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Report

Promoting research and education in basic space science: the approach of the UN/ESA workshops ☆

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Abstract

The United Nations/European Space Agency workshops on basic space science are a long-term effort for the development of astrophysics and space science and regional and international cooperation in this field on a world-wide basis, particularly in developing nations. The first four workshops in this series (India (1991), Costa Rica and Colombia (1992), Nigeria (1993), Egypt (1994)) explored the status of astrophysics and space science in Asia and the Pacific, Latin America and the Caribbean, Africa, and Western Asia, respectively. One major recommendation that emanated from the first four workshops was that small astronomical facilities should be established in developing nations for research and education programmes at the university level and that such facilities should be networked in the future. Subsequently, a teaching module and observing programmes for small optical telescopes were developed or recommended and astronomical telescope facilities have been inaugurated at UN/ESA workshops on basic space science in Sri Lanka (1995), Honduras (1997), and Jordan (1999). UN/ESA workshops on basic space science in Germany (1996), France (2000), Mauritius (2001), and Argentina (2002) have made contributions to the establishment and operation of small astronomical telescope facilities in developing nations.

1. Introduction

> Nobody knows for sure what is going on inside the Sun (Raymond Davis Jr., Nobel Laureate, Physics, 2002).

Research and education in astronomy and astrophysics are an international enterprise. The astronomy community has long shown leadership in creating international collaboration and cooperation because (i) astronomy has deep roots in virtually every human culture; (ii) it helps us understand humanity's place in the vast scale of the universe; and (iii) it teaches humanity about its origins and evolution. Humanity's activity in the quest to explore the universe is reflected in the history of scientific institutions, enterprises and sensibilities. The institutions that sustain science—the moral, religious, cultural and philosophical sensibilities of scientists themselves—and the goal of the scientific enterprise in different regions on Earth are subject of intense study [1].

Decadal reports for the last decade of the 20th century and the first decade of the 21st century [2] have been prepared primarily for the North American astronomy community; however, it may have gone unnoticed that these reports have also had an impact on a broader international scale, as they can be used, to some extent, as a guide to introduce basic space science, including astronomy and astrophysics, in nations where this field of science is still in its infancy. Attention is drawn to the website at http://www.seas.columbia.edu/~ah297/un-esa/ where the initiative is publicized on how developing nations are making efforts to introduce basic space science into research and education curricula at the university level. This initiative was born in 1990 as a collaborative effort among developing nations, the United Nations, the European Space Agency (ESA), and the government of Japan, and covers the period of time from 1991 to 2003. Through annual workshops and subsequent follow-up projects, particularly the establishment of astronomical telescope facilities, this initiative is gradually bearing results in the regions of Asia

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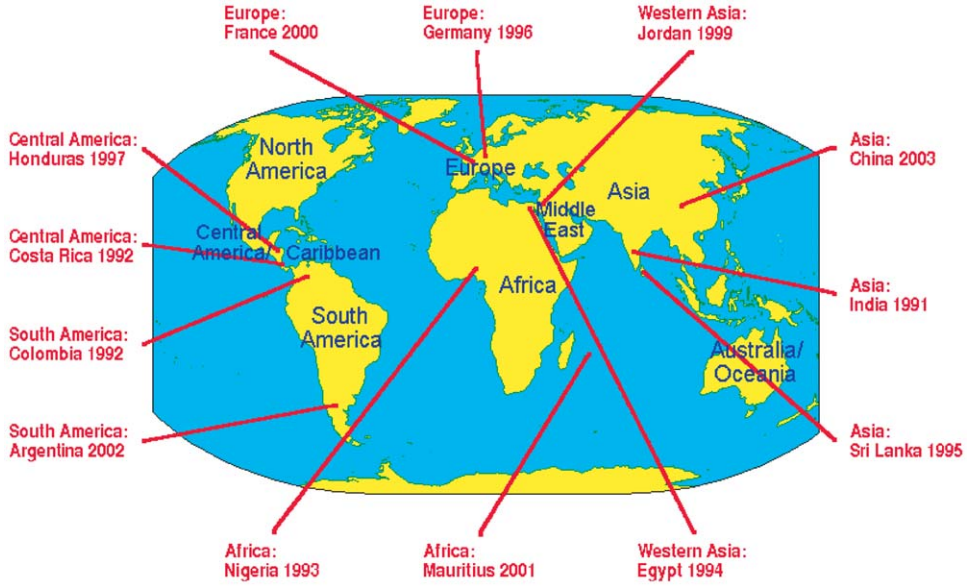

