Abstract

The Exceptional Properties of Superconductivity in Cuprates

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Copper oxides are the only materials that have transition temperatures,Tc, above the boiling point of liquid nitrogen, with a maximum Tcm of 162 K under pressure. Their structure is layered, with one to several CuO2 planes, and upon hole doping, their transition temperature follows a dome-shaped curve with a maximum at Tcm. In the underdoped regime, i.e., above Tcm, a pseudogap T* is found, with T* always being larger than Tc, a property unique to the copper oxides 1). In the superconducting state, Cooper pairs (two holes with antiparallel spins) are formed that exhibit coherence lengths on the order of a lattice distance in the CuO2 plane and one order of magnitude less perpendicular to it. Their macroscopic wave function is parallel to the CuO2 plane near 100% d at their surface, but only 75% d and 25 % s in the bulk, and near 100% s perpendicular to the plane in YBCO. There are two gaps with the same Tc 2). As function of doping, the oxygen isotope effect is novel and can be quantitatively accounted for by a two-band vibronic theory 3). These cuprates are intrinsically heterogeneous in a dynamic way. In terms of quasiparticles, bipolarons are present at low doping, and aggregate upon cooling 1), so that probably ramified clusters and/or stripes are formed, leading over to a more Fermi-liquid-type behavior at large carrier concentrations above Tcm.

1) For an overview see: K.A. Müller, J. Phys: Condens. Matter 19, 251002 (2007).
2) R. Khasanov, A. Shengelaya et al. Phys. Rev. Lett. 98, 0570007 (2007).
3) H. Keller, A. Bussmann-Holder, and K.A. Müller, Materials Today 11, 38 (2008).