stood conductance: It should depend on the metal, its temperature and the relative proportion of impurities in it. It should not depend on the locations of individual impurities. According to A. Douglas Stone of the State University of New York at Stony Brook, "[T]his plausible and long-standing belief is clearly mistaken." In these small samples the conductance depends strongly on the locations of individual impurities. "Each specific sample has a conductance that goes with that impurity configuration," Skocpol says. Magnetic fields can tune the phases of the electron waves. Using varying magnetic fields, the experimenters study the effects of the impurities. Each sample yields its own "magnetoprint," a unique relation of conductance to changes in magnetic field. Sometimes changing just one impurity can have a greater effect than changing the whole sample.

These are wave-coherence effects, occurring because the electron waves "remember" their phases, rather than losing them in the averaging process as they were expected to. The ring experiments sought a particular coherence effect, the Aharonov-Bohm effect. Experts had said that averaging the effects of impurities would destroy the coherence necessary for this effect also.

In experiments looking for the Aharonov-Bohm effect (SN: 3/1/86, p. 135), the ring encloses a magnetic field. The current is split to go around the ring both clockwise and counterclockwise. In this geometry the conductance of the ring should oscillate with quantized changes of the magnetic field. As Sean Washburn of the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., describes it, they kept finding an oscillation that was half what they were looking for. Stone repeatedly advised them to make the rings larger so that the magnetic field would not actually penetrate the metal. When they finally did it, they found the Aharonov-Bohm oscillations. The rings, it seems, will produce both kinds, depending on the geometry and the field configuration. In one case, it seems, electrons go around the ring once; in the other case they backscatter and go around twice. At Yale University ring experiments with indium and silver have been done by Daniel Prober and collaborators. They see the non-Aharonov-Bohm effect in all their rings but the Aharonov-Bohm only in silver.

Summing up the significance, Prober calls these experiments "a first bridge between the quantum mechanical world of atoms and molecules and the larger-scaled world in which we live. . . ." He foresees new classes of devices that "will take their operating principles not from the behavior of semiconductors, but rather from the quantum mechanical world of atoms and molecules."

*— D.E. Thomsen*

# Retiring reactors: What's the cost?

Nuclear reactors don't live forever. Once their owners decide to shut them down permanently — a procedure known as decommissioning — there are three basic options: dismantling the plant and burying its parts; "mothballing," or storing, the plant for 10 to 50 years before dismantling; and permanently "entombing" the plant in concrete walls where it stands. Today, none of these options is inexpensive or politically attractive. Moreover, the growing need to choose among them and to resolve their relative costs "is getting less attention than it deserves," according to a report released this week by the Washington, D.C.-based Worldwatch Institute.

More than a dozen power reactors have already been retired worldwide. Within 15 years, says the report's author Cynthia Pollock, 66 more are likely to be decommissioned. Dismantling has just begun on the 72-megawatt Shippingport Atomic Power Station outside Pittsburgh — the first commercial U.S. nuclear plant and the world's largest dismantling project to date.

However, despite the apparent readiness to decommission Shippingport, which the Energy Department says is not a typical dismantling project, Pollock reports that not one of the 26 nations using nuclear power "is adequately prepared" to cope with decommissioning today. The primary issues facing the owners of retired plants are high costs and locating communities willing to accept their radioactive refuse.

Right now, the report notes, no country has a plan for disposing of the high-level wastes now stored at any reactor. And then there is the additional issue of where to send the more than 3,000 cubic yards of low-level radioactive wastes that would result from the dismantling of a used plant. In the United States, home to most of the world's nuclear plants, low-level-waste sites are prohibited from accepting materials contaminated with long-lived radioactive species. Moreover, all three U.S. low-level-waste sites currently in operation are seeking to limit the volume of wastes they must accept in the near future, especially from out-of-state generators (SN: 1/11/86, p. 22).

In the long run, Pollock expects that the financial uncertainties — not only how much it will cost to decommission a large commercial plant but also whether a utility will be able to afford those costs when a plant's retirement time arrives — will prove less important than the radwaste issue. However, with cost estimates ranging from $50 million to $1 billion or more per reactor, the report says, "nuclear decommissioning could be the largest expense facing the utility industry." Pollock asserts that the industry's lack of decommissioning experience with the large 1,000-megawatt plants that are typical today makes most current decommissioning-cost projections little more than guesses based on "varying degrees of wishful thinking." For this reason, her report recommends that utilities begin collecting money from their users as soon as possible and hold it in escrow to fund the plant's decommissioning costs.

While few argue with the report's general intrepretation of the radwaste issue, some criticize its assessments of uncertainties — both technical and financial — associated with decommissioning. For example, the report asserts that further research and new technologies will be necessary for the dismantling of large-scale plants. But Robert Shaw, a manager in the Palo Alto, Calif.-based Electric Power Research Institute's nuclear division, told SCIENCE NEWS that after analyzing this issue, "we came to the conclusion that nuclear plants can be dismantled in a very safe way with techniques and technologies that have already been proven."

Moreover, he says, the industry's experience in repairing large plants and decommissioning small plants — like Shippingport — involves activities "that in many instances would parallel the kinds of things that one would need to do in order to decommission a large plant." By piecing together these experiences, utilities "can come up with very reasonable cost estimates," ones that are much smaller than some of those considered in the Worldwatch report. Dave Harward of the Bethesda, Md.-based Atomic Industrial Forum, an industry group, put "reasonable" utility estimates of decommissioning a large plant at only up to about $170 million.

Pollock counters that current decommissioning technology involves many technologies that are still in their infancy and often almost prohibitively costly — like robotics for remote handling of very radioactive equipment. As to her citation of potentially exaggerated cost estimates, she says that at least one of her sources was from within the nuclear industry itself. The French Atomic Energy Commission's decommissioning director, she says, reported at an international meeting last year that his cost estimates for decommissioning, using available techniques, "would be at least 40 percent of the cost to build [a plant]" — a figure that for new U.S. plants could easily exceed $1 billion.

*— J. Raloff*