

On the pairing interaction in high T_c superconductors

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Abstract. It is argued, from the dependence of the critical current density and of T_c on applied magnetic field, that the pairing interaction in high T_c superconductors must be strongly field-dependent.

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We have earlier shown (Ravi Kumar and Chaddah 1988a, b) that the existing magnetization data on high T_c superconductors is explained by a critical current density J_c that decays exponentially with applied field. Since data on single crystal $\text{YBa}_2\text{Cu}_3\text{O}_7$ are also consistent with $J_c \approx J_{c0} \exp(-H/H_0)$, we have considered this behaviour to be intrinsic to high T_c superconductors. Farrell *et al* (1987) have observed a zero field $J_c \approx 2 \times 10^7 \text{ A/cm}^2$ at 4.2 K, and this is close to the depairing limit of $\approx 10^8 \text{ A/cm}^2$. Their sample also shows an exponential decay of J_c with field. One possible reason for the observed decay of J_c with H could be that the depairing current itself decays exponentially with field. Within the BCS model this would correspond to the isotropic and k -independent pairing interaction V varying with field as $1/(H+K)$ where K is a constant. Such a variation is not possible for phonon-mediated interactions, but could be visualized in a pairing interaction mediated by local spin configurations as modelled, for example, by Emery (1987).

Such a pairing interaction would result in a sharp decay of the superconducting gap with increasing field, but no field dependent measurements of the gap have so far been reported. The dependence of T_c on the applied field is, however, available from the H_{c2} data. It will now be argued that the H_{c2} data also indicates a field dependent pairing interaction.

It has been reported in literature (Orlando *et al* 1987) that for $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ and $\text{RBa}_2\text{Cu}_3\text{O}_7$ compounds the resistive transition broadens rapidly with increasing applied field. A second feature is not emphasized but is apparent from the published data and is more important. The curvature of T_c vs H (or that of H_{c2} vs T) is concave near T_c . Such a curvature is contrary to the BCS result (or even WHHM theory) which yields a convex curvature for a field-independent V . Since this feature is not emphasized in literature we will discuss it in some detail.

Since the first non-trivial solution to the BCS gap equation will occur at the temperature where resistivity is zero (and not at the midpoint of the resistive transition), the $H_{c2}(T)$ relevant to any discussion strictly corresponds to the temperature at which $\rho = 0$. A close look at the reported resistive transitions in $\text{La}_{1.85}\text{Sr}_{0.15}\text{CuO}_4$ (Kwok *et al*