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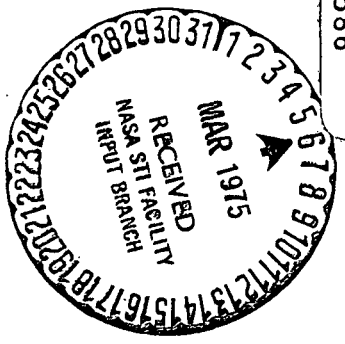
JOVIAN MAGNETIC FIELD IS COMPLEX, PIONEER 11 SHOWS

Forces at work in the seething interior of giant Jupiter are far more complicated than had been previously believed.

Data returned by Pioneer 11 suggest that the liquid planet's magnetic field, unlike Earth's, may be created by several ring currents--like electric generators--deep within the planet.



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Earlier measurements made from a distance of 210,000 kilometers (131,000 miles) by Pioneer 10, Pioneer 11's predecessor, had indicated only a simple magnetic envelope with a single "generator", much like Earth's.

But this apparently is not so, according to scientists sifting through the mountain of data returned by Pioneer 11, which flew three times closer last December.

It now seems that Jupiter's interior may contain a large ring current or generator, along with many eddies or smaller generators, rather than a single large one.

Pioneer experimenter Dr. Walker Fillius of the University of California, San Diego, points out that such a complex field close to the planet would be required to explain the field's high-energy particle pattern, as well as the bursts of intense radio energy long-observed to emanate from Jupiter at long wave lengths.

Planetary magnetic fields are believed to be produced by motions of the liquid material in planets' interiors, through mechanisms similar to those of electric dynamos. Earth and Jupiter are the only known planets with a substantial magnetic field.

Wobbling and tilting like a plate on top of a juggler's stick, Jupiter's field sometimes stretches across 9 million miles of space, and at other times shrinks in volume by three-fourths or more. Inside this pulsating field are the belts of intense radiation. Electrons trapped there are 10,000 times more intense than those in the Van Allen radiation belts which girdle the Earth, and their energies range upward to more than 30 million electron volts. Trapped protons, the nuclei of hydrogen atoms, are also intense.

Pioneer 11 found that peak intensities of high-energy electrons were moderately higher than Pioneer 10 experienced. And the peak proton intensity experienced by Pioneer 11 was a hundred times stronger than that encountered by Pioneer 10. But these very-high-energy protons were concentrated in small and very thin, shallow regions. Pioneer 11 sliced through these narrow regions so quickly, at a record speed of 171,000 km (107,000 mi.) an hour, that it received relatively low total radiation.

Neither the Pioneer 11 spacecraft nor its scientific instruments suffered damage in the belts, although radiation particles produced effects which resulted in dozens of false commands to some of the instruments, temporarily interfering with their operation and causing some loss of data.

Pioneer 11, renamed Pioneer Saturn, is now headed upward out of the ecliptic--the celestial plane containing the planets. It will reach a point 160 million km (100 million mi.) above this plane--exploring new regions of space--in 1977.

The robot spacecraft will continue on to Saturn, arriving at the ringed planet in September 1979, after a 2.4-billion-km (1.5-billion-mi.) journey across the solar system. The target point at Saturn has not been selected. One possibility is for Pioneer to fly between Saturn's surface and its innermost ring, and to explore Saturn's planet-sized moon, Titan, considered a possible abode for complex organic molecules, the building blocks of life.

Besides the new findings on Jupiter's erratic magnetic field, the flight of Pioneer 11 has provided a number of new details about the planet, its poles and its moons, and a greater insight into the nature of cosmic rays from the stars.

The early findings include the following:

• In making the first observations of Jupiter's immense polar regions (which cannot be seen from the Earth), the spacecraft found that the planet's cloud tops are substantially lower at the poles than at the equator, and are covered by a thicker transparent atmosphere. The cloud tops at the South Pole are lower than those in the North Polar regions.

• Though there is much less evidence of rapid atmosphere circulation at the poles than at the equator, the polar areas unexpectedly showed many small convective cells, dwarfing similar Earth thunderstorms. "Blue sky" also was visible at the poles and is attributed to the same cause as Earth's blue sky--multiple molecule-scattering of light by gases of the transparent atmosphere at Jupiter's poles.

• Scientists suggest that Jupiter's relatively stagnant polar regions would be the best place to search for life on the planet. Pioneer 11 infrared measurements show that the polar regions are about 5 degrees Fahrenheit cooler than the equatorial regions, and become steadily cooler with proximity to the poles themselves. On the other hand, the temperature difference between the equator and polar regions on Jupiter is not great as on Earth, because two-thirds of Jupiter's heat is radiated from the planet's high-temperature interior and is radiated uniformly over the planet. On Earth, heat is received from the Sun largely at the equator, and there is little internal heat generation, so Earth's equator is much warmer than the poles.

