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PROPOSED INDIAN NATIONAL PROGRAMME FOR THE INTERNATIONAL HELIOSPHERIC STUDY

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Abstract

"Ulysses" is an International Solar Polar Mission (ISPM) to be carried out jointly by European Space Agency (ESA) and NASA. The Ulysses spacecraft will be launched in May 1986 by means of a Space Shuttle. The primary objective of the Ulysses mission is to investigate, for the first time, the properties of solar wind, the structure of Sun/wind interface, the heliospheric magnetic field, solar radio bursts and plasma waves, solar X-rays, solar and galactic cosmic rays and the interplanetary/interstellar neutral gas and dust, all as a function of solar latitude. The out-of-ecliptic phase of the Mission, which will occur during 1988 to 1992, has been designated by COSPAR as the period of the International Heliospheric Study (IHS).

It is proposed that India should actively participate in IHS both experimentally and theoretically. On experimental side, one could think of variety of ground-based, balloon, rocket and satellite observations of the Sun and interplanetary medium. On theoretical side also one could think of modeling linear and nonlinear plasma processes occurring on the Sun and their effects on particles and fields in the heliosphere. It is suggested that the best way to organize Indian effort for the above purpose would be to constitute a national steering committee for promotion of research in Solar Physics in general and heliospheric study in particular. This steering committee should be responsible for generating an overall strategy for formulation and implementation of research activities in this field in India.

1. Introduction

The heliosphere is a vast region of space in which radial outflow of solar wind dominates. It is an extended plasmasphere of the sun. It is expected that the physical properties of the heliosphere to be drastically different as one moves away from the ecliptic plane to the higher heliolatitudes. This is analogous to the variation of the properties of the Earth's magnetosphere with geomagnetic latitude. So far the knowledge regarding the physical processes occurring in the heliosphere has been gained from observations made in the narrow belt of heliolatitudes (+7.25° to -7.25°) accessible to the spacecraft in the ecliptic. The International Solar Polar Mission (ISPM), recently renamed as "Ulysses", is to be jointly carried out by ESA and NASA for the exploration of the heliosphere within a few astronomical units over the full range of heliolatitudes.

The Ulysses spacecraft will be launched in May 1986 by means of the space shuttle, using a Centaur upper-stage motor to inject the spacecraft into an ecliptic transfer orbit. The spacecraft will arrive at Jupiter 14 months after launch and will pass slightly above or below the ecliptic plane. At this point, the Jovian gravitational field will deflect the spacecraft into a high inclination orbit, taking it either north or south of ecliptic plane.

Table 1 represents a summary of different phases of the mission. The out-of ecliptic trajectory is such that, 2.5 years after Jupiter encounter, the spacecraft will pass

Table 1
Typical Ulysses mission timeline, based on 22 May 1986 launch

Event	Average time elapsed (months)	Calendar date (south orbit)
Launch	0	22 May 1986
First superior conjunction	10	March 1987
Jupiter encounter	14	July 1987
First polar pass	45	Jan. 90/May 90
Ecliptic crossing	51	August 1990
Second polar pass	56	Nov. 90/Mar. 91
End of mission	58	31 March 1991

over the northern or the southern pole at a distance of about 2 AU above the ecliptic. Following this polar passage, it then crosses the plane of the ecliptic, heads for a second (opposite) polar passage, eight months after the first. The mission will be completed when the heliographic latitude of the spacecraft falls below 70°. A minimum of 150 days above 70° heliographic latitutde has been fixed as a mission design guideline.

Section 2 deals with the scientific objectives of the Ulysses mission and in-situ experiments that will be carried out on the spacecraft from May 1986 to 31 March 1991.

Section 3 describes the IHS in terms of COPSAR decisions.

Section 4 gives a brief account of the 19th ESLAB Symposium which highlighted the importance of IHS.

Section 5 makes a proposal for the Indian Programme for IHS and strategy to evolve the same.

Section 6 deals with the strategy for planning and implementation of research activities for IHS in India.

2. Scientific Objectives of Ulysses

According to the report on the scientific satellites of the European Space Agency (May 1985), the primary objective of the Ulysses mission is to investigate, for the first time,

- the properties of the solar wind
- the structure of the Sun/Wind interface
- the heliospheric magnetic field
- solar radio bursts and plasma waves
- solar and galactic cosmic rays, and
- interstellar/interplanetary neutral gas and dust,

Secondary objectives include:

- interplanetary-physics investigations during the in-ecliptic Earth-Jupiter phase
- measurement of the Jovian magnetosphere during the Jupiter fly-by phase
- the detection of cosmic gamma-ray bursts, and
- a search for gravitational waves.

A summary of the nine flight experiments and other radio-science investigations which make up the spacecraft payload is given in the report (ESA. SP-1072).

3. What is IHS? (Ref.2 and 3)

As recommended by COSPAR (1982 Decision No.5/82), the duration of the International Heliospheric Study (IHS) is the period between January 1988 to December 1990. This COSPAR decision reads as follows:

"COPSPAR,

recognizing that in the priod 1986-1990

(1) there will exist an extensive network of spacecraft distributed throughout the interplanetary medium, and

(2) proposals have been made for additional interplanetary spacecraft, suggests that steps be taken first to co-ordinate the various plans and later to ensure the efficient exchange and comparison of data, and recommends that the period January 1988 to December 1990 be designated the period of the International Heliospheric Study, and further recommends this study be conducted under the auspices of COSPAR, with assistance from the other appropriate ICSU bodies."

