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THERMAL PROPERTIES OF UPdSn AND UCuSn

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Abstract

We report on the specific-heat and the thermopower of UPdSn and UCuSn, both of which order antiferromagnetically at low temperatures. Both compounds show similar behaviour in the specific heat, and the large magnetic-entropy changes around T_N are evidence for a large degree of 5f-electron localizations. The thermopower, on the other hand, behaves very different in the two compounds. While prominent features are seen in the temperature dependence of the thermopower of UCuSn, only weak changes are observed for UPdSn. This may indicate that, for these compounds, the thermopower response is due to mechanisms other than purely magnetic ones.

I. Introduction

5f-ligand hybridization is known to dominate the magnetism within the large group of UTX compounds (T = transition metal, X = p-electron metal), where the full range properties ranging from magnetism due to localized to itinerant magnetism can be found [1].

Here, we concentrate on two UTX compounds with more localized 5f electrons, namely UPdSn and UCuSn. UPdSn has been studied extensively on single crystals by magnetic [2] and neutron-diffraction [3] experiments. For this compound, two antiferromagnetic transitions around 25 and 40 K have been identified unambiguously. Likewise, the bulk results for UCuSn indicate two transitions around 25 and 60 K [4]. Neutron diffraction [5] showed that antiferromagnetic order sets in at 60 K, but the nature of the 25-K transition has not been resolved yet.

In this paper, we present the specific heat and thermopower of UPdSn and UCuSn. For both compounds, some specific-heat results have been reported previously [2,5], and we have

extended the temperature range and the analysis here. No thermopower has been reported earlier.

II. Experimental results and discussion

Specific heat was measured in the temperature range from 1.5 to 250 K in a set-up developed by Kim-Ngan [6], which allows measuring the specific heat by various methods (standard adiabatic, standard relaxation-time and heat-pulse technique). The results are shown in Fig. 1. Both compounds show a similar behaviour in temperature dependence of the specific heat. While we find pronounced maxima at the Neel temperatures (40 and 60 K in UPdSn and UCuSn, respectively), only very weak shoulders are seen at the low-temperature transitions of both compounds (around 25 K). The low-temperature extrapolations of both specific heats to T = 0 K yields electronic contributions γ of about 5 and 64 mJ/K^2mol for UPdSn and UCuSn, respectively. In order to get the estimates of the lattice contribution to the specific heat, we have measured the specific heat up to 250 K, where phonos dominate. We have then fitted the Debye functions to the high-temperature part of the specific heats taking into account an additional linear temperature term due the fact that we measured C_p and not C_V (which is described by the Debye function). The resulting Debye functions for UPdSn and UCuSn are shown in Fig. 1 by solid lines in Fig. 1. We obtain similar Debye temperatures for both compounds yielding values of about 185-190 K. Subtraction of such lattice contributions yield magnetic-entropy changes to about 1.1Rln2 (at 45 K) and Rln2 (at 65 K) for UPdSn and UCuSn, respectively. Such values for the magnetic entropy belong to the highest among the UTX series (see e.g. [7]) and indicate the large degree of 5f-electron localization in both compounds. Furthermore, there is some indication for an additional Schottky contribution to the specific heat of UPdSn. For this compound, crystal fields have been indeed observed by inelastic-neutron-scattering experiments [8] and further analysis of the specific heat taking into account the observed level splittings is underway.

The temperature dependences of the thermopower of UPdSn and UCuSn were measured between 4.2 and 300 K using the standard stationary technique [9]. The thermopower of UPdSn does not show distinct features at either magnetic transition (25 and 40 K), though weak changes at these temperatures are visible in the derivative. Note, that there is also almost no change seen in the electrical resistivity at the 25-K transition of UPdSn, which again shows up only in the derivative. In contrast to UPdSn, we find pronounced anomalies in the electrical resistivity and the thermopower of UCuSn at both magnetic-transition temperatures (25 and 60 K). Around 60 K, the thermopower of UCuSn drops to negative values and goes positive again at the 25-K transition, where also a large drop in the resistivity is found. Finally, we find an

additional drop in the thermopower of UCuSn around 10 K. We have very little idea about the origin of this last anomaly.

