Report：MERIT Long-term Overseas Dispatch

Dept. of Advanced Material Science
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1. Abstract

Period： Oct. 4th 2016 – Dec. 29th 2016
Host：Johns Hopkins University (JHU), US
Supervisor：Prof. Collin Broholm
Project：The study of quantum criticality in Yb based valence fluctuation system with neutron scattering measurement

2. Research

Prof. Broholm group studies strongly correlated electron systems, especially spin frustration system and heavy fermion system with neutron scattering measurement. They had and are having a lot of collaboration work with Nakatsuji group.

β-$YbAlB_4$ is focused on as a heavy fermion superconductor and a strange metal system even though it exhibit valence fluctuation. Its isostructural material α-$YbAlB_4$, is also valence fluctuation system, shows Fermi liquid behavior as the ground state. It has same local symmetry around Yb as β-$YbAlB_4$ and exhibit strange metal behavior with Lifshitz transition with applying 3 T magnetic field at very low temperature.

Usually, these non-Fermi liquid behaviors are related with the spin fluctuation of electron. The relationship between quantum criticality and spin correlation was studied on $CeRhIn_5$ and other systems. Non-Fermi liquid behaviors in α,β-$YbAlB_4$ are expected to relate with valence fluctuation. However, there is no knowledge on its correlation. Therefore, I performed neutron scattering measurement on α-$YbAlB_4$ to investigate it.

On the neutron scattering measurement, the sample size is one of the issue because its signal amplitude depends on it, so that this measurement was performed on α-$YbAlB_4$ because crystal size of β-$YbAlB_4$ was 0.1mg/piece. The crystal size of α-$YbAlB_4$ was 3-5mg/piece. Even this size was too small so that I put 70 crystals (~300 mg) on the sample stage in parallel in this measurement.

I performed 2 measurements in the dispatch with Shan Wu, a student in Prof. Broholm's group. The first one was measured in CNCS (Cold Neutron Chopper Spectrometer), Oak Ridge National Laboratory at 10/17-24. The second one was measured in MACS (Multiple Axis Crystal Spectrometer), National Institute of Science and Technology at 11/17-25. On the first measurement, we targeted to observe the

quantum critical behavior in 3 T. The parallel alignment worked well (Its error was in 2 degree.), however the signal from a magnet was so strong comparing from samples that we could not observe anything except Bragg peak. On the 2nd measurement, we targeted to observe any correlation signal without putting magnet. As a result, we observed signals which may come from magnetic correlation.

3. Life in the US

Just before the departure from Japan, I broke my left arm born. Fortunately, there was no need to put a cast and to go hospital in US, so this dispatch was done as scheduled. When I walked through campus with putting a bandage on my arm, people in campus, even shop clerks and strange men asked me “What happened?”. It is impressive for me that people in the US have the open mind. I was very influenced from this circumstance during the stay, so sometimes I was said that my personality changed after I came back Japan.

Picture, Bloomberg center (Phys. and Astronomy department)

Most of the scientists and students were morning persons in JHU. Some of them came even 7:30 a.m. And most of them went back their home at 6:00 p.m. They did not stay in office long time and kept regular hours, however they produced a lot of outcomes. This style is very rational behavior and I should learn from it.

Acknowledgement

I really appreciate for Prof. Collin Broholm for accepting my visit and Ms. Shan Wu for supporting my experiment. I thank my supervisor, Prof. Satoru Nakatsuji, who is visiting JHU, my roommate, Takashi Nishikawa and Dr. Man Huiyuan for supporting my stay in US. And I thank for member of Nakatsuji lab and MERIT secretariat members for supporting my visit, especially Ms. Asano to overcome the problem related with traffic accident in Japan.