THE INTERNATIONAL HELIOPHYSICAL YEAR

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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, Sun-Earth Connection, planetary science and the heliosphere in general. Now, 50 years later, we have the unique opportunity 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 was an international effort to coordinate scientific research, and the deployment of scientific instrument arrays, preserve the history of the IGY, and to raise the public awareness of space physics.

Keywords: Heliophysics, Sun, Heliosphere, Magnetosphere, Ionosphere-thermosphere

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, man is beginning 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.

We have the unique opportunity to further advance our knowledge of the global heliosphere, space weather and its interaction with planets, and the interstellar medium through the International Heliophysical Year (IHY) in 2007 currently underway. The IHY has four main objectives, (1) the comparative study of Universal Processes that are essential for understanding planetary environments in a number of solar system settings, (2) the deployment of distributed arrays of small instruments to observe global phenomena in the ionosphere and heliosphere, (3) the development of international collaborations to foster space science research, and (4) the communication the excitement of space science to the public.

2 A BRIEF HISTORY OF PREVIOUS INTERNATIONAL YEARS

The IHY 2007 coincided with the fiftieth anniversary of the International Geophysical Year (IGY) in 1957, one of the most successful international science programs of all time.

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.

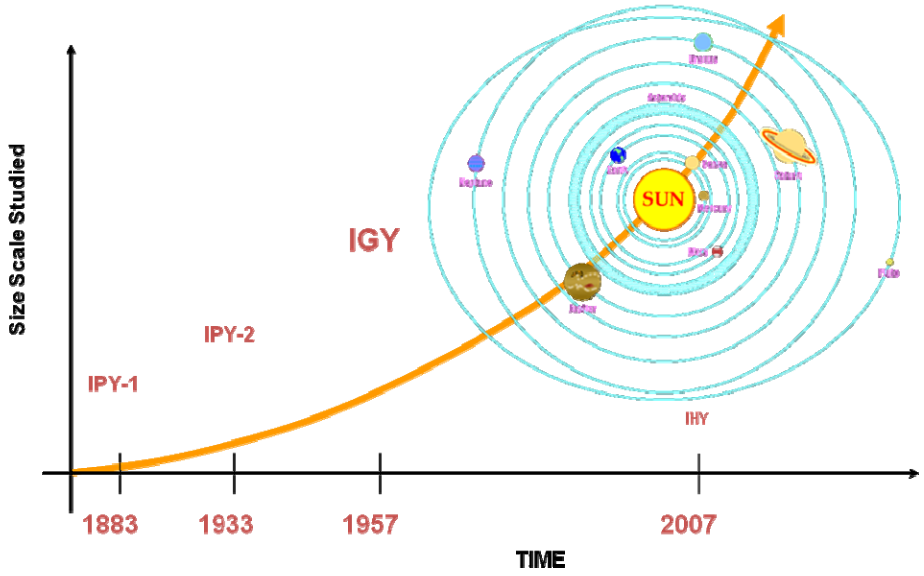

Figure 1 The International Heliophysical Year builds on the legacy of previous Science Years by extending global synoptic studies to the entire Solar System.

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 (Figure 1). The 2nd 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 continues the legacy of these previous events, extending global synoptic study to the heliosphere (Figure 1)..

3 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, six major goals were identified for the IHY, each corresponding to a unique opportunity afforded by:

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.

To accomplish these goals the International Heliophysical Year Program was divided into four main components. (Figure 2)

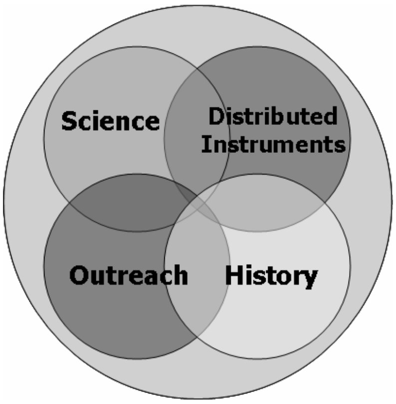

Figure 2 The primary thrusts of the IHY.

