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Magnetic entropy and phase transitions in Gd, Tb, Dy and Ho

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Abstract

An experimental investigation of magnetization and magnetic entropy change in the vicinity of the magnetic phase transitions in Gd, Tb and Dy has been made. The nature of the transition in the paramagnetic state was established on the basis of experimental results and nonlinear molecular field theory.

1. Introduction

The behavior of different properties of Rare Earth Metals (REM) in the vicinity of magnetic structure transformation temperatures has advanced significantly in the last years [1].

The magnetic phase transitions (PT) at the Curie points of ferromagnets Θ_C or the Néel points of antiferromagnets Θ_2 are usually second order phase transitions with respect to thermodynamics. But in recent years a lot of papers discussing magnetic transitions having the features of first and second order PT at the same time have been published [2–8].

The pure rare-earth metals show these phenomena all too strikingly. Anomalies in the temperature dependence of elastic modules $E(T)$ and internal friction $Q^{-1}(T)$ above Θ_2 (Θ_C) have been described in Ref. [9] for a few metals. The hysteresis of different magnetic parameters has been found in some papers. These phenomena can be connected with the appearance of cluster systems, and this PT, for example, in Tb cannot be considered as a second order transition. The authors of Ref. [10] obtained that the magnetic part of the specific heat of dysprosium did not equal zero above Θ_2 in the absence of a magnetic field. It can also be explained by the presence of antiferromagnetic clusters near the transition point and proves that the PT is not of second order. The temperature hysteresis of resistance near the point of transition in the paramagnetic state of polycrystalline dysprosium [11] was observed. Therefore classification of PT in paramagnetic state requires modification and more details.

The results of investigations of neutron scattering [12], heat capacity [13], thermal expansion [14] and temperature hysteresis of magnetic moment [7] of holmium also show that PT at Θ_2 has the features of a first order transition.

The same conclusion for erbium has been made in Ref. [8] because temperature hysteresis of the magnetization at $T > \Theta_2$ has been observed.

Magnetic phase transitions in the paramagnetic state can be ascribed to second order PT by the Ehrenfest classification method [15]. According to Ref. [15] the PT can be characterized by the deriva-

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