been conducted of how NExT participants fare, but that will be done during the second 3-year grant period.

In an informal survey, project participants say they are more than satisfied. Jose Giraldo, a 1994 fellow, says that in his first year at Texas A & M University at Corpus Christi, his colleagues were not interested in the ideas for change he brought from graduate school—for example, using graphing calculators in the classroom and assigning students small projects throughout the term. After a year of struggling for permission to try these techniques, he recalls, "I was going to quit." Giraldo says that what he learned at NExT workshops helped bring his colleagues around, however. "It gave me credibility and confidence. If I mentioned an idea for reform in teaching, I'd support it with references," he says. Now, he adds, his department is "completely behind me."

Project NExT has also made it easier for young mathematicians to make the contacts they need to advance in their profession. In the sometimes intimidating atmosphere of a national conference, all they need to do to find a friendly face is look for the colored dots on name tags that signify project participants. "At a large conference, with few people around that you knew, you could just walk up to someone with a dot and start talking—instant companion," says Heather Hulett of Miami University in Ohio, who attended the first NExT workshop in 1994.

As a result of such contacts, numerous NExTers have gotten involved in regional activities or committees of the MAA; and the board of the Young Mathematicians Network, an independent Web-based organization, is composed entirely of NExTers. Moreover, their positive experiences keep them coming back to national professional meetings. "By bringing young mathematicians to meetings several years in a row, you show them the value of contacts," says John Ewing, executive director of the American Mathematical Society. "Most young mathematicians learn that slowly, over many years, or never learn it at all. Project NExT fellows have it handed to them for free."

Could Project NExT serve as a model for similar programs in the other sciences? The physicists apparently think so, and have started a similar program (see sidebar). "If you look at the bare-bones structure, it's discipline-independent," Leitzel says. "There are three principles: to connect new Ph.D.s with the broader community of their discipline, to acquaint them with the issues of teaching and learning, and to provide a support network for them."

–Dana Mackenzie

Dana Mackenzie is a writer in Santa Cruz, California.

PHYSICS

Snare for Supernova Neutrinos

How do you see into the heart of an exploding star? Simple, says an international team of physicists: Go almost a kilometer deep into the earth and wait. These researchers hope to convert deep salt deposits into a pair of underground observatories that would capture thousands of the elusive particles called neutrinos, which spray from the very core of a supernova—carrying clues to its workings.

Led by researchers at four different institutions in the United States and the United Kingdom, the project, called Observatory for Multiflavor Neutrinos from Supernovae (OMNIS), has already settled on a general design and preferred locations; now it faces the struggle of raising tens of millions of dollars from funding agencies. If OMNIS gets up and running, the waiting will begin—years or decades—until a 10-second burst of neutrinos announces a supernova in our galaxy.

The project's roughly 20 collaborators say it promises more than just a view into exploding stars. The observatories, one in a salt deposit already excavated for a nuclear waste dump in Carlsbad, New Mexico, and the other in the Boulby Salt Mine in the United Kingdom, could also help settle the vexing question of whether the neutrino has mass.

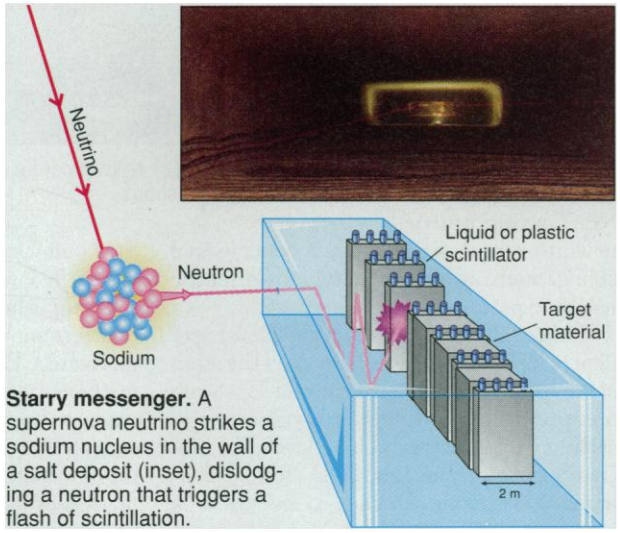
Unlike existing neutrino observatories, OMNIS could readily detect all three "flavors" of neutrinos, which would differ subtly in behavior if the particles do have mass—a finding that would open up new theories in physics and cosmology. "No question about it: I would love to see [OMNIS] go forward," says Mark Vagins of the University of California (UC), Irvine, and a collaborator on Japan's SuperKamiokande (Super-K), now the world's largest neutrino detector.

