POSSIBLE CRYSTALLINE ELECTRIC FIELD EFFECTS IN NEW CUBIC UX_2ZN_{20} (X=Co, Rh, Ir) HEAVY-FERMION COMPOUNDS

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Introduction

Only a handful of uranium-based intermetallic compounds show crystalline electric field (CEF) effects, i.e., the localization of the 5f electrons. A new class of cubic UX_2Zn_{20} (X=Co, Rh, Ir) heavy-fermion has recently been discovered. Both URh_2Zn_{20} and UCo_2Zn_{20} exhibit a peak at 5-10 K in specific heat and magnetic susceptibility indicating the presence of a CEF excitation to a low-lying excited level. In contrast, UIr_2Zn_{20} displays ferromagnetic order below T_c=2.75 K with a saturation moment μ_{sat}=0.5 μ_B. All compounds in this series are heavy fermion materials with enhanced electronic specific heat coefficients γ = 150-300 mJ/molK^2.

Experimental

Single crystals of UX_2Zn_{20} were grown in Zn flux. Measurements of specific heat in magnetic fields up to 15 T were carried out in the 15 T magnet at the NHMFL. In addition, magnetization and de Haas van Alphen measurements were performed in the 50 T mid-pulse magnet at the NHMFL.

Results and Discussion

Figure 1 shows the specific heat, plotted as $\Delta C/T$ vs. T, of URh_2Zn_{20} in magnetic fields (H||111) where the nonmagnetic contribution of $ThRh_2Zn_{20}$ has been accounted for. In magnetic field, the peak first decreases, then increases above 10 T for both field directions as shown in the inset of Fig. 1. As displayed in Fig. 2, magnetization measurements do not show any sign of magnetic order up to 30 T. Both these results are consistent with a CEF model in which a triplet excited state resides 20 K above nonmagnetic singlet ground state in a 5f^2 localized configuration of U. Measurements on UCo_2Zn_{20} are similar. No de Haas van Alphen signals were found in these materials.

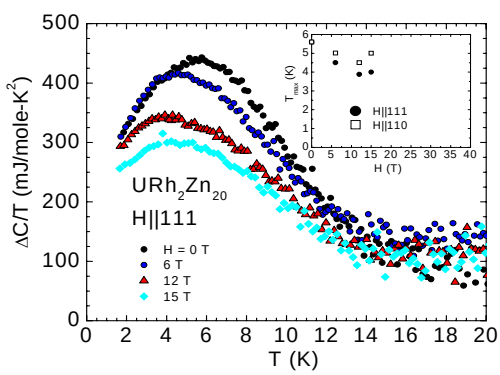

Figure 1. Specific heat $\Delta C/T$ vs. T of URh_2Zn_{20} in magnetic fields up to 15 T.

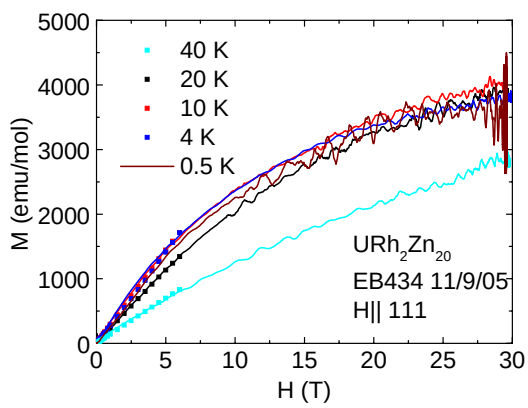

Figure 2. M(H) of URh_2Zn_{20} up to 30 T.

Conclusions

Measurements of specific heat and magnetization up to 30 T are consistent with a particular crystalline electric field configuration in URh_2Zn_{20}. Thus, magnetic fields have proven invaluable for elucidating the nature of the electronic structure of U, i.e. a localized 5f^2 configuration, in these UX_2Zn_{20} materials.