Do superconducting currents choose stripes?

Since the discovery of high-temperature superconductors more than a decade ago, scientists have puzzled over how these remarkable ceramics work (SN: 6/7/97, p. 351). One controversial theory holds that recently discovered stripe patterns in the magnetic and electronic features of the materials provide fast lanes for electrical charges. Doubters maintain that stripes either play no role in superconductivity or even stifle the phenomenon.

Now, experiments from California and Japan offer the first direct evidence that electrical charges move along the lanes. The findings, revealed in three separate reports this week, encourage stripe enthusiasts to believe they're on the right track but leave skeptics unmoved.

The new results are "very important and very striking," comments Steven A. Kivelson of the University of California, Los Angeles. "These experiments in various ways strongly corroborate that stripes play a central role in the physics of the high-temperature superconductors," he says.

Although the experiments are "good physics," concedes Philip W. Anderson of Princeton University, the research teams involved "are not learning what's going on that causes or is characteristic of high-temperature superconductivity." The narrowness of stripes would hinder electron pairing vital to superconductivity, he says.

A superconductor permits electric current to flow with zero resistance when the material is cooled below a critical temperature. The critical temperatures of high-temperature superconductors range up to roughly 150 kelvins. If researchers can understand how superconductivity arises in these materials, they may find ways to increase the critical temperature.

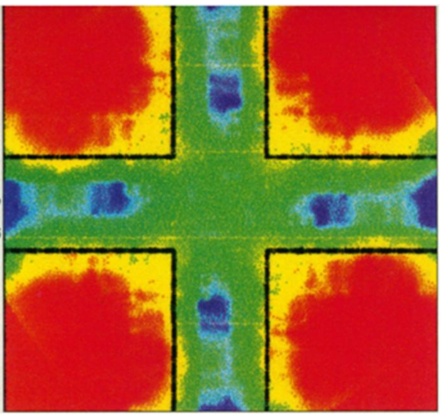
The compounds consist of repeating horizontal layers of copper and oxygen atoms separated by layers of transition metals, such as lanthanum and yttrium, which contribute mobile, positive electric charges known as holes. Researchers led by Zhi-xun Shen of Stanford University have now taken a close-up look at the electronic structure of a material—lanthanum-strontium-copper oxide with a smattering of neodymium—closely related to a superconductor.

The researchers report in the Oct. 8 SCIENCE that they used photons of ultraviolet light to eject electrons from the material. Then, they measured the particles' energy and momentum to infer how the holes left behind were behaving.

Their data show that holes move mainly in two perpendicular directions in the copper-oxygen layers. Shen says that the ejected electrons come simultaneously from multiple, tiny regions in the surface. In each region, the stripes run along one of the two perpendicular crystal axes. The direction of particle movement detected would be a composite of both types of regions. Therefore, the cross-shaped pattern observed indicates that the holes travel along the stripes. However, Shen says, "our data give no direct information about whether superconductivity is caused by stripes."

A second report in the issue of SCIENCE also looks at the movement of charges within the same type of copper oxide. However, scientists at the University of Tokyo, led by Shin-ichi Uchida, study the charges' bulk motion when a current induced by an electric field gets a sideways shove from a magnetic field—a phenomenon known as the Hall effect. This effect was reduced in an experiment in which the current ran parallel to the stripes. Apparently, stripes make it difficult for charges to move sideways.

In a different compound, yttrium-barium-copper oxide, Yoichi Ando and his colleagues at the Central Research Institute of Electric Power Industry in Tokyo used a magnetic field to turn the stripe pattern. Rotating the stripes from parallel to perpendicular with respect to a current flowing along the copper-oxygen lattice, they measured an increase in resistance. Reporting their findings in the Oct. 4 PHYSICAL REVIEW LETTERS, the researchers say that they have presented "strong evidence" that such stripes "have a considerable impact on electron transport." —*P. Weiss*


Xingjiang Zhou et al./SCIENCE

Vertical and horizontal blue-green bars cross in this plot of the quantum properties of a copper oxide's charge carriers. The bars indicate that charges flow along stripes oriented perpendicular to each other in different parts of the material.

Math error equals loss of Mars orbiter

Two summers ago, NASA knew the thrill of victory when its tiny robotic spacecraft landed on Mars within kilometers of its target. Last week, after failing to properly use the metric system, the space agency learned the agony of de-feet.

NASA reported Sept. 30 that it had lost the $125 million Mars Climate Orbiter because the force exerted by the orbiter's thrusters remained in the system of units based on pounds and feet rather than being converted to metric.

The problem, believed to have originated before the craft's launch last December, wasn't caught until days after Climate Orbiter vanished on Sept. 23 (SN: 10/2/99, p. 214). It had dipped 100 kilometers lower than planned into the Martian atmosphere.

"Truly, it is just dumbfounding, flabbergasting—all those superlative adjectives—that this could possibly happen," says space-policy analyst Marcia S. Smith of the Congressional Research Service in Washington, D.C.

A preliminary review has now found that the problem doesn't plague the Mars Polar Lander, scheduled to arrive on the Red Planet on Dec. 3, says Carl Pilcher, NASA's director for solar system exploration. Two NASA committees and an independent panel are investigating why the Climate Orbiter blunder went unnoticed.

The problem arose because two teams working on the Mars mission weren't using the same units of measure. Scientists at NASA's Jet Propulsion Laboratory in Pasadena, Calif., had assumed that thrust data they received from Lockheed Martin Astronautics in Denver, which built the craft, were expressed in metric units, as newtons. Although propulsion engineers typically express thrust as pounds of force, it's standard practice to transform these to newtons when integrating the information into the design of a spacecraft, says Noel W. Hinners, vice president for flight systems at Lockheed Martin Aeronautics.

Somehow, no one did that. "We should have converted," he says.

One pound of force is roughly 4.45 newtons. Moving from one set of units to another boosts the chance for miscommunication, and "there are very few software packages that would avoid such an error," says Peter G. Neumann of SRI International in Menlo Park, Calif.

In 1985, he notes, controllers calculated distance in feet rather than nautical miles and inadvertantly pointed a mirror on the space shuttle Discovery away from Earth instead of toward a laser on Hawaii's Mauna Kea.

Pilcher notes, "The particular nature of the [Orbiter] error is less important than the fact that it was not recognized and corrected." Neumann and his colleagues are developing software that can check for consistency and reliability of data in spacecraft systems.

"Twenty years ago, we went through this whole hassle of, Should the U.S. go metric?" says Hinners. "I wish we had." —*R. Cowen*