Fig. 1.

and the Pacific (Sri Lanka [3], Medagangoda [4], Pakistan [5], Malaysia [6], India [7]), Latin America and the Caribbean (Paraguay [8,9], Uruguay [10], Peru [11], Mexico [12]), Africa (Zambia [13], Ethiopia [14], Yemen [15]), and Western Asia (Lebanon [16], Jordan [17], Syrian Arab Republic [18], Saudi Arabia [19]) (Fig. 1).

2. Workshops on basic space science

In 1959 the United Nations recognized a new potential for international cooperation and formed a permanent body by establishing the Committee on the Peaceful Uses of Outer Space (COPUOS). In 1970 COPUOS formalized the UN Programme on Space Applications to strengthen cooperation in space science and technology between developing and industrialized nations. In 1991 the UN, in close cooperation with developing nations, ESA, and the Japanese government, started a series of annual workshops on basic space science, which were hosted by UN member states in the five economic regions: India, Costa Rica, Colombia, Nigeria, Egypt, Sri Lanka, Germany, Honduras, Jordan, France, Mauritius, Argentina, China [20].

Over the past decade, the workshops established a close interaction between scientists from developing and industrialized nations to discuss research findings at the current front lines in basic space science. The workshops also initiated direct interaction among scientists from developing nations. In-depth discussions in working groups were fostered to allow the identification of needs—especially common needs, which could be addressed on a larger scale—and to enhance the participation of the developing nations in basic space science and identify the best ways and means in which each nation could accelerate its participation in a meaningful endeavour.

3. Astronomical telescope facilities

A number of governments (among them Honduras (1997) and Jordan (1999)), in cooperation with international partners, have acquired and established astronomical telescope facilities in their countries (Meade 16″ Schmidt-Cassegrain models).

In conjunction with the workshops, and to support research and education in astronomy, the Government of Japan has donated high-grade equipment to a number of developing nations (among them Sri Lanka (1995), Paraguay (2000) and the Philippines (2001)) within the scheme of ODA of the Government of Japan [21]. We refer here to 45 cm high-grade astronomical telescopes furnished with photoelectric photometer, computer equipment, and spectrograph (or CCD). After the installation of the telescope facility by the host country and Japan, young observatory staff members from Sri Lanka, Paraguay, and the Philippines were been invited by the Bisei Astronomical Observatory for education and training on how to operate such high-grade telescopes, and sponsored by the Japan International Cooperation Agency (JICA) [21,22].

The research and education programmes at the newly established telescope facilities focus on time-varying phenomena of celestial objects. The 45 cm class reflecting telescope with photoelectric photometer attached is able to detect celestial objects up to the 12th magnitude,

and with a charge-coupled device (CCD) attached up to the 15th magnitude. Such results have been demonstrated for the light variation of the eclipsing close binary star V505 Sgr, the X-ray binary Cyg X-1, the eclipsing part of the long-period binary ε Aur, the asteroid No. 45 Eugenia, and the eclipsing variable RT Cma Teles [21]. In forthcoming workshops, common observational programmes for variable stars and telescope networking for all the telescope facilities are envisaged [23–28].

