NASA Facts

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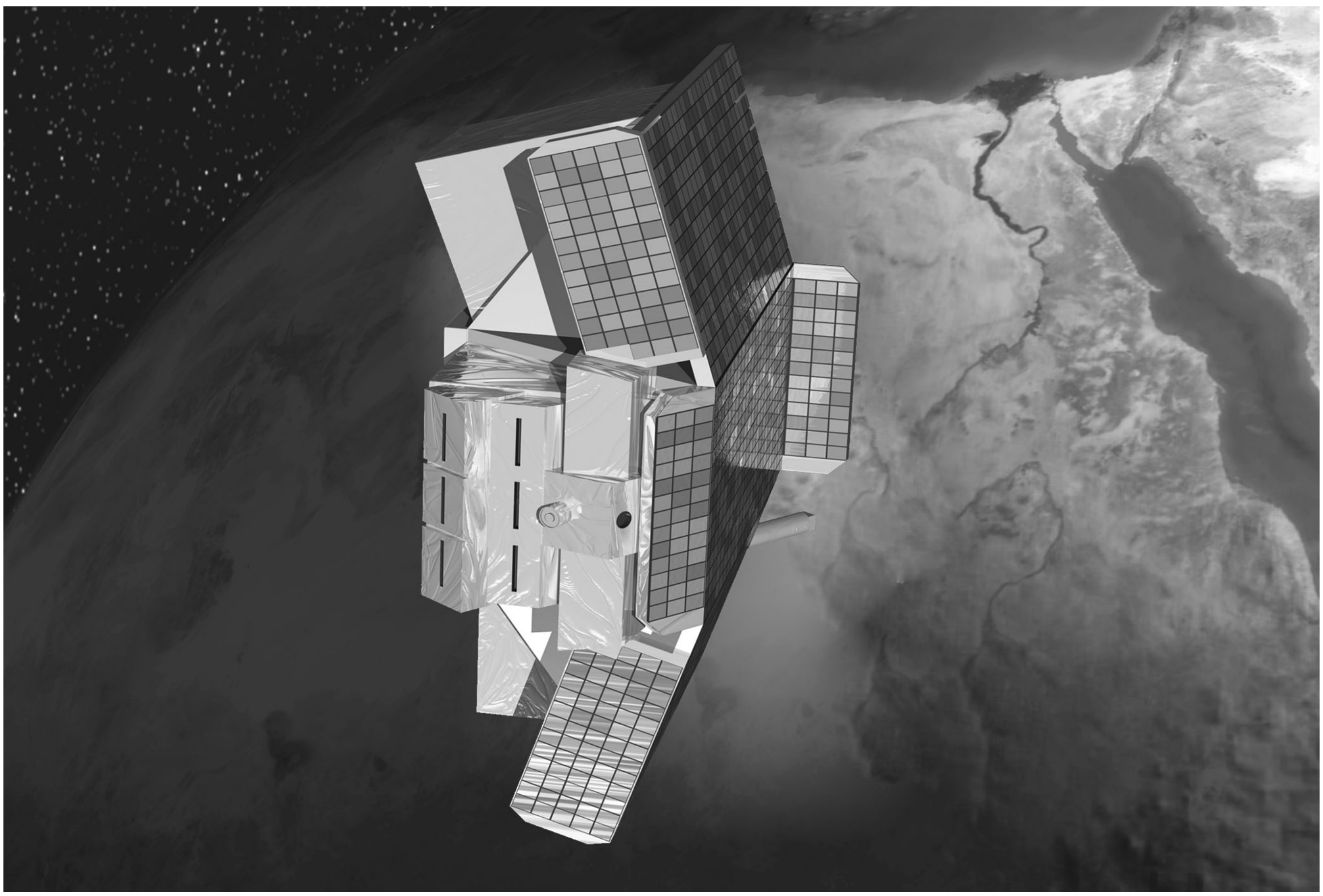
Cosmic Hot Interstellar Plasma Spectrometer (CHIPS): Studying the Interstellar Medium



The Cosmic Hot Interstellar Plasma Spectrometer satellite is the first NASA University-Class Explorer mission. The CHIPS mission is studying the very hot, very low-density gas in the vast spaces between the stars in our local astronomical neighborhood. The majority of the power radiated by this hot gas occurs in the short-wavelength, extreme ultraviolet region of the electromagnetic spectrum, centered around 170 Angstroms (Å). This is a relatively unsurveyed band and the emissions at this wavelength may contain important clues about the process of cooling that takes place in the Local Bubble of the Interstellar Medium.

