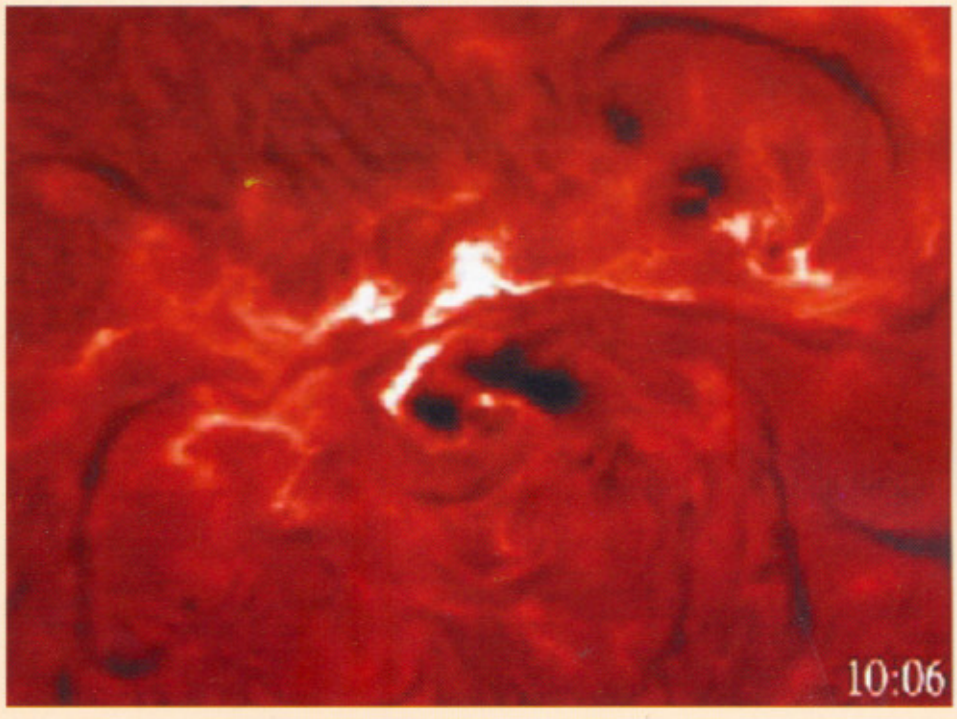
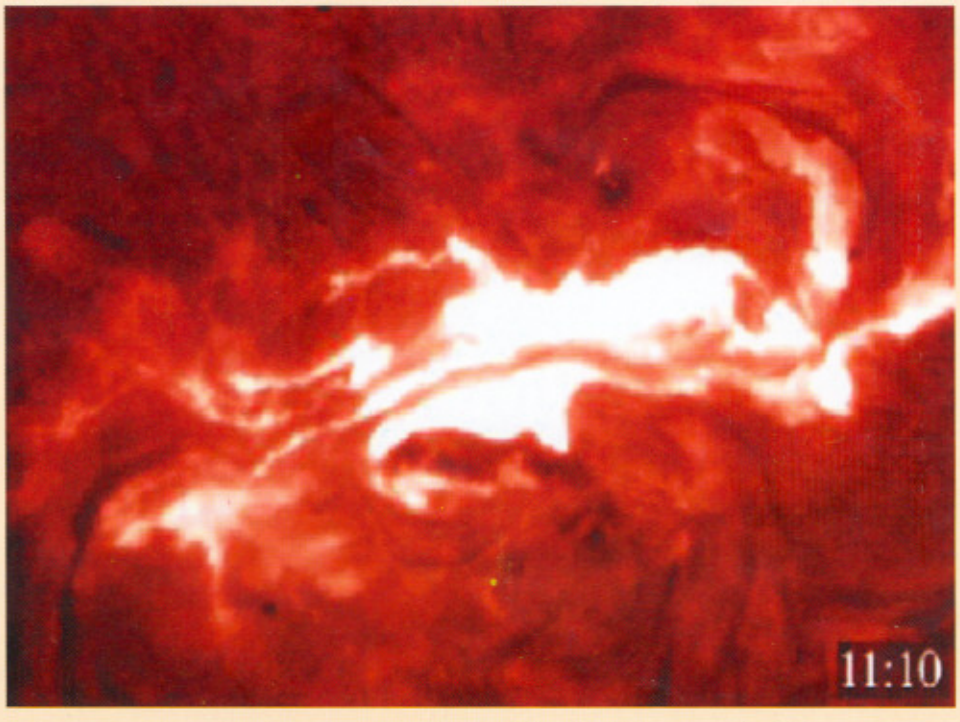
April-June 2004

SPACE india

इसरो ISRO INDIAN SPACE RESEARCH ORGANISATION





Maximum phase of a flare that was observed by the Udaipur Solar Observatory on 28 OCT 2003 around 11:10 UT. On this day of unusual sunspot activity, the above two pictures show the development of the bright flare ribbons *(see article on page 13).*

Cover Page:
Logo of India-United States Conference

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Editorial / Circulation Office
Publications & Public Relations Unit, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bangalore - 560 094, India. www.isro.org *Printed at: SN Process Pvt Ltd, Bangalore-560030.*

India-United States Conference on Space Science, Applications and Commerce
-Strengthening and Expanding Cooperation

Organised by: Astronautical Society of India and American Institute of Aeronautics and Astronautics

JUNE 21-25, 2004, BANGALORE, INDIA

India-United States Conference on Space Science, Applications and Commerce

Held at Bangalore

The India-United States Conference on Space Science, Applications and Commerce jointly organised by the Astronautical Society of India (ASI) and the American Institute of Aeronautics and Astronautics (AIAA) was held at Bangalore during June 21-25, 2004. The Indian Space Research Organisation (ISRO), the Indo-US Science and Technology Forum and the US Department of State in co-operation with the US Department of Commerce, the National Aeronautics and Space Administration (NASA) and the US National Oceanic and Atmospheric Administration (NOAA) sponsored the Conference. The main objective of the conference was to strengthen and expand the cooperation between India and the US in the field of space science and applications as well as the related commercial activity.

