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Special Session 5
Astronomy for the developing world

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Preface

The International Astronomical Union has a strong commitment to the development of astronomical education and research throughout the world, especially in those countries developing economically. This commitment is in part through the work of IAU Commission 46 for astronomy education and development. Within that commission, the Program Group for the *World-wide Development of Astronomy* (PGWWDA) coordinates many of these activities, promoting the development of astronomy in developing countries.

Six years ago, at the time of the IAU XXIV General Assembly in Manchester, Alan Batten, who was then chair of the PGWWDA, organized a special session on 'Astronomy for developing countries' (A. Batten. ed., 2001, *Astronomy for Developing Countries*, Proc. IAU XXIV GA Special Session (San Francisco: ASP). The success of that meeting has led Commission 46 to propose another Special Session, this time at the IAU XXVI General Assembly, in Prague, 2006. These pages present highlights from that two-day session, known as Special Session 5 on *Astronomy for the Developing World*.

A key theme proposed for SpS 5 was a survey of the development of astronomy in different geographical regions of the world, such as Latin America, eastern Europe, Africa, central Asia and the Far East. There are contributions here from all these places. In addition SpS 5 strived to bring together several other programmes promoting astronomy and space science in the developing world, from agencies outside the IAU. These include the United Nations Office for Outer Space Affairs (UNOOSA), the International Heliophysical Year (IHY) program for 2007, and the Committee on Space Research (COSPAR), amongst others.

Moreover, SpS 5 had as one of its aims to promote the concept of establishing a Third-world Astronomy Institute or Network (TWAI/TWAN) – an idea championed by Professor Jayant Narlikar and presented in the introductory session. Moves are already underway to give the Inter-University Centre for Astronomy and Astrophysics in Pune, India, an international dimension. This will be a step towards realizing this dream, to do for astronomy what the International Centre for Theoretical Physics in Trieste is already doing for physics.

The interest in SpS 5 'Astronomy for the developing world' was much greater than expected. In these pages, the abstracts of 61 papers are presented. Sixteen of these were invited papers, 26 were contributed oral talks and the rest were poster papers. The first authors came from 37 different countries. What is more, about 280 astronomers from 61 different countries registered their interest in participating in the SpS 5 session; it was a truly multinational gathering.

The following pages no more than summarize the papers presented at SpS 5. The full text of these papers is published as by J.B. Hearnshaw & P. Martinez, P. (eds., 2007, *Astronomy for the Developing World*, Proc. IAU XXVI GA Special Session No. 5, Cambridge: CUP).

Scientific Organizing Committee

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John Hearnshaw and Peter Martinez,
co-editors of Special Session 5,
Christchurch, NZ, and Cape Town, SA, November, 2006

1. Overview to astronomy in the developing world

1.1. *Introduction*

This introductory section to the Special Session on 'Astronomy for the developing world' takes a general overview of this theme. There are just three papers: that by Rajesh Kochhar takes a look at the historical and cultural antecedents to modern astronomical science, and the different perceptions of the origin of science seen in the East and the West. He makes an interesting closing comment on the gifting of scientific facilities to developing nations.

John Hearnshaw's paper is an analysis of the present state of astronomical activity in the world. He uses statistical data on author affiliations from ADS to measure activity in different countries by the number of papers published, and correlates this with other parameters, such as GDP per capita and number of IAU members.

Finally Jayant Narlikar makes a bold proposal for a Third-World Astronomy Institute or Network, in the hope that instituions can be established where astronomers from the developing world can visit and do research work.

1.2. *TWAN: a way of networking third-world astronomers*

Jayant V. Narlikar, Inter-University Centre for Astronomy and Astrophysics, Ganeshkind, Pune, India, email: jvn@iucaa.ernet.in

This talk will elaborate upon the concept of Third World Astronomy Network (TWAN) discussed at an earlier IAU meeting. TWAN is suggested as a way of improving the level of teaching, research and development in Astronomy and Astrophysics (A&A) in developing nations. Networking of astronomers in these countries with fast e-mail/internet connection and a few selected institutions serving as nodes are proposed. A range of activities may be carried out within the network. These are briefly outlined and the budgetary aspects described.

1.3. *A survey of published astronomical outputs of countries from 1976 to 2005 and the dependence of output on population, number of IAU members and gross domestic product*

John B. Hearnshaw, Department of Physics and Astronomy, University of Canterbury, Christchurch, New Zealand, email: john.hearnshaw@canterbury.ac.nz

In this paper I report the results of a survey of the astronomical outputs of all 63 IAU member countries as well as several non-member countries, based on an analysis of the affiliations of the authors given for nearly 900 thousand astronomical papers appearing in ADS between the years 1976 and 2005. The results show a roughly three-fold increase in the number of published papers per year over this 30-year interval. This increase is seen both in developed and also in most developing countries. The number of publications per IAU member correlates strongly with gross domestic product per capita. It is over 2 papers per IAU member per year in the countries with the strongest economies but less than 0.5 in the countries with low GDP per capita.

Since 2000 there has been a dramatic increase in the number of multi-author multinational papers published. This increase is especially noticeable for authors in developing countries, indicating that astronomers in these countries are increasingly participating in international collaborations for their research activities.

1.4. *Promoting astronomy in developing countries: an historical perspective*

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Any international effort to promote astronomy world wide today must necessarily take into account its cultural and historical component. The past few decades have ushered

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in an age, which we may call the Age of Cultural Copernicanism. In analogy with the cosmological principle that the universe has no preferred location or direction, Cultural Copernicanism would imply that no cultural or geographical area, or ethnic or social group, can be deemed to constitute a superior entity or a benchmark for judging or evaluating others.

In this framework, astronomy (as well as science in general) is perceived as a multi-stage civilizational cumulus where each stage builds on the knowledge gained in the previous stages and in turn leads to the next. This framework however is a recent development. The 19th century historiography consciously projected modern science as a characteristic product of the Western civilization decoupled from and superior to its antecedents, with the implication that all material and ideological benefits arising from modern science were reserved for the West.

As a reaction to this, the orientalized East has often tended to view modern science as 'their' science, distance itself from its intellectual aspects, and seek to defend, protect and reinvent 'our' science and the alleged (anti-science) Eastern mode of thought. This defensive mind-set works against the propagation of modern astronomy in most of the non-Western countries. There is thus a need to construct a history of world astronomy that is truly universal and unselfconscious.

Similarly, the planetarium programs, for use the world over, should be culturally sensitive. The IAU can help produce cultural-specific modules. Equipped with this paradigmatic background, we can now address the question of actual means to be adopted for the task at hand. Astronomical activity requires a certain minimum level of industrial activity support. Long-term maintenance of astronomical equipment is not a trivial task. There are any number of examples of an expensive facility falling victim to AIDS: Astronomical Instrument Deficiency Syndrome. The facilities planned in different parts of the world should be commensurate with the absorbing power of the acceptor rather than the level of the gifter.

2. Astronomy in Latin America and in the Caribbean

2.1. *Introduction*

There were many participants at the Special Session 5 from Latin America and the Caribbean. Fourteen papers are summarized here, while others from this part of the world appear in section 7 on astronomy education.

Hugo Levato's paper provided an authoritative overview of astronomy in Latin America, and divided countries into three groups, depending on the level of astronomical education in each. The strong group (Mexico, Argentina, Chile, Brazil) all have well developed astronomical infrastructure. The weakest group have little or no astronomical activity.

Julieta Fierro and Patricia Rosenzweig discuss various aspects of astronomy education in respectively Mexico and Venezuela. Overviews of astronomy in Trinidad, Cuba and Colombia are given by Shirin Haque, Ramón Rodríguez and William Cepeda. Important public outreach initiatives in Chile and Cuba are reviewed by Antonieta García, G. Argandoña (both in Chile) and Oscar Álvarez. Summaries of some research facilities are given by José Ishitsuka and Erick Vidal (Peru) and Gonzalo Tancredi (Uruguay). The work of the Ibero-American Astronomy League (LIADA) is discussed by Paulo Bretones (Brazil).

There is an astonishing range of astronomical activity in Latin America, at all levels of development, and this diversity is reflected in the contributions within this section.

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2.2. *Formal education in astronomy in Latin America*

Hugo Levato, CASLEO, Complejo Astronómico el Leoncito, San Juan, Argentina, email: hlevato@casleo.gov.ar

I will make a summary of the formal programs for education in astronomy in different countries of Latin America. I will provide a list of three different groups of countries, one with those that have very well developed careers in astronomy, another group of countries that will need some efforts to consolidate incipient careers, and a third group that will need strong efforts to develop formal education in astronomy.

2.3. *Astronomy for teachers in Mexico*

Julieta Fierro, Institute of Astronomy, UNAM, Mexico City, Mexico, email: fierroju@astroscu.unam.ac.mx

Mexico has added five more years of compulsory education to its national education system. In the past it only included six years of elementary (grammar) school. Now three years of pre-school (kindergarten) and three years of middle school are being implemented. At present an optional course on astronomy is offered in high school (pre-college). During my presentation I shall discuss problems concerning education in Mexico; these are mainly the lack of continuity in different levels of education, the lack of teacher training in science in general and the small number of topics in astronomy that are addressed. I shall mention support for teacher training and public education, which includes books, lectures and videos.

2.4. *Astronomy – the Caribbean view from the ground up*

Shirin Haque, Department of Physics, University of the West Indies, St Augustine, Trinidad, email: shirin@tstt.net.tt

This presentation reviews the historical development of astronomy in the Caribbean within its cultural and environmental framework. The present status of astronomy in education, research and at the popular level will be presented as well. The focus will be on its development in the island of Trinidad and Tobago in particular. The presentation will review what works in small developing islands versus larger developed countries and the peculiar trials and tribulations of our circumstances as well as the rewards of such efforts. The critical role of students and volunteer effort will be highlighted. The psychological and cultural aspect of the human response to its development in the Caribbean will also be examined in the paper. Based on an examination of the impacting variables on its development, a proposal will be presented for the next 10-year development of this area in the Caribbean, with consideration of the importance of the development of the Third World Institute of Astronomy and the possibility of it being located in this region of the world.

2.5. *Encounters with science at ULA, Venezuela: an incentive for learning*

Patricia Rosenzweig, Universidad de Los Andes, Facultad de Ciencias, Mérida, Venezuela, email: patricia@ula.ve

In the School of Science of the Universidad de Los Andes (ULA), in Mérida, Venezuela, a very successful event focused on high school students and primary school students, was founded in 2000. The name of this event is 'Encounters with Physics, Chemistry, Mathematics, and Biology' (hereinafter 'Encounters with Science'), and it integrates these disciplines as well as astronomy.

