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46. TEACHING OF ASTRONOMY (ENSEIGNEMENT DE L'ASTRONOMIE)

(Committee of the Executive Committee)

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VICE-PRESIDENT: J. Kleczek.

ORGANIZING COMMITTEE: G. Abell, E. K. Kharadze, E. Kononovich, V. Kourganoff, M. Minnaert, P. Routly, E. Schatzman, T. Swihart.

MEMBERSHIP

During the 13th IAU General Assembly in Prague it was decided that each nation adhering to the IAU should be represented in Commission 46 by one member interested in the teaching of Astronomy. Six nations were already represented by the members of the Organizing Committee. For all other nations the Commission President contacted the head of the National Delegations to the IAU with the request to designate one IAU member of the particular country as member of Commission 46. With only a few exceptions every IAU member nation designated a representative in this Commission which now contains representatives of 33 nations. It is hoped that the missing nations in our Commission will also soon be represented by an IAU member active in the promotion of Astronomy education. Each member is responsible to (a) promote the teaching of Astronomy in his own country, (b) to keep in touch with the Astronomy teachers of his country, and (c) to communicate to the Commission President any programs and developments, problems and needs concerned with Astronomy education in his country. It is also hoped that institutions in countries not yet adhering to the IAU but which might wish to start some Astronomy teaching, could contact the Commission and, in some specific cases, could designate a Consulting Member to the Commission.

WORK OF THE COMMISSION

1. *Astronomy educational material*

A. *Bibliography*

With the kind collaboration of the Commission members from 22 nations a world wide list of *Astronomy Educational Material* has been prepared which collects the available teaching material recommended by Astronomy teachers of IAU member nations. It contains the following Tables: I. Books; II. Atlases, Catalogues, Encyclopedias, Dictionaries; III. Magazines, Journals, Yearbooks; IV. Lecture Notes, Exercises, Examination Problems; V. Films; VI. Filmstrips, Photographs, Slides. For each item information is given as to the educational level it refers to, where it can be ordered, what its price is, and any other remark which might be of interest. In order to keep its cost low, the A.E.M. list is being reproduced in mimeographed form and will be distributed free of charge to members of the Commission and to the Division of Science Teaching of UNESCO. It is intended to make it available to any astronomer or science teacher involved in the teaching of astronomy. The Commission members will be responsible to give the list of A.E.M. a wide distribution in their respective countries. How this can best be done will be discussed during one of the Commission sessions in Brighton. Every three years, at successive IAU General Assemblies an Addendum of the A.E.M. should be prepared which will contain the recent material useful for the teaching of Astronomy.

B. *Didactics of astronomy*

So far only little has been published concerning the didactics and methods of Astronomy teaching

which is essential for the education in Astronomy at elementary and secondary Schools and College level as well as for the education of Astronomers. It will be one of the topics to be discussed during one of the Commission sessions in Brighton. We should clearly distinguish between "Education of Astronomers" and "Education in Astronomy" both being of equal importance for our Commission. The education in astronomy should already start at the school level. It also should be done in public lectures and in courses for non-scientists, as Taylor (1969) puts it: "We should try to encourage people who will not become astronomers to take an intelligent interest in astronomy". The few books on didactics of Astronomy teaching which have been published in recent years are included in the A.E.M. list. Some additional useful references to recent articles on the subject may be mentioned here. A special issue of the journal *Astronomie in der Schule* (1969) is devoted to the development of the teaching of Astronomy at the secondary school level in the German Democratic Republic and in Czechoslovakia. In the United Kingdom a special meeting was held in 1968 on the Education of Astronomers (1969) during which a number of British Astronomers involved in the teaching of Astronomy presented their views on the subject. R. C. Roeder reported the following: "The Dominion Observatory in Ottawa (Ontario) publishes pamphlets in English or French for the elementary school level on the following subjects: Moon, Sun, Eclipses, Planets, Stars, the Solar System, Jupiter, Mars, Saturn, the Orbits of the Planets, the Space Age, Astronomy in Canada". R. Berendzen sent the following information: "Articles on teaching astronomy to children appear from time to time in several English-language journals, e.g. *Science and Children*, *Science Teacher* (both of which are published by the National Science Teachers' Association in the U.S.), and *School Science Review* (which is published in England). The entire issue of *Science and Children*, 5, no. 4, December 1967, was devoted to teaching about the Moon to elementary school children." R. Berendzen is editor of the *Journal of College Science Teaching*, a journal "which is, hopefully to become an organ for distinguished papers on astronomy education". In addition, R. Berendzen mentions that M. Hoskin (Cambridge University) is editor-in-chief of another newly formed publication: the *Journal of History of Astronomy* which is to include the educational use of history of astronomy. S. S. Ross (1969) describes the session on Laboratory Exercises in Astronomy which was held during the session devoted to methods and needs in astronomical education after the August 1969 meeting of the American Astronomical Society. An Informal Resource Letter on astronomy laboratory exercises was prepared by Wentzel and Smith (1969) which contains published manuals and articles on laboratory exercises as well as sources for photographs and other material for teaching aid. An interesting outline of an "Astronomy" course given to non-science students has been prepared by Wentzel (1969) in which he "demonstrates that science is a human endeavour, that it involves social judgments and philosophical implications as well as established facts".

