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A NEW TYPE OF SPIN ORDERING IN THE HEXAGONAL FERRITE (Sr, Ba)$_2$Zn$_2$Fe$_{12}$O$_{22}$(Y)

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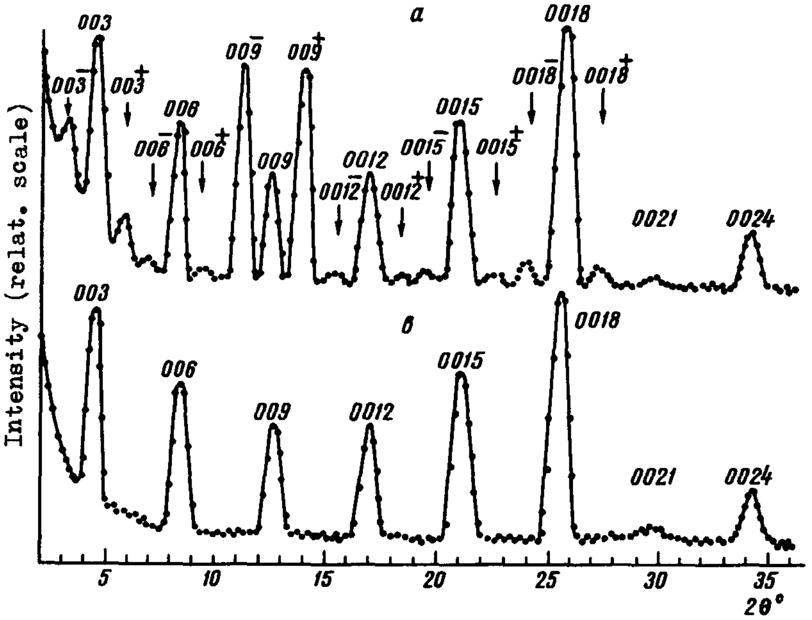
The large family of hexagonal ferrites is subdivided into five fundamental and simplest structural types: M, W, X, Y, and Z [1]. From considerations of the magnitude of the exchange interaction, Gorter [2] tentatively established for these fundamental structures spin-ordering models that agree satisfactorily with the observed magnetic properties. In some cases these models were confirmed in neutron-diffraction experiments [3,4]. However, the results obtained by Enz [5] on the magnetic properties of the ferrite (Sr, Ba)$_2$Zn$_2$Fe$_{12}$O$_{22}$(Y) could not be explained on the basis of Gorter's collinear model, in which connection the existence of helicoidal spin ordering was proposed.

We present in this communication an interpretation of the results of neutron-diffraction measurements performed by us on single-crystal Sr$_{1.6}$Ba$_{0.4}$Zn$_2$Fe$_{12}$O$_{22}$(Y) [6].



Neutron diffraction pattern of Sr$_{1.6}$Ba$_{0.4}$Zn$_2$Y (001 reflection) at 293°K; a - no magnetic field, b - 20 kOe field applied parallel to $\vec{\varkappa}$.

The figure shows the diffraction patterns of the investigated ferrite (reflection 001 from single-crystal sample), obtained at 20°C: a - without external magnetic field, b - with a field of 20 000 Oe applied parallel to the scattering vector $\vec{\varkappa}$. Comparison of a and b shows that the magnetic contribution to the diffraction is fully concentrated in the superstructure magnetic reflections which are symmetrical with respect to the structure peaks. The position of these superstructure reflections varies with the sample temperature and also with the direction and intensity of the superimposed magnetic field [6].

The presence of superstructure reflections in the diffraction pattern, connected with structure reflections and symmetrically located on both sides of the latter, is characteristic of helical spin configurations.

The best agreement between the experimental and the calculated intensities of the neutron diffraction was obtained on the basis of the model of "quasihelical" magnetic structure. According to this model, the unit cell of the investigated ferrite is broken up along the C axis into three structurally equivalent blocks T, each of which contains six layers of oxygen ions. Inside the blocks T, the spins remain collinearly ordered, in accordance with Gorter's scheme. However, the spin axes of the blocks (the directions along which the spins are oriented in the blocks) are arranged to form an angle ω, the magnitude of which changes appreciably with the temperature and with the external magnetic field. These axes are arranged along a helix with a propagation direction parallel to the C axis.

