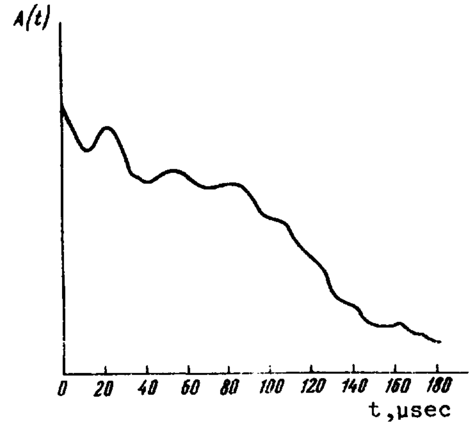
At 77°K and 333.94 MHz we observed in I_2 (I^{127}) an intense spin-echo signal ($t = 2\tau$) for the $\pm 1/2 \rightarrow \pm 3/2$ transition. A false low-intensity echo signal at $t = 3\tau$ is sometimes observed in semiconductors.

From the drop of the amplitude of the stimulated echo after the third 90° pulse at 77°K, the spin-lattice relaxation time for the $\pm 1/2 \rightarrow \pm 3/2$ transition was found to be T_1 = 450 μsec. When the time interval τ between pulses was varied, the envelope of the echo signals exhibited "slow beats" (see the figure). The frequencies of the "slow beats" were 7 and 25 kHz. In other substances, such as SnI_4, no "slow beats" were observed in a zero external magnetic field. Nor were "slow beats" observed in the echo envelope of Br^{79} nuclei in $SbBr_3$, etc., i.e., where there is no spin-spin line splitting. On the other hand, the frequency of the "slow beats" in Br_2 turned out to be of the order of 10 kHz; this does not contradict the stationary measurement procedure.



Envelope of spin-echo signals at $t = 2\tau$, where τ is the time interval between the 90 and 180° pulses.

It remains to propose that we succeeded, for the first time, to observe in NQR "slow beats" in the echo-signal envelope; these beats are to to indirect spin-spin interactions between iodine nuclei. This uncovers a way of investigating indirect spin-spin interactions between nuclei in crystals in NQR with the aid of pulsed methods.

Our research touches upon recently initiated experiments on hyperfine splitting in EPR by the spin-echo method [8], which also led to the appearance of "slow beats" in the envelope.

Observation of this new phenomenon in nuclear quadrupole resonance calls for the development of a theory for different interacting spins as applied to pulsed methods.

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CORRELATION PROPERTIES OF GAMMA BEAMS IN THE X-RAY BAND

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The purpose of the present research was to study the correlation properties of gamma beams in the x-ray band. The monochromatic source of the Mossbauer gamma quanta of energy 23.8 keV was the radioactive isotope Sn^{119m}. The characteristic K-series radiation of the tin was filtered out with palladium 20 μ thick. The radiation from source 1 passes through collimator 2 and strikes a rock-salt crystal 3 suitably oriented by means of a goniometer head (Fig. 1). The diffracted rays belonging to one set of reflections pass through a protective screen with apertures 4 and are incident on the NaI(Tl) scintillator crystal of photomultiplier 5 (FEU-13). Apertures 4 are provided with shutters that can be opened and closed independently. The accuracy with which the counter crystal is set relative to the diffracted rays is ±0.5 mm. Unlike similar experiments in the optical region, where the method of delayed coincidences is usually employed, we used a procedure based on the properties of a photon counter having a dead time.

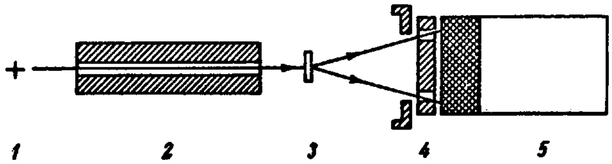

Fig. 1. Diagram of experimental setup: 1 - radiation source, 2 - collimator, 3 - scattering crystal, 4 - screen with apertures and shutters, 5 - photomultiplier with crystal.

During the preliminary stage of the experiments we measured the dead time of the entire recording system, by using controlled variation of the source intensity. The radiation source was an x-ray tube. In this case the dead time τ can be obtained from the expression

$$\tau = \frac{kI_1 - I_2}{I_2(I_2 - I_1)},$$

where $k = i_2/i_1$, $i_{1,2}$ - first and second values of the anode current in the tube, and $I_{1,2}$ - the corresponding intensities.

According to our measurements, $\tau \sim 3 \times 10^{-6}$ sec. The somewhat exaggerated value of τ can be attributed to the impossibility of regulating smoothly the high voltage on the tube anode. However, as will be shown later, there is no need for a greater accuracy in the determination of τ.

