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Quantum phase transitions, non-Fermi liquid and the dHvA effect in $Ce_xLa_{1-x}B_6$

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$Ce_xLa_{1-x}B_6$ is well known as a cubic dilute or dense Kondo system with $(4f)^1$ configuration. The ground crystal electric field (CEF) state of 4f electron is a Γ_8 and the first excited Γ_7 stays at 540 K. One of the characteristics of $Ce_xLa_{1-x}B_6$ is the CEF ground state which carries both the magnetic dipolar and electric quadrupolar moments. In pure CeB_6, paramagnetic phase I, antiferromagnetic phase II and phase III in which an antiferromagnetic and antiferroquadrupolar orders coexist appear with decreasing temperature successively. In the last decade, it has been revealed that $Ce_xLa_{1-x}B_6$ show anomalous magnetic phase diagrams when the Ce concentration shows high values. In $Ce_xLa_{1-x}B_6$ (x=0.65, 0.70, 0.75), an unusual magnetic phase IV appears. The order parameter of this phase has not been established regardless of much effort. In $Ce_xLa_{1-x}B_6$ (x=0.50, 0.60), no long range order is found in low magnetic fields and antiferromagnetic and antiferroqudrupolar orders are induced by the field. This indicates that the field induced transitions are quantum phase transitions (QPT).

In this paper we focus on the behaviors of the conduction electrons in the considered systems and present the transport properties and Fermi surfaces of $Ce_xLa_{1-x}B_6$. Divergence of the coefficient A of the T^2-term in the electric resistivity has been found in phases III and II of $Ce_{0.5}La_{0.5}B_6$. The resistivity of this system shows non-Fermi liquid behaviors in phase I. In phase IV of $Ce_{0.65}La_{0.35}B_6$, the resistivity shows T^2 behavior which indicates heavy fermion state. Regardless of the random distribution of rare earth ions, dHvA oscillations have been detected in $Ce_xLa_{1-x}B_6$ and $Pr_xLa_{1-x}B_6$ at every concentration of rare earth ion. The Fermi surface of the $Ce_xLa_{1-x}B_6$ changes with increasing the Ce concentration. On the other hand, the Fermi surface of $Pr_xLa_{1-x}B_6$ is independent of the concentration of Pr ions.

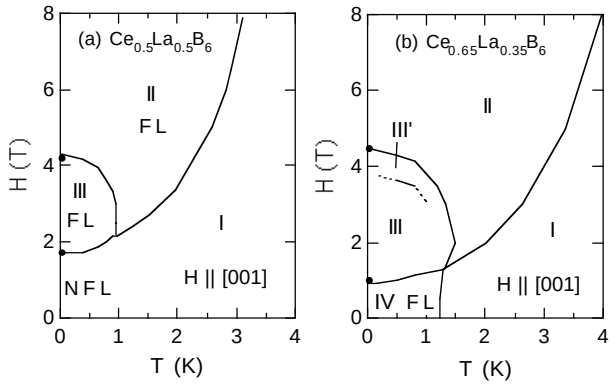

Figure 1: Magnetic phase diagrams of (a) $Ce_{0.5}La_{0.5}B_6$ and (b) $Ce_{0.65}La_{0.35}B_6$.

[1] S. Nakamura, M. Endo, H. Aoki, N. Kimura, T. Nojima, S. Kunii, Phys. Rev. B **68** (2003) 100402(R).