Two Regimes in Conductivity and the Hall Coefficient of Underdoped Cuprates in Strong Magnetic Fields

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Introduction

Nature of high temperature superconductivity (HTSC) in cuprates remains unresolved. Unlike in superconductors of the "old generation" where superconductivity emerges from the normal Fermi liquid phase, HTSC is preceded by the so called pseudogap phase with numerous abnormal properties. In the first place, it concerns most uncommon features in the energy spectrum of excitations in the pseudogap phase. Thus, the angle resolved photoemission experiments (ARPES) see coherent excitations only at "arcs" of the finite length instead of the whole Fermi surface. Quantum oscillations reveal the presence of small electronic pocket(s) but are not capable to identify their position in the Brillouin zone. Finally, analysis of resistivity data shows the T-square contribution of the Fermi-liquid type existing in the resistivity. Those facts are suggestive that a clue to understanding HTSC may lie in better understanding of phenomena in the pseudogap phase.
Experimental situation in the field of HTSC cuprates is aggravated by the fact that many of these puzzling findings were obtained by separate groups, on different materials and with the use of different techniques. Most results, however, deem convincing, so that the consensus exists about their general character. Best studied are three families of the underdoped cuprates: yttrium based YBCO, single-layer mercury compound Hg1201 and the strontium-doped La2CuO4 (LSCO). However, ARPES is not feasible in YBCO and Hg1201, while observation of QO in LSCO is hindered by disorder.
The goal of the present study is assuming in the model [1] that holes on the Fermi arcs and electrons on a pocket are the ubiquitous feature of the energy spectrum in underdoped cuprates; to investigate their manifestations in the magneto-transport properties of these materials, i.e. the conductivity and, especially, the Hall Effect in high magnetic fields.

Results and Discussion

We found two regimes. At higher temperatures (at the field fixed) electrons are dragged by holes on the Fermi arcs. The pocket being small its contribution into conductivity and the Hall coefficient is negligible. At lower temperatures electrons decouple from holes and behave as a Fermi gas in the magnetic field. Mobility of holes on the arcs decreasing in strong fields with decrease of temperature, there is a crossover temperature below which the pocket electrons prevail and even may change sign of the Hall coefficient in the low temperature limit. Such behavior agrees with recent high-field experiments.

Conclusions

We consider the above results also as confirming the presence of an electronic pocket in the energy spectrum.

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References

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