In our galaxy alone, there are several hundred billion stars. Nearby stars are easy to see, although most of the stars in the Milky Way are so distant that their combined light appears as a fuzzy band stretching across the sky on a clear night. Equally easy to see is the space between the stars - but how often do you wonder about this space? Most of us have an idea that these vast spaces are empty, a perfect vacuum. In fact, these spaces are filled with a very thin gas and microscopic grains of dust. The material between the stars is known as the Interstellar Medium (ISM) and contains important clues about the formation and evolution of galaxies.

The ISM literally contains the seeds of future stars, and all the stars we see were once formed out of the same kind of diffuse gas and dust. When the gas in the ISM cools and collapses, the gas forms clumps that can evolve into stars and planets. Stars, in turn, expel enriched material back into the ISM as they age. One of the biggest puzzles in astrophysics is understanding this cyclical process.

Processes that heat the ISM are fairly well understood. Stellar winds blow through galaxies, transferring huge amounts of energy. Massive stars explode as supernovae shortly after their formation, stirring and heating the gas out of which they formed. These injections of energy from supernovae and stellar winds profoundly affect the ISM and determine the rate at which new stars form.

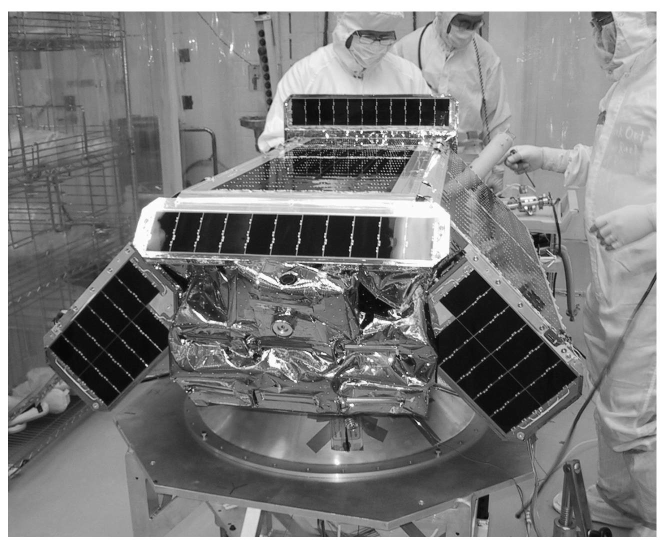
The Interstellar Medium—What is it?

Most of us, at one time or another have learned that space is a perfectly empty vacuum. But the vast space between the stars is really not empty; it is sparsely sprinkled with gas and dust. This 'stuff' in the vast spaces between the stars is known as the Interstellar Medium.

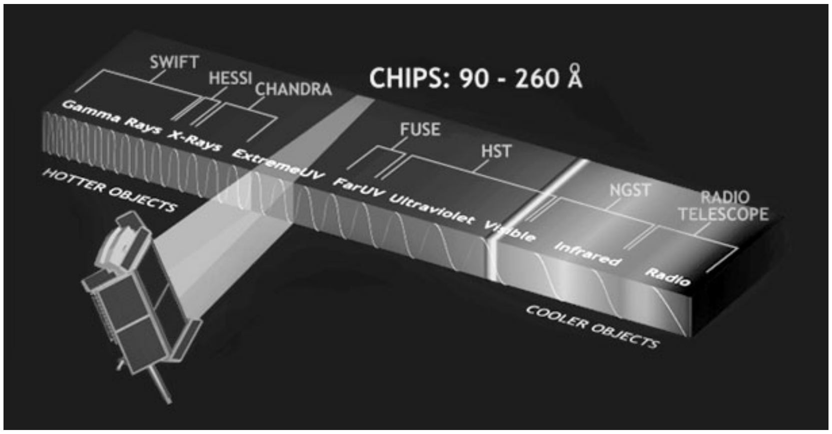
About 99% of the ISM is gas (hydrogen and helium), the remaining one percent consists of heavier elements and dust. The gas is extremely dilute, with an average density of about 1 atom per cubic centimeter. The air we breathe is approximately 30 quintillion (30,000,000,000,000,000,000) times more dense than the ISM. Picture this: an "empty" coffee mug in the ISM would contain about 500 hydrogen molecules. The same "empty" coffee mug sitting on your desk contains about 1500 quintillion gas molecules - mostly nitrogen, hydrogen and oxygen.

The dust in the ISM is made of tiny, irregularly shaped particles of silicates, carbon, ice and iron. In areas where the dust is thick, the light from nearby stars can be completely blocked - similar to the way dark clouds block light from the sun.

Thinner clouds of interstellar dust may dim the light passing through, without completely blocking it. This is known as extinction. The interstellar dust scatters blue light more effectively than red light - which means that most of the light that reaches us through the interstellar dust is reddish. This is known as inter-



CHIPS six apertures for observing the ISM are located just below the small disk in the center of the forward end. The black rectangles are solar cells. (Photo UCB)



CHIPS will observe a relatively unsurveyed band of the electromagnetic spectrum in the extreme ultraviolet region centered around 170 Angstroms.

stellar reddening. A similar process happens on Earth at sunset - which is why sunsets often appear red. Light from nearby stars also can be reflected from the interstellar dust, similar to the way light from a car's headlights can reflect off fog.

