The International Heliophysical Year (IHY) 2007

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Abstract. The International Geophysical Year (IGY) of 1957, a broad-based and all-encompassing effort to push the frontiers of geophysics, resulted in a tremendous increase of knowledge in space physics, the Sun-Earth connection, planetary science, and the heliosphere in general. Now, fifty years later, we have the unique opportunity to advance our knowledge of the global heliosphere and its interaction with planetary bodies and the interstellar medium through the International Heliophysical Year (IHY) in 2007. This will be an international effort which will raise public awareness of space physics. Because of its unique geographic position, Africa is well-positioned to play a critical role.


Introduction

On 4 October 1957, only 53 years after the beginning of flight, the launch of Sputnik 1 marked the beginning of the space age as man took his first steps of leaving the protected environment of the Earth’s atmosphere. Discovery of the radiation belts, the solar wind and the structure of the Earth’s magnetosphere prepared the way for the inevitable human exploration that followed. Soon, cosmonauts and astronauts orbited the Earth, and in 1969 astronauts landed on the Moon. Today, a similar story is unfolding: the spacecraft Voyager has crossed the termination shock, and will soon leave the heliosphere. For the first time, man will begin to explore the local interstellar medium. During the next 50 years it is inevitable that exploration of the solar system including the Moon, Mars and the outer planets will be the focus of the space programme, and, as was the case 50 years ago, unmanned probes will lead the way, followed by human exploration.

The IHY 2007 will coincide with the fiftieth anniversary of the International Geophysical Year (IGY) in 1957, one of the most successful international science programs of all time. The tradition of international science years, however, began almost 125 years ago with the first international scientific studies of global processes of the Earth's poles in 1882–3 (Figure 1). A second International Polar Year (IPY) was organised in 1932, but a world-wide economic depression curtailed many of the planned activities. A more complete history of international years is given by Davila¹ and others¹³⁶. The IHY will continue the legacy of these previous events, extending global synoptic study to the heliosphere.

Fig. 1. The International Heliophysical Year is the natural extension of the International Geophysical Year and the previous International Polar Years to the larger heliospherical system.
Universal Processes

The International Heliophysical Year (IHYZ) will focus on the cross-disciplinary study of universal physical processes in the solar system, observed in a variety of settings. It is now widely recognized that evolution in the solar system proceeds through a set of universal processes, i.e., reconnection, particle acceleration, plasma wave-generation and propagation, etc. By studying these universal processes in diverse environments and in comparative ways, new scientific insights will be gained. This is perhaps best understood by citing a few examples:

(1) Shocks are observed in situ in the interplanetary medium. Shocks are believed to play a role in the acceleration of particles in the solar corona, and standing bow shocks and termination shock separate the major regions in the heliosphere. Shock formation and particle acceleration are universal processes. (2) Aurorae (Figure 2) are observed on Earth, Saturn, and Jupiter, and Jovian auroral “footprints” have been observed on Io, Ganymede and Europa. The formation of aurorae is observed to be the universal response of a magnetised body in the solar wind. The cross-disciplinary study of these processes will provide new insights that will lead to a better understanding of the universal processes in the solar system that affect the interplanetary and planetary environments, and pave the way for safe human space travel to the Moon and planets in the future, and will serve to inspire the next generation of space physicists.

Objectives and Goals of the IHYZ

The IHYZ has three primary objectives:

• Advancing our understanding of the fundamental heliophysical processes that govern the Sun, Earth and heliosphere;

• Continuing the tradition of international research and advancing the legacy on the 50th anniversary of the International Geophysical Year; and

• Demonstrating the beauty, relevance and significance of space and Earth system science to the world.

More specifically, we have identified six goals of IHYZ, each corresponding to a unique opportunity afforded by IHYZ:

1. Develop the basic science of heliophysics through cross-disciplinary studies of universal processes.
2. Determine the response of terrestrial and planetary magnetospheres and atmospheres to external drivers.
3. Promote research on the Sun-heliosphere system outward to the local interstellar medium – the new frontier.
4. Foster international scientific cooperation in the study of heliophysical phenomena now, and in the future.
5. Preserve the history and legacy of the IHYZ on its 50th anniversary.
6. Communicate unique IHYZ results to the scientific community and the general public.

The IHYZ is an integrated programme of many diverse activities working at an international level to achieve all of these goals.

