoms like for instance the Rutherford atom model.

Everything is still done in the laboratory, and he knows the physical procedures to obtain spectra. But when he comes to spectra emmited by celestial objects, like the sun and the stars he must start to speculate and extropolate from his laboratoey to locations lightyears away.

He reads then about relativity, quantum theory and all kinds of fundamental physics theories, less and less based on data from the laboratory and more and more on mathematics till finally he finds out that a great deal is pure speculation and not yet confirmed in the laboratory. He hears about "theories of everything",singularities and infinities and it becomes more and more difficult to conceptualize, to imagine what happens in those "singularities" and finally he gives up and waits for the next uninmaginable theory to come along.

It is for these students that the "Chinese-puzzle" method was invented.

Method.

1. The basic element of the "Chinese-puzzle" consist of a parallel aray of strips, of metal, plastic or other cheap material each of which has a symmetrical axis lengthwise fixed to it.
2. The strips can be turned around any number of turns.
3. All the strips can be numbered according to whatever scheme the manipulater has in mind.
4. All the strips are easily removed and can be fixed in any sequence.
5. The whole array can be rotated around three axis simultaneously.

6. All three axis of rotation are perpendicular to each other.
7. Depending on how to axis of rotation is fixed, we get three circular rotations perpendicular to each other or for instance ellipses or ellipsoids or combinations thereof.
8. All kinds of geometrical configurations can be drawn on the surface of the strips.
9. How to work the "Chinese-puzzle":

No.	Strip-operation	Results
1.	Strip piled up random fashion.	
2.	A normal human face is displayed on the combined strip. The red-with marks on the box are visible. The strips are numbered from 1 to 8.	What we observe is a human face.
3.	The observer moves to the other (back) side of the box. The box itself does not change orientation, does not move.	The observer sees a black line sloping from the lower lefthand side to the upper righthand side and a line of red dots going from the lower lefthand side to the upper righthand side. Everything is in the original state. There are no red-white marks and the numbers on the strips from left to right are 8 to 1.
4.	Every single strip is rotated counter clockwise.	The black line slopes from the upper left to the lower right, and the red-dot line slopes from upper left to lower right. The red-white line is in front and the strips display the numbers (1) left to (8) right.

5.	Every single strip is rotated counter clockwise only once.	The normal skape of the human face is observed. The red-white line is in evidence in front. The strip numbers read 1 (left) to 8 (right).
6.	The observer moves to the back; the box is stationary.	The black line moves from down left to upper right. The red dots likewise slope from the lower left to the upper right. The red-white line is not in evidence. The strip numbers read 8 (left) to 1 (right).
7.	Every strip is rotated clockwise.	We observe the human face symmetrically distorted. Strip numbering read 8 (left) to 1 (right).
8.	Every strip is rotated clockwise.	The black line changes its orientation from upper left to lower right hand side. We observe the red-white line in front and the strip numbering reads 8 (left) to 1 (right).
9.	Every strip is rotated counter clockwise.	The face is distorted symmetrically. Strip numbering is from 8 (left) to 1 (right). The red-white line is not in evidence.

10.	Every single strip is rotated once counter clockwise.	The change in slope of the black line is from the upper left to the lower right. The line of red points go from upper left to the lower right The red-white line is in front. The strip numbering goes from 1 (left) to 8 (right).
11.	Every strip is taken out and given a new position.	We observe the normal human face. The red-white line is now in the back. The strip numbering now read 1 (left) and 8 (right).
12.	The observer moves to the back; the box is not moved at all.	The black line slopes from the lower left to the upper right and the red dots like wise go from the lower left to the upper right. The red-white line is in the front and the strip numbers go from 8 (left) to 1(right).
13.	Every single strip is rotated clockwise.	The face is distorted symmetrically. The red-white line is visible and the strip numbering is from 8 (left) to 1 (right).

14.	Every single strip is rotated clockwise.	The black line goes from upper left to lower right and the red-dot line likewise goes from upper left to lower right. The red-white line is not visible and the strip numbering goes from 1 (left) to 8 (right).
15.	Every single strip is rotated counter clockwise.	The human face is distorted symmetrically. The red-white line is visible in front. The strip numbering goes from 8 (left) to 1 (right).
16.	Every single strip is rotated counter clockwise.	The black line slopes from upper left to lower right. The red-white line is in the back and the strip numbering goes from 1(left) to 8(right)

Note:

1. M P = red-white line.
2. K = no-colour edge.
3. 1-8 = strips show the smallest number (1), on the left and the largest number (8), on the right.
4. 8-1 = strips the largest number (8) on the left
5. At no point in the whole process are numbers taken off the strips. They are glued to the strips and adhere to the strips during all the manipulations and rotations.
6. Outside the sloping lines there is always a horizontal line which is the basic reference line for all operations.

Results.

The "Chinese-puzzle" instrument is a kind of Kaleidoscope in which one can by the use of symmetrically placed mirrors get all kinds of symmetrical figures, often in colors.

The "Chinese-puzzle" instrument differs from the kaleidoscope that the student can generate all kinds of situations which are either symmetric or not; but by rotating all the planes a symmetric movement is generated.
By using coloured pencils easily erased, one can use the instrument over and over again.

Discussion.

The "Chinese-puzzle" method is in essence a "reversed-problem-method".
Whereas usually the student is at the "receiving" end in the tug-of-war between student and instructor, in this case he can generate all kinds of problems because he starts out with the answer and ends up with the question.

For instance, he can draw a coloured cat on one side and a straight line on the other side of the parallel array of strips. He then mixes up all the strips and asks his opponent to find out what he had in mind.
His opponent gets a randomly marked array of strips of different colors to start out with. The strips are not yet fixed to the rotating frame.

The problem looks insoluble.

But by standard methods of analysis, for instance, gathering all the colours in one aray looking for a baseline, etc. etc. in fact doing the same procedures one has to do analysing an unknown element in a spectrum of a celestial source one can often get the answer to the problem.
One can also try to generate by different procedures to generate well known cosmological configurations. For instance: how does one generate a spiral? If one can generate a

spiral, how will the spiral move in one, two or three dimensions?
Or, with everything rotating can we still have a stationary point? The "Chimnese-puzzle" method like the kaleidoscope can be use by small children for fun and for grownups to help the visualize movements which are very involved mathematically.

How can we simulate symmetry, and supersymmetry?

It has been remarked that everything done with the "Chinese-puzzle" instrument can be done with a computer.
I doubt it. If every rotation (and its reverse) are manipulated by three students, the resulting movements are "3X infinite". And this is only the beginning.

If random impulses are introduced. We will have another family of phenomena. There is no computer to my knowledge wich can cope with the magnitude of that problem.

One problem for instance in sub-atomic physics is what happens when an electron switches from one "Pauli-orbit" to its symmetrical counter part. We only are told that the electron-spin is the only difference.
However no-one can imagine what happens between the flipping over from one spin to the other.
Since no-one has ever seen an electron this should not be taken too seriously.
The "Chinese-puzzle" is only to help you to create problems to visualize processes.

In astronomy this has been done many times before, for instance by Kepler and by Hieronymous who made an armillary sphere with the signs of the Zodiac in Vulpariae, Florence in 1554.

Conclusion.

The "Chinese-puzzle" in and outside the field of astronomy can be usd for fun and profit.

In the hands of children it can be great fun, in the hands of a future Kepler, it will earn a Noble-prize or two.

Future Work.

By using small electromotors and video-cameras, the "Chinese-puzzle" method will become more sophisticated. However entropy (law of diminishing returns) will raise its ugly head; also the prize goes up.

Acknowledgement.

Thanks are due to my three secretaries, and the staff of the solar physics laboratory, in particular to Mr.Ruslan, my assistant in physics and astronomy who constructed the various "Chinese-puzzles".

References.

1. Davies, Paul and Gribbin, John,
"The Matter Myth". Viking Press, 1991.
2. Buckley, Paul and Peat, F.David,
"A question of physics. Conversations in physics and Biology" Univ. of Toronto Press, 1938.
3. Pagels, Heimz, R.
"Perfect symmetry". Penguin 1985.
4. Tinkham, Michael.
"Group theory and quantum mechanis"
Mc.Graw-Hill, New York. 1964.
5. Collins, P.D.B., Martin A.D. and Squires. E.J.
"Particle physics and Cosmology". Wiley New York. 1989.

BIO - DATA

M.S.A.Sastroamidjojo was a lecturer at the Faculty of Science Gadjah Mada University, Yogyakarta, Indonesia (1949-1986).

Born the 21d of July 1921 in Selat Panjang, East Sumatera, Indonesia. Educated at M.I.T. (B.Sc Physics), U.C.L.A. (M.Sc.E Nuclear Engineering) and A.N.U. (Australian National University where he got his Ph.D. (Solid State) in 1974.

He is now the head of the S.E.R.C. (Solar Energy Research Centre) was a co-editor of the International Journal of Solar Energy Materials and a senior scientist on the staff of the Indonesian Space Agency.

In February 1985, he applied for a place on board the ill fated Challenger, as "space-mission-specialist" in the field of Astrophysics specifically to record "sun-spot evolution".

In July 1985 he got the annual award for outstanding work in the fields of Biology, Food-Technology, Renewable Energy Sources Physics and the Philosophy of Physics Education.

Outside his professional activities he is interested in Synergetics as a key to understanding the Javanese shadow puppet performance and in "Sufic teaching methodology in wayang stories". He is currently engaged in analysing the aspects of "chance and necessity" in Javanese philosophy.

Astronomical Easy-to-Use-Paper-Tools

Tiansheng Xiao
The Planetarium of the Children's Palace of
China Welfare Institute

Ⅰ. Abstruct

Many astronomical phenomena hold strong appeals to childrern. The elementary knowledges of astronomy are closely linked with observation, that is why the teaching of astronomy is always linked with observing practice. However, because of the poor means and some interferences in teaching of astronomy especially in elementary and middle school, it is very hard to arrang teaching practice. for example, 1. Most observing must be at night, this is not so suitable to children. 2. Light pollution on city makes observing much more difficult than ever before. 3. Communication difficulties allow students few chances to go suburb for observing practice. 4. Most schools have no telescope. 5. The weather conditions and fee to arrang activities are also problems to be concernded, That will make students feel dull very often. Little by little, students will lost their interesting in astronomical study, and we will lost our teaching objective.

Ⅱ. Astronomical Easy-to-use-paper-tools

To attract students' interesting in astronomy, and encourage them to thought and hand on activities to offset the poor prectice means, the Planetarium of the Children's Palace of China Welfare Institute has designed dozens of astronomical easy-to-use-paper-tools and applied in teaching. Some of the tools can be used as demonstrators to show the astronomical phenomena and make abstract concepts into concrete. (like Terrestrial Globe, Lunar Globe, Martian Globe, Celestrial Globe, Demonstrator of the Earth Revolution with Solar Terms, Demonstrator of Black Hole & Meteo and Planetarium Projector). Some are used as instruments for special observation (like Sundial, Pinhole Meter of Solar Terms and Theodolite). While the others are used as instruments to predict future astronomical phenomena (like Predictor of Lunarphases and Tides, Predictor of Planets' Position, Predictor of Venus' and Mars' Motions, Double Directions Planisphere).

** These tools are as follows:

2.1 The Earth and Sun

a. Terrestrial Globe.

b. Pinhole Meter of Solar terms
—— Measure the solar terms and longitude.

c. Demonstrator of Sunshine with solar terms
—— Demonstrate the sunshine in different places and in different solar terms or dates.

d. Terrestrial Globe with time zone
—— Demonstrate the different local time on different time zone while in the same time.

e. Demonstrator of the Earth Revolution with solar terms
—— Demonstrate the earth's revolution, rotation and precession. Also it can demonstrate tropical motion, solar terms and solar positions in zodiacal signs.

f. Demonstrator of the Earth Revolution in Zodiacal Sign
—— Demonstrate the earth's revolution, rotation and precession in zodiacal signs.

g. Sundial
—— Measure the time, direction and the day or solar terms.

h. Theodolite
—— Measure the latitude, longitude and time.

2.2 The Moon and Eclipses

i. Moon Globe

j. Demonstrator of Lunarphases
—— Demonstrate the Lunarphases.

k. Predictor of Lunar phases & Tides
—— Predict the lunarphases, time of moonrise, moonset and tides.

l. Predictor of the Eclipses
—— Predict solar and lunar eclipses. If co-used with the Predictor of lunarphases and tides together, the exact dates of eclipses can be predicted.

2.3 Planets

m. Martian Globe

n. Predictor of Mars' and Venus' position in zodiacal signs.

o. Predictor of Planets' Position
—— Predict Venus', Mars', Jupiter's and Saturn's positions in zodiacal signs.

2.4 Consterlltion

p. Planisphere

q. Double directions Planisphere

r. Circumpolar Planisphear

—— Demonstrate the starry sky and measure the time or the directions.

2.5 Celestrial Globe

s. Celestrial Globe

—— Demonstrate Celestrial Coordinates.

t. Planetarium Projector

—— Demonstrate its diurnal, annual precessional and latitute movements of planetarium sky.

u. Astronomical Basic Creation 7 in 1

—— 1) Demonstrate the starry sky. 2) Predict the lunarphases. 3) Measure the time . 4) Predict the solar and lunar eclipses. 5) Measure the solar terms. 6) Mesure the latitude and longitude. 7) Predict the dates and the direction when Venus appear.

v. Demonstrator of Black hole and Meteo

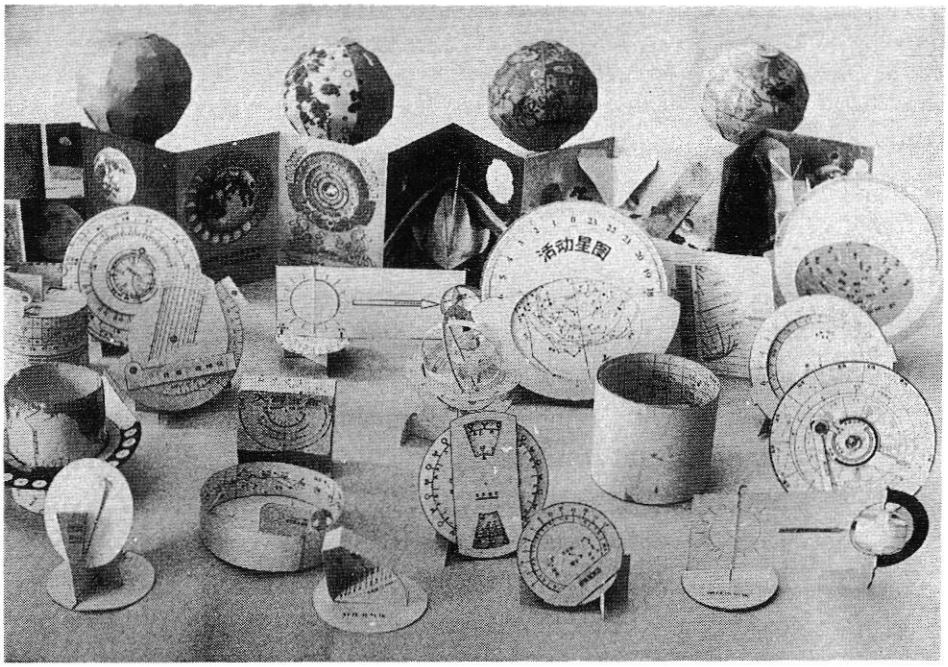
—— Demonstrate light fall into a black hole, also show a meteo.

w. Fly to the Moon

—— A pop-up book including a Predictor of Lunarphases and Tides, a rocket fly to the moon, the moon car, the astronauts on the moon, and telescope on the moon.

