NASA Facts

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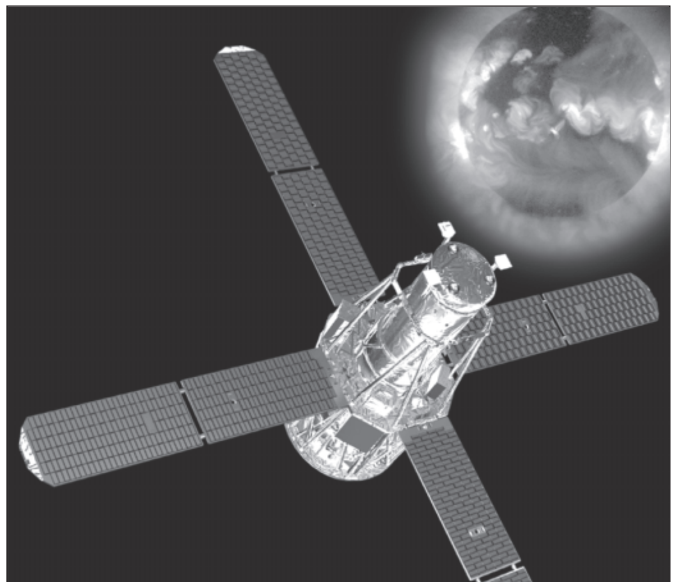
Exploring The Most Powerful Explosions in the Solar System with NASA's HESSI Spacecraft

Solar flares, the solar system's mightiest explosions in the atmosphere of the Sun, are packed with as much energy as a billion megatons of TNT. Caused by the violent release of magnetic energy, in just a few seconds flares can accelerate particles to high energies and heat material to tens of millions of degrees.

Electrically charged particles – electrons, protons and other ions – in the solar atmosphere are accelerated during a flare to very high velocities, some almost to the speed of light (186,000 miles per second). When some of these particles crash into, or are deflected by other particles in the Sun's atmosphere, some of their energy is converted into gamma rays and X-rays that can escape from the Sun.

X-rays that reach the Earth can change the structure of the Earth's electrified upper atmosphere, or ionosphere. The sort of intense energy release caused by solar flares can interfere with spacecraft electrical systems and orbits, and affect astronaut activities.

Analyzing and predicting solar flare activity is imperative because we are becoming increasingly dependent upon this advanced technology to support our daily activities.



Artist concept of the HESSI spacecraft studying solar flares from its circular orbit 373 miles (600 kilometers) above the Earth. (Image courtesy of Spectrum Astro, Inc.)

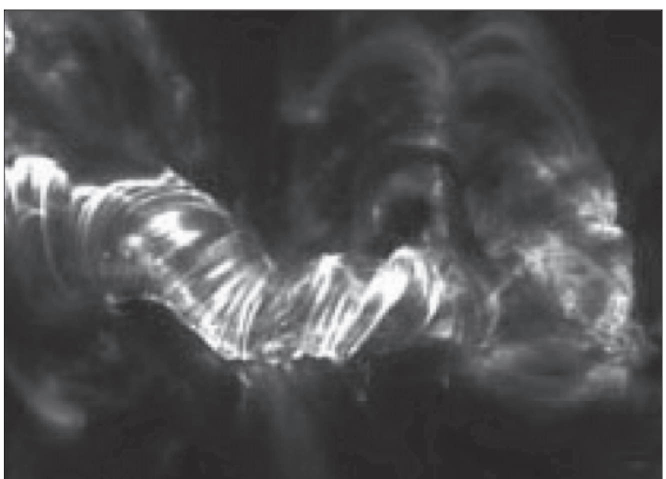
Solar flares occur in areas of strong magnetic fields within the solar atmosphere called active regions. These regions often contain sunspots, which increase as the peak in solar activity occurs.

The launch of NASA's High Energy Solar Spectroscopic Imager, or HESSI, is timed to coincide with a peak in the Sun's 11-year magnetic activity cycle.

Scheduled to launch from Cape Canaveral Air Force Station, FL aboard a Pegasus rocket during the summer of 2001, HESSI will study the dynamics of solar flares during the Sun's intense period of activity. Data produced by HESSI will provide scientists with the finest images and spectra ever made using the gamma rays and the highest energy X-rays emitted by these flares.

HESSI's New Approach

During a solar flare, large numbers of electrically charged particles are rapidly accelerated to high energies and the gas is quickly heated to tens of millions of degrees. The high-energy particles and the gas emit all types of electromagnetic radiation over the entire energy range, from low-energy radio through visible light to the highest energy X-rays and gamma rays. Unable to penetrate the Earth's atmosphere, these X-rays and gamma rays can only be detected from space.



Aftermath of a solar flare, captured by NASA's Transition Region and Coronal Explorer (TRACE), in the light emitted by gas at about 2.7 millions degrees Fahrenheit. The flare is enormous - 23 times the size of the Earth.

(Image courtesy of NASA/Lockheed Martin Solar and Astrophysics Laboratory)

Although instruments onboard Skylab, the Solar Maximum Mission, Yohkoh, and other spacecraft have recorded flares in X-rays for more than 30 years, and ground-based observatories have recorded visible and radio outbursts, scientists still cannot differentiate between mechanisms for accelerating the particles and heating the gas.