4. Observing with the telescopes: research

In the course of preparing for the establishment of the telescope facilities, the workshops made intense efforts to identify available material to be used in research and education by utilizing such facilities. It was discovered that variable star observing by photoelectric or CCD photometry can be a prelude to even more advanced astronomical activity. Variable stars are those whose brightness, color, or some other property varies with time. If measured sufficiently carefully, almost every star turns out to be variable. The variation may be due to geometry, such as the eclipse of one star by a companion star, or the rotation of a spotted star, or it may be due to physical processes such as pulsation, eruption or explosion. Variable stars provide astronomers with essential information about the internal structure and evolution of the stars. The most predominant institution in this specific field of astronomy is the American Association of Variable Star Observers (AAVSO). AAVSO coordinates variable star observations made by amateur and professional astronomers, compiles, processes and publishes them, and in turn, makes them available to researchers and educators. AAVSO receives over 350,000 measurements a year, from more than 550 observers world-wide. The measurements are entered into the AAVSO electronic database, which contains close to 10 million measurements of several thousand stars.

To facilitate the operation of variable star observing programmes and to prepare a common ground for such programmes, AAVSO has developed a unique package entitled "Hands-On Astrophysics". It includes:

- 45 star charts;
- 31 35 mm slides of five constellations;
- 14 prints of the Cygnus star field at seven different times;
- 600,000 measurements of several dozen stars;
- user-friendly computer programmes to analyse them (Fourier analysis and wavelet analysis) and enter new observations into the database;
- an instructional video in three segments;
- a comprehensive manual for teachers and students (http://www.aavso.org/, http://www.aspsky.org/)

Assuming that the telescope is properly operational, variable stars can be observed, measurements can be analysed and sent electronically to AAVSO.

The flexibility of the "Hands-On Astrophysics" material allows an immediate link to the teaching of astronomy or astrophysics at the university level by using the astronomy, mathematics and computer elements of this package. It can be used as a basis to involve both the professor and the student to do real science with real observational data. After a careful exploration of "Hands-On Astrophysics" and thanks to the generous cooperation of AAVSO, it was adopted by the above astronomical telescope facilities for their observing programmes [29,30]. The results of this effort will be reviewed at forthcoming workshops on basic space science.

5. Teaching astrophysics: education

Various strategies for introducing the spirit of scientific inquiry to universities, including those in developing nations, have been developed and analysed [31]. As far as the spirit of the workshops on basic space science is concerned, they have been organized and hosted by governments and scientific communities which have already agreed on the need to introduce or further develop basic space science at the university level. To this end they are prepared to establish adequate facilities for pursuing such a field of science in practical terms, i.e. operating an astronomical facility for the benefit of the university or research establishment (and prospectively making the results from the facility available for public educational efforts). In addition to hosting the workshops, the governments have agreed to operate such a telescope facility in a sustained manner, calling on the international community for support and cooperation in devising respective research and educational programmes. Gradually, this policy is being implemented for those telescope facilities established through the workshops in cooperation with the UN, ESA, Japan and other national and international organizations.

Organizers of the workshops have acknowledged in the past the desire of the local scientific communities to use educational material adopted and available at the local level (prepared in the local language). However, the workshops have also recommended exploring the possibility of developing educational material (additional to the above-mentioned "Hands-On Astrophysics" package) which might be used by as many university staff as possible in different nations, while preserving the specific cultural environment in which

astronomy is being taught and the telescope is being used. The most promising step in this direction was made with the project "Astrophysics for University Physics Courses" [32]. This project has been highlighted at the IAU/COSPAR/UN Special Workshop on Education in Astronomy and Basic Space Science held during the UNISPACE III Conference at the United Nations Office in Vienna in 1999 and during each UN/ESA Workshop on Basic Space Science. Additionally, a number of text books have been reviewed over the years which, in the view of astronomers from developing nations, are particularly useful in the research and teaching process (for example, to name just a few of them: Bennett et al. [33], for teaching purposes; Lang [34], a reference work in the research process).

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