The de Haas-van Alphen Effect on $CeIn_3$ Doped with La

T. Ebihara, K. Tezuka, Y. Iwamoto, H. Kitagawa (Department of Physics, Shizuoka University);
N. Harrison (NHMFL, LANL)

Introduction

Since the discovery of superconductivity in heavy fermion system, much attention has been paid to the system because it was implied that magnetic correlation mediated its superconductivity. $CeIn_3$, which crystallizes into $AuCu_3$-type cubic structure and orders antiferromagnetically at 10K, was explored to show superconductivity under pressure and has been known as a typical example of magnetically mediated superconductor in heavy fermion system. In heavy fermion superconductors, the 4f-electron should contribute to mediating superconductivity but the mechanism of 4f electron contribution is not very clear. We attempted to clarify the electronic states of a typical heavy fermion superconductor $CeIn_3$ by the de Has-van Alphen (dHvA) measurements with La substitution to Ce for controlling 4f population.

Experimental

Single crystals of $Ce_{1-x}La_x\ In_3$ (x=0~1) were made by the flux method in Shizuoka University. Every composition sample was determined its lattice constant by X-ray diffraction. The single crystals were checked their orientations and shaped for pulse field dHvA measurements in National High Magnetic Field Laboratory, Los Alamos.

Results and Discussion

The Néel temperature in La doped $CeIn_3$ becomes lower with increasing La composition as a linear function The Néel temperature at high magnetic field becomes lower than that of $CeIn_3$ at zero field and pressure as a quadratic function. Lower Néel temperature implies lower Néel critical field comparing to that at 60T in $CeIn_3$. Thus, we could observe dHvA oscillations in $Ce_{1-x}La_x\ In_3$ (x=0.25, 0.4, 0.5, 0.6, 0.4, 0.3, 0.2) in polarized paramagnetic state. In all compositions, the largest Fermi surface, which is denoted by a-branch being with F≈7kT in non-magnetic reference compound $LaIn_3$, was observed where H||<111> except x=0.3. The dHvA frequency of a-branch becomes lower as La concentration increases. When lattice constant increases, volume of Brillouin zone becomes smaller. Therefore, Brillouin zone shrinking causes shrunk Fermi surface volume by La doping. The ratio between a-branch and Brillouin zone volumes is constant.

Conclusions

We observed de Haas-van Alphen oscillation in most of La doped $CeIn_3$ compounds. The redeveloped a-branch in high magnetic field was observed in most of composition. The Fermi surface volume is constant if we take into account shrunk Brillouin zone in volume because of lattice constant enlargement by La doping.

Acknowledgements

Part of this work by T. E was performed under auspices “100 Tesla Spin Science” and basic research (C) by MEXT. T. E. also expresses many thanks to Asahi Glass Foundation, CASIO science promotion foundation and Suzuki Foundation.

References

[1] N. D. Mathur, *et. al.*, Nature, **394**, 39-43 (1998).
[2] I. R. Walker, F. M. Grosche, D. M. Freye and G. G. Lonzarich, Physica C, **282-287,** 303-306 (1997).
[3] J. M. Lawrence and S. M. Shapiro, Phys. Rev. B, **22** 4379-4388 (1980).
[4] N. Harrison, S. E. Sebastian, C. H. Mielke, A. Paris, M. J. Gordon, C. A. Swenson, D. G. Rickel, M. D. Pacheco, P. F. Ruminer, J. B. Schillig, J. R. Sims, A. H. Lacerda, M.-T. Suzuki, H. Harima, and T. Ebihara, Phys. Rev. Lett., **99**, 056401-4 (2007).
[5] Takao Ebihara, N. Harrison, M. Jaime, Shinya Uji, and J. C. Lashley, Phys. Rev. Lett., **93**, 246401-4 (2004).