Its main purpose is that young minds can become familiar with the methods of science inquiry and reasoning, and can understand the concepts and processes of the sciences through thoroughly prepared experiences. This flourishing program is continuing to grow

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and to become strong. As a matter of fact, in its sixth edition (2005), the number of high and elementary school students coming from all over the country, has reached the outstanding number of nine thousand.

Among all the experiences that the students could be engaged in were many involving astronomy. These experiences were prepared by professors, together with graduate and undergraduate students, who are pursuing their degrees in all branches of science including astronomy. Although there is this incredible team of faculty members and graduate and undergraduate students working together, the target is the students of the high and elementary schools.

We certainly focus on engaging and encouraging students to experience scientific work first hand. Additionally, our professors have prepared excellent didactic material that can, together with hour-long lectures, prepare high school and elementary school students for a better understanding of science, particularly, helping in this way for a better education in astronomy.

The main event of the Encounters lasts five days in the School of Science of ULA, but subsidiary events are spread all over the year and around the country. As a successful program, it can be interesting to see if other countries can adopt this method to recruit or to trigger the interest of students to pursue their studies in the sciences.

2.6. *Developing astronomy in Cuba Ramón Rodríguez Taboada,*

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Beginning from a brief historical introduction the present-day situation of astronomy in Cuba is presented and the topics relevant for astronomy development are analyzed from the view point of a person actually working in astrophysics. Arising from national needs, astronomical calculations is the only 'native-born' branch of astronomy in Cuba. Cuba was an observational platform capable to provide the Soviet Union with a 24-hour solar patrol, needed by its Space Agency System to protect men in orbit. This was the beginning of a very fruitful development of solar research in Cuba. Russia installed the instruments, trained the people to operate them, and gave the academic environment to develop the scientific work in solar physics, space weather, and related topics.

What about stellar astronomy? The Cuban astro-climate is not good to develop an observational base. We are trying to develop stellar astronomy in collaboration with institutions capable to provide both the academic and technical environment; but to continue developing stellar astronomy we need to influence public opinion and convince people they need groups working in astronomy. How do we do that? By publishing, giving conferences, talking about OUR work, not only like spectators of science. Showing science is the culture of modern times. Showing projects in astronomy can be cheap. This is very important! Astronomy is not a luxury.

As a real possibility, I consider the Virtual Observatory concept as the more appropriate in the near future, but it is necessary to have an internet connectivity level that is not commonly provided in Cuba, and to train the people.

Concluding remarks: From my experience 'engagement' is the key word for astronomy development in developing countries. Astronomy can not be developed without an appropriate academic environment, and we do not have not this at present. It is not 'only' about financial resources, it is also about 'real collaboration' with a mature partner and common research goals.

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2.7. *Planetario Habana: a cultural centre for science and technology in a developing nation Oscar Álvarez, Ministry of Science, Technology and the Environment (CITMA), Havana, Cuba, email:* oscar@citma.cu

Astronomical education in Cuba is not widespread in the educational system; nevertheless the public interest in sciences in general but particularly in astronomy issues is very high, as it has become reflected by the attention paid to educational and scientific program broadcasts in the national television channels. The 'Planetario Habana' Cultural Centre for Science and Technology, which is under construction, is aimed at guiding the interest towards basic sciences and astronomical formation of the people, in the most populated and frequented area of the country. A key objective of this project shall be serving as an instructive motivation and entertainment for the casual or habitual visitors to these facilities, offering them the possibility to enjoy vivid representations, play with interactive amusement equipment and listen to instructive presentations on astronomy and related sciences, all guided by qualified specialists.

Another fundamental purpose shall be the establishment of a plan for complementary education in coordination with schools, in order to allow children and young people to participate in activities enabling them to get into the fascinating world of astronomy, exploration of outer space and life as a cosmic phenomenon.

The setting up of the Planetario Habana Cultural Centre for Science and Technology is under the general administration of the Office of the Historian of the City of Havana, and methodologically is being led by the Ministry of Science, Technology and the Environment, and will show in operation the GOTO Planetarium G Cuba custom, obtained under a Japanese Cultural Grant Aid. It will develop into a an unparalleled centre in the national environment for scientific outreach and education of these sciences.

Surrounded by the attractiveness of the colonial 'ambience', it shall become a centre for dissemination of information about new discoveries and scientific programs developed at national and international level. Here we present a general view of the project, and its present and future development.

2.8. *Astronomy in Colombia*

William Cepeda-Peña, Observatorio Astronómico Nacional, Universidad Nacional, Bogotá, Colombia, email: wecepedap@unal.edu.co

Astronomy in Colombia has been done since the beginning of the nineteenth century, when in 1803 one of the oldest (or may be the oldest) astronomical observatories of America was built. This is a very beautiful, historical and ancient building. A small dome with a small telescope is also on the university campus.

The observatory has led, since then, the development of astronomy in Colombia as a professional science. At the present time a Master's program and a specialization program are successfully carried out with a good number of students. The observatory has a staff of eleven professors, all with a master's degree in the sciences; two of them also have a PhD, and in a couple of years, five staff members will have a PhD in physics. With some international collaboration, they will undertake in a few years a doctoral astronomical program.

There are several research lines, mainly in the fields of astrometry, galactic and extra-galactic astronomy, cosmology, astro-statistics and astro-biology. Three research groups have got recognition from the governmental institution that supports research in the sciences, COLCIENCIAS. Several papers have been published in national and international journals. Besides the professional activities in astronomy, the observatory also sponsors

several non-professional Colombian astronomical groups that work enthusiastically in the field of astronomy.

2.9. *Astronomy education and popularization facilities at Guanajuato University in Mexico*

Hector Bravo-Alfaro, K.-P. Schroeder, and L. Ramirez, Universidad de Guanajuato, Guanajuato, Mexico, email: hector@astro.ugto.mx

At the Astronomy Department of Universidad de Guanajuato, 400 km NW of Mexico City, nine professional astronomers do research and teaching at both graduate and undergraduate level. In addition, in the last few years, this group has carried out astronomy popularization activities at three different sites. First, there is a rudimentary observatory named 'La Azotea' (the roof) on the top of the main building of the University (at Guanajuato centre), which includes a 16-cm refractor in a dome, a couple of XIXth century astronomical instruments, and a classroom with capacity for 50 people. The refractor was out of use for about twelve years, but will be fully operational before summer 2006.

Second, the 'Observatorio de La Luz', 20 km away from Guanajuato centre, includes a professional 0.6 m Cassegrain and a 2 m radio telescope, with a 21 cm receiver. Finally, on the roof of the Astronomy Department headquarters, an optical 0.4 m Dobsonian is available. We also have internet connections everywhere and six portable 8-inch telescopes (two at each site), devoted to regular astronomical observations for the general public, specially for scholars. Numerous repair works are currently carried out on the building of 'La Azotea', and recently a project to establish there a Centre for Popularization of Astronomy has been approved by the Regional Science Council.

The main activities, some of them currently developed at these sites are: (1) a permanent program of astronomical observations for a wide audience; (2) training in observational astronomy for physics undergraduate students; (3) regular talks on astronomy and other science domains; (4) summer schools in astronomy for elementary and high-school teachers; and (5) in the near future, the foundation of an amateur society of astronomy.

2.10. *Implementing an education and outreach program for the Gemini Observatory in Chile*

M. Antonieta Garcia, Gemini Observatory, La Serena, Chile, email: agarcia@gemini.edu

Beginning in 2001, the Gemini Observatory began the development of an innovative and aggressive education and outreach program at its Southern Hemisphere site in northern Chile. A principal focus of this effort is centered on local education and outreach to communities surrounding the observatory and its base facility in La Serena Chile. Programs are now established with local schools using two portable StarLab planetaria, an internet-based teacher exchange called StarTeachers and multiple partnerships with local educational institutions. Other elements include a CD-ROM-based virtual tour that allows students, teachers and the public to experience the observatory's sites in Chile and Hawaii. This virtual environment allows interaction using a variety of immersive scenarios such as a simulated observation using real data from Gemini. Pilot projects like 'Live from Gemini' are currently being developed which use internet video-conferencing technologies to bring the observatory's facilities into classrooms at universities and remote institutions. Lessons learned from the implementation of these and other programs will be introduced and the challenges of developing educational programming in a developing country will be shared.

2.11. *ESO strategy to promote astronomy and science culture in Chile*

G. Argandoña, European Southern Observatory, Santiago, Chile, email: gargando@eso.org

With three astronomical sites operating in Chile (La Silla, Paranal and Chajnantor), the European Organization for Astronomical Research in the Southern Hemisphere, ESO, has developed multiple approaches to foster astronomy and science culture in the country, implemented both nationally and locally. At the national level, an annual fund has been established to provide grants for individual Chilean scientists, research infrastructures, scientific congresses, workshops for science teachers and astronomy outreach programmes for the public. This has been complemented by multiple partnerships and formal collaborations with relevant bodies, like the Chilean Ministry of Education, the National Science and Technology Commission (CONICYT), science museums and the national mass media.

At the local level, the education and outreach program includes traditional public visits to the observatories, support to science teaching at local schools, promotion of astronomy clubs, organization of a mobile observatory, among other activities. An overview of these national and local projects will be given, along with a review of the development of Chilean astronomy in recent years, including the latest statistics on the number of professional astronomers, science productivity and the percentage of access to international observatories by the Chilean astronomical community.

2.12. *Projects of the Ibero-American League for Astronomy (LIADA) teaching and popularization section*

Paulo S. Bretones and V.C. Oliveira, Instituto de Geociências, Universidade Estadual de Campinas, Campinas, Brazil; and Instituto Superior de Ciências Aplicadas, email: bretones@mpc.com.br

The goal of this work is to present an analysis of the projects developed by the Teaching and Popularization Section of the Liga Ibero-Americana de Astronomía (LIADA). We first present a brief outline of the LIADA and its objectives, with emphasis in the attempts to organize, conduct and stimulate the collaboration between the professional and amateur astronomers in Latin-America. The Section is based in Brazil and counts with the support of 16 coordinators from most Latin-American countries. Presently several projects are being developed, such as astronomy in schools, oppositions, conjuctions, eclipses and transits.

The home page (<http://www.iscafaculdades.com.br/liada>) of the section communicates the observational projects and this aims to attract the attention of the general public, teachers and students to encourage the observation. The participants gather astronomical data at the home page, supplemented by the aid of local coordinators and spontaneous collaborators. The strategy is to circulate important support material and open a discussion forum about each of the observed phenomena, so as to enhance their public consideration and visibility.

We have analyzed the records and present an evaluation of the projects executed jointly with other institutions and individuals, their importance for scientific education, the nomination and relationship with the coordinators, the difficulties with written reports, the need for a dynamical maintenance of the home page, the question of the language, the establishment of a useful communications network and the visibility of the LIADA activities.

We conclude with a critical assessment of these activities, their strengths and weaknesses, as observed by us, and future projects of astronomy education.