All these tools are made of papers. The only tools to making these tools is a scissor and glue. The instruction for making are available, so it is easy for students' making. These tools forming a whole teaching system for students younger than teenages, allow students to think and do by themselves and imply teaching in playing. With years practice, we have found this system is workable.

The Astronomical Easy-to-Use-Paper-tools' copyright by Min Naishi, associate professor of the Planetatium of the Children's Palace of China Welfare Institute.


活动星图

SPACE ART AND ASTRONOMY

LI Yuan
Professor, Chinese Institute for Popular Science
P.O.Box 8113, Beijing, P.R.of China

Part I. A Historical Survey of Space Art.

Space art is the art of astronomy and astronautics. It is the art of the universe and space and reflects the astronomical achievements and discoveries, as well as space flight and space technology.

The earliest space art that I know of was done by the Italian artist Donato Cret in 1711. He did eight astronomical oil paintings of the sun, the moon, the planets Mercury, Venus, Mars, Jupiter and Saturn and a comet. These paintings are now kept in the Vatican Monument. They were published by the Pergamon Press for the Proceedings of the 11th Lunar and Planetary Science Conference, 1980 (Vol 1).

Another early work in space art was done in 1865 as an illustration for Jules Verne's famous book called "From the Earth to the Moon".

At the end of the 19th century, many astronomical paintings were done by the German artist W.Kranz. They were published in the five volume encyclopedia "Weltall und Menscheit" (Universe and Mankind) in Berlin.

During the early years of the 20th century, Abbe Moreux, E.L. Trouvelot and Lucien Rudaux produced some beautiful astronomical paintings for the book "Splendour of the Heavens" (published in London) and another two books called "Le Ciel et l'Universe" and "Le Ciel" published in Paris.

The French astronomer and artist Lucien Rudaux can be called the pioneer of space art in modern times. His authoritative work "Sur les Autres Monde" (on Other Worlds) was publised by Larousse in 1937. Rudaux has received many awards and recently, a Martian crater was named after him.

Perhaps one can say the most famous amatuer astronomer and space artist is the American named Chesley Bonestell. His series of paintings called "Saturn from its Moons" was published by Life Magazine in May 1944, while his book "Conquest of Space" came off the press in 1949.

The well-known space artists of today, inclue David Hardy in London, Andrei Sokolov in Moscow, Ludek Pesek in Prague, Kazuaki Iwasaki in Japan and Ron Miller, William Hartmann, Michael Carrol, Don Davis, Don Dixon, Helmut Wimmer and Robert McCall in the United States.

Part II. Space Art and Astronomy

Art and Science have usually been regarded as two opposite ends of the spectrum. Interestingly, space art is once again combining these two while astronomical art reflects mankind's fascination with the untamed frontier. One may say that space art has surged in popularity because the "high frontier" has become a part of everyday life.

Astronomical teaching and popularization owe much to space art, while its importance in exploring the universe cannot be underestimated.

(a) Space Art and Astronomical Teaching

It need hardly be said that beautifully designed diagrams and illustrations are very important for both the teacher and student in astronomical teaching.

Let us take the German artist Helmut Karl Wimmer who joined the American Museum, Hayden Planetarium in New York in 1954. Apart from designing planetarium shows, his artistic works have appeared in numerous publications, including the Natural History, the Smithsonian, the Reader's Digest and the New York Times. With the cooperation of the Astronomer, Dr. Franklyn M. Branley, Wimmer's paintings have appeared in a series of astronomy books witten espescially for young people and university students. In 1975, Wimmer's works also appeared in F.M. Branley's text book for university students. Wimmer also did all the illustrations of basic astronomy, astronomical instruments, the solar system,

eclipses, constellations, starts, mebulae and galaxies for "Skyguide" published in 1982. In my opinion his three-dimensional, coloured illustrations are easy to understand and are the best astronomical diagrams for educational purposes that I have seen so far.

(b) Space Art and Astronomical Popularization

The French astronomer Lucien Rudaux (1874 - 1947) was a grue astronomical artist. While many other artists have illutrated extraterrestrial scenes before him, Rudaux was the first to specialize in this subject and was also the first to make an attempts to popularize astronomy equally through art and text.

Over a period of nearly forty years, Rudaux wrote and illustrated many successful books on astronomy, including the encyclopedic and authoritative "Astronomy" published by Larousse in 1948. He established a high standard for detail, accuracy and aesthetics - an influence still felt today by artists he inspired.

The American amateur astronomer and space artist Chesley Bonestell (1888 - 1986) has had tremendous influence on the popularization of astronomy. In 1944, Life Magazine published his series of paintings showing the planet Saturn as seen from some of its sattellites. Using his knowledge of camera angles, perspective and a life-long interest in astronomy, he produced the most plausibly realistic portrayals of other worlds yet done. He also painted several murals, panorama of the lunar surface for the planetaria.

The Czechoslovakian artist Ludek Pesek (born 1919) illustrated many space art books, such as "The Moon and the Planets", "Journey to the Planets", "our Planet Earth" and "Bildatlas des Sonnensystems". All of these books are very useful in the popularization of astronomy.

The Japanese artist Kazuaki Iwasaki (born 1935 in Dalian, China) is a nova in the space art sky and is called the "Eastern Bonestell". His paintings have been collected in a

book called "Visions of the Universe". It was published in 1981 and carries a text by Isaac Asimov and a preface by Carl Sagan - an international effort if there ever was one.

Kazuaki Iwasaki is a new generation of painters following in Bonestell's footsteps. The well-known American astronomer Carl Sagan said: "Iwasaki's paintings not only have graphic acuity and meticulous care which make the best Bonestells, but also depict the latest scientific findings".

Interestingly, both Bonestell's and Iwasaki's paintings have been on recent show in the Beijing Planatarium.

Of interest to our readers, Time-Life has published recently a 20 volume astronomical library called "Voyage Through the Universe", which contain many paintings and illustrations by space artists.

(c) Space Art in the Exploration of the Universe

As we all know, space art is closely related with the space programme. Chesley Bonestell provided much of the art for the great Collier's series on space flight, which were later transformed into the classic "Conquest of the Moon", "The Exploration of Mars" and "Across the Space Frontier". The texts were written by the world famous space expert Werner von Braun, Willy Ley and others. Bonestell received the British Interplanetary Society Special Award and the Medallion for lifetime accomplishments in space exploration and the Dorothea Kumke Robert's Award from the Astronomical Society of the Pacific.

NASA's artist Robert McCall, born in 1919, is perhaps the greatest space artist in the world at present. His books "Our World in Space", published in 1974 with a text by Asimov; "Vision of the Future" published in 1982 and "The Art of Robert McCall" published recently in October 1992. He has illustrated concepts of space exploration and colonization from the very near tomorrow to the very imaginative future.

McCall was among the first artist to be invited to take part in NASA's fine arts programme and has continued to document the manned space programme. He has also designed commemorative postage stamps, the latest one is the Space Achievements Stamps to commemorate 35 years of space exploration and the International Space Year. These stamps were reprinted in the Sky and Telescope Magazine of October 1992.

McCall's most-photographed work of art is a six-story-high mural for the National Air and Space Museum in Washington, D.C.

The American astronomer and artist William K. Hartmann and the well-known artist Ron Miller have published three books namely "The Grand Tour" published 1981, "Out of the Cradle" published 1984 and "Cycles of Fire" published 1987. All these books have space photographs and art works of a high standard.

"Cycles of Fire" is a book full of over a hundred pictures exploring the stars, galaxies and the wonders of deep space. As far as I know, it is the only space art book with paintings of deep space.

"Man and the Universe" is illutrated by the Soviet Astronaut A.Leonov and artist A.Sukolov. It was published in Moscow in 1984 and is already in its 2nd edition. The book contains one hundred colour space paintings which are a good representative of space art of the former U.S.S.R.

Part III. Space Art in China

Sixty years ago, a couple of beautiful astronomical paintings were published in the Astronomical Calendar which was edited by the National Institute of Astronomy. Later, these pictures were also printed in many popular books.

As a young student, the first time I saw one of Bonestell's space pictures called "Saturn from its Satellites" was in 1944. I was so impressed that I began my collection of astronomical pictures.

In 1950 several of Bonestell's reproductions were put on display at the Purple Mountain Observatory in Nanjing. In 1954, the "Album on Astronomy" with over twenty space paintings and edited by myself, was published in Shanghai. In 1957,

about 16 copies of Bonestell's space reproductions were put on exhibition at the Beijing Planetarium for a whole year.

In 1979, I contacted space artists Ron Miller and F.C.Durant in the United States and they provided me with many space art books and posters. In 1983, Durant and Miller edited a beautiful book in colour called "Worlds Beyond - the Art of Chesley Bonestell". I was asked to make a contribution and wrote and told them how I had been so impressed as a young man by the article "The Solar System" with Bonestell's illustrations, that I decided to devote my life to the popularization of astronomy.

In 1980, I became acquainted with the Japanese space artist Kazuaki Iwasaki and since then he has sent me books on space art, calendars and posters.

In 1984, supported by the China Institute for Popu-Lar Science (CAST), the Chinese Astronomical Society and the Beijing Planetarium, I organized a Space Art Exhibition using my personal collection of over a hundred large space art posters and pictures. It ran for three years at the Beijing Planetarium. Later, the exhibition was taken to Nanjing and Shanghai and several other large cities in the country. In 1988, a special exhibition of Kazuaki Iwasaki's space works was held in Dalian, his birth-place. It is estimated that about three million people saw the above mentioned exhibition.

On Chesley Bonestell's 97th birthday, he wrote me saying "I am honoured to learn that you have been exhibiting reproductions of my work in China and appreciate your efforts. I hope that the exhibits have been successful, for I know that the best way to interest people in astronomy is for them to see interesting astronomical art and photographs and the best way to develop the future generation of space artists is to introduce them to space art and astronomy when they are young."

In recent years, I have written about one hundred articles introducing space art and artists to the Chinese people and they have been published in books, magazines and news-

papers. China, as you all know, discovered gun powder and developed astronomy centuries and centuries ago. I am happy to say that astronomy in China is still on the march. With space technology of her own, space artists have also sprung up, like ZHANG Bozhi, TIAN Rusen and YU Jingchuan. I would like espescially to mention YU Jingchuan, who is only 24 years old and I have high hopes that he will become the Bonestell of China.

I would like to express my appreciation to Ms.WANG Chunjing for her help

THE PRESENT CONDITION OF CHINESE ASTRONOMICAL INSTRUMENTS USED FOR ASTRONOMICAL EDUCATION

LU BAOLUO
NANJING ASTRONOMICAL INSTRUMENT RESEARCH CENTRE
ACADEMIA SINICA

Astronomy is an observational science. Through telescopes, people can observe many different kinds of astronomical bodies. That is a main and valid practical way in astronomical education. While learning, if students observe the astral world by telescopes with their own eyes or take colorful astronomical objects pictures with their own hands, it would be beneficial to not only astronomy but also many other fields, such as optics, electronics, mathematics and physics.

Since 1958 while Beijing Planetarium, including a small observatory, was set up, a lot of small observatories have been built all over china. Especially in the last ten years, for cooperating the education of astronomy, some colleges and middle schools, as well as primary schools have built up many kinds of big or small observatories, equiped with different telescopes and attachments. Using these instruments, students can observe sunspots in the day, and at night students can observe other objects systematically, the moon, planets, binary, variable, nebula, cluster, comet, etc. Also, some national observing activeties have been organized for the solar eclipse, favourable opposition of Mars, transit of Mercury, regression of Hallay comet, and so on.

By estimate, there are more than 100 observatories in China now. The diameters of the domes are from 3M to 8M and the apertures of the telescopes from 150mm to 400mm. The optical type of telescopes includes reflective, refractive and catadioptric, each of them has automatic tracking system. Although the auxiliary equipments are different, most of them equiped with solar project and shooting units (including dry plate magazine and camera connectors), some of them added TV sets, photoelectric photometers and small spectrometers.

< Table 1 > shows some telescope's installation in small observatory.

Except above fixed telescopes with dome, there are also many schools owning portable telescopes and having done a great deal of popular astronomical education in the last ten years. Most of them

is MAKSUTOV reflective telescopes or twin tube refractive telescopes with apeature of 100mm and 80mm.

In order to improve the effect of various telescope, it is necessary to equip with auxiliary equipments. Special sun project system is a regular device, it is special designed by second imagin lens, which has four in two groups, to enlarge sun picture from 120mm to 200mm, for drawing dark core group.

A good quality photocounting photometer could be equiped with amateur telescopes. It is controlled by a microprocessor and has a tiny printer which out the data , a clock and its time display a photometer head with anoptic grate, an eye piece lens, a fabric lens and a rotating filter wheel which has four pieces of filter. S/N ratio is 56 dB and counting dynamic range is about 100000. It can be mainly used in U.B.V. three color measure for vary stars and other photo counting subject.

However, at present in China, telescope's installation of small observatory has some weakness to be improved. Firstly, most observatories are built in campus where harmful sky light is very serious and therefore the received of telescope decreased greatly. Secondly, the optical system of most telescopes has less than 1/12 in related aperture, that is too small to observe surface objects such as comet and nebula. To improving that, some schools have equiped telescopes with 1/4.5 of high related aperture. For this reason, I recommend school a telescope with four tubes to satisfy the needs of observing different objects. The basic installation of the four tubes shows in <table 2>.

This multitube telescope will be equipped in a 6M dome.

