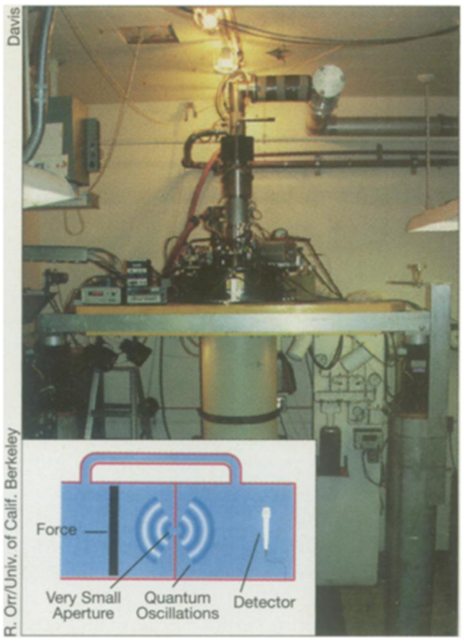
Whistling a superfluid quantum melody



R. Orr/Univ. of Calif. Berkeley

Davis

Special refrigerator used to chill helium-3 to less than 1 millikelvin. Inset: In this drawing of the apparatus, a force causes a slight pressure difference between two reservoirs of the superfluid, which induces it to oscillate through a tiny aperture, generating waves that can be picked up by an extremely sensitive detector.

For physicists probing the curious quantum behavior of superfluids, "Whistle While You Work" is a highly appropriate theme song.

By detecting a high-pitched whistle, researchers have obtained the first clear indication that helium-3 atoms can shuttle back and forth between two containers separated by a thin membrane perforated with tiny holes. Instead of flowing from one container to the other in response to a slight difference in pressure, the helium-3 superfluid oscillates at a characteristic frequency.

"The discovery is fundamental to our understanding of superfluids and, by analogy, of the phenomena we observe in superconductors," says physicist Richard E. Packard of the University of California, Berkeley. Packard, James C. Davis, and their coworkers report their findings in the July 31 NATURE.

This represents "a beautiful, direct demonstration of quantum mechanics in action on the macroscopic scale," says Peter McClintock of Lancaster University in England.

Physicists first observed such oscillations in an electric current passing between two superconductors separated by an extremely thin layer of electrically insulating material. Named the Josephson effect for Brian D. Josephson of the University of Cambridge in England, this phenomenon serves as the basis of various electric devices, including the world's most sensitive detectors of magnetic fields.

More than 30 years ago, theorists predicted that analogous oscillations would occur when a minuscule aperture connects two reservoirs of the same superfluid at different pressures. A superfluid is a state of matter in which all atoms belong to the same quantum state and move in a coordinated manner, allowing the liquid to flow without resistance.

Researchers expended considerable effort looking for the predicted effect. Earlier experiments by Packard's team and by Oliver Avenel of the Centre d'Études de Saclay in Gif-sur-Yvette, France, and his collaborators failed to furnish unambiguous evidence of oscillations.

Two years ago, the Berkeley team decided to use a barrier with an array of holes instead of just a single aperture. "We thought there was a small chance that all of these holes would quantum mechanically act together," Packard says.

When that experiment didn't work, the researchers tried a membrane in which the holes were more widely spaced than before. Fabricated from silicon nitride, the barrier was 50 nanometers thick, punctured by 4,225 holes about 100 nm wide and 3 micrometers apart.

The researchers made a fortuitous decision to connect headphones directly to the detector to listen for the oscillations rather than attempt to view the signal on an instrument. When they did the experiment, they could hear, above the background noise, a distinct, though faint, high-pitched whistle—the helium-3 oscillations. As the pressure difference decreased, the pitch dropped, just as theory predicted.

"It's amazing how the brain picks out the tone from the background noise, like hearing a faint piccolo against the background of a large orchestra," Davis says.

"It worked fantastically," Packard remarks. "That was something that I had wanted to do for more than 10 years, and I didn't really expect it to happen."

—*I. Peterson*

Is synergy of estrogen mimics an illusion?

It's not hard to find evidence of synergy in the endocrine system. Simultaneous exposure to one unit of hormone A and one unit of hormone B often yields effects exceeding—by 2 to 10 times—the sum of effects seen with each hormone alone. Last year, however, a team of researchers in New Orleans reported a startling synergy in which low-level exposures to two estrogen-mimicking pollutants generated as much as 1,600 times the effect seen with just one of the agents.

Now it appears that this amazing synergy (SN: 6/8/96, p. 356) was too bad to be true.

At the fourth federally sponsored Estrogens in the Environment meeting, held last week in Arlington, Va., a spate of studies reported finding no evidence of synergy between estrogen-mimicking pollutants. Two of the studies used the same pesticide duo—dieldrin and toxaphene—that had exhibited the greatest synergy in the New Orleans tests. A third study employed 10 different tests to probe another pesticide pairing studied by the New Orleans group.

John A. McLachlan, head of the Center for Bioenvironmental Research at Tulane and Xavier Universities, where the New Orleans study was conducted, noted at the meeting that even his group couldn't replicate its initial results, though they still find small amounts of synergy. "We've struggled mightily during the last 6 months to find a mechanism to explain our early results," he told SCIENCE NEWS. Yet none of these studies substantiated the earlier, dramatic findings.

Consequently, he said, "it seemed only appropriate to withdraw the paper," which he did in the July 25 SCIENCE.

With estrogen mimics, "nobody's been able to get synergy. That's the long and the short of it," argues Stephen H. Safe of Texas A&M University in College Station, a coauthor of several studies that have found only additive effects of such agents. Though synergy can be seen between distinct types of hormonelike agents, he says that what made McLachlan's initial report unique was its claim that all the agents were operating through the same estrogen-receptor pathway. "I'll be very surprised if there's synergy ever found for two compounds acting through the same pathway," Safe says.

David P. Crews of the University of Texas at Austin is less certain. He and Judith M. Bergeron recently replicated their earlier study showing a fivefold synergy in the ability of estrogenlike pollutants to alter the gender of developing turtles (SN: 10/8/94, p. 239). Together with McLachlan's team, they have also demonstrated a roughly fourfold synergy between various natural estrogens.

However, Bergeron concedes, "we have not yet confirmed that [any of this synergy] works through a single receptor."

In fact, points out Frederick S. vom Saal of the University of Missouri-Columbia, several studies at last week's meeting show that some estrogen mimics do not work solely through estrogen pathways. "So it might be possible for them to exhibit synergy using two different pathways."

—*J. Raloff*

Science Service, Inc. is collaborating with JSTOR to digitize, preserve, and extend access to *Science News*. www.jstor.org