Unlocking secrets of the Martian interior

Two spacecraft exploring Mars—one just beginning its mission, the other more than 2 months beyond its 30-day expected life—have gleaned new findings about the inside of the Red Planet.

Last month, shortly after the Mars Global Surveyor entered orbit around the planet, it detected what appeared to be a weak, global magnetic field (SN: 9/20/97, p. 182). After analyzing several more measurements taken as the craft passed within 110 kilometers of the surface, researchers now conclude that any global field the planet might once have had petered out long ago.

Still, the crust is littered with at least eight magnetic patches a few hundred kilometers across. Their magnetic axes all point in different directions, as if bar magnets had been strewn beneath the surface, says Jack Connerney of NASA's Goddard Space Flight Center in Greenbelt, Md. The strongest local field Surveyor measured is 400 nanoteslas, or 1.3 percent of Earth's field, he reported Oct. 2 at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif.

The most likely explanation for the magnetic features, Connerney says, is that they are relics of a global field active long ago on Mars. Like Earth's present magnetic field, the Martian field may have arisen from a dynamo generated by the rise and fall of material around a liquid core.

As molten, iron-rich rock rose from the depths of the planet, it cooled and solidified, trapping the imprint of the field. In this model, the crustal features have different magnetic orientations because each is a snapshot of the planetwide field at a particular time.

"These relics are basically recording the history of the Mars dynamo," says Connerney. Scientists believe that the Martian core froze early in the planet's history, extinguishing the dynamo.

By combining a detailed magnetic map with knowledge of the age of those parts of the crust that harbor magnetic features, Connerney's team hopes to determine how often Mars' magnetic field reversed direction and when it shut off. This, in turn, could reveal the composition of the core.

To make a complete map of the magnetic anomalies, Surveyor will need to make many more low-altitude passes. This feat is possible only if the craft continues to dip into the upper Martian atmosphere, a maneuver intended to round the craft's highly elongated orbit. On Oct. 12, however, NASA suspended the maneuver for at least 2 weeks after finding that the atmosphere had exerted troubling pressure on a loose panel on Surveyor.

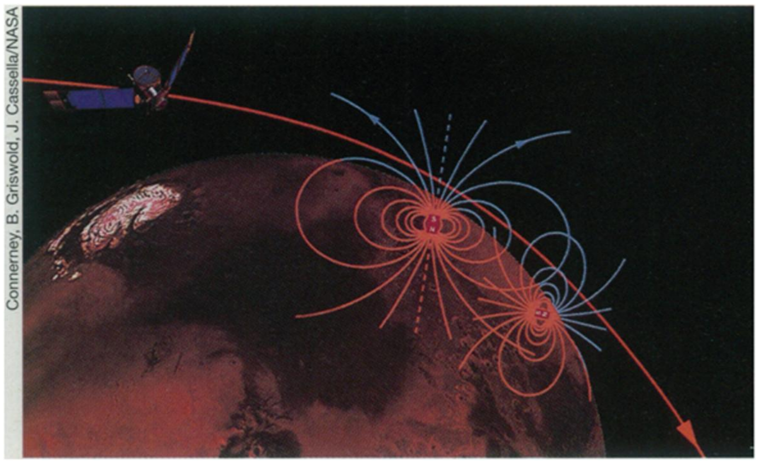
Data from Mars Pathfinder, which landed on July 4, are also unveiling the planet's internal workings. By comparing the arrival time of radio signals recently bounced off Pathfinder and the Viking landers 2 decades ago, researchers have deduced how much the planet's spin axis wobbles over time. The wobble, says William Folkner of JPL, indicates that Mars is not a uniform ball but consists of a core, mantle, and crust, with the heaviest material near the center.

Geologists had assumed that Mars has a layered architecture, but the radio data provide the first direct evidence of it, notes Pathfinder investigator Ronald Greeley of Arizona State University in Tempe. This structure, he adds, is a requirement if Mars once had a dynamo-generated magnetic field.

The measurements reveal that the core of Mars has a radius of at least 1,300 km, Folkner notes, assuming the core is made of solid iron. If it is a mixture of iron and sulfur, its radius could be as much as 2,000 km. The planet's radius is 3,400 km.

Scientists have not received data from Pathfinder since Sept. 27. They suspect its batteries died, forcing it to rely entirely on solar power and thus limiting its ability to radio Earth. Since the craft's rover, Sojourner, can transmit information only via the lander, it too is mute. The rover is programmed to return to the craft if it has not had a command in 5 days, but no one knows whether it has obeyed that order. —*R. Cowen*

Schematic of two of the magnetic sources buried inside the crust of Mars. Light patch is the north polar cap.



Connerney, B. Griswold, J. Cassella/NASA

Simulated hydrogen flows free of friction

Helium is one of a select group of substances that at low temperatures can form superfluids, liquids that flow without friction. A new computer simulation demonstrates that molecular hydrogen could gain entry into that exclusive club.

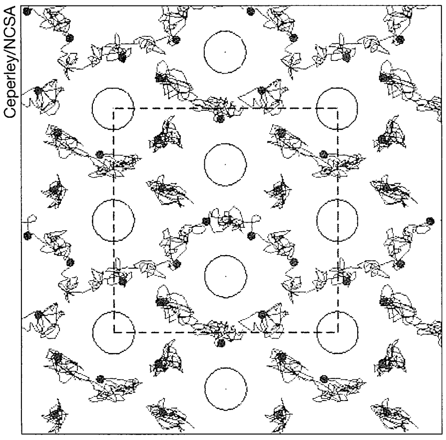
Researchers modeled the movement of hydrogen molecules on a flat silver surface dotted with alkali metal atoms such as potassium or cesium. The simulation shows that in this environment the hydrogen chills into a superfluid at 1.2 kelvins, just above absolute zero.

By themselves, hydrogen molecules solidify readily at low temperatures because they attract each other strongly. In the computer simulation, the alkali atoms, spaced about 1 nanometer apart, separated the hydrogen molecules and thus kept the substance liquid. "On the silver surface," says David M. Ceperley, "the alkali atoms naturally sit where we need them to be."

He and M. Carmen Gordillo, both at the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign, report their findings in the Oct. 20 PHYSICAL REVIEW LETTERS.

The simulation traced out the paths of a group of hydrogen molecules and showed that many of them swapped positions as they moved among the alkali atoms. Molecules that change places freely constitute a portion of a liquid that can flow with no resistance—a superfluid, says Ceperley.

Simulations could explore other unusual superfluid systems, such as mixtures of two fluid components, Ceperley says. This particular simulation suggests how researchers might try to produce superfluid hydrogen in the laboratory. —*C. Wu*



Ceperley/NCSA

A computer simulation traces the movement of hydrogen molecules (red dots) among potassium atoms (blue circles) on a silver surface. Molecules whose paths are connected exchange positions with each other, indicating that they are part of a superfluid.