PRESSURE EFFECT ON ANTIFERROMAGNETIC ORDERING IN UPb_3*

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We investigated the pressure dependence of the antiferromagnetic transition temperature $T_{\rm N}$ of UPb_3 by the electrical resistivity measurement. We found that at low pressures $T_{\rm N}$ increases with increasing pressure. It has a maximum value 38 K at 5 GPa, then decreases with increasing pressure. In addition we observed another resistive anomaly followed by a steep decrease in resistivity below $T_{\rm N}$ under pressure. The maximum pressure of 8 GPa in the present study was not enough to suppress the antiferromagnetic ordering. The critical pressure is estimated to be around 10 GPa.

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1. Introduction

Uranium intermetallic compounds UX_3 (X = Si, Ge, Sn, Pb) form a variety of magnetic properties including Pauli paramagnetism in USi_3 and UGe_3, spin fluctuations in USn_3 and antiferromagnetism in UPb_3 [1], which is ordered below the Néel temperature 32 K with a large electronic specific heat $\gamma = 110$ mJ/K^{2}mol. This large γ value and the relatively small ordered moments ($\sim 1.7\mu_{\rm B}$/U) [2,3] characterize this compound as a heavy fermion antiferromagnet.

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In this paper, we report the electrical resistivity under high pressures up to 8 GPa to clarify the pressure dependence of the antiferromagnetic ordering in UPd_3.

2. Experimental

Single crystals of UPb_3 were grown using the self-flux method. Pressures up to 8 GPa were produced by a cubic anvil with a 250 ton press. A mixture of fluorinert FC-70 and 77 was used as a pressure-transmitting medium in all the experiments. The electrical resistivity measurement was carried out using the dc four-probe method. Electrical contacts were made using gold wires and silver paste.

3. Results

Figure 1 shows the temperature dependence of the electrical resistivity of UPd_3 under pressures. The resistivity in the ambient pressure decreases with decreasing temperature, as shown in the inset of Fig. 1. A small hump is seen around 30 K, corresponding to the antiferromagnetic transition. The value agrees with our earlier results and indicates a negative curvature dependence

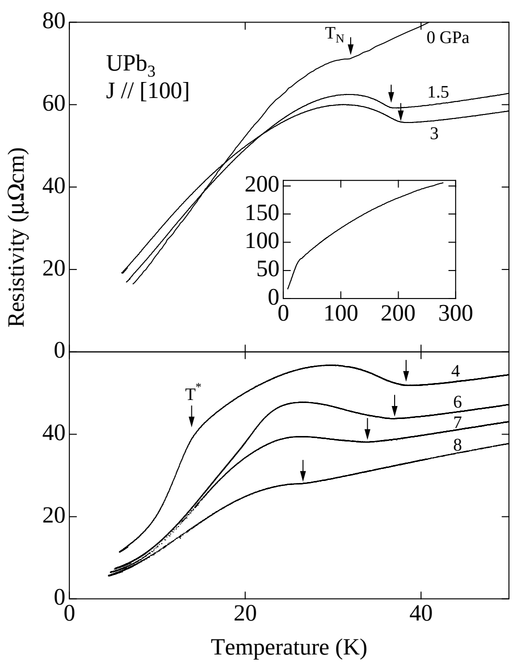

Fig. 1. Temperature dependence of the electrical resistivity under pressure in UPb_3.

of T^n $(n < 1)$ at elevated temperature [5]. Below the Néel temperature T_N the resistivity follows approximately T-linear behavior. With increasing pressure, the transition temperature becomes higher and this hump becomes more prominent. T_N has a maximum at 5 GPa and then decreases with increasing pressure, as shown in the lower panel of Fig. 1. We found another resistive anomaly denoted as T^* at 4 GPa. Below T^* the resistivity decreases steeply with decreasing temperature, roughly following a T^2 dependence below 8 K. The origin of T^* is unclear.

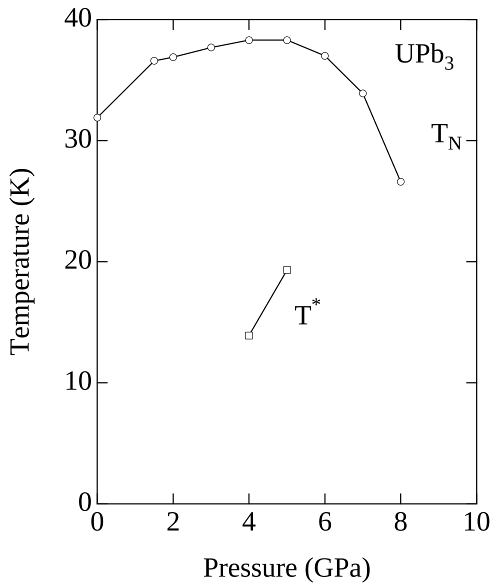

Fig. 2. Pressure phase diagram in UPb_3.

We show in Fig. 2 the pressure-temperature phase diagram obtained from present measurements. We found that at low pressures T_N increases with increasing pressure. It has a maximum value of 38 K at 5 GPa, then decreases rather rapidly with increasing pressure. In addition we observed another resistive anomaly followed by a steep decrease in resistivity below T_N under pressure. The maximum pressure 8 GPa in the present study was not enough to suppress the antiferromagnetic ordering. The critical pressure is estimated to be around 10 GPa. In the high pressure region above 5 GPa the low-temperature resistivity follows the AT^2 dependence, corresponding to the Fermi liquid nature. The coefficient A decreases with pressure as seen from Fig. 1, in contrast with the enhancement of A near the critical pressure observed in the heavy fermion antiferromagnet such as $CeIn_3$ [4].

4. Summary

We measured the electrical resistivity under high pressure up to 8 GPa and constructed a pressure phase diagram. $T_{\rm N}$ increases with increasing pressure, having a maximum at 5 GPa, then decreases with increasing pressure. We observed a new resistive anomaly above 4 GPa followed by a steep decrease in resistivity.

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