Researchers Plan Mission To Reveal Secrets Of The Solar Wind

By James Cornell
Smithsonian News Service

Spewing out of the sun at a million miles an hour, the great gushing geyser of broiling gas and supercharged particles known as the solar wind blast through space, enveloping all the planets, moons and small bodies of the solar system in a hot, seething soup that affects everything in this corner of the universe, including human life itself.

As this cosmic jet stream rams into the Earth's magnetic field, most of it is thankfully deflected into interstellar space. But billions of wind-driven particles still manage to break through the planet's warped and twisted protective shield. They spiral down into the atmosphere over the poles to produce aurorae, geomagnetic storms, disruptions in radio communications and power surges along transmission lines.

The existence of this powerful solar wind has been known since the early days of space exploration, but its origin inside the sun--like much else about our nearest star--remains a mystery.

Sometime in the next decade, however, a satellite experiment called the Ultraviolet Coronagraph Spectrometer, working in concert with several other space instruments, may at last reveal the secrets of the solar wind. The project is part of a massive international campaign to study the complex relationship among the sun, Earth and human activities.

"An ultraviolet coronagraph-spectrometer is our name for an artificial eclipse machine," says Dr. John Kohl of the Smithsonian Astrophysical Observatory in Cambridge, Mass., and principal investigator for the project now being developed with researchers in Italy and Switzerland as well as at several U.S. universities.

The Smithsonian's solar wind experiment is one of several aboard a satellite called the Solar and Heliospheric Observatory (SOHO) to be built by the European Space Agency in cooperation with the National Aeronautics and Space Administration.

"The solar wind seems to originate in the sun's corona, or outer atmosphere," Kohl explains. "This pearly white ring of hot gas is visible from Earth only during a total solar eclipse. To see what's happening in this region on a regular basis, we have to block out the sun's bright disk, which otherwise simply overwhelms the corona."

In fact, most aspects of the hot gas and charged particles in the wind--detectable as high-energy ultraviolet light--are invisible to ground-based optical telescopes. But observations of this light to determine the solar wind's velocity, temperature and composition can be made from space.

Smithsonian News Service illustration courtesy of the European Space Agency

In this artist's conception, NASA's Solar and Heliospheric Observatory--known as SOHO--watches the sun while a small armada of satellites called "Cluster" circles the Earth to observe interactions between the solar wind and the Earth's magnetic field.

"Our coronagraph-spectrometer is a device that creates a permanent eclipse," says Kohl. "Thus, we can observe the corona--and the outpouring of the wind--continuously.

Continuous observation is absolutely necessary because the flow of the solar wind is not constant. It changes dramatically and frequently, often over periods of a few hours. Since the sun makes one full rotation every 27 days, streams of hot, high-speed gas spiral out like the spray of water from a spinning lawn sprinkler. The wind also displays other long-term variations linked, perhaps, with the same 11-year cycle that brings sunspots and flares to the sun's surface.

The solar wind was first detected by equipment aboard the Mariner 2 spacecraft in 1961. Since then, numerous spacecraft in orbit around both the Earth and the sun have measured the wind at distances as close as 30 million miles from the solar surface.

In the mid-1970s, for example, X-ray observations from the manned Skylab space station revealed that the sun's outer atmosphere was laced by great dark regions and that some of the powerful solar wind was pouring out of these "coronal holes."

"Except for the coronal holes," says Dr. George Withbroe, an associate director at the Harvard-Smithsonian Center for Astrophysics, also in Cambridge, "we have so far been unable to determine where the wind originates--or what mechanism drives it away from the sun. Some of the energy required to accelerate the wind and allow it to escape the sun's great gravitational pull must be associated with the same unknown mechanism that heats the coronal gas to 1 million degrees Celsius."

The coronal holes, some large enough to cover 20 percent of the sun's visible surface change shape, size and location with time. At periods of maximum solar flare and sunspot activity, they may disappear completely and, with them, the high-speed solar wind streams.

The variability of the solar wind, combined with the dynamic and complicated system of magnetic fields and electrical currents in the vast domain of geospace surrounding Earth, add up to a complex array of physical effects.

The largest region of geospace, for example, is the "magnetosphere," where all phenomena are dominated by the Earth's own magnetism. The gusty solar wind compresses the magnetosphere into a giant, bowlike shockwave on the day side of Earth and pulls it out like a string of taffy on the opposite, or night, side.

The second region is the "ionosphere"--the broad band of atmosphere some 40 to 300 miles above the Earth. Here, solar interactions, including the charged particles driven inward by the wind, give rise to the great magnetic storms that produce spectacular Northern and Southern lights displays as well as disrupt communications.

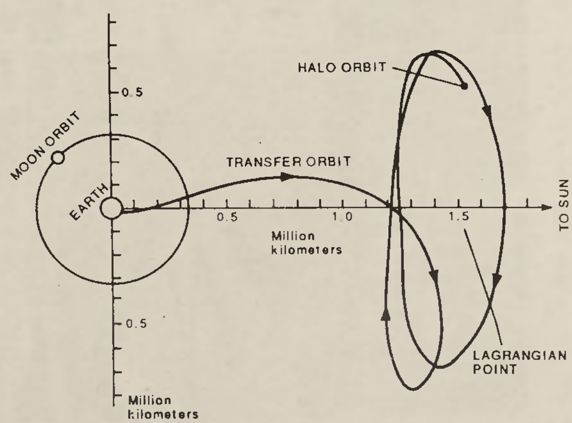
In the Earth's lower atmosphere, chemical reactions and wind patterns, triggered by solar wind interactions hundreds of miles above, may affect local weather conditions and, perhaps, even global climatic patterns. The mechanism linking these various phenomena, however, is still poorly understood.

More alarming, increasing evidence suggests that many human activities--fossil fuel burning and unrestrained release of chlorofluorocarbons in aerosols among them-may be affecting not only the lower atmosphere, but the entire geospace. The outstanding example of this is the "ozone hole" detected in recent years over Antarctica.

Understanding the solar wind is essential to unraveling this intertwining of many related phenomena, and a diverse battery of experiments planned in the next decade under the broad umbrella of the

(Continued On Page 3)

Smithsonian News Service illustration courtesy of the Smithsonian Astrophysical Observatory



The "halo" orbit planned for NASA's Solar and Heliospheric Observatory will allow the satellite to monitor the sun continuously. The orbit is located at the "Lagrangian point," an area between the sun and the Earth where the gravitational pull of the two bodies on the satellite is equal. Here, the satellite can maintain a near-perfect circular orbit. (A kilometer is about five-eighths of a mile.)