NMR Investigation of the High-Field Phase in $YbInCu_4$

Ben-Li Young (National Chiao Tung University, Electrophysics); P. L. Kuhns, A. P. Reyes (NHMFL); E. D. Bauer (LANL)

Introduction

$YbInCu_4$ is one of the few heavy fermion (HF) metals that show an intriguing first-order valence transition, which can be controlled by applying pressure or magnetic fields. Recent high pressure experiments have shown that a pressure-induced ferromagnetism occurs in $YbInCu_4$ near the critical pressure (~25 kbar) and a quantum critical point (QCP) for the valence transition temperature $T_V = 0$ is ruled out.[1] Whether a similar magnetism or a QCP can be induced by a high magnetic field near the critical field (~34T) is an interesting question. We therefore have conducted the high-field NMR experiments in $YbInCu_4$ in order to explore the nature of the critical phenomena in this first-order valence transition.

Experimental

$YbInCu_4$ has two good NMR nuclei, ^{63}Cu and ^{115}In. Since our sample is a polycrystal, we have chosen ^{115}In as the primary probe nucleus because it gives a single ^{115}In NMR line without any quadrupolar satellite broadening.[2] We have measured the ^{115}In NMR spectra and spin-lattice relaxation rate $1/T_1$ at various magnetic fields up to 35 tesla and down to 2 K. All the experiments were conducted at Cell 7 31.5 T and Cell 8 35 T magnets.

Results and Discussion

Figure 1 shows the plot of the NMR linewidth and peak frequency as a function of magnetic field at 4 K in the Fermi liquid (FL) state. The linewidth starts to increase dramatically above 30 tesla, which suggests that the electronic state becomes very inhomogeneous near H_c. Above 33 tesla, the Fermi liquid undergoes a paramagnetic (PM) spin liquid. As for the spectra from the PM state, we do not find any signature of field-induced magnetism in our present temperature window because neither line broadening nor change of the Knight shift are observed at 2 K when approaching H_c. Figure 2 gives the temperature dependence of $1/T_1$ at various fields. A field enhancement of $1/T_1$ is observed for both the FL and PM states. This is different from the high-pressure experiments where the $1/T_1$ in the FL and PM states are insensitive to the pressure.[3] This suggests that the mechanisms for the magnetic field and pressure on tuning the valence transition in $YbInCu_4$ are different. In the former, the Zeeman effect is involved in the competition between the Kondo and RKKY interactions, whereas in the latter, the inter- and intra-site coupling is directly controlled by the pressure effect.

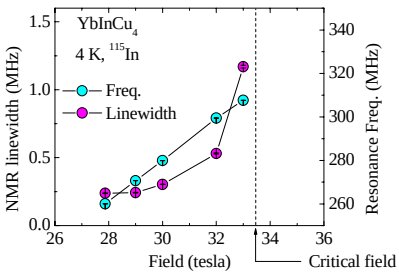

Fig. 1 The NMR linewidth and resonance frequency as a function of field.

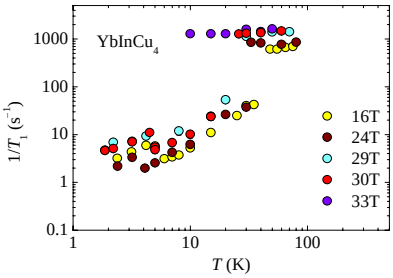

Fig. 2 The temperature dependence of $1/T_1$ as a function of field.

Conclusions

Our results show that the FL state in $YbInCu_4$ is strongly perturbed by magnetic fields and become inhomogeneous as approaching the critical field. No signature of the field-induced magnetism is observed for H up to 35 tesla and T down to 2K.

Acknowledgements

BLY acknowledges support from NSC (Taiwan) and MOE ATU Program.

References

[1] T. Koyama, et al., Phys. Rev. B **71**, 184437 (2005).
[2] H Nakamura, et al., J. Phys.: Condens. Matter **10**, 9123–9127 (1998).
[3] B.-L. Young, et al., Phys. Rev. B **71**, 224106 (2005).