The Prime Minister of India, Dr Man Mohan Singh, in his message, hoped that the conference would help in identifying and generating an awareness of market opportunities and contribute to building confidence between the two countries for cooperation in a way that reflects their transforming relationship and common interests. In his message, the US President Mr George W Bush Jr urged the space scientists from India and the United States to identify new areas of cooperation in the civil space programme and inspire the next generation to explore the universe. Inaugurating the conference, Mr Prithviraj Chavan, Minister of State in the Prime Minister's Office, said that India and the US can collaborate on technical, policy and business issues to build a stronger future in the area of space. In his address, Mr G Madhavan Nair, Chairman, ISRO, recalled the Indo-US co-operation in space from a historic perspective, and, in the context of India's present capabilities in space, stressed the need for the delegates of both the countries to identify areas of common interest.

Dr David C Mulford, US Ambassador to India, Mr Kenneth I Juster, Under Secretary, US Commerce Department and Dr Frederick D Gregory, Associate Administrator of NASA were amongst the senior officials from the US who participated in the inaugural function.

One of the highlights of the India-US Conference was the address by the President of India, Dr A P J Abdul Kalam, who is himself an accomplished space scientist. He delivered his lecture titled "Dynamics of Indo-US space co-operation" to the delegates before the closing plenary through a satellite bridge established with Delhi. Dr Abdul Kalam nostalgically recalled the first sounding rocket launch from India in November 1963 and unveiled his vision of future space exploration. He felt that both India and the US have acquired enriching experience in furthering space technology for benefiting the society. He underlined

the need for reducing the cost of access to space and felt that cost reduction strategies require a global effort.

Dr Kalam suggested a five-point space mission – i) finding ways to bring down the cost of launch; ii) use of nano-technology, Indo-US partnership in the areas of Solar Powered Satellites (SPS); iii) exploration of the asteroids, mining on the moon and the establishment of first habitats on Mars; iv) earthquake prediction; and v) dissemination of the benefits of space research to the entire humanity. At the end of his lecture, the President interacted with the delegates over the satellite bridge.

The idea of holding the Bangalore Conference emerged when the Prime Minister of India and the President of the United States issued a Joint Statement in November 2001 that both sides would discuss ways to stimulate bilateral high technology commerce and civil space cooperation. In October 2002, ISRO and the US State Department held initial discussions on possible methods of strengthening cooperation in these two areas. With the encouragement of other government agencies in India as well as the US and with extensive support from industry, professional societies such as ASI in India and AIAA in the US and organisations such as the Indo-US Science and Technology Forum, both countries decided to hold a high level conference in India that could act as a catalyst for strengthening cooperation. The main objective was to bring together US and Indian space scientists, policy makers and private entrepreneurs to explore cooperative programmes and business opportunities. The American Institute of Aeronautics and Astronautics (AIAA) and the Astronautical Society of India (ASI) were chosen to organise the conference. To ensure strong participation from industry in both the countries, industry level discussions were also held between India's Antrix Corporation and US-India Business Council along with the participation of the Confederation of Indian industries.

Indo-US Cooperation in Space

The Indo-US cooperation in the area of space dates to the start of Indian space

Mr Prithviraj Chavan, Minister of State in the Prime Minister s Office inaugurates the Conference as Dr David C Mulford (to his left), Ambassador of the US to India, Mr. Kenneth I Juster, Under Secretary, US Commerce Department (to his right) and Mr G Madhavan Nair, Chairman, ISRO (extreme left), look on

Dignitaries on the dais during the inauguration. (From L to R) Dr Frederick D Gregory, Associate Administrator, NASA, Dr P S Goel, Chairman, Indian National Advisory Committee of the Conference, Mr Kenneth I Juster, Under Secretary, US Commerce Department, Mr G Madhavan Nair, Chairman, ISRO, Mr Prithviraj Chavan, Minister of State in the Prime Minister s Office, Dr David C Mulford, Ambassador of the US to India, Dr K N Shankara, Director, Space Applications Centre, Gen. John J Kelley Jr, Deputy Under Secretary of Commerce for Oceans and Atmosphere, NOAA and Mr S K Das, Additional Secretary, Department of Space, Government of India

programme. The Thumba Equatorial Rocket Launching Station (TERLS), established in the early 60s, received assistance from the US through the supply of equipment and sounding rockets for carrying out scientific experiments. The very first sounding rocket, a Nike-Apache launched from Thumba on November 21, 1963 was a US made rocket that carried instruments to conduct ionospheric experiments over the earth's magnetic equator that passes over Thumba.

India conducted the Satellite Instructional Television Experiment (SITE) in the mid 1970s for which NASA moved its Applications Technology Satellite-6 (ATS-6) over the Indian Ocean. SITE involved deployment of Direct Reception TV sets in about 2400 villages across six states of India to receive educational programmes via ATS-6, covering agriculture, family planning, health and hygiene, etc. The experiment was hailed as the world's largest sociological experiment. This played a significant role in demonstrating the application of satellites for TV-based developmental education for a large country like India.

This was followed by the establishment of the multipurpose Indian National Satellite (INSAT) system in the 80s. India procured all the four satellites under the INSAT-1 series from a US company and three of them were launched by US built vehicles. All subsequent INSAT satellites were built indigenously. Today, INSAT has become the largest domestic satellite system in the Asia Pacific region.

