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New Physics Law Unifies Several Superconducting Compounds

A research group led by Christopher Homes, Physics Department, has discovered a simple relationship that mathematically links the properties of a class of high-temperature superconductors, materials that, below a certain temperature, conduct electricity with no resistance. This new, unexpected law applies to superconductors with very different structures and compositions, and may provide clues to understanding the mechanism of high-temperature superconductivity. It is discussed in the July 29, 2004 issue of *Nature*.

"Because this law unifies many different materials, it may allow us to predict the behavior of other superconductors, giving us deeper insight into how these systems work," said Homes.

This research is the result of a collaboration between researchers at BNL, including Sasa Dordevic of Physics; the University of British Columbia; the Central Research Institute of Electric Power Industry, Japan; Stanford University, in particular, Martin Greven of Stanford; the Stanford Synchrotron Radiation Laboratory; the University of California at San Diego; and McMaster University. The research was funded by the Office of Basic Energy Sciences within DOE's Office of Science, the National Science Foundation, the Natural Sciences and Engineering Research Council of Canada, and the Canadian Institute for Advanced Research.

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> *— Christopher Homes*

To do this research, Homes and his team focused on several members of a class of high-temperature superconductors known as cuprates, which are characterized by layers of copper oxide. They studied each material using a wide range of light, from microwaves to ultraviolet rays, and then determined its electronic properties. In some cases, they worked at the National Synchrotron Light Source, a facility that produces infrared, ultraviolet, and x-ray light for research.

The scientists found a relationship between three of each cuprate's physical properties: direct-current (dc) conductivity (how much direct current it conducts); critical temperature (the temperature below which it superconducts); and the "superfluid density" in the superconducting state. This last property refers to how many current carriers — electrons or "holes," which are spaces in the electron sea that act positively charged — are in the superconductor.

The new law, called a scaling relation, states that the superfluid density is proportional to the dc conductivity multiplied by the critical temperature. When the researchers plotted this relationship on a graph for each material and compared the shape of these plots, they observed that the overall result is a straight line.

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"The interpretation of this result and exactly what it says about the nature of the superconductivity in these materials is a source of ongoing debate," Homes said, "but it should provide insight into the origins of superconductivity in these materials, or even give us a way to predict the behavior of other superconductors."

Homes also applied the scaling law to two conventional superconductors, the metals lead and niobium, using known measurements from literature. He and his group will continue to study certain other conventional superconductors, to see if they obey the scaling law.

— Laura Mgrdichian

For more details on this research, see www.bnl.gov/bnlweb/pubaf/pr/2004/bnlpr073004.htm.