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;

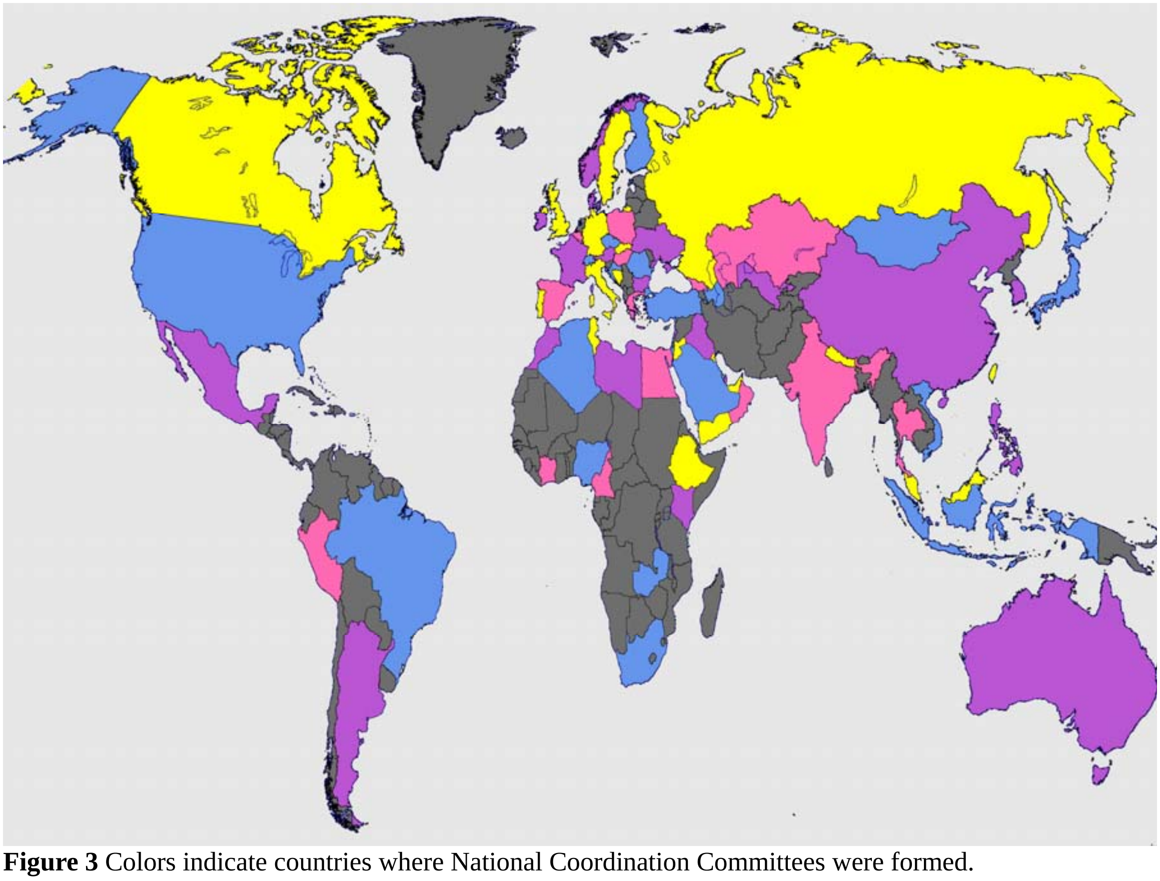

Figure 3 Colors indicate countries where National Coordination Committees were formed.

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.

IHY planning committees were organized in more than 60 countries. In addition to collaborating on the international objectives, each committee planned and implemented unique local activities.

