Jupiter's lopsided (?) magnetic field

Is James Warwick's exotic prediction correct? Pioneer 10 should find out.

by Jonathan Eberhart

Strange indeed is Jupiter. Eleven times the diameter of the earth, it takes almost 12 years to circle the sun, yet its day is less than 10 hours long. Four of its 12 moons travel backward in their orbits. Its only pronounced surface feature visible from earth is a huge, unexplained red spot, which may be either in the atmosphere or on the surface. In fact, there may be no surface at all—just a ball of gas that is so highly compressed near the center that it becomes a liquid metal and possibly a solid at the bottom.

The Pioneer 10 spacecraft, launched 14 months ago, will fly by close to the planet on Dec. 4, probably without shedding light on any of these oddities (SN: 11/13/71, p. 330; 3/11/72, p. 167). It may well, however, provide either confirmation or a death-stroke for an exotic prediction that could be one of Jupiter's greatest mysteries: an almost incredibly off-center magnetic field.

That the planet even has a substantial magnetic field is surprising enough, if only because most bodies in the solar system, except for the earth, apparently don't. But the mind-stretching part is the proposal, by one of the world's most devoted and respected Jupiter-watchers, that the field's dipole—its hub, so to speak—may be almost 30,000 miles away from the center of the planet, less than a third of the way in from what passes for the surface.

James W. Warwick of the University of Colorado is not a scientist to be taken lightly. One of the first to study the giant planet's high-frequency emissions (discovered in the late 1950's), he is described as Mr. Jupiter by some of his colleagues. Thus few are willing to impugn his researches. But in his radical model of the Jovian magnetic field, which he developed in 1962 and bravely reiterated last month before the American Geophysical Union in preparation for Pioneer 10's fly-by, he is virtually alone.

Because the model is, as one astrophysicist succinctly puts it, "weird." So weird, in fact, that even if it is correct, Warwick himself can't explain it. On the other hand, if the model is wrong, he can't explain his own data. "To say that I'm apprehensive," says Warwick, "is the understatement of the week."

Actually, Warwick believes, the dipole is off-center not just one way, but three. The only one about which there is any agreement is the tilt; that is, the axis of the dipole is tilted in relation to the planet's axis of rotation. The consensus, based on radio astronomical observations including the "rocking" of the plane of polarization of the field as the planet rotates, seems to be that the tilt is about 10 degrees. The limits of the resolution of radio telescopes, however, leave some room for interpretation, and Warwick thus thinks the tilt is only about 8 degrees. Such a tilt is not unexpected—earth's dipole has an even larger one in fact, apparently of about 11 degrees.

Another way of displacing the dipole is to move its center out from the center of the rotating planet, in the plane of the equator. Earth's dipole shows this displacement too, with its center moved about five percent of the planet's radius out from the center of rotation. Warwick's analysis of Jupiter's field, however, puts that dipole's center out more than 15 percent of the planet's radius, a much more radical displacement. In this displacement, though, there has been at least a hint of a similar finding by another researcher. In 1968, Nicholas Branson of the University of Cambridge, England, reported using the Cambridge one-mile radio telescope in observations that revealed an apparent "small asymmetry either in the electron density or more probably in the magnetic field at a longitude close to 190 degrees," although, he said, with "any real displacement of the magnetic field from the center being less than about one-tenth of the radius of the planet."

Warwick's major departure is, however, his belief that Jupiter's dipole is centered not only off to one side, but far to the south, more than seven-tenths of the radius of the giant planet "downward" from the plane of its equator. This shows up, he says, not only in his own studies, but in data from the observations of other researchers in 1963, 1964 and 1968 including some from the huge Parkes radio observatory in Australia. (The Australian researchers, Warwick admits, reported neither equatorial nor north-south displacements in their own analyses of the same data.)

"I have tried to interpret the radio emission data as completely as I could," Warwick says, "and to make those conclusions which I felt were justified." When making the analyses which revealed the displacements, he declares, he had no preconceived reason to expect them. In fact, he says, "My first impulse was to center the dipole . . . I've tried hard to center it." But the data, as he saw them, insisted otherwise. "If there is no displacement," says Warwick, with somewhat the tone of a man facing an obviously impossible ghost standing implacably before him, "there are some pretty weird things going on up there."

