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Breakdown of One-Paramater Scaling in Quantum Critical Scenarios for the High-Temperature Copper-oxide Superconductors[1]

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We show that if the excitations which become gapless at a quantum critical point also carry the electrical current, then a resistivity linear in temperature, as is observed in the copper-oxide high-temperature superconductors, obtains only if the dynamical exponent, z, satisfies the unphysical constraint, z¡0. At fault here is the universal scaling hypothesis that, at a continuous phase transition, the only relevant length scale is the correlation length. Consequently, either the electrical current in the normal state of the cuprates is carried by degrees of freedom which do not undergo a quantum phase transition, or quantum critical scenarios must forgo this basic scaling hypothesis and demand that more than a single correlation length scale is necessary to model transport in the cuprates.

In collaboration with Philip Phillips, Univ. of Illinois at Urbana-Champaign.

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