Field-Induced Fermi Surface Reconstruction in $CeRhIn_5$

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Introduction

$CeRhIn_5$ provides a prototype system for studying unconventional superconductivity and quantum phase transitions among the heavy fermion compounds. It has been theoretically proposed that Fermi surface (FS) can act as an important parameter to characterize and classify the local and spin-density-wave (SDW)-type quantum critical points (QCPs) [1]. A dramatic change of FS was previously reported at the pressure-induced QCP when a sufficiently large magnetic field is applied to suppress superconductivity in CeRhIn5 [2], supporting a scenario of local QCP [1]. Our recent measurements of dHvA effect and specific heat in a pulsed magnetic field showed that the antiferromagnetic (AFM) transition of CeRhIn5 can be eventually suppressed to zero temperature by applying a magnetic field of about $B_{c0}\approx 50T$ [3]. A sharp change of FS was observed around $B^*=35T$, which is well inside the AFM state [3]. These results suggest the existence of multiple quantum phase transitions in CeRhIn5 which can be indeed characterized by the measurements of FS. In order to further confirm these important new findings and provide extra evidence, further measurements are highly demanded.

Experimental

Measurements of the dHvA effect and Hall resistivity were performed by using the facilities of 45T DC magnet at NHMFL-Tallahassee. The dHvA effect was measured by a torque method developed in NHMFL and the Hall resistivity was detected by a standard 4-contact method. The single crystals for both measurements showed very high sample quality with RRR~1000.

Results and Discussion

The dHvA measurements at very low temperatures showed the appearance of new dHvA frequencies at high fields. As an example, we plot the quantum oscillations at T=0.31K in Fig. 1(a), from which a new dHvA frequency with f_5=10619T can be clearly identified above $B^* \approx 31T$. These results are highly consistent with those we obtained in the pulsed magnetic field [3], confirming the existence of a field-induced FS reconstruction in CeRhIn5. Furthermore, the Hall resistivity $\rho_{xy}(B)$ undergoes a sudden jump around B* at temperatures below 1.7K, providing new evidence for a change of electronic structure at B*. Our results are compatible with the scenario of localized-itinerant transition at B* in CeRhIn5, providing new inputs to the QCPs. Further measurements are still under way in order to fully elucidate the nature of QCPs in this compound.

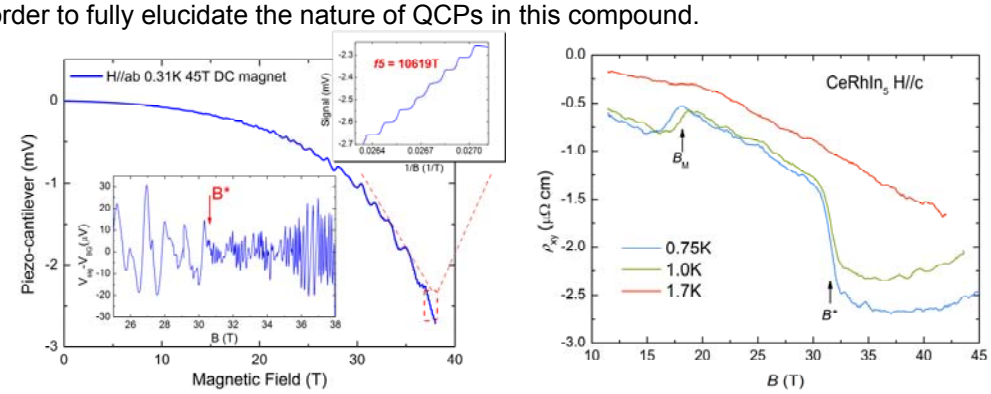

Fig. 1 (a) The quantum oscillations and (b) Hall resistivity,$\rho_{xy}(B)$ of CeRhIn5 measured in the 45T DC field. B* marks the changes of electronic structure and the kinks around B_M=15T corresponds to a metamagnetic transition.

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References

[1] Si, Q., and Steglich, F., Science 329, 1161 (2010).
[2] Shishido, H., Settai, R., Harima, H. and Ōnuki, Y., J. Phys. Soc. Jpn. **74**, 1103 (2005).
[3] Jiao, L., *et al*., arxiv 1308.0294.