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Report on the Eleventh United Nations/European Space Agency Workshop on Basic Space Science: the World Space Observatory and the Virtual Observatories in the Era of 10-metre Telescopes

(Córdoba, Argentina, 9-13 September 2002)

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I. Introduction

A. Background and objectives

1. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) and the Vienna Declaration on Space and Human Development recommended that activities of the United Nations Programme on Space Applications promote collaborative participation among Member States at both the regional and international levels, emphasizing the development of knowledge and skills in developing countries.[1]

2. At its forty-fourth session, in 2001, the Committee on the Peaceful Uses of Outer Space endorsed the programme of workshops, training courses, symposiums and conferences planned for 2002.[2] Subsequently, the General Assembly, in its resolu-tion 56/51 of 10 December 2001, endorsed the United Nations Programme on Space Applications for 2002.

3. Pursuant to resolution 56/51 and in accordance with the recommendation of UNISPACE III, the Eleventh United Nations/European Space Agency (ESA) Workshop on Basic Space Science: the World Space Observatory and the Virtual Observatories in the Era of 10-metre Telescopes was organized by the United Nations, ESA and the Government of Argentina at the Centro Espacial Teófilo Tabanera of the Comisión Nacional de Actividades Espaciales (CONAE), in Córdoba, Argentina, from 9 to 13 September 2002. CONAE hosted the Workshop on behalf of the Government of Argentina.

4. The Workshop was the latest in a series of United Nations/ESA workshops on basic space science that had been organized for the benefit of developing countries in India (1991) and Sri Lanka (1996) for Asia and the Pacific (see A/AC.105/489 and A/AC.105/640); in Costa Rica (1992) and Honduras in 1997 for Central America (see A/AC.105/530 and A/AC.105/682); in Colombia (1992) for South America (see A/AC.105/530), in Nigeria (1993) and Mauritius (2001) for Africa (see A/AC.105/560/Add.1 and A/AC.105/766); in Egypt (1994) and Jordan (1999) for Western Asia (see A/AC.105/580 and A/AC.105/723); and in Germany (1996) and France (2000) for Europe (see A/AC.105/657 and A/AC.105/742). The workshops were co-organized by the Abdus Salam International Centre for Theoretical Physics, the Austrian Space Agency, the Centre national d'études spatiales of France, the Committee on Space Research, ESA, the German Space Agency (DLR), the Institute of Space and Astronautical Science of Japan, the International Astronomical Union, the National Aeronautics and Space Administration (NASA) of the United States of America, the National Astronomical Observatory of Japan, the Planetary Society and the United Nations.

5. The main objective of the Workshop was to provide a forum to highlight recent scientific results obtained using the major space-borne observatories for studies of the stars and the far reaches of the universe. Such satellite missions constitute an impressive means of studying all aspects of basic space science from space as a complement to studies being done from the ground. The question of the large volumes of data generated by such missions was discussed in relation to changing research needs within the scientific community, as well as the question of how access to the important databases maintained by major space agencies could be

facilitated. The issues of data research and education based on space missions were discussed, together with the relevance of such missions to those developing countries wishing to participate actively in the voyage of discovery through the universe. Future access to space by means of a world space observatory or other international project was seen as crucial. The developments that were expected to take place in the long term would necessitate early planning and an examination of the capabilities associated with the running of such an observatory.

6. The present report was prepared for submission to the Committee on the Peaceful Uses of Outer Space at its forty-sixth session and to its Scientific and Technical Subcommittee at its fortieth session, in 2003.

7. During the deliberations of the Workshop, the Government of China announced that the China National Space Administration would host the Twelfth United Nations/European Space Agency Workshop on Basic Space Science and Development in the Twenty-first Century: the Next Phase on its behalf and the workshop would be held in Beijing from 8 to 12 September 2003. Programme topics for that workshop would be, among others, (a) access to data and imagery from space missions through international data archives, (b) space mission project development, (c) concurrent design capability for the development of international space-related projects, (d) participation of developing countries in large international space-related projects, (e) case studies in the evaluation of the achievements of past United Nations/ESA workshops on basic space science and (f) astrophysics and space science of the solar system.

B. Programme

8. At the opening of the Workshop, introductory statements were made by representatives of CONAE, the Universidad Nacional de Córdoba, the Universidad Nacional de La Plata, ESA and the United Nations. The Workshop was divided into scientific sessions, each focusing on a specific issue. Presentations by invited speakers describing the status of their findings in research and education were followed by brief discussions. Sixty papers were presented by invited speakers from both developing and developed countries. Poster sessions provided an opportunity to focus on specific problems and projects in basic space science.

