FOUR MAGNETIC IRON SUBLATTICES IN INDIUM-GALLIUM IRON GARNET

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We report in this paper observation of four non-equivalent positions for the iron ions Fe^{3+} in the system of indium-gallium garnets $Y_3In_xGa_xFe_{5-x}O_{12}$.

We investigated the Mossbauer effect on the Fe^{57} nuclei at temperatures 78 and 300°K. The polycrystalline compound $Y_3In_{0.15}Ga_{0.15}Fe_{4.5}O_{12}$ was investigated in greatest detail. Figures 1a and b show the Mossbauer spectra of this garnet, obtained with a Co^{57} source in Cr. Unlike the spectral characteristic of the yttrium iron garnet [1], an additional splitting of the hyperfine lines occurs in the indium-gallium garnet. The over-all form of the spectrum agrees with the well known two-sublattice structure of the indium garnet, but the outermost lines of the spectrum acquire a doublet structure (see Figs. 1a and b). An impression is gained that the octahedral and tetrahedral lattices of the iron break up each into two sublattices. The intensities of the lines in the doublets are unequal.

The complicated spectrum of Fig. 1 can be relatively easily broken up into four six-line spectra, corresponding to four nonequivalent positions a, a', and d, d' of the Fe^{3+} ions in the garnet. The values of the effective magnetic fields H_{eff} acting on the Fe^{57} nuclei in each sublattice are listed in the table.

For greater reliability, the Mossbauer spectra of the garnet $Y_3In_{0.15}Ga_{0.15}Fe_{4.7}O_{12}$ were plotted several times with different setups and with different sources: Co^{57} in stainless steel, in Cr, and in Pd. A most thorough x-ray phase analysis indicates a complete absence of any extraneous phase. The lattice constant of the garnet $Y_3In_{0.15}Ga_{0.15}Fe_{4.7}O_{12}$ a = 12.423 ± 0.002 Å. A chemical analysis of the samples revealed no divalent ions Fe^{2+}.

To explain the nature of the four magnetic sublattices of the iron, we plotted neutron diffraction patterns of the investigated sample at temperatures 4.2, 78, and 300°K. No additional hyperfine structure peaks were observed on the neutron diffraction patterns at all temperatures. The magnetic moment of the sample, measured at liquid-helium temperature, turned out to be 4.88 μ_B. This value agrees fully with the value of the magnetic moment for the "normal" substitutions of iron garnets [2], when the Fe^{3+} ions are replaced by nonmagnetic ions in the tetrahedral and octahedral sublattices simultaneously.

We find it difficult to explain the presence of four non-equivalent positions for the nuclei Fe^{57} in indium-gallium iron garnets. There are several factors capable of causing the observed effect: first, the so-called "canted structure" can appear in the garnet, wherein one of the magnetic sublattices breaks up into two with magnetic moments directed at an angle to each other (this scheme was recently proposed by Geller et al. [2]). Such a structure exists within each unit cell taken separately, but has no translational periodicity in the crystal, in view of the random orientations of the magnetic moment of the different cells. Therefore such a structure cannot be recorded by the neutron-diffraction method and can be observed only with the aid of the Mossbauer effect. Second, a complicated Mossbauer spectrum can be caused by the dependence of the observed electric-field gradient (EFG) on the angle

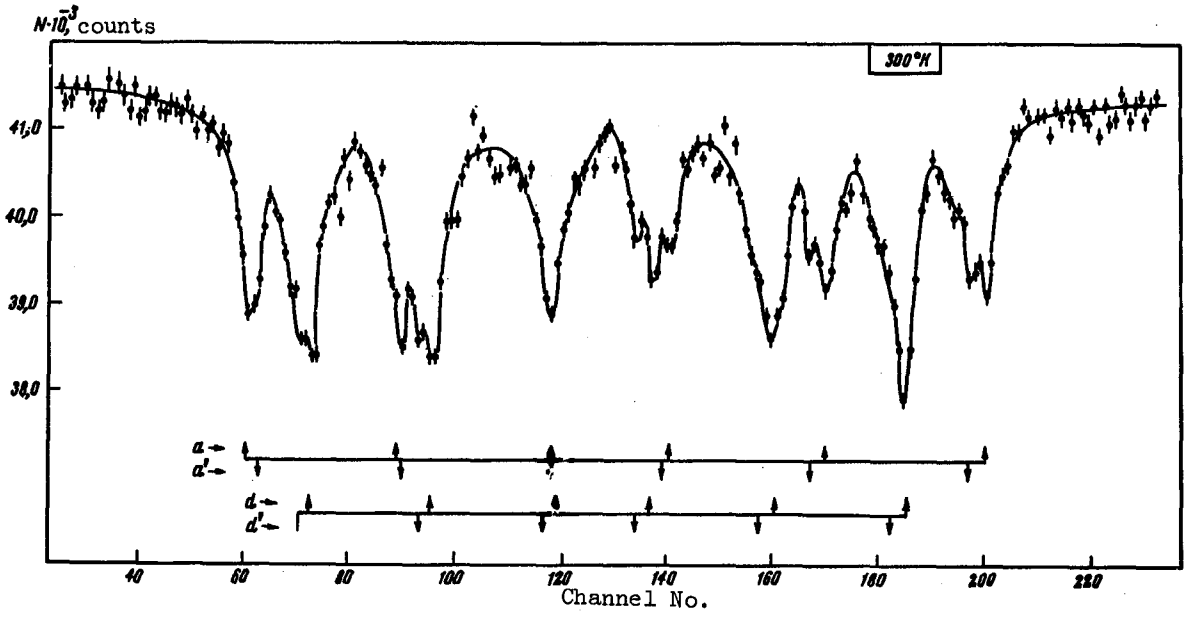

Fig. 1a. Mossbauer absorption spectra of Fe^{57} nuclei in the garnet $Y_3In_{0.15}Ga_{0.15}Fe_{4.7}O_{12}$ at a temperature 78°K.