** TABLE ONE **

NAME	MAIN TUBE		GUIDER		FINDER		AUXILIARY EQUIPMENT
	EFF. APE.	FOC. LEN.	EFF. APE.	FOC. LEN.	EFF. APE.	FOC. LEN.	
400 mm telescope	400 mm	4,900 mm	100 mm	1,200 mm	60 mm	540 mm	XY micrometer, solar projector, dry plate magazine,
300 mm catadioptric telescope	300 mm	3,000 mm	100 mm	1,200 mm	60 mm	540 mm	same above
200 mm refrcative	200 mm	2,400 mm	100 mm	1,200 mm	60 mm	500 mm	same above
150 mm telescopee	150 mm	1,800 mm	100 mm	1,200 mm	60 mm	320 mm	same as above

*** EFF: effctive FOC: focus
*** APE: aperture LEN: lenth

this reason, I recommend schoola telescopewith fourtubesto satisfy theneedsofobservingdifferentobjects.Thebasic installation of the four tubes shows in <table 2>.

** TABLE TWO **

TYPE NO.	APERTURE	FOCAL LENGTH	PURPOSE
TUBE 1	200 mm	2,400 mm	solar projection,observing and shooting for planet and moon
TUBE 2	100 mm	1,200 mm	guiding taking picture for the sun directiy
TUBE 3	80 mm	500 mm	finding
TUBE 4	150 mm	675 mm	observing and shooting for comet and nebula

This multitube telescope will be equipped in a 6M dome.

Planetarium Projectors in China and their Education-Orientated Applications

YAN Peiran *WU Shaohao*

Beijing Institute of Technology
P.O.Box 327, Beijing 100081

ABSTRACT

Gives a brief retrospective overview of the appearance and development of planetarium projectors of various sizes in China. Distinctive features of some representative projectors are given.

Describes in some detail the design features of a medium projector with an orientation to adapt itself to instructional/educational purposes when necessary. Representation of the different celestial coordinate systems are given due prominence. The coordinates are displayed with sharply imaging optical systems, graduated and marked with numerals and characters. Relationships between the equatorial, alt-azimuth and ecliptic systems can be seen clearly. Many astronomical relationships hard to visualize, e.g. the astronomical triangle, can be demonstrated figuratively. Provision of markings for twenty-four traditional Chinese calendarial divisions on the ecliptic, something very much popularized in China, gives the audience a deeper understanding of the calendar in relation to climate changes.

A compact and ingenious solar system mechanism demonstrates, e.g., the apparent motion of the planets, the relationship between the sidereal vs. the apparent and mean solar time, phasing of the moon, etc.. Interlinked diurnal and annual motion of the instrument depicts the relationship between the diurnal rotation of the earth vs. its helio-centered rotation. Availability of these and other features marks the distinction of the projector, as they are generally available only in planetariums of larger sizes.

PLANETARIUM PROJECTORS IN CHINA AND THEIR EDUCATION-ORIENTED APPLICATIONS

Prof. YAN Peiran Prof. WU Shaohao

(Beijing Institute of Technology, Beijing 100081)

Abstract Gives a brief retrospective overview of the appearance and development of planetarium projectors in China--the major, universal planetariums and then the medium to small sized ones. Distinctive features of some representative projectors are given.

Educational applications, especially those of a medium to small sized planetarium projector, are illustrated with a typical model, the S-10, showing what may be done with such an instrument. Examples shown include the presentation of celestial coordinate systems and relevant practical applications, presentation of the seemingly sophisticated apparent motions of the planets, of the lunar motion and its phasing in relation to the traditional Chinese solar-lunar calendar, as well as of the connection between the diurnal rotation of the earth and its heliocentric rotation connected with the solar calendar, etc. Presentation of the mean sun will explain the relationship between the various time systems. Contributions of ancient Chinese astronomy such as the twenty-four traditional calendarial divisions, still remaining guidelines in things connected with the climate and agriculture on the grass root level, can be demonstrated very figuratively with such an instrument.

The paper seeks to show, with these typical examples, that possible educational applications of a small sized planetarium like the S-10, can truly be copious.

1, Major, universal planetariums in China

China began its R. and D. on, and then making, its own planetarium projectors shortly after the inauguration of the Beijing Planetarium Museum in September 1957. Optical Engineering Department of the Beijing Institute of Technology (BIT) completed a major planetarium projector(for use in projection domes 23 m. diam.) around 1964. That instrument, however, was not put into actual use with the ensuing outbreak of the "Cultural Revolution" shortly afterwards. Year

1976 saw the completion of a new major sized planetarium (Fig. 1) designed in the Beijing Institute of Technology and made in collaboration with some manufacturing firms in Beijing. The new instrument incorporated most of the then state-of-the-art new developments in the field, besides many novel features of its own. As a planetarium it distinguishes itself by the adoption of a geocentric arrangement of mechanisms for the demonstration of the apparent motions of visual solar system bodies; and (1) by the use of an original set of mechanisms for the simulation of the apparent Keplerian movement of the planets, attains higher accuracy than those of other major planetariums then available, also (2) by the introduction of an innovative set of drives for the lunar mechanism it can account for the advance of the perigee, besides the regression of its node (with this, the simulation of moon's movement can eliminate a principle error about 6°15' and attain a higher degree of accuracy than is possible in other major planetariums). Other features include: (1) the use of inversed telephoto objective systems for the projection of fixed star sky to attain much more uniform illumination within their fields of projection; (2) the adoption of torque motors to give much wider speed ranges for the various drives, especially advantageous in those close-to-stationary motions of the instrument; (3) the incorporation of projection systems for the constellation figures (both international and traditional Chinese) selectable both individually and in groups; (4) the incorporation of features reflecting historical achievements in China's astronomy, e.g. the twenty-four calendarial divisions on the ecliptic, as well as a series of other original design features. This instrument has been in successful , continued operation in the Beijing Planetarium Museum since 1976, receiving thus far tens of millions of audiences.

2, Medium to small sized planetariums

Medium and small sized planetarium projectors in China followed the pace somewhat later than the major ones. As of date, there are over 50 planetarium museums or centers open to the public, of which the overwhelming majority are equipped with projectors designed and made in China. These projectors belong to two categories: those with optical systems for the projection of fixed stars and those projecting the stars mainly through pin-holes. As representative instruments

belonging to the two categories may be counted: (1) the S-10 "Super Star", for use with dome sizes 8-12 m, which will be described in more detail later, (2) the TX-10 model, an optical projection type compact planetarium for use with dome sizes 6-10 m, (3) the TXY-1 model, employing pin-hole imaging for the fixed stars, for use with dome sizes around 3 m, and (4) another variety of pin-hole imaging type of projector-- the model II.

Features of the projector model S-10 will be accounted for separately. The model TX-10 is a very compact planetarium projector of the "dumbbell" type. Optical projection of about 2,000 stars down to the 5th magnitude. motor driven diurnal and latitudinal movements, position of celestial equator, ecliptic, meridian and horizon shown by lines in 10° segments, positions of the sun, moon and visual planets manually adjustable according to almanac data. Model XTY-1 is a portable type of planetarium for use in small sized domes, very modest in cost. It can project a starry sky from the 4th magnitude up. The instrument has a motor driven diurnal movement, but latitudinal changes have to be made manually.

3, Cases of educational applications, based on a medium to small planetarium

For educational purposes the medium to small sized planetarium is often quite handy for use. Among them we might cite the popular "Super Star" model S-10 (Fig. 2,3) as a typical case, which is designed by Beijing Institute of Technology (BIT) and manufactured by Jinguang Instrument Factory. It has many desirable features of merit. The following cases can be taken as examples of what may be done with such an instrument.

(1) Presentation of the celestial coordinate systems

Reference frame in the celestial sphere-- the celestial coordinate systems are given much prominence in the design of the instrument, and all the three systems in general use-- the horizon, equatorial and ecliptic network systems can be superimposed over the background of starry firmament. They are displayed with sharply imaging optical systems and are finely graduated to the degrees, very handy in their use during demonstrations in the determinations of coordinate positions of heavenly bodies. Mutual conversions of coordinates, their practical applications and many relationships

such as the solution of astronomical (nautical) triangles can be demonstrated. Such relationships are generally hard to visualize and depict through oral instructions alone but will be readily comprehensible with the help of the planetarium.

(2) Planetary and lunar motions, lunar and solar calendars, sidereal time vs. mean/apparent solar time, etc.

The provision of a compact and ingenious system for the solar system and lunar movement permits the audience to comprehend at a glance the seemingly sophisticated apparent motions of the planets. It can be shown that they are predictable, thus the mysticism of astrology can be seen as ultimately untenable. The lunar movement around the earth, its travel in connection with the diurnal, phasing of the lunar disc, rotation of the earth, etc., shows to the audience an account of some basic facts relating to the traditional lunar calendar, still of much influence in China. Moreover, the diurnal motion in the instrument is interlinked to the annual motion through accurately figured of gearing, this enables the demonstration of relationship between the diurnal rotation of the earth vs. its heliocentric rotation, and the basis for the setting up of the Solar Calendar can be given without difficulty. Besides, the S-10 planetarium is provided with a mechanism for the demonstration of the mean sun, so the seemingly somewhat intricate phenomenon of the various time system-- the mean solar time as against the apparent solar and sidereal time, can easily be explained to the public.

(3) Contributions of ancient Chinese astronomy in relation to the daily life

China is a nation with very rich and distinguished achievements in ancient and traditional astronomical sciences. Many of these achievements are reflected in matters connected with the daily life of the people. Among these the tweenty-four traditional Chinese calenderial divisions on the ecliptic have persisted for centuries and still remain as guidelines in things related with the climate and agricultural activities among the lay people. And it remains the infallible linkage between the Lunar and Solar calendars. This can be shown very figuratively in the planetarium, leaving a very vivid impression to the audience concerning the close relationship between astronomy, and calendar, on the one hand, and climate and agricultural activities on the other.

4, Epilogue

Of course we should never purpose to enumerate, however briefly, the education oriented programs for such an instrument, but it can be seen from the above that a medium to small sized planetarium projector like "Super Star" S-10 can provide a truly abundant amount of possibilities for educational purposes to the layman, various trainees concerned with astronomical objects, as well as professionals. With a few dedicated auxiliary instruments and diascopic projectors, the range of demonstration can be enlarged much further.

