MÖSSBAUER SPECTROSCOPY OF DyMe2Si2 COMPOUNDS

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To cite this version:

HAL Id: jpa-00218609
https://hal.archives-ouvertes.fr/jpa-00218609
Submitted on 1 Jan 1979

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MÖSSBAUER SPECTROSCOPY OF DyMe$_2$Si$_2$ COMPOUNDS


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Résumé.- On présente les résultats d'absorption résonante de $^{161}$Dy dans les composés DyMe$_2$Si$_2$ (Me = Mn, Fe, Co, Ni et Cu) et de $^{57}$Fe dans DyFe$_2$Si$_2$.

Abstract.- Results of resonance absorption measurements on $^{161}$Dy nuclei in DyMe$_2$Si$_2$ compounds (Me = Mn, Fe, Co, Ni and Cu) and on $^{57}$Fe nuclei in DyFe$_2$Si$_2$ are presented.

Compounds represented by the formula ReMe$_2$Si$_2$, where Re is the rare earth and Me the 3d metal, crystallize in the ThCr$_2$Si$_2$ type tetragonal structure in the space group $I4/mmm$ /1/. Investigated compounds were prepared by arc-melting of dysprosium, silicon and the 3d metal (Mn, Fe, Co, Ni or Cu) in argon atmosphere. To achieve good homogeneity they were annealed in vacuum at 800°C for ca. 4 days. The X-ray analysis indicated in each case the presence of a single phase. All absorbers were prepared in a powder form with the natural abundance of the $^{161}$Dy isotope.

The Mössbauer effect measurements for $^{161}$Dy nuclei were carried out with the $^{161}$Dy/Dy$_2$O source at room temperature using a 2 atm.Kr proportional counter for detection of the 25.6 keV gamma line. The velocity scale of the spectrometer was calibrated with a Dy-metal absorber.

Bulk magnetization measurements, performed until now, show that DyFe$_2$Si$_2$ and DyNi$_2$Si$_2$ are paramagnets down to 4.2 K whereas DyCo$_2$Si$_2$ is antiferromagnetically ordered below 19 K.

All $^{161}$Dy resonance absorption spectra taken at liquid helium temperature reveal the hyperfine splitting caused in paramagnetic samples by the long relaxation time of the dysprosium magnetic moment. For DyMn$_2$Si$_2$ and DyNi$_2$Si$_2$ the hfs spectra at 4.2 K could not be described in terms of the static magnetic interaction. Therefore, measurements for these compounds were also done at temperatures below 4.2 K. Spectra obtained for DyMn$_2$Si$_2$ at 1.85 K and for DyNi$_2$Si$_2$ at 2.1 K can be satisfactorily fitted using the static hyperfine Hamiltonian. In figure 1 the Dy spectrum for DyFe$_2$Si$_2$ is shown as an example. In table 1 the obtained ratios $H_{hf}/(H_{hf})_{Dy}$-metal and $eq/(eq)_{Dy}$-metal are presented. In all cases errors amount to 0.2 per cent for the magnetic and to 4 per cent for the quadrupole interaction.

Table I: Hyperfine parameters obtained from $^{161}$Dy resonance absorption measurements in DyMe$_2$Si$_2$ compounds.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Lattice constants</th>
<th>$H_{hf}$/$(H_{hf})_{Dy}$</th>
<th>$eq/(eq)_{Dy}$</th>
<th>$T_{exp}$ (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DyMn$_2$Si$_2$</td>
<td>3.93 10.24</td>
<td>0.999 0.93</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td>DyFe$_2$Si$_2$</td>
<td>3.90 9.97</td>
<td>0.99 0.87</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>DyCo$_2$Si$_2$</td>
<td>3.89 9.75</td>
<td>0.97 0.89</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>DyNi$_2$Si$_2$</td>
<td>3.95 9.55</td>
<td>0.91 0.80</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>DyCu$_2$Si$_2$</td>
<td>3.98 10.10</td>
<td>0.89 0.77</td>
<td>4.4</td>
<td></td>
</tr>
</tbody>
</table>

The hyperfine magnetic fields and the electric field gradients change considerably along the series of the investigated compounds. Because of a quite small change of lattice constants the variation of the hyperfine fields can be probably attributed to the change of the polarization density of the conduction electrons.

The iron resonance absorption in DyFe$_2$Si$_2$ does not reveal any magnetic splitting of the Fe Mössbauer spectrum down to the temperature of 2 K. This contradicts the results obtained by Felner et al. /2/, where the superposition of single and magnetically splitted components was observed for Fe in the same kind of compounds. The value of the isomer shift for $^{57}$Fe nuclei (+0.19 ± 0.04 mm/s) with respect to Fe metal excludes, in our opinion, the possibility of $3d^{10}$ configuration for iron ions, suggested in /3/. The configuration of the low spin Fe$^{2+}$ seems to be more justified.
Fig. 1: $^{161}$Dy resonance absorption spectrum for DyFe$_2$Si$_2$

Fig. 2: $^{57}$Fe resonance absorption spectrum for DyFe$_2$Si$_2$

References