MERIT Overseas Dispatch

Masaki TSUJIMOTO D2, Advanced Material Science Department
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Subject: Magnetocaloric Effect Measurement for the Investigation of Quantum Criticality due to orbital fluctuation in non-magnetic heavy fermion compound PrV_2Al_{20}.

I was in Experimental Physics 6 group (Gegenwart group, University of Augsburg (Germany)) to do the research about non-magnetic QCP in PrV_2Al_{20}.

1. Introduction

Heavy fermion system can be realized by the strong hybridization between *f* electrons and conduction electrons in crystals. In those systems, we can easily tune the strength of the hybridization, and fluctuation of the moments of electrons become large in a special condition. The point where satisfy the condition is called Quantum Critical Point (QCP). We can observe various kinds of interesting phenomena in QCP, such as non-Fermi liquid behavior and heavy fermion superconductivity. Especially, the QCP due to the electron orbital fluctuation is very interesting subject to investigate partly because that may have a relationship with high T_c superconductivity.

QCP due to electronic orbital fluctuation is more difficult for investigation than magnetic version of QCP is because there is few example for the investigation of orbital version of QCP. For the investigation of orbital version of QCP, both non-magnetic Γ_3 crystal electric field ground state and strong hybridization are necessary. However, finding non-magnetic Γ_3 system which has strong hybridization is difficult.

PrV_2Al_{20} is very rare example which shows Γ_3 ground state and strong hybridization. Besides, orbital version of QCP has been realized at 11 T by electric resistivity measurement. It is very interesting to investigate this very rare orbital QCP.

2. Purpose

Magnetocaloric effect (MCE) measurement is very effective for the study of QCP. MCE is the effect that the temperature of sample changes corresponding to the applied magnetic field. Magnetic grueneisen ratio Γ_H can be derived by MCE measurement, and Γ_H diverge at field induced magnetic QCP. Then, we can investigate other aspects of orbital QCP by measurement of MCE in PrV_2Al_{20}. Therefore, I was in the group of Prof. Gegenwart (University of Augsburg, Germany) where the technique of MCE measurement has been established.

3. Results

Before I went to University of Augsburg, I synthesized the crystals of PrV_2Al_{20} in our laboratory where we have equipment for synthesis of good quality samples, and evaluated the crystals by electrical resistivity measurement. As I found 2 good quality samples, we used those samples for MCE measurement. The samples are put on the platform like Fig. 1.

First, we measured specific heat which is needed for the precise analysis of MCE. As a result, we found that the quality of 1 sample is not good due to ununiformity of the crystalline while another is good. Γ_H shows peak at around 12 T (QCP is 11 T) in both samples. Especially in higher quality sample, we can see sign change of Γ_H at around 11 T which is the critical field of PrV_2Al_{20}. This sign change is usual in magnetic QCP and is the first observation in nonmagnetic system.

Next, we measured temperature dependence of Γ_H under various magnetic fields. Γ_H is enhanced as sample goes to low temperature at around 11 T, which leads to divergence of Γ_H at QCP. On the other hand, Γ_H is nearly 0 at low magnetic field region, which reads the new finding that the anomalous metallic behavior of PrV_2Al_{20} in electrical resistivity, magnetic susceptibility, and specific heat measurement at 0 T have no relationship with QCP of orbital fluctuation.

4. Acknowledgement
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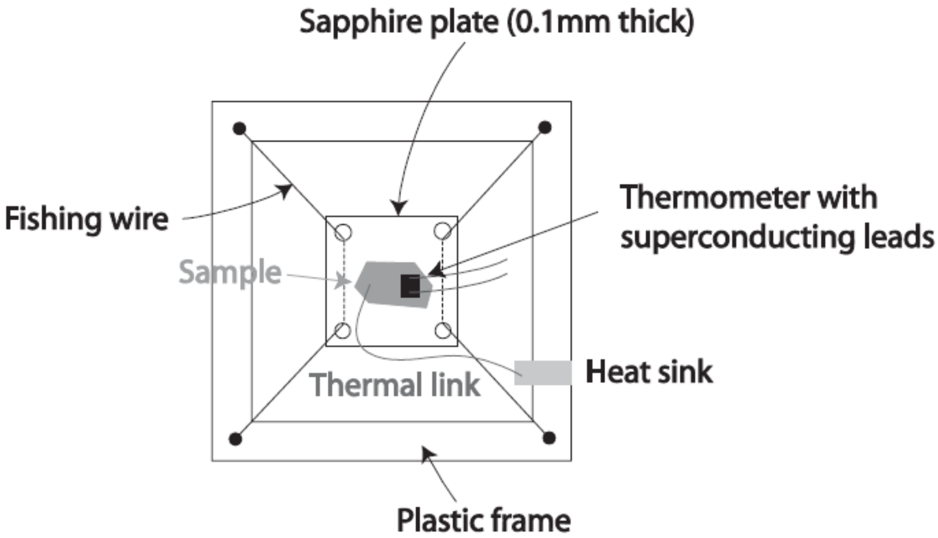

Fig 1. The layout of the platform and the sample for MCE measurement.
Y. Tokiwa, and P. Gegenwart, Rev. Sci. Instrum. 82, 013905 (2011).