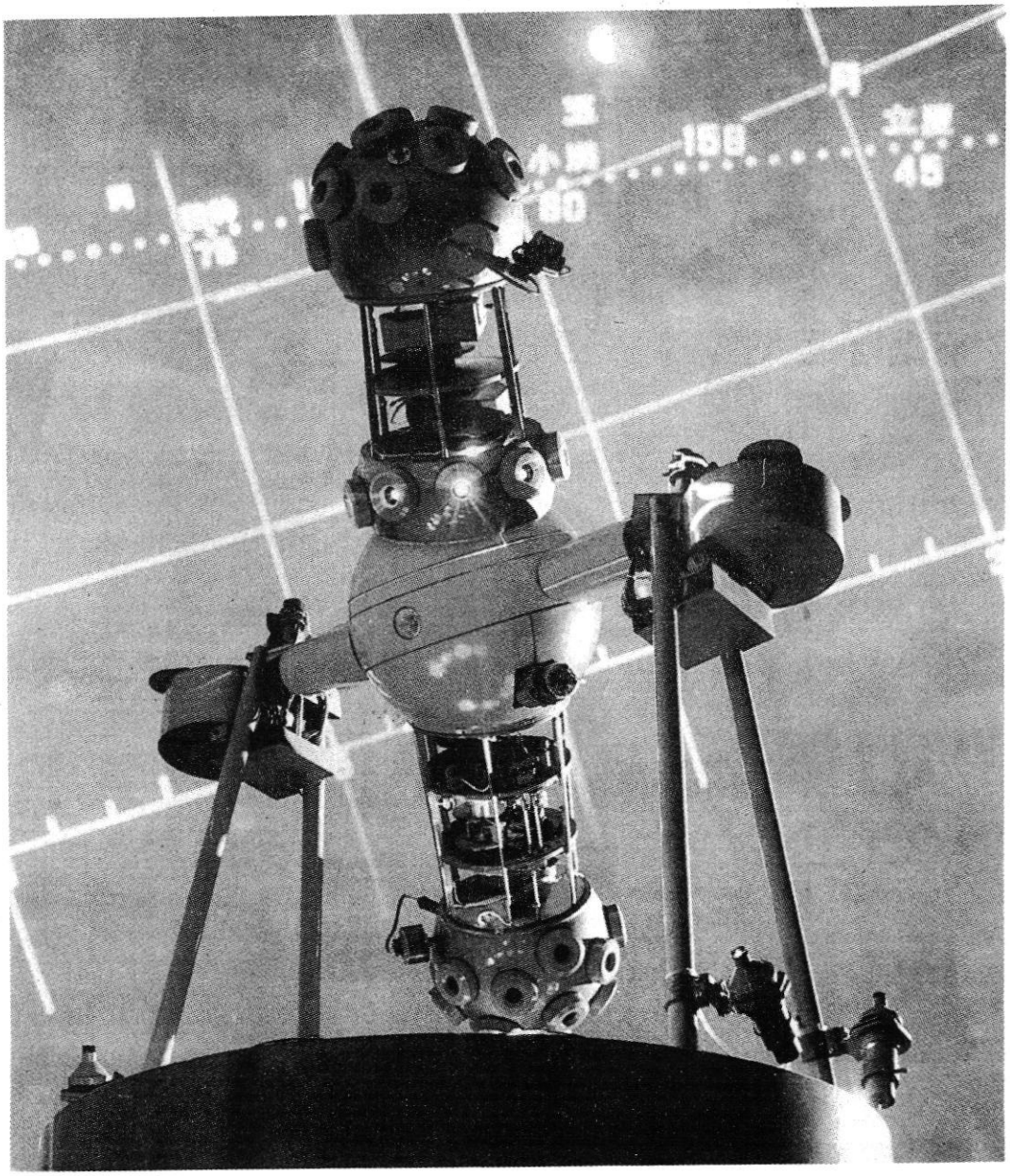


Fig. 2

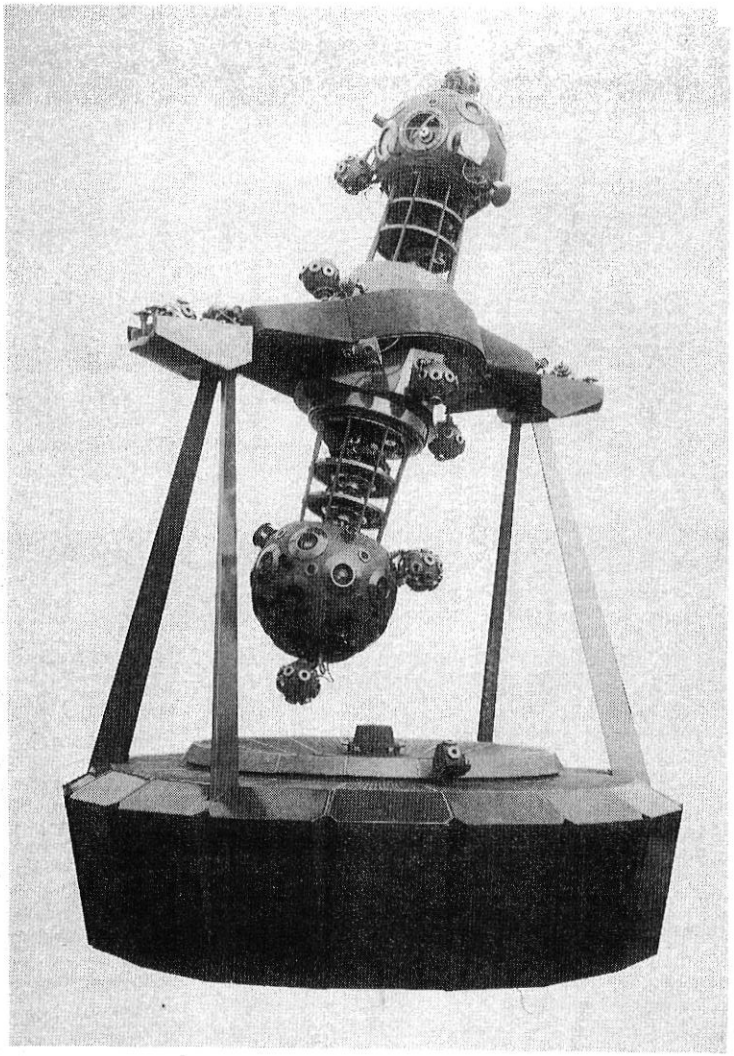
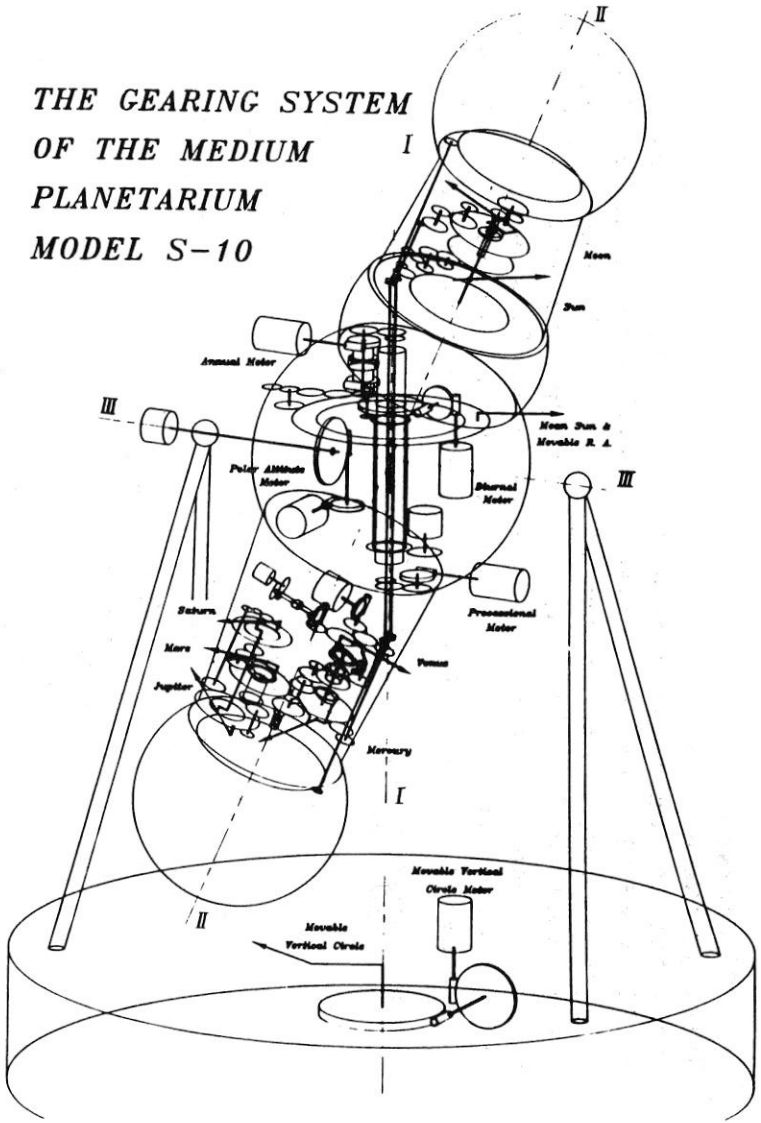


Fig. 1

Fig. 3 →


THE GEARING SYSTEM
OF THE MEDIUM
PLANETARIUM
MODEL S-10
II
I
Moon
Sun
Annual Motor
III
Moon Sun &
Movable R. A.
Polar Altitude
Motor
Sturnal
Motor
III
Saturn
Precessional
Motor
Mars
Venus
Jupiter
Mercury
I
Movable Vertical
Circle Motor
II
Movable
Vertical Circle

POPULARIZING ASTRONOMY IN SHANGHAI

Ji Desheng

(Shanghai Observatory,Academia Sinica)

Shanghai is the biggest city in China, There are 512423 pupils in middle school and 1113828 pupils in elementary school. A portion of them is very interisted in astronomy. They often participate various activities of popularizing astronomy. In 1985--1986, when Comet Halley returned, hundreds and thousands pupils took part in observing activities. On September 23d,1987,more pupils observed the annular eclipse. From such activities,young amatuer astronomers have learned more knowledge in astronomy.

Situation

The orgaization of popularizing astronomy in Shanghai is as following: A committee dealing with popularization of astronomy was set up in Shanghai Astronomical Society. It is responsible for popularizing astronomy in Shanghai. A small planetarium belongs to Shanghai Children's Palace. There are two astronomical teachers to dedicate to the popularization of astronomical knowledge. Shanghai Observatory,Chinese Academy of Sciences pay attention to popularizing astronomy. There are some people who work in scientific and technical centre to be responsible for popularizing astronomy. Shanghai Planetarium was prepared to build by the Shanghai Museum. Several people who work in Shanghai Museum are engaged in popularizing astronomy. In 1979,Shanghai Association of Young Amateur Astronomers was established. At that time,some association of young amateur astronomers were established in some middle schools as well.

Number of astronomy lovers is difficult to count, but can be estimated over one thousand. Generally, there is a telescope in one middle school, there is a association of young amateur astronomers too. The typical number of the association of young amateur astronomers is about 60. There are some astronomy lovers in other middle schools. There are about 100 pupils astronomy lovers in Shanghai Association of young Amateur Astronomers. Among young workers in some factory, a portion of them loves astronomy.

Since 1991, courses of astronomy have been given in 10 middle schools in Shanghai. A portion of middle school geographical and physical teachers on astronomical keowledge have been trained in Shanghai. In 1985--1986, and in 1987, many astronomical observation guidance teachers were trained. Those teachers, now, give astronomical lessons to middle school pupils. Astronomical courses are being prepared to give in other 13 middle schools. It will be expand gradually.

There are various forms in popularizing astronomy. Systematic lessons in astronomy are given to young amateur astronomers by Shanghai Children's Palace periodically, and organize them to take part in astronomical observation. The middle school that there is a telescope often arrange pupils to observe. Some pupils were organized to go to suburbs for observing meteor shower. There are some pupils using computer to calculate the orbit of celestial body. The competition of astronomical knowledge is holded each year in Shanghai by the popularization Committee of Shanghai Astronomical Society, Shanghai Children's Palace and Shanghai Planetarium. The pupils who win the prize are organized to take part in astronomical summer camps.

Telescope

The main instruments that are used by amateur astronomers are optical telescope. After observing Comet Halley and annular eclipse, the number of telescope has increased. Table 1 lists the main telescope.

Table 1 telescope

No.	Name of school	Aperture (cm)	Type
1	Middle School Attached to Shanghai Teacher's University	40	reflecting telescope
2	No.2 Secondary School Attached to Hua Dong Teacher's University	12	catodioptric telescope
3	Ji Guang Middle School	15	refractor
4	Ge Zhi Middle School	12	catodioptric
5	Shi Xi Middle School	20	catodioptric
6	Shi Bei Middle School	23	catodioptric
7	Pu Ming Normal School	12	catodioptric
8	Popularizing Commitee of Shanghai Astronomical Association	23	reflecting
9	The same as No.8	15	reflecting
10	Shanghai Planetarium	12X4	catodioptric
11	Shanghai Children's Palace	12 15	catodioptric reflecting
12	Children's Palace of Yang Pu District	20	refracting
13	Educational College of Nan Shi District	12	catodioptric
14	Educational College of Lu Wan District	12	catodioptric
15	Wei Yu Middle School	40 *	reflecting
16	Third Middle School Attached to Hua Dong Teacher's University	30 *	catodioptric
17	Shanghai High School	22 *	refracting

This is not completely statistical.

* The last three telescopes are being built.

How to train and hold activities

The guidance teacher is important in holding popularization astronomical activities. Hower, it is difficut to find a teacher who graduated from the department of astronomy. The first thing is to train a number of astronomical guidance teacher. This work started in 1985. The short courses of astronomy were arranged frequently for geographical and physical teachers by astronomical experts. Such courses were given in the educational institutes of several districts also. Systematic lessons in astronomy were given in Shanghai Children's Palace. All of above activities not only given teachers astronomical knowledge but also taught them to practise observations.

There are various ways to train pupils. The teachers who have been trained give lessons in astronomy in their own schools. The member of Shanghai Association of Young Amateur Astronomers go to Shanghai Children's Palace to have a astronomical lesson periodically. The popularization Commettee of Shanghai Astronomical Society and Shanghai Children's Palace organize young amateur astronomers to go Seshan that is the observation base of Shanghai Observatory to observe celestial body.

ASTRONOMICAL LEADERSHIP TRAINING IN HONG KONG

L.C. Suen (Ms), H.C. Ng, K.C. Leung

HONG KONG ASTRONOMICAL SOCIETY

Abstract

There is no formal academic astronomy course in Hong Kong - and public amateur societies play an important role in popularising astronomy to the general public.

The Hong Kong Amateur Astronomical Society (HKAAS) in 1986 organised the first training course on astronomical leadership, the aim of which was to better equip amateur astronomers with the skills in popularising astronomy. The course covered skills in delivery lectures and conducting star parties. Over the years about a thousand teenagers took part in the training courses and successfully applied their newly acquired skills in their schools or local organisations.

The following pages summarise the background, the main features and future development of the course on astronomical leadership training and its effects on popularising astronomy.

ASTRONOMICAL LEADERSHIP TRAINING IN HONG KONG

L.C. Suen (Ms), H.C. Ng, K.C. Leung

HONG KONG ASTRONOMICAL SOCIETY

Introduction

There is no formal academic astronomy course in Hong Kong - and public amateur societies play an important role in popularising astronomy to the general public.

In 1986, the Hong Kong Amateur Astronomical Society (HKAAS) organised the first training course on astronomical leadership. The aim of the training course was to better equip amateur astronomers with the skills in popularising astronomy. The course mainly covered skills in delivering lectures and conducting star parties. Since then over a thousand teenagers took part in the training courses and successfully applied their newly acquired skills in their schools or local organisations.

The following paragraphs summarise the background, the main features and future development of the course on astronomical leadership training, its effects on popularising astronomy is also discussed.

* It was resolved in the Annual General Meeting of the Society held on 13 September, 1992 to change the name of the Society from "Hong Kong Amateur Astronomical Society" to "Hong Kong Astronomical Society."

Astronomy Education in Hong Kong

There is no formal academic astronomy course such as astrophysics offered in the local universities. Only limited genereal knowledge in astronomy is being taught in primary and secondary schools. As a result, no professional astronomys have ever been trained locally in Hong Kong. However, the general public is increasingly eager to learn more about astronomy and, therefore, the need for popularisation of astronomy increases.

Until the establishment of the Hong Kong Space Museum in 1980, there was no governmental body taking up the responsibility of popularising astronomy to the general public. The role of popularising astronomy was, therfore, wholly borne by the local amateur astronomical societies. The setting up of the Hong Kong Space Museum in 1980, arouse further the interest of the general public on astronomy and the local amateur societies have to cater for a even greater demand, particularly when the Space Museum is incapable of providing actual astronomical observation opportunities.

The Hong Kong Amateur Astronomical Society

In order to allow the general public the chance of knowing more about astronomy, our Society has, since its establishment in 1974, been organising public lectures, star parties, special lectures and running astronomical columns in the local newspapers. These activities demand a lot of resources, particularly lecturers who must be competent in their knowledge of astronomy as well as the skills in sharing their knowledge with others. We concluded that in order to

better serve the aims of the Society, it is necessary to train astronomical leaders.

Features of the Leadership Training Course

Our Society decided in 1986 to organise an in-house astronomical leadership training course cater for the needs of the Society. The course was organised for members of the Society only.

The aims of the course were as follows.

(a) To strengthen the human resources needed for the popularisation of astronomy; and

(b) To prepare the next line of keen members who will eventually develop into dedicated committee members or active members leading the Society.

The contents of the leadership training course included skills in delivery lectures, conducting star parties, making slides for the lectures, oragnisation technique and human relationship. These skills were taught by veteran members who were experienced in popularsing astronomy; their practical experience earned throughout the years was particularly useful. All participants were given an elaborate set of handouts to act as reference. From the outset, actual practice sessions were emphasised. Participants of the training course must pass a practical exercise in order to be qualified as an astronomical leader. The exercise also reviews whether the skills being taught were adequate and appropriate. The practical session helped the participants to learn of their strength and weaknesses and this will enable them to improve in the right direction and to gain more confidence in actually delivering a talk or leading a star party.

Expansion of the Course

It was noticed then that the general astronomical knowledge of the course participants increased and this was obviously a benefit to themselves as well as to others. Having been successful in organising the in-house training course. Our Society decided to expand the course to outsiders who already have acquired basic astronomical knowledge. From 1988 onwards, it had been agreed that the training course would be jointly organised yearly by our Society and the Hong Kong Space Museum, which basically provided a bigger venue to entertain more participants. Up to this moment four courses has been organised. The contents of the training course covered those in 1986's together with skills in organising astronomical activities. Also participants were taught on the management skills in running societieis both in schools and in public societies.

As there were nearly two hundred participants in each course, it was impossible for us to assess the skills of all the participants after they have attended the course and regretably we could only assess participant-members of our Society. Nonetheless, the expanded course seemed to be fairly successful as, at present, there are over a hundred astronomical organisation in our local schools.

