New Cuprate Superconductor May Challenge the Classical Wisdom

Superconductivity is one of the most mysterious phenomena in nature in that the materials can conduct electrical current without any resistance. The cuprates hold the record for critical temperature of superconductor at ambient pressure so far, but understanding their superconducting mechanism remains a big challenge of physical sciences – it was listed among the 125 open questions chosen by *Science* at the turn of its 125th anniversary in 2005 and remains unsolved till now.

Concerning this open question, some consensuses have been achieved as a result from the long-term efforts by global physicists. First, the main stream theories are built based on single band model of $3dx^2$-y^2 orbital that locates at the top of Fermi surface; Secondly, the superconducting transition temperature T_c is sensitive to the doping level (p); thirdly, overdoping beyond the certain carrier density diminishes superconductivity. A newly discovered cuprate manifests some unique properties that might subvert the consensuses.

Recently, Prof. JIN Changqing's team at the Institute of Physics, Chinese Academy of Sciences (IOP) discovered a new high-T_c superconductor Ba_2CuO_{4-y}. This new cuprate shows two unique features: an exceptionally compressed local octahedron and heavily over-doped hole carriers. These two features are in sharp contrast to the favorable criteria for all previously known cuprate superconductors. The compressed local octahedron results into a reversed orbital order with $3z^2$ lifted above $3dx^2$-y^2, leading to strong multiband scenario; while the overdoped state violates the previous mot holding for superconducting phase. Impressively, the new material demonstrates a superconducting transition temperature above 73 K, 30 K higher than that for the isostructural classical "conventional" superconductor based on La_2CuO_4. Thus, the discovery of the high T_c superconductivity in Ba_2CuO_{4-y} calls into question the widely accepted scenario of superconductivity in cuprates, providing new possibilities to search for further high T_c superconductors.

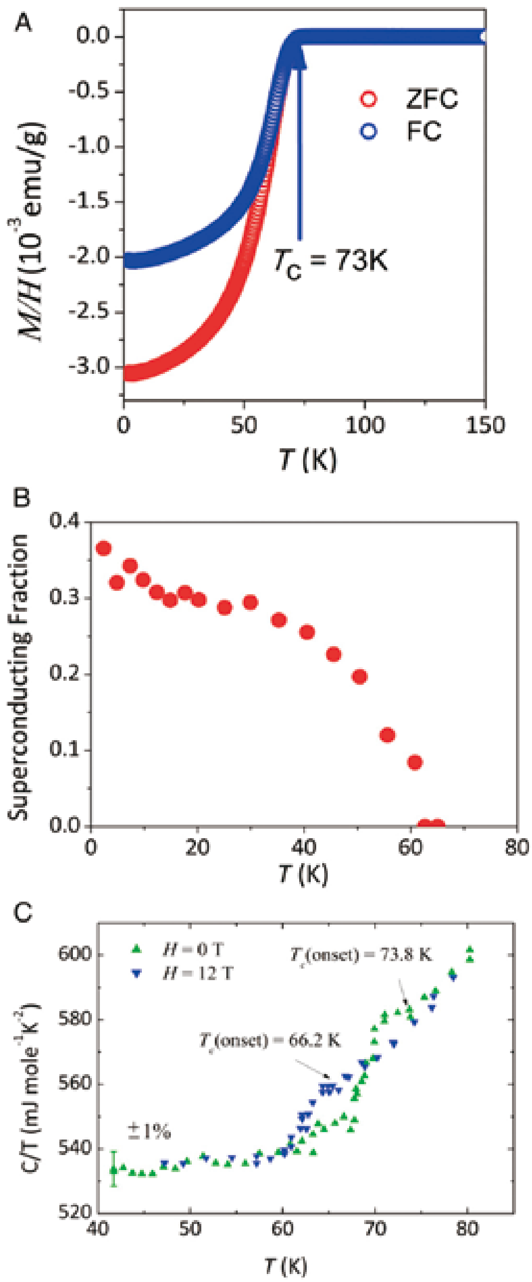

Figure 1: The superconducting transition of the sample showing a T_c at 73 K. (A) The Meissner effects; (B) Superconducting volume fraction in terms of superfluid density estimated from μSR; (C) Specific heat measurement.

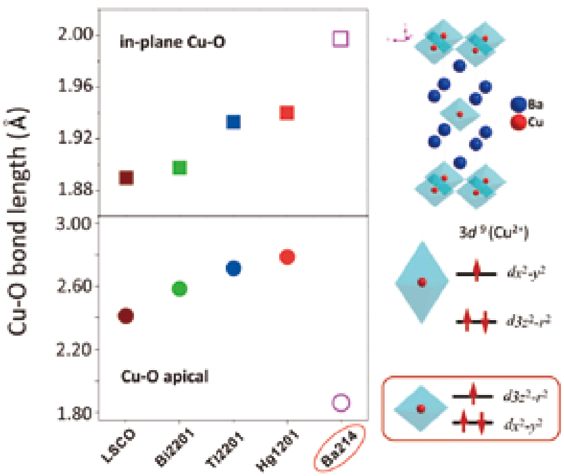

Figure 2: The in-plane Cu-O and apical Cu-O bond length showing the unique compressed local octahedron coordination that leads to the orbital reversal in cuprate superconductors.

This study, entitled "Superconductivity in a unique type of copper oxide", was published on *Proceedings of the National Academy of Sciences* (www.pnas.org/cgi/doi/10.1073/pnas.1900908116).

The study was supported by the National Natural Science Foundation of China as well as the Ministry of Science and Technology of China.

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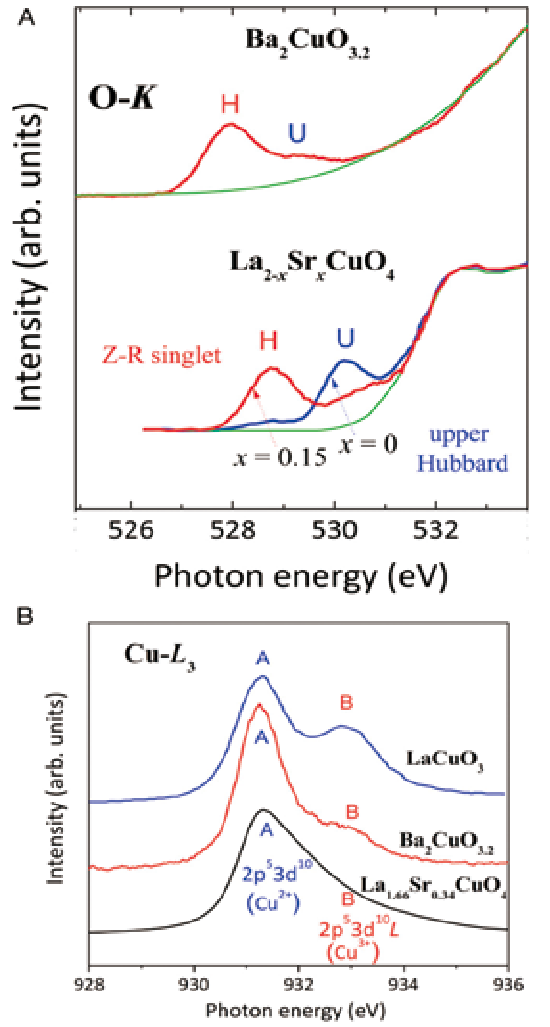

Figure 3: XAS measurements (A) O-K edge and (B) Cu-L_3 edge showing the extremely overdoping state.