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SPECIAL REPORT
Focus on Winning Mission Concepts

The Escape of the Atmosphere

Proposed Mission to Study Plasma Outflow Using Earth as a Laboratory

A team of scientists want to use Earth as a laboratory to understand how planets lose their atmospheres.

In a proposed mission that some believe represents the "Holy Grail" in the study of the Sun and its effects on space, a team led by Goddard scientist Thomas Moore is advancing a dual-satellite, polar-orbiting mission that would study the universal processes that control atmospheric erosion and its interaction with stellar winds, the continuously flowing stream of charged particles released from the Sun's corona.

Called Mechanisms of Energetic Mass Ejection-eXplorer, or MEME-X, the mission was one of five proposals that received Phase-A funding under NASA's Small Explorer Program. NASA also selected another Goddard mission, Focusing Optics X-ray Solar Imager, proposed by Principal Investigator Steven Christe (see related story, page 7). Of the five, NASA is expected to select one or two for development and implementation.

Cross-Disciplinary Mission

"MEME-X has strong cross threads across NASA's scientific disciplines — planetary, heliophysics, astrophysics, and Earth science," Moore said. In addition to providing details about the loss of mass in Earth's upper atmospheric layers, the mission could enhance scientists' understanding of the role that solar wind played in transforming Mars from a warm and wet environment that might have supported surface life to the cold, arid planet of today, he said.

To that end, MEME-X will focus on one principal question: how does plasma escape from Earth's ionosphere, which lies 50 to 620 miles above the surface, into the protective magnetosphere that shields the planet from potentially harmful solar wind and other space weather, and then out into space. "Atmospheric escape is a fundamental process with wide-reaching consequences across space and planetary sciences," Moore said.

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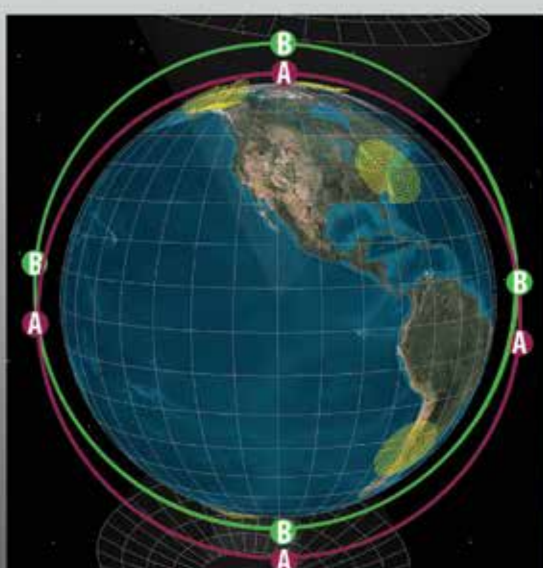
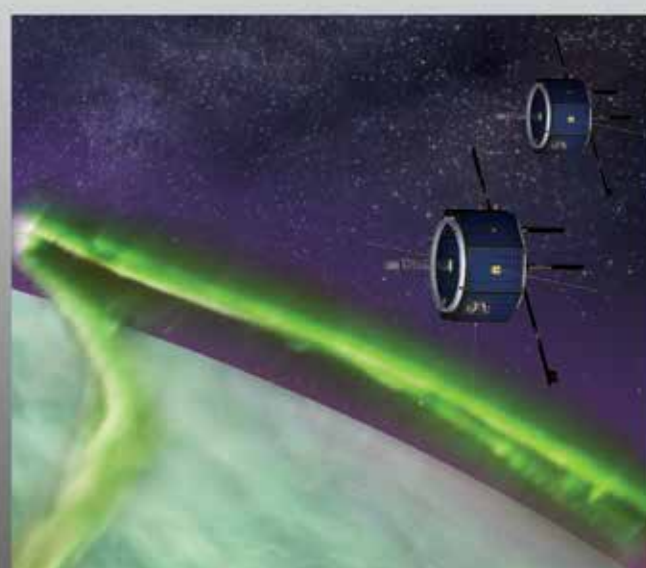


MEME-X's two spacecraft would fly in a polar orbit to find out how plasma escapes from Earth's ionosphere, which lies 50 to 620 miles above the surface, into the protective magnetosphere that shields the planet from potentially harmful solar wind and other space weather, and then out into space.



