Magnetization of NdIn3, GdIn3 and DyIn3 single crystals

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Magnetization of $NdIn_3$, $GdIn_3$ and $DyIn_3$ single crystals

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Résumé. — L'aimantation de monocristaux de $NdIn_3$, $GdIn_3$ et $DyIn_3$ a été mesurée suivant trois axes cristallographiques principaux dans le domaine antiferromagnétique ordonné, sous champ magnétique continu jusqu'à 19 T. On a observé sur $DyIn_3$ un processus d'aimantation à plusieurs sauts attribué à la structure magnétique spécifique de ce composé. L'aimantation à saturation de $NdIn_3$ et $DyIn_3$ atteint des valeurs inférieures aux valeurs calculées pour les ions terres rares libres.

Abstract. — The magnetization of $NdIn_3$, $GdIn_3$ and $DyIn_3$ 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 $DyIn_3$ due to its specific magnetic structure. Saturation magnetization of $NdIn_3$ and $DyIn_3$ reaches the values lower than those expected for free RE^{3+} ions.

In the present work the results of the magnetization measurements of $NdIn_3$, $GdIn_3$, and $DyIn_3$ 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 $CeIn_3$ and $PrIn_3$ single crystals.

The compounds investigated here are antiferromagnets with T_N equal to 7 K, 42-44 K, and 18.5-20 K for $NdIn_3$, $GdIn_3$, and $DyIn_3$, respectively the applied magnetic field being equal to 2 T. For $GdIn_3$ and $DyIn_3$ 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 $GdIn_3$ and $DyIn_3$, 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 $DyIn_3$ 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

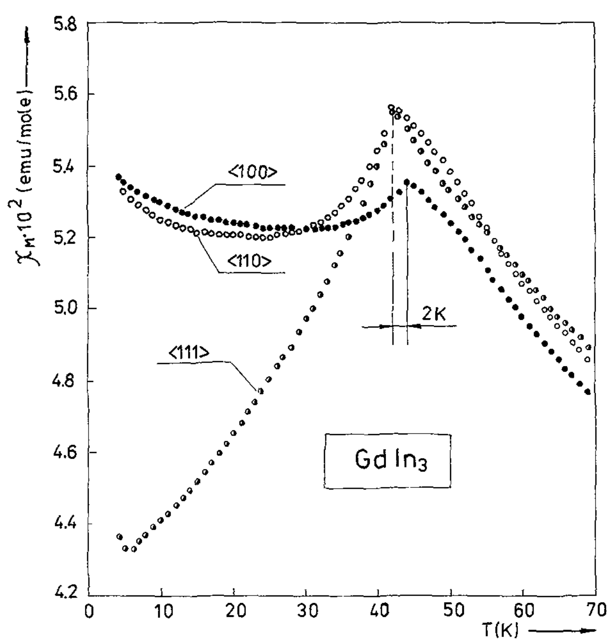

Fig. 1. — Temperature dependence of molar magnetic susceptibility at 2 T for $GdIn_3$ single crystal.

these compounds confirmed in the case of $DyIn_3$ by neutron diffraction method by Lethuillier *et al.* [5].

The magnetization of $NdIn_3$ along all three principal crystallographic axes as well as that of $DyIn_3$ along ⟨ 110 ⟩ and ⟨ 111 ⟩ axes reaches at 4.2 K saturation with the values equal to 2.20, 2.26 and 2.05 μ_B for $NdIn_3$ and 8.67, and 8.43 μ_B for $DyIn_3$ along the above mentioned axes, respectively. For

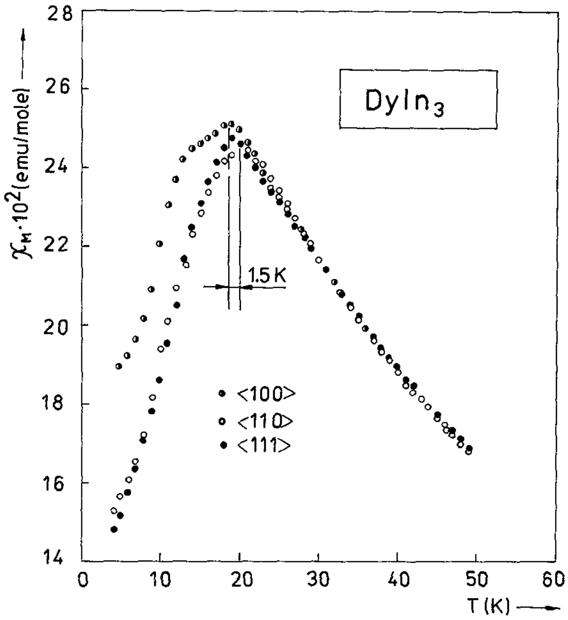

Fig. 2. — Temperature dependence of molar magnetic susceptibility at 2 T for $DyIn_3$ single crystal.

$GdIn_3$, in magnetic field of 19 T, the magnetization reaches the values equal to but 1.74, 1.54, and 1.69 μ_B along $\langle$ 100 $\rangle$, $\langle$ 110 $\rangle$, and $\langle$ 111 $\rangle$ axes, respectively.

In the magnetization process of $NdIn_3$ 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 ($\pi\pi0$) type [5] magnetic structure.

