Low Temperature C/T of Heavy Fermion Materials *and* of Micro-Particles of $Ce(Ru_{0.4}Rh_{0.6})_2Si_2$

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Introduction

We have measured the specific heat down to 0.05 K in zero and applied magnetic field of several heavy Fermion systems, including $YbIr_2$ and the newly discovered UIr_2Zn_{20} doped with Th[1]. In addition, we have almost finished our study of the specific heat and magnetic susceptibility of the quantum critical, non-Fermi liquid system $Ce(Ru_{0.4}Rh_{0.6})_2Si_2$ as a function of particle size as the size is decreased from the micron regime down into the nanometer regime.

Experimental

Using the 20T superconducting magnet with dil frig at NHMFL, Tallahassee, measurements were made on the specific heat, C, down to 0.05 K in fields ≤18 T using the specific heat apparatus of Takano/Andraka. Samples were 2-10 mg in size.

Results and Discussion

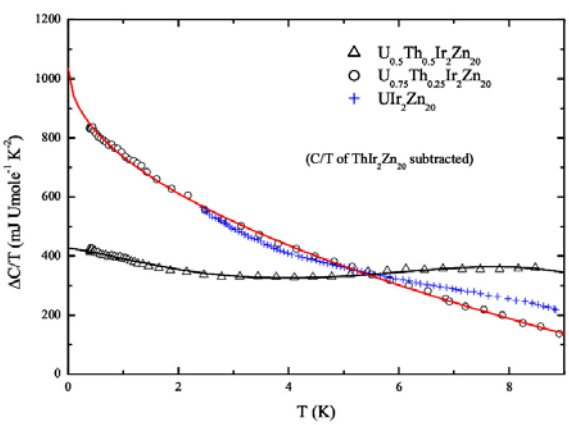

Fig. 1 Low temperature specific heat (corrected for the lattice contribution) of $U_{1-x}Th_xIr_2Zn_{20}$, x=0, 0.25, 0.5. Upon doping with 25% Th, the ferromagnetic transition at 2.3 K is suppressed, and antiferromagnetic character in $1/\chi$ as well as $C/T = \gamma - A\sqrt{T}$ are observed. See ref. 1.

Results[1] for the specific heat of Th-doped UIr_2Zn_{20} are shown at the left in Fig. 1. The temperature dependence of the specific heat for $U_{0.75}Th_{0.25}Ir_2Zn_{20}$ is consistent with 3-dimensional weakly coupled spin fluctuations, while the data for 50% Th are consistent with paramagnon (Fermi liquid) behavior. This wide range of behavior in one system is under further investigation.

Our work on small particles of $Ce(Ru_{1-x}Rh_x)_2Si_2$ has overcome large damage caused by the milling procedure, which in the last report gave Kondo behavior in the ~ micron and sub-micron particle size regime due to the damage preventing compensation of the local Ce-spins. In our improved samples, the behavior of χ and C/T is monotonic with decreasing size, until a small Kondo peak in C occurs in the 1.2 – 3 μ sized particles. The temperature dependence of C/T for size < 3 μ is more divergent than the C/T ~ log T observed for > 3 μ and is under further study.

Conclusions

Specific heat data at dilution refrigerator temperatures continues to reveal fundamental insights into the nature of highly correlated systems. Results on small particles of $Ce(Ru_{1-x}Rh_x)_2Si_2$ at the QCP concentration x=0.6 indicate extraordinary enhancements of C/T below 1 K as size decreases into the nanometer regime.

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References

[1] Kim, J. S., *et al.*, Phys. Rev. B, **78**, 35121-1 to 4 (2008).