LETTER

Orbital origin of field-induced ‘‘quantum criticality’’ in overdoped $Tl_2Ba_2CuO_{6+x}$

Shibauchi *et al*. (1) report high-field *c*-axis resistivity ρ_c data for the overdoped cuprate $Tl_2Ba_2CuO_{6+x}$ citing evidence for a field-induced quantum critical point coincident with B_{c2}. Such a claim has profound implications for our understanding of the cuprate phase diagram. Our own extensive angle-dependent magnetoresistance studies of $Tl_2Ba_2CuO_{6+x}$, however, offer an alternative explanation for their findings based entirely on cyclotron (orbital) effects.

Contrary to claims in ref. 1, orbital magnetoresistance for **B**//**I**//*c* is significant in $Tl_2Ba_2CuO_{6+x}$ because of its mod2 symmetric *c*-axis warping (Fig. 1*A*) (2). As shown in the simulation in Fig. 1*B*, for sufficiently clean samples this orbital effect is large enough to create an upturn in $\rho_c(T)$ at low temperatures. At a particular intermediate field (25 T in this example), ρ_c appears to follow a T^2 dependence over a wide temperature range. However, neither the upturn nor the T^2 crossover regime has any physical meaning.

The authors argue that the observed violation of Kohler's rule proves that the critical scaling is intrinsic and not simply governed by $\omega_c\tau$. This is not necessarily correct. Kohler's rule is obeyed only if $\omega_c\tau$ is isotropic or its basal plane anisotropy remains constant with temperature (Fig. 1*C*). As reported in ref. 3, $\omega_c\tau$ in $Tl_2Ba_2CuO_{6+x}$ has a *T*-dependent anisotropy at low temperatures that is sufficient to account for the observed violation (Fig. 1*D*). In short, had the authors of ref. 1 studied samples with different levels of impurity, or measured in-plane resistivity data (with **B**//*c*), they may have reached very different conclusions about their measurements.

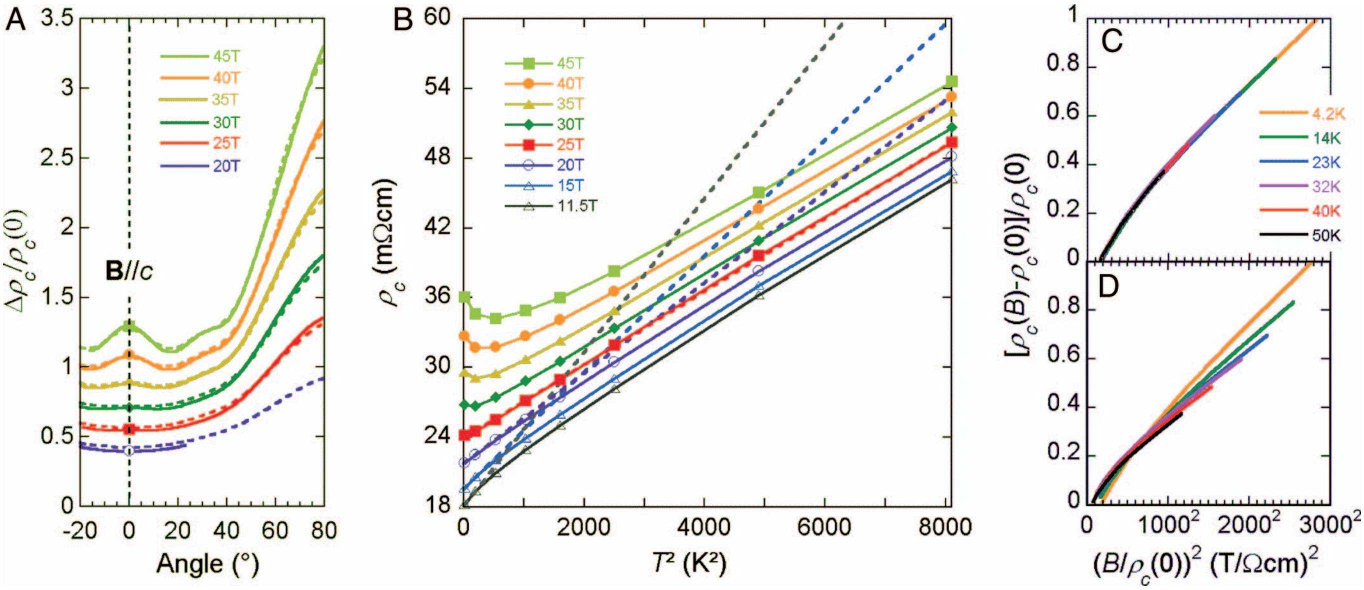

Fig. 1. (*A*) Polar angle-dependent magnetoresistance data (solid lines) in overdoped $Tl_2Ba_2CuO_{6+x}$ (T_c = 15 K) at T = 4.2 K for various field strengths up to 45 Tesla. Dashed lines are fits obtained by using the semiclassical Boltzmann equation and a Fermi surface representation of $Tl_2Ba_2CuO_{6+x}$ consistent with its body-centered tetragonal symmetry (3). The peak at **B**//*c* arises because of the effective cancellation of the *c*-axis velocity around an in-plane cyclotron orbit in this representation. (*B*) ρ_c versus T^2 for a sample of higher quality than reported in ref. 1 at different field strengths. The 45 T line is measured data. Lines at lower fields are produced by simply scaling the data by the appropriate $\omega_c\tau$ value. When $\omega_c\tau$ is large enough at low temperatures and high fields, an upturn is clearly visible. For this particular sample, the data at 25 T resemble the 45 T data shown in ref. 1. Indeed, the straight line fits to the low-*T* data for $B \leq 25$ T (dashed lines) show an evolution with field very similar to those reported in ref. 1. (*C*) Kohler plot simulation assuming that $\omega_c\tau$ is isotropic within the basal plane. Kohler's rule is clearly obeyed in this case. (*D*) If $\omega_c\tau$ has fourfold basal-plane anisotropy that is *T*-dependent, however, Kohler's rule is violated, as observed experimentally.

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The authors declare no conflict of interest.

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