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MÖSSBAUER AND MAGNETIC INVESTIGATIONS OF Y(Fe₆Al₆₋ₓ)₂

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Although both compounds YFe₂ and YAl₂ have the cubic MgCu₂ structure, for 0.5 < x < 0.65 the hexagonal MgZn₂ structure type was observed. Since tendencies for a preferential accommodation of Fe in compounds of the hexagonal structure type are obtained /1/, these samples have been omitted. ⁵⁷Fe MÖssbauer investigations on Y(Fe₆Al₆₋ₓ)₂ are only reported for the Fe-rich mixed crystals /2,3/. Therefore in connection with bulk magnetic measurements MÖssbauer measurements have been performed for 0.1 < x < 1 in the temperature range 5 to 300 K and partly in applied fields of 1.72 T.

The mean hyperfine field was evaluated by Murakawa et al /4/, whereas Besnus et al /2/ fitted the spectra by means of two different subspectra with large line-widths. A model which takes into account the influence of nearest (n) and next nearest (m) Fe neighbour configurations was used by van der Kraan et al /3/. A similar fitting procedure was applied for the present analysis. For a chosen x value the intensity ratios are calculated from a binomial distribution and kept unchanged throughout the fitting procedure.

On the Fe-rich side the 3d moments for different surroundings can be calculated using the measured hyperfine field values (fig.1) from

\[ \mu_{3d}^{(n,m)} = \frac{1}{3d} [H_{hf}^{(n,m)} - A_s \mu_B] \]

\[ (\lambda_{3d} = -12.5 T/\mu_B, A_s = 178 T/\mu_B, \mu_B = -0.02 \mu_B) \]

deduced from YFe₂. The first term represents the corepolarization, the second the Fermi contact interaction.

The mean 3d moments estimated by means of a binomial distribution \( P(n,m) \)

\[ \bar{\mu}_3 = \sum_{n,m} P(n,m) \mu_{3d}^{(n,m)} + \bar{\mu}_S \]

are in good agreement with the mean moments determined from bulk magnetic measurements at 4.2 K.

Fig.1: Concentration dependence of the hyperfine field at 5 K. The numerous denote the number of nearest/next nearest Fe neighbours and specify the numbers of different surroundings, which are condensed to one subspectrum for the analyses. The broken lines connect the weighted mean values determined for a distinct number of nearest Fe neighbours.
and 6.5 T (fig.2). From these analyses a decreasing Fe moment with both decreasing number of nearest and next nearest Fe neighbours as well as increasing Al content must be concluded.

The temperatures $T_A$ (determined by the vanishing of the magnetic hyperfine splitting) increase with increasing Fe content for $0.5 \leq x \leq 0.7$, although from bulk magnetic measurements no magnetic order was detected at temperatures $\geq 2K$. A large discrepancy between $T_A$ and $T_C$ (determined from $\sigma^2 (H/d)$ diagrams) was obtained for $x=0.8$ (fig.2). However above $T_A$ a line-broadening was observed up to approximately 90K. For the same Fe concentration no change of the shape of the spectrum measured in an applied field of 5.0 T at 4.2 K was reported /3/. Further experiments are necessary to explain this complicated dependence of the magnetic hyperfine interaction on the temperature below $T_C$.

A complex magnetic order must be concluded for $x=0.7$. From bulk magnetic measurements no magnetic order was detected /2,5/. For the magnetization measured in low dc-fields after cooling to 4.2 K without any field a maximum is obtained at 30 K, which is comparable with $T_A=37 K$. Furthermore irreversible magnetization processes, magnetic history effects, displaced hysteresis loops after cooling in a magnetic field and a time dependence of the remanence were measured. Neutron depolarization measurements down to 30 mK confirm the absence of any spontaneous long-range magnetic order but point to a field induced short-range order /6/. The shape of the Mössbauer spectra measured at 5 K does not change for fields of 1.72 T and only minor changes occur for spectra recorded after cooling in the applied field. These facts point to a spin glass and/or micromagnetic like behaviour.

For $x \leq 0.4$ only quadrupole split spectra were recorded at 5K. The overall shape agrees with the shape of the spectra obtained at room temperature. In an applied field of 1.72 T an effective hyperfine field of 1.24 T was determined taking into account comparable magnetic and quadrupole interactions for $x=0.3$ at 5K, which clearly reflects the existence of an Fe moment even on the Al-rich side.