Spacecraft probes beneath sun's surface

Glimpsed by the naked eye, the sun's surface appears smooth and uniform. Solar astronomers, however, see it as a witch's cauldron, belching blobs of hot gas and energetic radiation far into space. Data from a spacecraft now allow scientists to dig deep under the surface, probing the turbulent motions that power these eruptions.

By watching the rise and fall of gas at the surface, motion generated by sound waves emerging from the deep interior, researchers over the past 2 decades have begun mapping the flow of gases thousands of kilometers below (SN: 4/3/93, p. 213). The latest maps, compiled from data collected by an instrument aboard the Solar and Heliospheric Observatory (SOHO) spacecraft, may provide new insight into the origin of sunspots, concentrated magnetic fields that appear from Earth as dark blemishes.

The data, presented last week at a NASA press briefing in Washington, D.C., highlight the sun's diversity. Ground-based observations taken more than a decade ago had indicated that the sun is ringed by bands of gas moving at different speeds. The observations from SOHO, launched in late 1995 and now poised 1.5 million kilometers sunward from Earth, confirm the existence of these bands and reveal that they extend far beneath the surface, penetrating at least 19,000 km.

Each belt is a swath, more than 64,000 km wide, of charged gas that travels about 16 km per hour relative to its surroundings. Researchers liken the belts to the trade winds circling Earth's equator or the colorful bands of gas ringing Jupiter. Intriguingly, note SOHO investigators Craig DeForest and Jesper Schou of Stanford University, the boundaries between neighboring belts are precisely where sunspots form.

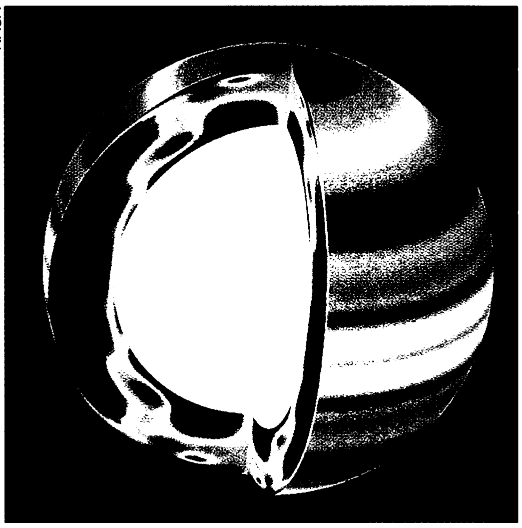
The change of speed across the boundaries could twist and intensify magnetic field activity inside the sun, suggests solar astronomer Douglas O. Gough of the University of Cambridge in England. At the surface, such activity could generate a sunspot. Alternatively, notes SOHO researcher Philip H. Scherrer of Stanford, cause and effect may work the other way around: The intense magnetic field may present an obstacle to the flow of gas, giving rise to the bands.

In either case, the link between the bands and magnetic field activity provides "an inroad to understanding the 11-year sunspot cycle, which has been puzzling us for centuries," DeForest says. As the sunspot cycle progresses, the sites where these short-lived features originate move from the north and the south toward the equator. Like the illusion of sinking stripes on a barber pole, "the bands that we see are also slowly migrating toward the equator, at just the same rate as the sunspots," says Gough.

This movement, he adds, is complicated by another global pattern detected by SOHO. Data taken over the past year show that the sun's outer layer, to a depth of at least 24,000 km, displays an overall flow of gas from the equator to the poles of about 80 km per hour.

"That's quite different from Earth, and that is something we have yet to understand," says Gough.

Another SOHO discovery ranks as an even bigger surprise, says Schou. Data compiled by the craft's Michelson Doppler imager show evidence of jet streams near the poles. Within several flattened oval regions that ring the sun at 75° latitude, gaseous material moves about 10 percent faster than the surrounding gases. Moreover, these streams are entirely submerged. Gough theorizes that the feature may be temporary, a signpost of the new solar cycle that began about 1.5 years ago. —*R. Cowen*



NASA

False-color image shows variations in speed between different regions on the sun. Red and yellow denote faster-than-average motion; blue is slower. The bands on the left side of the image extend at least 19,000 km beneath the surface. In the cutaway section, red ovals at the poles are newly discovered jet streams.

Trapping tiny particles electrostatically

For picking up small things, an ordinary pair of tweezers usually does the trick. Nanometer-size particles, however, require a more sophisticated tool.

Researchers at Delft University of Technology in the Netherlands and the Institute for Inorganic Chemistry in Essen, Germany, have fabricated just such a device. Consisting of two tiny electrodes, it traps clusters of a few thousand atoms. The device offers a way to study how electrons move through single molecules, says physicist Cees Dekker.

Such measurements could, for example, "shed some light on the mechanism of conducting polymers," Dekker says. Currently, it's hard to identify the contributions of individual molecules to the bulk properties of a material. Dekker and his colleagues describe their work in the Sept. 1 Applied Physics Letters.

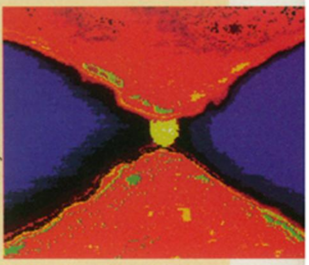
In the future, a device such as theirs could also aid in the development of molecular electronics, in which individual molecules serve as wires, switches, and other components. "With these small probes, we can start checking feasibility and potential of these molecules," Dekker says.

The researchers constructed the device with techniques used to make the complex circuits in computer microchips. They formed electrodes by first etching away part of a silicon wafer, leaving a bridge with a gap in the middle. They then deposited platinum on this structure. Placing a drop of water containing suspended palladium particles on the device, they applied a small voltage to capture clusters of atoms in the field between the two electrodes. After evaporating the water, they could see, under a scanning electron microscope, a single palladium cluster caught in the gap.

Paul L. McEuen of the University of California, Berkeley says, "Many people have thought of the idea [of snaring particles by using electric charge], but no one had done it." Other teams had simply tried to drop particles into a trap.

The electrode spacing, which can be as narrow as 4 nanometers, determines how many clusters get captured. "If the gap is bigger than the particle size, we end up with a string of particles in a chain," says Dekker. The device can also snag much larger particles, such as micrometer-size carbon nanotubes.

The group's experiments on trapped palladium have already revealed some interesting electron behavior—an unexpected profile of how a single electron crosses the gap. —*C. Wu*



A. Bezryadin et al./Delft Univ.

Two platinum electrodes (red) trap a cluster of palladium atoms (yellow) that is 17 nanometers in diameter. This image is a colorized electron micrograph.