Transport properties of overdoped cuprates and generic two-dimensional metals

Jonathan Buhmann, Matthias Ossadnik, Maurice Rice, and Manfred Sigrist
Institute for Theoretical Physics, ETH Zürich, Zürich, Swizerland

We study charge transport properties in the normal state of heavily overdoped high-temperature superconducting cuprates. We analyze the effect of strongly anisotropic and temperature dependent quasiparticle scattering rates on the electrical resistivity within a semiclassical approach based on the Boltzmann transport theory. The scattering rates are computed using a functional renormalization group calculation. We solve the linearized Boltzmann equation numerically including the full energy and momentum dependence of the distribution function and derive the resistivity, the Seebeck coefficient, and the Hall coefficient as a function of both temperature and doping.

This study is motivated by the correlation between charge transport and superconductivity for $Tl_2Ba_2CuO_{6+x}$ reported by Abdel-Jawad et al. [1] and the non-perturbative linear temperature dependence of the anisotropic part of the quasiparticle life times found within a functional renormalization group study [2]. In addition, N. Hussey et al. [3] have experimentally probed the resistivity in $La_{2-x}Sr_xCuO_4$ for several doping levels and found anomalous scaling behavior which we aim to discuss within our theoretical study.

We also study transport properties of generic two-dimensional metals with focus on the band structure dependence of the Seebeck effect. Metals are typically not considered to be interesting for thermoelectric applications due to their low Seebeck coefficient. We analyze the role of special Fermi surface geometries on the quasiparticle scattering rates that determine the electronic transport and consequently the Seebeck effect. We will show that strong gradients of the electrical conductivity with respect to the band filling can be found for Fermi surfaces at special values of the band filling. For systems that match these requirements the Seebeck coefficient is believed to be strongly enhanced according to Mott's formula. We compute the Seebeck coefficient and analyze the validity of Mott's formula.

[1] M. Abdel-Jawad et al., Nature Physics **2**, 821 (2006).
[2] M. Ossadnik et al., Phys. Rev. Lett. **101**, 256405, (2008).
[3] R.A. Cooper et al., Science **323**, 603 (2009).