SCIENCE NEWS of the week

# Synchrotron Beam Sees Record Tiny Crystal

Scientists have pushed the limits of their technologies to make supertiny wires and superintense X-rays. And by combining these two advances, they have demonstrated that crystallographers can now discern the structure of sub-micrometer-sized samples.

Earl F. Skelton and his colleagues spent several days working around the clock at the Synchrotron Light Source at Brookhaven National Laboratory in Upton, N.Y., trying to detect radiation bouncing off atoms in an ultrathin bismuth filament. The filament measured 0.22 micrometer in diameter – less than 1 percent of the thickness of a typical human hair.

Finally, on the third morning, they succeeded. Their computer detected scattered X-rays that provided key information for determining the material's structure. The scientists discovered that their filament actually consisted of a single crystal, not numerous tiny ones as they had thought. And that crystal, they say, is the smallest ever observed.

"We're of the opinion that we have set a new record in terms of diffraction of small crystals," says Skelton, a physicist with the Naval Research Laboratory (NRL) in Washington, D.C. Using a measurement called scattering power, which takes into account the number of electrons per unit volume as well as the absolute size of the sample, the researchers calculated that their samples were several orders of magnitude smaller than the tiniest crystal previously observed, he says.

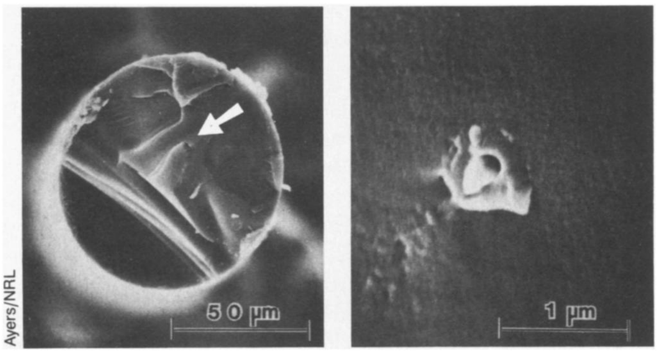
To probe the structure of such small samples, Skelton's group used a "wiggler beam," which intensifies the radiation by making the synchrotron's electrons zigzag several times through a magnetic field. The electrons emit bursts of energy with each wiggle, creating extra-bright radiation.

In addition, the team used a sophisticated technique, developed by crystallographer Larry W. Finger and his colleagues at the Carnegie Institution of Washington (D.C.), that detects any diffracted radiation.

"You get very fine beams of radiation coming out [of the sample], so it's like a spider web. You have to look at it just right [to see it]," Skelton says.

Such capability can help crystallographers overcome the frustrating inability to produce large samples of key molecules, says Nobel laureate Jerome Karle, a crystallographer at the NRL. "The possibility of looking at much smaller crystals than was possible before is a worthwhile development," he told SCIENCE NEWS.

NRL metallurgist Jack D. Ayers produced the filaments for the synchrotron study by first putting a tiny piece of bismuth into a glass capillary tube. He heated the materials until the glass softened and the metal melted, then drew the glass into a longer, thinner tube. As it cooled, the metal expanded and was pulled lengthwise by the glass. Ayers then put the glass-metal filament into another capillary, repeating the procedure to make ever-thinner wires.




Ayers/NRL

*Scanning electron micrographs show cross section of the glass-enshrouded filament (left, arrow) and close-up of the bismuth (right).*

Theorists have predicted that such small dimensions would alter a metal's character – perhaps leading to superconductors. The filament-drawing technique thus opens up new avenues in research, says Skelton.

Skelton and his collaborators describe their study in the Sept. 6 SCIENCE. The team has since used the wiggler beam to examine samples as tiny as 0.042 micrometer across. They observed that the ultrathin bismuth underwent a phase transition, most likely due to the stress imposed by the glass surrounding it, Skelton told SCIENCE NEWS. The atoms in the filament arranged themselves as a cubic crystal instead of the hexagonal array that typifies bismuth crystals, he says. *– E. Pennisi*

# Tardy antiprotons trapped in liquid helium

Antiprotons – the negatively charged, antimatter counterparts of protons – normally last just a few nanoseconds in the presence of ordinary matter. But researchers have now discovered that some of the antiprotons fired into a vat of liquid helium survive as long as 15 microseconds.

"This is a thousand times longer than the normal lifetime of an antiproton in a system like this," says particle physicist Peter Kitching, who works at the TRIUMF cyclotron at the University of British Columbia in Vancouver. The finding suggests that a small number of antiprotons get captured by helium nuclei and settle into atomic arrangements that delay proton-antiproton annihilation.

T. Yamazaki of the University of Tokyo, Kitching and their collaborators describe the new results in the Sept. 2 PHYSICAL REVIEW LETTERS.

The researchers fired a beam of antiprotons into a liquid-helium target, then used a sodium iodide detector to measure the energy – in the form of unstable particles known as pions – coming out of the target. From these data, they deduced the proton-antiproton annihilation rate.

"You see a big peak at the very short times corresponding to the fact that most of the antiprotons annihilate almost immediately," Kitching says. But the plotted results also show a long tail, indicating that about 3.6 percent of the antiprotons somehow delay annihilation. Most of these antiprotons appear to last an average of 3 microseconds, although a few survive longer.

The tardy antiprotons apparently get trapped in relatively long-lived atomic states, in which an antiproton temporarily replaces one of the two electrons bound to a helium nucleus. For a brief period, the orbiting antiproton stays far enough away from the protons in the nucleus to forestall immediate annihilation.

"We saw it in liquid helium, where it was predicted to occur, but when we put the antiprotons into other things like liquid nitrogen, there was no long-lived state apparent," Kitching says.

A possible next step in the experimental work, he suggests, would be to determine whether the lifetimes of these trapped-antiproton states depend on the temperature or physical state of helium. "It would be very exciting to see a state that was in some sense stable," Kitching notes. "That would offer a means of storing antiprotons. You could put some into liquid helium and carry them around."

"We haven't found that," he adds, "but we have seen long-lived states that are much longer than the normal lifetimes of antiprotons." *– I. Peterson*