In the field of remote sensing, India was one of the very first to establish a reception station for receiving data from NASA's LANDSAT. This venture helped India to gain first hand experience in the reception, processing and application of space-based remote sensing data. A number of joint experiment projects in remote sensing was also undertaken using the LANDSAT data with the participation of end users. These efforts helped India decide to design and build its own operational Indian Remote Sensing satellites (IRS) and establish National Natural Resources Management System (NNRMS) for the exploitation of data from these satellites. Today, India has the world's largest constellation of remote sensing satellites to provide data

in a variety of spatial resolutions and spectral bands which is being received by several ground stations from all over the world including the USA.

In 1997, the Department of Space (DOS) and the Department of Science and Technology (DST) from India and NASA and NOAA from the US signed a Memorandum of Understanding for joint research in Earth and Atmospheric Sciences.

The Bangalore Conference

Both India and USA have a successful history of space activities and have their own strengths. There has been a number of instances of successful cooperation. This background augured well for the India-US conference at Bangalore to explore future cooperative and collaborative ventures for mutual benefit. The topics for the conference included:

- Earth Observation Science, Technology and Applications
- Satellite Communications Technology and Applications
- Satellite Navigation and Applications
- Space Science
- Natural Hazards Research and Disaster Management Support
- Space Commerce

In all, there were 148 presentations spread over 15 sessions with 70 speakers from India and about 75 from the US.

The delegates to the Bangalore Conference included:

Government – the US Embassy in India, the Department of State, Department of Commerce, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the US Department of Agriculture, the Department of Transportation, the Federal Aviation Administration, the US Agency for International Development and the National Science Foundation.

Private Industries – Boeing, Raytheon, Panamsat, Intelsat, Trimble, Honeywell, Northrop Grumman, Space Systems Loral, Worldspace, Space Imaging, Digital Globe, Orbimage, ESRI, ERDAS, Qualcomm, Overland, HP and Viasat.

Academia – University of Texas, George Mason University, California Institute of Technology, University of California, University of Wisconsin, University of Arizona, University of Cincinnati and University of Colorado.

High-level dignitaries including US Ambassador to India, Under Secretary of Commerce, Deputy Administrator of NASA, Deputy Under Secretary of NOAA

A section of the delegates and invitees during the inauguration of the Conference

and Deputy Assistant Secretary of State participated in the conference.

From India, the Minister of State in the Prime Minister's Office and high level officials from the Prime Minister's Office, the Ministry of External Affairs, Ministry of Commerce, Department of Space, Ministry of Water Resources, Ministry of Agriculture, Ministry of Rural Development, Ministry of Urban Development, Department of Bio-Technology, Department of Science & Technology, Department of Ocean Development, Department of Land Resources, Airport Authority of India, Antrix Corporation, IGNOU, Care Health Foundation, INRIMT, Speck systems, RMSI, Godrej, Bharat Electronics, Hindustan Aeronautics, National Aerospace Laboratories, Centre for the Development of Advanced Computing and various universities participated in the conference.

In all, 550 delegates including 200 from the US attended the conference.

In the opening plenary of the conference, all the speakers were unanimous in their opinion on the high potential for co-operation and commerce in the area of space between the two countries. At the same time, the need for creating a conducive environment and policies that would encourage high levels of co-operation and commercial partnerships was also felt. Mr G Madhavan Nair, Chairman, ISRO, made a comprehensive presentation on the Indian space programme and highlighted its societal and national developmental orientation. Recalling the past co-operation between India and the US, Mr Madhavan Nair envisioned a road map to emerge from the conference that would enable both nations to take concrete steps for enhanced co-operation and mutually benefiting commercial partnerships. In his address, Mr Kenneth I Juster stressed that, together, the United States and India have the potential to transform the future into a safer, more prosperous tomorrow so that both countries can harness civil space co-operation for the lasting benefit of entire humankind. Mr Sheelkant Sharma, Additional Secretary, Ministry of External Affairs, Government of India, provided a perspective of the Indo-US relationship and the steady progress made by both sides in recent times. Dr Frederick D Gregory, Associate Administrator of NASA described his experiences as an astronaut. He suggested that Indian and US scientists could join together in making President Bush's Vision for space exploration a reality. Mr Lee M Morin, Deputy Assistant Secretary, the US Department of State, expressed the hope that the two nations could expand co-operation in civilian nuclear activities, civilian space programme and high technology trade. Gen John J Kelly Jr, Deputy Under Secretary of Commerce for Oceans and Atmosphere, NOAA, emphasised that the United States and India are involved in the ongoing international effort to develop an integrated and sustained global Earth Observing System which can have far-reaching benefit for humankind.

There were three public outreach programmes during the India-US conference. In the first programme, Dr K Kasturirangan, Member of Parliament (Rajya Sabha) and former Chairman, ISRO, delivered a lecture "Indo-US Space Co-operation - A Ringside Perspective". He spoke about the past Indo-US cooperation and suggested that the future of India-US space co-operation is to be built around the ideals of the spirit of exploration; humanitarian outlook, ensuring global environmental integrity; societal upliftment and deriving economic benefits. Besides, he strongly advocated better co-operation and unified efforts to eradicate illiteracy, improve the health care and management of natural resources across the globe.

In the second public outreach programme, Dr Sandra Magnus, a NASA astronaut, Mr Jean Pierre Harrison, a NASA consultant and late Dr Kalpana Chawla's husband, delivered illustrated lectures. Mr Harrison provided a detailed account of Kalpana Chawla's life and achievements. Dr Magnus said that Dr Kalpana was a great example of an exploring personality and being an astronaut is the best opportunity

Dr P S Goel, Chairman, Indian National Advisory Committee of the Conference, thanking Dr A P J Abdul Kalam, President of India, after the President's special address to the delegates

for any explorer. The third public outreach programme featured a lecture by Prof U R Rao, Chairman, Physical Research Laboratory (PRL) Council and former Chairman, ISRO. Prof Rao felt that a new chapter has begun in Indo-US relations and called for the humanisation of globalisation to avoid the adverse effects of globalisation on developing countries. He was of the opinion that Indian capabilities in the applications of space for addressing national development perspectives could be a model for many other developing nations to adopt.

