Astronomy

Ulysses begins polar exploration

At long last, Ulysses has reached its final destination. After nearly 4 years of sailing through the inner solar system, this spacecraft is now mapping uncharted solar territory. Moving out of the plane in which the planets orbit the sun, Ulysses began in late June to study the star's polar regions.

Through December, the craft will orbit about 2.4 astronomical units (AU) below the solar south pole; a similar sojourn above the north pole begins next June. (One AU is the average distance between Earth and the sun.)

From its unique vantage point some 70° south of the sun's equator, Ulysses can study the south polar magnetic field, probe the solar wind at this location, and examine more fully the nature of the sun's upper atmosphere, or corona. Though the craft won't get its best view of the south pole until mid-September, the data already gathered hold several surprises, says Ulysses project scientist Edward J. Smith of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif.

The craft hasn't yet found an increase in the strength of the magnetic field at the sun's south pole – even though researchers believe that the field is most intense at the poles. But Ulysses did find large variations over time in the field's direction. Scientists model magnetic fields as taut rubber bands; the time fluctuations may stem from waves generated in the bands by intense activity at the poles, Smith notes.

The variations over time may explain why Ulysses didn't find an increase in the intensity of cosmic rays – high-speed atomic nuclei arriving in the sun's vicinity from other parts of the galaxy. Astronomers had expected the magnetic field to bend the path of incoming cosmic rays, thus enabling them to reach the poles more easily. But the changes over time could weaken the field's ability to redirect the particles, Smith says.

The craft also found that at the poles, the solar wind blows out from the sun twice as fast as it does at lower latitudes. This dovetails with evidence that the south pole has a large coronal hole, a source of the wind.

Ida's moon: A sharper view

Last spring, images radioed by the Galileo spacecraft from a 6-hour encounter with the asteroid 243 Ida revealed a tiny satellite orbiting this rocky body – the first moon of an asteroid ever photographed (SN: 4/2/94, p.214). NASA recently released Galileo's sharpest view of the moon, taken a year ago and radioed in June. The image of the kilometer-size, egg-shaped moon resolves features as small as 50 meters across.

The picture shows more than 12 craters that exceed 80 m in diameter, indicating that the tiny body has taken quite a battering from solar system debris. In fact, this suggests that the moon can't be more than a few hundred million years old, says Michael J.S. Belton of the Kitt Peak National Observatory in Tucson. An older object this small probably wouldn't have survived the additional impacts, he adds.

Belton suggests that the direct ancestor of the moon is not the same one that fragmented to create Ida. But both the asteroid and its satellite ultimately stem from the breakup of the much larger body that formed the Koronis asteroid family, he says. Infrared spectra taken by Galileo also suggest that Ida's moon isn't just a chip gouged from Ida. These data show that the surface abundance of the minerals pyroxene and olivine on the moon differs from that on Ida, says Robert W. Carlson of JPL.


JPL/NASA

Galileo's sharpest view of the moon orbiting 243 Ida.

Mathematics

Richard Lipkin reports from San Diego at a meeting of the Society for Industrial and Applied Mathematics

Simulating how molecules move

A complex molecule, whether a fullerene, protein, or strand of DNA, is an unwieldy object to describe. Though a stick-and-ball model can reveal its structure, one can only guess how such an entity will move when it flexes and folds.

Biochemists have now joined with mathematicians to make computer programs that show how complicated molecules – sometimes composed of thousands of atoms – move.

Benedict J. Leimkuhler and Eric J. Barth, both mathematicians at the University of Kansas in Lawrence, report devising a model that simulates the interactive motions of a large molecule. Their algorithm, which illustrates "constrained molecular dynamics," not only captures the movements within complex molecules, it also speeds up such simulations.

"The problem we're addressing as mathematicians is to improve the algorithms used to model biomolecules," explains Leimkuhler. "The models treat molecules as a collection of point masses connected by forces. Our goal is to make those algorithms more efficient for . . . more powerful simulations."

To mimic motion in a protein with 10,000 atoms, the algorithm breaks up the molecule's twisting into discrete units. "It determines the state of the molecule at each time step. At any moment, the algorithm knows where the molecule has been and then predicts where it is going," says Leimkuhler.

In a stepwise fashion, the program shows how a molecule's components interact with and affect one another. "The goal is to make an algorithm efficient so it can show realistic motions over a reasonable span of time," says Leimkuhler. "Right now we're working in femtosecond, or 10^{-15}, increments. Ultimately, we want to show how proteins fold, or how nylon stretches, or how buckyballs lubricate a surface. These actions take place over 1 or more seconds, so we have a long way to go."

Listening for deep oil deposits

Fossil fuels lie buried within Earth. The problem is finding them. To plumb those depths, scientists set off surface explosions and then listen for the returning shock waves. Such seismic rumbles give telltale clues of hidden oil reserves.

Geophysicists dig a hole some 100 meters deep, pack in explosives, seal the hole, and set off a downward-directed kaboom. Some of the shock waves from this focused blast radiate through Earth's stratified layers and reverberate back. Bouncing off rock, hydrocarbon reserves, or other sediments, these reflected waves bear unique signatures from which scientists can decode the properties of underground materials.

Susan E. Minkoff and William W. Symes, both mathematicians at Rice University in Houston, report a new analytical method for estimating the energy of the explosion and the characteristics of the reflected shock wave. Their work represents a novel approach to seismic inversion.

"Inversion techniques are very common," Minkoff notes. "But for some reason, no one has tried to estimate both the energy source and the reflectivity of a seismic event using an inversion method."

Geophysicists correlate the waves' velocities with the densities of underground materials, Minkoff says. Based on this information, they figure out the types of rocks and locations of hydrocarbon deposits. "In order to do that, they need to know the energy source," she says. Since scientists can't determine exactly how much of the explosive energy is focused directly into a shock wave, they estimate it. "This inversion method gives them a more accurate way to estimate that energy source," Minkoff explains.

Minkoff and Symes tested the inversion method with data from a seafloor experiment in the Gulf of Mexico. "When we did an inversion for both the energy source and the reflectivity, we cut the error rate in half," she says. "That's the bottom line."