The experimental procedure is quite simple. By successively opening the shutters of the screen 4, it is possible to measure the average counts $\overline{N}_1$ and $\overline{N}_2$ in t seconds from each diffraction beam separately and to determine the counting rates $I_1 = \overline{N}_1/t$ and $I_2 = \overline{N}_2/t$, and then measure the average count $\overline{N}_{1,2}$ in t seconds from the two beams together. Since the recording system has a certain dead time τ, the intensity $I_{1,2}$ obtained from the joint action should be somewhat lower than the sum of the intensities $I_1 + I_2$, owing to possible simultaneous random incidences (within the interval τ) of quanta from the first and second beams:

$$I_1 + I_2 - I_{1,2} = 2I_1I_2\tau. \tag{1}$$

In the presence of a background, Eq. (1) goes over obviously into

$$I_1 + I_2 - (I_{1,2} + I_b) = 2(I_1 - I_b)(I_2 - I_b)\tau. \tag{2}$$

On the other hand, if Eq. (2) does not hold, then there are grounds for assuming the presence of a correlation in the arrival of the pulses at the input of the recording apparatus.

More complete information on the correlation properties of the beams can be obtained by measuring the spectral distributions of the counts for each beam separately and for both together. The spectral distribution of the count of each beam separately obeys the normal law:

$$n^{\circ}(N_i) = \frac{1}{\sqrt{2\pi D_i}} \exp - \frac{(N_i - \bar{N}_i)^2}{2D_i}; \quad i = 1,2 \tag{3}$$

with a maximum at $\bar{N}_1$ and $\bar{N}_2$. The count N_i is made up of the signal proper $\bar{N}_i^0$ and the constantly present background $\bar{N}_b$:

$$\bar{N}_i = \bar{N}_i^0 + \bar{N}_b.$$

The additional background that enters the window is included in $\bar{N}_i^0$ and will not be considered separately. The spectral distribution of the count produced by both beams together also obeys a normal law and has in the general case the form

$$n^{\circ}(N_{1,2}) = \frac{1}{2\pi\sqrt{D_1 D_2(1 - R^2)}} \exp - \frac{1}{1 - R^2}\Big[\frac{(N_1 - \bar{N}_1^{\circ})^2}{2D_1} - R\frac{(N_1 - \bar{N}_1^{\circ})(N_2 - \bar{N}_2)}{\sqrt{D_1 D_2}} + \frac{(N_2 - \bar{N}_2)^2}{2D_2}\Big]. \tag{4}$$

If the times of arrival of the quanta in the different beams are completely independent, then (4) goes over into

$$n^{\circ}(N_{1,2}) = \frac{1}{\sqrt{2\pi D_{1,2}}} \exp - \frac{1}{2}\frac{[N_{1,2} - (\bar{N}_1^{\circ} + \bar{N}_2)]^2}{D_{1,2}}, \tag{5}$$

i.e., into a normal distribution with maximum $\bar{N}_1^0 + \bar{N}_2$ and dispersion $D_{1,2} = D_1 + D_2$. *

Expressions (3) - (5) have been written under the assumption that $\tau = 0$; in our case of small counting rates, this assumption is fully justified.

On the other hand, if the radiation beams have similar space-time structures, then the parameter R in (4) differs from zero and can assume values in the range $0 \le |R| \le 1$. The case R = 1 corresponds to strict correlation in the beams.

The results of our measurements are shown in Fig. 2. The abscissas show the count in t = 10 sec, and the ordinates the absolute frequencies of the appearance of the given count. Each curve is the result of ~300 measurements.

Curves 1 and 2 are the spectral distributions of the count of each beam separately, including the background. Curve 1,2 is the experimental distribution of the count under the simultaneous action of the beams. Finally, the dashed curve 3 is the theoretical distribution plotted under the assumption that the beams are completely independent, in accordance with (5).

The presented distributions show quite clearly that curve 1,2 does not coincide with curve 3, and can therefore be identified as a spectral distribution of dependent events when

$R \neq 0$.

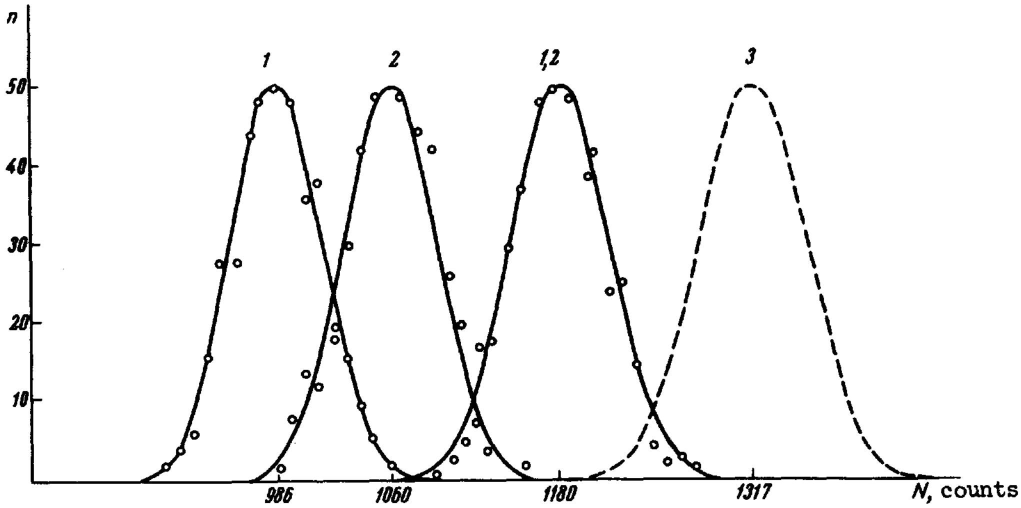

Fig. 2. Spectral distribution of the counts of the first beam (1), the second beam (2), of the two beams together (1,2), and the theoretical curve (3) plotted under the assumption that beam 1 and 2 are completely independent (dashed).