Plans for the IHYZ

The International Heliophysical Year Programme has four main components, which are called programmatic thrusts:

1. Science activities, consisting primarily of Coordinated Investigation Programmes (CIPs) dedicated to the study of the extended heliophysical system and the universal processes common to all of heliophysics;
2. The United Nations Basic Space Science (UNBSS) Observatory Development Programme, dedicated to the establishment of observatories and instrument arrays to expand greatly our knowledge of global heliophysical processes, while increasing the viability of space science research and education in developing nations and regions that traditionally have not been active in space research;
3. Education and public outreach, increasing public awareness of heliophysics and educational activities for “students” of all ages, and
4. The “IGYZ Gold” History Initiative, preserving the history and legacy of the IGY of 1957 by identifying and recognising planners of and participants in the first IGY preserving and making available items of historical significance and organising commemorative activities and events.

The four programmatic thrusts of IHYZ are roughly related to the above goals of IHYZ as follows:

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Each of the four Programmatic Thrusts of IHYZ is planned as part of one integrated programme. The plans, progress and current state of these individual activities will be discussed throughout this publication.
Science Activities

During the IHY, Coordinated Investigation Programmes (CIPs), utilising space- and ground-based observatories will be organised to study universal processes at work throughout the solar system. Maximum use of the internet and world-wide-web infrastructure will be used to facilitate communication and organisation. These research campaigns will operate similar to SOHO Joint Observing Projects. The resulting data sets will be processed and assembled for easy access to the global science community. Coordinated data analysis will be performed during a series of workshops and the results will be published and made available to the science community.

CIPs will be entered by individuals within the research community (Figure 3); discipline coordinators will review all suggestions and organise similar CIPs into observing programmes that can actually be implemented. Observatory coordinators, representing each of the instruments participating in the IHY will assist in this process. Later, the observing programmes will be organised into cross-disciplinary topical Universal Process Workshops to discuss and communicate the scientific results of the IHY campaigns.

Joint campaigns with organisations having overlapping goals will minimise the resources required for the IHY. The IHY will seek to identify areas where it can support programmes like CAWSES (Climate and Weather of the Sun-Earth System), IPY (International Polar Year), eGy (Electronic Geophysical Year), perhaps for example, by providing the web-based campaign planning database software developed to support IHY to these groups. Detailed discussions on areas of support were carried out during 2005, leading to detailed cooperation and coordination in 2006. IHY workshops and coordination meetings will be held in conjunction with major scientific meetings whenever possible to minimise travelling time and expense.

United Nations Basic Space Science (UNBSS) Observatory Development Programme

Through a cooperative programme with the United Nations Basic Space Science (UNBSS) programme for 2005–2009, the IHY will facilitate the deployment of a number of arrays of small instruments to make global measurements of space physics related phenomena. These may range from a new network of radio dishes to observe interplanetary coronal mass ejections (CMEs) to extending existing arrays of GPS receivers to observe the ionosphere. These instrument concepts are mature, and are developed and ready to be deployed. A coordination meeting was held between IHY and UNBSS representatives in October 2004 in Greenbelt, Maryland in the United States of America. As a result, the UNBSS programme has dedicated its resources and activities through 2009 to providing the IHY with a link to developing countries. The programme has provided more than 2000 scientist contacts in almost 200 countries, many of whom are eager to participate in international space science activities.

The purpose of the Observatory Development Programmatic Thrust of the IHY is to develop activities and facilitate partnerships that stimulate space and Earth science activities throughout developing regions of the world, such as the establishment of ground-based instrument arrays and research programmes. This includes the deployment of small, inexpensive instruments such as magnetometers, radio antennas, GPS receivers, all-sky cameras, etc. around the world to provide global measurements of ionospheric and heliospheric phenomena. Nearly all of the proposed instruments require global coverage to be effective; however, there are notable (and scientifically important) geographical gaps where coverage is minimal. The continent of Africa is one of these gap regions. The IHY Observatory Development Programme will attempt to address this by facilitating instrument deployment in these sparsely covered regions of the world.

The basic Observatory Development concept is summarised as follows

- The lead scientist or principal investigator will provide instrumentation (or fabrication plans) for the instruments in the array;
- The host country provides the workforce, facilities, and operational support to obtain data with the instrument, typically at a local university;
- The instrument host scientists become part of PI teams;
- All data, and data analysis activity is shared with all members of the group; and
- Publications and meetings involve the participation of all team members when possible.

The Observatory Development Programme facilitates partnerships between instrument providers and instrument host institutions. The tripod approach, with the three legs of the tripod consisting of instrumentation, education and observation, leads to scientific cooperation which produces

![Fig. 3. The Coordinated Investigation Programmes (CIPs) lead to observational plans organised by Discipline Coordinators. Scientific results are communicated through a series of topical Universal Process Workshops.](image-url)
excellent science and improves viability of space science around the world, providing an important link between scientific outreach and first-class science research.