On the concluding day of the India-United States Conference, ISRO and NOAA expressed intention to explore working together on the National Polar-orbiting Operational Environmental Satellite System (NPOESS), which is the next generation US environmental satellite system.

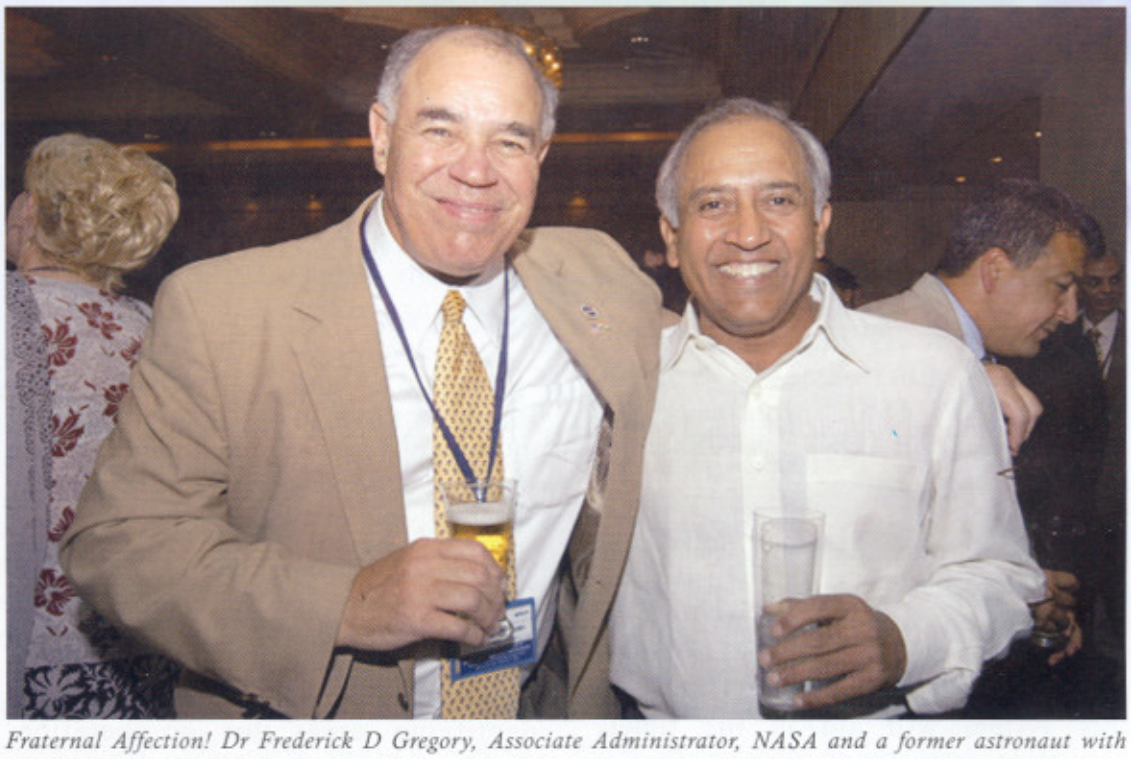
NPOESS will provide rapid distribution of global and regional environmental imagery, meteorological, climatic, terrestrial, oceanic and solar-geophysical data for use by the international community. Data from this system will aid in the timely prediction of cyclones; support disaster management efforts; and benefit the development and management of agriculture, fisheries, maritime industries and other economic sectors.

The ISRO-NOAA effort will support timely receiption of high quality data derived from the NPOESS system. As part of this programme, it is envisaged to set up fifteen worldwide reception stations located on all seven continents. One of these stations could be in India. NOAA industry partners Northrop Grumman and Raytheon are under contract to implement the worldwide NPOESS system.

The reports of the different Symposiums held during the conference were presented in the Closing Plenary. Dr P S Goel, Chairman, Indian National Advisory Committee of the India-US conference, was optimistic when he mentioned that the scientific collaborations and commercial activities between India and the US would get a new fillip. He hoped that the two countries would now reassess priorities and commit to collaborate and develop mutually beneficial partnerships. He noted that the conference had achieved its objectives in identifying areas for co-operation. Ms Meera Shankar, Additional Secretary

Mr Craig Tiedman of NASA handing over a memento to Mr G Madhavan Nair, Chairman, ISRO, during the valedictory session

(International Security), Ministry of External Affairs, Government of India struck a positive note when she envisioned the conference as the start of a new process and stressed that both sides must work at making the recommendations of this conference into a reality. Mr Donald Anderson, Programme Manager, Office of Earth Sciences, NASA observed that both India and the US had capabilities that could be converged to benefit each other's programme and felt that the information exchanged during this conference had been phenomenal. Mr A M Powell, Deputy Director, Office of Research and Applications, NOAA said that the Conference had set reachable goals and recommendations, especially through the Symposiums.



Fraternal Affection! Dr Frederick D Gregory, Associate Administrator, NASA and a former astronaut with Mr Rakesh Sharma, the first Indian to travel to space

The India-US Conference culminated with the issue of a Vision Statement that would serve as a road map for the two countries in pursuing cooperation in space.

Exhibition

To coincide with the India-US Conference, an exhibition was also organised at the conference venue – The Hotel Grand Ashok. The exhibition had a significant participation from space agencies and space industries of both the countries. On the Indian side, participants included ISRO and its commercial arm ANTRIX Corporation, Bharat Electronics Limited (BEL), Centre for the Development of Advanced Computing (C-DAC) and Hindustan Aeronautics Limited (HAL), while NASA, NOAA and prominent private industries including Boeing, Honeywell, Northrop Grumman and Raytheon represented the US side.

