Preparing for the International Heliophysical Year (IHY) 2007

J. M. Davila, N. Gopalswamy and B. J. Thompson

NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

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, Sun-Earth Connection, planetary science and the heliosphere in general. Now, 50 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.

Index Terms. Heliophysics, ionosphere-thermosphere, magnetosphere, Sun.

1. Introduction

On October 4, 1957, only 53 years after the beginning of flight, the launch of Sputnik 1 marked the beginning of the space age; as mankind took the first steps to leaving the protected environment of Earth's atmosphere. Discovery of the radiation belts, the solar wind, and the structure of Earth's magnetosphere prepared the way for the inevitable human exploration to follow. Soon, Cosmonauts and Astronauts orbited Earth, and then 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, humans will begin to explore the local interstellar medium. It is inevitable that, during the next 50 years, exploration of the solar system including the Moon, Mars and the outer planets will be the focus of the space program, and like 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. However, the tradition of international science years began almost 125 years ago with the first international scientific studies of global processes of the Earth's poles in 1882-3. A second International Polar Year (IPY) was organized in 1932, but a world wide economic depression curtailed many of the planned activities. A more complete history of international years is given by Davila et al. (2001), and others (Chapman, 1959; Sullivan, 1961; Hyde, 1957). The IHY will continue the legacy of these previous events, extending global synoptic study to the heliosphere.

2. A brief history of previous international years

The first world-wide observation network was organized by Carl Freidrich Gauss in 1832, after the suggestion by Alexander Humbolt. The focus was to obtain a synoptic, set of observations of the global magnetic field of the Earth. With the support of the British Royal Society and the Russian Czar, Gauss was able to set up a network of 53 stations in places like Greenwich, Dublin, Toronto, St Helens, Cape of Good Hope, and Tasmania. The East India Company added 4 more in India and Singapore, and Russia established an additional 10 stations, plus one in Beijing. The first world-wide network resulted in the identification of "Magnetic Storms," a term coined by von Humbolt.

Fig. 1. Karl Weyprecht proposed the first International Polar Year in January 1875.

The First International Polar Year was the idea of an Austro-Hungarian Naval lieutenant Karl Weyprecht (Fig. 1). Weyprecht had just returned from a polar expedition where he commanded one of the research vessels. In January 1875 at the Academy of Sciences in Vienna, Weyprecht expressed his ideas to establish an international collaboration to obtain a set of simultaneous observations, extending over a considerable time period, at various locations around the Arctic (Heathcote, 1959). The concept was presented again in September 1875 at the 4th Meeting of the Association of

German Naturalists and Physicists at Gratz. In 1877 a detailed program was prepared and submitted to the International Meteorological Congress. In 1879 the International Meteorological Congress met in Rome and recognized the importance of the proposal.

On October 1-5, 1879 the 1st International Polar Conference (IPC) met at Hamburg. It was determined that a minimum of eight Arctic stations was needed, to obtain observations of at least one-year duration. The Conference also established the IPC with representatives from Austria, Hungary, Denmark, France, Germany, The Netherlands, Norway, Russia, and Sweden. Dr. G Neumayer of Hamburg was the first Commission president. In July 1880 the 2nd IPC met at Berne, Switzerland. There an Italian representative joined the existing representatives, and Prof. H. Wild became the second president. On August 1, 1881 the 3rd IPC met at St Petersburg. The United States joined the group, and a program of observations was adopted. The First International Polar Year began Aug 1, 1882 and continued for 13 months to Sep 1, 1883. Scientific results and observational data were published in the Bulletin of the International Polar Commission. In 1884 and 1891 the 4th and 5th Polar Conferences were convened. Weyprecht did not live to see the culmination of his grand concept. He died on March 29, 1881. One of the primary science advances was the improved understanding of the auroral oval (Fig 2).