Looking Forward

At the end of each course, we conducted course evaluation. From the feedback we found that the participants claimed that they would need to enhance their basic astronomy knowledge in order to be more effective in giving lectures and leading star parties. To tackle this point, we have decided to introduce more

advanced courses. The Astronomical Education Centre of our Society which was just established should be able to offer these advanced courses, particularly in providing systematic astronomical observation practices.

Conclusion

Based on our experience, we can conclude as follows.

(1) Course participants are able to deliver talks and lead star parties competently;

(2) They are also capable of organising astronomical activities and running astronomy clubs;

(3) Some leaders are now able to become trainers themselves;

(4) The added resources now allow the Society to expand its popularization role by organising a variety of activities, such as exhibitions, conventions, and large star parties.

There are still problems left unsolved but we believe that by culminating the efforts of both the organisers and the participants, these problems would eventually be taken care of.

Appendix : Contents of the Leadership Training Course

1. How to prepare a lecture;
2. How to be a astronomical leader;
3. How to organise and run an astronomy club in school;
4. Let the night sky be the teacher;
5. How to organise a star party;
6. How to lead a star party;
7. How to organise and run a public amateur astronomical society.

ON TEACHING OF SOLAR-TERRESTRIAL KNOWLEDGE IN ASTRONOMICAL TEACHING

Jia-long Wang

Beijing Astronomical Observatory
Chinese Academy of Sciences
Beijing, 100080, China

Abstract

The necessity of teaching of solar-terrestrial knowledge at schools is greatly increasing with the rapid development of space action of mankind. The increasing necessity is being recognized by more and more people and teachers, now. The sun as a nearest star provides us with the most part of energy we use every day. The direct utilization of solar radiation must have a good prospect owing to its no pollution, low price and huge reserves as an energy resource. On the other hand, the conditions of the space environment of the earth and the atmosphere of the earth are considerably modulated by the sun, and solar events often cause serious disturbances in ionosphere, geomagnetic field and particle condition of the earth. To study and predict these disturbances an international network, IUWDS, has been established jointly by URSI, IAU and IUGG since 1962. A very widely international cooperation is being carried out over the world in this field.

The very close relation between solar activity and mankind's action impels us to be going to study and teach solar-terrestrial phenomena continuously. The teaching in this field should at least include the knowledge of our sun, solar activities and their influences on our earth.

I. Necessity of Teaching Solar-Terrestrial Knowledge

Teaching of astronomy is one of the most interesting branches of the universal education. In teaching of astronomy, knowledge on solar-terrestrial relationship seems to be part of the most important content. The necessity of teaching of solar-terrestrial knowledge is, now, becoming more notable along with the great progress made by mankind in space research and space utilization. Actually, the solar-terrestrial knowledge is very attractive for people, especially for young people or students.

The sun as the nearest star to us may supply us with an almost inexhaustible energy and this kind of energy, so called solar energy, is a most clean and cheapest one. But, it has been known that not only the waterlogging and drought but also the conditions of space environment of our earth, ionosphere and geomagnetic field are disturbed, even controlled in some case, by solar activities. Satellite operations and long distance communications are very often faced serious problems during solar maxima. We know the causality between changes of the space conditions of the earth and solar activities very roughly, and we need to understand the global behaviour of the sun-earth system and the dynamic link between the sun and our earth.

At present it seems that a consensus in solar-terrestrial research is that for the near future, we should have more and more young scientists to study and try to resolve problems such as how solar activities influence the space environment and the atmosphere of the earth and what the degree of the influence is in a certain case. People over the world will get high gains from the resolution of those problems mentioned above, greatly. As a scientist or a teacher working of astronomy, we should and perhaps have to pay more attention to the solar-terrestrial teaching in our astronomical education.

II. What Should We Teach in This Field?

A) Fundamental Knowledge We should firstly teach students or people fundamental knowledge about the sun, earth and the interplanetary space. The content of the teaching should include (1) solar interior, layer-structure of the solar outer atmosphere and solar wind, (2) the atmospheric structure of the earth and geomagnetic field, and (3) the physical condition of the interplanetary medium.

B) Conceptions of Solar Activities and of the Effects of Solar Activities on the Earth The teaching should give students correct conceptions of solar activities. There are lots of confusions in understanding of what the solar activity is. The various solar activities could be divided into two kinds of activities. They are gradual activities and eruptive activities. Sunspots ae typically gradual solar activities. Sunspot groups are generally cores of solar active regions where eruptive phenomena are produced. There are various activities on the sun, so various solar active indices may be used to describe solar activities in addition to sunspots. However, different indices may have different active periods and may act out of phase to each other. Electromagnetic emissions and particle emissions produced by solar bursts cause very often SIDs (Sudden ionosphere disturbances), ionospheric storms and geomagnetic storms. The close relation between solar events and terrestrial events might be illustrated fairly clearly. Wang(1992) illustrated the time sequences of solar and geophysical events associated with important solar Active Region No. 4711 in February, 1986 and famous solar Active Region No. 5395 in March, 1989 by two figures. Figure 1 is an example of this kind of illustrations. Speich (1989) described troubles we had on the earth and caused by solar events occurring in Active Region No. 5395 in March 1989. The series of solar events of Active Region 5395 made about 60 SWFs (Short Wave Fadeout), two of these disturbances lasted for more than 12 hours. The large burst of 10th March made an increase of soft X-rays by a factor of hundreds and an enhancement of the flux of protons with an energy greater than 10 MeV by a factor of thousands, at the earth orbit. Also an intense geomagnetic storm was caused by the large burst. During the storm, OSCAR satellites were taken out of service for days, the number of uncorrelated targets tracked by US Navy was more than 5000, NOAA TIROS weather satellites experienced problems due to the increased atmospheric drag, Hydro-Quebec, Canada suffered a wide blackout and so on.

Thus, satellite operations, communications and other kinds of business require us to monitor the sun time by time and forecast solar activity and space conditions of the earth. To meet the requirements in this field, a new science, the so called space weather, has been developed recently.

C) International Cooperation As we know that no area over the world can get sun shine for 24 hours per day except Arctic and Antarctic areas and that countries have

different solar observational instruments for their own solar work. But as we know too

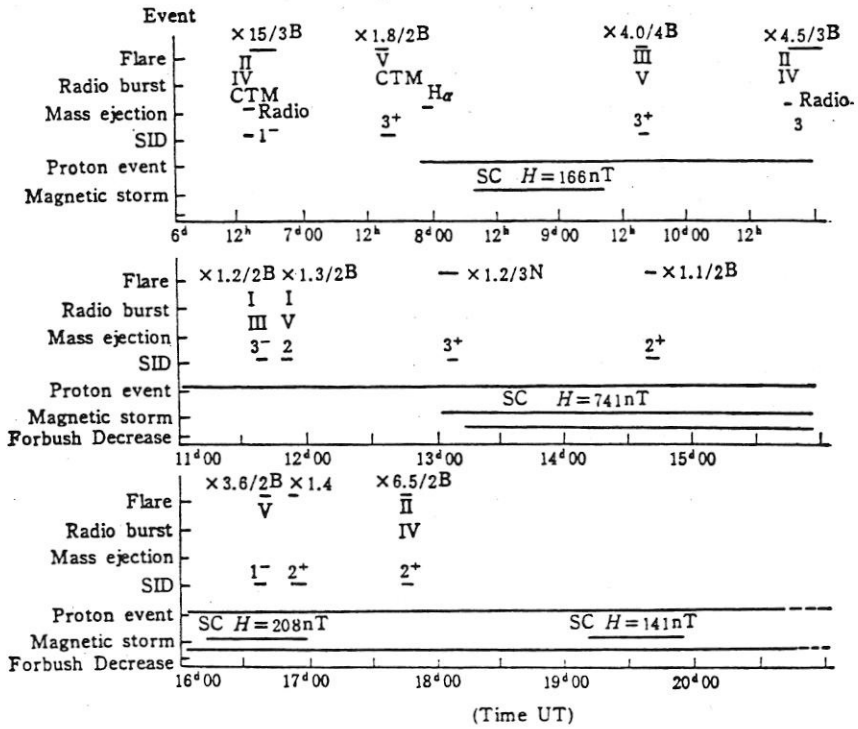


Fig. 1. Time sequence of solar and geophysical events associated with AR 5395 in March 1989

that the space weather monitor and space weather forecast require us to observe the sun with no time gap and to exchange the observational data as soon as possible. Hence, in our teaching of solar-terrestrial knowledge international cooperation in this area should be included.

Now, a widely international cooperation for meeting the requirement mentioned above is carried out by the international organization IUWDS(International Ursigram and World Day Service). IUWDS has ten regional Warning Centers located at ten countries. In Asia, we have three regional centers. They are RWC-Tokyo, RWC-Beijing and RWC-New Delhi. Observational data and forecasts made at regional centers are exchanged very often or regularly to each other. The common purpose of these regional warning centers is to supply a good solar-terrestrial services.

III. Discussions

A) Teaching Should Be Made in Various Ways A popular teaching of astronomy must include that of solar-terrestrial knowledge which is so interesting and useful that students and people must be attracted by it. We can give people the education of solar-terrestrial

knowledge in many ways. Certainly, classrooms and planetariums are the best places for such a kind of education. In addition, clubs and societies are good places for the teaching, too. Short talks and simple exhibitions of solar-terrestrial relation should be presented at public places often, so that people are encouraged to concern with our living environment.

B) International Cooperation in the Teaching Should be Strengthened A strengthening of the international exchange of teachers working on this topic and data of the teaching could benefit countries who take part in the international cooperation. The cooperation may supply an opportunity to the countries to share the relevant data and experiences. Actually, the world needs a set of films describing solar-terrestrial relation and the film should be explained in various languages.

C) Along with the increasing of the number of artificial satellites and spacecrafts in the space the degree to which the interplanetary space is polluted is increasing rapidly. An attached, but very important, task of the teaching of solar-terrestrial knowledge is to tell people and their governments that we are going to live in a dirty and dangerous environment if we do not pay attention to the problem of keeping our space clean. An international cooperation is also needed in completing this difficult but glorious task.

References

Speich, D., 1989, in Developments in Observations and Theory for Solar Cycle 22, ed. by wingle, R. M. and Dennis, B., USA, P. 233

Wang Jia-Long, 1992, in Advances in Solar-Terrestrial Science of China, ed. by Hu Wenrui et al., Science Press, Beijing, P. 67

Simple Discussion on Astronomical Textbooks for Nonastronomy Students

Zhou Ti-jian
Department of Geophysics, Peking University

Abstract

Due to the profound development of astrophysics in the last few decades, both contents and conveyance in new editions of foreign general astronomical textbooks have been revised very much as compared with former editions. Simple descriptions are reduced while theoretical explanations are promoted with more physical models. There is an obvious tendency of using united and evolutionary view points to treat astronomical objects and phenomena. Accordingly, some considerations for editing new Chinese astronomical textbooks for nonastronomy students are given.

1. General survey of recent foreign textbooks

Many new foreign astronomical textbooks, including those for liberal arts students, are different extensively as compared with classical textbooks of 1950's or even those of 1960's. The changes come obviously from the profound development of astrophysics in the last few decades. We can now observe the universe with almost the whole electromagnetic waveband in a 10^{10} ratio of wavelength, instead of a ratio of 2 (350 nm to 700 nm) before the fifties. Many new objects and phenomena have been discovered since then. Practically, most knowledge about galaxies and cosmology and quite a lot of knowledge about stars are obtained in recent 40 years. Even for solar system, the most studied field, is known more clearly by means of the improvement of observing facilities and the development of space technology. All these new achievements impel the revision of textbooks. The difference between old and new textbooks is not limited in the contents of new discoveries, the following changes are more spectacular.

1. Simple enumeration and description are largely replaced by explanation of the origin and essence of the phenomena, more theoretical models are given in new textbooks.

2. Basic physical theories are used extensively to illustrate astronomical phenomena and to build up theoretical models, not only in textbooks for astronomy or other natural science students but also in textbooks for liberal arts students.

3. The emphasis is shifted to stars and galaxies from the solar system. Many textbooks have chapters on cosmology and even bioastronomy.

4. Celestial objects are no more taken as separate things, but taken as parts of unified universe. All celestial bodies and phenomena are studied in a unified and evolutionary point of view.

5. The tradition of selecting only those generally accepted conclusion into textbook is weakened. Many controversial new observational results or theoretical models are selected into textbooks and sometimes even opposite viewpoints are simultaneously presented.

6. Moreover, there are quite a lot of new textbooks break the traditional arrangement of beginning with the Earth and Solar System. Taking the Sun as a particular sample of stars, they talk about the general properties and evolution of stars at first.

The most essential point in the above is the extensive addition of physics into astronomical textbooks. Now let us open some simple discussion of these changes or revisions.

Is it correct to put more physics into astronomy textbooks even for liberal arts students? Since astrophysics occupies the largest portion in astronomy nowadays, to avoid physics in teaching astronomy is impossible. Robert Jastraw and Malcoln H. Thompson, authors of *Astronomy: Fundamentals and Frontiers*, answered this question with: "The appeal of astronomy to the nonscientist is further strengthened by the fact that its subject matter forces the imagination to contemplate larger expanses of space and time than fall within the province of any other scientific discipline. These qualities make the study of astronomy a uniquely attractive means of introducing the liberal arts student to the physical science."

Can the physical explanation be accepted by nonscientist? Mare Kutner, author of *Astronomy: A Physical Perspective*, answered with: "One of the most fascinating aspects is that many phenomena can be understood interms of relatively simple physics. This doesn't mean that we can explain every detail. However, we can explain the basic phenomena". And he added, "As our astronomical horizon expands, we can still use familar physics to explain a wealth of phenomena ..... there is usually still a way of understanding that the laws of physics are small in number and applied universally". Many foreign astronomical textbooks do well to approach astronomy with only middle level of physics and mathematics and do the best to give students physical pictures of astronomical problems.

A general survey of about 20 foreign astronomical textbooks of 1970's and 1980's shows that the percentage of stars, galaxies and cosmology and the emphasis of evolution tend to increase with time. This is consistent with the growth of astrophysics.

