Magnetism of novel heavy fermion compound $YbCu_4Ni$ investigated by μSR

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The f-electron systems show many examples of quantum critical phenomena.[1)] In previous works, high-quality crystals and advanced experimental methods provided many instances of quantum critical phenomena originating from antiferromagnetism. Recently, quantum critical phenomena that cannot be explained by the self-consistent renormalization (SCR) theory have attracted much attention. However, to study such quantum critical phenomena, actual candidate materials and adequate experimental methods are required.

We focused on $YbCu_4T$ (T = transition metal) because this family exhibits exotic physical phenomena such as the valence transition at zero field and ambient pressure in $YbCu_4In$.[2,3)] In $YbCu_4Au$, valence and magnetic transitions are induced by applying a magnetic field.[4)] Since the Yb site in this family has three-fold symmetry, this system may show an ordered phase originating from geometrical frustration.

The temperature dependence of the specific heat (C/T) of $YbCu_4Ni$ shows a power-law behavior. This behavior is consistent with the quantum critical phenomena, but the SCR theory cannot explain the temperature dependence of C/T.[5)] The purpose of our research is to understand the origin of the power-law behavior of C/T in $YbCu_4Ni$. Magnetism usually plays the vital role of quantum criticality. Thus, we performed muon spin relaxation (μSR) measurements at RIKEN-RAL because μSR is a powerful tool to obtain information on static and dynamic spin correlations.

Figure 1 shows the temperature dependence of the μSR time spectra. To derive the magnetic fluctuation of the f-electron, we applied a longitudinal magnetic field of 100 G. Rapid relaxation was observed at low temperatures below 2 K, indicating the appearance of magnetic fluctuation. However muon spin precession was not observed down to the lowest temperature of 0.4 K. We determined the asymmetry of the spectrum at 0.4 K for the time after ∼4 μs as the baseline (∼16%). These results suggest the inhomogeneous magnetic field at the muon stopping site even at the lowest measurement temperature.

Here, we discuss the origin of the power-law behavior of C/T from the viewpoint of magnetic fluctuation. As in the case of antiferromagnetism, it is highly possible that the magnetic fluctuation is the cause of the temperature dependence of C/T. There are two possible origins of the magnetic fluctuations: (1) the novel quantum criticality and (2) magnetic inhomogeneity. For the former case, it was theoretically aspect pointed out that a dramatic increase in effective mass should be observed near the quantum critical point, other than that from the antiferromagnetic phase.[6)] For example, the temperature dependence of C/T shows logarithmic behavior in β-$YbAlB_4$ even when the valence fluctuation contributed to the physical properties.[7)] For the latter case, owing to the distribution of the Kondo temperature originating from the magnetic inhomogeneity, C/T at low temperatures may show a behavior similar to quantum criticality.[8)] Since inhomogeneous states such as the spin-glass state may appear because of the geometrical frustration, the latter case is also a candidate scenario. μSR measurements below 0.4 K may provide evidence to clarify the above two possibilities.

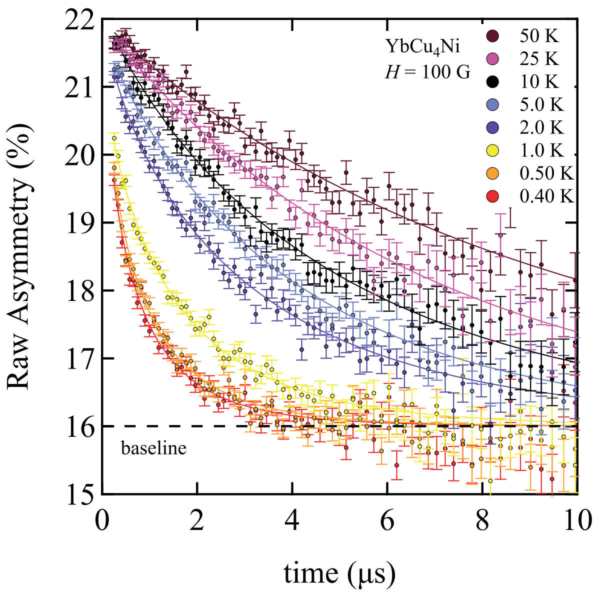

Fig. 1. Temperature dependence of the μSR time spectra of $YbCu_4Ni$ in a longitudinal field of 100 G.

In conclusion, we performed the μSR measurements of $YbCu_4Ni$. At low temperature, the magnetic fluctuation increased. It is highly possible that the power-law behavior of C/T is caused by this fluctuation.

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