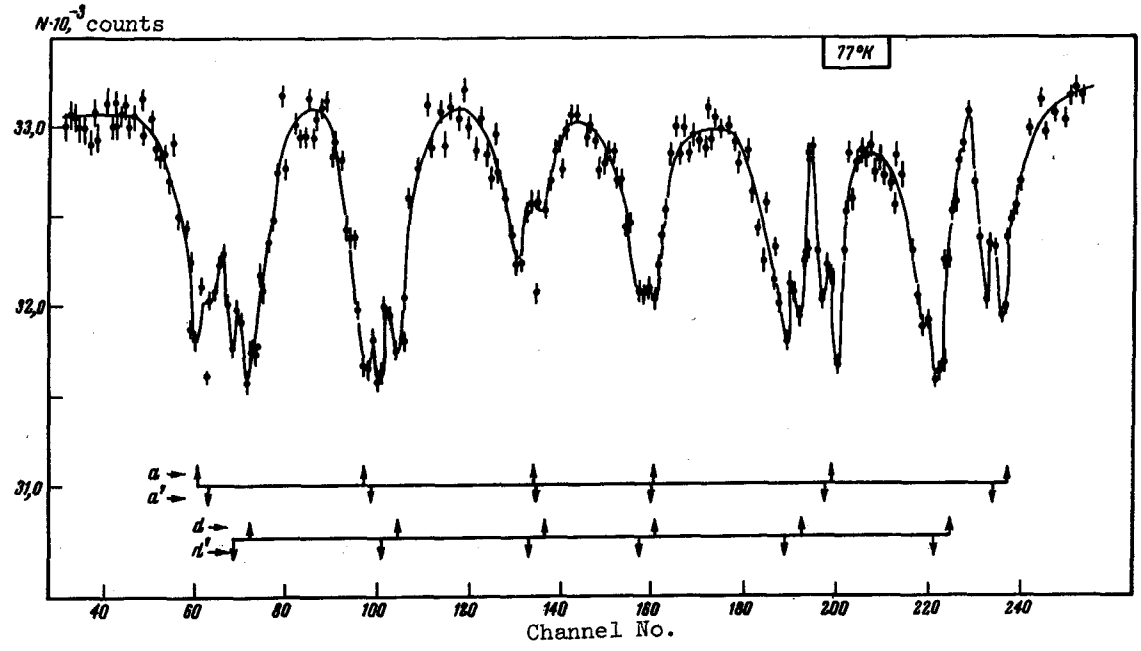

Fig. 1b. The same as Fig. 1b, but at 300°K.

Values of certain parameters of Mossbauer spectra: H_{eff} - effective magnetic field at Fe^{57} nucleus in the corresponding sublattice; $(S_1 - S_2)$ - quantity characterizing the quadrupole splitting (S_1 - distance between first and second lines of six-line spectrum, S_2 - distance between fifth and sixth lines); $\delta_a - \delta_{a'}$ and $\delta_d - \delta_{d'}$ - differences of the isomer shifts for the sublattices a and a', d and d'.

T, °K	H^a_{eff}, kOe	$H^{a'}_{eff}$, kOe	H^d_{eff}, kOe	$H^{d'}_{eff}$ kOe	$(S_1 - S_2)^a$, mm/sec	$(S_1 - S_2)^{a'}$, mm/sec	$(S_1 - S_2)^d$, mm/sec	$(S_1 - S_2)^{d'}$, mm/sec	$\delta_a - \delta_{a'}$, mm/sec	$\delta_d - \delta_{d'}$, mm/sec
300	464 ±5	442 ±5	373 ±5	367 ±5	−0,18 ±0,07	−0,28 ±0,07	−0,18 ±0,07	−0,21 ±0,07	+0,05 ±0,07	+0,18 ±0,07
78	547 ±6	530 ±6	468 ±6	470 ±6	−0,16 ±0,08	−0,08 ±0,08	+0,04 ±0,08	+0,04 ±0,08	0 ±0,08	+0,36 ±0,08

between the EFG axis in the field H_{eff} (which coincides with the easiest magnetization axis). This case was considered in sufficient detail in [1, 3], and was apparently observed experimentally by van Loef [4].

A preliminary analysis shows that the effect observed by us cannot be fully explained by any of the aforementioned mechanisms.

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ANGULAR DEPENDENCE TO TWO-PHOTON ABSORPTION IN A ZINC-SULFIDE CRYSTAL

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We measured the dependence of two-photon absorption in a crystal of zinc sulfide on the mutual orientation of the polarization of the light and the crystallographic axes. The results show that the two-photon transition in the region near 5 eV occurs between the bands Γ_{15} and Γ_1.

To measure the angular dependences of the two-photon absorption we used a procedure with two independent light sources, as described in [1, 2]. In this procedure, the light from the two sources passes through the crystal in opposite directions, both beams are linearly polarized, and the directions of the electric vectors $\vec{E}_1$ and $\vec{E}_2$ in the beams can be established parallel or perpendicular to each other. The high-power light source was a ruby laser with power of about 10 MW/cm^2. The two-photon absorption was determined by measuring the decrease of the transmission of the light from the second source (ordinary flash lamp) at the instant of action of the light from the laser on the crystal.