taining less than 3 milligrams of curium. Showing the difficulties inherent in this field, the effort yielded a mere six nuclei the team believes were ^{266}106. Still, that meager nuclear harvest was enough to bear out Sobiczewski's prediction. A silicon sensor, provided by the Livermore researchers, identified the nuclei by the signature of their predicted decay chain: an alpha-decay followed by fission. Because the researchers did not know the exact moment when the nuclei were created, they could not time their half-life directly. But based on the energy of the first alpha-decay, they estimate that ^{266}106 has a half-life of between 10 and 30 seconds.

For nuclear physicists, learning that the actual half-life is so close to the theoretical value "is equivalent to a home run," says Lougheed. Adds Nix, "It sheds credence on the theoretical approach." And that success has encouraged the researchers to try getting closer to the rock in January, when they will bombard uranium-238 with sulfur-34 in an effort to create ^{268}108, just two neutrons short of the rock itself.

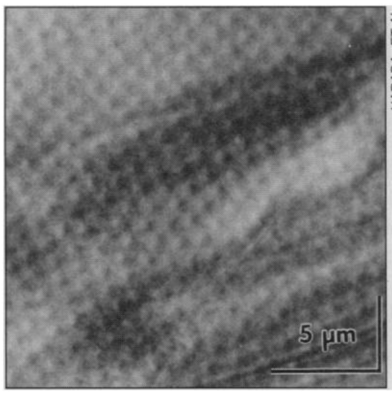
Why not push on and make a nucleus of ^{270}108? Lougheed explains that the experimenters lack one of the ingredients: nuclei of sulfur-36, a rare and expensive isotope. So for the moment, the researchers are circling the rock, confirming theoretical predictions about the stability of nearby nuclei. If the January experiment succeeds, they plan to try to create isotopes of element 110, an entirely new element that should share some of the rock's stability. Like explorers taking their first steps into new territory, says Lougheed, "We're just mapping out the region."

–**Daniel Clery**

SOLID-STATE PHYSICS

Superconductor as Movie Star

Seven years after the discovery of high-temperature superconductors, most of the applications prophesied for these materials—super-powerful motors, high-field magnets for levitating trains, loss-free electrical transmission cables—are still no more than promises. One reason for the delay is that high-temperature superconductors, which lose all resistance to electrical currents when cooled with liquid nitrogen, have a maddening habit of regaining their resistance when subjected to even modest magnetic fields, which are unavoidable in most of the envisioned large-scale applications. Researchers still believe it will be possible to design high-temperature superconductors that avoid this problem—but first they need to understand exactly how magnetic fields kill the superconductivity.



HARADA, ET AL.

Frozen flux. Magnetic vortices in a superconductor form a rigid lattice (dappled pattern) at low temperatures; they vanish when the sample is warmed.

That should be a lot easier now, thanks to a new movie starring a high-temperature superconductor. In an experimental tour de force, a group at Hitachi's Advanced Research Laboratory led by Akira Tonomura has produced a blow-by-blow record of a magnetic field destroying a superconductor's ability to carry current without resistance. "This is just a spectacular experiment," says AT&T Bell Laboratories superconductivity researcher David Bishop. The information provided by the new technique, he says, should offer clues about how to modify high-temperature superconductors to cure them of their susceptibility to magnetic fields.

Over the past several years, researchers have sketched out a theory of how a high-temperature superconductor falls victim to a magnetic field. If the field is strong enough, it penetrates the superconductor and passes through it in discrete lines, called flux lines or vortices, each containing a single quantum of magnetic flux. When a current passes through the material, it pushes on the flux lines. At low temperatures the flux lines are "pinned" in place, but as the temperature increases, the current can dislodge them, and their movement dissipates energy, creating electrical resistance and destroying the superconductivity. The results can be dramatic: A material that retains its superconductivity up to 80 degrees Kelvin in zero magnetic field may lose it at 20 K in a magnetic field of 100,000 gauss, typical of the fields that would be generated in such potential applications as superconducting magnets.

But Bishop and other researchers believe they might be able to tame the flux lines if they could get a clearer picture of the lines' behavior. The flux lines are aligned in a regular array, and if that "lattice" is rigid, it should be possible to pin it in place at just a few points—"like tacking down a piece of carpet," Bishop says. The pinning could be accomplished, for instance, by introducing small defects into the material that would snag the flux lines when they tried to move. But if the lines can move freely, then pinning them all into place will be much harder. A theoretical model proposed by Bishop and fellow Bell Labs scientist Peter Gammel suggests that the flux lattice is rigid up to a particular temperature, which depends on the magnetic field, but above that point the lattice "melts." Some recent experiments support this model, but, Bishop says, "you'd really like to be able to see a picture, to get an image of the flux lines as they melt."

Researchers have developed a number of techniques to image flux lattices, such as "magnetic decoration," which uses small magnetic particles to pinpoint the location of the flux lines, but none of them could both resolve the individual lines and follow their movement in real time. So superconductivity scientists have had to settle for snapshots of the flux lattice instead of movies. No longer.

Tonomura's group has developed a way to track the motion of the flux lattice using a method called electron holography. As reported in the 15 November *Physical Review Letters*, the group passes a beam of electrons through a thin sample of superconductor. The flux lines induce slight changes in the phases of the electrons as they pass to one side or another of the lines. The phase-shifted electrons create an interference pattern, revealing the flux lines as a collection of spots that are half dark, half bright.

The principle is straightforward, but realizing it was a technical feat, say other researchers. The technique demands an electron beam that is extremely well collimated, so that the electrons are all moving in almost exactly the same direction—something Tonomura was equipped to supply because he has been working on such "coherent" electron beams for 25 years. Besides perfecting the electron beam, Tonomura's group had to build a special building to isolate the experiment from vibrations and electromagnetic noise that could mask the subtle effects of the flux lines on the electrons.

The preparations paid off in a movie that shows the flux lattice in a high-temperature superconductor gradually disappearing as the temperature increases past a critical point—an observation that Bishop believes supports his theory of flux lattice melting. Other researchers, such as Harvard University superconductivity theorist David Nelson, say more analysis is needed before a final verdict is rendered on the basis of this video evidence. But one way or the other, Nelson says, the work has opened a new window into what goes on inside superconductors—a window that should eventually bring these materials much closer to practical use.

–**Robert Pool**