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2.13. *Activities of the Observatorio Astronómico Los Molinos, Uruguay*

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The Observatorio Astronómico Los Molinos (OALM) is the only professional observatory in Uruguay and among the few observatories in the Southern Hemisphere mainly dedicated to the observations of asteroids and comets. At present we have the following observing programmes: (1) Confirmation and follow-up of recently discovered Near-Earth Objects (NEOs); (2) Photometric and astrometric follow-up of Comets to determine the perihelion light-curve; (3) Search for NEOs in the direction of the radiants of their orbits during twilight. The surveys are performed in regions of the sky where we expect a higher probability to find NEOs; and (4) Observations of asteroids in cometary orbits (ACOs) to detect the existence of a possible residual activity.

Though we have very modest equipment (a wide field 46 cm telescope), we have been able to make a relevant contribution in this field of research. The number of astrometric and photometric reports to the IAU-Minor Planet Center has increased a lot in the last year. We will present some results of this successful strategy to concentrate our research in a field where we can make a contribution at an international level, even with modest equipment.

In addition to these research programmes, we are conducting a very intense outreach activity that will be described.

2.14. *A new astronomical facility for Peru: transforming a telecommunications 32-metre parabolic antenna into a radio-telescope*

José Ishitsuka[1], M. Ishitsuka[2], M. Inoue[1], N.Kaifu[1], S. Miyama[1], M. Tsuboi[3], M. Ohishi[1], K. Fujisawa[4], T. Kasuga[5], T. Kondo[6], S. Horiuchi[7], T. Umemoto[3], M. Miyoshi[1], K. Miyazawa[1], T. Bushimata[1], and E.D. Vidal[2],
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In 1984 Nippon Electric Company constructed an INTELSAT antenna at 3 370 meters above the sea level on the Peruvian Andes. Entel Peru, the Peruvian telecommunications company, managed the antenna station until 1993. This year the government transferred the station to a private telecommunications company, Telefónica del Peru. Since the satellite communications were rapidly replaced by transoceanic fiber optics, the beautiful 32-metre parabolic antenna has been unused since 2002. In cooperation with the National Astronomical Observatory of Japan we began to convert the antenna into a radio-telescope.

Because researchers on the interstellar medium around Young Stellar Objects (YSO) will be able to observe the methanol masers that emit at 6.7 GHz, initially we will monitor the 6.7 GHz methanol masers and survey the southern sky. An ambient temperature receiver with $T_{\rm rx} = 60$ K was developed at Nobeyama Radio Observatory and is ready to be installed. The antenna control system is the Field System FS9 software installed in a Linux PC. An interface between the antenna and the PC was developed at Kashima Space Research Center in Japan. In the near future we plan to install 2 GHz, 8 GHz, 12 GHz and 22 GHz receivers.

The unique location and altitude of the Peruvian Radio Observatory will be useful for VLBI observations in collaboration with global arrays such as the VLBA array for

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astronomical observation and geodetic measurements. For Peru, where few or almost no astronomical observational instruments are available for research, the implementation of the first radio observatory is a big and challenging step, and it will foster science at graduate and postgraduate levels in our universities.

Worldwide, telecommunications antennas are possibly unused, and with relatively modest investments they could be transformed into useful observational instruments.

2.15. *Application of Field System-FS9 and a PC to the Antenna Control Unit interface in Radio Astronomy in Peru*

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We are in the process to transform a 32-m antenna in Peru, used for telecommunications, into a radio-telescope to perform radio-astronomy in Peru. The 32-m antenna of Peru constructed by NEC was used for telecommunications with communications satellites at 6 GHz for transmission, and 4 GHz for reception. In collaboration with the National Institute of Information and Communications Technology (NICT) Japan, and National Observatory of Japan we have developed an antenna control system for the 32-m antenna in Peru. It is based on the Field System FS9, software released by NASA for VLBI station, and an interface to link a PC with FS9 software (PC-FS9) and the Antenna Control Unit (ACU) of the 32-meter antenna. The PC-FS9 controls the antenna, commands are translated by the interface into control signals compatible with the ACU using an I/O digital card with two 20-bit ports to read azimuth and elevation angles, one 16-bit port for reading the status of the ACU, one 24-bit port to send pulses to start or stop operations of the antenna, while two channels are analogue outputs to drive the azimuth and elevation motors of the antenna, an LCD display to show the status of the interface and error messages, and one serial port is used for communications with PC-FS9.

The first experiment of the control system was made with the 11-m parabolic antenna of Kashima Space Research Center (NICT), where we tested the correct working of the routines implemented for the FS9 software, and simulations were made with looped data between output and input of the interface. Both tests were done successfully. With this scientific instrument we will be able to contribute to research in astrophysics. We expect in the near future to work at 6.7 GHz, to study methanol masers, and higher frequencies with some improvements of the surface of the dish.

3. Astronomy in Africa

3.1. *Introduction*

By any measure that one cares to define, Africa lags significantly behind the rest of the world in the development of astronomy. There are currently 143 members of the IAU based in the 52 countries that comprise Africa and the Independent Island States. Thus it is important that a section of the Special Session on 'Astronomy for the Developing World' is devoted to the African continent.

Six papers are presented in this section. The first is by Peter Martinez, who presents an overview of the status of professional astronomy on the continent. He notes that the advent of large-scale facilities for ground-based astronomy in southern Africa presents a unique opportunity to promote astronomy throughout the continent. He also presents some lessons learnt from various capacity-building activities.

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Paul Baki argues that astronomy can be used to teach basic skills of scientific reasoning. He suggests that by incorporating traditional African beliefs about the night skies into astronomy curricula, astronomy may be perceived less as a 'foreign' subject by the people of Africa. Baki also discusses how to create an enabling environment for astronomy in Africa. The theme of astronomy education is further developed by Hassane Darhmaoui and K. Loudiyi, who discuss astronomy education in Morocco. They discuss their programmes, successes and challenges.

Africa has some of the best astronomical sites in the world. The last three papers in this section focus on site selection issues. The Moroccan Atlas Mountains have been identified as one of five potential locations for the Extremely Large Telescope (ELT). Zouhair Benkhaldoun describes the ELT site prospecting programme in Morocco. The determination of astronomical extinction and aerosol content at two potential ELT sites in Morocco is discussed by E.A. Siher, A Bounhir and Z. Benkhaldoun.

3.2. *Capacity building for astronomy education and research in Africa*

Peter Martinez, South African Astronomical Observatory, Cape Town, South Africa, email: peter@saao.ac.za

About 1.5 % of the world's professional astronomers are based Africa, yet in terms of research output, African astronomers produce less than 1 % of the world's astronomical research. The advent of new large-scale facilities such as SALT and HESS provides African astronomers with tools to pursue their research on the continent. Such facilities also provide unprecedented training opportunities for the next generation of African astronomers. This paper discusses recent efforts to develop astronomy education and research capacity on the continent. Various capacity-building initiatives are discussed, as well as the lessons learnt from those initiatives.

3.3. *Spreading astronomy education throughout Africa*

Paul Baki, Department of Physics, University of Nairobi, Kenya, email: pbaki@uonbi.ac.ke

Although Astronomy has been an important vehicle for effectively passing on a wide range of scientific knowledge, for teaching the basic skills of scientific reasoning and for communicating the excitement of science to the public, its inclusion in the teaching curricula of most institutions of higher learning in Africa is rare. This is partly due to the fact that astronomy appears to be only good at fascinating people but not at providing paid jobs and also due to the lack of trained instructors, teaching materials and a clear vision of the role of astronomy and basic space science within the broader context of education in the physical and applied sciences. In this paper we survey some of the problems impeding the spread of astronomy in Africa and discuss some interdisciplinary traditional weather indicators. These indicators have been used over many years to monitor the appearance of constellations, such as Orion, and are closely intertwined with the indigenous cultures of some African societies. They could be incorporated into the standard astronomy curriculum as a way of making the subject more 'home grown' and to be able to reach out to the wider populace in popularizing astronomy and basic sciences. We also discuss some of the other measures that ought to be taken so as to create an enabling environment for sustainable teaching and the spread of astronomy throughout Africa.

3.4. *Astronomy education in Morocco – a new project for implementing astronomy in high schools*

Hassane Darhmaoui and K. Loudiyi, Al Akhawayn University in Ifrane, School of Science and Engineering, Ifrane, Morocco, email: H.Darhmaoui@aui.ma

Astronomy education in Morocco, like in many developing countries, is not well developed and lacks the very basics in terms of resources, facilities and research. In 2004, the International Astronomical Union (IAU) signed an agreement of collaboration with Al Akhawayn University in Ifrane to support the continued, long-term development of astronomy and astrophysics in Morocco. This is within the IAU program 'Teaching for Astronomy Development' (TAD). The initial focus of the program concentrated exclusively on the University's Bachelor of Science degree program. Within this program, and during two years, we were successful in providing adequate astronomy training to our physics faculty and a few of our engineering students. We also offered our students and community general astronomy background through courses, invited talks and extra-curricular activities. The project is now evolving towards a wider scope and seeks promoting astronomy education at the high-school level. It is based on modules from the Hands on Universe (HOU) interactive astronomy programme. Moroccan students will engage in doing observational astronomy from their PCs. They will have access to a world-wide network of telescopes and will interact with their peers abroad. Through implementing astronomy education at this lower age, we foresee an increasing interest among our youth, not only in astronomy but also in physics, mathematics, and technology. The limited astronomy resources, the lack of teachers' experience in the field and the language barrier are amongst the difficulties that we will be facing in achieving the objectives of this new programme.

3.5. *ELT site prospecting in the Moroccan Atlas Mountains*

Zouhair Benkhaldoun, University Cadi Ayyad, Laboratoire de Physiques des Hautes Energies et Astrophysique, Marrakech, Morocco, email: zouhair@ucam.ac.ma

The Extremely Large Telescope site testing working group has selected Morocco's mountains, as one of five locations over the world, to test for this European project. For that purpose, we first of all carried out a selection of two sites basing on their location relative to the dominant wind flow, the cloud cover and the circulation of the Saharan aerosols. We will detail in the communication which we present here, the methodology followed and results obtained. We also present the localizations of both sites with a cartographic, and geological study and some seismic information. The first measurements of the seeing will be also presented.

3.6. *Astronomical extinction over the ELT Moroccan sites from aerosol satellite data*

El Arbi Siher[1], Z. Benkhaldoun[2], and A. Bounhir[2], [1]Faculté des Sciences et Techniques, Beni Mellal, Morocco; [2]Laboratoire de Physiques des Hautes Energies et Astrophysique, Faculté des Sciences, Semlalia, Marrakech, Morocco; email: siher@ucam.ac.ma

Two Moroccan sites have been selected to be characterized as ELT candidate sites. These sites are in the Atlas Mountains, between Oukaimeden (where the national observatory is located) and the Canary Islands. For a preliminary study, we will use the TOMS/Nimbus7 aerosol index (AI), threshold 0.7, to extract the astronomical extinction (AE), threshold 0.2 mag/airmass. In fact, on the one hand, one previous work showed the link between these parameters over the Canary Islands (ORM Observatory). On the other hand, many studies proposed the dust characterization for any future extremely large telescope as a mandatory qualification.