This joint programme, a collaboration between the IHY and the United Nations Basic Space Science (UNBSS) Initiative, centres around a series of annual workshops hosted in varying international locations (including the 2005 Workshop in Al-Ain, United Arab Emirates). The Al-Ain Workshop brought together instrument providers and interested instrument providers for the first time to discuss facilities and requirements for each of the planned arrays. Attendees of the Workshop included approximately 20 instrument providers, and 30 potential instrument hosts selected from over 150 applicants. The first element of a new North African AWESOME VLF array has already been delivered to the University of Tunis. Efforts are underway between the University of Tunis and Stanford University to bring this element into full operation.

**Education and Public Outreach**

One of the primary objectives of the IHY/UNBSS programme is to encourage the study of space science in developing countries providing the opportunity to participate in space science research, while at the same time developing the curriculum and facilities to demonstrate and teach space science in the university environment. The IHY fully supports these objectives, and will be preparing booklets describing a space science curriculum for each of the deployed instrument arrays. Scientists at participating institutions will use these as a guide in teaching, and fully participate in the analysis of the data from the array and in the scientific discoveries that follow.

**“IGY Gold” History Initiative**

During 2004, the IGY Gold Club was established to commemorate the achievements of the IGY participants. The first recipient, Dr. Alan Shapley, was presented with the award at the IGY Workshop in Boulder, Colorado in February 2005. The Gold Club award consists of a certificate and a pin upon which the IGY logo is embossed. To be eligible for membership, one must: (1) have participated in the IGY in some manner, and (2) provide some historical material (copies of letters, books, etc.) to the IGY history committee. This material will provide a lasting legacy of the IGY for generations to come. This is a cooperative effort between the IGY, the History Committee of the AGU and the IAGA History Committee.

**Schedule and Basic Plan**

Planning for the IHY is organised into seven regions; North and South America, Africa, Europe, Western Asia, Eastern Europe/Western Asia, and Asia-Pacific. Each of these regions has formed a regional planning committee to coordinate regional IHY participation. Representatives from each of these regions met in Toulouse, France in July 2005 to commence the joint international planning process. International planning will continue at regional and international organising meetings. Additional information on planned meetings and regional organisations is available at the IHY website (http://ihy2007.org).

Major planning activities have taken place for all aspects of the IHY programme. Hundreds of local, regional and international planning conferences and meetings have taken place. Teams continue to form, implementing IHY activities in all the regions of the globe. The basis for the four main Programmatic Thrusts of IHY (Science, Outreach, Observatory Development and History) and a means by which all of these activities will be coordinated, are necessary to enable the individual organisations and institutions to develop unique IHY programmes that suit their own goals and challenges. It is the activities and programmes developed by these individual organisations and institutions that form the “building blocks” of the IHY. Therefore, the IHY’s international planning activities have focussed on the establishment of the four main components of IHY and on enabling the individual IHY regions and nations to commence with their planning activities.

The numerous local and regional planning activities have consisted primarily of IHY team meetings and special sessions at scientific meetings. IHY team meetings have occurred in each of the IHY’s seven regions and local planning teams continue to develop and implement elements of their programme in coordination with international efforts. Numerous special sessions on IHY have occurred at a wide range of scientific meetings, addressing all four of the IHY Programmatic Thrusts. These special sessions provide a venue for members of the community to learn about IHY activities and begin to contribute to the IHY effort.

As one would expect, the number of IHY events has increased exponentially in the past several years. The “Events” section of the IHY website (http://ihy2007.org) lists a representative number of these activities, especially those pertaining to the “Science” and “Observatory Development” aspects of the programme.

In preparation for the “official launch” of IHY activities in 2007, many precursor activities are required for the 2005–2006 timeframe. For the science component, the regional coordinators have already established a list of several hundred observatories planning to participate in IHY science activities, and members of the international scientific community have begun proposing their Coordinated Investigation Programmes for implementation during the IHY. Scientific sessions on IHY science activities at various meetings have focussed on bringing discussions of IHY science to the forefront and identifying campaigns to be implemented as CIPs. The Observatory Development component has been the focus of intensive activity in concert with the United Nations Basic Space Science Initiative. In particular, the deployment of individual instruments at remote sites has already begun as an essential step towards the establishment of global arrays by 2007. New instrument programmes and new “host” sites for these activities continue to be identified on a regular basis. The component has already launched several activities worldwide, emphasising the linkage to individual local programmes, while the IGY Gold History Programme was implemented in 2004 with plans to continue through 2009.