2. Some considerations on textbooks for liberal arts students

According to temporal physics and mathematics level of Chinese liberal arts students, the following problems may be the essential considerations on astronomical textbooks for them:

1. What physical knowledge should and how can the students be complemented?

The main content of new general astronomical textbooks should be astrophysics. In quite a lot of foreign textbooks, not only classical physics is applied for explanation but also the modern physics. Although Chinese liberal arts students lack some natural science knowledge, to help them to understand astronomical phenomena with elementary physics is still quite possible. The only requirement is to replenish them with some physical knowledge as bedding, introduction and supplement. The contents should include: conservation and transformation of energy, cause and property of electromagnetic radiation, gravitation and its relativistic revision, atomic theory, nuclear reaction and so on. In the complement and application of basic physical theory, the mathematical tools used would better be not higher than middle school level, even for superior students. It is recommended to add some elementary concept of calculus. From teaching practice, the liberal arts students fear mathematics more than physics, and feel special difficulty to transform mathematics into physical picture. The physical concepts used would better be drawn out from dayly life or common experience or from already accepted theoretical understanding. If the concept can not simply explained, it is often possible to describ it in some physical picture instead of abstract theory or formula.

2. Should unconclusive results be adopted?

Since many recent discoveries are quickly explained by some theoretical models or theories which can never be conclusive before a long time, the adoption of them is straightforward. For instance, it is surely not enough to talk about pulsar only as something radiates pulses but without models. In practice, no simple description without models or explanations even not so ripe to any new discovery is satisfactory for a reader. Of course, some selection must be made between various models or explanations.

3. Comparison between textbook with popular reading

The most important property of a university textbook is its accuracy and comprehension in science. But as a textbook for liberal arts students, it can also be vivid and interesting. In this aspect, it may have some common general property with the popular reading. Nevertheless, there are essential difference between them. The most important difference is that the textbook must present quite comprehensive theoretical system with some depth while popular reading may not. A vivid textbook can be read as a popular reading, but ordinary popular reading can not be taken as a textbook.

3. Astronomical textbook for students of physical science

Because astrophysics has mobilized all branches of physics to deal with astronomical objects, the astronomical textbooks for nonastronomy students of physical science should be textbooks of astrophysics in essence. Perhaps the following points would be the main consideration:

1. Reduce ordinary content of general astronomy to the least.

Since the students are already familar in most branches of natural science, knowledges in general astronomical textbooks especially those descriptive and those too specialised content can be reduced.

2. Discuss basic laws of cosmos with united point of view

To discuss basic laws which govern all celestial bodies and states of materials in the universe from a perspective and united view will help students to stand on higher level.

3. Relate various celestial bodies with evolutionary point of view

The universe and all its constitutes are evolving. To relate them with evolutionary point of view will help student to understand the universality and relationship of physical laws.

4. Increase the weight of galaxies and cosmology

The discoveries of galactic nucleus activity, quasar and other active phenomena, bring about a lot of difficulty to physical science. Letting students to know those will help them to catch up the frontiers of research.

The above is some advices summarized from about 20 new foreign astronomical textbooks. Wish them can be useful when our new editions of astronomical textbooks are being compiled.

Astronomy Is Too Important To Be Left To The Astronomers

Bian Yulin

Beijing Astronomical Observatory, Chinese Academy of Sciences
Beijing 100080, P.R.CHINA

ABSTRACT. In this paper, the functions of popular science, the importance and feasibility of popularizing astronomy, and popular astronomy in P. R. China are discussed. The key points are: (1) "Astronomy is too important to be left to the astronomers" and "Popular science is too important to be left to the popular science writers"; (2) what we should make our great efforts to do is that "To spread astronomical knowledge among the people, including those VIPs and the very rich, to get sympathy, and both moral and opinion support, and eventually get the money for making astronomy"; (3) we could meet difficulties, but we should always remember these proverbs — "They who cannot do as they would, must do as they can", and "The shortest answer is doing the thing"!

1. INTRODUCTION

The well-known French statesman Georges Clemenceau (1841-1929) used to give such a very famous statement that **"War is too important to be left to the armymen."**

Paraphrasingly, the great American writer Isaac Asimov (1920-1992) gave his statement on science as follows: **"Science is too important to be left to the scientists."**

Once again paraphrasingly, as an amateur science writer, I would like to say that **"Popular science is too important to be left to the popular science writers."**

At the same time, as an astronomer, I should say that **"Astronomy is too important to be left to the astronomers."**

Last of all, as both an astronomer and a science writer, I have to say that **"Popular astronomy is too important to be left to the popular astronomy writers."**

In view of these opinions, this essay is produced, in which some items are just very briefly presented while the others are more or less in detail. The functions of popular science, the importance and feasibility of popularizing astronomy, and popular astronomy in P. R. China are discussed in sections 2, 3, and 4, respectively.

2. FUNCTIONS OF POPULAR SCIENCE

Popular science has four main functions: (1) to train people towards profession, (2) to meet the needs of developing science itself, (3) to build spiritual civilization, and (4) to build material civilization.

2.1. To Train People Towards Profession.

♠ Please read following words quoted from the obituary to Isaac Asimov written by Carl Sagen (*Nature*, **357**, 14 May 1992):

"It will never be known how many practising scientists owe their initial inspiration to a book, article or short story by Asimov – nor how many ordinary citizens are sympathetic to the scientific enterprise for the same reason. M. Minsky, one of the pioneers of artificial intelligence, was first motivated by Asimov's robot stories (conceived to illustrate human/robot partnership and to counter the prevailing notion, going back to *Frankenstein*, of robots as necessarily malign)."

In one of his last books, Asimov wrote that "my life has just about run its course and I don't really expect to live much longer", "It's been a good life, and I am satisfied with it. So please don't worry about me." Then, Sagen wrote that "I don't. Instead, I worry about the rest of us, with no Isaac Asimov around to inspire the young to learning and to science."

♡ It is generally considered in China that popular science ia a classroom out of schools. Since all of us know the importance of classrooms, so as to the importance of popular science — the classroom out of schools, it goes without saying!

2.2. To Meet the Needs of Developing Science Itself.

For a pyramid, the broader its base is, the taller its body. This is the reason why Sir Isaac Newton wrote, in a letter to Robert Hooke in 1676, that "If I have seen further than other men, it is because I stood on the shoulders of giants."

Now, the question is: "where did/do/will the giants come from?"

After all, they must emerge from the public, rather than out of nothing!

2.3. To Build Spiritual Civilization.

Especially, it is for struggling against pseudo-science, superstitions or blind faith. As a good example, let us have a look at these points presented in the book *Science and the Paranormal — Probing the Existance of the Supernatural*(1981, eds. George O. Abell and Barry Singer) as follows:

"A dispassionate observer of the current scene can only be astonished by the rapid growth of bizarre beriefs in recent years among wide sectors of the public. ..."

"What should be the response of scientists to the current outbreak of irretional beliefs? Until recently, many scientists have chosen to ignore them. ... Fortunately, there are also a number of scientists who have recognized that they have a responsibility that goes beyond their own specialties: to apply the methods of science to the scrutiny of claims of the paranormal and thus contribute to public information and education."

"The contributors to this volume are eminently qualified to deal with the many controversial claims made about the paranormal". "For example, ... Carl Sagen has devoted a good deal of his attention as an astronomer to the theories of Immanuel Velikovsky, and he helped to initiate and plan a special controversial session of the American Assocoation for the Advancement of Science to discuss his theories. ... George Abell, a noted astronomer, is an expert on astrology and has actually sought out, worked with, and debated astrologers about their claim. ..."

— Quoted from Foreword by Paul Kurtz (1925-), Professor of Philosophy at the State University of New York at Baffalo. In 1976 he was the driving force behind the formation of the Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP) and has served as the committee's chairman since.

2.4. To Build Material Civilization.

That means to develop production, bring about a prosperous economy, raise living standard, and so on. It is, of course, self-evident!

3. POPULARIZATION OF ASTRONOMY

3.1. Does Popularization of Astronomy Have All Functions As Mentioned in Section 2? Yes, definitely.

3.2. Astronomy Is One of the Oldest Sciences, which has been paid attention by both govenments and people for thousands of years.

♠ On the one hand, for example, as early as 3000 years ago, there had been the Astronomer Royal already in China.

♡ On the other hand, astrology is a seriously distorted shadow of astronomy, which used to be and still is popular at wide-spreaded places over all the world, even in those highly developed countries. We should try to do our best to let people see what the undistorted object (astronomy) of that distorted shadow (astrology) is.

3.3. Astronomy Is a Big Science in Modern Time.

♠ Of importance, see Figure 1.

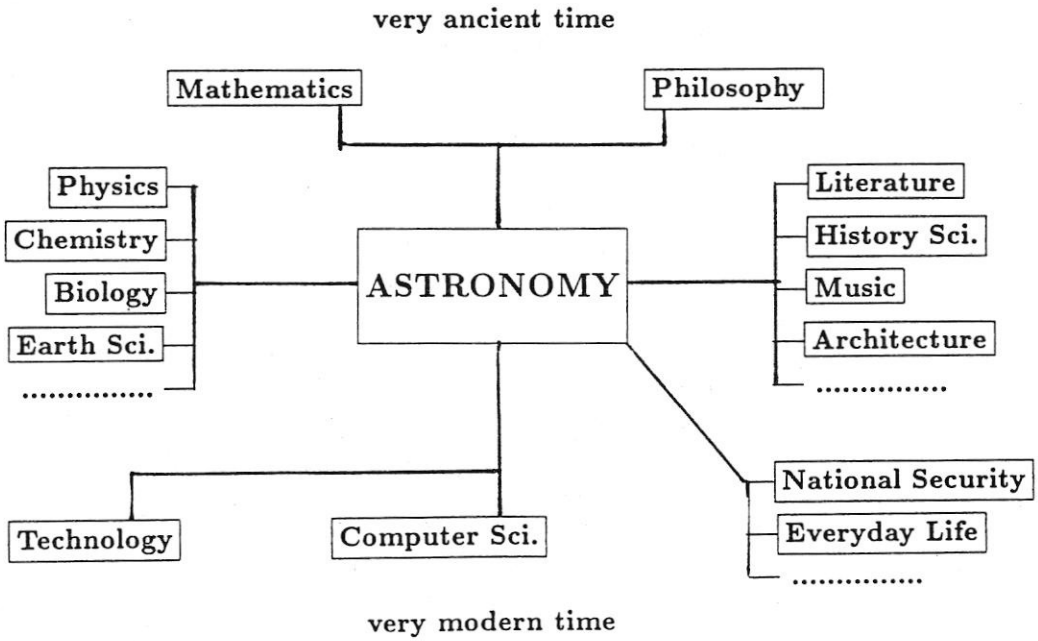


Figure 1 Astronomy – a great science

♡ Concerning a big science, these words, in my opinion, are really instructive:

"Tycho's effort were already big science in the most pejorative sense of that term. Without royal support from the Danish king and essentially the whole economic output of a sizeable population on the island of Hveen, Tycho could not have done what he did. ... the demand for larger and larger telescopes quickly made observational astronomy impossible without support from govenments or, at least, the very rich. It would be well for those who bemoan the current dependency of astronomical research on govenmental support to consider the history of the subject..."

— Quoted from James E. Gunn: Expanding the universe: Space telescope and beyond in the next twenty years, in *Bubbles, Voids and Bumps in Time: the New Cosmology*, ed. by James Cornell, Cambridge Univ. Press, p.147, (1989).

◇ So, don't bemoan and just do what we should do:

To spread astronomical knowledge among the people, including those VIPs and the very rich, to get sympathy, and both moral and opinion support, and eventually get the money.

If without popularization of astronomy, can we attain our objective? Think about it, and think it over, please!

3.4. The Feasibility of Popularizing Astronomy.

♠ In principle, it should be possible to popularize any sorts of scientific knowledge at some certain levels. I completely agree with Isaac Asimov's idea as follows:

"Yet modern science need not be so complete a mystery to nonscientists. Much could be accomplished toward bridging the gap if scientists accepted the responsibility of communication – explaining their own fields of work as simply and to as many as possible – and if nonscientists, for their part, accepted the responsibility of listening. To gain a satisfactory appreciation of the developments in a field of science, it is not essential to have a total understanding of the science. After all, no one feels that one must be capable of writing a great work of literature in order to appreciate Shakespeare. To listen to a Beethoven symphony with pleasure does not require the listener to be capable of composing an equivalent symphony. By the same token, one can appreciate and take pleasure in the achievements of science even though one does not oneself have a bent for creative work in science."

— quoted from Isaac Asimov: *Asimov's New Guide to Science*,(1984).

♡ Historical experience: (a) some examples of very successful science propagators.

Bernard le Bovier de **Fontenelle** (1657-1757), became perpetual secretary of the French Academy of Sciences in 1697. He wrote annual summaries for its activities and obituaries for famous scientists as they died. He was considered as the first person to make a reputation in science on the basis of his popular science writing alone. His *Conversations on the Plurality of worlds* (1686) was an introduction of the astronomy of the telescope; a careful consideration of each of the planets from Mercury to Saturn, with speculations as to the kind of life that might be found upon them. This book is so successful that even today it is frequently referred when extraterrestrial civilizations are talked about.

In modern time, please consider the success of Isaac **Asimov** in U.S.A., Patrick **Moore** in U.K., and many others in different countries.

◇ Historical experience: (b) some examples of very successful popularization made by famous professional astronomers.

Joseph Jerome Le Francais de **Lalande** (1732-1870), being well-known especially for his grand star catalogue of forty-seven thousand stars among which is Lalande 21185, one of the nearest stars from the Sun, was a great popularizer of astronomy and wrote all the astronomical articles in Diderot's Encyclopedia.

Nicolas Camille **Flammarion** (1842-1925). His *Popular Astronomy* (1879) was the best book of its sort produced in the 19th century...

Sir James Hopwood **Jeans** (1877-1946) was the author of the very famous books *The Universe Around Us (1929), Through Space and Time (1934)*...

Sir Arther Stanley **Eddington** (1882-1944) was the author of a number of books on astronomy for the layman in the 1920s and 1930s, notably *The Expanding Universe*, published in 1933.

Henry Norris **Russell** (1877-1957) was one of the inventors of the H-R diagram. Since 1900, he wrote articles monthly for the journal *Scientific American* and by 1943 the total number of them was five hundreds!

George **Gamow** (1904-1968), in addition to his first-rate science, proved to be one of the most effective and consistently charming popularizers of science. This second career began with his *Mr. Tompins in Wonderland* (1939)...

Sir Fred **Hoyle** (Born in 1915) is a source of continuous creation and many other spectacular ideas. He is a worthy successor to those other astronomer-writers, Jeans and Eddington, and perhaps the most eminent of those contemporary scientists who have written science fiction under their own names...

Carl **Sagen** (born in 1934): the author of the outstanding *Cosmos* (both in book and TV series versions), many books, and a number of popular articles...

Stephen William **Hawking** (born in 1942): his *A Brief History of Time* (1988) was listed as best-seller for dozens of weeks!

And others in countries over all the world.

