Startling Tales From the Magnetotail

Although Galileo's first pass by Earth represented no more than a day in its long and winding trek to Jupiter, the instrument-laden spacecraft made the most of its opportunity. On Dec. 8, 1990, Galileo overtook Earth and plunged deep into its magnetic tail to capture a brief but tantalizing glimpse of a rarely visited region of the planet's magnetosphere.

A first look at the data from four instruments that monitor magnetic fields and the motion of masses of charged particles, or plasmas, suggests a surprisingly high level of activity there. Some of the data also appear to contradict findings obtained by another spacecraft nearly a decade ago. Those earlier findings have been widely used to support theoretical models of plasma movement in Earth's magnetic field.

"It's exciting," says Donald J. Williams of the Johns Hopkins Applied Physics Laboratory in Laurel, Md. "What we learn about the magnetized plasmas around the Earth is very pertinent when we go and look at other planets."

The findings also reveal important details concerning how the solar wind emanating from the sun interacts with Earth's magnetic field. Moreover, they may shed light on how large a role magnetotail activity plays in generating auroras and other atmospheric phenomena above the Earth.

"There's a tremendous amount of interest in exactly how the magnetotail moves and accelerates plasmas," says Louis A. Frank of the University of Iowa in Iowa City. "The tail is supposedly the region that supplies the first steps toward providing the energy for an auroral storm."

At last week's American Geophysical Union meeting in Baltimore, several research teams described their preliminary analyses of the magnetic and plasma data obtained by Galileo.

The magnetic tail results from the pressure of the solar wind on magnetic field lines emerging from or pointing toward the planet's magnetic poles. This portion of Earth's magnetosphere extends over a vast region of space, trailing for many millions of miles behind the Earth and directed away from the sun.

Galileo's magnetometer data show that the magnetotail can respond quickly and dramatically to local shifts in the solar wind's magnetic field, which sometimes put a corkscrew twist in the tail.

"This was quite startling," says Margaret G. Kivelson of the University of California, Los Angeles, who heads the magnetometer team. "The tail really twists around through a rather large angle ... with remarkably little delay."

Controversial results emerged from an analysis of the motions of electrons and positively charged ions in magnetotail plasmas. Frank and his co-workers discovered that electrons and ions tend to move in different directions, not – as most researchers had assumed – in the same general direction. Frank's team also found that plasma electrons travel nearly 10 times faster than indicated by measurements from ISEE-3, the third in a family of satellites called the International Sun-Earth Explorers, which sampled Earth's magnetotail in 1982.

"We expected to go into the magnetotail and then build upon what ISEE-3 measured, but we found something completely different," Frank says. "It means that all those past interpretations of plasma motions have been based on improper information. It's disastrous."

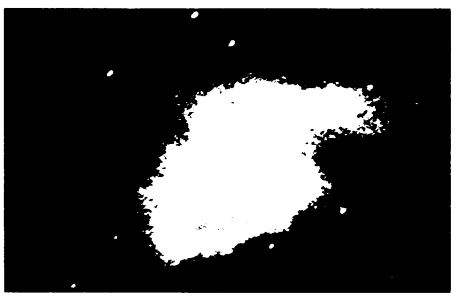
"I think everyone agrees that more detailed and further analysis of the Galileo data is needed," Williams says. "But if these early indications are correct, then indeed it will have an impact on how we look at plasma flows in the geomagnetic tail."

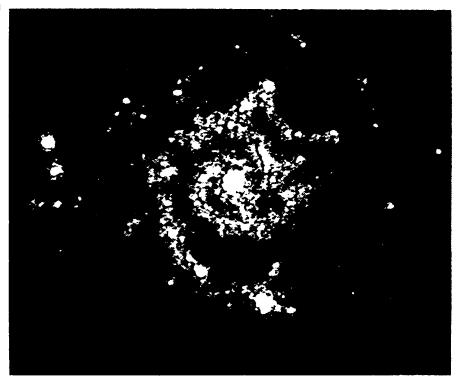
Researchers are now awaiting the July 1992 launch of the Japanese Geotail satellite, which will follow a highly elliptical orbit. That orbit will allow the satellite to monitor Earth's magnetic tail on a regular basis.

In the meantime, researchers continue to comb through the Galileo data, tracking down intriguing hints of links between auroral storms observed from Earth and activity in the magnetotail. Along with auroral radio emissions, Galileo's plasma-wave detector even picked up the characteristic signals of Earth-based AM radio stations. — *I. Peterson*

Crab, spiral galaxy caught in UV light

When the Astro Observatory spent nine days in space last December, only one of its instruments – an ultraviolet imaging telescope – carried camera and film. The telescope photographed more than 900 objects, including many never before imaged in the ultraviolet (SN: 1/26/91, p.52). Now, scientists have released a second set of Astro photos, shedding light on structures both within our galaxy and far beyond.





NASA

Astro's portrait of the Crab nebula (left), a famed supernova remnant in the Milky Way, depicts the ultraviolet glow produced as electrons rush out from the spinning neutron star at the nebula's center. Intense magnetic fields surrounding the star force the charged particles to move in spiral paths and radiate ultraviolet light. In this false-color, near-ultraviolet image, blue represents the lowest intensity and the white at the nebula's center highlights the region of highest intensity.

However, comparing this image with one taken in the far-ultraviolet (not shown) reveals that the hottest, highest-energy regions do not lie at the center, reports Robert W. O'Connell of the University of Virginia at Charlottesville. He and other Astro scientists believe the energy unleashed as the high-speed electrons smash into a dense shell of dust and gas surrounding the neutron star may explain the hotspot's slightly off-center location.

A third Astro image (right) reveals new details about star formation within the spiral galaxy M74, about 55 million light-years from Earth. The white spots surrounding the nucleus signify regions of starbirth in the spiral arms. Scientists had already identified this starbirth pattern in ground-based, visible-light observations. But the ultraviolet photo illuminates a feature never before clearly pictured: several disruptions in M74's spiral arms that may hint at how the arms formed.

O'Connell and other Astro investigators presented the three photos at last week's American Astronomical Society meeting in Seattle.