Nanoscale Imaging Shows Link between Attractive and Repulsive Forces in Copper-Oxide Superconductors (DMR-0213706)

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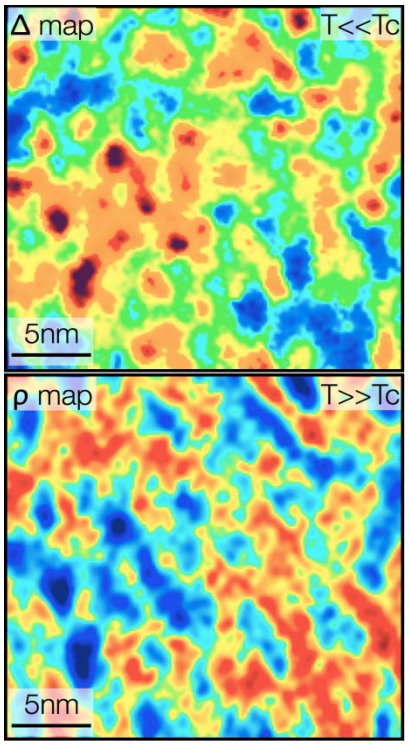
In a normal material, electrons repel each other due to their charge. In the copper-oxide superconductors, however, an attractive force develops between electrons that pairs them up at temperatures up to 140 degrees above absolute zero. Understanding the reason for this pairing has remained an elusive goal in condensed matter physics research over the past two decades. Using a new experimental technique, Princeton researchers have been able to study the properties of individual atoms of these compounds as the temperature is lowered from well above the superconducting transition temperature to well within the superconducting phase. Such measurements lead to the unexpected conclusion that the attractive pairing force between the electrons at low temperature is strongest in space at the same locations where the repulsive force between electrons is strongest at high temperature. This paradoxical result shows that superconductivity in these compounds is intimately linked to the presence of strong repulsive forces between electrons in these materials.



Using a specially-designed scanning tunneling microscope, PCCM researchers tracked the properties of individual atoms of the copper-oxides from low temperatures (top panel, where the material is a superconductor) to high temperatures (bottom panel, where the material is not a superconductor). The color scale of the top panel indicates the strength of the attractive force between electrons in the superconducting phase with dark red indicating a strong force. The color scale of the bottom panel indicates the repulsion between electrons at high temperature where dark blue indicates strong repulsion. The two panels show the intimate relationship between the attractive pairing force at low temperature and the repulsion at high temperature.

Reference: A. N. Pasupathy, A. Pushp, K. K. Gomes, C. V. Parker, J. Wen, Z. Xu, G. Gu, S. Ono, Y. Ando, and A. Yazdani *Science* **320**, 196 (2008).