A general description of the IHY timeline is as follows:

- 2001–2003: establishment of IHY Secretariat; establishment of the main elements of the IHY programme; initialisation of planning activities on all continents;
- 2004: national and regional coordination meetings begin...
Science on a Global Scale:  
Connecting Local Ionospheric Disturbances over the Hawaiian Islands to Global Processes

The figure below shows the effects on the naturally occurring ionospheric emissions caused by an instability process generated at the magnetic equator in addition to a geo-magnetic storm. The local structures, seen in the data as depletions in the airglow intensity, are caused by an instability process generated at the magnetic equator. The turbulence within these local structures can disrupt transionospheric communication and navigation signals. The local structure typically drifts from west to east. In this example, simultaneously with the development of this equatorial instability process, a travelling ionospheric disturbance (TID) propagates equatorial-ward from the polar region, launched by energy input in the auroral region due to the onset of a geomagnetic storm.

Within this TID are electric fields and neutral winds which can differ significantly from their respective quiet-time values. As the TID passes over Hawaii, the perturbed electric fields and neutral winds affect the observed local structure by both reversing the drift direction to the west and initiating the development of secondary instabilities on the eastern edge of the primary local structure.

The instabilities introduced by TIDs and other ionospheric phenomena impact our ability to communicate through the ionosphere (e.g. GPS and satellite communications). The lack of ability to predict such phenomena leads to unanticipated transionospheric communications outages that negatively impact everyday aspects of life in the 21st century. In order to mitigate the effect of these outages, we need a global predictive capability. A global capability requires comprehensive and extended observations that can resolve both the fine scale structures as well as the global coupling effects that influence the development, structure, and impact of ionospheric disturbances on transionospheric radio signals.

Fig. 4. A series of images capturing the development of structures, seen as dark regions, associated with an equatorial instability process. The images are of the 630.0-nm emission that occurs naturally in the Earth’s ionosphere/thermosphere system and were recorded from the site of the Haleakala Volcano on Maui, Hawaii. These structures are modified by the passage of a traveling ionospheric disturbance, seen as an enhancement traveling from northeast to southwest, associated with energy input in the auroral region.
to take place; the four essential components of IHY are defined; synergy/co-ordination discussions with professional organisations; establishment of CIP structures; launch of the IHY UNBSS and IGY Gold History Programmes;

• 2005: continuation of national and regional co-ordination meetings; synthesis and co-ordination from regional to international; precursor activities for each of the four main components continue; instrument deployment begins and CIPs proposed by individual community members begin to form the fabric of the IHY science campaigns;

• 2006: focus on the implementation of the four main IHY components and on the integration of national and local activities with the international IHY community; prototyping year, particularly for numerous CIPs and outreach activities that serve as trailblazers and/or testbeds;

• 2007–2008: IHY is launched as an integrated international programme. Science, Observatory Development, Outreach and History activities occur around the globe, and the efforts of each individual component and region are multiplied in impact by their co-ordination with the worldwide effort; and

• 2008–2009: IHY activities continue. Results of the IHY CIPs and science campaigns are analysed at a wide range of workshops and analysis activities; Observatory Development continues through IHY UNBSS legacy programmes; Outreach activities incorporate major scientific results and breakthroughs.

Summary

The International Heliophysical Year, on the 50th anniversary of the International Geophysical Year, is a tremendous opportunity to advance our understanding of the Sun-Earth system, and to demonstrate the beauty, relevance, and significance of Earth science to the people of the world. Scientists and educators in African nations will play important roles in the IHY, and each of the IHY’s four programmatic thrusts benefits from strong African participation. For the Scientific Thrust, African scientists participating in and leading research programmes will result in scientific advances that make optimal use of instrumentation currently in place in Africa or to be deployed in Africa as part of the IHY. For the Observatory Development Thrust, Africa is the most crucial region because of its positioning relative to the equator and because of the scientific advances made possible by establishing instrument arrays throughout the African continent. The Education Thrust benefits greatly because of special activities, such as the March 2006 trans-African solar eclipse, and because of the educational opportunities made available by coordination with and among African scientific institutions. The History Thrust will be able to focus on the contributions of individual scientists during the IGY, as well as the developments in space science over the past 50 years. The richness of IHY activities occurring on the African continent and the dedication of the African scientists and leaders are fundamentally important to the global success of IHY.

References

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