In 1927 Dr. J. Georgi at Deutsche Seewarte in Hamburg suggested that a Second International Polar Year be conducted on the fiftieth anniversary of the first (Laursen, 1959). A proposal was submitted to the International Meteorological Committee, and then forwarded to Reseau Mondial and Polar Meteorology. In June 1928 an informal organizational meeting was held in London to discuss plans for the event. Finally, in 1929 the Meteorological Conference of Directors in Copenhagen endorsed the plan for the cooperative study of magnetic, auroral and meteorological phenomena. Also in 1929 the International Cloud Commission passed a resolution for an international year for clouds coinciding with the Polar Year. The Commission for the Polar Year 1932-1933 was appointed to prepare detailed plans for the observations to be made and the methods for making them. Collaboration was established between the Commission for the Polar Year and the International Union of Geodesy and Geophysics. In August 1930 the first meeting of the Commission for the Polar Year took place in Leningrad, to further refine proposals for the Polar Year. In Dec. 1930 at a meeting in London the Commission prepared a detailed report containing proposals, for research programs in meteorology, terrestrial magnetism, atmospheric electricity, aurora, and aerology. At a subsequent meeting in Sep. 1931 the Commission for the Polar Year, despite being urged to delay due to poor economic conditions worldwide, decided to go ahead with the Polar Year program. On 1 Aug. 1932 the Second International Polar Year began. It continued until 1 Sep. 1933.

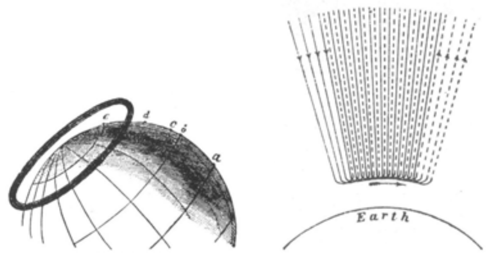

Fig. 2. The first IPY resulted in improved understanding of the auroroal oval (left), while during the period of the second IPY the concept of Birkland currents (right) was developed during IPY-2.

The Commission introduced the concept of "International Days". The scientific objective was to study phenomena on the largest possible scale with simultaneous observations, the same as the last previous polar year. The most significant new development that affected how the program was conducted was the advent of radio communication.

In 1950, a proposal for the International Geophysical Year, 25 years after the Second Polar Year, was brought before the Mixed Commission on the Ionosphere, which endorsed it.

Fig. 3. Professor James van Allen (left) and two colleagues celebrate the successful launch of Explorer during the IGY, which eventually demonstrated the presence of Earth's radiation belts.

The Mixed Commission on the Ionosphere was formed by the International Council of Scientific Unions (ICSU) under the sponsorship of the International Union for Scientific Radio (URSI) with the cooperation of the International Astronomical Union (IAU) and the International Union for Geodesy and Geophysics (IUGG). The IUGG drew up a tentative program, and adopted a resolution to transmit it to the International Council of Scientific Unions (ICSU), which sponsored the event. All bodies endorsed the proposal by 1951. The IGY is generally recognized as the dawn of the space age (Fig. 3).

World Days (typically 3 days per month) were planned as part of the IGY. During these periods special programs of research, focused on short-timescale events or special events (e.g. during the times of meteor showers), were carried out.

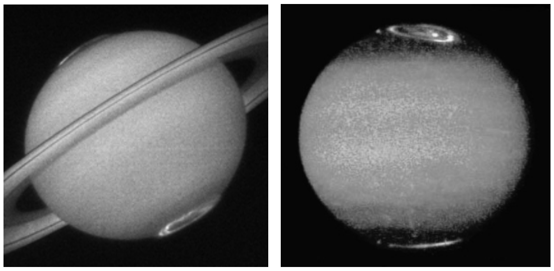

Fig. 4. Aurorae, visible in these photographs of Saturn (left) and Jupiter (right) are common features in the magnetospheres of planets in the solar system. These provide an excellent example of Universal Processes that can best be studied through a cross-disciplinary study involving a number of plasma environments.

