Impurity-scattering assisted umklapp scattering as the origin of low-temperature resistivity in the normal-state of cuprate superconductors

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The transport experiments reveal that the low-temperature resistivity in the normal-state of cuprate superconductors is quadratic in temperature (T-quadratic) in the underdoped pseudogap phase, while it is linear in temperature (T-linear) in the overdoped strange-metal phase [1,2], however, the full understanding of these different behaviours is still a challenging issue. Here starting from the microscopic electronic structure of cuprate superconductors, the low-temperature resistivity in the normal-state is investigated from the underdoped pseudogap phase to the overdoped strange-metal phase [3,4]. It is shown that the mechanism requires both the impurity scattering and the umklapp scattering: the impurity scattering is needed to restrict the modification of the distribution function to at around the antinodal region, while the impurity-scattering assisted umklapp scattering from a spin excitation is at the heart of the behaviour in the low-temperature resistivity, where the doping dependence of the temperature scale exists, and presents a similar behavior of the antinodal spin pseudogap crossover temperature. In the low-temperature region above the temperature scale in the overdoped strange-metal phase, the resistivity is T-linear, however, in the low-temperature region below the temperature scale in the underdoped pseudogap phase, the opening of the spin pseudogap lowers the spin excitation density of states at around the antinodal region, which reduces the strength of the electron umklapp scattering from a spin excitation associated with the antinode, and thus leads to a T-quadratic behaviour of the resistivity [3,4].

References:

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