• Biggest obstacle to life on Jupiter, which appears to have all the necessary organic building blocks, had been thought to be the planet's rapid vertical circulation in its atmosphere. Huge regions of dense room-temperature atmosphere probably are carried down by this circulation to areas too hot to support life. But the relatively warm and stagnant poles conceivably could harbor living organisms, because the atmosphere there circulates more slowly. Pioneer did find less circulation at the poles than in the equatorial regions.

• Another feature seen by Pioneer 11's electronic camera for the first time was an oval cell of down-moving atmosphere, surrounded by a bright ring of upwelling clouds.

• Many more flow features were seen in the clouds around the Great Red Spot than were seen a year ago by Pioneer 10. The Great Red Spot is believed to be a 32,000-km (20,000-mi.)wide "permanent hurricane." Within the Spot, a number of details were seen for the first time, suggesting convection and circulation. The center of the Spot, which could easily swallow three Earths, is clearly brighter than the edges, which form a broad, darker border. Enhanced versions of the new close-up pictures of the Great Red Spot should provide a further explanation.

• A Pioneer finding which bears directly on many studies of our Galaxy concerns electrons. In measuring electrons close to the planet, scientists found that there were ten times as many as had been predicted from Earth-based radio studies of Jupiter. Electrons produce radio signals as they spiral around the lines of force of Jupiter's magnetic field.

Astronomers have made extensive calculations of the numbers of such particles in stars, pulsars, interstellar gas clouds, and other celestial objects, using data from radio emissions similar to those emitted by Jupiter. If the Pioneer findings stand up, various celestial theories will have to be reviewed.

Pioneer experimenter Dr. John Simpson, University of Chicago, points out that Jupiter is a sort of "poor man's star." Like many stars, and unlike Earth, it is a fast-spinning body with strong magnetic fields.

- Pioneer 11 determined very accurately the mass of the Jovian moon Callisto, a possible site for future manned landings. Callisto's mass is 1.5 times that of the Earth's moon. Pioneer also observed for the first time an extensive white, south-polarcap on Callisto.

- Scientists have found that "magnetic weather" in Jupiter's enormous magnetosphere is extremely variable--much more so than in Earth's magnetosphere. Conditions when Pioneer 11 passed through the magnetosphere last December were far different from those found during the passage of Pioneer 10 a year earlier.

Jupiter's magnetic envelope, always inflated by hot, ionized gas, apparently can be squeezed down in volume as much as eight times by pressure from the solar wind. This compression, in turn, may churn up the various regions within the magnetosphere. Jupiter's magnetosphere fluctuates continually in size like a huge, cosmic jellyfish.

• Findings that appear to hold for all magnetosphere states include the fact that the planet's huge envelope appears to be relatively blunt as it faces into the solar wind. Most of the time, this magnetic bubble is probably about as thick as the distance of its boundary from the planet, according to Pioneer's project scientist, Dr. John Wolfe of Ames Research Center, Mountain View, Calif.

• The current sheet, which bisects the outer magnetosphere horizontally, now appears to be a relatively permanent feature of the magnetosphere and to extend completely around the planet. The current sheet is formed by electrified particles spun out from the top of Jupiter's ionosphere by the planet's high-speed rotation. The sheet can become disturbed when the magnetosphere undergoes drastic changes in size due to pressure changes in the solar wind. Pioneer 11 found that the magnetosphere boundary can move back toward Jupiter as rapidly as 320,000 km (20,000 mi.) an hour.

As magnetic lines of force produced by the current sheet cancel each other out, experimenters suggest, particles are accelerated to nearly the speed of light. This makes Jupiter the only other significant source of high-energy particles in the solar system besides the Sun.

• Pioneer scientists report that all of Jupiter's large moons "sweep out" particles from the radiation belts, reducing the belts' intensity. The closest large moon, Io, absorbs virtually all the low-energy electrons between its orbit and Jupiter.

The passages of these moons, each with a different period, constantly stir up the magnetosphere like "a spade in a bucket of molasses," says Dr. James Van Allen, of the University of Iowa, a Pioneer experimenter. As a result, there are rapid changes in the magnetosphere, shown by the fact that radiation on Pioneer's outgoing pass was ten times higher than on the incoming leg. Distribution of high-energy particles also was far different, incoming from outgoing--and far different from the Pioneer 10 findings a year earlier.

The Pioneers are managed for NASA's Office of Space Science by Ames. They are built by TRW Systems Inc., Redondo Beach, Calif.

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