The second COSPAR decision No.5/82, which is also an important one, reads as follows:

"COSPAR

noting Internal Decision No.5/82 (Ottawa, May 1982) designating the period of January 1988 to December 1990 as the period of the International Heliospheric Study (IHS), and

recognizing SCOSTEP'S decision to support COSPAR in the conduct of the IHS,

invites SCOSTEP to participate with the IHS Steering Committee, composed of members of Sub-Commission D.1 (on the Three-Dimensional Heliosphere) and Sub-Commission E.2 (on Solar Physics) to plan, oraganize and conduct the IHS urges the national adherents to establish internal groups that will act as liaison and as a focus for co-ordinated ground- and space-based observations before and during the out-of-ecliptic exploration of three-dimensional heliosphere, and encourages national bodies to take IHS objectives into account when planning or developing space missions which can provide in-ecliptic baseline measurements."

4. The 19th ESLAB Symposium on The Sun and the Heliosphere in Three Dimensions and Solar Wind Studies using International Scintillation Techniques in India

This Symposium was held at Les Diablerts, Switzerland during 4-6 June, 1985. The main topics of the Symposium were:

1) Effects of Solar Activity on the Heliosphere,
2) Structure and dynamics of the Heliosphere, and
3) Ulysses in the context of IHS.

The aim of this Symposium, taking place one year prior to the launch of Ulysses was to bring together the international scientific community to review our current knowledge of the structure and dynamics of the three-dimensional heliosphere and the possible implications for Ulysses.

The Interplanetary Scintillation (IPS) project has been undertaken by the Physical Research Laboratory (PRL) to measure solar wind velocity at different heliolatitudes

using 3-station interplanetary scintilltion data at 103 MHz of a grid of compact radio sources around the sun. For this purpose, PRL has set-up three large radio telescopes at Thaltej (Ahmedabad), Rajkot and Surat. It is possible to keep track of turbulence in the interplanetary plasma on day-to-day basis by measuring fluctuations in the daily scintillation index of different radio sources with the help of a single radio telescope. It will be interesting to compare solar wind parameters using IPS technique and in-situ measurements of Ulysses relating to the three-dimensional aspects of the heliosphere.

5. Proposed Indian Programme for IHS

As mentioned earlier, COSPAR has recommended that the period from January 1988 to December 1990 be observed by national adhering organizations for the International Heliospheric Study. It is felt that the Indian National Science Academy through its national committees like INCOSPAR, INSCOSTEP and INCA, etc. may have to take initiative to organize our efforts for IHS. The Department of Science and Technology and the Department of Space, and University Grants Commission, which are some of the main funding agencies, may jointly hold a national Workshop for IHS in order to evolve a scientifically worthwhile programme.

Broadly speaking, one could think of an experimental as well as a theoretical programme for IHS. It is fortunate that there are active scientists in different institutions in India engaged in experimental and theoretical investigations in solar, interplanetary and heliospheric physics. They should be brought together on a common platform and asked to review the present status of the existing facilities for conducting research in solar and interplanetary and heliospheric physics and make recommendations for new research activity relevant to IHS using both the ground-based and space techniques.

It is well known that India has competence in the solar experimental studies at the optical and radio wavelengths, which are received at the ground level. These studies can be augmented by incorporating the latest but sophisticated observational techniques with better spectral, angular and temporal resolutions. We should also take note of the availability of space platforms like balloons, rockets and satellites for solar observations in different electromagnetic "windows", such as UV, X-ray and gamma-rays.

What is the relevance of ground-based solar observations for IHS? As is well known, it is possible to make solar observations at optical and radio wavelengths from ground. One might think of a coordinated programme of photospheric, chromospheric and coronal observations at optical wavelengths using appropriate spectral, temporal and spatial resolutions. Such solar observations would be extremely important to understand particles and fields in the heliosphere and their relation to solar activity. The IIA, UPSO and USO are already equipped to undertake observational programmes on the above lines. So far as radio observations of the sun are concerned, IIA and PRL are the main institutions interested in solar work in addition to a couple of Universities. There is an urgent need for multi-wavelength heliography ranging from decameter to millimeter wavelengths not only for IHS but for the next solar cycle. In May 1985, the Committee of European Solar Radio Astronomers (CESRA) have made several recommendations for the growth of solar radio astronomy in the next decade, which supports establishment of new observational facilities for solar radio work. There is a great upsurge of interest in sensitive, high resolution digital radio spectroscopy and heliography in European Solar radio observatories. Japan has a vigorous programme in solar radio spectroscopy and heliography using the latest acousto-optical techniques. The Indian programme should be evolved taking into account the above realities so that our efforts would yield adequate scientific returns. Any facility for solar radio work set up in India will fill the longitudinal gap in solar observations between Japan and Europe. As mentioned earlier, the interplanetary scintillation technique, which is useful for solar wind studies in three dimensions, has been in operation at PRL with the help of three spaced radio telescopes. This work combined with single station IPS observations carried out at IIA, RRI and TIFR would be quite relevant for IHS for the study of interplanetary medium.

So far India had no facility for making solar observations in UV, X-ray and gamma-rays since these experiments can only be done from space-platforms. With the availability of space platforms like balloon, rocket and satellite in India, it should be possible to generate a coordinate programme of solar observations in UV, X-ray, and gamma-ray parts of the spectrum with imaging capability. This would enable the study of evolution of coronal and polar holes, which affect the structure of solar wind and other heliospheric plasma phenomena.

6. Strategy for Planning and Implementation of Research Activities for IHS in India

An ideal way to recognize Indian effort to promote research in Solar Physics in general and IHS in particular would be to form a National Steering Committee, which should identify active research workers/institutions and generate a worthwhile research programme. This committee should be responsible for formulating both the short-term and long-term research plans in Solar Physics and approach governmental funding agencies for support.

References

1. ESA.SP-1072, pp.63-69, May, 1985.
2. COSPAR Information Bulletin No.94, pp.26-27, August 1982.
3. COSPAR Information Bulletin No.101, pp.54-55, December 1984.