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THE MECHANISM OF HIGH-T_c SUPERCONDUCTIVITY DUE TO BOUND HOLE MEDIATORS: RELATIONSHIP TO FERROELECTRICITY

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The mediation by bound-holes creating Cooper pairing in high-T_c superconductors has its origin in charge transfer excitations on the multivalence cation (virtual excitons) and in bound excitons or polarizations associated with the oxygen 2p electrons. These phenomena are produced and/or enhanced by a high internal electric field which is itself created by virtue of the unique crystal structures and polyhedral building blocks of high-T_c materials. The polarizations which can create oxygen holes (in addition to excitons) may be due to simply the internal electric field or to polaronic and electron-deficient bond behavior. This gives rise to two energy-dependent oxygen bands near the Fermi level. The magnitude and direction of the internal electric fields have been calculated for $Y_1Ba_2Cu_3O_{7-}$ (1-2-3) and show strong z-direction fields at the Cu(2), O2, and O3 sites and an even stronger -z direction field at the O4 site. The field calculations also show why electrical conductivity in the 1-2-3 material is essentially in the base plane of the CuO_5 pyramid (the CuO_2 plane). Empirical studies show that T_c scales with the number of bound holes associated with the pyramidal building block, and this scaling is refined by taking into account the lifetime and the degree of monopolar character of these holes. Recent work shows for both the 1-2-3 and the bismuth containing superconductor that the positive Hall (R_H) coefficient as a function of temperature undergoes reversible anomaly as temperature is decreased toward T_c indicating a decrease in the concentration of bound holes near the pre-onset temperature (where the resistance vs temperature data first begins to deviate from linearity). Experimental work also shows that the pre-onset temperature is associated with the inception of small oscillations in resistance vs time, the amplitude of which is strongly B field dependent up to 11T and saturates at higher B-field, the pre-onset temperature is also correlated with the spin and the magnetic moment associated with the paramagnetic rare earth which can substitute for Y^{3+}. It appears that Cooper-pairing of electrons is not stabilized until at least somewhere near the middle of the collapsing resistance transition, this being suggested by the B-field induced divergence of the R vs 1000/T data at $T<T_c$, and by a reverse in the sign of the slope of the $+R_H$ vs T data (and in the sign of R_H) at $T<T_c$. Strong relationship between high-Tc and ferroelectric materials suggests that T_c should be dependent on $(T^*-T_o)^n$ where T_o is the Curie Temperature, T^* is the temperature at which the dielectric constant peaks, and $n \approx 3/2$. The value of T_c actually specifies the temperature at which the lifetime of the bound holes is sufficiently large to mediate the electron-electron Cooper pairing interaction ($\sim 10^{-13}$ sec). Superimposed on the bound hole mechanism there seems to be a conventional electron-phonon interaction, as well as the possibility of a contribution to T_c due to spin fluctuations from antiferro-magnetism.