Pseudogap Ground State of the High-Tc Superconductors $Bi_2Sr_{2-x}La_xCuO_6$

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Introduction

The problem of high temperature superconductivity is among the most outstanding issues in condensed matter physics. Understanding the uncommon normal state, in particular, the so-called pseudogap phase, is at the heart of research. We have studied the ground state of the pseudogap phase by NMR, with application of very high magnetic fields up to 43 T to suppress superconductivity in $Bi_2Sr_{2-x}La_xCuO_6$ [1].

Experimental Results and Discussion

We find that the pseudogap phase persists deep inside the overdoped region but terminates at around x =0.05, which corresponds to the hole doping concentration of approximately 0.21. Beyond this critical point, the normal state is a Fermi liquid that persists as the ground state when superconductivity is removed by the magnetic field (Fig. 1).

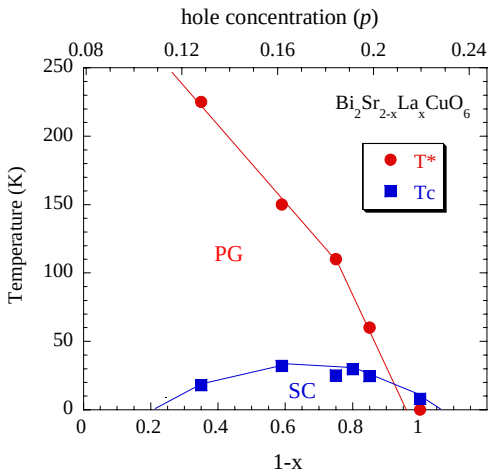

Fig. 1: Phase diagram of $Bi_2Sr_{2-x}La_xCuO_6$ obtained from this study. PG and SC stands for pseudogap and Superconducting phase, respectively.

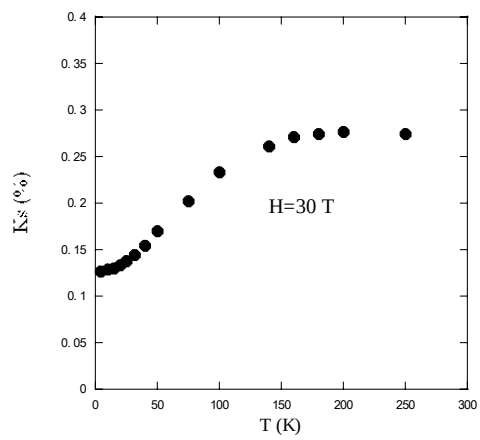

Fig.2: Knight shift (DOS) in $Bi_2Sr_{1.6}La_{0.4}CuO_6$. The PG temperature T* is around 150K

We also find that there remains substantial density of states (DOS) at the Fermi level when the superconductivity is removed by applying a very strong magnetic field (Fig. 2), which suggests that the zero-temperature pseudogap state is a "Fermi-patch (pockets or arcs)" metal. This is in contrast to the electron-doped counterpart in which the zero-temperature normal state is a correlated Laudau Fermi liquid [2]. Figure 2 also shows that below T*, the spin susceptibility decreases, which is a strong evidence for that the pseudogap is a phenomenon of loss of DOS.

Conclusions

From these results, we conclude that the pseudogap and superconducting gap are coexisting states of matter [1], and that a finite size of the Fermi surface is remained in the zero-temperature pseudogap phase. Namely, the ground state of the pseudogap phase is a "Fermi patch" (arcs or pockets) metallic state.

References

[1] G.-q. Zheng, P.L. Kuhns, A.P. Reyes, B. Liang and C.T. Lin: Phys. Rev. Lett. **94**, 047006 (2005).
[2] G.-q. Zheng, T. Sato, Y. Kitaoka, M. Fujita and K. Yamada: Phys. Rev. Lett. **90**, 197005 (2003).