9. The session of the Workshop focused on (a) virtual observatories and automated networks: how to use them, (b) great eyes of astronomy: pathways to evolution, (c) World Space Observatory, (d) major statistical studies as observatories and use of data from different observatories to study particular regions of the sky, (e) astronomical telescope facilities, (f) astrophysical applications of concepts from non-extensive statistical mechanics and the Sun and (g) planetology and solar terrestrial interactions. Working group sessions were held on (a) education programmes in astronomy and astrophysics, including the education curricula of the regional centres for space science and technology education (affiliated to the United Nations) (see A/AC.105/782, A/AC.105/L.238, A/AC.105/L.239, A/AC.105/L.240 and A/AC.105/L.241), (b) the World Space Observatory, and (c) new horizons in solar physics.

C. Attendance

10. Researchers and educators from developing and developed countries from all economic regions, in particular from Latin America and the Caribbean, were invited by the United Nations and ESA to participate in the Workshop. Participants held positions at universities, research institutions, observatories, national space agencies and international organizations and were involved in all the aspects of basic space science covered by the Workshop. Participants were selected on the basis of their scientific background and their experience with programmes and projects in which basic space science played a leading role.

11. Funds provided by the United Nations, ESA and CONAE were used to cover the travel, living and other costs of participants from developing countries. A total of 75 specialists in basic space science attended the Workshop.

12. The following 24 Member States were represented at the Workshop: Argentina, Austria, Bolivia, Brazil, Canada, Chile, China, Colombia, Cuba, Germany, Honduras, Indonesia, Japan, Luxembourg, Mexico, Paraguay, Peru, Saudi Arabia, South Africa, Spain, Trinidad and Tobago, United Kingdom of Great Britain and Northern Ireland, Uruguay and United States.

II. Observations and recommendations

13. The participants of the Workshop:

(a) Recommended that the cooperation opportunities within a geographical region be reinforced and publicized through a web site for wider reach. The previous efforts made by the United Nations Office for Outer Space Affairs of the Secretariat to publicize such opportunities were commended (see table in section IV). Establishing basic space science coordination through a web site was considered likely to be effective;

(b) Welcomed the offer of the University of Sonora of Mexico to host and maintain such a web site through the Carl Sagan Observatory. The regional institutes that offered or were interested in the further development of regional collaboration in basic space science were invited to supply information for the web site, which would be located at http://cosmos.astro.uson.mx;

(c) Reiterated recommendations from previous workshops that the education of teachers, public outreach and the education of the general public formed an important part of the social structure support needed to continue the accelerated and sustainable development required for participation in basic space science;

(d) Recognized the importance of travelling planetariums, made possible through cost-reduction and the newly available technology for manufacturing, as a means of bringing basic space science to schools and educators in otherwise inaccessible areas in order to promote awareness of basic space science;

(e) Currently, developing countries were not participating in and contributing to the development of virtual observatories because access to electronic data channels, through the Internet, was limited. However, the availability of virtual observatories in the future would be a strong incentive for the advanced development of basic space science in developing countries. Virtual observatories were recognized as important tools for accelerated and sustainable development in basic space science and would stimulate the collaboration of scientists across the industrialization barrier (see http://archive.esa.org/avo);

(f) Reiterated that the electronic communications bandwidth required for active participation in basic space science represented an important stimulus for scientific collaboration, but at the same time was an important tool for the general socio-economic development of developing countries. That would provide strong support to building the capacities to participate in the "communications society";

(g) Recognized the importance of the Astrophysics Data System (ADS) for the development of basic space science in developing countries (the web site of ADS is at http://adswww.harvard.edu/);

(h) Recommended the continuation of an e-mail-driven access to ADS, which currently enabled, even in the absence of the bandwidth for interactive access, scientists in developing countries also to benefit from ADS services, which had proved to be of great value to scientists in all countries;

(i) Noted that the currently available archives of processed data from the major space agencies and astronomical observatories had already contributed significantly to the enhanced participation of scientists from developing countries in front-line basic space science and had stimulated collaboration in a very meaningful way;

(j) Commended the World Space Observatory Implementation Committee for its efforts and progress in the implementation of the World Space Observatory/Ultraviolet (WSO/UV) project;

(k) Considered the defined science operations structure of the WSO/UV project to be a very valuable support to increase the role of basic space science in sustainable development. The coordination associated with WSO/UV in developing countries in different areas of science and technology provided a strong stimulus for higher education and would generate enhanced awareness in developing countries of the importance of basic space science. It would allow equitable partnerships in resource-sharing among scientists of all countries (the web site of the project is at http://wso.vilspa.esa.es);

(l) Recognized and recommended further expansion of the following coordinated regional activities in basic space science for the application of important scientific advances with small telescopes:

(i) The Latin American Astrometry Network Programme (Astrometria de Latino-América) (the Network web site is at http://www.astro.iag.usp.br/~adelabr/);

(ii) The coordination of observation and monitoring of near-Earth objects and small bodies in the solar system by the South American Spaceguard Foundation using small telescopes;