4 THE SCIENCE OF UNIVERSAL PROCESSES

The large scale structure of the universe is controlled mainly by two forces, gravitation and magnetism. Gravitation is the dominant force controlling the evolution of dense matter in the universe, including planets, stars, planetary systems, galaxies, and clusters of galaxies. Magnetism, a second long-range force, is dominant in the rarefied, ionized matter which generally occupies the space between gravitationally condensed regions. The most easily observed example is the plasma environment of the solar system where the magnetic field 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. 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, and exhibit their own energetic evolution.

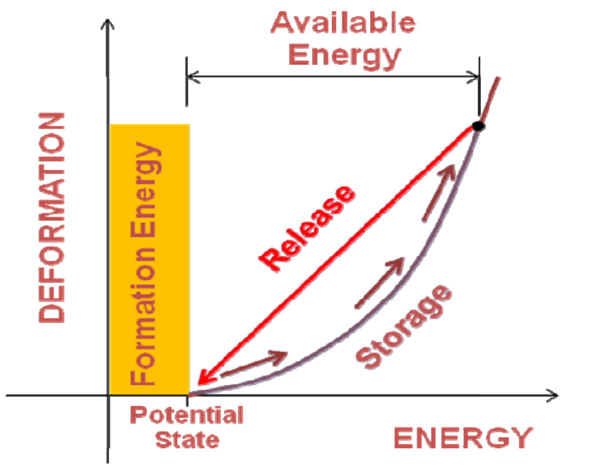

Figure 4 Magnetic energy is stored in structures over a long time-scale, then released suddenly.

A common property of both gravitationally and magnetically structured objects is their ability to store, release, and transfer energy in response to internal and external drivers. For example thunderstorms generate atmospheric gravity waves that transfer energy into the stratosphere, the magnetosphere of Earth continually adjusts in response to the variable solar wind, and the magnetic field of the Sun is constantly buffeted by convective motions in the photosphere.

To illustrate this point, consider an isolated magnetic. The magnetic field of the Sun is largely contained in individual loops which maintain their identity while interacting with the surrounding corona. Typically these loops are potential, i.e. current free, which is the lowest energy state for the structure. Convective motions at the surface of the Sun twist and deform the loop causing it to store energy. When the stored energy reaches a large enough level rapid energy release can be triggered returning the loop to its potential state, resulting the production of plasma flows, particle acceleration, waves, or heating.

The evolution of magnetic structures and planetary atmospheres in the solar system proceeds through a set of Universal Processes (Crooker2004), e.g. reconnection, particle acceleration, wave generation and propagation, etc. Energy is stored in magnetic structures on the Sun, in Earth's magnetosphere, the magnetospheres of other planets, and in the heliosphere itself. Each of these structures evolves in a similar way. By studying these Universal Processes together, in diverse environments, and in a comparative way, new scientific insights are gained. By studying these Universal Processes together, a deeper understanding of the underlying physics can be obtained. These processes are evident in astrophysical settings as well. The study of Universal Processes in heliophysics provides a sound physical basis for the interpretation of astrophysical phenomena.

During the IHY, Coordinated Investigation Programs (CIPs), utilizing space- and ground-based observatories were 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 was used to facilitate communication and organization. These research campaigns operated 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 workshops have been organized, and additional workshops will be performed during a series of workshops and the final results will be published and made available to the science community.

CIPs were entered by individuals within the research community. Discipline coordinators reviewed all suggestions and organized similar CIPs into observing programs that were actually implemented. Observatory coordinators, representing each of the instruments participating in the IHY assisted in this process. At the present time, the observing programs are being 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 supported joint research programs with organizations like CAWSES (Climate and Weather of the Sun-Earth System), IPY (International Polar Year), eGY (Electronic Geophysical Year), and The Year of Planet Earth.

5 OBSERVATORY DEVELOPMENT PROGRAM

Through a cooperative program with the United Nations Basic Space Science (UNBSS) program, the IHY has worked to 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.