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3.7. *Effect of altitude on aerosol optical properties Aziza Bounhir and Zouhair Benkhaldoun, UCAM University, Marrakech, Morocco email:* bounhir@fstg-marrakech.ac.ma

The ELT project is currently underway in Europe and North America. Astronomical sites critically depend on sky transparency and then on aerosol loadings. A quantitative survey of aerosol optical properties at candidate sites is an essential part of the site selection process. There are basically two methods to scan and characterize aerosol properties: ground based measurements and satellite measurements. In this paper we will establish a full climatology of two sites very close to each other, but with a difference of 2300 m in altitude. They are Izaña and Santa-Cruz, located in the Canary Islands. Both have sun photometers from the AERONET Network. AERONET provides a set of aerosol optical properties: atmospheric optical thickness, aerosol optical thickness, angstrom parameter, aerosol size distribution, aerosol refractive index, single scattering albedo, water vapour content, phase function, direct sun radiance and sky radiance. We also use satellite data from TOMS to determine the aerosol index.

The aim of this work is to see how these properties change with altitude. We establish a correlation between the TOMS index and the aerosol optical thickness at both sites. Aerosol optical properties show very good correlation between Izaña and Santa-Cruz. As a result, we establish a set of relationships helpful to characterize sites at high altitude from the data of a neighbouring site. In the ELT site selection and evaluation process, a preliminary study from satellite measurements and from AERONET neighbouring sites is very important.

4. Astronomy in eastern Asia and the Pacific

4.1. *Introduction*

This section presents several papers from eastern Asia and the Pacific. Boonrucksar Soonthornthum from Thailand reviews astronomy in his region. In fact two other papers, by Busaba Kramer, are also from Thailand, which reflects the strong development of astronomy in that country at the present time. (Thailand has just joined the IAU and founded the National Astronomical Research Institute of Thailand, of which Boonrucksar is the inaugural director.)

There are also papers by Nguyen Quynh Lan on astronomy in Vietnam, Osamu Hashimoto on the collaboration between ITB Bandung Indonesia and Gunma in Japan, and Sergei Gulyaev on the nascent development of radio astronomy in New Zealand.

4.2. *Astronomy in Asia Boonrucksar Soonthornthum, National Astronomy Research Institute of Thailand, email:* boonraks@chiangmai.ac.th

Astronomy in Asia has continuously developed. Local wisdom in many Asian countries reflects their interest in astronomy since the historical period. However, the astronomical development in each country is different which depends on their cultures, politics and economics. Astronomy in some Asian developing countries such as China and India are well-developed, while some other countries, especially in south-east Asia, with support such as new telescopes, training, experts etc., from developed countries, are trying to promote relevant research in astronomy as well as to use astronomy as a tool to promote scientific awareness and understanding for the public. Recently, a new national research institute in astronomy with a 2.4-metre reflecting telescope has been established in Thailand. One of the major objectives of this research-emphasis institute would to aim at a

collaborative network among south-east Asian countries, so as to be able to contribute new knowledge and research to the astronomical community.

4.3. *Astronomy in Thailand Busaba Hutawarakorn Kramer, National Astronomical Research Institute, Chiang Mai, Thailand, email:* busaba@nari.or.th

During the last few years, Thailand has seen a significant change in the way astronomical research and education are pursued in the country. The government has approved the establishment of the National Astronomical Research Institute (NARI) which aims to develop not only astronomical research but also astronomy education at all levels, both in formal and informal education. A framework of national key projects exists which includes national facilities, national collaborative research networks, teacher training and public outreach programmes. Examples of these programmes will be presented in this talk.

4.4. *Astronomy development in Thailand: Roles of NARI Busaba Hutawarakorn Kramer, Boonrucksar Soonthornthum, and S. Poshyachinda, National Astronomical Research Institute, Chiang Mai, Thailand, email:* busaba@nari.or.th

The development of astronomy in Thailand has improved significantly during the last few years. The government has approved the establishment of the National Astronomical Research Institute (NARI). The roles of NARI in the development of astronomical research and astronomy education in Thailand include a national framework, national facilities, collaborative research networks, teacher training and public outreach programmes. The new 2.4-metre reflecting telescope will serve not only the astronomical community in Thailand, but also in Southeast Asia.

4.5. *Astronomy in Vietnam Nguyen Quynh Lan, Hanoi University of Education, Hanoi, Vietnam, email:* nquynhlan@dhsphn.edu.vn

We overview in this paper the development of astronomical education in Vietnam. We also discuss proposals to advance the development of astronomy in Vietnam, with support and assistance from the International Astronomical Union.

4.6. *Collaboration and development of radio-astronomy in Australasia and the South-Pacific region: New Zealand perspectives Sergei Gulyaev and Tim Natusch, Centre for Radiophysics and Space Research, Auckland University of technology, New Zealand, email:* sergei.gulyaev@aut.ac.nz

Radio telescopes in the Asia-Pacific region form a natural network for VLBI observations, similar to the very successful networks in North America (Network Users Group) and Europe (European VLBI Network). New Zealand's VLBI facility, which we have been developing since 2005, has the potential to strengthen the Asian-Pacific VLBI network and its role in astronomy, geodesy and geoscience. It will positively influence regional and international activities in geoscience and geodesy that advance New Zealand's national interests.

A self-contained radio astronomy system for VLBI, including a 1.658 GHz (centre frequency), 16 MHz bandwidth RF system (feed and down-conversion system locked to a rubidium maser and GPS clock), an 8-bit sampler/digitization system, and a disk-based recording system built around a commodity PC, was developed in New Zealand at the Centre for Radiophysics and Space Research. This was designed as a portable system for use on various radio telescopes. A number of trans-Tasman tests has been conducted in

2005 – 2006 between the CRSR system installed on a 6-metre dish located in Auckland and the Australia Telescope Compact Array in Narrabri, Australia. This work has been successful, with fringes located from the recorded data and a high resolution image of the quasar PKS1921−231 was obtained.

Experiments were recently conducted with Japan and new tests are planned with Korea and Fiji. Plans have been made to build a new 16.5-m antenna in New Zealand's North Island and to upgrade an 11-m dish in the South Island. A possible future of New Zealand's participation in the SKA is being discussed.

4.7. *Mutual collaboration between the Institute of Technology Bandung (ITB), Indonesia and the Gunma Astronomical Observatory (GAO), Japan*

Osamu Hashimoto[1], *Hakim Malasan*[2], *H. Taguchi*[1], *K. Kinugasa*[1], *B. Dermawan*[2], *B. Indradjaja*[2], *and Y. Kozai*[1]

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The Institute of Technology Bandung (ITB), Indonesia, and the Gunma Astronomical Observatory (GAO), Japan, have been proceeding with several programs of mutual collaboration in the fields of astronomical research and education since 2002. ITB with Bosschca observatory has a great interest in education of astronomy for the general public, as well as in university education and research of their own. GAO is a public observatory operated by Gunma Prefecture (local government) and is equipped with a 150-cm reflector and some smaller telescopes, which are capable of scientific research of high grade.

We will report some of our cooperative activities, including the remote accessing of the telescopes of each observatory by each other, which can provide opportunities for astronomical experiences in the opposite hemisphere for various people of each country. Some scientific collaboration programs, such as common instruments and data analysis systems, which have been developed on both sites, will be also presented.

5. Astronomy in the Middle East and central Asia

5.1. *Introduction*

This section on astronomy in central Asia was one of the most compelling and interesting sessions of the SpS 5 meeting. Once again it is a very diverse region, stretching from the Ukraine to Mongolia, and including several countries of the former Soviet Union, such as Uzbekistan and Armenia.

Especially pertinent to the present political situation was the account by Athem Alsabti of the struggle to develop astronomy again in Iraq after two major conflicts in recent years. The initiative to rebuild the Mt Korek Observatory in the northern Kurdish region of Iraq is an initiative he is leading. The talk by Yousef Sobouti on astronomy in Iran and the proposed founding of a new astronomical observatory there was of great interest. Unfortunately Professor Sobouti was unable to come to Prague and Edward Guinan (Villanova University, USA) gave this talk for him. Sona Hosseini's paper gives information on site-testing for the Iranian observatory.

There are papers on astronomy in Uzbekistan (theoretical astrophysics from Bobomurat Ahmedov) and the new Suffa radio-telescope project from G.I. Shanin. Batmunkh Damdin discusses astronomy in Mongolia, a country that has just joined the IAU. The outstanding meterological conditions there make it a prime country for the future development of optical astronomy.

Finally interesting papers by Nikolai Bochkarev (Russia), Svetlana Kolomiyets (Ukraine) and Hayk Harutyunian (Armenia) discuss astronomy in the former Soviet states. Bochkarev gives a wide-ranging review of astronomy in many former Soviet territories, not just Russia.

5.2. *Astronomy in Iraq*

Athem Alsabti, University College London, UK, email: a.alsabti@ucl.ac.uk

The history of modern Iraqi astronomy is reviewed. During the early 1970s Iraqi astronomy witnessed significant growth through the introduction of the subject at university level and extensively within the school curriculum. In addition, astronomy was popularized in the media, a large planetarium was built in Baghdad, plus a smaller one in Basra. Late 1970 witnessed the construction of the Iraqi National Observatory at Mount Korek in Iraqi Kurdistan. The core facilities of the Observatory included 3.5-metre and 1.25-metre optical telescopes, and a 30-metre radio telescope for millimetre wavelength astronomy. The Iraqi Astronomical Society was founded and Iraq joined the IAU in 1976.

During the regime of Saddam Hussain in the 1980s, the Observatory was attacked by Iranian artillery during the Iraq-Iran war, and then again during the second Gulf war by the US air force. Years of sanctions during the 1990s left Iraq cut off from the rest of the international scientific community. Subscriptions to astronomical journals were halted and travel to conferences abroad was virtually non-existent. Most senior astronomers left the country for one reason or another. Support from expatriate Iraqi astronomers existed (and still exists); however, this is not sufficient. Recent changes in Iraq, and the fall of Saddam's regime, have meant that scientific communication with the outside world has resumed to a limited degree.