C. Astronomy as a career

It is important to inform the young people with some interest in astronomy what the general requirements are for becoming an astronomer and what possibilities they have when choosing astronomy as a career. The following recent publications on this subject were communicated to the President; C. Schalén published a booklet in Swedish on the study of astronomy. McNally (1968) summarizes what is needed in an astronomer, gives advice on what and where to study, and lists Universities and Observatories in the United Kingdom where an astronomical education can be obtained. R. C. Roeder mentions a pamphlet on Astronomy as a Career published by the Guidance Centre, Ontario College of Education, Univ. of Toronto. Berendzen (1968) wrote a thesis on The Career Development and Education of Astronomers in The United States in which he studied the education, vocational developments, pedagogical viewpoints, and employment of U.S. astronomers. He compiled information from astronomers themselves, astronomy departments, governmental and private organizations and the literature, and he has a large compilation of the literature on the subject. A brochure on How to Become an Astronomer was published by Miller (1969) which contains among others a section on "qualifications and expectations", and one on "education of an astronomer", and a very useful appendix on Graduate Departments of Astronomy in the United States. The American Institute of Physics has published two handbooks concerning Astronomy

studies: (1) *Graduate Programs in Physics and Astronomy in the United States (1968)*, this being a handbook for advisors of prospective doctoral and master's students; and (2) *Directory of Physics and Astronomy Faculties in 1968-96 in the United States, Canada, and Mexico (1969)*.

D. Material most needed

All Commission members were invited to list the material for Astronomy teaching which they considered most needed in their own countries. Many members expressed the need for good slides and photographs as teaching aids. The Table VI of the A.E.M. list will give detailed information about photographs, slides and film-strips available and where they can be purchased. It is suggested that in each individual country a rental service is organized either through the astronomical society or the astronomy department of the principal university, such as is done for example in Canada (Roy. Astr. Soc. of Canada), in France (Soc. Astr. France), Great Britain (Roy. Astr. Soc.), Switzerland (S. A. G.), U.S.S.R. (Soc. Moscow Planetarium), etc. Some members mentioned the need of a planetarium; others felt the lack of a real good modern textbook on Astronomy and Astrophysics – the latter being possibly a language problem and also the quite different educational level at which Astronomy is taught in different countries. An interesting comment on "needs" was communicated by J. Hers who wrote: "J. Wolterbeek feels that there is a real need to make star catalogues available to students, so that they will have an opportunity to learn how to use them. Although many catalogues are today almost antique, and have been shown to contain many systematic errors, they are still of outstanding educational value, and some might well be reprinted. Catalogues are required of accurate positions, approximate positions, proper motions, radial velocities, trigonometrical and other parallaxes, magnitudes, spectral types, nebulae and clusters, variable stars, zodiacal stars, observational results of *E*-regions and of Kapteyn Selected Areas, visual and other double stars, minor planets, comets, etc. etc.". This question on Catalogues should be discussed by the Commission members present at the Brighton meeting.