Existing neutrino observatories, including an earlier version of Super-K, have already demonstrated the principle of OMNIS by detecting a handful of neutrinos—19 ± 1, to be exact—from a 1987 supernova. But Super-K and its peers specialize in drawing the maximum possible information from the low-energy electron neutrinos—one of the three flavors—that stream from the sun (see *Science*, 10 January, p. 159). They are unlikely candidates for a decades-long watch for the pulse of high-energy neutrinos from a type II supernova.

Type IIs are thought to explode when a massive star's core runs out of fusion fuel, cools, and collapses. It then rebounds, generating a ferocious shock wave. The shock slows as it plows into the outer layers of the star, but theorists believe that a blast of neutrinos released from the core revives the shock, which blows the outer part of the star into space, says Adam Burrows, a theorist at the University of Arizona in Tucson.

OMNIS, which germinated around 1990 in discussions between David Cline of UC, Los Angeles, George Fuller of UC, San Diego, and others, "should be a world-beater in many respects" for unraveling the details of this story, says Burrows. Super-K detects faint trails of light when electron neutrinos interact with a huge tank of water, but the high energies of supernova neutrinos would allow OMNIS to use a simpler scheme: detecting the neutrons thrown off when a tiny fraction of the neutrinos crashes into atomic nuclei deep underground. Muon and tau neutrinos—the two other neutrino flavors—would hit either sodium and chlorine nuclei in the salt walls of the mine or iron nuclei in slabs near the detectors. Electron neutrinos, which are expected to shed some of their energy reviving the supernova shock, wouldn't pack enough punch to break up those nuclei. Instead, slabs of lead, which has more fragile nuclei, might be added to generate some of those events.

The neutrons released by the nuclei would rattle around the tunnel and strike scintillation detectors. "The whole flood of 2000 events lasts only 10 seconds, with 60% in the first 2 seconds," says Peter F. Smith, a collaborator at the Rutherford Appleton Laboratory in the United Kingdom. Collaborators hope the OMNIS design



Starry messenger. A supernova neutrino strikes a sodium nucleus in the wall of a salt deposit (inset), dislodging a neutron that triggers a flash of scintillation.

DOE

ILLUSTRATION: LIZ CARROLL SOURCE: P. F. SMITH/OMNIS will be cheap enough to run that it could ultimately see several events.

The shape of the neutrino pulse would tell astrophysicists whether they really understand how such stars explode and would clear up such mysteries as whether a black hole, from whose gravity nothing can escape, sometimes forms when the star's core collapses. "A sudden cutoff of neutrinos would be strong evidence for black-hole formation," says Super-K's Vagins. The dual detectors would help pinpoint a supernova's location and ensure that at least one detector is constantly working, says Richard Boyd, a collaborator at Ohio State University in Columbus.

Meanwhile, OMNIS's ability to pick out tau and muon neutrinos could help show whether neutrinos have mass. For a fixed energy, a particle with even a minute mass will move more slowly and hence take longer to traverse thousands of light-years than a massless particle will. The relative timing and pulse shapes of a supernova's electron-neutrino signal—seen primarily at Super-K and other detectors—and the muon and tau signals at OMNIS should reveal even slight mass differences. The Sudbury Neutrino Observatory in Ontario, Canada, which should begin taking data on solar neutrinos next year, could beat out OMNIS, because it could see as many as a quarter of OMNIS's expected haul of muon and tau neutrinos. But it relies on a tank of heavy water, provided through a lease from the Canadian government that is due to expire in 2001.

OMNIS collaborators are now putting together funding proposals for submission to the U.S. Department of Energy and the National Science Foundation. Estimates of construction costs range between $20 million and $40 million. One thing the project won't have to pay for is space underground. Wendell Weart of Sandia National Laboratory in Albuquerque, New Mexico, until recently technical project manager of the Carlsbad waste dump, says site managers would be happy to have the physicists as their guests. "It would be nice to think we're using it for some truly beneficial, scientific purpose in addition to disposing of this waste."

