Electrical and Magnetic Properties of CeGa Single Crystal

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Abstract

The magnetic susceptibility and the electrical resistivity of single crystal CeGa were measured in magnetic fields up to 9 T and at pressures up to 7.0 kbar. The T_N under magnetic fields applied along the c-axis and a-axis direction is determined. These results can be explained on the basis of magnetrocrystalline anisotropy effects.

Key words: Antiferromagnetism; CeGa; effect of pressure, magnetrocrystalline anisotropy;

1. Introduction

Heavy-fermion system shows interesting phenomena such as unconventional superconductivity at low temperature under magnetic fields and pressures.

Among them, CeGa with orthorhombic CrB-type structure shows antiferromagnetic transition at $T_N = 5.8$ K under ambient pressure. Specific heat measurements on single crystalline sample of CeGa revealed that the T_N decreased and vanished near 6.0 T with magnetic fields applied parallel to the b-axis [1]. We measured high field magnetization curves of CeGa at $T = 1.5$ K. A spin flopping was observed at $H = 3.2$ T along the b-axis and at $H = 2.6$ T along the c-axis. The magnetic moment of Ce atom reaches 1.74 μ_B along the c-axis (easy magnetization direction), 1.35 μ_B along the b-axis and 0.47 μ_B along the a-axis (hard magnetization direction) at $H = 28$ T [2].

In this paper, we report the magnetic susceptibility and electrical resistivity measured along the c- and a-axis under magnetic fields and pressures.

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2. Experimental

A single crystalline sample of CeGa was grown by self-flux method using excess Ce as a flux in Al_2O_3 crucible. The crucible was placed in a sealed evacuated quartz ampoule. The ampoule was heated to 1200 °C and cooled slowly to 800 °C in a furnace. The ampoule was taken from the furnace at 800 °C . Electrical resistivity was measured by means of AC method under magnetic fields up to 9 T in a temperature range of 2-300 K. Magnetic measurements was done using a SQUID magnetometer at magnetic fields up to 5.5 T in a temperature range of 2-300 K. In order to generate hydrostatic pressure, we used a piston-cylinder type clamp cell. The details of the high-pressure apparatus on SQUID magnetometer were reported previously [3].

3. Result and Discussion

Temperature dependence of the susceptibility at various magnetic fields applied parallel to the c-axis at $P = 2.4$ kbar is shown in Fig.1. A sharp peak due to the antiferromagnetic transition at $T_N = 5.6$ K is observed. The T_N is determined as a temperature where $d^2\chi/dT^2$ shows the minimum. The T_N decreases and the anomaly in susceptibility fades out with increasing magnetic fields up to 5 T. These results can be understood as a consequence of a spin flopping phenomenon induced by the external magnetic field.

Figure 2 shows the T_N under magnetic fields as a function of temperature at various pressures. It is found that the effect of pressure on the T_N becomes larger near 4 T.

On the other hand, it is shown that a kink observed in the electrical resistivity-temperature curve corresponds well to the T_N at ambient pressure. In Fig.3, the T_N estimated from the kink is plotted as a function of temperature at various magnetic fields along the a-axis. It is seen that the T_N decreases slightly with increasing applied magnetic field along the a-axis below 7.0 kbar.

By comparing Fig.2 with Fig.3, it is clear that the difference of T_N under magnetic fields at various pressures comes from the magnetocrystalline anisotropy effect, because the a-axis and c-axis are a hard and an easy magnetization direction, respectively. The suppression of T_N observed at 7.0 kbar around 5.0 T shown in Fig.3 seems to correspond to the large change of T_N observed along the c-axis in Fig.2. It is worth noticing, furthermore, that the magneto-resistance observed along the a-axis shows a large pressure effect at around 5 T. This result suggests that a change of electronic structure may take place and is accompanied by the spin flopping.

4. Summary

We measured magnetic susceptibility and electrical resistivity under magnetic fields and pressures of a single crystalline CeGa. The T_N decreases and fades out around 5 T along the c-axis. The effect of pressure on the T_N becomes larger near 4 T. On the other hand, the T_N decreases slightly with increasing magnetic field at various pressures, along the a-axis. The different behavior of the T_N between each direction is attributed to the magnetocrystalline anisotropy.

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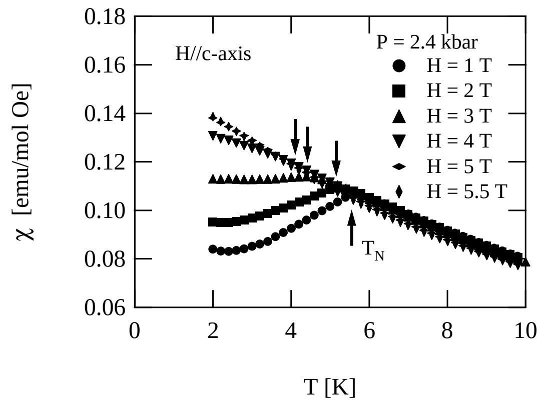

Fig. 1. Magnetic susceptibility at various magnetic fields applied parallel to the c-axis at $P = 2.4$ kbar.

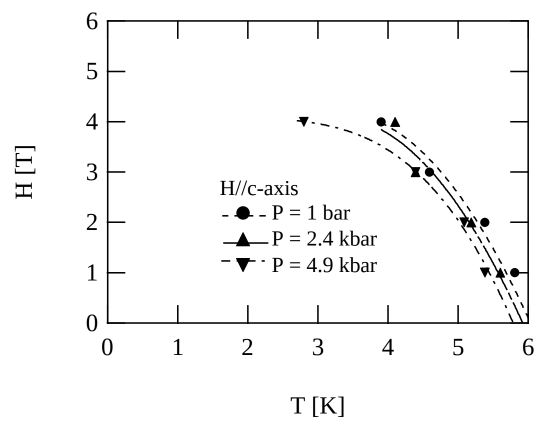

Fig. 2. The T_N under magnetic field parallel to the c-axis as a function of temperature at various pressures.

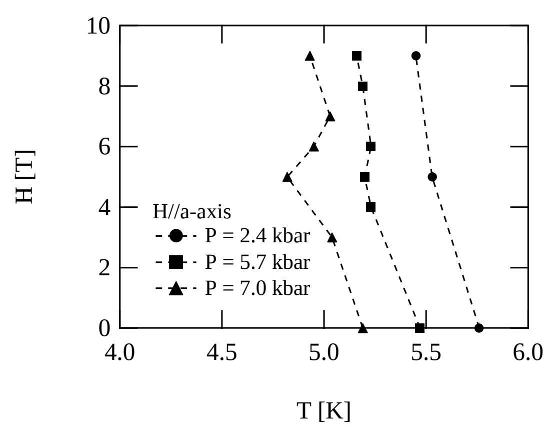

Fig. 3. The T_N obtained from resistivity with the magnetic fiels applied parallel to the a-axis.