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FEATURE

## A Giant Breach in Earth's Magnetic Field

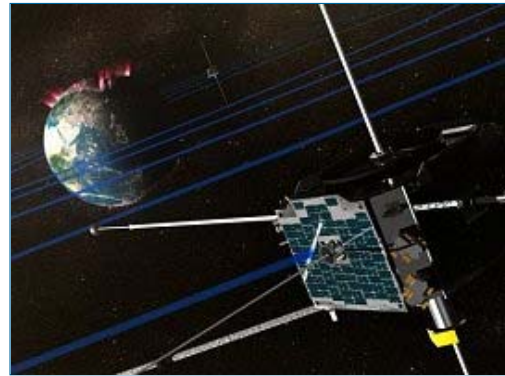
12.16.2008

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**Dec. 16, 2008:** NASA's five THEMIS spacecraft have discovered a breach in Earth's magnetic field ten times larger than anything previously thought to exist. Solar wind can flow in through the opening to "load up" the magnetosphere for powerful geomagnetic storms. But the breach itself is not the biggest surprise. Researchers are even more amazed at the strange and unexpected way it forms, overturning long-held ideas of space physics.

"At first I didn't believe it," says THEMIS project scientist David Sibeck of the Goddard Space Flight Center. "This finding fundamentally alters our understanding of the solar wind-magnetosphere interaction."

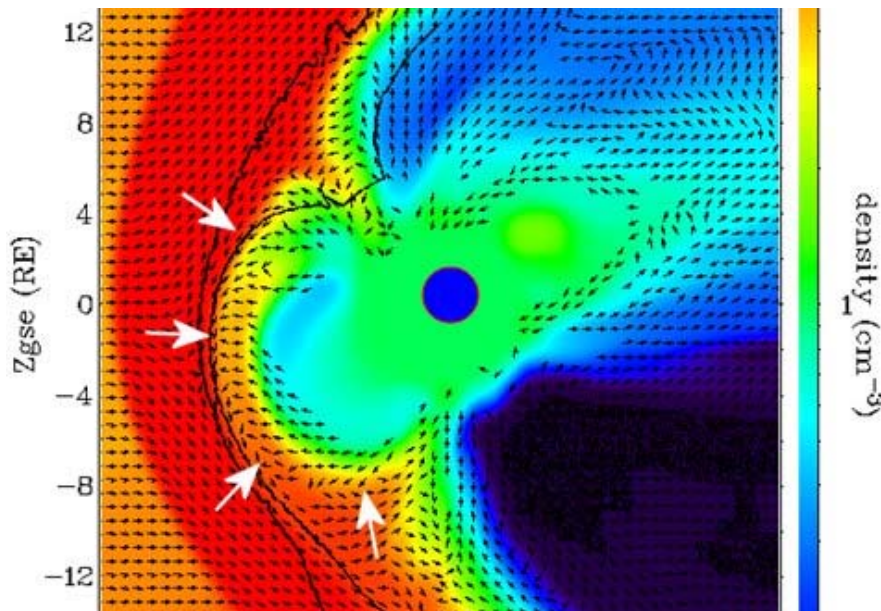
The magnetosphere is a bubble of magnetism that surrounds Earth and protects us from solar wind. Exploring the bubble is a key goal of the THEMIS mission, launched in February 2007. The big discovery came on June 3, 2007, when the five probes serendipitously flew through the breach just as it was opening. Onboard sensors recorded a torrent of solar wind particles streaming into the magnetosphere, signaling an event of unexpected size and importance.



**Right:** One of the THEMIS probes exploring the space around Earth, an artist's concept. [\[more\]](#)

"The opening was huge—four times wider than Earth itself," says Wenhui Li, a space physicist at the University of New Hampshire who has been analyzing the data. Li's colleague Jimmy Raeder, also of New Hampshire, says " $10^{27}$  particles per second were flowing into the magnetosphere—that's a 1 followed by 27 zeros. This kind of influx is an order of magnitude greater than what we thought was possible."