In our case, the parameter R can be identified with the first-order normalized correlation function, and is equal to

$$R = \frac{\bar{N}_1^0 + \bar{N}_2^0 - \bar{N}_{1,2}^0}{\bar{N}_1^0}, \quad \bar{N}_i^0 = \bar{N}_i - \bar{N}_b, \tag{6}$$

where $\bar{N}_1^0 < \bar{N}_2^0$. The dispersion D_R from (6) is $D_R = (\bar{N}_1^0)^{-2}(\bar{N}_1^0 + \bar{N}_2^0 + \bar{N}_{1,2}^0)$, so that numerically $R = 0.4$ and the relative error δ_R is equal to $\sqrt{D_R}/R \approx 5.0\%$.

Thus we have demonstrated experimentally the possibility of obtaining partly coherent beams in the x-ray band. This is of interest not only in the sense of extending the ideas of visible-band optics to the x-ray region, but as a possible basis for a unique and complete solution of the phase problem of structure analysis [1].

The observed correlation of the photons for low-lying nuclear resonances with relatively long de-excitation times ($\tau \sim 10^{-7}$ sec for Sn^{119m}) can be attributed to the interaction of the elementary emitter in the source. If it is assumed that the transition of nuclei from the excited state to the ground state via emission of a gamma quantum occurs in a reconciled manner within the limits of τ for a certain excitation region, or even for several overlapping regions, then the wave packet emitted in some direction is formed by several quanta simultaneously. The single crystal serves only as a semitransparent mirror, dividing the front of the wave packet as well as the amplitude, but the separated beams continue to have similar space-time structures. Therefore when both windows are open the number of coincidence increases compared with the random coincidences (or else compared with the number of coincidences due to the Bose statistics). We are unable to stop to consider the general problems of optic coherence and photon statistics. The modern status of the problem is presented in considerable detail in the lectures of Glauber [2] and in the review of Wolf and Mandel [3].

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* The maximum of the distribution (5) occurs at $\bar{N}_{12} = \bar{N}_1^0 + \bar{N}_2^0 + \bar{N}_b$. According to measurements, $\bar{N}_1^0 = 257$, $\bar{N}_2^0 = 331$, and $\bar{N}_b^0 = 729$, and therefore $\bar{N}_{12} = 1317$.

"ISOMAGNETIC JUMP" IN THE FRONT OF A STRONG COLLISION-FREE SHOCK WAVE

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Investigations of collisionless shock waves with the aid of magnetic probes have revealed a change in the front structure and an increase in its width Δ when the critical Mach number $M_{cr} \simeq 3$ is reached [1]. The values of Δ and M_{cr} do not contradict the theoretical notions concerning the toppling of a strong shock wave [2]. From the theory and from the results of simulation by means of an electric computer [3] it follows that the toppling of the wave is preceded by a unique effect, namely an increase in the relative slope of the jump in the plasma density n. In addition, the subsequent violation of the single-stream character of the flow should alter the initial distribution of the physical parameters in the front (when $M < M_{cr}$).

We present in this paper the results of an investigation of the distribution of the density and magnetic field H on going through the critical value of the Mach number.

The experiments were performed with the UN-4 setup [4]. The plasma ($n_0 \sim 10^{13} - 10^{14}$ cm^{-3}) was produced in a cylindrical volume of 16 cm [sic!] placed in a quasistationary magnetic field (H_0 = 100 - 1000 Oe) and was subjected to compression by a rapidly growing field ($H_\sim^0$ = 2 - 3 kOe). The resultant cylindrical shock wave propagated towards the axis. The profile of the magnetic field in the wave was registered with a magnetic probe (single loop of 2 - 3 mm diameter; Fig. 1). The microwave probing (λ = 2 mm) was carried out in the plane of the wave front with the aid of miniature dielectric antennas of 1.5 mm diameter, spaced $l \sim 3\lambda$ apart. The system ensured spatial resolution within the shock discontinuity (Δ ~ 1 - 4 cm). The magnetic probe and the microwave antennas were placed at the same distance from the axis ($r \simeq R/2$) and were shifted 30° in azimuth.

In order to trace qualitatively the realignment of the front structure, the measurements were performed initially by using a "cutoff" scheme [5]. The detector registered the microwave