This artist's rendition shows MEME-X's dual spacecraft as they observe the aurora.

LEFT Image Credit: NASA
RIGHT Image Credit: NASA

Plasma consists of negatively charged electrons and positively charged ions; that is, atoms that have lost their electrons. It is a fourth state of matter — not a gas, liquid, or solid. It conducts electricity and is affected by magnetic fields. On an astronomical scale, plasma is common. It's found in the Sun, in the constant stream of material that flows from the Sun — the solar wind — and throughout space.

For heliophysics, understanding the outflowing of ionospheric plasma is particularly crucial, Moore added. The upflow of plasma from the high-latitude polar cap and auroral regions appears to affect the magnetosphere's response to variations in the solar wind, which in turn influences space weather, making space weather unpredictable.

"For 40 years, we've had a long-standing mystery about how a portion of the atmosphere is heated by a factor of a hundred or more and ejected into space, where it dramatically modifies the near-Earth environment," said MEME-X Deputy Principal Investigator Doug Rowland, a Goddard heliophysicist. "MEME-X, with its pair of miniaturized spacecraft and advanced instrumentation, will finally give us the tools we need to solve this problem."

Equipped with plasma analyzers, which will be mounted on short booms extending along the spacecraft's spin axes, and other instruments developed in part with Goddard R&D funding, MEME-X will provide the first multipoint measurements of plasma to determine if the matter is being ejected by pressure, as in a geyser, or vacuumed away from Earth, as in a waterspout.

Atmospheric Evolution and Habitability

In addition to revealing the plasma outflow's effect on space weather, the mission could help answer important questions regarding the evolution of planetary atmospheres and planet habitability, Moore said.

A case in point is Mars. Once wetter and warmer, and possibly congenial for life, the planet now looks dead. It's a desert world, with a sparse atmosphere and virtually no protective magnetic field. NASA's Mars Atmosphere and Volatile Evolution mission recently discovered that most of the planet's atmosphere has been lost to space, violently scraped from the planet by solar wind.

The question scientists want to answer is the role of the magnetosphere in atmospheric loss, particularly as it relates to solar wind. "This is a quest to discover and characterize fundamental processes that occur within the heliosphere and throughout the universe," Moore said. "We want to use the Earth's atmosphere as a laboratory." ❖

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FOXSI to Focus on Where Space Weather Begins

NASA has selected a Goddard-led team to advance a mission revealing unprecedented details about solar flares, powerful eruptions that explode with the force of more than 100-megaton hydrogen bombs.

The proposed mission, Focusing Optics X-ray Solar Imager, or FOXSI, was one of five proposals that received Phase-A funding under NASA's Small Explorer Program. NASA also selected another Goddard mission, Mechanisms of Energetic Mass Ejection-eXplorer (see related story, page 6). Of the five, NASA is expected to select one or two for development and implementation.

Although scientists are familiar with the effects of solar flares, they don't completely understand the physical mechanisms that unleash these bursts of energy and light, or that which powers associated clouds of electrons and ions that can be accelerated up to near the speed of light.

Once unleashed, these bursts of energy and light affect all the Sun's atmospheric layers. They pass through the Sun's outermost layer — the corona where they also are known to originate — and race across the solar system. When they travel toward Earth, the particles and energy can interfere with space-based communications systems or even trip onboard electronics. The more scientists understand this process, the more situational awareness they have to protect assets in space.

"FOXSI is very new and very different," said Principal Investigator Steven Christe, who leads the multinational FOXSI team. "We've not done a mission like this before."

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