Unlike the dust in the interstellar medium, which can only reflect or block light, the gas in the interstellar medium glows in visible and many other wavelengths. In the region of hot, newly formed stars, clouds of hydrogen gas are ionized by the ultraviolet radiation emitted from the stars. When free electrons recombine with the ionized hydrogen, visible red light is emitted from the hydrogen gas. This accounts for the red colors in photographs of emission nebulae, such as the Trifid and Orion Nebulae.

In the hottest regions of the interstellar medium, hydrogen and helium are fully ionized, or stripped of their electrons. Spectral features in the light emitted by this gas, therefore, originate from heavier elements. At one million degrees Kelvin, the brightest spectral features are predicted to arise from partially ionized iron atoms in the interstellar medium. CHIPS will be the first mission to search for these spectral emission features with sufficient sensitivity to detect them and sufficient resolution to distinguish them from one another.

The Local Bubble: Our Astronomical Neighborhood

Our solar system is located in an unusual region of space called the Local Bubble. The Local Bubble is about 300 light years in diameter and is filled with extremely low-density gas (about 0.001 gas molecules per cubic centimeter) — this is much less dense than the average ISM surrounding it. The coffee mug that would contain about 500 hydrogen molecules in the ISM would only contain 1 hydrogen molecule (or maybe none at all!) if it were in the Local Bubble. This gas also is extremely hot — about one million Kelvin, or almost 200 times as hot as the surface of the sun! Astronomers believe that a supernova explosion may have created this bubble - that is, the explosion "blew" most of the gas and dust from the interstellar medium outward. It is this extremely diffuse gas, inside the Local Bubble, that the CHIPS mission is studying.

Within the Local Bubble are smaller, denser clouds of interstellar gas. Our sun and solar system, along with some other nearby stars, are within but near the edge of one such cloud that is roughly 20 light-years in diameter.

What Questions Does CHIPS Seek to Answer?

The key questions about the ISM that the CHIPS mission will seek to answer:

- At what wavelengths does the majority of the power radiated by local hot gas emerge?
- What are the physical processes by which the hot interstellar gas of the Local Bubble cools?

- What is the thermal pressure of hot gas in the Local Bubble?
- What is the morphology and distribution of hot gas within 100 parsecs of the Sun?
- What is the ionization history of the Local Bubble cavity?
- How can this knowledge be applied to other diffuse hot plasmas in the Universe?

Because of the far-reaching effect of the hot interstellar medium in shaping the structure of spiral galaxies, the CHIPS mission primarily supports NASA's Structure & Evolution of the Universe theme. Through the star formation connection, CHIPS also supports NASA's Astronomical Search for Origins and Planetary Systems theme.

CHIPS Mission Information

CHIPS will carry out all-sky spectroscopy of the diffuse background at wavelengths from 90 to 260 Å with a peak resolution at the wavelength 100 (about 0.5 electron volts). CHIPS data will help scientists determine the electron temperature, ionization conditions, and cooling mechanisms of the million-degree plasma believed to fill the local interstellar bubble. The majority of the luminosity from diffuse million-degree plasma is expected to emerge in the poorly explored CHIPS band, making CHIPS data of relevance in a wide variety of galactic and extragalactic astrophysical environments.

The CHIPS satellite is a three-axis stabilized spacecraft, with a solar-panel array roughly orthogonal to the field of view of the spectrograph. Weighing 60 kilograms and the size of a large suitcase, CHIPS will orbit about 590 kilometers above the Earth. It is expected to operate for one year. CHIPS is the first mission ever to use end-to-end satellite operations via the Internet.

The CHIPS satellite is sponsored by the Office of Space Science, NASA Headquarters, Washington, D.C. The CHIPS instrument was built at the Space Science Laboratory of the University of California, Berkeley, and the spacecraft bus was built by SpaceDev, Inc. of Poway, Calif. The project is managed at the NASA Goddard Space Flight Center's Wallops Flight Facility, Wallops Island, Va., through the NASA Explorers Program.

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More information on CHIPS is available at:

http://chips.ssl.berkeley.edu

NASA Explorers Program
http://explorers.gsfc.nasa.gov/index.html

CHIPS Quick Facts

Launch Date: December 2002
Launch Vehicle: Delta II 7320-10C
Launch Site: Vandenberg Air Force Base, Calif.
Orbit: 590-kilometer (350 miles) circular, 94-degree inclination
Mission Duration: 1 year
Spacecraft mass: 60 kilogram (131 pounds)
Total Power: 42 watts