(iii) The establishment of small astronomical telescope facilities in developing countries would contribute to the development of space science and technology. It would also stimulate the exchange of ideas and transfer of expertise between developing and developed countries in the field of space science and technology; and

(iv) The Global Positioning System (GPS) Environmental and Earth Science Information System (http://www-genesis.jpl.nasa.gov/html/index.html);

(m) Recognized that the upgrading and incorporation of new radio telescopes, such as the Sicaya Antenna, in the global Very Long Baseline Interferometry Network of radio telescopes could be important and would enable collaboration in technology and basic space science to develop. Employing a regional approach would also stimulate basic space science in individual countries;

(n) Noted with satisfaction the many results in basic space science presented, where a full equal intellectual partnership in the work between developing and developed countries had become a reality;

(o) Recognized the importance of enabling small developing countries to participate early in the implementation of the WSO/UV project and stimulating regional or other bilateral collaborations that offered unique opportunities in basic space science;

(p) Recognized and commended the countries involved in the successful collaboration of the Pierre Auger project for making an important contribution to basic space science. The project stimulated technological and scientific collaboration between developing countries and their industrialized partner countries. The first results had clearly shown the great importance of collaboration efforts of that type (the project web site is at http://www.auger.org.ar);

(q) Recognized that the efforts of the Office for Outer Space Affairs in implementing the basic space science tripod (that is, the three elements for the development of basic space science: astronomical telescopes donated by the National Astronomical Observatory of Japan to institutions in developing countries, Hands-on Astrophysics research and education material from the American Association of Variable Star Observers, and the Astrophysics for University Physics Courses teaching material from the University of Maryland in the United States) continued to give valuable support to basic space scientists in developing countries;

(r) Noted with appreciation the following scientific results and educational impact associated with the basic space science workshop series:

(i) The first Master's degree granted at the Observatorio Astronómico Centro Americano de Suyapa de la Universidad Nacional Autónoma de Honduras;

(ii) The light curves and results presented from the small astronomical telescope located at the Universidad Nacional de Asunción in Paraguay;

(iii) The asteroid discoveries and comet recoveries made at the Observatorio Astronómico Los Molinos in Uruguay;

(iv) The light curves and period variation of V645 Her observed at the Universidad Nacional Mayor de San Marcos in Peru.

(s) Recognized the importance of creating awareness of historical photographic data that, although of low resolution, were unique and irreplaceable through the digitalization of such data, especially the digitalization of the "Carte du

Ciel", which would preserve those unique data and enhance access to them by the world scientific community;

(t) Recognized the importance of the concurrent design facilities of the major space agencies to be used in support of and in collaboration with developing countries in their effort to participate in the early stages of space mission development;

(u) Recognized the value of the regional centres for space science and technology education affiliated to the United Nations and recommended establishing more of those regional centres in regions that did not yet have them;

(v) Recognized the importance and value of the Committee on Space Research (COSPAR) education workshops on basic space science for educational development at professional level in developing countries. The incorporation of those workshops in the support activities of the International Council of Scientific Unions was considered evidence of the recognition of the value of basic space science for developing countries and the importance of the efforts of COSPAR in that area.

III. Summary of presentations

A. Access to the historical and current astronomical literature through the Astrophysics Data System of the National Aeronautics and Space Administration of the United States of America

14. The Astrophysics Data System (ADS) was the search system of choice for astronomers worldwide. The searchable database contained over 2.5 million records. In addition, ADS has over 2 million scanned article pages from about 270,000 articles, dating back as far as 1829. There were currently more than 10,000 regular users. ADS users issued almost 1 million queries per month and received 30 million records and 1.2 million scanned article pages per month. ADS was accessed from almost 100 countries with a wide range in number of queries per country. Approximately one third of the use was from the United States, one third from Europe, and one third from other regions of the world. In order to improve access from different parts of the world, ADS maintained nine mirror sites in Brazil, Chile, China, France, Germany, India, Japan, the Russian Federation and the United Kingdom. Automatic procedures facilitated the updating of the mirror sites over the network. Both the search system and the scanned articles in ADS could be accessed by e-mail. E-mail could be used by users that were on slow or unreliable Internet connections. It allowed access to ADS for people who did not have a connection that was good enough to use an Internet browser. ADS was currently in the process of developing a stand-alone ADS system that could be updated through digital videodiscs (DVDs). That would provide access to the capabilities of ADS from sites that did not have any Internet access at all. The current capacity of hard disk drives was now sufficiently large to store a complete ADS system on one large DVD.

