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Magnetization of NdIn₃, GdIn₃ and DyIn₃ single crystals

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Abstract. — The magnetization of NdIn₃, GdIn₃ and DyIn₃ single crystals has been studied in the antiferromagnetically ordered state along three principal crystallographic axes in stationary magnetic fields up to 19 T. The multiple-step magnetization process has been found in DyIn₃ due to its specific magnetic structure. Saturation magnetization of NdIn₃ and DyIn₃ reaches the values lower than those expected for free RE³⁺ ions.

In the present work the results of the magnetization measurements of NdIn₃, GdIn₃, and DyIn₃ single crystals in the antiferromagnetically ordered state in high stationary magnetic fields up to 19 T are reported. In the former paper [1] similar data partially obtained in Service National des Champs Intenses at Grenoble have been presented for CeIn₃ and PrIn₃ single crystals.

The compounds investigated here are antiferromagnets with T_N equal to 7 K, 42-44 K, and 18.5-20 K for NdIn₃, GdIn₃, and DyIn₃, respectively. The applied magnetic field being equal to 2 T. For GdIn₃ and DyIn₃ the Néel temperature varies with crystallographic axis along which the magnetic field is applied (Figs. 1, 2) reaching the highest values along <100> and <110> for GdIn₃ and DyIn₃, respectively. It should be mentioned here, that the observed change of T_N is expected for a spiral antiferromagnetic structure [2]. It has been found also that the Néel point values for DyIn₃ single crystal samples are lower than that for the polycrystalline material for which T_N = 23.5 K being close to the value reported by Buschow et al. [3]. This effect is probably due to the influence of internal stresses in polycrystalline samples.

The characteristic feature of the field dependence of magnetization of all investigated compounds in ordered state is a markedly nonlinear behaviour at lower fields what according to Dzyaloshinsky et al. [4] may be caused by the appearance of quadratic (generally even) terms with respect to H in the field expansion of the magnetization of an antiferromagnet. The observed magnetic behaviour indicates an existence of noncolinear antiferromagnetic ordering in these compounds confirmed in the case of DyIn₃ by neutron diffraction method by Lethuillier et al. [5].

The magnetization of NdIn₃ along all three principal crystallographic axes as well as that of DyIn₃ along <110> and <111> axes reaches at 4.2 K saturation with the values equal to 2.20, 2.2G, and 2.05 MB for NdIn₃ and 8.67> and 8.43 J“B for DyIn₃ along the above mentioned axes, respectively. For

Fig. 1. — Temperature dependence of molar magnetic susceptibility at 2 T for GdIn₃ single crystal.
GdIn₃, in magnetic field of 19 T, the magnetization reaches the values equal to but 1.74, 1.54, and 1.69 μ₀B along <100>, <110>, and <111> axes, respectively.

In the magnetization process of NdIn₃ one observes a hysteresis loops between 3.85 and 4.30 T (Fig. 3) for all three principal crystallographic axes. Moreover, the magnetization curves reveal an inflection point at about 6.5 T. The above behaviour cannot be understood an assuming the (ππ0) type [5] magnetic structure.

The magnetization of GdIn₃ along the <100> and <111> directions does not reveal any anomalies, and shows a tendency to reach the saturation in the
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fields above 12.5 T. However, along the ⟨110⟩ direction it has an inflection point at 2.6 T and above this field it consists of two straight lines intersecting each other at 9.5 T.

The magnetization of DyIn₃ exhibits three transitions along ⟨110⟩ and ⟨111⟩ axes and two along ⟨100⟩ axis with almost discontinuous changes along ⟨111⟩ direction. The critical fields determined from the positions of the maxima of $dM/dH$ are as follows: 4.7 and 11.2 T for ⟨100⟩, 4.4, 8.8 and 15.5 T for ⟨110⟩, and 4.7, 12.3 and 15.2 T for ⟨111⟩ axis. The character of the magnetization curves seems to be comprehensible on the basis of the proposed [5] magnetic structure of this compound.

References


