MAGNETIC PROPERTIES OF THE $U_{0.5}Ho_{0.5}Ga_2$ COMPOUND[1]

МАГНИТНЫЕ СВОЙСТВА СОЕДИНЕНИЯ $U_{0.5}Ho_{0.5}Ca_2$

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The magnetic susceptibility of polycrystalline samples of UGa_2, $HoGa_2$ and $U_{0.5}Ho_{0.5}Ga_2$ has been measured at a low field, from 15 to 300 K and an a.c. susceptibility at low temperatures ($T > 1.5$ K). While UGa_2 is a collinear ferromagnet, both $HoGa_2$ and $Ho_{0.5}U_{0.5}Ga_2$ are antiferromagnets with small exchange interactions ($T_N = 8$ K and 16 K resp.). All samples show good Curie–Weiss fits. Magnetization measurements have been done at $T = 4.2$ K in magnetic field up to 5 T. These measurements show a metamagnetic behaviour with a low value of the critical field (<0.1 T).

Table 1

Experimental effective moments (μ_{eff}), Curie–Weiss temperatures (Θ), ordering temperatures, type of magnetism and ordered magnetic moments at the applied field 5 T and the temperature 4.2 K.

compound	$\mu_{eff}(\mu_B$/f.u.)	Θ (K)	ordering temperature (K)	magnetism	ordered moment (μ_B/f.u)
$U_{0.5}Ho_{0.5}Ga_2$	7.92	15.5	16	complex antiferro-magnet	5.05
UGa_2	3.56	125.5	125.5[5]	collinear ferromagnet	2.35[5]
$HoGa_2$	11.03	−1	8	collinear antiferro magnet	8.25

$HoGa_2$ belongs to the group of the RGa_2 compounds (R = La to Er) with the AlB_2-type hexagonal structure and becomes a collinear antiferromagnet at approximately 8—10 K [1—4]. On the other hand UGa_2 (isostructural to $HoGa_2$) is a collinear ferromagnet with $T_C = 125.5$ K [5]. The aim of this contribution is to find the magnetic behaviour of the $U_{0.5}Ho_{0.5}Ga_2$ compound, consisting of two different f-character atoms and to judge the dominant interactions.

[1] Contribution presented at the 6th Conference on Magnetism in Košice, September 2—5, 1980.

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The polycrystalline $U_{0.5}Ho_{0.5}Ga_2$ sample was prepared in an arc furnace. The purity of Ho is 99.9 %, U 99.8 % and Ga 99.999 %. X-ray diffraction study at room temperature showed no impurity phases and confirmed the supposed hexagonal AlB_2-structure with $a = 0.4205$ nm and $c = 0.3985$ nm. We have observed a small deficit (~ 1 %) of Ga during the preparation of the compound.

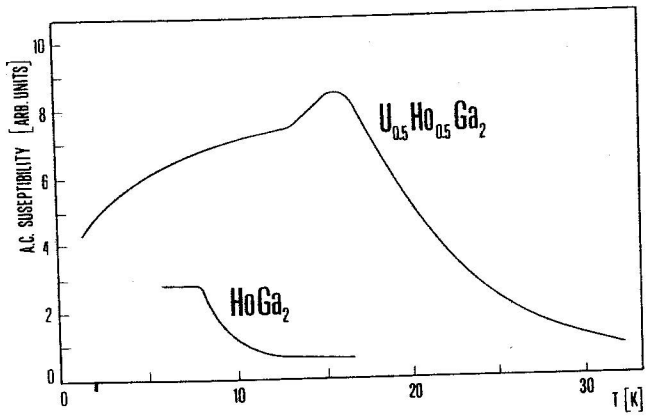

Fig. 1. Temperature dependence of a.c. susceptibility for $U_{0.5}Ho_{0.5}Ga_2$ and $HoGa_2$ ($H \approx 0$).

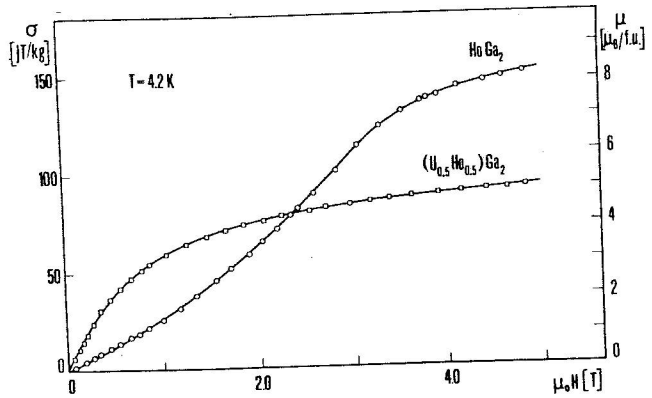

Fig. 2. Magnetization versus applied magnetic field at 4.2 K for $U_{0.5}Ho_{0.5}Ga_2$ and $HoGa_2$.

The magnetic susceptibility of $U_{0.5}Ho_{0.5}Ga_2$ was measured by the Faraday method in the low magnetic fields up to 0.5 T in the temperature region 15 to 300 K. For better judgement we have measured the susceptibility of UGa_2 and $HoGa_2$ as well. The Curie–Weiss fits of all three compounds are very good linear in the whole temperature region. The values of μ_{eff} and Θ are listed in Table 1. The detailed investigation in the low temperature region ($1.6 < T < 30$ K) has been covered by the a.c.-susceptibility measurement by means of an induced method at the frequency of 220 Hz. The temperatures of magnetic phase transitions has been determined from the observed temperature

dependence of the a.c.-susceptibility of $HoGa_2$ und $U_{0.5}Ho_{0.5}Ga_2$ (Fig. 1). We have obtained $T_N = 8 \pm 2$ K for $HoGa_2$ and $T_N = 16 \pm 2$ K for $U_{0.5}Ho_{0.5}Ga_2$.

Magnetization versus applied magnetic field up to 5 T has been measured for $HoGa_2$ and $U_{0.5}Ho_{0.5}Ga_2$ at $T = 4.2$ K (Fig. 2) by a vibrating sample magnetometer. The results for $HoGa_2$ are very similar to [2, 4].

The exchange interactions of Ho atoms in $HoGa_2$ are weaker than in the case of UGa_2 for U atoms as it follows from comparing the ordering temperature. Then it is plausible to expect: (1) the U – Ho interactions in $U_{0.5}Ho_{0.5}Ga_2$ are of the same order as the Ho – Ho interactions in the case of $HoGa_2$ and (2) the U – U interactions are reduced due to the substutution of Ho atoms. The magnetic behaviour of $U_{0.5}Ho_{0.5}Ga_2$ thus approaches closely the group of the RGa_2 compounds. This conclusion can be supported by the very similar field dependence of magnetization of $U_{0.5}Ho_{0.5}Ga_2$ to that studied in [4], where the metamagnetic transitions were observed. The value of critical field one can expect somewhere below 0.1 T. The observed magnetic moment $\sim 5\ \mu_B$ at the field 5 T already corresponds to a nearly parallel arrangement of the U and the Ho magnetic moments (Table 1). The obtained values of μ_{eff} fit very well with the equation $\mu^2_{eff}[1/2(U+Ho)] = 1/2[\mu^2_{eff}(U) + \mu^2_{eff}(Ho)]$, being consistent with the localized character of both the U and the Ho magnetic moments.

A more detailed investigation is necessary to be carried out of the prepared (U, Ho)Ga_2 and (U, Y)Ga_2 systems.

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Received October 13th, 1980