Antiferromagnetism of β-Ce under Hydrostatic Pressure

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Cerium is arguably the most interesting elemental metal among the lanthanide series in terms of its rich structural and physical properties [1]. The pressure-temperature phase diagram of Ce and its polymorphic transformation between two fcc phases $\gamma \rightarrow \alpha$ with 16% volume collapse has been of great interest. The intermediate β-phase is an antiferromagnet with Néel temperature $T_N \approx 12.7$ K [2]. This value lies well above that (3.3 K) anticipated from simple de Gennes factor scaling compared to the Curie temperature (293 K) of Gd.

Although, under pressure the magnetic ordering temperatures of most lanthnides have been studied and in some cases found to soar to anomalously high values [3], the magnetic properties of β-Ce have not yet been determined under pressure. This is primarily due to difficulties in isolating this phase in its pure state.

In the present work allotropically pure β-Ce samples were prepared using a thermal cycling and annealing process originally described in Ref. [4] and ac magnetic susceptibility measurements on these samples were carried out under hydrostatic He-gas pressure [5] up to 4.5 kbar. Pressure was applied at low temperature, but at least 5 K above the melting curve of He. Initially, the Néel temperature is found to increase with pressure at the rate $dT_N/dP = +0.32 \pm 0.05$ K/kbar. The subsequent release of 4.5 kbar pressure at 40 K results in a markedly reduced magnetic susceptibility anomaly associated with the antiferromagnetic transition. Surprisingly, T_N is also found to shift by 1.3 K to higher temperatures after the pressure is released (Fig 1). Both effects likely arise from an irreversible $\beta \rightarrow \alpha$ transition under pressure. Possible mechanisms of the observed behaviors will be discussed.

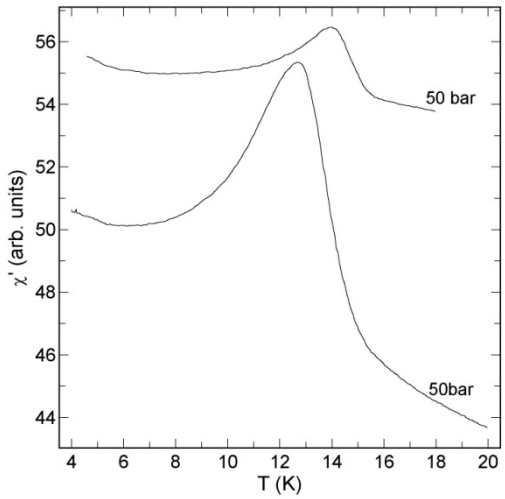

Figure 1. Temperature-dependent ac magnetic susceptibility data in β-Ce measured at 50 bar before and after applying 4.5 kbar pressure, whereby the Néel temperature T_N is found to increase by 1.3 K.

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