Research Group for Condensed Matter Physics of Heavy Element Systems

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In heavy element (*f*-electron) systems, valence fluctuations, the Kondo effect, and the RKKY interaction compete with one another. Because of this, exotic behaviors such as quantum criticality, heavy fermions, non-Fermi liquids, anisotropic superconductivity and multipolar ordering appear when such competition is strong. Recently, it has become clear that these exotic behaviors for 5*f*-electron systems are different from those for 4*f*-electrons. This is because electrons with different spin and orbital character can coexist in 5*f* actinide systems, in contrast to the case of 4*f* electrons. By means of microscopic spectroscopy: NMR and μSR, our research group tries to clarify these exotic behaviors emerging from the "many-fold" character of both 4f and 5*f* compounds, including transuranium.

Coexistence of Fermi and non-Fermi liquids near quantum critical phase transition in $YbRh_2Si_2$ [1, 2]

Quantum critical phase transitions (QCPT) at T=0K in the heavy fermion state of a Kondo lattice offer various interesting aspects. In the heavy fermion system $YbRh_2Si_2$, the QCPT is not the usual case of spin density wave (SDW) instability observed in Ce-based compounds, but a candidate for the novel locally critical QCPT case. In $YbRh_2Si_2$, the weak antiferromagnetic transition below T_N=70mK is easily suppressed to T = 0, *i.e.* the QCPT appears with a small critical applied field H_c. In this study, coexisting, static Fermi liquid (FL) and non-Fermi liquid (NFL) states near the QCPT in $YbRh_2Si_2$ are brought to light by means of ^{29}Si-NMR nuclear spin-lattice relaxation time (T_1) studies with H ‖ a and c axes. Figure Fig. 1 shows the colour map of proportion $R= f_{NFL}/f_{FL}$ of the NFL to FL state in the (H,T) plane, where f_{NFL} and f_{FL} are the population of NFL and FL states, respectively. In the red region, the NFL state is dominant; in contrast, the FL state is dominant in the blue region. Consistently with the previously determined phase diagram (solid and dashed lines [3]), the NFL state remains to be dominant at low temperatures around H_c. Now investigation into the origin of this new coexisting state is under progress.

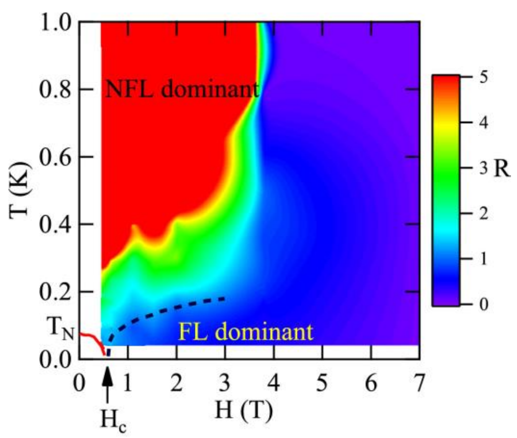

Fig. 1 Colour map of the proportion R of the NFL to FL states for H ‖ c in $YbRh_2Si_2$ [1]. Solid line: H-dependence of T_N; dashed line: crossover between NFL and FL regions. These lines are determined in previous transport measurements [3].

Partially disordered Sm magnetic moments in the antiferromagnetically ordered state of $SmPt_2Si_2$ [4]

The Kondo effect and related phenomena in *f*-electron systems have attracted much attention for more than three decades because of their nontrivial many-body characters. Recently, a new type of Kondo lattice was proposed in the heavy fermion compound $SmPt_2Si_2$. In this compound, a large Curie-Weiss type magnetic susceptibility is observed in the antiferromagnetically (AFM) ordered state, suggesting that magnetic moments at the Sm sites remaines to be partially disoredered [5]. This coexitence of ordered and disordered Sm sites is possibly related with a valance instability due to nearly degenerate f^5 and f^6 configurations. We have performed μSR measuremens in a single-crystalline sample of $SmPt_2Si_2$ to gain microscopic insights into coexistent ordered and disordered Sm moments. Figure Fig. 2 shows a μSR spectrum of $SmPt_2Si_2$ in zero applied field (ZF) at 1.6 K in the AFM ordered state. The coherent muon spin precession, which is clearly seen in the early-time region, manifests the existance of ordered magnetic moments. The spin-lattice relaxation time T_1 in the μs range is anomalously short compared to that in typical Sm-based magnets [6]. This suggests that magnetic fluctuations remain pronounced even in the AFM ordered state, which are consistent with the partially disordered moment picture. Further μSR investigations at lower temperatures and higher magnetic fields are in progress to elucidate the detailed nature of the partially disordered moments. NMR measurements are also now in progress.

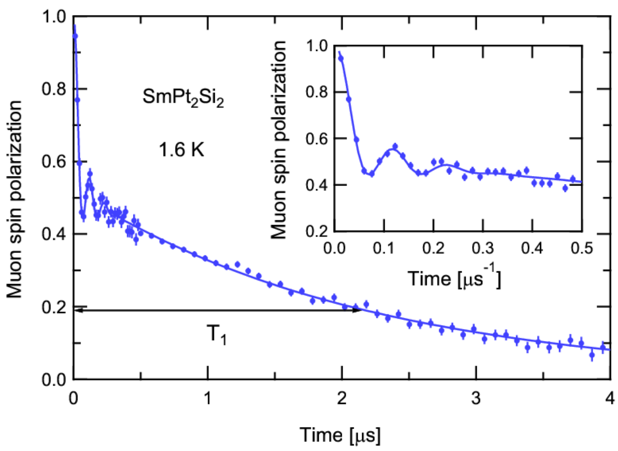

Fig. 2 ZF-μSR spectrum of $SmPt_2Si_2$ at 1.6 K. The inset shows an enlarged view of the early-time region (0-0.5 μs).

References

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