The Ministry of Higher Education in Baghdad, Baghdad University and the Iraqi National Academy of Science, have all played active roles in re-establishing Iraqi astronomy and re-building the damaged Observatory at Mount Korek. More importantly, the University of Sallahudin in Erbil, capital of Iraqi Kurdistan, has taken particular interest in astronomy and the observatory. Organized visits to the universities, and also to the observatory, have given us a first-hand assessment of the scale of the damage to the observatory, as well as the needs of astronomy teaching and research. Joint supervision for postgraduate level research was organized between local and expatriate Iraqi astronomers. The IAU was among the first international organizations to offer assistance. Many observatories worldwide have also given support. Plans will be proposed for re-building the observatory, supporting teaching and research, and establishing an institute for astronomy in Erbil, together with further suggestions on how the international astronomical community can assist Iraqi astronomers.

5.3. *Astronomy in Iran Yousef Sobouti, Institute for Advanced Studies in Basic Sciences, Zanjan, Iran,*

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In spite of her renowned pivotal role in the advancement of astronomy on the world scale during 9th to 15th centuries, Iran's rekindled interest in modern astronomy is a recent happening. Serious attempts to introduce astronomy into university curricula and to develop it into a respectable and worthwhile field of research began in the mid 1960s. The pioneer was Shiraz University. It should be credited for the first few dozens of astronomy- and astrophysics-related research papers in international journals, for training the first half a dozen of professional astronomers and for creating the Biruni Observatory. Here, I take this opportunity to acknowledge the valuable advice of Bob Koch and Ed

Guinan, then of the University of Pennsylvania, in the course of the establishment of this observatory.

At present the astronomical community of Iran consists of about 65 professionals, half university faculty members and half MS and PhD students. The yearly scientific contribution of its members has, in the past three years, averaged about 15 papers in reputable international journals, and presently has a healthy growth rate. Among the existing observational facilities, Biruni Observatory with its 51-cm Cassegrain, CCD cameras, photometers and other smaller educational telescopes, is by far the most active place. Tusi Observatory of Tabriz University has 60- and 40-cm Cassegrains, and a small solar telescope. A number of smaller observing facilities exist in Meshed, Zanjan, Tehran, Babol and other places.

The Astronomical Society of Iran (ASI), though some 30 years old, has expanded and institutionalized its activities since the early 1990s. ASI sets up seasonal schools for novices, organizes annual colloquia and seminars for professionals and supports a huge body of amateur astronomers from among high school and university students. Over twenty ASI members are also members of the IAU and take an active part in its events.

In the past five years, astronomers of Iran have staged an intensive campaign to have a National Observatory of their own (NOI). Initial planning is for one 2-m telescope and appropriate measuring devices. The project is approved and will be funded by the government in the course of five years. The site selection for NOI, however, is already in its third year and has been and is being generously funded by the government.

Last, but not least, Nojum, the only astronomical monthly magazine of the Middle East, is presently in its fifteenth year. It has a good readership among both professionals and amateurs of Farsi speaking communities within the country and abroad.

5.4. *Measurement of the light pollution at the Iranian National Observatory*

S. Sona Hosseini[1] *and S. Nasiri*[2]

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The problem of light pollution became important mainly since 1960, by the growth of urban development and using more artificial lights and lamps at nighttime. Optical telescopes share the same range of wavelengths as are used to provide illumination of roadways, buildings and automobiles. The light glow that emanates from man-made pollution will scatter off the atmosphere and affects the images taken by the observatory instruments. A method of estimating the night sky brightness produced by a city of known population and distance is useful in site testing of new observatories, as well as in studying the likely future deterioration of existing sites.

Now under planning, the Iranian National Observatory will house a 2-metre telescope and the project of site selection is underway. Hence studying the light pollution is being carried out in Iran. Thus, we need a site with the least light pollution, beside other parameters, i.e. seeing, meteorological, geophysical and local parameters. The seeing parameter is being measured in our four preliminary selected sites at Qom, Kashan, Kerman and Birjand, since two years ago, using an out of focus Differential Image Motion Monitor. These sites are selected among 33 candidate sites by studying the meteorological data obtained from the local synoptic stations and the Meteosat. We use Walker's law to estimate the sky glow of these sites having the population and the distances of the nearby regions. The results are corrected by the methods introduced by Treanor and Berry using the atmospheric extinction coefficients. The data obtained using an 11-inch telescope with an ST7 CCD camera for the above sites are consistent with the estimated values of the light pollution.

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5.5. *Astronomy in the former Soviet territory: fifteen years after the USSR disintegration*

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During the post-Soviet period, the main infrastructure of astronomy over the territory of FSU was kept intact, in spite of a dramatic decrease of financial support. The overall situation in FSU astronomy is stable. In Latvia, the 32-m radio-dish has been put into working order and this allows its joining VLBI programs. It has been handed over to the Venspils University. In Russia, all the three 32-metre radio dishes of the QUASAR VLBI system have been put into operation, as well as the 2-m telescope with a high-resolution spectrograph (up to resolution $R \simeq 500\,000$) and the horizontal solar telescope ($R = 320\,000$) of the Russian-Ukrainian Observatory on Peak Terskol (Caucasus, altitude 3100 m). But the situation with the observatory is worrying, because of the regional authorities' attempt to privatize its infrastructure. The process of equipping a number of CIS (including Russian) observatories with CCD-cameras is in progress.

To solve the staff problems, Kazakhstan, Tajikistan and Uzbekistan have begun to prepare national specialists in astronomy and the Baltic States, Armenia, Azerbaijan, Georgia, Russia, and the Ukraine all continue to train astronomers.

The teaching of astronomy at schools is obligatory only in the Ukraine and the Baltic countries. To maintain a 'common astronomical space' the Eurasian Astronomical Society (EAAS) continues the program of reduced-price subscription to Russian-language astronomical journals and magazines over the territory of the FSU, and the organization of international conferences and Olympiads for school students, lectures for school teachers and planetarium lecturers, etc.

5.6. *Relativistic astrophysics and cosmology in Uzbekistan*

Bobomurat Ahmedov[1,2], R.M. Zalaletdinov[1], and Z. Ya. Turakulov[1,2]
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Theoretical Astrophysics is the subject which has got an essential development in Uzbekistan during the last decade, especially through the newly established collaborations with western and eastern institutions. Our regional collaboration is supported by the ICTP (Trieste, Italy), TWAS (Trieste, Italy) and IUCAA (Pune, India) in the framework of BIPTUN (Bangladesh - India - Pakistan - Turkey - Uzbekistan) Network on Relativistic Astrophysics and Cosmology. Other important scientific collaboration is with the western partners, mainly at SISSA (Trieste, Italy), ICRA (Pescara, Italy), Dalhousie University (Halifax, Canada) and at the ICTP. Local scientific activity in theoretical astrophysics in Uzbekistan is partly supported through the Affiliation Scheme (ICAC-83) of the ICTP. These years some financial support towards the research in theoretical astrophysics was through NATO grants.

The theoretical results obtained in Uzbekistan in the field of relativistic astrophysics and cosmology are presented. In particular electrostatic plasma modes along the open field lines of a rotating neutron star and Goldreich-Julian charge density in general relativity are analyzed for the rotating and oscillating neutron stars. The impact that stellar oscillations of different type (radial, toroidal and spheroidal) have on electric and magnetic fields external to a relativistic magnetized star has been investigated.

A study of the dynamical evolution and the number of stellar encounters in globular clusters with a central black hole is presented.

In a cosmological setting the theory of macroscopic gravity is a large-distance scale generalization of general relativity. Exact cosmological solutions to the equations of

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macroscopic gravity for a flat spatially homogeneous, isotropic space-time are found. The gravitational correlation terms in the averaged Einstein equations have the form of spatial curvature, dark matter and dark energy (cosmological constant) with particular equations of state for each correlation regime. Interpretation of these cosmological models to explain the observed large-scale structure of the accelerating Universe with a significant amount of the nonluminous (dark) matter is discussed.

5.7. *The astronomical observatory 'Khurel Togoot' in Mongolia*

Batmunkh Damdin, Research Centre of Astronomy and Geophysics, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia, email: btmnh_d@yahoo.com

In my presentation the basic researches, telescopes and devices of our astronomical observatory, which was founded during the International Geophysical Year, are briefly described. Our astronomical observatory is located on Bogd Mountain near the capital city Ulaanbaatar. Almost 50 years of scientific works have been carried out there. In particular, astrometric researches, GPS, solar researches and observations of minor planets are conducted. Now these scientific researches basically are kept and extended, with the introduction of modern technology. As an example of the data received by our solar telescope 'Coronograph', some solar images will be shown. Recently we equipped this telescope with a CCD camera. Because of the transformation of the economy in Mongolia, there are at present difficulties with the preparation of young professional astronomers and with the purchase of new astronomical equipment.

5.8. *Astronomical education in Armenia*

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Astronomy pupils in Armenia get their first ideas on astronomy at elementary schools. Astronomy as a distinct subject is taught at all secondary schools in the country. Teaching is conducted according to a unified program elaborated jointly by professional astronomers and astronomy teachers. Unfortunately only one hour per week is allotted for teaching astronomy, which obviously is not enough workload to hire specialized astronomy teachers at every school, and at many schools this subject is tutored by non-specialists. Many schools partly compensate this lack of teachers by organizing visits to the Byurakan Observatory (BAO) for pupils, where they also attend short lectures on astronomy. In some schools optional training in astronomy is organized by amateurs, for the purpose of a deeper understanding in astronomy.

During recent years annual competitions for revealing gifted pupils in astronomy have been organized. These competitions have three rounds, namely, in schools, in districts and the final round is, as a rule, held at BAO. The national winners successfully participate in and win prestigious prizes at international astronomical Olympiads as well.

At Yerevan State University (YSU) there is a department for astrophysics, which was set up in 1946 and is operating to date. This department trains specialists for a career in astrophysics. Only one or two students graduate from this department yearly at present, while in the 1980s a dozen specialists were trained every year. BAO serves as the scientific base for the students of YSU as well, and a number of staff members from BAO conduct special courses for YSU students. YSU provides a Master's degree in astrophysics, and BAO is granting a Doctor's (PhD) degree since the 1970s.

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5.9. *On progress on the Suffa large radio-telescope project*

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The large-scale radio astronomy facility complex (analogous to the GBT at NRAO) is being created not far from Samarkand (Uzbekistan) on the Suffa plateau at 230 m (Trimble, 2001, A Year of Discovery: Astronomy Highlights of 2000, S&T, 101, 51). Originally it was designed as a basic part of the Earth-Space VLBI system (Kardashev *et al.*, 1995, Acta Astron., 37, 271), URL <http://www.asc.rssi.ru/suffa/>) and contains the radio telescope for 0.8-60 mm bandwith 70-m main reflector, two removable sub-reflectors; satellite communication station; data receiving and processing system and other necessary infrastructure. The adaptive optics principle will be used for control of the surface of the main mirror, consisting of 1200 trapezoidal panels.

