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The Exceptional Properties of Superconductivity in Cuprates

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Copper oxides are the only materials that have transition temperatures, T_c, *above* the boiling point of liquid nitrogen, with a maximum T_c^m of 162 K under pressure. Their structure is layered, with one to several CuO_2 planes, and upon hole doping, their transition temperature follows a dome-shaped curve with a maximum at T_c^m. In the underdoped regime, i.e., below T_c^m, a pseudogap T^* is found, with T^* always being larger than T_c, 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* CuO_2 plane and one order of magnitude less perpendicular to it. Their macroscopic wave function is parallel to the CuO_2 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 T_c [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 T_c^m.

[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).