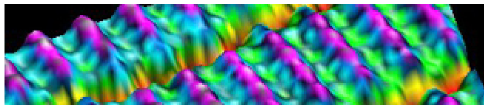

One Step Closer to Explaining Superconductivity

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Professor Pengcheng Dai's research group and his collaborators at Boston College have taken another step toward explaining high-temperature superconductivity. The results are published in their latest paper, "A distinct bosonic mode in an electron-doped high-transition-temperature superconductor," which appears in the December 13 issue of *Nature*.

Superconductivity is the phenomenon whereby electrons pair up to carry current with no resistance. In conventional superconductors, scientists have determined that phonons—mechanical vibrations with particle-like properties—cause this pairing. But in superconductors with a much higher critical temperature (*Tc*), research hasn't conclusively shown what prods the electrons to get together two-by-two. Some schools of thought suggest that, as with conventional materials, phonons are the reason. Others think spin excitations might be the cause. Still others suspect that there may be no mediator at all.

The Boston College/UTK collaboration studied the copper oxide $Pr_{0.88}LaCe_{0.12}CuO_4$, a high *Tc* superconducting material that is "electron-doped," meaning electrons are added to the copper oxide planes and act as charge carriers. They used high-resolution scanning tunneling microscopy (STM) to get a detailed view of the contours of the electronic properties of the material's surface. In the superconducting state, they found that a bosonic excitation appears at energies consistent with spin excitations they observed in earlier experiments using neutron scattering.

Bosons are elementary particles with integral spin whose behavior follows the laws of quantum mechanics. Spin is an intrinsic property of particles, atoms, and nuclei, just like charge or mass. And with spin comes a magnetic moment that dictates how particles arrange themselves within a magnetic field. The group's findings, then, indicate that magnetism is a good candidate to bring about electron pairing in high-*Tc* superconductors. Further, the energy levels where the bosonic excitation mode appears are much lower than the oxygen phonon energy modes that have been linked to superconductivity in other materials.

Professor Dai explains that scanning tunneling technology lets researchers see superconducting materials from a different angle to enhance findings from other experimentation methods. Tunneling, for example, gives scientists a view of the electrons themselves, while neutron scattering reveals their collective spin activity. The STM work was conducted at Boston College using samples grown at UTK. The *Nature* paper was built on earlier findings the Dai group published September 20 in the *Proceedings of the National Academy of Sciences* and in *Nature* ***442***, *59 (2006)*, where they linked magnetic resonance to the superconducting state in the material $Pr_{0.88}LaCe_{0.12}CuO_{4-\delta}$.

The question of what causes high-temperature superconductivity has intrigued scientists for more than two decades, and the fundamental research at UTK and elsewhere gets researchers ever closer to a definitive explanation.

As Professor Dai says, "This will not end the debate, but it's another step."