The site location provides good seeing conditions for the cm–mm range. Averaged annual atmospheric transmission coefficients at the zenith were derived as 0.90 - 0.98 for 3.1 mm and 5.8 mm wavelengths and about 0.60 for 1.36 mm (Hojaev & Shanin, 1996, JKAS, 29, S411).

The project started as far back as the period when the Soviet Union was stalled, since its disintegration. Quite recently the firm decision on completing the project has been endorsed by our Governments, and Russia will invest for this; therefore the project's layouts have been considerably modernized and updated in order to build up a state-of-the-art instrument. It should be operational in 2009.

Now we are arranging for a scientific consortium further to explore the Suffa site more deeply and to learn the main 'radio-astro-climate' parameters by means of new technology ('radio-seeing', radio transparency in different sub-mm, mm and cm bands, PWV, their intercorrelation and correlation with meteo-parameters) for the atmospheric modelling at the site, and to try to forecast the 'radio-weather' for reliably planning the scientific schedule of the future telescope.

5.10. *IHY: Meteor astronomy and the New Independent States (NIS) of the Former Soviet Union*

Svetlana Kolomiyets, Kharkiv National University of Radioelectronics, Kharkiv, Ukraine, email: s.kolomiyets@gmail.com

The purpose of this paper is to emphasize, that there are some specific features of the development of science in the New Independent States (NIS) of the Former Soviet Union. These features demand enhanced attention of the organizers of the IHY. The creation of effective mechanisms for the stimulation of connections to world science is necessary. This is because there exists a dormant sector of fundamental scientific knowledge in these countries, which has been saved up for the fifty years since the IGY in 1957. Probably, the IHY is the last opportunity for rescuing the dormant part of this knowledge from full oblivion.

The method used in this paper is to display the general tendencies in individual displays. The features and history of the development of meteor astronomy during the existence of the Soviet Union and the subsequent period give a key to an understanding of the problem. Meteor astronomy can be assumed to be a young science. It is an example of a cross-disciplinary science. It is also an example of a science having a sharp rise, due to the project of the IGY and to subsequent geophysical projects. Meteor astronomy is a science directly connected with the launching of the first space satellite of the Earth and with the resolution of problems of meteoroid danger to space missions.

Commission 22 (Division III) of the IAU coordinated the development of meteor astronomy during the IGY. The well-known Soviet researcher of meteors, V. Fedynskiy, has headed this Commission during four years since 1958. In the USSR, numerous meteor centres were created and activated. The general management was concentrated in Moscow. Despite a close interaction under global projects of the Soviet Union with other countries, there existed a language barrier. The language barrier, together with other reasons, led to the creation in the USSR of a powerful meteor science only in the Russian language. After the disintegration of the Soviet Union, the meteor centers have remained, but without the normal central management. The scientific outputs have therefore remained as isolated, and inaccessible, although the science is published in English.

A reunification of the scientific achievements of the last few years with international science should become the task of the IHY in the NIS. Revival of the activity of some of the centres will be useful.

6. Astronomy in eastern Europe

6.1. *Introduction*

These three papers give an overview of different aspects of astronomy in the former Yugoslavia. Olga Atanackovic-Vukmanovic gives a review of astronomy in Serbia and in Montenegro (the two countries dissolved their federation just before the IAU XXVI General Assembly). Aleksandra Andic discussed astronomy education in Bosnia and Herzegovina. Finally Davor Krajnovic presents information on a new program of distance education in astronomy in Split, Croatia. All these regions of the former Yugoslavia have undergone very different political and economic developments, so evidently the support for astronomy differs widely across this relatively compact region, as is reflected in these papers.

6.2. *Astronomy in Serbia and in Montenegro*

Olga Atanackovic-Vukmanovic, Faculty of Mathematics, University of Belgrade, Belgrade, Serbia, Yugoslavia, email: olga@matf.bg.ac.yu

A review of professional and amateur astronomy in Serbia and in Montenegro is given. After a brief historical survey of the foundations and development of astronomy education in Serbia and in Montenegro, special attention is given to a new curriculum that is being prepared for all educational levels.

6.3. *Astronomy and astrophysics in Bosnia and Herzegovina*

Aleksandra Andic, Prirodno Matematicki Fakultet, Banja Luka, Bosnia and Herzegovina, and Queen's University, Belfast, UK, email: a.andic@qub.ac.uk

In Bosnia and Herzegovina, astronomy teaching is almost non-existent. There are only several courses in universities and they are usually taught by physicists who often had only elementary courses in astrophysics. On the other hand, there is a huge interest for astrophysics in the student population. When it comes to educational outreach, the situation is even more grim. There are several solutions and possibilities which I will present, together with the main obstacles which need to be overcome.

6.4. *Study astrophysics in Split!*

Davor Krajnovic, University of Oxford, Oxford, UK, email: dxk@astro.ox.ac.uk

Beginning in autumn 2008 the first generation of astronomy master's students will start a two-year course in astrophysics offered by the Physics Department of the University of

Split, Croatia (<http://fizika.pmfst.hr/astro/english/index.html>). This unique master's course in south-eastern Europe, following the Bologna convention and given by astronomers from international institutions, offers a series of comprehensive lectures designed greatly to enhance students' knowledge and skills in astrophysics, and to prepare them for a scientific career. An equally important aim of the course is to recognize the areas in which astronomy and astrophysics can serve as a national asset, and to use them to prepare young people for real life challenges, enabling graduates to enter modern society as a skilled and attractive work-force.

I will present this new programme as an example of a successful organization of international astrophysics studies in a developing country, which aims to become a leading graduate program in astrophysics in the broader region. I will focus on the goals of the project, showing why and in what way astronomy can be interesting for third-world countries, what are the benefits for the individual students, nation and region, and also for research, science and the astronomical community in general.

7. Astronomy education in developing countries

7.1. *Introduction*

Astronomy education provides the foundation upon which any astronomical community rests. This foundation provides the human capital that is necessary for developing the infrastructure of astronomy in a country. The eleven papers presented in this section fall into three broad themes: University-level education, the use of small telescopes for teaching and research, and popularisation of astronomy.

Many developing countries suffer from the isolation of astronomers and their graduate students, working in very small groups, with little contact with the mainstream astronomical community. For such a group, an infusion of international expertise can be tremendously beneficial, not only in terms of scientific contacts, but also in terms of raised levels of support for astronomy in the country. For nearly fourty years the IAU has conducted the International Schools for Young Astronomers (ISYA). Michele Gerbaldi describes the ISYA programmes, of which she has been a key driver for many years.

John Percy discusses undergraduate and graduate programmes in astronomy for developing countries. He highlights the importance of imparting not only subject knowledge, but also practical skills that can find application outside of astronomy, as well as exposing the students to a culture of research and learning. Where attendance at a formal university course is not possible, distance education is a possibility. Barrie Jones of the Open University discusses his experiences gained from teaching astronomy via distance education for the past 30 years. Paulo Bretones and his colleagues discuss the pedagogic aspects of astronomy education. He presents the Latin-American Journal of Astronomy Education, which addresses the need for teaching resources in Spanish and Portuguese, as well as general pedagogical aspects of the teaching of astronomy.

Small telescopes have a huge role to play in the teaching of astronomy and in the development of observing skills by astronomy students. Shiva Pandey presents examples of the use of small, commercially available telescopes equipped with photometers or CCD cameras to perform laboratory exercises in astronomy and small, publishable research projects. Eder Martioli and J. Jablonski describe how they use small telescopes and commercial CCDs to search for planetary transits from a university campus, where the seeing conditions may not be excellent, but where accessibility for students is. John Baruch and his colleagues take the concept of small telescopes for teaching into the realm of the internet by presenting the potentials of small robotic telescopes to support basic

astronomy education through the internet by servicing thousands of users spread across the globe for free. Taking this theme yet one step further removed from the telescope, Hayk Harutyunian and M. Mickaelian discuss the potentials of Virtual Observatories as teaching tools in astronomy.

The final group of papers in this section focusses on the role of public outreach and the amateur community in developing astronomy. Veteran eclipse chaser Jay Pasachoff discusses the immense potentials of solar eclipses to capture the imagination of the public and policy makers alike for the development of astronomy. A.P. Sule and colleagues discuss the role of amateur astronomy organisations in astronomy popularisation, pointing to examples of the Indian experience. The funding of capacity building acitivities is always a challenge. The final paper in this section is a proposal by Meelis Kaldalu that the IAU consider the marketing potentials associated with the naming of celestial objects as a possible source of revenue for astronomy development.

7.2. *International Schools for Young Astronomers (ISYA): their new horizon*

Michèle Gerbaldi, Institut d'Astrophysique, Paris, France, email: gerbaldi@iap.fr

This talk outlines the main features of this programme developed by the International Astronomical Union (IAU) since 1967 and its perspective at the time of the development of virtual observatories. The main goal of this programme is to support astronomy in developing countries by organizing a school over three weeks for students typically with an M.Sc. degree.

The context in which the ISYA were developed changed drastically in the past ten years. From a time when the access to any large telescope was difficult, and mainly organized on a national basis, nowadays the archives are developed at the same time that any major telescope is planned, whether ground-based or in space, and these archives are accessible from everywhere. The concept of the virtual observatory reinforces this access. However, the technological development of telecommunications and of world-wide internet connections do not remove all the difficulties, among which is the problem of the isolation of the scientist working in a small institution. In this context, the role of the ISYA will be addressed.

7.3. *Undergraduate and graduate programs in astronomy for developing countries*

John Percy, University of Toronto, Toronto, Canada, email: jpercy@utm.toronto.ca

This presentation will discuss some aspects of the design of undergraduate and graduate astronomy curricula, broadly defined, for developing countries. A fundamental requirement is to develop students' ability and desire to learn, both in university and beyond. I will then discuss several topics of the curriculum:

(*i*) The program of course work in astronomy and related topics, such as physics and mathematics;

(*ii*) The associated practical and project work to develop skills as well as knowledge;

(*iii*) linking the course work, effectively, to various aspects of research;

(*iv*) Development of general academic and professional skills such as oral and written communication, teaching, planning and management, and the ability to function as part of an interdisciplinary team; and

(*v*) Orientation to the culture of the university and to the science and profession of astronomy.

To accomplish all of the goals may seem daunting, especially as many of them are not achieved in the most affluent universities. But much can be achieved by recognizing that there are well-established 'best practices' in education, achieved through research, reflection and experience. Simple resources, effectively used, can be superior to the highest

technology, used without careful thought. It is often best to do a few things well; 'less can do more'. And effective partnership, both within the local university and with the outside astronomical community, can also contribute to success.

