Optical Investigation of Dysprosiumaluminumgarnet (DyAlG)

By
S. HÜFNER, M. SCHINKMANN, and H. SCHMIDT

With 5 Figures

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The absorption spectrum of the transitions $^6H_{15/2} \rightarrow ^6F_{3/2}, ^6F_{5/2}$ in Dysprosiumaluminumgarnet (DyAlG) is investigated. In the antiferromagnetic state ($T_N = 2.49$ °K) a splitting of the crystal field levels by an internal magnetic field is observed. The splitting of the lowest crystal field level $I$ of the groundterm in the internal field is $(5.2 \pm 0.5)$ cm$^{-1}$, extrapolated to 0 °K.

I. Introduction

There has been an increasing interest in recent years in the investigation of rare earth (RE) compounds which undergo a transition from the paramagnetic to a magnetically ordered state at relatively high temperatures ($T > 1$ °K). One of the most studied compounds [1–10] is Dysprosiumaluminumgarnet (DyAlG), which orders antiferromagnetically at $T_N = 2.49$ °K. BALL et al. [1–6] investigated the magnetic and specific heat properties of DyAlG in much detail both experimentally and theoretically.

Paramagnetic resonance measurements showed that the splitting factor of the lowest crystal field doublet of the $^6H_{15/2}$ groundterm in DyAlG is highly anisotropic with $g_x \approx g_y \approx 0$ and $g_z = 18.2$ [2]. This pronounced anisotropy suggested a sublattice model for the antiferromagnetic state, by which BALL et al. [2] in fact could explain their experimental data. Following a procedure first applied by HARRIS to explain the magnetic properties of MnO [11], Cooke et al. [10] carried out a Monte Carlo calculation for the magnetic energy of DyAlG and achieved good agreement with the experimental data. Finally the magnetization curve of DyAlG below the Néel temperature was measured with the neutron diffraction technique by HEBPIN and MERIEL [8].

The theoretical analysis of the measurements showed [2] that in the antiferromagnetic state magnetic fields of the order of $5 \cdot 10^3$ Oe should be acting in
this substance producing splittings of the crystal field levels of the order of 1 cm\(^{-1}\). This makes it tempting to investigate this substance by high resolution optical spectroscopy; by this experimental technique one should be able to detect the expected splittings in some cases. Therefore the spectroscopic investigation of DyAlG was started; a brief account of first results has already been published \[9\]. Similar investigations were carried out independently by Cooke et al. \[10\] at Oxford.

II. Experimental

The spectra were investigated with a 3,4 m Ebert spectograph using a 30000 lines per inch grating; they were photographed on Kodak IV plates or directly photorecorded with an EMI 9565S multiplier. The crystals of 30 \(\mu\) to 300 \(\mu\) thickness were placed in a conventional glass dewar. The temperature was measured by measuring the vapour pressure above the liquid helium; the calibration of this measurement could be easily checked in each run at the \(\lambda\)-point. The temperature measurement is believed to be accurate to \(\pm 0.1^\circ\text{K}\).

The DyAlG single crystals were grown by the method described by Lefever et al. \[12\]. Single crystals up to 1 cm in diameter were obtained.

III. Experimental results

In order to obtain most simple spectra we investigated only transitions to excited terms with a low value of the total angular momentum \(J\). So our results

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\begin{figure}
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\includegraphics[width=\textwidth]{Fig1}
\caption{Transition \(6H_{15/2} \rightarrow \ ^{6}P_{3/2}\) in the absorption spectrum of DyAlG. Direct photorecording}
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