B. Scientific impact of the Hubble Space Telescope

15. The Hubble Space Telescope was the flagship of a growing fleet of modern space-borne astronomical telescopes. The unique power of the Hubble Telescope derived from its combination of extremely sharp images, covering relatively wide angular fields in the sky, with a deep dynamic range, low background noise and sensitivity to wavelengths from the vacuum ultraviolet to the near-infrared. Its greatest achievement was the facility with which it had converted so many prior hypotheses into objectively demonstrated truth. However, beyond that, it had provided a detailed view of the unimagined complexity and diversity of the universe, as well as its startling beauty. It had yielded numerous surprises and raised new questions. With each new instrument inserted by astronauts on servicing missions, the Hubble Telescope grew in capability by a factor of 10. Its main scientific accomplishments to date and the main expectations for its second decade of discoveries were presented.

C. Current status of the Pierre Auger cosmic ray project in Argentina

16. The Pierre Auger project aimed at building two observatories, located in both the northern and southern hemispheres, in order to study ultra-high energy cosmic rays. The construction of the austral observatory started in 2000. Prior to that, in 1995, an international collaboration had been formed encompassing 200 scientists and technicians from institutions in 16 countries. The Pierre Auger project was a basic space science enterprise that studied the highest energies known in nature (10^{20} eV), which were cosmic rays coming from outer space and arriving at the Earth's surface at a very reduced flow. That was the reason for constructing a giant observatory spanning an area of 3,000 km^2 in the area of Malargüe and San Rafael, in the Province of Mendoza, Argentina. The other distinctive feature, besides the exceptional size of the observatory, was its hybrid nature: it was constituted by 24 fluorescence detector telescopes and 1,600 surface detectors. It would provide a large number of events with less systematic detection uncertainties. The construction of the observatory was well advanced and the buildings at the Central Station in Malargüe city were already operational. So were the telescope buildings at Cerros Los Leones and Coihueco in Argentina, two telescopes, 32 surface detectors and the telecommunications and data acquisition systems. From a scientific point of view, the most important achievement was the first detection of a hybrid event (a cosmic ray detected by both telescope and the surface detectors) in January 2002. It confirmed that the equipment operated within the design parameters. Twenty hybrid events per month have been detected within energies typically below 10^{19} eV.

D. Cosmic ray muon observation at the Southern Space Observatory in Brazil

17. Under an agreement on scientific cooperation between Brazil and Japan, since March 2001 a prototype detector of cosmic ray muons had been operating at the Southern Space Observatory, located at São Martinho da Serra, Brazil (29°S, 53°W), in order to observe cosmic ray precursors of geomagnetic storms. That detector

played a key role in the prototype network of muon observations, together with two larger detectors operating in Australia and Japan. The planned extension of the detector would complete the global coverage of Brazil's muon detector network. The prototype network had already discovered the cosmic ray precursors of several magnetic storms. The Southern Space Observatory had also observed Forbush Decreases, as well as the precursory enhancements of cosmic ray anisotropy preceding the onset of geomagnetic storms. The description of the network and some results obtained since the prototype detector implementation were reported.

E. Accessing Astronomical Archives as Virtual Telescopes: from archival research to the astrophysical virtual observatory

18. Given the high cost of modern astronomical observing facilities, it was evident that efforts had to be made to exploit data optimally in order to maximize the return on investment. That concept was first implemented on a large scale for the Hubble Space Telescope and had since been taken up for other space-borne and large ground-based facilities. The European Hubble Space Telescope Science Data Archive was located at the European Southern Observatory (ESO). It had been extended to include data from ESO telescopes and instruments, especially the Very Large Telescope and Wide Field Imager. It was thus natural to design the archive such that queries could be extended across its full content, regardless of the origin of the data. That constituted a first step towards a virtual observatory. The Accessing Astronomical Archives as Virtual Telescopes (ASTROVIRTEL) programme, first established in the period 1999-2000 with funding provided by the European Commission, made it possible for scientists to use that facility for their investigations. At the same time, it allowed the establishment of science requirements for archive cross-queries, and the definition of capabilities required for virtual observatories. Recently, the European Commission had decided to provide funding for the implementation of the Astrophysical Virtual Observatory. That would include several European observatories and scientific organizations. It was being developed in close coordination with the United States National Virtual Observatory.

F. Astrometry with virtual observatories

19. With the advent of the virtual observatories, most astrometry-oriented projects currently under development and those to come in the near future would be enriched. Among those projects were double stars and multiple systems, proper motion detection, identification of lost high proper-motion stars, a detailed census of open cluster members and recovery of natural satellites, minor planets and comets. To achieve the goals proposed by the concept of virtual observatories, a massive amount of high-quality astrometric data was needed in advance. It had been shown that today's astrometry was ready to face those new challenges.