E. Miscellaneous teaching material offered

Upon the President's encouragement Commission members kindly made a survey of possible exercise material that might be available in various Observatories of the different countries, and that could be placed at the disposal of astronomy teachers in other universities. The result of this enquiry allowed the listing of the following material. Colleagues interested in any of the following items are invited to contact directly the person or Observatory offering the material.

i. The Sun

The Göttingen Observatory offers reproductions of used observational material (for example spectra of sunspots). Address: Prof. H. H. Voigt, Universitäts-Sternwarte, Geismarlandstrasse 11, 34 Göttingen, Germany.

The Kandilli Observatory offers reproductions of filtergrams of the sun made in H-alpha and in the Ca II K-line. Address: Prof. M. Dizer, Astronomical Observatory, Kandilli, Istanbul, Turkey.

The Utrecht Observatory can offer spectrograms, microphotometer records, and interferometric records of radio-frequency observations, either already used for research work or rejected but still sufficiently good for teaching purposes. Address: Prof. M. Minnaert, Sterrewacht "Sonnenborgh", Zonnenburg 2, Utrecht, The Netherlands.

ii. Planets

The Konkoly Observatory offers copies of photographic plates on minor planets. Address: Dr. B. Szeidl, Konkoly Observatory, Szabadsaghegy, Budapest XII, Hungary.

iii. Stars

Mme M. Hack offers reproductions on paper of spectra of Bp and Ap stars (dispersion 9.4 Å/mm). Address: Prof. M. Hack, Osservatorio Astronomico, Via G. B. Tiepolo 11, I-34131 Trieste, Italy.

Mme R. Herman offers reproductions on paper of used spectra of Be type stars. Address: Mme

Dr. R. Herman, Observatoire de Paris-Meudon, Section d'astrophysique, 92-Meudon, France.

The Konkoly Observatory offers (1) copies of used photoelectric records and photographic plates of RR Lyrae stars; (2) copies of used photographic plates of globular clusters. Address: See above, *Planets*.

iv. *Exercise material requested*

In exchange for Exercise Material the Remeis Sternwarte can spare the following motion pictures:

- (1) Solar Prominences, 16 mm, length: 119 m, duration 15 min;
- (2) Solar Prominences, 16 mm, length: 80 m, duration 10 min;
- (3) The Moon, 16 mm, length: 198 m, duration 18 min.

Address: Prof. W. Strohmeier, Remeis Sternwarte, Sternwartestr. 7, Bamberg, Germany.

F. *Atlas of Stellar Spectra*

At the IAU General Assembly in Prague Dr. Anne Underhill reported on the possibility and cost of preparing an atlas of tracings of high dispersion stellar spectra. The atlas could either be a compilation of tracings or be available in digitized form, the latter being preferred from the standpoint of low cost of production. Since one or several atlases of high-dispersion stellar spectra are of very great help for teaching purposes, the Commission members were asked to give an estimated number of copies that might be ordered by Observatories and Astronomical Institutes in their own countries. Obviously, the number of copies ordered of such an atlas will largely depend on the cost of a single copy. The result of the enquiry gave a total of about 100 copies which might be ordered, and more if the cost is low.

2. *Visiting professors project*

During the IAU meetings in Prague both Commissions 38 and 46 stressed the importance of the Visiting Professors Project which is to help the needs of countries remote from the main centers of astronomical research. As President of Commission 38 and member of the Organizing Committee of this Commission, Prof. M. Minnaert prepared a questionnaire for countries wishing to participate in the project and mailed it to various countries together with an explanatory letter in which he points out that "it is not sufficient to enable a few young astronomers from such countries to work for some time in more developed parts of the world, but that in some respects it might be more useful and economic if experienced astronomers were prepared to stay for some time in countries wishing a closer participation in modern astronomical research". So far, two positive answers have been received, one from Hyderabad (India) and one from Bandung (Indonesia). In the next IAU Information Bulletin an announcement will be published inviting colleagues to contact either Prof. M. Minnaert or Prof. E. A. Müller if they are interested to teach for some time at one or the other of the Observatories desiring to have a visiting professor.

