Thus, in the system under consideration the nonuniformity of the magnetization distribution at certain values of the stationary field strength sharply limits the possibility of exciting parametric oscillations.

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Bragg diffraction of 14.1-keV resonant γ quanta by a mosaic α-$^{57}Fe_2O_3$ crystal in an oblique magnetic field

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The energy dependence of the intensity of the scattering of 14.4-keV resonant γ radiation is measured for all even (from the second through the tenth) orders of the Bragg reflection ($2n\ 2n\ 2n$) from a single crystal of hematite placed in an oblique magnetic field. The experimental results are compared with calculations performed for models of a mosaic and an ideal crystal.

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We have previously[1,2] observed and investigated systematically the polarization-induced dependences of the interference between nuclear-resonance and electron Rayleigh scattering on the scattering angle, on Δm of the nuclear transition, and on the direction of the magnetic field at the iron nuclei. We measured in these studies the energy dependences of the scattering of 14.4-keV resonant γ radiation of ^{57}Fe for all even (from the second through the tenth) orders of the Bragg reflection from a single crystal of hematite (α-Fe_2O_3) at two mutually perpendicular directions of the external magnetic field applied to the crystal. The experimental curves were compared with the theoretical calculations based on the model of an ideal crystal. The agreement with experiment was good.

The obtained curves turned out to be very sensitive to the orientation of the external magnetic field. It was therefore of interest to perform the measurements at an intermediate orientation of the magnetic field. This case is of particular interest because, in contrast to the heretofore considered simpler cases,[1,2] the π and σ polarizations of the incident beam are no longer the natural ones. Namely, when and if the incident radiation is, say, π-polarized, the scattered radiation contains γ quanta with the other polarization (σ). The polarization picture is here therefore greatly complicated.

The measurments were performed with a Mössbauer diffractometer[3] at room temperatures. The γ rays from a single-line Mössbauer source (^{57}Co in Cr, 200 μCi) were incident on a single crystal of α-Fe_2O_3 (85% ^{57}Fe, mosaic angle ~30") placed in one of the positions of the symmetrical Bragg scattering ($2n\ 2n\ 2n$). The crystal was in a magnetic field ~1 kOe situated in the plane of the crystal and making an angle 45° with the scattering plane (Fig. 1).

Figure 2 shows the measured dependences of the integrated intensity of the reflection of 14.4-keV quanta on the source velocity for all the existing orders of the reflection. As already mentioned, the polarization picture under these conditions becomes much more complicated. It turns out that the general system of dynamic equations that describe the propagation of the γ quanta in the crystal[4] no longer breaks up into two independent subsystems for the π and σ polarizations of the incident radia-

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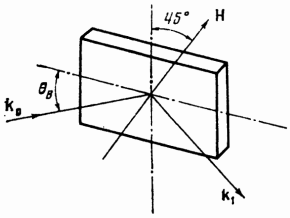

FIG. 1. Experimental setup. **H** is the external magnetic field applied to the crystal and lies in the scattering plane; $\mathbf{K}_0$ and $\mathbf{K}_1$ are the wave vectors of the incident and scattered radiations.

tion. The solution of the diffraction problem can be obtained here by numerical means, but for our case the calculation can be greatly simplified by using the formulas derived in[5] (see also[6]) for the coefficient of reflection from a mosaic crystal.

This circumstance, together with the results of the earlier experiments, has prompted us to consider a

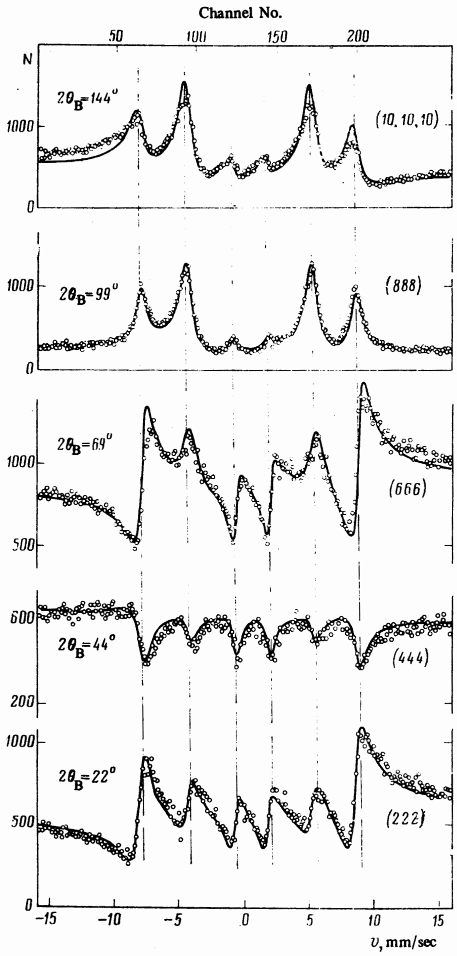

FIG. 2. Dependence of the reflection intensity on the velocity of the source (^{57}Co in chromium) for even orders of symmetric Bragg reflections ($2n$ $2n$ $2n$) of 14.4-keV γ rays from an α-$^{57}Fe_2O_3$ single crystal. The vertical lines show the positions of the nuclear resonances, measured in transmission, N is the total number of the counts in the analyzer channel, and the solid curves were calculated with a computer using a mosaic-crystal model.