G. Archives, databases and the emerging virtual observatories

20. Historically, the existence of any newly discovered object needed to be confirmed by optical observations. Catalogues such as the Parkes Catalogue of

Radio Sources were published, complete with stamp-sized photographs that enabled readers to see what had just been found. That remained the case, although fewer catalogues were now published than in the past. An information overload, with more efficient instruments, larger detectors, multiple wavelength coverage and an increasing number of ground-based and space-based facilities had been reached. Information technology was catching up, however, enabling data to be used regardless of their location. An increasing need for multi-wavelength observations to understand the underlying physics of the observed phenomena, coupled with the availability of formal and informal data archives and the realization that petabyte databases presented a particular challenge in terms of mining valuable data, was leading to a move to set standards and cooperation among computer scientists and astronomers to create the infrastructure that would lead to a virtual observatory, a cyberspace location where the data were ready to be analysed. In the United States, the National Science Foundation and NASA were funding initiatives that would lead to the creation of that entity.

H. Coordination of near-Earth object observers in South America

21. The search for near-Earth objects was currently concentrated on the northern hemisphere. None of the six existing survey programmes could reach declinations below -30^{o}. Nevertheless, two small surveys were about to start in the near future in the southern hemisphere: an extension of the Catalina Sky Survey using the Uppsala Schmidt telescope in Siding Spring, Australia, and the Búsqueda Uruguaya de Supernovas, Cometas y Asteroides project in Uruguay (the BUSCA web site is at http://www.fisoca.edu.uy/oalm/busca.html). Many of the near-Earth objects discovered by the northern surveys could reach the southern sky, with declinations unreachable for a northern observer. Furthermore, the recovery of an asteroid in subsequent oppositions could come indistinctly in the northern and southern sky. A network of well-equipped observers in the southern region was therefore essential to any campaign to catalogue the near-Earth object population. The Planetary Society, through its near-Earth object grant system, had therefore already supported many observers in the southern hemisphere. The planetary science community in South America had grown considerably in the previous 10 years. It had well-known research groups in Argentina, Brazil and Uruguay. Those groups had established many scientific links by exchanging graduate students and organizing joint meetings. In particular, they had already held two workshops in planetary science in South America (at La Plata, Argentina in 1999 and at Montevideo in 2000), each attracting over 25 participants. Recently, in February 2002, they had organized a workshop of near-Earth object observers in Montevideo, with the participation of more than 20 professional and amateur observers from the following countries: Argentina (the Observatorio Astronómico Felix Aguilar-Yale Southern Observatory in San Juan and the Centro Regional de Investigaciones Científicas y Tecnológicas in Mendoza); Brazil (the Observatorio Abraes de Moraes in San Pablo, the Observatorio Wykrota Belo Horizonte and the Observatorio Nacional in Rio de Janeiro); Paraguay (the Observatorio Nacional de Asunción and Sociedad de Estudios Astronómicos at Asunción); and Uruguay (the Departamento de Astronomía of the Facultad de Ciencias, the Observatorio Astronómico Los Molinos and the Observatorio Kappa Crucis in Montevideo). The Workshop established (a) the South American Spaceguard Association to provide a framework for the

coordination of activities, (b) a web site to exchange information about observing plans, objects in need of follow-up only reachable by southern observers, software exchanges, and so forth, and (c) support for the efforts of the astronomers of the Córdoba and La Plata observatories in cataloguing the archive plates, useful for pre-discovery images. The members of the group owned or had access to more than a dozen telescopes up to 60 cm in size. They had already created a discussion forum at http://spaceguard-sa@fisica.edu.uy to promote coordination efforts.

I. Survey in Uruguay of near-Earth objects in the southern hemisphere

22. The search for near-Earth objects had concentrated to date on the northern hemisphere. Six dedicated near-Earth object survey programmes were already in place: five were located in the United States (four in the south-western part of the country and one in Hawaii), and one was located in Japan. Since none of those surveys reached most of the southern sky, more than 25 per cent of the celestial sphere was not covered by any project. The Comisión Nacional de Investigación Ciencia y Tecnología of Uruguay funded a small project to install a telescope to search for near-Earth objects at the Observatorio Astronómico Los Molinos. The financial resources had been used to acquire a 46 cm (f/2.8) telescope (Centurion 18 inch manufactured by Astro Works). With further support from the Universidad de Uruguay, the Minister of Education and Culture and the Planetary Society, a charge-coupled device (CCD), a personal computer and the control software had been acquired. The telescope would be located in a dark area of the countryside, 200 km from Montevideo and support for the buildings had been given by the government of the Province of Maldonado. The construction would start in May 2003. In the meantime, the telescope had been installed at the site of the Observatorio Astronómico Los Molinos, where software and hardware were being tested by starting survey observations. An asteroid (K02H09A) had already been discovered in that testing phase. The telescope would be fully controlled from the Observatory in Montevideo through the Internet. All the operations would be performed remotely. Follow-up observations of the discovered objects would be carried out from other telescopes of the Observatory, as well as through collaboration with astronomers of the South American Spaceguard Association, with telescopes in Argentina, Brazil, Paraguay and Uruguay.