3. *List of Observatories*

For many years Commission 38 has prepared a list of Observatories which offer facilities for visiting astronomers. The most recent list published by M. Minnaert may be found in the *IAU Information Bulletin* no. 23, p. 47, 1970. Furthermore many Observatories prepare pamphlets listing their main astronomical instrumentation and their various research programs. Undoubtedly, all solar physicists know that the journal *Solar Physics* publishes regularly brief descriptions of the Solar Observatories of the world. A pamphlet on Observatories of the World was prepared by T. L. Page for the last IAU General Assembly which, however, needed to be corrected and brought up-to-date. It is now understood that Commission 9 will be in charge of this project.

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THE INTERNATIONAL SCHOOLS FOR YOUNG ASTRONOMERS

With the financial support of UNESCO the IAU organized three International Schools for Young Astronomers (ISYA) so far, the first in Manchester, United Kingdom (1967), the second in Arcetri, Italy (1968), and the third in Hyderabad, India (1969). The organization was in the hands of Dr. J. Kleczek, secretary of the ISYA. The report on the Manchester School is published in the *IAU Trans. XIII B*.

The Arcetri ISYA was devoted to modern Solar Physics. Ten students from seven different countries attended the school (Bolivia:1, Brazil:2, Czechoslovakia:3, Hungary:1, Poland:1, Sweden:1, and Turkey:1). The Arcetri astronomers were in charge of most of the 70 hours lectures, the 142 hours of practical training and the series of seminars held during the school of 8½ weeks duration. In addition, two European professors were invited to give a couple of lectures. The school was financed in part by UNESCO and in part by the Arcetri Observatory and the Italian Government. M. Rigutti prepared a detailed report on the basis of (a) his and his colleagues' experiences during the ISYA, and (b) the answers to a questionnaire he had mailed after the end of the school to all attending students. Prof. Rigutti's excellent report is a very useful document and should be used as guideline for the planning of future ISYA.

The subject of the ISYA at the Osmania University in Hyderabad was Stellar Astronomy and Astrophysics. It was attended by 23 students from 5 Eastern countries (Ceylon:2, China:1, India, 18, Japan:1, New Zealand:1). During 8 weeks the students attended a total of 200 hours of lectures and practical training which were given by 7 invited professors from abroad and 6 professors from various Indian Universities and the astronomical staff of the Hyderabad Observatory. The school was financed in part by UNESCO, in part by the New Delhi University Grant Commission, and in part by the IAU.

The following is a brief synthesis of the results of the three ISYA as reported by J. Kleczek:

"In general, both the lecturers and the young astronomers considered the ISYA a success. They appreciated the 'home-like' and friendly atmosphere. To many young astronomers the school was of great help in formulating and preparing their future research programs. This is especially true about young astronomers from countries where the possibilities of education and research in astronomy are not very advanced. The contacts between the young astronomers and the lecturers, and among the young astronomers themselves do not end with the termination of the school. These post-school relations are an important result of our schools."

"In organizing the schools in Manchester and Arcetri young astronomers from various countries were brought to an Observatory to work with local lecturers and instruments. At Hyderabad, on the contrary, a new scheme was tried, namely to bring foreign lecturers and experienced research workers to an Observatory which, with newly acquired telescopes, is developing its astronomical research programs. The scheme was effective and it has the advantage that the experienced astronomers can help the host Institute to plan future research programs. For example, a special seminar was arranged at Hyderabad dealing with the exploitation of medium-size telescopes. (In the nearest

future, the three principal Indian Observatories will begin to work with new telescopes of about one meter diameter)."

"Participants of all three schools complained that the instruction was too concentrated and that they had difficulties assimilating the new material. We are facing a dilemma: either to limit the lectures or to have schools of three months' duration. To reduce the lectures would mean to cripple the whole program; nothing unimportant is taught. Prolongation of the school, on the other hand, would require the reduction of the number of participants; we are limited by the available finances. For the moment, the young astronomers must try to finish assimilating the new material at their home institutes. They receive mimeotyped texts of the lectures for this purpose."

"It is the Secretary's opinion, that the ISYA brings great benefit to young astronomers from astronomically developing countries. Preference should be given to them, while a small number of participants from astronomically more developed countries should be admitted too. We had a few very good young astronomers who, for quite different reasons, had no possibility to continue their studies and research at home. The ISYA Secretary is grateful to the Commission members for not being indifferent to such cases."

