UNH Institute for the Study of Earth, Oceans and Space

UNH Scientist Sheds New Light on How Solar Wind Impacts Earth's Magnetic Field

By Sharon Keeler
UNH News Bureau

DURHAM, N.H. -- Scientists for the first time ever have observed conclusive evidence for a phenomenon in space called magnetic reconnection, which provides new information on where and how solar wind enters the region of space occupied by the Earth's magnetic field. Such data will help researchers better understand magnetic storms set off by solar flares and coronal mass ejections. These storms can disrupt satellite communication systems, power grids and radio transmissions.

Reported in the April 20 issue of the science journal "Nature," the scientists reveal two spacecraft simultaneously observing highly ionized gas jets traveling in two directions -- called bi-directional plasma jets -- at the magnetopause. The magnetopause is the boundary between the Earth's magnetic field and the "solar-wind" magnetic field, which is located approximately 64,000 kilometers in the direction toward the Sun.

The presence of these jets shows that the Earth's magnetic field connects with the sun's impinging field. These connected field lines are swept to the nightside of the Earth, where they reconnect in an area called the magnetotail. The plasma in this region is then accelerated down magnetic field lines into the polar regions, striking Earth's atmosphere.

These trapped particles sometimes alter the way electrical currents behave, disturbing communication systems. The intricate light display, known as the aurora or northern or southern lights, is the result of the accelerated particles colliding with oxygen and nitrogen as they rush to the Earth.

"Observation of bi-directional jets completes the magnetopause reconnection picture," says Lynn Kistler, research professor at the University of New Hampshire's Institute for the Study of Earth, Oceans, and Space, and one of the scientists involved in the project. "Due to the single-spacecraft nature of past observations, only single jets have been reported before. The existence of the counter streaming jet -- the other half of the reconnection picture -- has always been assumed but never confirmed. Our observations also reveal evidence for a stable and extended reconnection line, implying substantial solar wind entry."

The data proving these bi-directional plasma jets was acquired Feb. 11, 1998, for more than an hour by Equator-S and Geotail, satellites that are part of an international fleet of spacecraft designed to study Sun-Earth interactions. They were the result of a coronal mass ejection, a phenomenon that sends streams of highly charged particles and a billion tons of ionized gas, or plasma, racing toward the Earth at a rate of 400 kilometers per second.

An instrument designed and built by a team led by Kistler -- the Equator-S Ion Composition (ESIC) instrument -- was vital to tracking and measuring the electrically-charged atoms present in this event. About the size of a desktop computer monitor, the instrument collected data until Equator-S failed four months into its mission.

"The magnetic storms it was sent to study eventually killed it," says Kistler.

Coronal mass ejections that approach Earth do not directly impact the atmosphere, since the planet's magnetic field, the magnetosphere, tends to deflect particles and magnetism imbedded in the mass ejection. What does happen, says Kistler, is the ejection interacts with Earth's magnetic field, compressing and altering it. When the magnetosphere changes in a major way, a "geomagnetic storm" results.

"Small storms may last four hours or so, and there is not a lot of radiation," Kistler explains. "But a major geomagnetic storm can last a day or two."

More of these major storms, she says, are likely to occur over the next couple of years, as the Sun is headed toward peak activity called the solar maximum. This phenomenon, which takes place every 11 years, leads to stormy space weather and the pounding of the Earth's magnetosphere with radiation and highly charged particles.

"Magnetic reconnection is the fundamental mode of energy conversion in plasmas in the Sun-Earth connected system, yet little is understood about it," says Kistler. "Our study establishes that the bi-directional jets converted from this magnetic energy are the result of reconnection between the solar wind and magnetosphere magnetic fields, proving what was before only established in theory. "

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