TF-μSR study of $YbCu_4Ni$

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Several examples of quantum critical phenomena have been reported in f electron systems.[1)] The reason is that the energy scale is so small that it can be controlled by the pressure and magnetic field generated in a laboratory system. Thus, it is an ideal situation for investigating quantum critical phenomena as a whole. However, there are few examples of materials near the quantum critical point at ambient pressure and zero magnetic field. Therefore, the search for such materials is a significant challenge..

We focused on $YbCu_4Ni$, which has a large electronic specific heat coefficient.[2)] Recently, we have succeeded in synthesizing pure materials. We have also succeeded in using $YbCu_4Ni$ as a magnetic refrigeration material by exploring its large electronic specific heat coefficient.[3)] However, there are two possible origins of the large value: (i) Kondo disorder, (ii) quantum criticality. To determine the actual origin, we performed TF-μSR experiments.

The purpose of this study is to determine the origin of the large electronic specific heat coefficient of $YbCu_4Ni$. The linewidth of the μSR spectrum increases with a decrease in the temperature when the Kondo disorder is dominant, as noted in previous studies on UCu_4Pd,[4,5)] $CeRhRuSi_2$,[6)] and $YbRh_2Si_2$.[7)] To obtain the information on $YbCu_4Ni$, we compared the μSR spectra at 10 K and 35 mK under TF-300 G. The μSR measurements were performed with a dilution refrigerator using the D1 μSR spectrometer at Materrials and Life Science Experimental Facility (MLF) in J-PARC, Japan. The powder sample was placed on a silver plate and covered with silver foil.

Figure 1 shows the 10 K and 35 mK μSR spectra; the spectrum at 35 mK is narrower than that at 10 K. This rejects the main magnetic contribution of the Kondo disorder. Therefore, we determined that $YbCu_4Ni$ is a quantum critical material. Previous studies on $YbCu_{5-x}Au_x$ reported that the smaller the lattice constant, the closer to the quantum critical point.[8–12)] However, it is difficult to syntheize the samples with small value of x because of the change in crystal structure at ambient pressure. Because $YbCu_4Ni$ has a smaller lattice constant than these samples, the quantum criticality may be observed at ambient pressure and zero magnetic field.

In this study, we performed TF-μSR experiments to investigate the origin of the large electronic specific heat coefficient of $YbCu_4Ni$. The spectrum at 35 mK was observed to be narrower than that at 200 K, suggesting that $YbCu_4Ni$ has a quantum criticality. In future studies, we will determine the origin of quantum criticality by synthesizing pure single crystals and determining the band structure. Further, μSR measurements will be carried out in collaboration with KEK and RIKEN groups.

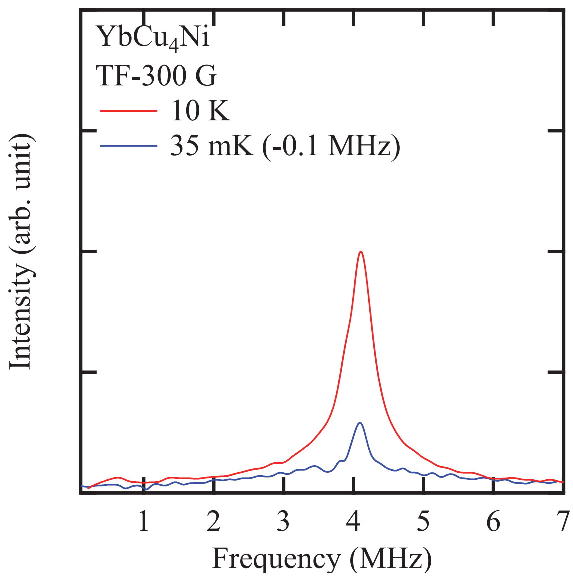

Fig. 1. μSR spectra of $YbCu_4Ni$ at 10 K and 35 mK.

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