The IAU Executive Committee has re-appointed Dr J. Kleczek as Secretary of the ISYA for another period of three years.

Dr J. Kleczek hopes to organize the 1970 ISYA in Argentina for the benefit of the Latin American young astronomers, and for the 1971 ISYA he is considering an African country.

In the name of the Commission and of all students attending the ISYA, the Commission President wishes to thank the UNESCO, the IAU, and the host countries for their generous financial support without which our schools would not have been feasible. Our greatest appreciation goes to Dr J. Kleczek for all his efforts and the efficient organization of the ISYA, and to the lecturers and astronomers of the host Observatories for their kind collaboration. They all contributed to make our ISYA so successful.

COLLABORATION WITH INTERNATIONAL COMMISSIONS ON SCIENCE TEACHING

In 1968 the CIES (Commission Internationale de l'Enseignement des Sciences) – an inter-union commission of ICSU organized a congress which was held from September 11 to 19 at the international center in Droujba near Varna (Bulgaria). The IAU was represented by Prof. M. Minnaert replacing Prof. E. A. Müller who was unable to attend. The proceedings of this congress are published by the Secretary of the CIES, Prof. P. Fleury (3, Boulevard Pasteur, Paris XV). The following two papers related to astronomy were presented:

M. G. J. Minnaert: The Integration of Astronomy into a Course of Physics

E. Schatzman: Place de l'astronomie par rapport au autres sciences.

Prof. M. Minnaert's report on the congress is reproduced here in abbreviated form:

"The general tendency of the congress was to have at the elementary school an integrated teaching by one and the same teacher, including mathematics as well as sciences. In the first cycle of the secondary school the sciences of nature should be integrated, while mathematics ought to have a separate teaching. In the second cycle the same could apply to pupils not wishing to follow later a career in sciences. For the others, integration seemed not desirable, except perhaps between physics and chemistry; but close coordination between the different disciplines was expected. The eastern countries and Denmark were least inclined to the integration which different groups in the U.S.A., Australia, and Great Britain propagated. – It was most interesting to see the display of excellent textbooks written for integrated courses in sciences for secondary schools. The subjects treated are essentially: air, water, the forest, the farm, food, the seasons, motion, light, energy, etc. The connection with life at large was most enjoyable."

"The subject of integration in the teaching of the different sciences and of mathematics is, of course, of considerable importance for the teaching of astronomy. Here is an opportunity to have our science taught to a great part or to almost all of the pupils. On the other hand, there might be the danger that it would lose its proper value, especially if it were taught by a teacher who is not

sufficiently prepared for this part of his task. – In the higher classes there is the problem of whether astronomy should be integrated with physics or with the earth-sciences (geology, meteorology, etc.). In the present situation I prefer the combination with physics, because as it is now, the teacher of earth sciences will not have been educated in modern astronomy; moreover, earth sciences are only taught in some countries.”

“In a plenary session I stressed the great significance of astronomy in secondary education. Later, in one of the working groups, I showed in a more extensive and somewhat more technical manner how astronomy may be integrated with physics, but what precautions have to be taken in this case in order to save the proper value of astronomy as such. – At the end of the congress a concluding report was read and approved to which were added 15 statements, summarizing the main recommendations of the congress to pedagogical authorities and departments. In the final *report* the following paragraph appears:

Astronomie et physique

L’astronomie fait emploi des mathématiques et de la mécanique, mais elle participe surtout de la physique sous toutes ses formes. Elle a en outre des points communs avec les sciences de la terre et avec la chimie. Des notions d’astronomie moderne, comprenant spécialement l’astrophysique, sont indispensables dans l’enseignement secondaire. L’astronomie mérite d’être enseignée comme une discipline autonome; elle peut être aussi intégrée dans l’enseignement de la physique. Dans ce dernier cas il sera nécessaire, à fin des cours, de récapituler en quelques leçons les notions acquises, en les regroupant de manière à construire un modèle synthétique de l’univers.”

In the concluding statements, issued by the congress and which will be diffused on a much larger scale, Prof. Minnaert succeeded in having the following statement printed:

“The physics teacher should be responsible for teaching *mechanics* as well as *astronomy*; the introduction of some notions of astronomy in secondary schools is desirable.”