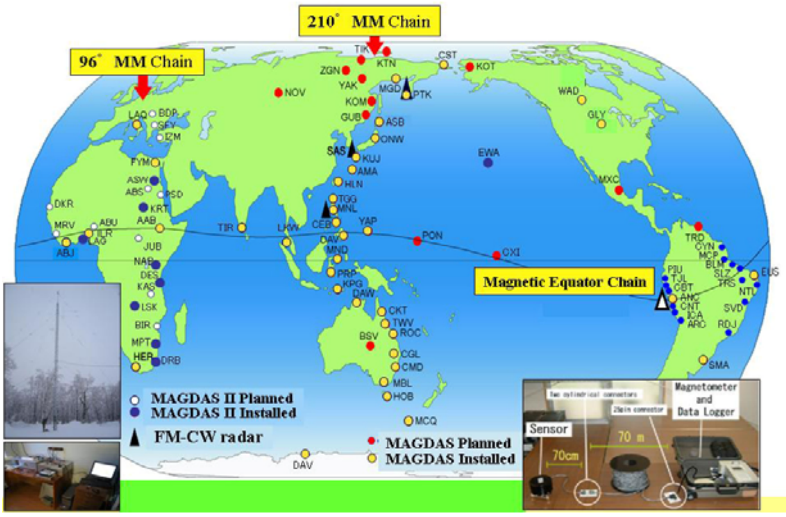

Figure 5 Locations of the MAGDAS magnetometers, many of which were installed as part of the IHY-UNBSS instrument program.

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, 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 program addresses this by facilitating instrument deployment in these sparsely covered regions of the world. MAGDAS (Figure 5) is one example, a more complete map is shown in Figure 6.

The basic Observatory Development concept is summarized as follows:

- The lead scientist or principle investigator provides 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.