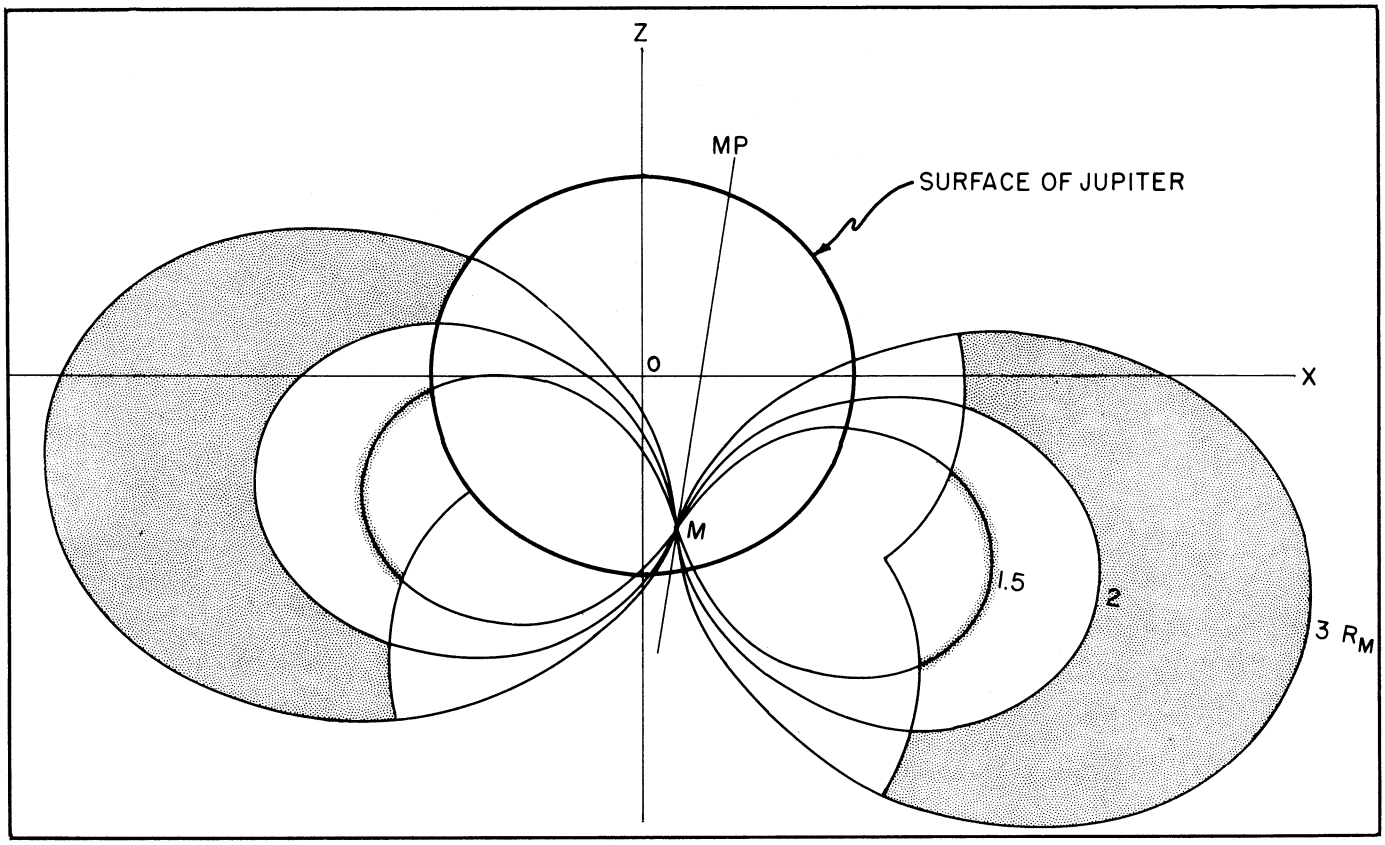
Pioneer 10 should provide the answer. It carries a magnetometer capable of measuring in all three dimensions, whose results will go promptly to a team of seven scientists, largest of the 13 groups working with the space probe's experiments. By comparing the magnetometer's three-dimensional measurements with Pioneer's route past the planet, the investigators should get clear indications of the presence—or absence—of any such irregularities in the dipole's location and orientation.

Edward J. Smith of the Jet Propulsion Laboratory in California, principal investigator for the magnetometer experiment, describes Warwick's model as "very detailed" compared with the resolution of the data on which it is based. "But," he says, mindful as are other researchers of the Colorado scientist's abilities, "I'm open-minded."

