rium and the far more abundant hydrogen in the clouds have such similar spectral signatures that disentangling the two is a delicate, not to say risky, task.

The first widely reported deuterium measurement appeared in a 1994 *Nature* paper by Antoinette Songaila and Lennox Cowie of the University of Hawaii, along with Hogan and Rugers. They had studied a cloud along the line of sight to the quasar known as Q0014+813. Based on the depth of a small notch in the spectrum next to a deep well of hydrogen absorption, this group reported the 1–5000 ratio of deuterium to hydrogen atoms—but only as an upper limit. The reason for their caution, they explained, was the possibility that a small, nearby "interloper" cloud of hydrogen might be drifting through the line of sight to the main cloud. The motion of the interloper could have shifted its absorption spectrum by just enough to mimic all or part of a deuterium feature in the main cloud.

In their later *Ap. J. Letters* paper, however, Rugers and Hogan concluded that this ratio could be interpreted as a firm value rather than just an upper limit. They had reanalyzed the same data and found a sharp spike of reduced absorption in the center of the apparent deuterium feature. The spike split the notch into two narrower features that looked even more like the fingerprints of deuterium. Rugers and Hogan concluded that they were seeing the shadows of high deuterium in two separate clouds. "The spike was the thing that made us think it was [purely] deuterium," says Hogan.

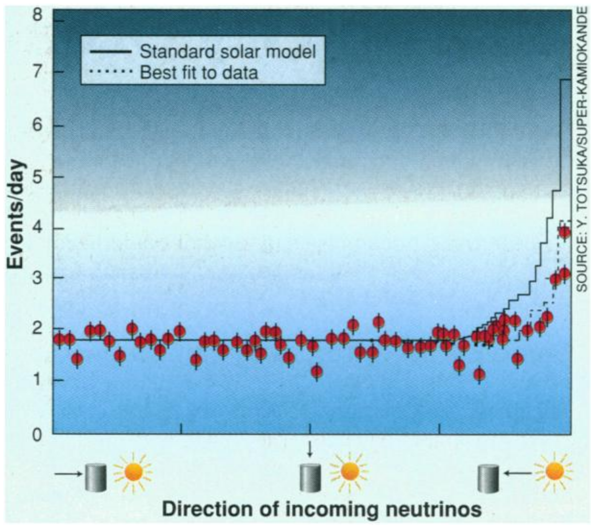
But when Tytler and UCSD's Scott Burles and David Kirkman observed the same cloud with the Keck on two nights in early November, they saw no spike at all. In retrospect, say researchers close to the project, the spike may have resulted from a technical glitch in the reanalysis. What's more, the UCSD team found that the entire notch had shifted slightly, moving it away from the frequency expected if it were caused only by deuterium. A small interloper cloud may be at least partly responsible for the hints of high deuterium after all, say researchers who have read the group's preprint.

Tytler and co-workers, says E. Joseph Wampler of the National Astronomical Observatory in Japan, "have pretty convincingly shown that the earlier models … are incorrect, at least in detail." But the real value of primordial deuterium is yet to be determined and could still emerge from this cloud, he says. Cowie, for example, not only raises questions about Tytler's own measurements on a different cloud but says new, unpublished data he and Songaila have gathered on Q0014+813 support their original upper limit. In cosmology as in politics, every headline is subject to change.

–James Glanz

NEUTRINO DETECTION

Japan's 'Super' Site Confirms Deficit



Not enough. Super-Kamiokande is measuring half the predicted number of neutrinos from the direction of the sun.

CHICAGO—If neutrinos were precious gemstones, the supply of these elusive particles would scarcely be enough to satisfy holiday shoppers in one of this city's wealthier neighborhoods. But last month brought good news: Japanese researchers reported that the world's largest neutrino detector—a $100 million device located in a mine 300 kilometers west of Tokyo—has begun to collect enough data to satisfy an international clientele. These scientific customers all hope to explain why even the best source of these cosmic messengers—the sun—seems to fall short.

Speaking at the 18th Texas Symposium on Relativistic Astrophysics, held here on 15 to 20 December, Yoji Totsuka of the University of Tokyo, spokesperson for Japan's Super-Kamiokande detector, said that the count rate at the newly constructed detector confirms a mysterious deficit in the flux of neutrinos from the sun. That deficit, which had been seen in data from Super-Kamiokande's predecessor, Kamiokande, as well as other facilities, is a crucial clue in the quest to determine whether these particles have mass—a question with profound consequences for physics and cosmology.

The data are coming in so fast, says Totsuka, that researchers should soon be able to piece together the neutrinos' energy spectrum, which may help them determine just what causes the shortfall. In just 102 days of running time since April, Super-Kamiokande "has more events than all previous solar-neutrino experiments have gotten in 30 years," says John Bahcall of the Institute for Advanced Study in Princeton, New Jersey, another speaker at the conference. "For me, it's thrilling."

Neutrinos are weakly interacting particles first identified in 1956 after being posited a quarter century earlier to explain aspects of radioactive decay. They are commonly produced in many kinds of nuclear reactions, including those that power the sun and that take place when cosmic rays collide with the upper atmosphere. They come in three "flavors," one of which—the electron neutrino—is easiest to spot with water-filled detectors like Super-K. And according to physicists' standard picture of particles and forces, they are massless.

The solar shortfall, however, could be a sign of neutrino mass. Bahcall, who is not part of the Super-K team, and others have suggested that neutrino mass could allow the easily observed electron neutrinos to "oscillate," or transmute, into one of the other two types as they travel from the sun's core to Earth, eluding detection. Then again, the apparent deficit might reflect an imperfect understanding of the sun's workings.

The details of the shortfall could help physicists choose between these explanations. Like Kamiokande, Super-K detects trails of Čerenkov light given off by electrons after their rare interactions with neutrinos. With 50,000 metric tons of water and 11,200 photodetectors, Super-K is picking up about 10 neutrinos a day from the direction of the sun (see graph). That's only half the number predicted by solar theory and the Standard Model of particle physics, which assumes massless neutrinos. In that respect, said Totsuka, "we have already confirmed the old Kamiokande data. [The detections] are well below the predicted numbers."

Totsuka says the project is now seeking to measure the energy spectrum of the arriving neutrinos. That information, he says, should begin to emerge in a few years, after "about a factor of 5 more data." Well before then, the team also hopes to have data on another neutrino problem: the observed shortfall of one type of atmospheric neutrino.

The results add up to "a beautiful experiment," says Douglas Duncan, an astronomer at the University of Chicago who chaired the neutrino session. And the data promise to keep neutrino-hungry astronomers in a holiday mood for several more shopping seasons.

–James Glanz