–**James Glanz**

ATMOSPHERIC CHEMISTRY

Rising Damp From Small Comets?

First, there were the strange, dark spots in the upper atmosphere, seen this spring in ultraviolet images from a satellite. Now comes evidence that the atmosphere has a relatively wet layer 70 to 80 kilometers (km) up.

In the standard picture of the atmosphere, water vapor is trapped below 12 km or so by a moisture barrier at the bottom of the stratosphere, keeping the mesosphere—the region between 50 and 90 km—almost bone dry. But last week, a satellite instrument detected signs of as much as 50% more water vapor at those altitudes than is called for by any conventional theory.

To space physicist Louis Frank of the University of Iowa in Iowa City, the explanation is clear: Fluffy, house-size comets are pummeling the outer reaches of the atmosphere 20 times a minute, releasing water that ultimately ends up in the mesosphere. Other researchers are far more cautious. "You have to give the man credit for predicting something we're now seeing," says Robert Conway of the Naval Research Laboratory (NRL) in Washington, D.C., principal investigator of the latest orbiting instrument to see signs of abundant mesospheric water. But Robert Meier of NRL, who endorsed Frank's detection of dark spots last spring (*Science*, 30 May, p. 1333), stresses that "this doesn't confirm snowballs in space. You have to look at alternative explanations" for a moist mesosphere.

The first hints of excess water in the mesosphere actually came late last year, when James Russell of Hampton University in Virginia and his colleagues reported a reanalysis of data gathered by the Halogen Occultation Experiment (HALOE) on the Upper Atmosphere Research Satellite. The satellite has been flying since 1991, and earlier analyses of data from HALOE, which measures solar absorption by the upper atmosphere, didn't show any unusual concentrations of water. But the latest look at the data revealed a peak in water vapor at an altitude of about 70 km.

"We were very skeptical at first" of the HALOE reanalysis, says Conway. But now his own instrument, NRL's Middle Atmosphere High Resolution Spectrograph Investigation (MAHRSI), has found abundant hydroxyl radicals, a breakdown product of water, in the mesosphere above high northern latitudes. Flown on a satellite deployed by the Space Shuttle, MAHRSI is the first instrument that is able to pick out the sunlight-induced glow of hydroxyl from the glare of scattered sunlight in the mesosphere. Its observations reveal high concentrations of hydroxyl at an altitude of about 70 km, right where HALOE saw the peak in water. Both instruments also show that the mesosphere is dampest in summer at high latitudes, where the added water could help explain noctilucent clouds—the wispy clouds of ice particles seen at 85 km during high-latitude summers. "There's a startling amount of water above altitudes of 65 km," says Conway—8 to 10 parts per million versus the 6 to 7 parts per million predicted by what is considered quite reliable theory.

P. PARVIAINEN

Wet layer. Unexpected water in the high atmosphere could help form icy noctilucent clouds.

"There's definitely something very unusual going on in the mesosphere that we don't understand at all," says theoretician Michael Summers of NRL, "but I'm not even close to saying this supports the small-comet hypothesis." For one thing, he and others are skeptical of Frank's scenario for funneling water from an altitude of 800 km, where Frank says the comets would break up, down to the mesosphere, where increasing atmospheric density would stop the water. The clouds of vapor would have to slam through 700 km of thin atmosphere, leaving hardly a trace of water on the way.

Summers and others add that even if the mesosphere is damp, it's not nearly as damp as Frank's theory would have it. David Siskind of NRL, Summers, and others have calculated how big an influx of water from above would be needed to explain the 70-km peak seen by HALOE. Frank's small comets exceed it "by at least a factor of three," says Summers. "My preferred view is that it's off by a factor of 30." Summers and his colleagues are therefore pursuing other explanations for the water: Perhaps it is deposited by meteorites or created by unexpected chemical reactions.

The loose ends don't worry Frank. "The most important thing is the finding of excess water up there," he says. "It's a big step." Sorting out water fluxes and why the water abundance varies with latitude and season will require close monitoring of the variations he has already detected in the small-comet bombardment, he says. Meteorologist John Olivero of Embry-Riddle Aeronautical University in Daytona Beach, Florida, agrees that it's time to start taking small comets seriously. "It's when we get challenging observations like this that we start to rethink all of our assumptions," he says. "That's what science is supposed to be all about."

–**Richard A. Kerr**