We have observed quasihelix periods τ that were multiples of one-third of the unit-cell dimension along the C axis, namely $\tau = (2/3)C$, C, and $(4/3)C$, and respectively $\omega = 180$, 120, and 90° ($\omega = 2\pi C/3\tau$).

At temperatures below 240°K, the magnetic structure is a quasihelical configuration with angle $\omega = 90°$. In the temperature interval 270 - 320°K we have $\omega = 120°$, and above 350° $\omega = 180°$. ω maintains this value up to 380°K - the Neel point, above which no superstructure reflections are observed in the diffraction pattern.

Besides changing τ and ω, an increase in temperature also causes the spin axes to be no longer perpendicular to the C axis (collinearity in the blocks is maintained). When the temperature 380°K is approached, the spin axes are no longer parallel to the basal plane and become parallel to the C axis, remaining in this position up to 400°K (the Curie point).

We investigated also ferrites of the system $Sr_xBa_{2-x}Zn_2Fe_{12}O_{22}$(Y), with strontium content $x < 1.6$. They, too, revealed the existence of spin ordering of the type described above, but with larger values of the superstructure periods and accordingly smaller values of ω.

The existence of the observed magnetic structure can be attributed to local changes in the exchange interactions when the barium is replaced by strontium. An important role is played here apparently also by the zinc ions. Thus, in neutron diffraction patterns of crystals of the ferrite $(Sr, Ba)_2Co_2Fe_{12}O_{22}$ (the zinc replaced by cobalt) there were no superstructure reflections, and the magnetic contributions to the structure reflections could be correctly calculated with the aid of Gorter's collinear scheme.

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GENERATION INDUCED IN A Q-SWITCHED RUBY LASER BY AN EXTERNAL SIGNAL

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As follows from a theoretical analysis of the dynamics of the generation of a giant pulse in a laser with active Q-switch [1-3], the time τ_d of linear development of generation depends on the average number of spontaneous photons in the oscillation mode at the instant when the Q-switch is turned on. An estimate [1] has given for the corresponding energy W_0 a value on the order of 10^{-16} J.

So small an initial energy makes it possible in principle to control τ_d over a rather wide range by introducing into the laser cavity, after opening the shutter, energy from another laser, in spite of the fact that τ_d has a relatively weak dependence on W_0, in the form

$$\tau_d = K_1 \ln \frac{K_2}{W_0} . \tag{1}$$

(K_1 and K_2 are determined by the laser and pump parameters).

An investigation of this possibility is of interest both for the solution of the problem of synchronous operation of several lasers having the same spectral output, and for obtaining a single frequency giant-pulse generation regime.

We have therefore experimentally investigated the singularities produced in giant-pulse generation by a ruby laser when the fraction of the energy, ΔW, of another laser is introduced in its cavity after the opening of the electrooptical shutter. The second laser is also Q-switched. The experimental setup is shown in Fig. 1, where the following symbols are used: C - electrooptical cells, G - Glan-Thomson prisms, R - ruby rods, M - laser cavity mirrors, S - semitransparent mirrors, F - filter system. Both lasers were pumped simultaneously. The high-voltage pulse fed to the electrooptical cell used to Q-switch the synchronized laser (henceforth referred to as the second laser) was fed from a generator (VPG) through a 135-nsec delay line (DL).

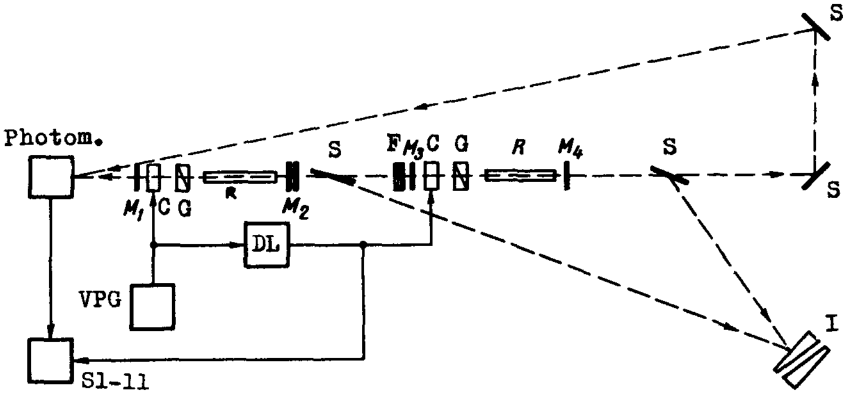

Fig. 1