ISRO/ANTRIX pavilion in the Exhibition during the Conference

US industries had a major participation in the Exhibition

STRENGTHENING & EXPANDING COOPERATION

India-United States Conference on Space Science, Applications and Commerce

VISION STATEMENT

Noting that the Republic of India and the United States of America share a history of four decades of cooperation in civil space activities;

Recognising that the achievements in space of the United States and its sustained commitment to space exploration have advanced scientific understanding; stimulated public interest in space exploration, science, technology and applications; and demonstrated vividly that humankind can benefit from space;

Recognising that India's space programme has evolved from its early steps of exploration to an important and advanced scientific, technological and business endeavor, oriented towards the developmental needs of the country and its sustainable economic growth, with significant potential for international cooperation;

Noting that the Joint Statement between the United States of America and the Republic of India of November 2001 expressed the commitment by the President of United States and the Prime Minister of India to broaden dialogue and cooperation in civil space activities and to discuss ways to stimulate high technology commerce between the two countries; and

Noting the statements by the President of the United States and the Prime Minister of India in January 2004 announcing the Next Steps in Strategic Partnership with India to expand cooperation in civilian nuclear activities, civilian space programs and high-technology trade, and to expand their dialogue on missile defense;

Welcoming the India-United States Conference on Space Science, Applications and Commerce – Strengthening and Expanding Cooperation as an opportunity to carry these initiatives forward;

STRENGTHENING & EXPANDING COOPERATION

Taking cognisance of the deliberations of the Conference, held in Bangalore on June 21-25, 2004;

The space communities of the United States and India, in the Closing Plenary of the Conference, hereby offer the following Vision for enhanced cooperation between the two countries to their governments, business enterprises and research institutions for their consideration and appropriate action:

1. *Both the United States and India have tremendous capability and capacity in space science, technology and applications. Through scientific and technological cooperation and farsighted commercial endeavors, and in an appropriate policy and business environment, these assets can be leveraged to the benefit of both nations and contribute to sustainable global economic growth and scientific advancement.*
2. *Areas with strong potential for enhanced cooperation in civil space research and other activities between India and United States, as discussed in the Conference, include:*
   a. *Earth Observation Science, Technology and related Applications – including natural resources management, water cycle, atmospheric sciences, infrastructure, etc.*
   b. *Satellite Communications Technology and Applications – including tele-medicine, tele-education, etc.*
   c. *Satellite Navigation and Applications*
   d. *Earth and Space Science – including Astronomy, Planetary Science and Solar Terrestrial science, etc.*
   e. *Natural Hazards Research and Disaster Management Support*
   f. *Education and Training in Space*

   Details of possible areas of cooperation are contained in the reports by the Symposia Co-Chairs.

STRENGTHENING & EXPANDING COOPERATION

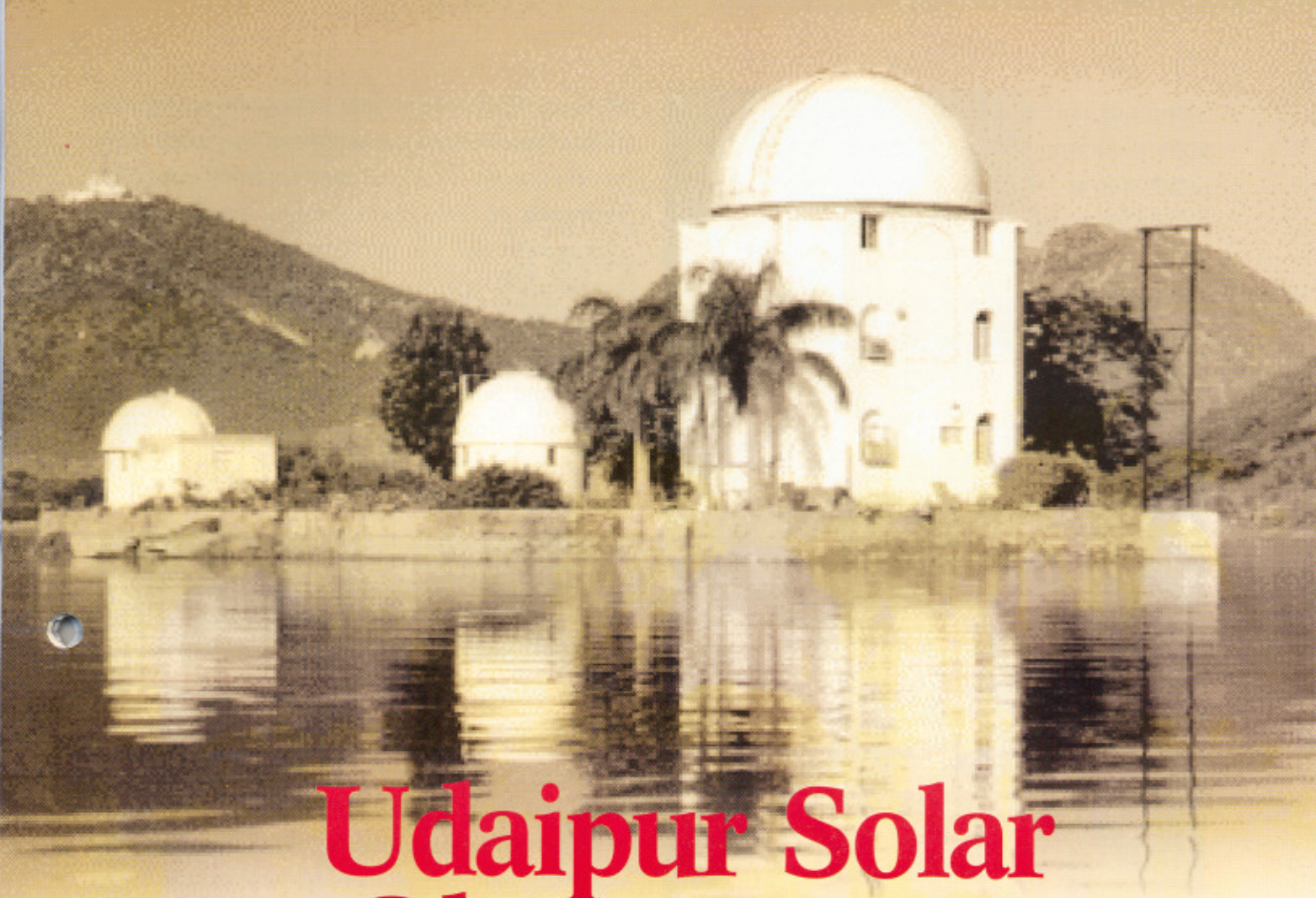
3. *In the commercial sector, aerospace enterprises from India and the United States can profitably explore promising opportunities for business development in the areas of Earth Observations, Satellite Communications and Satellite Navigation through possible collaborative business ventures serving national and global markets. These business opportunities are also outlined in the reports by the Symposia Co-Chairs.*