7.4. *Distance education at university level – how useful for developing countries?*

Barrie Jones, The Open University, Milton Keynes, UK,
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Many countries now have institutions devoted to distance education at university level. Not all of these are in the developed world. In this talk I will outline those in developing countries. I will then describe the main features of distance education as presently practised by The Open University in the UK. It first admitted students in 1970, and since then we have learned what is really necessary for distance education to be successful, not just in the UK, but beyond. Distance education in other countries can, and does, differ from that in the UK, and a few examples of the different challenges and practises will be given. But the focus of my presentation will be the time I hope to allow for comments and questions. It will be invaluable to have input from those present with experience of other open learning institutions, and from those eager to begin to explore the potential of distance learning in their own countries.

7.5. *The first two years of the Latin-American Journal of Astronomy Education (RELEA)*

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We present and discuss in this work the motivations, goals and strategies adopted for its creation and launch of the e-journal *Latin-American Journal of Astronomy Education* (RELEA). The RELEA 'first light' was in August, 2004 with the appearance of No. 1, and it is now completing two years of existence. The creation of the new journal was prompted by: (*a*) the noteworthy absence of a specific publication in the field in Latin-America; (*b*) the lack of classroom material in Spanish or Portuguese that could be directly used without too many adaptations; and (*c*) the need for a regional forum to discuss and suggest public policies concerning the teaching of sciences in general and astronomy in particular.

We identify and present the difficulties encountered for the achievement of the proposed objectives and operational issues in this period, together with the adopted solutions (refereeing procedure, periodicity, etc.). Finally, we attempt to evaluate the long-run impact of such initiatives on scientific education as a tool for effective citizenship decision making, so critical for third-world countries.

7.6. *Teaching and research in astronomy using small aperture optical telescopes*

Shiva K. Pandey, Pt Ravishankar Shukla University, Raipur, India,
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Small aperture (< 1 m, typically 20 - 50 cm) optical telescopes with adequate back-end instrumentation (photometer, CCD camera and CCD spectrograph, etc.) can be used for spreading the joy and excitement of observational astronomy among postgraduate and research students in colleges. On the basis of over a decade's experience in observing with small optical telescopes it has been amply demonstrated that such a facility, which

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any university department can hope to procure and maintain, can be effectively used for teaching as well quality research.

The Physics Department of Pt Ravishankar Shukla University at Raipur, India offers astronomy and astrophysics as one of the specializations as a part of the M.Sc. program in physics. A set of observational exercises has been incorporated with a view to provide training in observations, analysis and interpretation of the astronomical data to the students. Observing facilities available in the department include 8 – 14 inch aperture telescopes (CGE series from Celestron) equipped with the new-state-of-the-art back-end instrumentation-like photometer, CCD camera and also a CCD spectrograph.

An observing facility of this kind is ideally suited for continuous monitoring of a variety of variable stars, and thus can provide valuable data for understanding the physics of stellar variability. This is especially true for a class of variable stars known as chromospherically active stars. The stars belonging to this class have variable light curves, and the most puzzling feature is that their light curves change year after year in a rather strange way. A large fraction of these active stars are bright and, hence, the importance of a small aperture telescope for collecting the much needed photometric data.

For over a decade the research activity using a 14-inch optical telescope has been focused on photometric monitoring of well known as well suspected active stars. This, together with spectroscopic data using the observing facility at Indian observatories has led to identification of new chromospherically active stars. The talk is aimed at sharing our experiences, quoting examples with professional colleagues on the usage of small optical telescopes for teaching and research in colleges and universities.

7.7. *How to look for planetary transits using small telescopes and commercial CCDs in developing countries*

Eder Martioli and F. Jablonski, Divisão de Astrofísica, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brasil, email: eder,chico@das.inpe.br

The main goal of this work is to have a better understanding of the problems and characteristics of photometric surveys with small-sized affordable equipment, like the one available at the Astrophysics Division/INPE, in São José dos Campos, Brazil. The use of low-cost instruments also has an appeal in the context of the detection of Extrasolar Planets (ESP), in the sense that many observers are available for survey and follow-up programs. It could also make possible the inclusion of many developing countries in the search for planetary transits. We describe the data collection and analysis procedure for differential photometry of the transit of HD209458 b, using a small telescope and a commercial CCD camera. According to the HST observations of Brown *et al.* (2001), the transit produces a box-shaped light-curve with 2 % depth and 184 min duration. The orbital period is $\sim$3.5 days. The equipment consists of a f/10, 11-in Schmidt-Cassegrain Celestron telescope equipped with a SBIG ST7E CCD camera. Since the seeing at the campus is quite poor, we used a focal reducer to produce an effective focal ratio of about f/5, still keeping a good sampling of the PSF but with a larger field-of-view. The larger field-of-view allows the simultaneous observation of a relatively bright nearby star, suitable for differential photometry. We discuss the IRAF reduction procedures for the large number of images collected and present the results obtained in the transit of September 8, 2004.

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7.8. *Basic astronomy as part of a general higher education in the developing world*

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This paper describes a new initiative in support of the aim of Commission 46 of the IAU to develop and improve astronomy education at all levels throughout the world. This paper discusses the ideal specification of a facility to support basic astronomy within education programmes which are delivered to students who have access to the internet. The available robotic telescopes are discussed against this specification and it is argued that the Bradford Robotic Telescope, uniquely, can support many thousands of users in the area of basic astronomy education, and the resource is free. Access to the internet is growing in the developing world and this is true in the education programmes.

This paper discusses the serious problems of delivering to large numbers of students a web-based astronomy education programme supported by a robotic telescope as part of a general education. It examines the problems of this form of teaching for teachers who have little experience of working with IT and little knowledge of basic astronomy and proposes how such teachers can be supported. The current system (<http://www.telescope.org/>) delivers astronomy education in the language, culture and traditions of England. The paper discusses the need to extend this to other languages, cultures and traditions, although for trainee teachers and undergraduates, it is argued that the current system provides a unique and valuable resource.

7.9. *Modern facilities in astronomy education*

Hayk A. Harutyunian and M.A. Mickaelian
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Astronomical education in Armenia enters a new stage of organization and development. Though the economic difficulties restricted the former interest in astronomy for a decade or so, the present young generation gradually finds more and more attraction in space sciences. Knowledge of computers and the internet is their typical difference from the previous students. Thus, astronomy education requires heavy use of computer facilities and the internet, as it is in the case of modern astronomical research. The students need powerful computers, and also computing methods, the internet (including grid technologies), usage of large astronomical databases, virtual observatories (VOs), etc.

The Armenian astronomy has a unique database of the famous Markarian survey (Digitized First Byurakan Survey, DFBS), as well as the newly created Armenian Virtual Observatory (ArVO). Since 2005, we have introduced a new (for the first time in the world!) subject for the Yerevan State University graduate students called 'Astronomical surveys, databases and virtual observatories', which is connected directly with the modern understanding and treatment of large multi-wavelength data volumes. The new requirements suggest also training of new kind of (so-called) astronomy-computing specialists, who could heavily push the modern research and make it much more efficient.

7.10. *Observing solar eclipses in the developing world*

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The paths of totality of total solar eclipses cross the world, with each spot receiving such a view about every 300 years. The areas of the world from which partial eclipses are visible are much wider. For the few days prior to a total eclipse, the attention of a given country is often drawn toward the eclipse, providing a teachable moment that we can use to bring astronomy to the public's attention. Also, it is important to describe how to

observe the partial phases of the eclipse safely. Further, it is important to describe to those people in the zone of totality that it is not only safe but also interesting to view totality. Those who are misled by false warnings that overstate the hazards of viewing the eclipse, or that fail to distinguish between safe and unsafe times for naked-eye viewing, may well be skeptical when other health warnings – perhaps about AIDS or malaria prevention or polio inoculations – come from the authorities, meaning that the penalties for misunderstanding the astronomical event can be severe. Through the International Astronomical Union's Working Group on Solar Eclipses and through the IAU's Program Group on Public Education at the Times of Eclipses, part of the Commission on Education and Development, we make available information to national authorities, to colleagues in the relevant countries, and to others, through our websites at http://www.eclipses.info and <http://www.totalsolareclipse.net and through personal communication. Among our successes at the 29 March 2006 total solar eclipse was the distribution through a colleague in Nigeria of 400 000 eye-protection filters.

7.11. *Role of voluntary organizations in astronomy popularization: a case study of 'Khagol Mandal', Mumbai, India*

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In India, astronomy research institutions are few and far spaced as compared to the population density. Further, the public outreach activities of research institutes cannot cover most of the academic institutes in their area as they way out-number public outreach resource potential of any institute. The organizations of amateur astronomy enthusiasts do come handy in this scenario. We here present a case study of 'Khagol Mandal', a voluntary organization primarily based in Mumbai, India's economic capital. In 20 years since its inception in 1985 - 86, Khagol Mandal has given more than 1000 public outreach programmes in various schools, undergraduate colleges, famous city hangouts, apart from their regular overnight programmes in Vangani, a sleepy village on the outskirts of the city. Study tours on special occasions like TSE'95 and TSE'99 as well as regular study tours to meteor crater at Lonar, Maharashtra facilitate their volunteers with glimpses of real research work in astronomy. These have inspired a number of students to take professional astronomy careers. With a volunteer force, probably the largest in India or even South Asia, Khagol Mandal is well poised to take advantage of the newest tools like the Virtual Observatory and make the use of existing goodwill to take these tools to the layman. With little guidance from senior researchers, organizations like these can provide a solution to the ever-increasing need of man-power for secondary data analysis.

7.12. *A packet of proposals for collaboration between the IAU and the developing world*

Meelis Kaldalu, University of Tartu, Tartu, Estonia, email: ifoundu@hot.ee

The purpose of the presentation is to outline several opportunities on how astronomical society can contribute benefit to the developing world. The package of solutions described includes methods of peer-to-peer networking, collaboration with the international business community and a widespread dissemination campaign about the results of astronomical research. Preliminary realistic calculations estimate that at least 400 000 euro, or more, can be raised for the realization of the proposed plan of action. The presentation will be followed by a discussion about possible future activities, and ad hoc brainstorming for new solutions to popularize astronomy all over the world.

8. Promoting astronomy development through the UN, the International Heliophysical Year and COSPAR

8.1. *Introduction*

International scientific unions, such as the IAU and COSPAR, together with intergovernmental organisations, such as the UN and UNESCO, have done much to promote astronomy in the developing world. The United Nations Office for Outer Space Affairs has been instrumental in harnessing the prestige of the United Nations to organise a series of UN/ESA Workshops on Basic Space Science in developing countries in all regions of the world since 1991. Hans Haubold describes the philosphy behind this workshop series and their future thematic emphasis on the International Heliophysical Year. Keith Arnaud and Peter Willmore describe the COSPAR capacity-building workshops organised during 2000 – 2007. These are hands-on workshops intended to familiarise participants with the content of space mission data archives and the tools to use them.