3. Universal processes

The large scale structure of objects within the universe is determined mainly by two forces, gravitation and magnetism. Gravity is responsible for the structuring of planets, planetary systems, stars, galaxies, clusters of galaxies, and gravitation is the dominant force controlling the evolution of the universe since the big bang. Magnetism, a second long-range force is dominant in the rarefied, ionized matter. Magnetic forces at work within the plasma environment of the solar system is responsible for the storage and subsequent release of large quantities of energy in solar flares, coronal mass ejections (CMEs), magnetic storms, and other transient phenomena within the solar system. In addition the magnetic field of solid bodies like the Earth, Jupiter, Saturn, and even the Sun, dominate and define the structure of the space environment surrounding them.

It is now widely recognized that evolution in the solar system plasma proceeds through a set of Universal Processes (Crooker, 2004), i.e. reconnection, particle acceleration, and plasma wave generation and propagation. By studying these Universal Processes together, in diverse environments, and in a comparative way, new scientific insights will be gained (Fig. 4). 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 shocks separate the major regions in the heliosphere. Shock formation, and particle acceleration are universal processes. (2) Aurorae 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 magnetized 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.

4. Goals and objectives

The IHY has three primary objectives, (1) Advancing our Understanding of the Fundamental Heliophysical Processes that Govern the Sun, Earth and Heliosphere; (2) Continuing the tradition of international research and advancing the legacy on the 50th anniversary of the International Geophysical Year; (3) Demonstrating the Beauty, Relevance and Significance of Space and Earth Science to the World

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

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 IGY on its 50th Anniversary.
6. Communicate unique IHY results to the scientific community and the general public.

IHY is an integrated program of many diverse activities working on an international level to achieve all of the above goals.

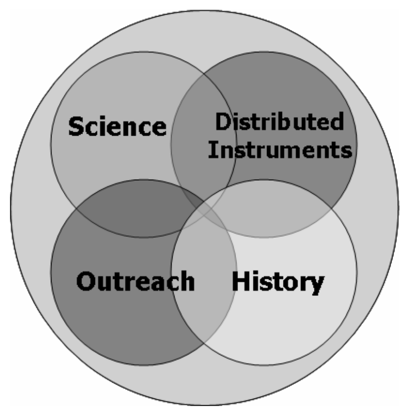

Fig. 5. The objectives and goals of the IHY are satisfied through the implementation of four interlinking thrusts, encompassing scientific research, observatory development, history and outreach.

5. Plans for the IHY

The International Heliophysical Year Program has four main components (Fig. 5), 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 Program,** 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 **"IGY Gold" History Initiative,** preserving the history and legacy of IGY 1957 by identifying and recognizing planners of and participants in the first IGY, preserving and making available items of historical significance from the IGY, and organizing commemorative activities and events.

5.1 Science activities

During the IHY, Coordinated Investigation Programs (CIPs), utilizing space- and ground-based observatories will be organized to study universal processes at work throughout the solar system (Harrison et al., 2005). Maximum use of the internet and world-wide-web infrastructure will be used to facilitate communication and organization. These research campaigns will operate similar to SOHO Joint Observing Projects (JOPs). 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 (Fig. 3). Discipline coordinators will review all suggestions and organize similar CIPs into observing programs that can actually be implemented. Observatory coordinators, representing each of the instruments participating in the IHY will assist in this process. Later the observing programs will be organized into cross-disciplinary topical Universal Process Workshops to discuss and communicate the scientific results of the IHY campaigns.

Joint campaigns with organizations, having overlapping goals, minimize the resources required for the IHY. The IHY will seek to identify areas where the IHY can support programs like CAWSES (Climate and Weather of the Sun-Earth System), IPY (International Polar Year), eGY (Electronic Geophysical Year), and The 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 will be carried out during 2005, leading to detailed cooperation and coordination in 2006. IHY workshops and coordination meetings will be held in conjunction with SHINE, GEM, and CEDAR and in conjunction with major society meetings (e.g. AGU, and EGU) whenever possible.