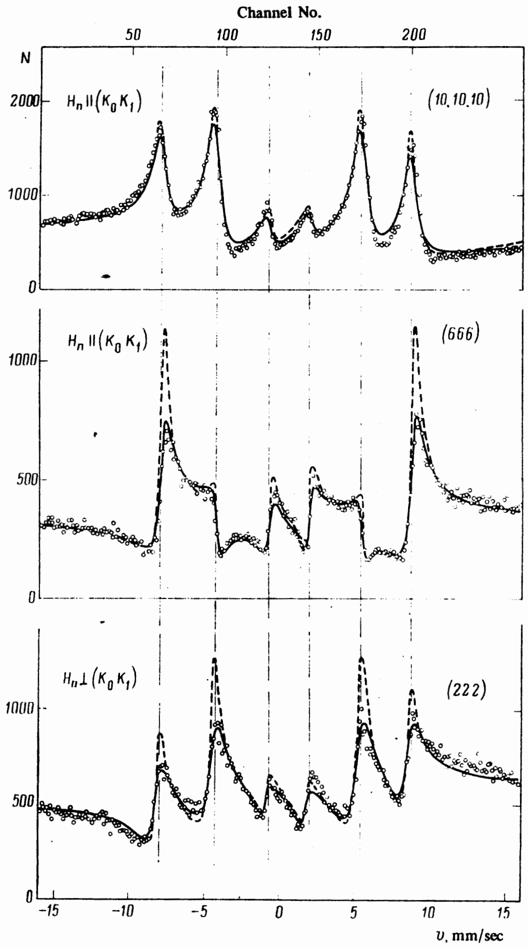

FIG. 3. Effect of mosaic structure of the crystal on the shape of the interference curves. The solid curves were calculated by a mosaic-crystal model, and the dashed ones by the model of an ideal crystal. The experimental spectra were taken from[2].

model of scattering by a mosaic crystal and to compare the theoretical calculations both in the two extreme cases ($\mathbf{H}_n \parallel \mathbf{K}_0$, $\mathbf{H}_n \parallel \mathbf{K}_1$ and $\mathbf{H}_n \perp \mathbf{K}_0$, $\mathbf{H}_n \perp \mathbf{K}_1$), and for an arbitrary direction of the magnetic field at the nucleus. It is seen from Fig. 2 that these theoretical curves agree well with the experimental results. A comparison of these curves with the spectra measured at the extreme orientations of the field[2] confirms their intermediate character. Namely, the peak-to-dip transitions (and vice versa) and the reversal of the sign of the asymmetry of the interference curves have a smooth behavior when the magnetic field is rotated.

It must be noted at the same time that the theoretical curves previously calculated[2] in the ideal-crystal model describe quite adequately the characteristic singularities of the spectra measured at $\mathbf{H}_n \parallel \mathbf{K}_0$, $\mathbf{H}_n \parallel \mathbf{K}_1$ and $\mathbf{H}_n \perp \mathbf{K}_0$, $\mathbf{H}_n \perp \mathbf{K}_1$. Nonetheless, on individual segments (in the region of the sharp peaks) we observed noticeable discrepancies, which we have attributed qualitatively to the deviation of the crystal from ideal. We have therefore performed calculations also for these cases by the mosaic-crystal model.

We obtained good agreement with experiment, since the physical picture of the polarization dependences of the interference remains the same. Particular notice should be taken here of the very fact that the forms of the calculated interference spectra become more similar (and even practically coincide in some cases) for the models of the ideal and mosaic crystals. This fact, paradoxical at first glance, can be understood by recalling that the differences of the results obtained with the ideal and mosaic models are most pronounced when the depth of penetration of the radiation in the crystal is determined mainly by extinction and not by ordinary absorption. In our case the picture is as a rule reversed, because the structure factors F_{HKL} of the investigated reflections (referred to one nucleus) are noticeably smaller than unity. Therefore the dynamic effects are greatly weakened in the scattering. Thus, e.g., $F_{444} = 0.06$ (for the iron nuclei) and the shapes of the calculated curves are perfectly identical for the models of the ideal and mosaic crystals and agree very well with experiment (Fig. 2; see also[2]).

The cases of the largest discrepancy between the calculated curves of ideal and mosaic crystals, together with the corresponding experimental spectra, are shown in Fig. 3. It is seen that the mosaic structure manifests itself principally in the sharpness of the maxima, and our crystal occupies an intermediate position between an ideal and a mosaic crystal, coming closer to the latter.

Thus, the form of the energy spectrum measured under conditions of interference of nuclear and electron scattering, even in relatively unfavorable cases, when the dynamic effects are greatly weakened, can serve as a sensitive indicator of the perfection of a crystal.

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