

Unveiling the magnetic transitions in the HoCoGa₅ compound

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Abstract

The study of novel compounds in condensed matter physics is a fundamental endeavor. Most of time, non-trivial materials as the heavy fermions display highly interesting properties like exotic magnetism, unconventional superconductivity and quantum criticality. In this detailed investigation, we have carried out magnetic susceptibility, electrical resistivity, specific heat, X-ray powder diffraction and Nuclear Quadrupolar Resonance measurements in order to characterize our single crystals of HoCoGa₅: a reference compound for the heavy fermion family CeMn₅ (M: Co, Rh, Ir). We observed a Néel transition temperature $T_N = 9.7$ K followed by an anomaly at $T_2 = 7.6$ K that remains unknown. Moreover, fitting the susceptibility data with the Currie-Weiss law give us the effective magnetic moment of Holmium, $p = 10,5\mu_B$ and the Currie-Weiss temperature $\Theta \sim 30$ K suggesting the existence of antiferromagnetic order.

Key words: Nuclear Quadrupolar Resonance, Crystalline Electrical Field Effect, Magnetism.

Introduction

Many 1:1:5 materials became of great interest after the discovery of unconventional superconductivity in the Heavy Fermion CeCoIn₅ compound.

Although HoCoGa₅ does not superconduct, it does become magnetic at low temperatures. Also, interesting crystalline electric field effects can be observed and may be related with the nature of its magnetic order. Therefore, single crystals of HoCoGa₅ have been synthesized in order to shed new light on the nature of the unknown anomaly as well as on the magnetic order observed at low temperatures.

Results and Discussion

As shown in Images 1 and 2, Specific heat measurements, entropy analysis and Currie-Weiss fit shows a Néel transition at $T_N = 9.7$ K and another anomaly at $T_2 = 7.6$ K

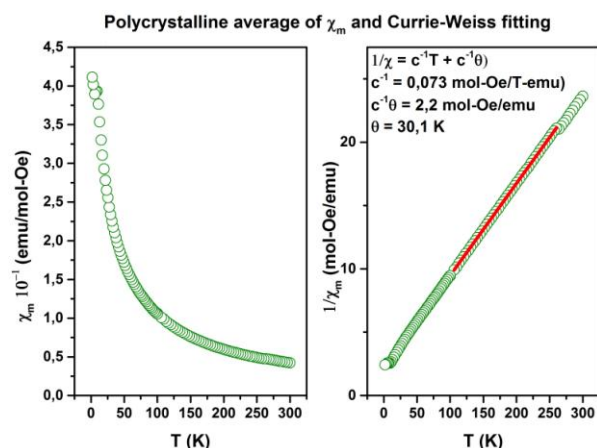


Image 1: Magnetic susceptibility of HoCoGa₅

The entropy variations in the antiferromagnetic transition at 9.7K reveals an effective moment $J_{\text{eff}} = 3/2$ which emphasizes the strong presence of crystalline electric field (CEF) effects.

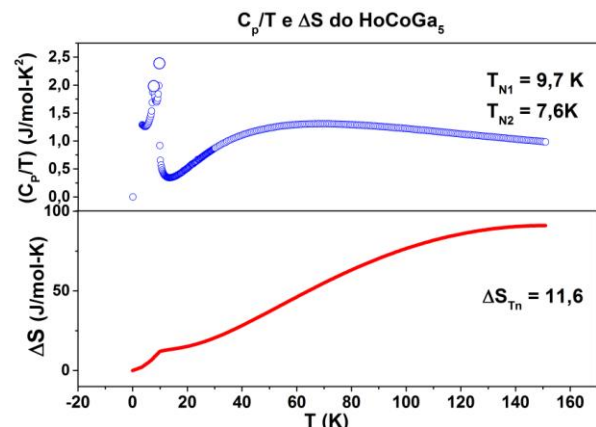


Image 2: Specific heat of HoCoGa₅

Conclusions

Calorimetric experiments revealed strong presence of CEF effects in HoCoGa₅ mainly in the antiferromagnetic transition $T_N = 9.7$ K. NQR experiments shed new light on the nature of the long ranged magnetic order observed at T_N as well as the anomaly found at $T_2 = 7.6$ K.

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