In conclusion, our specific-heat results provides some evidence for a more localized character of the magnetism in both compounds, UPdSn and UCuSn. The thermopower results, on the other hand, indicates that there are also substantial differences in the intrinsic properties of the two compounds. While rather featureless thermopower curves are not unusual observation in uranium compounds [9], we note that pronounced anomalies are seen in compounds where the electronic state changes (e.g. at the metal/semiconductor transition in UNiSn [9]). This may indicate that, in uranium compounds, the thermopower reflects mainly the effects of the Fermi surface rather than changes in the magnetic properties. It should be noted that changes in the Fermi surface of UCuSn have been argued earlier by Fujii et al.[4].

Acknowledgments

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Fig. 1: Temperature dependence of the specific heat of (a) UPdSn and (b) UCuSn in the representation Cp/T vs T. The solid lines represent the Debye functions mentioned in the text.

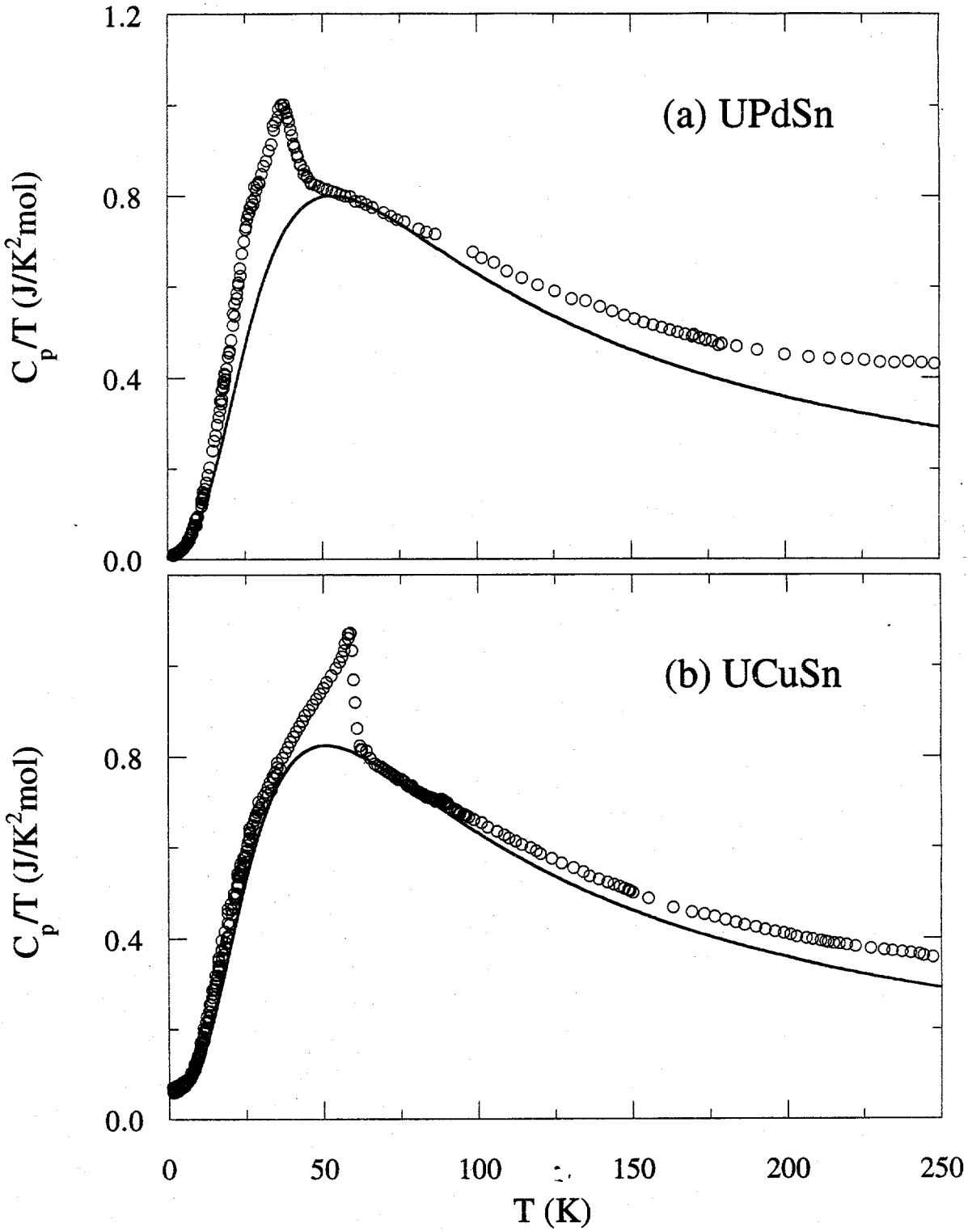

Fig. 1