In order to understand what triggers a flare and how it releases energy, scientists need to identify the different kinds of particles being accelerated, find the regions in a flare where the acceleration occurs, and determine when in the flare explosion the particles get accelerated.

HESSI's unprecedented ability to make images of solar flares in X-rays and gamma rays will enable scientists for the first time to track accelerated flare particles, exploring the sudden energy release in a way never before possible.

The sole instrument aboard HESSI will produce high-resolution spectrographic movies of a flare's rapidly changing features as seen in X-rays and gamma rays.

The Imaging Spectrometer

The imaging spectrometer aboard the spacecraft generates pictures using a method unlike conventional telescopes and cameras that need lenses or mirrors to focus the light to form images.

Because powerful X-rays and gamma rays penetrate all materials to some extent and cannot be easily focused, researchers are using closely spaced slats of high-density metal bars arranged as a grid to selectively block X-ray and gamma ray photons (particles of light).

As the spacecraft rotates, photons from a flare will be alternately blocked and then allowed to pass through spaces between the slats to detectors. To the detectors, the source will appear to be brightening and darkening in a regular pattern.

Just like someone casting shadow figures knows that the position and shape of their hands determines the shadow image formed, the particular pattern seen by the HESSI detectors will depend on the location of the source in relation to the spectrometer's rotating grids.

An ordinary spectrometer separates light into its component colors, which correspond to different wavelengths and energy levels similar to the way a prism separates white light into a rainbow of distinct colors.

Analyzing light by its wavelength and intensity allows astronomers to learn a great deal about the object emitting the light (such as its temperature, chemical composition, and motion).

However, the “colors” of X-rays and gamma rays are invisible to the human eye. Unlike a traditional spectrometer, the one aboard HESSI does not spread the spectrum of colors from a solar flare (X-rays and gamma rays do not readily bend when passing through matter). Instead it does this electronically.

X-ray/gamma-ray detectors aboard the spacecraft count the number of photons passing through the grids and measure their energy with exceptional precision. Computers back on Earth will use this information to create high-resolution pictures showing the color, or energy, of each part of the solar flare.

These "color" images will allow scientists to significantly advance their understanding of the fundamental high-energy processes that lie at the heart of the solar flare phenomenon.

Using Space Age Technology

The scale of features to be imaged with HESSI requires an angular resolution of two arcseconds - which is equivalent to seeing a penny at a distance of more than a mile.

HESSI will achieve this astonishing feat in X-rays by using tungsten and molybdenum grids with extremely fine slits, some as narrow as 20 microns wide (less than one thousandth of an inch). The manufacture of these grids was made possible by newly developed micro-fabrication techniques.

The HESSI spectrometer carries nine germanium crystals, one under each grid pair. This is the largest and most advanced array of germanium detectors ever flown in space.

These artificially grown crystals are pure to over one part in a trillion and maintained at a temperature of -324 degrees Fahrenheit (-198 Celsius) using a mechanical cooler. When cooled to cryogenic temperatures and a high voltage up to 4,000 volts is put across them, the crystals convert incoming X-rays and gamma-rays to pulses of electric current. The amount of current, proportional to the energy of the photon, is then measured by sensitive electronics.

Each HESSI detector can measure photons over a range of about a factor of 6,000 in energy. For comparison, the human eye can only measure photons with a range in energy of about a factor of two.

Mission Management

HESSI is the sixth Small Explorer (SMEX) mission and the first SMEX to be managed in the 'principal investigator' mode.

Professor Robert P. Lin of the University of California, Berkeley, is the principal investigator for HESSI. Lin is responsible for most aspects of the mission, including instrument and spacecraft development, operations, and data analysis.

The Explorer Program Office at NASA's Goddard Space Flight Center in Greenbelt, MD provides program management and technical oversight.

The HESSI mission costs about $85 million, which includes the spacecraft, science payload, launch vehicle, mission operations, and data analysis.

Hardware Providers

UC Berkeley provided the spectrometer, including the germanium detectors (fabricated by ORTEC, Oak Ridge, TN). They also provided the electronics (in conjunction with the Lawrence Berkeley National Laboratory, Berkeley, CA), integration and testing of the spacecraft, ground station, and the HESSI mission and science operations centers. The University also is responsible for operations and data analysis during the mission.

Goddard was responsible for the imaging grids (fabricated by Tecomet, a subsidiary of Thermo Electron, Inc. of Waltham, MA and Van Beek Consultancy in The Netherlands).

Goddard also provided the cooler for the detectors, fabricated by Sunpower, Inc. of Athens, Ohio, and provides data archiving as well as a portion of the data analysis for the mission.

The Paul Scherrer Institut in Switzerland provided the telescope tube assembly and optical systems, which determine the spacecraft's orientation.

Spectrum Astro, Inc. of Gilbert, AZ, built the HESSI spacecraft and provided integration support.

Mission Websites

For complete, up-to-date information about the HESSI mission, go to:

http://hesperia.gsfc.nasa.gov/hessi/
http://hessi.ssl.berkeley.edu

For more information about how HESSI produces solar flare images, go to:

http://hesperia.gsfc.nasa.gov/hessi/hessi_show_image.htm