5.2 Observatory development program

Through a cooperative program with the United Nations Basic Space Science (UNBSS) program 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) 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. As a result of that meeting, the UNBSS program has dedicated its resources and activities through 2009 to providing the IHY a link into developing countries. The program has provided more than 2000 scientist contacts in almost 200 countries, many of which 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 programs. This includes the deployment of small, inexpensive instruments such as magnetometers, radio antennas, GPS receivers, and all-sky cameras. 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 program will attempt to address this by facilitating instrument deployment in these sparsely covered regions of the world.

The basic Observatory Development concept is summarized as follows

- The lead scientist or principle 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 team
- All data, and data analysis activity is shared with all members of the group
- Publications and meetings involve the participation of all team members when possible

The Observatory Development program 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 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 program, a collaboration between the IHY and the United Nations Basic Space Science (UNBSS) Initiative, centers 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 for the Workshop will include 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.

5.3 Education and public outreach

One of the primary objectives of the IHY/UNBSS program 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 for a guide in teaching, and fully participate in the analysis of the data from the array and in the scientific discoveries that result.

5.4 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 IHY Workshop in Boulder, Colorado in February 2005. The Gold Club award consists of a certificate and a pin with the IGY logo embossed on it. To be eligible for membership, one must (1) have participated in the IGY in some way, and (2) provide some historical materials (copies of letters, books, etc.) to the IHY history committee. These materials will provide a lasting legacy of the IGY for generations to come. This is cooperative effort between the IHY, the History Committee of the AGU, and the IAGA History Committee.

6. Schedule

Planning for the IHY is organized into seven regions: North America, 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 begin the joint international planning process. International planning will continue in Regional and International Organizing meetings. Additional information on meeting plans and regional organizations is available at the IHY website (http://ihy2007.org).

Major planning activities have taken place for all aspects of the IHY program. Hundreds of local, regional and international planning conferences and meetings have occurred. 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, Observatory Development, Outreach, and History), and a means by which all of these activities will be coordinated, are necessary to enable the individual organizations and institutions to develop unique IHY programs that suit their own goals and challenges. It is the activities and programs developed by these individual organizations and institutions that form the “building blocks” of the IHY. Therefore, the IHY’s international planning activities have focused 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 program in coordination with the international effort. 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 program.

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 of IHY, 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 focused 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 activities 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 programs and new “host” sites for these activities continue to be identified on a regular basis. The component has already launched several activities worldwide, emphasizing the linkage to individual local programs, while the IGY Gold History Program was implemented in 2004 with plans to continue through 2009.

A general description of the IHY timeline is as follows:

2001-3: Establishment of IHY Secretariat; establishment of the main elements of the IHY program; initialization of planning activities on all continents

2004: National and Regional coordination meetings begin to take place; the four essential components of IHY are defined; synergy/coordination discussions with professional organizations; establishment of CIP structure; launch of the IHY UNBSS and IGY Gold History Programs

2005: Continuation of national and regional coordination meetings; synthesis and coordination from regional to international; precursor activities for each of the four main components continue to happen; 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

2007-8: IHY is launched as an integrated international program. 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 coordination with the worldwide effort

2008-9: IHY activities continue. Results of the IHY CIPs and science campaigns are analyzed in a wide range of workshops and analysis activities; Observatory Development continues through IHY UNBSS legacy programs; Outreach activities incorporate major scientific results and breakthroughs.

7. 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 programs will result in scientific advances that make optimal use of African instrumentation. For the Observatory Development Thrust, Africa is the most crucial region because of its positioning relative to the Earth's 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 trans-African solar eclipse of March 2006, and because of the educational opportunities made available by coordination with 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 during the past 50 years.

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