4. *Supportive policy and business environments in India and the United States will facilitate enhanced civil space cooperation and encourage active networking among government agencies, private enterprises, and academic and research institutions to the benefit of both nations and the world. Efforts by both governments to strengthen the bilateral relationship, address policy issues and facilitate commerce are welcome.*

5. *Efforts begun at this Conference should be continued. Cooperation and commerce between the two nations in the area of civil space could be facilitated through a high-level mechanism involving key representatives of government, business, academic and other non-governmental organisations from the United States and India. Under the leadership of the Ambassador of the United States to India and Chairman of the Indian Space Research Organisation, meetings at appropriate intervals could enable the mechanism to monitor and review progress on civil space collaboration between the two countries.*

6. *In addition, the contact points in key organisations and other forms of networking recommended by the Conference Symposia can usefully serve to address issues as they arise in order to ensure that the enhanced cooperation envisioned by this Conference will be realised.*

Adopted on June 25, 2004 by the participants in the India-United States Conference on Space Science, Applications and Commerce – Strengthening and Expanding Cooperation.



Udaipur Solar Observatory:
Staring at the Sun

The sun sustains life on earth. Most of the physical and chemical phenomena on the earth are inflenced by the sun – the weather, the ocean currents, ecology and environment. The modern space based communication systems are affected by the emission of high-energy particles and radiation from the sun. Therefore, it is essential and, at the same time, very interesting to understand this nearest star to earth which is the sole source of energy for earth.

The Udaipur Solar Observatory (USO) of the Physical Research Laboratory under the Department of Space has been staring at the Sun since three decades to find out the intensity and timing of the emission of high-energy particles and radiations from the sun. The observatory also carries out research on the physical causes of these emissions to provide warning on the occurrence of such events.

Udaipur was specifically selected for the observation of the Sun because it is mostly free of clouds for more than 270 days in a year. Besides, this city of lakes has provided a very appropriate location in the middle of the Lake Fatehsagar for the observatory; the water body around the observatory reduces the turbulence arising from ground heating during the day and thus, one can

Spar Telescope carrying the 15 cm achromatic lens as the objective (seen at the far-side), while the CCD camera that records the images is seen at the back-end of the telescope

observe the details of the various solar features more conveniently throughout the day.

The Phenomena on the Sun

Above the photosphere, which is the surface visible in white light, a hot layer of the atmosphere known as chromosphere exists over the sun. The most conspicuous features seen on the visible disk of the sun are the sunspots, which are dark regions that are cooler than their surroundings. Sunspots are dark because they are also the sites of strong magnetic fields. These fields are strong enough to prevent the transport of energy from the solar interior via convection, while the surrounding photosphere freely receives the convected energy from below. These magnetic fields spread out with height, but become more dominant at higher layers. They cause non-radiative heating of the chromosphere. Because of the magnetic dominance, the chromosphere appears highly structured in the form of many fibrils. These can be seen in any picture of the Sun obtained in the light of the spectral line of Hydrogen at 656.3 nanometer (nm). The footpoints of these fibrils become intensely bright during solar flares in the form of ribbons. One can also see dark regions called filaments, which are cool dense clouds of plasma suspended above bipolar magnetic regions. These filaments straddle the North and South polarities and mark the polarity inversion lines. The destabilisation of these structures accompanies flares and Coronal Mass Ejections (CMEs).

The USO has been monitoring this phenomenon of CME using a telescope that has a 15 cm diameter refractor placed on a 10 m tall pillar. A dome protects the telescope from the winds during observations and from the vagaries of terrestrial weather during monsoons.

The observed data of the chromosphere, recorded in digital form by CCD cameras for the past ten years are stored on compact disks (CDs). There is a comprehensive compilation of the daily log sheets, which can be used to locate interesting events. The archived data is also flagged with pointers to different kinds of events like flares, eruptive filaments, surges, etc.

