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Authors
Müller, T
Joss, W
van Ruitenbeek, JM
et al.

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MAGNETIC FIELD DEPENDENCE OF THE MANY-BODY ENHANCEMENT ON THE FERMI SURFACE OF CeB_6

T. MÜLLER, W. JOSS, J.M. VAN RUITENBEEK *, U. WELP **, P. WYDER

MPI für Festkörperforschung, Hochfeld Magnetlabor, B.P. 166X, F-38042 Grenoble, France,

and Z. FISK

Los Alamos National Laboratory, Los Alamos, NM 87545, USA

Low-temperature high-field specific heat measurements are presented which show that the density of states of the itinerant electrons in the Kondo lattice CeB_6 decreases strongly with field. CeB_6 is an ordered heavy electron system with a zero field electronic specific heat coefficient γ of about 250 mJ/mol K^2. The specific heat was measured with the heat pulse method at temperatures as low as 0.3 K and in steady magnetic fields as high as 22 T. At 22 T the linear term in the specific heat was found to be five times smaller than in zero field. The observed field dependence in the electronic specific heat is in good agreement with the field dependence of the cyclotron mass recently found in de Haas–van Alphen experiments.

CeB_6 is a well-studied Kondo lattice system [1] which orders quadrupolar antiferromagnetic at a temperature $T_Q = 3.2$ K and modulated antiferromagnetic at $T_N = 2.3$ K in zero field. The latter transition is suppressed by a magnetic field of $\simeq 1.5$ T, whereas the former transition is shifted to higher temperatures in high magnetic fields [2].

Here we present results of extended specific heat measurements on CeB_6 in magnetic fields up to 22 T, an compare them to field dependent results of de Haas–van Alphen measurements [3].

The sample was grown in an Al-flux and had a mass of 15 mg. To avoid discrepancy from different sample preparation, we investigated a crystal of the same batch of samples on which the de Haas–van Alphen experiments were made. The specific heat was measured with a heat pulse method in a ^{4}He-cryostat from 1.2 to 10 K [4] and in a ^{3}He-cryostat from 0.3 to 1.2 K in a polyhelix magnet in the Grenoble high field facilities in various magnetic fields, applied parellel to the $\langle 100 \rangle$ direction of the crystal. The temperature was measured with commercial RuO_2 thick film resistors, which were calibrated in a separate run.

The data in 0 T and 8 T are in agreement with data from other authors [5–7] within the experimental error of 20% in ^{3}He and 15% in ^{4}He. As the quadrupolar antiferromagnetic phase transition appears as a large peak in the specific heat, we extrapolated the linear specific heat coefficient γ from temperatures below $T < T_Q/5$.

Fig. 1 shows a typical curve of specific heat divided by temperature vs. temperature squared which was constructed from ^{3}He and ^{4}He data in a magnetic field of 18 T. Nuclear contributions of Boron are subtracted. According to [7] we assumed a term AB_{eff}^2/T^2 with a constant of $A = 22.36\ \mu\text{JK}/\text{T}^2$. For low temperatures ($T < 1.5$ K) the specific heat fits to $C \simeq 45$ [mJ/mol K^2]T + 60[mJ/mol K^4]T^3. We derived values for the linear specific heat coefficient γ from similar extrapolations in several magnetic fields. They are plotted in fig. 2 which shows a strong decrease of the linear specific heat coefficient with increasing magnetic field. γ varies from ~ 250 mJ/mol K^2

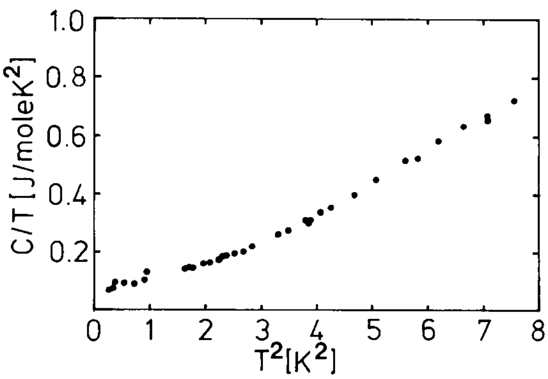

Fig. 1. Specific heat of CeB_6 divided by temperature vs temperature squared in a magnetic field of 18 T.

* Present address: Kamerlingh Onnes Laboratory, Rijksuniversiteit Leiden, 2300 RA Leiden, The Netherlands.

** Present address: Argonne National Laboratory, Argonne, IL 60439, USA.

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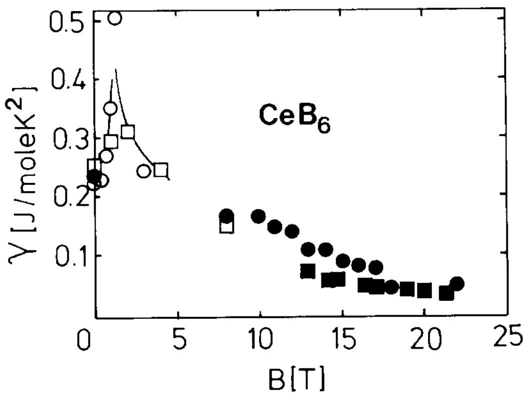

Fig. 2. Magnetic field dependence of the enhanced linear specific heat coefficient γ. Open circels were taken from Marcenat [6], and squares from Bredl [7]. The peak in γ at ~ 2 T is related to the phase transition from the quadrupolar antiferromagnetic to the modulated antiferromagnetic phase. The line is a guide to the eye. Filled squares are results from de Haas–van Alphen measurements [3]. The points were calculated from the measured cyclotron masses on the assumption that the mass enhancement going from LaB_6 to CeB_6 is roughly isotropic over the Fermi surface and scaling the mass $m^* = 0.61$ for LaB_6 as $\gamma = m^* \gamma_{La}/m^*_{La}$ to CeB_6.

in zero field to ~ 50 mJ/mol K^2 in 22 T. This value is still about 20 times higher than the γ of LaB_6 (2.6 mJ/mol K^2). The single particle density of states of the itinerant electrons is strongly suppressed but a magnetic field of 22 T is not sufficient to force the many-body enhancement into a limit.

Recently Stewart [8] has found a similar suppression of γ in the nonmagnetic heavy fermion system $CeCu_6$ in high magnetic fields. Here we presented measurements for the magnetic Kondo lattice CeB_6 which are in good agreement with results of previous published de Haas–van Alphen experiments.

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