J. Charge-coupled device photometry of the KZ Hya Star using the 45-centimetre telescope in Paraguay

23. An SX Phe-type pulsating variable KZ Hya Star (HD94033) was observed with the CCD camera set attached to the 45-cm reflector telescope at Asunción Astronomical Observatory in Paraguay. A total of 10 light maximum phases were covered. A new ephemeris had been obtained and the result suggested a probable change in the pulsation period of KZ Hya.

K. Activities using the 45-centimetre reflector telescope at Bosscha Observatory in Indonesia

24. In 1989, a 45-cm Cassegrain-type telescope had been installed, tested and commissioned at the Bosscha Observatory of the Institut Teknologi Bandung in Indonesia. It had been put into use for ultraviolet, blue, visible photometric observations of close binary systems. While the main function of the telescope was the making of photometric observations, the versatile design inherent to a reflector telescope made it possible to include a spectrograph in which spectral dispersion could match the Morgan Keenan spectral classification. The activities related both to education and research conducted using the reflector telescope since its installation were scientific activities (photometry, spectroscopy, imagery) and experiment in instrumentation activities (fibre-fed spectrograph, CCD camera in-situ testing). An important by-product of the photometric observations was an atmospheric study based on long-term atmospheric extinction coefficients. A multidisciplinary approach, involving meteorologists and mathematicians, to the study of natural and antrophogenic pollution of the atmosphere over Lembang had recently been undertaken. Currently, however, the telescope suffered from obsolete technology in its control functions. That had hampered its full utilization and therefore a plan to upgrade and extend its capability had been made. The future development of the telescope and its auxiliary instruments was discussed.

L. Observing at the Central American Astronomical Observatory of Suyapa, Honduras

25. In June 1997, within the framework of the Seventh United Nations/European Space Agency Workshop on Basic Space Science, held in Tegucigalpa, Honduras, the Central American Suyapa Astronomical Observatory was inaugurated, with the dedication of the René Sagastume Castillo telescope, a 42-centimetre Schmidt-Cassegrain Meade LX200 telescope located at latitude 14°05’ N, longitude 87°09’ W, and an altitude of 1,077 m above sea level, for the Central American countries (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama). The achievements that had been made using that facility as part of academic activities for outreach, training and research projects in observational astronomy with international cooperation were reported.

M. Current status of the Carl Sagan Observatory in Mexico

26. The current status of the Carl Sagan Observatory of the University of Sonora was presented. The project, which had been launched in 1996, focused on building a small solar-stellar observatory, operated by remote control. The Observatory was located at Cerro Azul, a 2,480-metre peak in one of the best regions in the world for astronomical observation, in the Sonora desert in Arizona. The Observatory was equipped with three 16-centimetre solar telescopes and a 55-centimetre stellar telescope. In addition to its scientific goals of studying solar coronal holes and type 1a Supernovae, the Observatory has a strong educative and cultural programme in astronomy at all levels. At the end of 2001, the Observatory launched a programme called Constelación to build small planetariums. Also, in July 2002, the

webcast system for transmission of the solar observations from the prototype Observatory at the campus had been expanded to webcast educational programmes on astronomy, including courses for the Latin American public.

N. Chromospheric models in solar-type stars

27. Areas of concentrated magnetic field on the Sun emitted Ca II H (396.8 nm) and K (393.4 nm) radiation more intensely than the non-magnetic background. The intensity of that emission increased in response to the amount of non-thermal heating of the chromosphere. By analogy with the Sun, it was reasonable to assume that Ca II emission in late-type stellar atmospheres that had physical properties and overall structure similar to the Sun's atmosphere would also be associated with magnetic structures. A widely used indicator of chromospheric activity, the S index, was produced using the fluxes in those two lines. To date, surveys of Ca II emission in the solar neighbourhood seemed to reveal a bimodal distribution in which most stars had weak chromospheric emission, as does the sun; some active ones had high levels of emission and only a few had intermediate levels. That gap in chromospheric emission, called the Vaughan-Preston gap, existed for stars in the range $0.45 < B\text{-}V < 1$. Different chromospheric models for stars with the same B-V as the Sun (B-V = 0.65) had been computed to investigate whether the Vaughan-Preston gap was due to the response of the Ca II lines to different changes in the chromospheric temperature with height.

O. Energetic phenomena on the Sun

28. Although impulsive phenomena were commonplace in the universe, solar flares were unique in astrophysical research because they provided the largest diversity of observational data, which meant diagnostic information available to the observer. Solar flares were truly unique, insofar as they provided the vantage point of seeing the development of impulsive phenomena with high temporal, as well as spatial, resolution. The most intriguing aspect of impulsive phase physics resided in the mechanism that led to the release of, say, 10^{30} erg in 10^{2} s. That was equivalent to the annihilation of a 100 Gauss field over a $(3 \times 10^{8}\ \text{cm})^{3}$ cube in such a time interval. It was demonstrated how images and spectra with an unprecedented combination of spatial, temporal and spectral resolution (2 arcseconds to 300 keV, tens of milliseconds and less than 1 keV resolution (full- with half-maximum) that were being provided by the High Energy Solar Spectroscopic Imager mission, could be used to gain new insights into the physical processes associated with those phenomena.