The next group of papers focus on the capacity-building opportunities associated with the International Heliophysical Year (IHY) 2007. Nat Gopalswamy and his colleagues discuss the United Nations Basic Space Science Initiative for IHY 2007 in terms of which there is a programme to deploy arrays of small, inexpensive instruments around the globe. This is an exciting opportunity to initiate space science research at interested institutions that can afford very little in the way of capital outlay, but who have interested and committed scientists to operate these insturements and to participate in the scientific work. David Webb and Nat Gopalswamy discuss the IAU's role in the IHY. Within the IAU, the IHY activities are conducted under Division II, Sun and Heliosphere.

The IHY presents an excellent opportunity to promote education in basic space science world-wide. Indeed, this is a major thrust of the IHY. Maria Cristina Rabello-Soares and colleagues discuss the IHY Education and Outreach Programme, which is coordinating the education and outreach activities of all the IHY partners. Developing countries may access teaching resources and educational particpation opportunities through this programme. One such 'hands-on' project is the Space Weather Monitor Project, presented by Deborah Scherrer and her colleagues. This project allows students around the world to track solar-induced changes to the ionosphere.

8.2. *The United Nations Basic Space Science Initiative*

Hans Haubold, United Nations Office for Outer Space Affairs, Vienna, Austria, email: Hans.Haubold@unvienna.org

Pursuant to recommendations of the United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) and deliberations of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), annual UN/European Space Agency workshops on basic space science have been held around the world since 1991. These workshops contribute to the development of astrophysics and space science, particularly in developing nations. Following a process of prioritization, the workshops identified the following elements as particularly important for international cooperation in the field: (*i*) operation of astronomical telescope facilities implementing TRIPOD; (*ii*) virtual observatories; (*iii*) astrophysical data systems; (*iv*) concurrent design capabilities for the development of international space missions; and (*v*) theoretical astrophysics such as applications of non-extensive statistical mechanics.

Beginning in 2005, the workshops focus on preparations for the International Heliophysical Year 2007 (IHY2007). The workshops continue to facilitate the establishment of astronomical telescope facilities as pursued by Japan and the development of low-cost, ground-based, world-wide instrument arrays as lead by the IHY secretariat.

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Further reading:

Wamsteker, W., Albrecht, R. and Haubold, H.J. (eds.), 2004, *Developing Basic Space Science World-Wide: A Decade of UN/ESA Workshops* Dordrecht: Kluwer

<http://ihy2007.org>

<http://www.unoosa.org/oosa/en/SAP/bss/ihy2007/index.html>

<http://www.cbpf.br/GrupPesq/StatisticalPhys/biblio.htm>

8.3. *The COSPAR Capacity-Building Workshop programme, 2000 – 2007*

Keith Arnaud[1] *and Peter Willmore*[2]*,*
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The objectives and mode of operation of the COSPAR Capacity-Building Workshop Programme will be described, together with the activities carried out and the results achieved in the first seven years of its existence. The policies in place to embed the skills imparted into the host scientific communities and to the methods used to monitor the effectiveness of the programme, will be discussed.

8.4. *The United Nations Basic Space Science Initiative for IHY 2007*

Nat Gopalswamy[1]*, J.M. Davila*[1]*, B.J. Thompson*[1]*, and Hans Haubold*[2]*,*
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The United Nations, in cooperation with national and international space-related agencies and organizations, has been organizing annual workshops since 1990 on basic space science, particularly for the benefit of scientists and engineers from developing nations. The United Nations Office for Outer Space Affairs, through the IHY Secretariat and the United Nations Basic Space Science Initiative (UNBSSI) will assist scientists and engineers from all over the world in participating in the International Heliophysical Year (IHY) 2007.

A major thrust of the IHY/UNBSSI program is to deploy arrays of small, inexpensive instruments such as magnetometers, radio telescopes, GPS receivers, all-sky cameras, etc. around the world to provide global measurements of ionospheric and heliospheric phenomena. The small instrument program is envisioned as a partnership between instrument providers, and instrument hosts in developing countries. The lead scientist will provide the instruments (or fabrication plans for instruments) in the array; the host country will provide manpower, facilities, and operational support to obtain data with the instrument typically at a local university.

Funds are not available through the IHY to build the instruments; these must be obtained through the normal proposal channels. However, all instrument operational support for local scientists, facilities, data acquisition, etc will be provided by the host nation. It is our hope that the IHY/UNBSSI program can facilitate the deployment of several of these networks world wide. Existing data bases and relevant software tools that can be used will be identified to promote space science activities in developing countries. Extensive data on space science have been accumulated by a number of space missions. Similarly, long-term data bases are available from ground based observations. These data can be utilized in ways different from originally intended for understanding the heliophysical processes. This paper provides an overview of the IHY/UNBSS program, its achievements and future plans.

8.5. *The IHY program and associated IAU activities*

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The International Heliophysical Year is an international program of scientific collaboration planned for the time period starting next year, the 50th anniversary of the International Geophysical Year. The physical realm of the IHY encompasses all of the solar system out to the interstellar medium, representing a direct connection between in-situ and remote observations. The IHY is of great interest to the IAU because of this broad astronomical coverage as well as its emphasis on international cooperation and developing nations. The IHY program is promoting worldwide participation in its activities that include dispersing networks of inexpensive instrumentation to achieve its scientific goals. Within the IAU the IHY program is organized under Division II, which covers the Sun and Heliosphere. Nat Gopalswamy is the IHY International Coordinator and Chair of the IHY subgroup within the IAU's Working Group on International Collaboration on Space Weather. David Webb is the IAU representative for the IHY and the outgoing President of Division II. The United Nations IHY effort is led by Hans Haubold under the UNBSS program and will be discussed next by Dr. Gopalswamy. Under this program the IAU is supporting the annual IHY Workshops and is facilitating the communications between scientists in developed and developing countries.

8.6. *Globalizing space and Earth science – the International Heliophysical Year education and outreach program*

M. Cristina Rabello-Soares[1], *C. Morrow*[2], *and B.J. Thompson*[3],
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The International Heliophysical Year (IHY) in 2007 and 2008 will celebrate the 50th anniversary of the International Geophysical Year (IGY) and, following its tradition of international research collaboration, will focus on the cross-disciplinary studies of universal processes in the heliosphere. The main goal of IHY Education and Outreach Program is to create more global access to exemplary resources in space and earth science education and public outreach. By taking advantage of the IHY organization with representatives in every nation and in the partnership with the United Nations Basic Space Science Initiative (UNBSSI), we aim to promote new international partnerships. Our goal is to assist in increasing the visibility and accessibility of exemplary programs and in the identification of formal or informal educational products that would be beneficial to improve the space and earth science knowledge in a given country; leaving a legacy of enhanced global access to resources and of world-wide connectivity between those engaged in education and public outreach efforts that are related to IHY science. Here we describe how to participate in the IHY Education and Outreach Program and the benefits in doing so. Emphasis will be given to the role played by developing countries; not only in selecting useful resources and helping in their translation and adaptation, but also in providing different approaches and techniques in teaching.

8.7. *The Space Weather Monitor project: bringing hands-on science to students of the developing world for the IHY2007*

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Stanford's Solar Center, Electrical Engineering Department, and local educators have developed inexpensive Space Weather Monitors that students around the world can use to track solar-induced changes to the Earth's ionosphere. Through the United Nations Basic Space Science Initiative (UNBSSI) and the IHY Education and Public Outreach Program, our Monitors are being deployed to 191 countries for the International Heliophysical Year, 2007. In partnership with Chabot Space and Science Center, we are designing and developing classroom and educator support materials to accompany the distribution. Materials will be culturally sensitive and will be translated into the six official languages of the United Nations (Arabic, Chinese, English, French, Russian, and Spanish). Monitors will be provided free of charge to developing nations and can be set up anywhere there is access to power.

9. The virtual observatory and developing countries

9.1. *Introduction*

Virtual Observatories, and the tools to use them, are being developed in all the astronomically developed countries. For astronomers in the developing countries Virtual Observatories have the potential to level the playing fields in terms of access to data and processing tools, *provided that the users are appropriately trained, and know what they are doing.* Ajit Kembhavi discusses these potentials and illustrates some of the facilities that are already available. Virtual Observatories are one area of astronomy where the instruments or tools may be contributed by people in developing countries, where there is much software development potential. Ganghu Lin and colleagues discuss VO software that they have developed to do common data processing tasks and the methods they have devised for data management and data sharing.

In order to realise their potential use in developing countries, the existing capacity building programmes of the IAU, COSPAR and the UN will have to create opportunities, such as hands-on workshops, to allow the users to interact with VOs under the guidance of experienced astronomers.

9.2. *Developing countries and the virtual observatory*

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A Virtual Observatory is a platform for launching astronomical investigations: it provides access to huge data banks, software systems with user friendly interfaces for data visualization and analysis, and even access to computers on which the analysis can be carried out. Virtual observatories the world over are seamlessly networked, and their resources can be accessed over the internet by astronomers regardless of their location, expertise and the level of access to their own advanced computing facilities. Due to their nature, virtual observatories can make an immense impact on the way astronomy is done in the developing world. I will consider in my talk some of the facilities that virtual observatories provide, discuss their possible use by astronomers, and also how even small groups in the developing world can contribute to the setting up of virtual observatories.

9.3. *Exploiting software towards easier use and higher efficiency*

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In developing countries, using data based on instruments made by themselves to the maximum extent is very important. It is not only related to maximizing science returns upon prophase investment, deep accumulations in every aspects but also science output. Based on the idea, we are exploiting a software (called THDP: Tool of Huairou Data Processing). It is used for processing a series of issues, which is necessary in processing data.

This paper discusses its design, purpose, functions, method and specialities. The primary vehicle for general data interpretation is through various techniques of data visualization, techniques which are interactive. In the software, we employed an Object-Oriented approach. It is appropriate to the vehicle. It is imperative that the approach provide not only function, but do so in as convenient a fashion as possible. As result of implementing the software, it is not only easier to learn data processing for a beginner but also more convenient. For experienced researchers TDHP has increased greatly the efficiency in every phase, including analysis, parameter adjusting, and the display of results. Under the framework of the virtual observatory, for developing countries, we should study more and newer related technologies, which can advance the ability and efficiency in scientific research, like the software we are developing.

9.4. *A series of technologies exploiting data sharing*

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One of the purposes of the Virtual Observatory is providing data sharing. The Solar Multi-Channel Telescope in Huairou Solar Observing Station, Beijing, China is not only used for science research but also for solar activity prediction and space environment prediction. For providing these services, we have been carrying through a series of technologies that enable data sharing. In this article, we will discuss the exploiting of this technology. The exploiting includes setting up a WWW server, network, network safety facility, data processing software and designing international unified meta data for our speciality, etc.

So far, as result of this work, the initial needs have been reached. We still have further work to implement, such as uploading data in real time, setting up a database with a query function, and continuous improvement of the software, etc.

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