The event began with little warning when a gentle gust of solar wind delivered a bundle of magnetic fields from the Sun to Earth. Like an octopus wrapping its tentacles around a big clam, solar magnetic fields draped themselves around the magnetosphere and cracked it open. The cracking was accomplished by means of a process called "magnetic reconnection." High above Earth's poles, solar and terrestrial magnetic fields linked up (reconnected) to form conduits for solar wind. Conduits over the Arctic and Antarctic quickly expanded; within minutes they overlapped over Earth's equator to create the biggest magnetic breach ever recorded by Earth-orbiting spacecraft.



**Above:** A computer model of solar wind flowing around Earth's magnetic field on June 3, 2007. Background colors represent solar wind density; red is high density, blue is low. Solid black lines trace the outer boundaries of Earth's magnetic field. Note the layer of relatively dense material beneath the tips of the white arrows; that is solar wind entering Earth's magnetic field through the breach. Credit: Jimmy Raeder/UNH. [[larger image](#)]

The size of the breach took researchers by surprise. "We've seen things like this before," says Raeder, "but never on such a large scale. The entire day-side of the magnetosphere was open to the solar wind."

The circumstances were even more surprising. Space physicists have long believed that holes in Earth's magnetosphere open only in response to solar magnetic fields that point south. The great breach of June 2007, however, opened in response to a solar magnetic field that pointed north.

"To the lay person, this may sound like a quibble, but to a space physicist, it is almost seismic," says Sibeck. "When I tell my colleagues, most react with skepticism, as if I'm trying to convince them that the sun rises in the west."

Here is why they can't believe their ears: The solar wind presses against Earth's magnetosphere almost directly above the equator where our planet's magnetic field points north. Suppose a bundle of solar magnetism comes along, and it points north, too. The two fields should reinforce one another, strengthening Earth's magnetic defenses and slamming the door shut on the solar wind. In the language of space physics, a north-pointing solar magnetic field is called a "northern IMF" and it is synonymous with *shields up!*



"So, you can imagine our surprise when a northern IMF came along and shields went *down* instead," says Sibeck. "This completely overturns our understanding of things."

Northern IMF events don't actually trigger geomagnetic storms, notes Raeder, but they do set the stage for storms by loading the magnetosphere with plasma. A loaded magnetosphere is primed for auroras, power outages, and other disturbances that can result when, say, a CME (coronal mass ejection) hits.

The years ahead could be especially lively. Raeder explains: "We're entering Solar Cycle 24. For reasons not fully understood, CMEs in even-numbered solar cycles (like 24) tend to hit Earth with a leading edge that is magnetized north. Such a CME should open a breach and load the magnetosphere with plasma just before the storm gets underway. It's the perfect sequence for a really big event."

Sibeck agrees. "This could result in stronger geomagnetic storms than we have seen in many years."

*A video version of this story may be found [here](#). For more information about the THEMIS*

mission, visit <http://nasa.gov/themis>

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Author: [Dr. Tony Phillips](#) | Credit: [Science@NASA](#)

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**What happened to conventional wisdom?** Researchers at the University of New Hampshire are using computer models to unravel the basic physics of the great breach. They're finding that reconnection at the poles is key. Conventional wisdom held that equatorial reconnection was more important, which is why the giant breaches were not anticipated until THEMIS flew through one.

[View a video version of this story.](#)

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THEMIS, short for [Time History of Events and Macroscale Interactions during Substorms](#), is the fifth medium-class mission under NASA's Explorer Program. The program, managed by The Explorers Program Office at Goddard Space Flight Center, Greenbelt, Md., provides frequent flight opportunities for world-class space investigations in Heliophysics and Astrophysics. The University of California, Berkeley's Space Sciences Laboratory managed the project development and is currently operating the THEMIS mission. Swales Aerospace, Beltsville, Md., built the THEMIS satellites.

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