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The Fluctuating Bond Model, a Glue for Cuprate Superconductivity?[1]

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Twenty years of research have yet to produce a consensus on the origin of high temperature superconductivity (HTS). The mechanism of HTS - which originates in the CuO_2 plane, common to all HTS families - can be constrained by some key experimental facts regarding superconducting and pseudogap behaviors. Superconductivity, involving a T_c of order 100K, exhibits an unusual d-wave superconducting gap, with Fermi liquid nodal excitations, and an anomalous doping- dependent oxygen isotope shift. A "pseudogap," also with d-symmetry, leads to a dip in the density of states below a characteristic temperature scale T^*, which has a *negative* isotope shift; we associate the pseudogap with the recently observed spatially inhomogeneous (nanometer- scale) C_4 symmetry breaking. The isotope shifts and other evidence imply a key role for oxygen vibrations, but conventional BCS single-phonon coupling is essentially forbidden by symmetry and by the on-site Coulomb interaction U. In a novel approach, we introduce a model based on a strong, local, nonlinear interaction between electrons within the Cu-O-Cu bond in the CuO_2 plane, and the oxygen vibrational degrees of freedom, termed the Fluctuating Bond Model (FBM) [D.M. Newns and C.C. Tsuei, Nature Physics **3**, 184 (2007)]. In mean field the model predicts a phase manifesting broken C_4 symmetry, with a d-type pseudogap, and an upper phase boundary in temperature, with a negative isotope shift, which we identify with T^*. An intrinsic d-wave pairing tendency is found, leading to a transition temperature dome and an anomalous isotope shift similar to that found experimentally. The softening in the oxygen vibrational frequency below T_c, seen in Raman and neutron spectra, has a natural explanation in the FBM. Recent *ab initio* calculations have been implemented which provide microscopic support for the model.

[1]Work done with C.C. Tsuei.