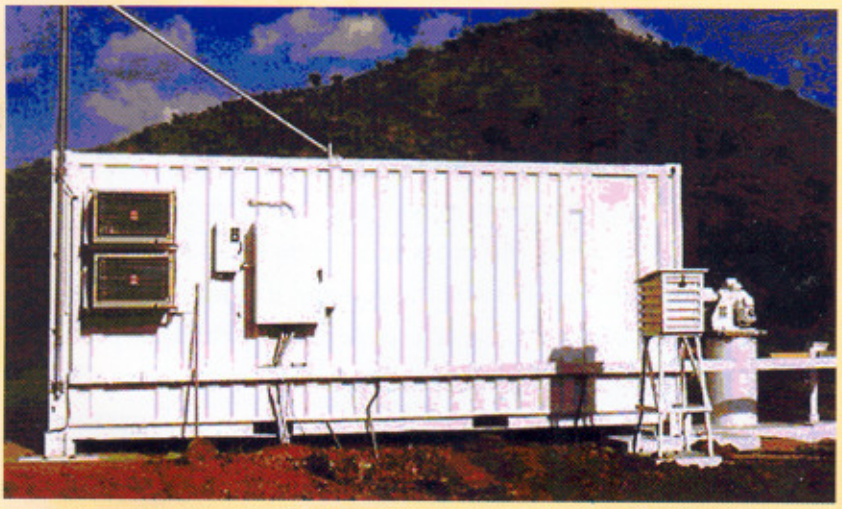
USO is also one of the six stations participating in the international Global Oscillations Network Group (GONG) which is aimed at the determination of the physical properties of the solar interior. This task has been accomplished to a high accuracy and it has provided tight constraints on the theory of stellar equilibrium.

Under GONG, six identical telescopes and identical instruments have been deployed around the world for continuous monitoring of solar oscillations. The data is recorded on magnetic tape cassettes and sent to the main station at Tucson, Arizona, USA. The data from all six stations are integrated and the data products are made available to the scientific community.

An important spin-off from GONG was the realisation that the solution of the solar neutrino problem must be sought outside the Sun. The resolution of this problem in terms of neutrino

oscillations led to the 2003 Nobel Prize for John Davis for his pioneering experiments on the detection of solar neutrinos.

At present, GONG is providing a new tool for space weather by imaging active regions on the far-side of the Sun using a technique called time-distance seismology. Using this technique, it is possible to obtain information on the active regions even before they appear on the earth facing side of the Sun, thus helping in space weather predictions.



GONG telescope and shelter. The Telescope is seen at the extreme right of the picture mounted on a white cylindrical pillar. The shelter houses a sophisticated Michelson Interferometer which is the heart of the instrument used for precise velocity and magnetic field measurements

One of the interesting scientific problems associated with flares is the determination of the physical configurations of the solar magnetic fields that are on the verge of violent relaxation leading to the flare. Apart from conducting the daily observations, the USO, using data from other facilities, has studied and quantified in a few physical parameters the evolution of "twistedness" or "curled-up" nature of the solar magnetic fields in relation to the onset of the flare. This has led to a variety of results and prompted the search for these changes in the chromospheric magnetic fields, as opposed to the current pre-occupation with the photospheric magnetic fields.

Yet another class of scientific problems is the relationship between physical properties of the CMEs and their solar origins to the severity of geomagnetic storms. The USO has contributed significantly to this research.

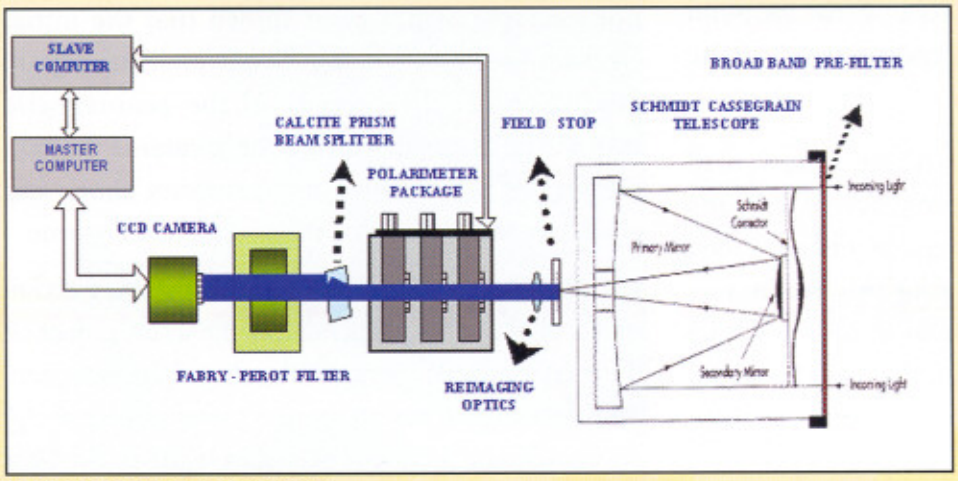
For example, it has been shown that the initial ejection speed of a CME could provide a good prediction for the severity of the geomagnetic storm. The larger the speed, the greater is the ram pressure of the resulting interplanetary shock and greater is the severity of the geomagnetic storm.

In another study, the USO has shown that the ejection speed of the CME depends on the $1/5^{th}$ power of the total magnetic energy of the source active region. This dependence has an uncanny resemblance to the dependence of the speed of a blast wave on the blast energy. This resemblance could well be a clue to a blast-like origin for the CME.

Using the GONG data products, USO has shown interesting relationships between the indices of solar activity and changes in the global frequencies of the solar oscillations. This result is puzzling since the direct effect of magnetic fields (the main cause of solar activity) on the frequencies is expected to be very small. A more likely explanation is that the distribution of the thermodynamic properties of solar plasma is altered in phase with the solar cycle. If so, this will point to fundamental effects of solar activity on solar parameters. On a still smaller time scale, it is seen that a solar flare can produce discernible changes in the oscillation properties.

Total solar eclipses provide interesting glimpses of the solar corona for a ground-based observer. USO has been following total solar eclipses to the different corners of the world. The latest eclipse observed was from Lusaka, Zambia in 2001, where a major result obtained was the polarization map of the corona in the green coronal line at 530.3 nm.

