Scudder makes first observations of process linked to northern lights

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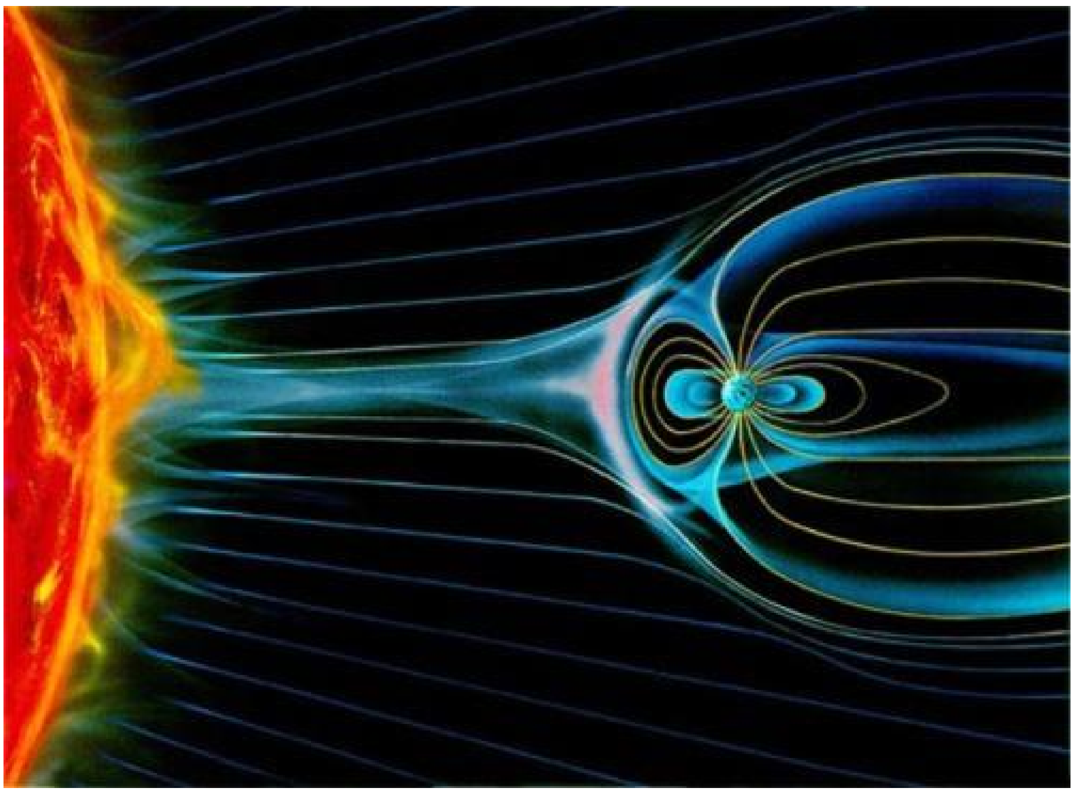

Diffuse gas—called plasma—flows outward from the sun as the “solar wind” and carries with it solar magnetic field lines that become entangled with the Earth's own magnetic field lines. Location of "holes" were detected in indicated pink layers, near Earth. Image courtesy of NASA.

(Phys.org) -- A University of Iowa researcher wants you to visualize a plate of spaghetti when you think of the northern lights.

That's because Jack Scudder, UI professor of physics and astronomy, and his colleagues have reached a milestone in describing how the northern lights work by way of a process called "magnetic reconnection."

The details are contained in a paper published in the June 5 issue of the journal Physical Review Letters; however, the process is best imagined as untangling twisted strands of spaghetti.

Diffuse gas—called plasma—flows outward from the sun as the "solar wind" and carries with it magnetic field lines ("spaghetti") from the sun.

The entanglement between magnetic field lines (spaghetti) from the sun and other field lines (spaghetti) anchored in the Earth's core occurs when these field lines are brought together by gusts of solar wind.

"In the process of smoothing this entanglement, one or more holes are created that now link field lines, with one originating in the sun and the other in the Earth's metallic core," says Scudder. "This linkage allows charged particles to cross a previously forbidden boundary that separates the Earth's volume from the sun's. The formation of these inter-connections represents a stress reduction. The aurorae are a byproduct of this change in how the strands of spaghetti are connected, since with the hole, charged particles from the sun are now allowed access into the atmosphere below the Earth's magnetic shield."

One result is the beautiful colors of the northern lights. "Most effects of solar weather that have an earthly influence gain entrance through holes of this type that are in place when a solar disturbance hits," Scudder says. "In this sense the sites of reconnection are the 'keyholes' for the intrusion of solar weather into near Earth space.

"After more than 30 years of research, my colleagues and I have announced a milestone discovery in astrophysics—the first experimentally resolved and unequivocal site of collision—less magnetic reconnection, in which magnetic field energy is converted into energetic particles," Scudder says. "When this process occurs, previously separated volumes of space become interconnected by magnetic fields, providing new highways for the prompt interchange of high temperature gases."

Because magnetic reconnection is thought to occur elsewhere in the universe, Scudder and his colleagues are delighted to have observed evidence of a hard-to-see hole.

In astronomical terms, the size of a hole is relatively small—about 1 kilometer in diameter seen at a distance of 57,000 kilometers from the Earth. If magnetic reconnection were occurring on the surface of the sun, at another star, or at a planet in another solar system, scientists would never be able to see it, Scudder says. Consequently, Scudder's work is all the more important because it serves to "bench test," or prove, an astrophysical process that mankind will never be able to directly corroborate in deep space.

In addition to being small, the hole Scudder observed was in constant motion.

Because the hole was in an unknown state of motion relative to the spacecraft, it could have been traversed many times previously without having been detected. To correct for this situation, researchers developed new techniques to reduce the time interval between "snapshots" by a factor of 11 using the same detector and without flying a new detector.

"This 'trick' is like having access to a microscope for the first time to re-examine data that was thought to have been acquired too slowly to find these holes. Resolving these holes in magnetic fields is somewhat similar to looking at stagnant water through a microscope for the first time and seeing the writhing molecular behavior that was only suspected previously," he says.

Scudder and his colleagues were able to observe the magnetic reconnection site in space by using data from NASA's Polar spacecraft and its Hydra, MFE and EFI experiments. Scudder says the process he observed is active not just in creating the northern lights, but many other astronomical phenomena as well.

"The experimental documentation of the physical process that enables this phenomenon provides the first support of the prevailing theories for explaining the production of solar flares, x-rays from black holes, as well as the causes of the aurorae that brilliantly light up the polar skies," he says.

The manner in which Scudder and his associates made the landmark observation involved five different comparisons across three independent detectors to reinforce the detection, similar to the teamwork involved in professional sports.

As part of NASA's Polar/Hydra program at the UI, data from three separate experiments were shown to reproduce the extreme signatures predicted by computer models of the process. These signatures were so unusual that nothing approaching their extremes had been recorded in 50 years of space research. Using the largest computer resources at NASA, the National Science Foundation, and the U.S. Department of Energy, the reference computer models solved six trillion equations of motion in order to predict the observations for the three experiments.

By showing scientists what combinations of observations can help identify these regions, Scudder's work will save time and energy for researchers preparing to explore magnetic reconnection in detail by using NASA's Magnetospheric Multi-Scale (MMS) mission set for launch in 2014.

Provided by University of Iowa