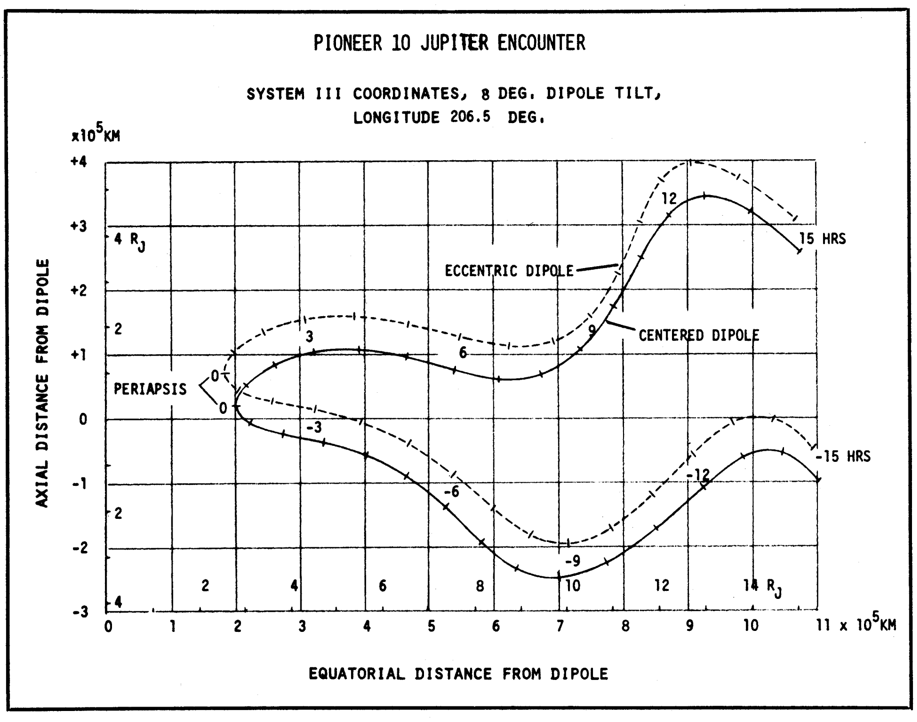
Two kinds of analysis will be used in figuring out what Jupiter's magnetic field looks like, according to Smith. The "frontwards" method will be simply to let a computer extrapolate Pioneer's measurements outward into a picture of the field. The "backwards" approach will be to try to fit the measurements against what a space probe on Pioneer's path would find in the presence of various proposed field models, including Warwick's. The competing models are being prepared for this comparison by Gilbert Mead of NASA's Goddard Space Flight Center.

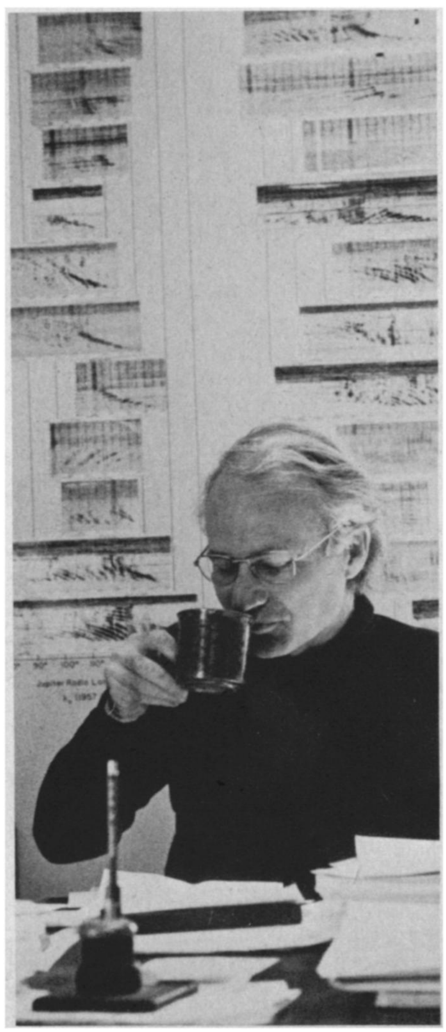
There's a real possibility, however, that the whole thing won't work. Some researchers believe that the proton levels in Jupiter's radiation belts may be high enough to "cook" the spacecraft's electronic components so that no data at all will get back to earth. Pioneer 10 is aimed to pass only 1.86 times the planet's radius away from the surface, with Pioneer 11, already en route, scheduled to go even closer (unless Pioneer 10 cooks and frightens it away).

Meanwhile, Warwick awaits December. "I went way out on a limb," he says. "I'll stand on it." □



James Warwick, flanked by charts of Jupiter's radio emissions, is sticking to his prediction that Jupiter's magnetic field is far off-center, both equatorially (to the right in the upper diagram) and "downward." His model indicates that the field's hub is almost 30,000 miles from the planet's center, or less than a third of the way in from the "surface." The truth should become known shortly after Pioneer 10 passes by Jupiter early in December, carrying a magnetometer that ought to determine whether the dotted line or the solid line in the chart below is correct. The dotted line is the path of Pioneer 10 relative to Warwick's field model, while the solid line shows the encounter with a more conventional one. "To say that I'm apprehensive," says Warwick wryly, "is the understatement of the week."*





Drawings: James W. Warwick

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