4. POPULAR ASTRONOMY IN P. R. CHINA

4.1. Planetaria. see the talk given by Cui Zhenhua at this meeting.

4.2. Astro- Movies, TVs, and Broadcasts. There are programmes from time to time, but, in general speaking, astro-movies, videos and broadcasts in P. R. China are still weak points, and we should improve the situation in the near future. While I hope someone else would give a special report on it, I prefer to give some words about the popular astronomical books and magazines in my country.

4.3. Books and Magazines.

♠ From 1922 (the birth year of the Chinese Astonomical Society) to 1992, some one thousand astronomical books in Chinese were published. Among them more than 80 percents are popular and most of them were published after the foundation of P. R. China.

♡ We have all levels of popular science magazines, ranging from children's to university students and scientists working in other fields. Although it is impossible for me to list all of them, it should be helpful to present, as examples, the names of those magazines in which some of my popular astronomical articles were published. See next subsection.

4.4. Of Myself.

While I am presently doing research work on the fields of extragalactic astronomy and observational cosmology, I am enthusiastic to popularize astronomy. I have translated quite a lot of books, mostly written by my friend Isaac Asimov, from English into Chinese, and have published several popular science books of myself. I have published more than 200 articles and essays at different levels on a variety of magazines/newspapers. Among them are:

Juvenile Science Pictorial
We Love Science
Middle School Students
Amateur Astronomers
Scientific Experiment / Science World
Popular Science / Science Pictorial
Young Scientists
Modernization
Spaceflight
(Chinese) Nature
All Sorts of Knowledge
High Energy Physics / Popular Modern Physics
Selected Translation of World Science
Science Garden
(Chinese) Science
Trees of Wisdom
Science and Future
Science and Technology Daily
Beijing's Evening
Guangming Daily
Texbook of Chinese Language for the 3rd year pupils in middle schools
Short Talks About Science
Sparks of Wisdom (in Esperanto)
Popular Science Works
Theories and Comments on Popular Science

Undoubtedly, popularizing astronomy is not a easy task. We could meet difficulties, but please just remember and follow these proverbs:

"They who cannot do as they would, must do as they can."

"The shortest answer is doing the thing!"

Vigorous Development of Popularization of Astronomy in China

By Cui Zhenhua, Chen Dan and Wang Zongliang
from
Popularization Committee, Chinese Astronomical Society

As early as it was founded, Chinese Astronomical Society set its purpose " striving for the advances of professional astronomy and popularization of astronomy among the public". The forerunners of China's modern astronomy, such as Gao Lu, Zhang Yuzhe, Chen Zungui, Li Heng and Dai Wensai, have left us a large number of popular works and popular translation works for popularization of astronomy, and brought up a large number of eminent scientists devoted to popularization of astronomy. All this has played a significant role in promoting the popularization of astronomy in China. Since 1949, Chinese government has set great store by popularization of sciences, allocating a large sum of resources and setting up necessary facilities. With the diligent efforts by modern astronomers of China, the year of 1957 saw the establishment of Beijing Planetarium, the first institution in China specially engaged in popularization of astronomy among the public. In 1978, Chinese Astronomical Society set up, within itself, the Popularization Committee, whose responsibility is to organize, direct and coordinate the popularization activities concerning astronomy nationwide. Thus, popularization of astronomy in China entered a new era of vigorous development.

Planetariums Are a Backbone for Popularization of Astronomy

According to the incomplete statistics, China has one large planetarium and 74 small and medium-sized planetariums. All the provinces, municipalities and autonomous regions, except some remote border regions or provinces like Xinjiang and Tibet, have their own planetariums. With 9 planetariums, Jiangsu Province tops others in terms of quantity. Furthermore, such big cities as Tianjin and Shanghai are exerting active efforts in making preparations for setting up large planetariums.

It is beyond any doubt that among the numerous planetariums, Beijing Planetarium plays a role of backbone. The first big planetarium ever built in China, Beijing Planetarium boasts a personnel involved in popularization that is most experienced and of tremendous strength. Apart from conducting routine popularization work by making use of space theater , exhibition hall and observatory as is done by other ordinary planetariums, Beijing Planetarium is also actively engaged in research on space theater and its auxiliary instruments, provides advice to planetariums newly built and to be built, and does research in theory and practice with regard to popularization of astronomy. Therefore, it is a center for popularization of astronomy as well as a center for providing advice in this field. It is also the seat of Popularization Committee of Chinese Astronomical Society.

Generally, the 74 small and medium-sized planetariums fall into two categories, planetariums for youngsters and university planetariums. Most of planetariums for youngsters are within children's palaces (children's activity centers) or science and technology popularization centers, providing services mainly to children. University planetariums are mostly a part of specialities as navigation, mapping, geography and physics in universities. And also some primary and secondary schools have set up planetariums recently. The main purpose of university or school planetariums are mainly intended to aid the astronomy teaching programs while some are open to the public as well.

Demonstration and exhibition are the major ways and means for popularization. Among various kinds of astronomical films, most are concentrated on astronomy popularization and education. The best films are " Traveling in Outer Space" and "Exploring the World of Planets", prepared and produced by Beijing Planetarium. The former, an inaugural program presented by Beijing Planetarium, is well-known as an interesting and vivid film, and has been held in repertoire for a long time. Over 10 million spectators have seen the film. The latter is the film shown in space theater of Beijing Planetarium since its equipment was entirely updated in the 80s. With the help of multi-media equipment, it presents the latest findings with respect to planet and space exploration vividly, representing best the technical level of presentation of astronomy in China. These two films are broadly adapted by small and medium-sized planetariums throughout China. As to exhibitions, the following are well-known and of far-reaching significance: "Exhibitions on Astronomical Knowledge" (1957, 1974 and 1987), "An Exhibition in Commemoration of Copernicus" (1973), "An Exhibition on Achievements in China's Ancient Astronomy" (1983) "An Art Exhibition about Outer Space" (1984) and "An Exhibition on Aerolites in China" (1990).

In a word, a network of planetariums, with Beijing Planetarium as the key, is being established. It is the backbone in astronomy popularization in China.

Publications with Comprehensive Contents and at Multilevel

Conducting popularization in astronomy by means of publications and books is our tradition. As early as in the 1930s, Chinese Astronomical Society published a monthly magazine "Universe" which specially published articles on popularization in this field. Until 1949, 20 volumes had been published, and after 1949, "Universe" was stopped publishing.

Currently, there are four types of publications for popularization which are published and issued in China. "Astronomical Amateur", co-sponsored by Chinese Astronomical Society and Beijing Planetarium, was initiated in 1958 for popularizing the basic knowledge of astronomy in various fields, and so far, 206 issues have been published. The highest circulation reached 120,000 copies in 1978, the champion of the astronomical publications for popularization in the world at that time. In 1979, "Astronomy Amateur" started to publish its magazine in Hongkong, Macro and foreign countries, since then, China's astronomy publications for popularization have been distributed in

the world.

"Astronomical Popular Yearbook" co-sponsored by Zijinshan (the Purple Mountain) Astronomical Observatory and Beijing Planetarium was initiated in 1977, which provides star catalogue, for observing the sun, the moon, planets, small planets, comets and materials for observing variable stars, nebulae and clusters. This is an annual magazine, which is the essential book for astronomical amateurs to observe celestial body.

"Study on Planetarium" sponsored by Beijing Planetarium was initiated in 1983, serving as a guide to meet the needs of the vigorous development in the field of astronomical popularization and education. The primary principle is to evaluate the development trends in the field of astronomical popularization and education, to study the theory, method and means of astronomical popularization and education and to provide practical and popular materials on science and technology with the main characteristics concentrating on the theory, practice and materials. "Study on Planetarium" has its unique characteristics among the astronimical publications for popularization.

"The Express Bulletin of Astronomical Amateur" published in 1992 and sponsored by popularization Committee of Chinese Astronomical Society specially provides the observatory materials on some emergency astronomical phenomena to astronomical amateurs.

Therefore, China now has various kinds of publications for comprehensively popularizing the basic knowledge of astronomy, specially providing observatory information, and studying theory, methods and means as well as providing practical and popular information, so as to form a rather complete publication system, from which the readers can obtain comprehensive and various information.

From the date of the birth of Chinese Astronomical Society until now, the Chinese popular science writers have written, translated and compiled about 1500 books of popular reading materials on astronomy. Due to the limits of this article, details are omitted.

Astronomical Amateur Groups and Popular Astronomical Observatories

Chinese Astronomical Society has always attached great importance to training amateurs in the field of astronomy. From the end of 1940s to the beginning of 1950s, " Popular Astronomy Society" was established and a large number of astronomical amateurs organized, and many members of the Society have become experts or backbones in the field of astronomy.

In 1978, a veteran astronomer, Mr. Li Hangchang proposed to establish " Association for Young Astronomical Amateurs". Hence, the astronomical amateur associations in Shanghai, Beijing and Yunnan Province were established

respectively. Since then, this kind of astronomical amateur groups has got rapid development, and so far there are about 20 astronomical amateur associations in China, which have become the backbone force in the field of astronomical popularization.

In addition to taking part in the astronomical popularization activities, a large number of astronomical amateurs have also engaged in astronomical observatory activities in their spare time. Therefore, mass astronomical observatory activities on considerable scale have been conducted, and remarkable progress has been achieved. Total solar eclipse in 1980, Halley comet return between 1985-1986 and annular eclipse in 1987 are some of the examples.

On this basis, the popular astronomical observatories in China have experienced vigorous development. Originally, popular astronomical observatories were part of the astronomical planetariums, but now, astronomical observatories have been established not only in schools, children's palaces, science and technology centres, but also in parks. Therefore, it is quite difficult to calculate the exact numbers of popular astronomical observatories in the country. If calculated in terms of astronomical telescopes, there are at least 200 sets of 120mm, 40 sets of 150mm, 4 sets of 300mm and 10 sets of 400mm across the country. However, many astronomical telescopes have not yet been installed in observatory rooms. So the total number of astronomical observatories should be less than the total number of astronomical telescopes.

The Chinese astronomical amateur groups often depend on astronomical planetariums, and rely on popular astronomical observatories as their observatory bases. Their activities have not only promoted astronomical popularization, but also served as an important supplement to professional astronomical observatory.

To sum up, the astronomical popularization and education in China have formed a considerable scale and developed a fairly comprehensive system. That is : conducting effective activities, with Popularization Committee of Chinese Astronomical Society as the agency to organize, guide and coordinate, with Beijing Planetarium as the core, with medium and small size planetariums and astronomical amateur associations as well as popular astronomical observatories as the organizational network and with 4 publications as the news media, so as to enhance the astronomical knowledge level of the whole nation.

Today, we are in the hi-tech age, and the space for mankind is narrowing and the environment of the earth sufferring a serious damage. Therefore, mankind must set eyes on space. It is also our duty to study and protect the earth from space. In this case, the desire of mankind to learn more knowledge about space will become stronger. Hence, being the astronomical popularization workers, our duty will be heavier.

With the increasingly development of national economy and raising of the science and technology level, the astronomical popularization in our country will be vigorously developed. It is foreseeable that when coming into the 21st century, the number of astronomical planetariums will be further increased, the quality of work and teaching services will improve to an extent much higher than today, and the knowledge of astronomical amateurs will be remarkably increased. By that time, China, with a good astronomical tradition and strong space technology strength, will truly join the major countrys' rank in the world in the field of astronomical popularization and education.

WORK FOR POPULARIZATION AND TEACHING OF THE BEIJING PLANETARIUM

Xu Deng-Li

The Beijing Planetarium, Beijing, China

The Beijing Planetarium was founded and opened in September, 1957. It is so far the sole large-scale planetarium in our country (mainland) , undertaking astronomical popularization, teaching and research work.

The main equipment and facilities of the Beijing Planetarium are: a space theatre with a diametre of 35m and a seating capacity of 600, equipped with a China-made large-sized planetarium and a variety of subsidiary devices; an exhibition hall covering a floor space of 400 square metres, in which on display are items with respect to rudimentary information and knowledge; an observatory equipped with a 13cm equatorial armilla; a solar chromospheric observatory equipped with a chromospheric telescope; a lecture room covering a floor space of 400 square metres with a seating capacity of 600, where academic activities and symposia are frequently organized.

The functional departments of the Beijing Planetarium are: the planetarium showing office, in charge of daily work open to the public; the technical office, responsible for development and maintenance of the instruments and devices; the editorial office, responsible for editing and publishing "Amateur Astromomer" and "Popular Astronomical Yearbook" ; the office of the Ancient Beijing Observatory, in charge of exhibition of China's ancient astronomical instruments and devices together with information and knowledge on them, as well as collection and reflection of information about cultural exchange on astronomy between China and the world; and finally, the research and teaching office, mainly engaged in teaching work.

The teaching work of the Planetarium has its own features: to cover a wide range of masses in all parts of the country and of different levels including primary and middle school pupils, college students as well as teachers and personalities of all walks of life; to utilize existing equipment and devices available to popularize knowledge on astronomy in various ways at the Planetarium and in all parts of the country.

This is now to be dealt with respectively as follows:

1. To utilize existing intruments and equipment available.

To give performances of starry sky with the help of the planetarium is one of the chief means for teaching on astronomical knowledge. Astronomical programmes amount to more than 100, which, according to the contents, may generally fall into two parts: one is intended for the average audience, the other is to coordinate with the teaching on astronomy in primary and middle schools, which has apparent aim at. Planning and writing of the programmes, from choosing of the topics to the contents, are integrated with lessons on astronomy in physical geography in primary and middle schools. Teachers of geography are widely consulted. The stress is to solve the problems which cannot be vividly explained at the classes. There are over 20 teaching programmes which have been continuously performed for years. Soon after the academic year opens every year, it is just the time for the lessons concerning astronomy will be given, so the teaching performances in the space theatre increase with the orpanized students to come enjoy, most of the students are from the city proper, some from the suburbs. The

Planetarium's teaching performances have played a positive role in coordinating with the school teaching, which has been well received and praised by the Beijing Municipal Educational Bureau and Beijing Scientifci and technological Society. In additon, Special performances, not planned and arranged in advance, are given in order to give on-the-spot demonstrations and explanations in accordance with questions put forward. This is especially provided for professional personnel.

Use of the exhibition hall to support teaching. The exhibition of astronomical information at the Planetarium is so far the largest one in scale in our country. Rudimentary knowledge on astronomy is introduced to the masses with the help of pictures, models and original items. To the school pupils, it is an outside school classroom for them to learn knowledge about astronomy. The exhibition basically covers all the contents on astronomy in the school classes, with those about evolution of the planets, stars and celestial bodies in addition. In the exhibition hall there are the professional guides, who explain to the average audience, especially to the school pupils, complementary mutually to the lessons in schol classes. This proved to be very effective. Many of the students frequently come to the hall, collectively or individually, with great interest, watching the exhibits carefully, taking notes in detail and raising questions in every respect. As a result, the exhibition hall has played a certain role in astronomical teaching.