The magnetization of $GdIn_3$ along the $\langle$ 100 $\rangle$ and $\langle$ 111 $\rangle$ directions does not reveal any anomalies, and shows a tendency to reach the saturation in the

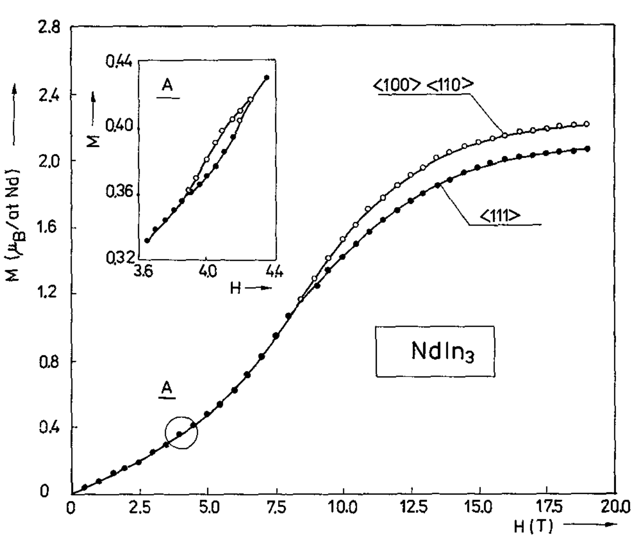

Fig. 3. — Magnetization *vs.* magnetic field at 4.2 K for $NdIn_3$ single crystal.

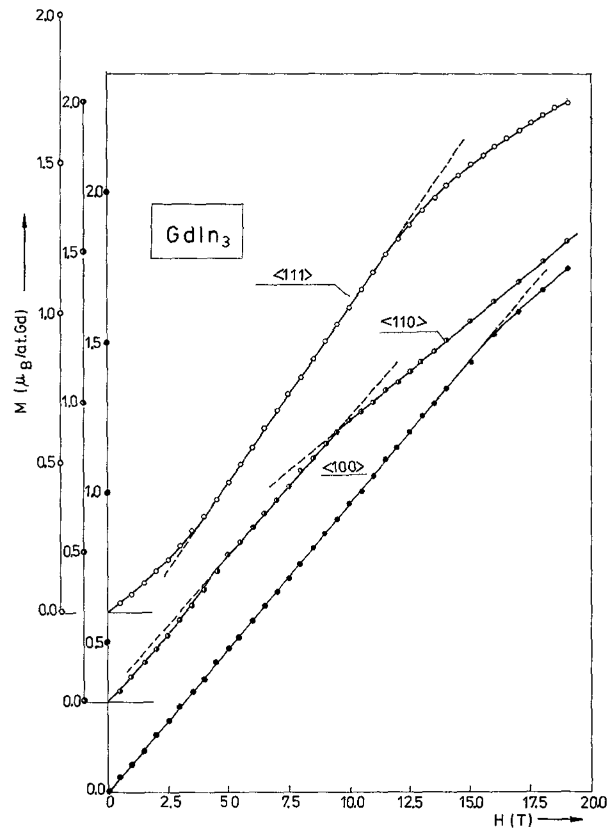

Fig. 4. — Magnetization *vs.* magnetic field at 4.2 K for $GdIn_3$ single crystal.

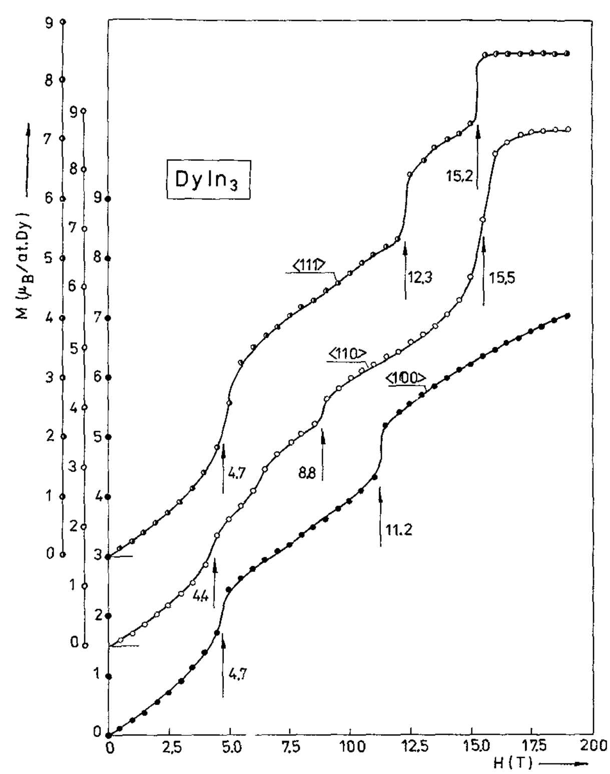

Fig. 5. — Magnetization *vs.* magnetic field at 4.2 K for $DyIn_3$ single crystal.

fields above 12.5 T. However, along the $\langle 110 \rangle$ 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 $DyIn_3$ exhibits three transitions along $\langle 110 \rangle$ and $\langle 111 \rangle$ axes and two along $\langle 100 \rangle$ axis with almost discontinuous changes along $\langle 111 \rangle$ direction. The critical fields determined from the positions of the maxima of $\mathrm{d}M/\mathrm{d}H$ are as follows : 4.7 and 11.2 T for $\langle 100 \rangle$, 4.4, 8.8 and 15.5 T for $\langle 110 \rangle$, and 4.7, 12.3 and 15.2 T for $\langle 111 \rangle$ axis. The character of the magnetization curves seems to be comprehensible on the basis of the proposed [5] magnetic structure of this compound.

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