Magnetic properties and phase transitions of RAlxGa2-x
(R = Tb, Ho)
K. Girgis, P. Fischer

To cite this version:
K. Girgis, P. Fischer. Magnetic properties and phase transitions of RAlxGa2-x (R = Tb, Ho). Journal de Physique Colloques, 1979, 40 (C5), pp.C5-159-C5-161. <10.1051/jphyscol:1979560>. <jpa-00218977>

HAL Id: jpa-00218977
https://hal.archives-ouvertes.fr/jpa-00218977
Submitted on 1 Jan 1979

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Magnetic properties and phase transitions of RAl$_x$Ga$_{2-x}$ (R = Tb, Ho)

K. Girgis
Institut für Kristallographie und Petrographie, ETHZ, CH 8092 Zürich, Switzerland

and P. Fischer
Institut für Reaktortechnik, ETHZ, CH 5303 Würenlingen, Switzerland

Résumé. — On a étudié la structure cristalline et des propriétés magnétiques des composés RAl$_x$Ga$_{2-x}$ (R = Tb, Ho : 0 ≤ x ≤ 2.0) par diffraction des rayons X et des neutrons, microanalyse et mesures de la susceptibilité.

Abstract. — Crystal structure and magnetic properties of RAl$_x$Ga$_{2-x}$ (R = Tb, Ho : 0 ≤ x ≤ 2.0) were investigated by means of X-ray and neutron diffraction, microprobe analysis and measurements of magnetic susceptibility.

Introduction. — RAl$_2$ crystallize with cubic structures of MgCu$_2$ type (Laves phase) and order predominantly ferromagnetic [1]. On the other hand the antiferromagnetic RGa$_2$ occur with hexagonal AlB$_2$ type structure. Many other compounds of Al and Ga are isostructural [2]. Magnetic structures of RGa$_2$ were investigated at Grenoble [3]. We determined [4] the influence of Ga substitution by Al in RGa$_2$ on crystal structures and magnetic properties. One anticipates enhanced exchange associated with modified interatomic distances and band structures. Similar investigations concerning RAlGa (R = Tb, Ho) were published recently by Gignoux and Asmat [5]. In contrast to this study our results furnish clear evidence for magnetic phase transitions in RAlGa and substantially increased Néel temperature of TbAlGa compared with TbGa$_2$. Coexistence of two helical phases is found in TbAl$_{0.5}$Ga$_{1.5}$.

1. Sample preparation, metallographic and X-ray investigations. — The samples were synthesized in an arc furnace in purest argon atmosphere from 99.999 % gallium (Alusuisse), 99.99 % aluminium (Alusuisse), 99.9 % holmium (Johnson, Matthey and Co., Ltd.) and 99.9 % terbium (Johnson, Matthey and Co., Ltd.) and remelted several times. The ingots were enclosed under vacuum in tantalum containers, homogenised at 1 000 °C for 24 h and finally annealed at 600 °C for 72 h. The samples were examined metallographically, by microprobe analysis and X-ray diffraction. The specimens prove to be homogeneous and correspond well to the nominal compositions.

Two phases exist in the composition range RAl$_x$Ga$_{2-x}$. The AlB$_2$ phase exists over a range of x = 0.0 to 1.6, the MgCu$_2$ phase from x = 1.25 to 2.0, i.e. both phases coexist in the range x = 1.25 to 1.6. Concerning substitution of Ga by Al the cell constants of the AlB$_2$ phase show a remarkably nonlinear dependence, whereas the change of the MgCu$_2$ cell constants is small and linear (cf. figure 1).
2. Magnetic susceptibility. — Figure 2 shows an example of the susceptibility measurements of TbAlGa, where (similar to HoAlGa) two transitions can be recognised.

![Fig. 2. Susceptibility measurements of TbAlGa compound (emu).](image)

3. Neutron diffraction studies. — Powder samples of RAl$_2$Ga$_{2-x}$ (cf. table I) were investigated by neutron diffraction at Würenlingen. Illustrative, absorption corrected patterns (wavelength 2.35 Å) are shown in Figure 3. The nuclear intensities confirm the AlB$_2$-structure model with statistical distribution of Al and Ga on B sites. RAl$_2$Ga$_{2-x}$ (R = Tb, Ho: $x \leq 1$) order antiferromagnetically (cf. figure 3 and table I). At $x = 1$ Néel temperatures are considerably larger compared to $x = 0$. The low temperature magnetic structure of HoAlGa (cf. figure 4) corresponds to Shubnikov group P6/mcc and is similar to CsCoCl$_3$ [6]. The incommensurate configurations are spiral structures of triangular type within (001) planes [phase angles ± (120°, 240°)], with propagation direction $c$ ($K = [1/3, 1/3, q]$) and $q$ increasing systematically with composition $x$.

![Fig. 3. Neutron diffraction patterns of HoAlGa. At 4.2 K magnetic reflections are indexed with respect to the magnetic (a$_m$ = 3 a, c$_m$ = 2 c) unit cell. $0_2 = \pm q$.](image)

![Fig. 4. Low temperature magnetic structure of RAlGa (R = Tb, Ho) [moments reversed at $z = 1/2$]. Signs indicate $z$ components.](image)

Table I. — Neutron results for RAl$_2$Ga$_{2-x}$. $T_N$ = Néel temperature, $T_i$ = temperature of magnetic phase transition, MS = magnetic structure. A denotes triangular moment configuration with undetermined orientation within (001) planes. $\mu$ = ordered magnetic moment. Standard deviations within parentheses refer to the last digit. * more stable above 15 K.

<table>
<thead>
<tr>
<th>R</th>
<th>x</th>
<th>Tb</th>
<th>0.5</th>
<th>1.0</th>
<th>Ho</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$T_N$ [K]</td>
<td>$T_i$ [K]</td>
<td>$q$</td>
<td>MS</td>
<td>$\mu$ [\mu_B]</td>
</tr>
<tr>
<td>Ho</td>
<td>23.0 [5]</td>
<td>17.8 [2]</td>
<td>0.419*</td>
<td>$A$ ($\Delta$)</td>
<td>6.2 [1]</td>
</tr>
</tbody>
</table>

* more stable above 15 K.
MAGNETIC PROPERTIES AND PHASE TRANSITIONS OF RAl₉Ga₉₋ₓ (R = Tb, Ho)

References