On December 12 and 13, 1969, E. A. Müller, as the President of the Commission 46, was invited by ICSU to Paris to attend the first meeting of a newly formed international Committee on Science Teaching (CST) under the chairmanship of Dr M. Matyas of Czechoslovakia. Participants were some representatives of ICSU and of UNESCO, and the presidents of the Teaching Commissions of the various Scientific Unions who reported on the activities of their Teaching Commissions. The topics discussed for the future programs of the CST were the following: modernisation and coordination of science teaching; integration of sciences; cooperation with UNESCO; exchange of information and teaching experiences among the various Scientific Unions; continuous education of the science teachers; guide-lines for improving the science teaching in developing and developed countries; social responsibilities of scientists. A second meeting of the CST is scheduled for the second part of April 1970.

REPORTS ON NATIONAL ACTIVITIES IN ASTRONOMY EDUCATION

The Commission members were invited to submit a report on new developments in the teaching of astronomy in their own countries. 75 % of the members sent a report, and some of the reports are very interesting and detailed and may interest other members of the Commission. Due to lack of space in the IAU Draft Report only a brief summary of the trends in the astronomy teaching activities can be presented here. The individual complete reports will be reproduced in mimeographed form and distributed to all Commission members. It should be added, that any astronomer interested in the detailed report of a particular country may order a copy either through the Commission member representative of that country, or through the Commission President.

1. *Astronomy education in elementary and secondary schools*

Members of the following countries reported that astronomy has been – or is in the process of being – introduced in Schools: Argentina, Belgium, Bulgaria, Canada, Czechoslovakia, Denmark, German Dem. Rep., German Fed. Rep., Japan, The Netherlands, New Zealand, Poland, Rouma-

nia, Switzerland, United Kingdom, U.S.S.R., and U.S.A. The level of astronomy teaching is quite different in the different countries. In the elementary school level astronomy is usually integrated in the earth sciences. At the secondary school level some notions of astronomy are given in either mathematics or physics courses, and in only a few places astronomy is taught as a separate course (usually optional) in either one of the last two years of secondary school. Often the teaching of astronomy in schools does not go much beyond the Earth-Moon and the Earth-Sun system. The main problem of school astronomy is that the teachers themselves are not well prepared, they know very little about modern astronomy. In order to overcome this difficulty, astronomy courses for teachers are being organized in several countries (e.g.: Argentina, German Fed. Rep., The Netherlands, Poland, Switzerland) during which the school teachers get acquainted with modern astronomy and astrophysics through lectures and practical training on school telescopes. Didactic books and guide-lines in astronomy for school teachers would be of very great help. In a few countries such teaching aids have been prepared, but much more should be done about this.

2. General astronomy education at the university level

In several countries new programs have been or are being developed for the introductory courses in astronomy and astrophysics. These courses are given to science students who may or may not become astronomers later on. A number of these students may eventually go into secondary school and/or college level teaching and, thus, will be better prepared for the astronomy teaching in schools than the teachers have been so far. Also, in some countries (e.g.: France, German Fed. Rep. and others) one tries to coordinate and unify the introductory and basic courses of astronomy and astrophysics given at various universities.

3. Education of astronomers

Everyone agrees that the education of astronomers starts with a good education in physics and mathematics. The training for becoming an astronomer then requires a number of basic astronomy and astrophysics lectures and seminars, and much practical training and research work. Obviously, the education of astronomers very much depends on the facilities available in individual countries and universities. In recent years many universities have reconsidered and modernised their programs for astronomy studies. Universities which only recently have started an astronomical program may make use of the facilities of an observatory of another university in the same country or in a neighbouring country. How in individual countries the education of astronomers has been improved or recently introduced can be read in the detailed report of the national activities in astronomy education.

4. Education in astronomy of the general public

Various Commission members report that astronomy education of the general public is done (a) by regular public lectures given by the astronomers themselves or by amateur astronomers, (b) by visits to planetaria, (c) by series of radio or television transmissions on astronomy, and (d) by a number of popular books which have appeared on the market in recent years.

EDITH A. MULLER
President of the Commission