Using neutrino telescopes to undress Earth

Geophysicists are looking to the heavens for help in probing Earth's inaccessible interior. Taking advantage of new astronomical instruments capable of detecting cosmic neutrinos, a team of researchers hopes to use these wraithlike particles from space as a planet-size CAT scanner for revealing Earth's inner structure.

At a meeting of the American Geophysical Union last week in San Francisco, Chaincy Kuo of the University of California, Berkeley, and her colleagues presented their scheme for "neutrino tomography," a technique that relies on gauging how readily these chargeless particles with little or no mass pass through Earth. The researchers plan to start their project next year. Although team members admit this technique is a bit of a gamble, the idea has excited many earth scientists because it could provide unique information about the huge currents of rock that move the wandering continents.

"Even though it's very much of a long shot, I am enthusiastic because it could make a profound contribution to our understanding of deep Earth layers," says Thorne Lay, a seismologist at the University of California, Santa Cruz.

Neutrinos are produced in the sun and in other celestial bodies such as supernovas and highly energetic, "active" galaxies. Moving at close to the speed of light, neutrinos interact so weakly with other matter that most of them, particularly those emitted by the sun, zip unhindered through Earth. Higher-energy neutrinos from outside the solar system, however, occasionally do collide with atoms inside the planet.

Interest in neutrinos surged after astronomers observed some of these particles in the wake of supernova 1987A. Several new neutrino telescopes are planned, and researchers are currently constructing one 4,800 meters below the ocean surface near the island of Hawaii. Called the Deep Underwater Muon and Neutrino Detector (DUMAND), the project will eventually consist of 216 light-sensing tubes strung along nine vertical lines anchored to the ocean floor. This month, workers began installing three of the lines, which will function on their own for the next year.

DUMAND does not actually detect neutrinos, but rather bursts of Cerenkov light given off by muons created when a neutrino collides with a proton or neutron near Earth's surface. The direction and strength of the light reveal the original direction and energy of the neutrino.

Because dense rock blocks neutrinos more readily than less dense rock does and because neutrinos from a given cosmic source pass through different parts of Earth as the planet rotates, Kuo and her colleagues propose to use the neutrino counts to study variations in density within Earth. The researchers will analyze DUMAND results over the next year to see whether the instrument observes enough neutrinos to make this technique feasible.

If viable, neutrino tomography would complement studies of the planet's structure made by seismologists who analyze how earthquake waves pass through Earth's crust, mantle, and core. While seismic investigations have yielded considerable information about the planet's interior, they cannot provide detailed information about density, nor can they resolve horizontal density differences, says Berkeley's Raymond Jeanloz, a collaborator in the neutrino-observing study.

"What's really interesting is that we can start getting 3-D lateral variations in density. That's the ultimate goal, because those density variations drive the convection of the mantle. That's really what drives geologic processes on a global scale," Jeanloz says.

Earth scientists could theoretically extract even more information from neutrino observations. Because atoms with higher atomic numbers block more neutrinos, researchers may eventually use DUMAND and other detectors to help decipher what types of minerals and elements make up Earth's mantle and core. Geoscientists have their suspicions about the planet's innards, but they cannot identify what lies hidden thousands of kilometers underfoot. *—R. Monastersky*

Superconductivity possible at 250 kelvins

"If it's true, it would be fantastic," says Miles V. Klein, a physicist at the University of Illinois at Urbana-Champaign. "250 degrees kelvin is almost room temperature in Siberia."

Klein was referring to the report this week by a French team that it had attained superconductivity at 250 kelvins (−23°C) in a thin film. Albeit a fleeting phenomenon in tiny samples, superconductivity at this temperature is the highest officially reported so far, nearly 100 kelvins above what other groups have published (SN: 10/2/93, p.214).

Reporting in the Dec. 17 SCIENCE, Michel Laguës, a physicist at a Centre National de la Recherche Scientifique (CNRS) facility in Paris, and his colleagues describe a method for making a finicky, thin film of copper oxide. The film contains eight layers of copper and oxygen molecules sandwiched between other layers of bismuth, strontium, calcium, and oxygen. The scientists built the thin film painstakingly atom by atom, using a method called sequentially imposed layer epitaxy.

The material itself — a type of cuprate compound belonging to a well-known family of materials denoted BiSrCaCuO — is not fundamentally new.

"The basic architecture of this material is well known," Laguës says. "What's new here is the way we grew these materials, layer by layer. It's not hard to make a sequence of layers — copper, calcium, copper, calcium — many times. But it's very difficult to get the structure just right, with the right conditions. So what we've done is made the material well enough to obtain superconductivity at this temperature."

Subjecting the material to standard tests for superconductivity, the researchers watched its electrical resistance drop by a factor of 100,000 as the sample cooled from 280 to 250 kelvins. At 235 kelvins, its resistance fell below detection levels. The sample also showed magnetic characteristics typical of superconductivity.

Still, many researchers, while hopeful, remain cautious about these results. Other groups have described superconductivity at such temperatures, but colleagues discounted the findings when they could not document or reproduce them. Laguës, in contrast, says his group has reproduced their results, though other laboratories have not yet confirmed the report.

"This paper improves the chances of there really being superconductivity at 250 kelvins, but it's not conclusive," says Theodore H. Geballe, a physicist at Stanford University. "The amount of material is very small, the signals they've measured are small, and more work must be done to find out what this material really is." He stresses the uncertainty associated with tiny samples. "But their paper is a step forward," he adds. "It's more conclusive than previous work."

Thirumalai Venkatesan, at the University of Maryland's Center for Superconductivity Research, also remains skeptical. "Their data are interesting but not entirely convincing," he says. "The magnetization signals are so low that it's difficult to use them as evidence. Also, there are not enough data points in the temperature-versus-resistance curve. It's not clear to me that this is reproducible. Something other than superconductivity could explain these results."

While some researchers question the French report, Paul C.W. Chu, a physicist at the Texas Center for Superconductivity at the University of Houston, doesn't find the results outlandish. "Based on what I've heard, these results sound reasonable."

"Let me put it this way," Chu adds. "Any group can have credible results. And any credible group can have incredible results." *—R. Lipkin*