The USO is now in the advanced stage of completing a Solar Vector Magnetograph, which poses a great experimental challenge in solar science. This device requires measurement of both linear and circular polarization changes produced in the line profile of a Zeeman sensitive spectral line. In order to counteract the effects of atmospheric



Schematic outlay of Magnetograph

distortion (called "seeing" by astronomers), the modulation of the solar light for polarimetric analysis must be done at a very fast rate.

Overall, the requirement of short exposure time and small spectral bandwidth reduces the number of photons available for analysis. Thus, the measurements have to be integrated for sufficient photons. This requires a steady telescope that does not jitter during the observations.

Also, the spectral isolation requires a stable Fabry Perot etalon that maintains the separation and parallelism during the observation. A 20 cm aperture Cassegrain-Schmidt commercially available telescope serves as the photon collector. A special entrance filter of optical quality that transmits only 15 nm of the visible sunlight eliminates the problems associated with solar heating. A set of quarter wave retarders serves as the polarization modulator. A calcite prism separates the ordinary and extra-ordinary polarizations and the two beams are jointly recorded in a CCD camera. A Queensgate air spaced Fabry Perot etalon with servo controlled plates serves as the spectral isolator.

Each module of the instrument is computer controlled. The entire system is run by a master computer programme. The students of the computer department of Mohan Lal Sukhadia University are also participating in the development of this instrument.

Ground based telescopes are severely affected by the distortion produced by various eddies passing in front of the aperture of the telescope. The distortion of the wave-front changes on a timescale dictated by the eddy size and speed. USO is setting up an adaptive optics system to image the corrected and less distorted image.

Solar observers work at the limit of photon availability. The solar phenomena become clearer with better spatial, temporal, and spectral resolution. Thus, one always aspires to collect more photons. This requires telescopes with large apertures. But for solar telescopes used for polarimetric analysis, there are restrictions on the size because the polarization analysis must be done before any oblique reflections to avoid the cross talk. Hence the telescope must constantly track the sun and it cannot be very long. A short focus telescope creates thermal problems due to low thermal conductivity of glass. Silicon Carbide (SiC), a ceramic matrix with large thermal conductivity, is the ideal choice but large mirrors are still not available. Mirrors up to 50 cm in diameter are available in SiC. USO has shown that the full potential of adaptive optics can be realised with a 50 cm telescope and plans to install the same in the place of the present 15 cm telescope.

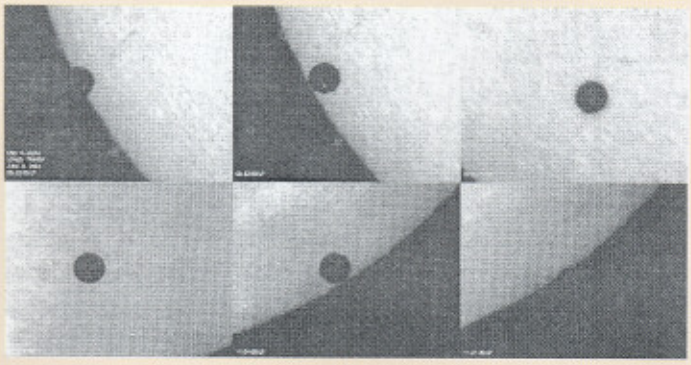
The new telescope, known as Multiple Application Solar Telescope (MAST), expected to be completed by December 2005 will be a Coude telescope, with the polarimetric analysis performed before the Coude beam is extracted. The Coude beam will be directed to the ground floor where the adaptive optics system will correct the wave-front distortions. The corrected wave-front will be fed to either a spectrograph or a narrow band filter. There will also be an option to avoid the adaptive optics system for obtaining filtergrams with higher field of view. The adaptive optics system will be used to obtain spectrograms of smaller fields of view with high spatial resolution.

(This article was contributed by P Venkatakrishnan, Professor & Head, Udaipur Solar Observatory)

Transit of Venus

On June 8, a rare celestial event, the transit of Venus, was visible over parts of Europe and most of Asia including India. As Mercury and Venus are much farther away from the Earth (when compared to moon), they project a small dark spot which moves across the brilliant solar disc for several hours during their transit. On June 8, it was Venus, which projected a small dark spot across the Sun's disc. By mid morning, as per Indian Standard Time, Venus touched the solar disc and till late in the afternoon it could be seen (from India) moving at a snail's pace as a black dot silhouetted against the bright solar disc.

On the special occasion of the Venus Transit on June 8, 2004, the Udaipur Solar Observatory (USO) had set up a coelostat on the southern terrace of its main building, feeding sunlight into a convex lens. The image formed by this lens was magnified by another lens and projected on a screen. Thus, a solar image of about 60.8 cm in diameter was obtained. The first contact was observed by all viewers. A group of children from North Eastern States had arrived to view the transit. These children made simple observations like noting time and calculating the lateral speed of Venus. Professor U R Rao, Chairman, Council of Management, Physical Research Laboratory, addressed the school children and spoke about the excitement of science.



The progress of the Venus transit as seen in the High resolution H-alpha solar images.

In spite of clouds, USO could obtain specklegrams of the Venus image. Another experiment was conducted on the island (in Lake Fatehsagar) in which the transit was observed in the light of Hydrogen-alpha at two different spatial resolutions. This is the first time that the transit has been recorded in this spectral line.

ISRO supported the Jawaharalal Nehru Planetarium at Bangalore to undertake several space science popularisation events on the occasion of this rare celestial phenomenon. These included a special video presentation on the phenomenon of Transit, arrangements for viewing the transit through telescopes fitted with special filters and regular briefing. Thousands of students and the general public visited the planetarium to view transit and to understand the phenomenon.

Large Crowd that gathered to watch the transit of Venus in the premises of Jawaharlal Nehru Planetarium

Venus appears as a dark circular patch on the bright disc of the sun during its recent transit – image taken at Jawaharlal Nehru Planetarium, Bangalore