P. Magnetic helicity budget of regions of solar activity

29. Magnetic helicity was one of the few solar physical magnitudes that was conserved even in non-ideal magnetohydrodynamics on time scales shorter than the global diffusion time. Magnetic helicity was generated in the solar interior and buoyant flux tubes transported it through the convective zone and injected it into the solar corona, where photospheric large-scale (differential rotation) and small-scale motions also contributed. Increasing observational evidence indicated that magnetic

helicity of a given dominant sign was injected in each solar hemisphere and that that sign did not change during the solar cycle. That being so, magnetic helicity would accumulate incessantly unless the Sun found a way the eliminate it. Coronal mass ejections (CMEs) were the phenomena through which magnetic helicity could be ejected from the Sun into the interplanetary medium. Twisted magnetic plasma structures, of which magnetic clouds were a subset, were frequently observed in the near-Earth environment. Based on observations and modelling of two well-studied CME productive active regions, the relative importance of the different sources of coronal magnetic helicity in those active regions had been evaluated. The helicity ejected in CMEs associating every one of them to an interplanetary magnetic cloud had been computed. For that computation, observational averaged values for the cloud parameters, together with standard cloud models had been used. It was found that the ejected magnetic helicity could only come from the twist (subphotospheric origin) inherent to the flux tube forming the active region. That kind of study aimed at characterizing the CME ejection mechanism and improving the ability to forecast CMEs.

Q. New ionosphere monitoring technology based on global positioning satellite observations

30. Several dual-frequency GPS receivers on board low-Earth orbit satellites such as the German Challenging Minisatellite Payload and the Argentine scientific applications satellite (SAC-C) were tracking the radio signals broadcast by 28 high-orbiting GPS satellites. In order to reach a receiver located on the Earth's surface or at a low height, the GPS signals had to travel through the ionosphere where they were subject to refraction by the ionosphere and troposphere. When the ultimate use was precise positioning, such refraction was considered a source of error that had to be removed with the appropriate mathematical treatment. From a complementary point of view, that refraction could be considered useful information gathered when travelling through the atmosphere. In that scenario, the GPS receiver was seen as a remote sensor that provided information from which parameters that described the conditions in the ionosphere and troposphere could be obtained. Therefore scientists could derive a surprising amount of information, including three-dimensional images of the Earth's ionosphere, a turbulent and mysterious shroud of charged particles that, when stimulated by solar flares, could disrupt communications around the world. The technology's biggest advantage could well be its low cost. GPS receivers, comparable in size and complexity to a notebook computer, could be built for a fraction of the cost of traditional space-borne sensors and placed unobtrusively on many low-orbiting spacecraft. Since most Earth satellites already carried such devices for timing and navigation, upgrading those instruments for science purposes might possibly ignite a revolution in Earth-observation remote-sensing. A single GPS receiver in low orbit could acquire more than 500 soundings a day, spread uniformly across the globe. That contribution offered some early analysis of three-dimensional global ionospheric maps derived using data collected by Earth- and space-based dual-frequency GPS receivers.

R. Non-extensive statistical mechanics and thermodynamics

31. A great variety of complex phenomena in diverse fields such as astronomy, physics, ecology and economics exhibited power-law behaviour, which reflected some kind of hierarchical or fractal structure. Such laws were of great interest to students of plectics, the study of simplicity and complexity. Many of the phenomena involved seemed to be amenable to description using approaches resembling those employed in statistical mechanics and thermodynamics. The research communities of Argentina and Brazil were spearheading those new developments in fundamental science (the web site on this topic is available at http://tsallis.cat.cbpf.br/biblio.htm).

