# QUANTUM CRITICALITY IN $CeIn_3$ AT HIGH MAGNETIC FIELDS

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## Introduction

$CeIn_3$ shows magnetically mediated superconductivity under pressure. The superconductivity appears at the vicinity between antiferromagnetic ground state and paramagnetic Kondo state. At absolute zero in temperature, the point separating those two sates is called Quantum Critical Point (QCP). At QCP, spin fluctuation plays major role to arise various physical phenomena. The QCP is a cradle of magnetically mediated superconductivity as seen typically in $CeIn_3$.

We have measured de Haas-van Alphen (dHvA) effects near QCP in $CeIn_3$. The dHvA results showed fluctuation hot spots in $CeIn_3$ concentrated in narrow angular region along <111> direction. The hot spots, possibly arisen by c-f interaction, should gradually disappear with subtraction of 4f electron. Clarifying electronic states in La doped $CeIn_3$ gives total picture of Quantum Criticality in $CeIn_3$. We observed dHvA in $Ce_{0.6}La_{0.4}In_3$ and $Ce_{0.75}La_{0.25}In_3$.

## Experimental

The dHvA measurements were performed by pulsed magnetic field up to 65 T with $^3$He cryostat of NHMFL/LANL. Single crystals with typical dimensions with 5x5x5 mm$^3$were grown and samples were shaped at Shizuoka University to fit in the pick-up coil with inner diameter with 0.4mm for pulsed field dHvA. For checking the composition and the Neel temperature, electrical resistivities for all samples are measured.

## Results and Discussion

The dHvA signals in both $Ce_{0.6}La_{0.4}In_3$ and $Ce_{0.75}La_{0.25}In_3$ are detected. Fig. 1 shows (a) typical dHvA signal and (b) its FFT spectrum in <100> direction of $Ce_{0.6}La_{0.4}In_3$. Although the only d-branch is observed in pure $CeIn_3$, the a-branch seen in $LaIn_3$ appears in <111> direction in $Ce_{0.75}La_{0.25}In_3$ and in both <110> and <111> directions in $Ce_{0.6}La_{0.4}In_3$. As revival of the a-branch with increasing La concentration, the d-branch disappears despite of existence of the d-branch for all angular region in pure $CeIn_3$. This means reconstruction of Fermi surface of $LaIn_3$ with La doping to $CeIn_3$.

Effective masses at <111> and <110> of a-branch in $Ce_{0.6}La_{0.4}In_3$ are estimated to be $7m_e$s that are heavier than those of $LaIn_3$ by a factor of ten. Effective mass at <111> of a-branch in $Ce_{0.75}La_{0.25}In_3$ is also with $7m_e$.

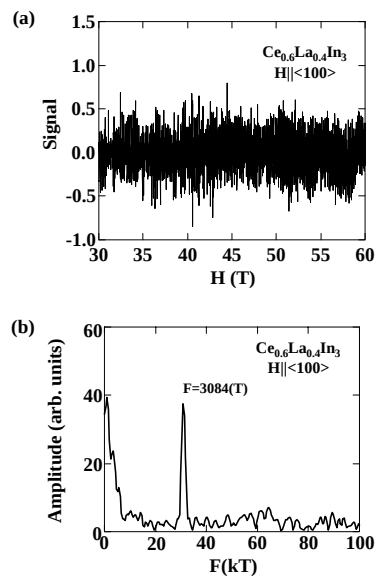


Fig.1 (a) Typical dHvA oscillation and (b) its FFT Spectrum

## Conclusions

We detected dHvA signals in both $Ce_{0.6}La_{0.4}In_3$ and $Ce_{0.75}La_{0.25}In_3$. Redevelopment of Fermi surfaces of $LaIn_3$ was implied and we are being able to map change of Fermi surfaces from $CeIn_3$ to $LaIn_3$. We clarified, in a part, hot spots behavior and Quantum Criticality in $CeIn_3$ with La dilution. For getting total picture of the hot spots and quantum criticality of $CeIn_3$, we need further research in higher concentration of La doping to $CeIn_3$.

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## References

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