Use of the observatory to supplement teaching. The 13cm equatorial armilla is used to observe the sun, the moon and the planets, and to take photos of them. The solar chromospheric telescope is used to observe and to have photos. This not only adds more perceptual knowledge, bue also trains the students to do astronomical observation.

In the lecture hall astronomers are often invited to come here to give academic reports. The listeners are mainly college students and school pupils as well as teachers. This is very beneficial to them to broaden their horizons and to understand better the developments of astronomy.

2. To engage in training courses

Training teachers: This task started in 1970s. Before 70s, geography and natural science lessons in primary and middle schools did not involve astronomical contents. Form 70s on, These textbooks added to astronomical contents, while most teachers had not studied astronomy. This fact brought about greater difficulties to the teaching. For this reason, the Beijing Planetarium conducted shortterm training courses many times, first training teachers in Beijing region. This measure played an active role in astronomical teaching in Beijing. Later on, training courses of this kind extended toother provinces. which was well received by educational departments and schools in these provinces. In 1983, the Beijing Planetarium co-operated with the Ministry of Education to conduct a " Lecture of Astronomical Knowledge in Ancient Chinese Prose". In these proses, much ancient astronomical knowledge is involved. The students were from the Departments of Chinese Language at Universities in all parts of the country.

In a period of half month, the students had fundamentally mastered astronomical knowledge in ancient proses and got acquainted with basic knowledge on modern astronlmy. This Lecture course helped a lot to the

teaching of ancient Chinese.

Training amateur astronomers: to popularize astronomical education, " Beijing Society of Young Amateur Astronomers" was set up in 1979 in Beijing, the members being students from Beijing middle schools. The Society after its founding has done a lot of work under the guidance of astronomers in Beijing and professional personnel of the Beijing Planetarium, developing scientific and technological activities, such as that the amateur were organized to join in the observations of total solar eclipse in 16 Feb. 1980 in Yunnan and total solar eclipse (partial solar eclipse seen in our country) in 31 July, 1987. They succeeded in having taken photos of "Baily beads" of the total solar eclipse in Yunnan, verifying the ancient's " observed the Sunbya oil-basin" and learned to use the Scaphe observation created by Guo Shoujing. At the annual conference sponsored by the Society in July, 1981, received were " small" theses amounting to more than 100 and models more than 50 made by its members. At the Youth Science Symposium held in Beijing in November, 1981, 10 pieces of papers offered by the society members won the first, the second and the third prizes respectively, which account for 1/5 of the prizes as a whole of the city. To this, the astronomical education of the Beijing Planetarium has made certain contributions as well.

Traning professional personnel of minor planetariums in other provinces: From 1970s to the present, approximate 50 small-sized planetariums have been set up one after another all over the country. The Beijing Planetarium has undertaken full resposibility of training their professional personnel. These short-term training has made them initially to know well astronomical knowledge, how to operate instruments and devices and how to carry out populaization work on astronomy. So far, several hundreds of personnel in other provinces working on astronomical popularization and deucation have been trained and fostered. This is a vital new force in this respect, large in number, wide in range and great in results. The minor planetariums all over the country coordinate with local youths and Children's Palaces, scientific and technological stations and schools, laying a sound foundation for national popularization of astronomical education.

3. To organize summer camps: Every summer vacation, the Beijing Astronomical Society, the Beijing Observatory and the Beijing Planetarium collectively organize " Summer Camp of Astronomy", those who attend are middle school students from all provinces in the country. Every camp is run for about two weeks, on purpose to learn astronomical knowledge mainly. Those attending are trained to develop their operating capacites through practice of observation. This way of studying is vivid, lively and effective, well accepted and supported by the schools and the students' parents.

4. To conduct short-term training courses in vacations:

Recently, the Beijing Planetarium coonducted short-term training courses, one week for each cours, two courses may be conducted in summer vacation, students coming from primary and middle schools. In a period of one week, the students are taught a bit of basic astronomical knowledge, the simple method of observation and the use of telescope. Despite that the short-term course cannot provide students with much knowledge on astronomy, it is effective to foster the students' interest in astronomy. The significance is, so to say, profound.

5. To edit and write books and reference materials and to develop teaching aids:

In accordance with the interrelated lessons in primary and middle schools, the Planetarium has edited and written "Astronmical Hanging Chart" together with its captions, and printed ten odd sets of slides, drawn turning star map and developed simple cosmosphere, transparent cosmosphere the model of the Sun, the Earth and the Moon and the lunar phase varying instrument. All of these are comparatively vivid and easy to understand. They are means indispensable to the teaching and well received by the schools.

6. To popularize ancient astronomical knowledge:

China's Astronomy originated quite early and developed rapidly. There had been calendar as early as in the ages of the Xia, the Shang and the Zhou Dynasties with distinguished scientific results, occupying a brilliant place in the historic development of world civilization. In our teaching, we should mention the brilliant past, the present deficiencies, and we should see into the future.

Summarily from the above-mentioned, the Beijing Planetarium in the past 35 years has done a lot of work on astronomical teaching and achieved great success. The reasons for this are as follows:

1. The state has attached importance to the cause

The state has consistently attached importance to basic science. Astronomy is one brance of basic science, as a result, its popularization and education are also valued. In 1950s when numerous tasks remained to be undertaken, the construction of the Planetarium being placed on the agenda had proved this point. The Beijing Planetarium was much in the thoughts of the state leaders, who many times visited, inspected it and gave instructions. Among them were Liu Shaoqi, Zhou Enlai, Deng Xiaoping, Chen Yi.

2. Astronomers have given backing to the cause

Veteran astronomers and scientists supported astronomical education in many ways. This not only accelerated the completion of the Planetarium's construcation, but also devoted major efforts to popularizing astronomical education. They often came here to give academic reports and to instruct the personnel in work.

3. Educational departments and mass organizations gave assistance to the cause.

Astronomical education has been shown solicitude by the educational departments all along. They deliberated, together with the Planetarium, the editing and writing of reading materials about astronomy, the making of teaching instruments and the ways of training, which helped astronomical education have a definite object in view. China Astronomical Society and Beijing Astronomical Society have assisted the Beijing Planetarium to organize various kinds of teaching activities.

4. The personnel at the Planetarium are active and initiative

To broaden the range of astronomical education, the personnel from the Planetarium went to various places to do popularizing, for instance, to the villages in the suburbs, mounting several small-sized telescopes there, to watch sunspots by day and to observe stars, planets and moon by night, with pictures attached. Questions raised by the masses can be explained at all

times when necessary. This method is applied as well in the parks in the city proper, which facilitates the masses who have no chance to go to the Planetarium, ot be able to enjoy popularization of astronomical education. This kind of task, arduous to the professional personnel at the Planetarium, depends on the professional personnel's zeal and initiative.

5. Vocational work kept in contact with other departments in every way The professional personnel have wide connection with all astronomical departments, joining them in some of their research work, on purpose to renew knowledge and to understand progress of astronomy in order to benefit popularization of astronomical deucation. It is the situation that demands, for minor small-sized planetariums and youth and youngster scientific stations now still look upon the Beijing Planetarium as their main professional instructor. Therefore, it is necessary for the personnel consistently to promote their own level of profession. They often keep wide connection with the Beijing Observatory, the Purple Mountain Observatory, the Yunnan Observatory, the Department of Astronomy at Beijing Normal University, the Speciality of Astrophysics in Beijing University etc. Practice prover that the personnel have promoted their professional level indeed.

The connections at home are wide in range, but international academic exchange is not enough. It is suggested that associations with other countries should increase if conditions permit.

the Beijing Planetarium

A STUDY OF THE COMPREHENSION OF PLANETARY MOTION

Dileep V. SATHE, Dadawala Jr. College
1433 Kasba Peth, PUNE : 411011, INDIA

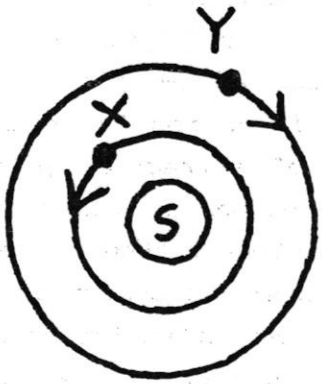
INTRODUCTION:- Persistence of the Aristotelian ideas among students of various levels, including the university level, is a global problem and has been confronting educationists for more than 20 years. In particular, it has been found out that the uniform circular motion is the most difficult concept for comprehension. This conclusion is supported by the fact that when students are asked to show the resultant force acting on a body, performing the u.c.m., many students tend to show the forward or tangential force instead of the centripetal force. This finding was reported first by John Warren /1/ in 1971, about 35% students from his group had given this particular wrong answer. Subsequently, many educationists made similar investigations all over the world and their findings did substantiate the finding of Warren. Since then, educationists have been putting blame upon students for their failure in understanding this important concept. In view of this situation, it was conjectured that the root of this problem could be found in the present way of teaching this concept in the introductory classes. Therefore a restudy of the teaching itself was initiated a few years ago, which brought out some startling facts and led the present author to put forth the hypothesis that the present treatment of u.c.m. has some flaws and these flaws motivate students to give wrong answer. There are two main issues to be considered. 1) In a typical introductory course, students have to learn some concepts which require the force and motion to have the same direction. For example, a) the concept of work, $W = F.S. \cos\theta$, b) the concept of potential energy, c) the law of parallelogram of forces. But in case of the u.c.m., the instantaneous displacement is perpendicular. This difference gives rise to conflict in minds of students and becomes an obstacle in the comprehension of u.c.m. and related topics. In the GR9 Conf. /2/ it has been shown by the present author that the

trouble arises in finding the equation of velocity of a planet on the assumption that the gravitational force provides the centripetal force for the planetary motion because the same force is used in the concept of gravitational potential energy- in which the motion is along the line of action and not perpendicular. 2) There is one more difficulty which deserves consideration of physicists as well as educationists. It has been termed as the Anticlockwise / Clockwise paradox, which was discussed first in the I.C.P.E. Conf. in Tokyo /3/ in 1986 but recently it has been shown that the A/C paradox causes difficulty in the teaching of planetary motion /4/ also. In nutshell, the A/C paradox is as follows. The present treatment of u.c.m. does assert that a body performs u.c.m. due to the centripetal force acting on it and due to this assertion, we can assume that the gravitational force provides the centripetal force for the planetary motion and that the electrostatic force of attraction provides the centripetal force for the motion of electron in Bohr's model of hydrogen atom. Therefore, the question arises : "How to decide the direction of motion of a **body**, on the basis of centripetal force acting on it?" This question has escaped our attention because we never consider two bodies, while teaching u.c.m., in the classrooms as well as in the textbooks - one moving anticlockwise and the other clockwise. We **can not** ignore this question because a body can move either anticlockwise or clockwise. To make this point more illustrative, let me quote a hypothetical situation. Suppose a teacher has used anticlockwise motion in the discussion in class A and clockwise motion in class B and suppose that the students of these classes are comparing their notes. After the comparison, students of one class will think that the teacher has committed mistake in the other class, and this will create confusion among all the students.

As the A/C paradox has escaped our attention so far, earlier investigators could simply observe the particular wrong answer of students but could not explain what motivates students to give that

particular wrong answer. Therefore three new questions were used by the present author in a recent investigation /5/ and the findings did support the hypothesis mentioned above. One of the questions dealt with a hypothetical solar system, responses of students are described below - which throw light on the comprehension of planetary motion by the students.

The QUESTION :- We have a hypothetical solar system, as shown in Fig. 1, with planets X and Y orbiting in opposite directions, but with constant speeds. Draw arrows Rx and Ry to show the resultant forces acting on X and Y respectively. Any comment may be made in the space below the figure.



ANSWERS OF STUDENTS : - Sixty-seven students from some sr. colleges responded to my questionnaire. Only one student gave the correct answer and, on the other hand, one student stated " No forces are acting on planets X and Y." and one student did not answer. Remaining answers are between these extremes. These 64 answers vary greatly in their versions, which makes the statistical analysis difficult. Therefore some answers are reproduced below which seem to be important from the point of view of comprehension.

Out of 64, twenty-six students have shown the resultant force in the direction of instantaneous displacement. Twelve students from these 26 have used the terms centripetal force

and/or centrifugal force for that resultant force. According to 6 students, centripetal force acts on one planet and centrifugal force acts on the other planet. Ten students have used radial as well as **tangential** forces in their answers. Two students have asserted that the centripetal force **and the centrifugal force cancel each other, resulting in the planetary motion.**

DISCUSSION:- This investigation is the first of its kind as the students were confronted with two bodies moving in opposite directions. Most of the students showed the tangential force as the resultant force, supporting my hypothesis. However, none of them made any specific comment - which could have enabled me to study their patterns of thinking in a better way. It should be noted that these students were studying in the final year of B.Sc. course, with physics/electronics as the principal subject and some of them are now doing M.Sc. but no one thought of "initial conditions" also. This also I had expected because we specifically assume that the gravitational force provides the centripetal force for the planetary motion. I have already shown, in the GR9 Conf. mentioned above, how the use of assumption as well as the initial conditions creates problem in the understanding of planetary motion.

So, what are the implications of this investigation for educationists and physicists. Educationists are urged to use my questionnaire to see the patterns of thinking among their students and give some feedback to physicists who will develope effective ways of teaching. It may be noted that the Education Department of Harvard-Smithsonian Center for Astrophysics, U.S.A., has already sent my questionnaire to the pilot teachers - who are working for that Department and I hope that educationists from other parts of the world will join this movement soon, either by using my questionnaire in English or by using its translation in the regional language.

ACKNOWLEDGEMENT:- The author gratefully acknowledges the grant received from the Organizers of "Asian-Pacific Meeting on Teaching of Astronomy" held in Beijing, CHINA in October 1992.

REFERENCES

1. Warren, J.W.(1971) Physics Education, 6, p. 74
2. Sathe, D.V. (1980) the 9th International Conf. on General Relativity and Gravitation, Jena, East GERMANY, 1, p. 202
3. Sathe, D.V. (1986) the International Conf. on Physics Education, Tokyo, JAPAN Proceedings, (II), p. 72
4. Sathe, D.V. (1991) Bulletin (#3) for Teaching of Astronomy in Asian-Pacific Region, p. 22
5. Sathe, D.V. (1991) Proceedings, GIREP Conf., Torun, POLAND, p. 379