Catching space weather in the act

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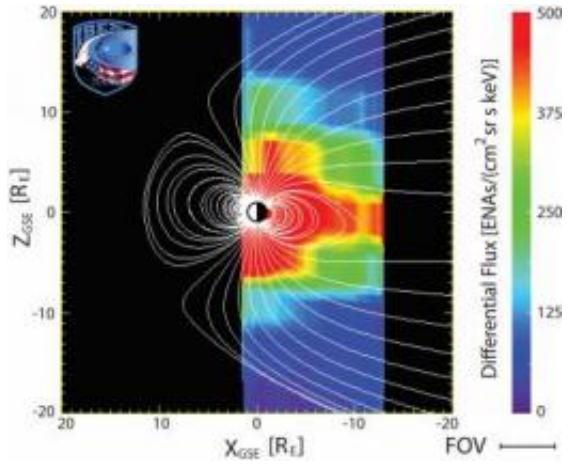

The white lines show a model of where magnetic field lines are expected in Earth's magnetic atmosphere. The bright red colors show the densest part of the plasma sheet as imaged by IBEX. Credit: Southwest Research Institute/IBEX Science Team

Close to the globe, Earth's magnetic field wraps around the planet like a gigantic spherical web, curving in to touch Earth at the poles. But this isn't true as you get further from the planet. As you move to the high altitudes where satellites fly, nothing about that field is so simple. Instead, the large region enclosed by Earth's magnetic field, known as the magnetosphere, looks like a long, sideways jellyfish with its round bulb facing the sun and a long tail extending away from the sun.

In the center of that magnetic tail lies the plasma sheet. Here, strange things can happen. Magnetic field lines pull apart and come back

together, creating explosions when they release energy. Disconnected bits of the tail called "plasmoids" get ejected into space at two million miles per hour. And legions of charged particles flow back toward Earth.

Such space weather events cause auroras and, when very strong, can produce radiation events that could cause our satellites to fail. But until now no one has been able to take pictures of these fascinating processes in the plasma sheet.

"Earth's magnetic tail and its charged particles are invisible to conventional cameras that detect light," says Jim Slavin, a magnetotail researcher who is the Director of the Heliophysics Division at NASA's Goddard Space Flight Center in Greenbelt, Md. "Events going on there have only been inferred based on other kinds of measurements."

Now, special cameras aboard the Interstellar Boundary Explorer, or IBEX, spacecraft have snapped the first shots of this complex space environment. Instead of recording light, these two large single-pixel cameras detect energetic neutral atoms. Such fast-moving atoms are formed whenever atoms in the furthest reaches of Earth's atmosphere collide with charged particles and get sent speeding off in a new direction. Called Energetic Neutral Atom or ENA imaging, the technique captured unprecedented images of the plasma sheet.

"The image alone is remarkable and would have made a great paper in and of itself because it's the first time we've imaged these important regions of the magnetosphere," says Dr. David McComas, principal investigator of the IBEX mission and assistant vice president of the Space Science and Engineering Division at Southwest Research Institute in San Antonio, Texas. The results appeared online in the *Journal of Geophysical Research* on Feb. 16, 2011.

But when they looked closely, the group realized they didn't only have a

picture of a quiescent plasma sheet. The various images appear to show a piece of the plasma sheet being bitten off and ejected down the tail. They think they've caught a plasmoid in the moment it was being formed. If they're correct, this would be the first time such an event was directly seen.

"Imagine the magnetosphere as one of those balloons that people make animals out of. If you take your hands and squeeze the balloon, the pressure forces the air into another segment of the balloon," says McComas. "Similarly, the solar wind at times increases the pressure around the magnetosphere, resulting in a portion of the plasma sheet being pinched away from a larger mass and forced down the magnetotail."

Because researchers believe this phenomenon generally occurs deeper in the magnetotail, the IBEX team is considering other explanations for the event, as well. One possibility is that the plasma sheet is being squeezed by the solar wind.

While not specifically designed to observe the magnetosphere, IBEX's vantage point in space provides twice-yearly (spring and fall) seasons for viewing from outside the magnetosphere. Since its October 2008 launch, the IBEX science mission has flourished into multiple other research studies as well. In addition to supporting magnetospheric science, the spacecraft has also directly collected hydrogen and oxygen from the interstellar medium for the first time and produced the first ENA images of the outer edges of the bubble surrounding the Sun, called the heliosphere.

"Based upon the IBEX mission and its revolutionary ENA camera technology," says Slavin, "future NASA science missions may be able to make high definition videos of the development of space weather systems around the Earth to advance our scientific understanding of

these phenomena and, eventually, enable space weather prediction like Earth weather prediction."

IBEX is the latest in NASA's series of low-cost, rapidly developed Small Explorers spacecraft. The Southwest Research Institute developed the IBEX mission with a team of national and international partners. Goddard manages the Explorers Program for the Science Mission Directorate in Washington.

Provided by NASA's Goddard Space Flight Center