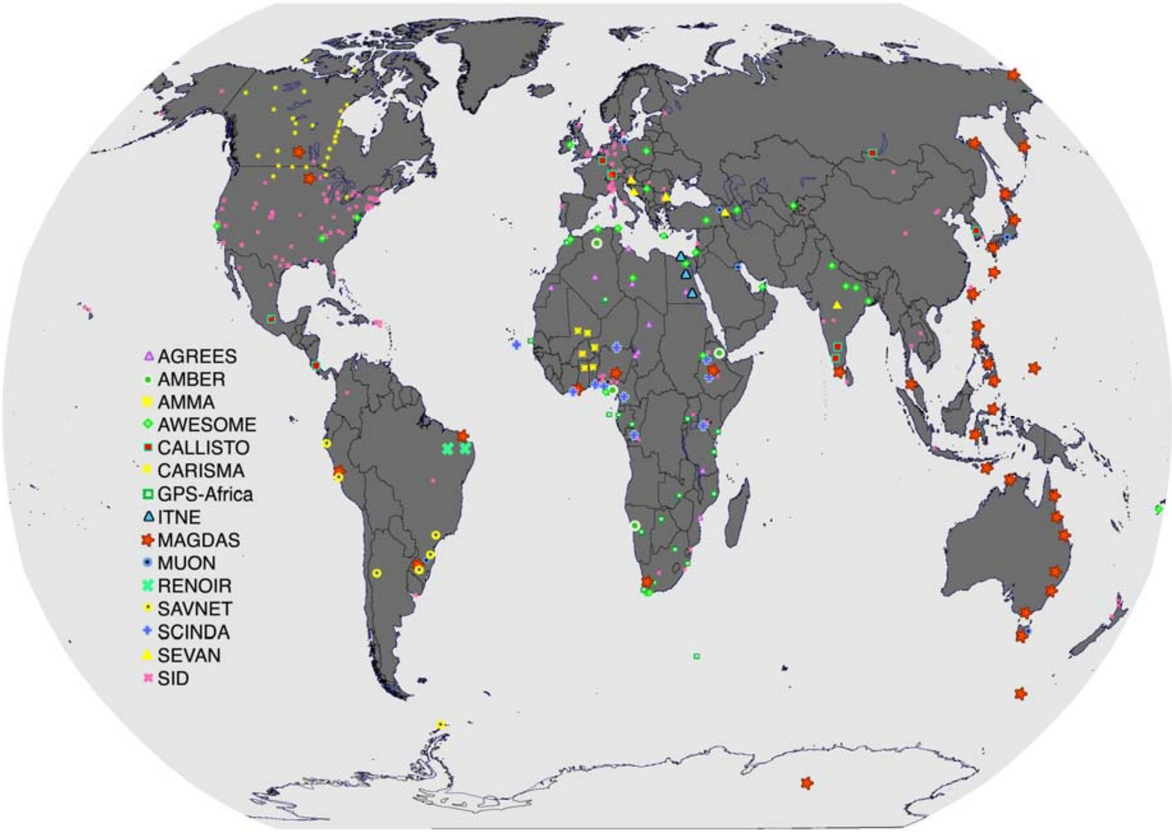

Figure 6 During the IHY the deployment of several small instrument arrays was coordinated.

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. Additional workshops in India, Bulgaria, and South Korea continued this work.

6 EDUCATION AND 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.

For example, IHY-Europe launched a special event called “Open Doors Day,” where IHY institutes and observatories around the world invited the public to learn about IHY and heliophysics. 80 institutes in Europe participated, including Czech Republic, Finland, France (5 institutes), Germany (5), Hungary (6), Italy (9), Ireland, Slovakia (4), Spain (11), Sweden, Switzerland (4), and the UK (3). “Open Doors Day” drew over 20,000 participants across Europe. The SWEETS mobile exhibition helped attract thousands of visitors to the Belgian Open Doors Day at the Royal Observatory of Belgium, the Belgian Meteorological Institute, and the Belgian Institute for Space.

The international science community was invited to a "Joint CAWSES/IHY Virtual Conference: The State of the Sun-Earth System During Extreme Space Weather." The conference was held online from November 13 – 17, 2006, and virtual sessions on heliophysical topics from the Sun to the ionosphere allowed scientists from around the world to participate. The spirit of the virtual conference was the advancement of the "next era" of scientific interaction, where researchers from around the globe can easily and efficiently collaborate

The 2006 Sun-Earth Day, held March 29, centered on a total solar eclipse. It attracted participants in 175 countries, more than 135,000 teachers and students, and an audience of more than 1.5 million for the webcast stream. 2007's Sun-Earth Day, "Living in the Atmosphere of the Sun," held on March 20, was subtitled "Celebrating International Heliophysical Year" and heralded the official opening of IHY. In addition to events held around the world, it attracted a web stream audience of nearly 2 million. 2008's Sun-Earth Day focused on the effects of the interconnected heliophysical system by launching events about "Space Weather Around the World." It attracted similar audiences, and featured a supplemental event in August 2008 called "Eclipse – Live From China." The connections forged between the Sun-Earth Day program and the educators throughout the international IHY community ensure that future Sun-Earth Days will have an even greater audience, and the worldwide impact will continue to grow.

7 IHY GOLD HISTORY PROGRAM

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.

Figure 7 IGY participants were awarded a pin with the IGY logo to recognize their contribution to Space Science.

There have been hundreds of people, from all of the continents, inducted into the IGY Gold Club, and a great deal of valuable historical information has been obtained and preserved for posterity. The first award was presented at a special IHY ceremony to Alan Shapley, who served as Co-chair of the U.S. IGY Committee. Additionally, the University of Iowa had a special presentation for James Van Allen, Explorer I project scientist and one of the original proposers of the International Geophysical Year. World Space Week and Yuri's Night World Space Parties (described in Section V) are both IHY partner programs inspired by the dawn of the space age. These events were celebrated annually throughout IHY, and many individual IHY nations supported these programs with their own events.

8 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 played 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 happening 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.

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