S. World Space Observatory: status report

32. The World Space Observatory (WSO) was an unconventional space project proceeding via distributed studies. Some of the aspects of initiating the concept for WSO had been described at the Eighth United Nations/European Space Agency Workshop on Basic Space Science. The idea of a WSO has also been introduced in the UNISPACE III report (A/CONF.184/6, para. 207). Under the auspices of the World Space Observatory Implementation Committee, considerable progress had been made in the planning and preparatory work to make WSO, in the shape of WSO for the Ultraviolet (WSO/UV), a reality. The present design, verified for feasibility and currently under Phase A study, consisted of a 1.7-metre telescope operating near the second Lagrangian point of the Earth-Sun system. The focal plane assembly consisted of three ultraviolet spectrometers covering the spectral band from Lyman-alpha to the atmospheric cut-off with R~55,000 and offering long-slit capability over the same band with R~1,000. In addition, a number of ultraviolet cameras and one optical imager viewed fields adjacent to that sampled by the spectrometers. The performance of the imagers compared well with that of the Hubble Telescope Advanced Camera for Surveys and the spectral capabilities of WSO exceeded those of the Hubble Telescope Cosmic Origins Spectrograph. WSO/UV, as currently conceived, would be constructed and operated with a distributed philosophy, which would allow many groups and countries to participate, each contributing as much as possible, but allowing multinational participation. Although designed originally with a conservative approach, WSO embodied some innovative ideas and would allow a world-class mission to be carried out on a moderate budget. The importance of such a mission, which could coordinate with observing capabilities at other wavelengths (especially the X-ray domain) was highlighted, both in the context of the astrophysical aspects, as well as with a view to the participation of the developing countries. The current state of support, interest and plans for further development for implementation and launch by 2007 were discussed.

IV. Regional distribution of requests for information on the results of United Nations/European Space Agency workshops on basic space science in 2002

33. The table below contains information available in the database of the Office for Outer Space Affairs on the regional distribution of requests for information on the results of the United Nations/European Space Agency workshops on basic space science in 2002. It is an updated and revised version of the table in document A/AC.105/766. The addresses used to distribute the information, by post and e-mail, to the requesting individuals in their respective countries were also provided to national and international astronomical organizations for the dissemination of scientific information.

Notes

[1] See *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. I, resolution 1, para. 1 (e) (ii), and chap. II, para. 409 (d) (i).

[2] *Official Records of the General Assembly, Fifty-sixth Session, Supplement No. 20* and corrigendum (A/56/20 and Corr.1), para. 74.

Distribution of requests for information on the results of the United Nations/European Space Agency workshops on basic space science, by region, 2002

Region										
Africa		*Asia*		*Eastern Europe*		*Latin America and the Caribbean*		*Western Europe and others*		*World total*
Algeria	28	Bahrain	2	Bulgaria	2	Argentina	51	Australia	5	
Angola	1	Brunei Darussalam	1	Croatia	1	Bolivia	3	Austria	9	
Botswana	3	China	13	Czech Republic	7	Brazil	6	Belgium	8	
Burkina Faso	1	Taiwan Province of China	3	Hungary	4	Chile	6	Canada	17	
Burundi	2			Lithuania	2	Costa Rica	7	Denmark	5	
Cameroon	6	India	44	Poland	5	Cuba	5	Finland	1	
Central African Republic	1	Indonesia	9	Romania	4	Ecuador	2	France	57	
Côte d'Ivoire	3	Iran (Islamic Republic of)	2	Russian Federation	20	El Salvador	5	Germany	66	
Democratic Republic of the Congo	2	Iraq	3	Slovakia	1	Guatemala	3	Greece	5	
Egypt	49	Japan	16	The former Yugoslav Republic of Macedonia	1	Honduras	22	Ireland	1	
Eritrea	1	Jordan	17	Ukraine	2	Mexico	15	Israel	8	
Ethiopia	5	Kazakhstan	3			Nicaragua	4	Italy	25	
Gabon	1	Kuwait	11			Panama	3	Malta	1	
Ghana	10	Lebanon	7			Paraguay	3	Netherlands	9	
Guinea	4	Malaysia	3			Peru	4	New Zealand	1	
Kenya	12	Mongolia	5			Uruguay	8	Norway	2	
Liberia	1	Oman	4			Venezuela	2	Portugal	2	
Libyan Arab Jamahiriya	14	Pakistan	7					Spain	20	
		Papua New Guinea	3					Sweden	3	
Madagascar	4	Philippines	4					Switzerland	17	
Malawi	4	Qatar	4					Trinidad and Tobago	1	
Mauritania	3	Republic of Korea	2					Turkey	8	
Mauritius	26	Saudi Arabia	1					United Kingdom of Great Britain and Northern Ireland	34	
Morocco	25	Singapore	1					United States of America	159	
Mozambique	5	Sri Lanka	7							
Namibia	4	Syrian Arab Republic	5							

Region										World total
Africa		*Asia*		*Eastern Europe*		*Latin America and the Caribbean*		*Western Europe and others*		
Niger	1	Tajikistan	1							
Nigeria	79	Thailand	5							
Rwanda	1	United Arab Emirates	5							
Senegal	2	Uzbekistan	1							
Sierra Leone	2	Viet Nam	4							
South Africa	112	Yemen	5							
Sudan	6									
Swaziland	2									
Togo	1									
Tunisia	10									
Uganda	3									
United Republic of Tanzania	5									
Zambia	10									
Zimbabwe	12									
Total requesting	460		198		49		149		464	1 320

Note: Requests from a total of 122 countries and areas were received and processed.