Let us analyze the results from the point of view of the theory developed in [1, 2]. According to [1], the limiting values of the electric fields E^- and E^+ are determined from the condition $eE^{\pm}\tau^{\pm} = P_0$, where τ^+ is the time of spontaneous emission of the optical phonons, and τ^- is the time of elastic relaxation, amount to 40 and 3000 V/cm for p-Ge with carrier density 10^{13} cm^{-3} at hydrogen temperature. The electric fields at which the characteristic singularities on the gauss-ampere characteristics were observed fall in the field interval predicted by the theory. The theory agrees also with the observed dependence of E on H_c, at which the dissipative current should disappear, and the slope of the $E = \phi(H)$ plot coincides with the theoretical value $E/H_c = P_0/2cm$ within 20%. The indicated agreement with theory gives grounds for assuming that the observed singularities on the $j = f(H, E)$ curve are connected with the changes of the distribution function of the carriers [1] when critical magnetic fields are applied to the sample. The reason why only a kink is observed on the $j = \phi(H, E)$ curve at the points corresponding to the critical magnetic field, instead of a steep decrease, still remains unclear.

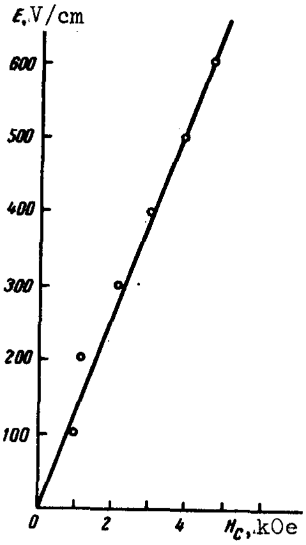

Fig. 2. Connection between the electric and magnetic fields corresponding to the inflection points on the $j = \phi(H, E)$ curves.

It is possible that one of the reasons for such a behavior of the gauss-ampere characteristics is the large initial momentum spread ΔP, which can be possessed by the carriers prior to the application of the electric field, as a result of which they reach the energies of the optical phonons at different values of E, and also the fact that the frequency of the optical phonon has likewise a definite spread. Naturally, these causes cannot explain fully the fact that the dissipative current does not vanish.

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DIRECT OBSERVATION OF ANOMALOUS TRANSMISSION OF RESONANT γ RAYS OF Fe^{57} BY SINGLE CRYSTAL Fe + 3% Si

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We have investigated the angular dependence of the transmission of resonant 14.4-keV γ rays of Fe^{57} by an ideal single crystal Fe + 3% Si (made of unenriched iron) in the Bragg-angle region (θ_B). According to the theory of Kagan and Afanas'ev [1], when the Bragg conditions are satisfied, total or partial suppression of the nuclear resonant absorption of the γ rays takes place, and the angle interval for which the absorption vanishes or is noticeably decreased is of the order of 10". Therefore there should be observed a peak of anomalous transmission in the angular dependence of the transmission of the resonant γ rays in the region of θ_B. Experimental observation of this peak entails two difficulties: 1) the employed γ-ray beam must have a small angle divergence, ∿10", 2) the nonresonant absorption of the γ rays by the electrons is also attenuated in the region of θ_B as a result of the Borrmann effect. It is therefore necessary to measure the angular dependence of the intensity of the γ rays passing through the crystal $N(\theta)$ under two conditions: (a) in the basence of resonant absorption, i.e., off resonance (at $v = \infty$), $N_\infty(\theta)$, and (b) at resonance (at $v = v_{res}$), $N_{res}(\theta)$. Both curves should have peaks at $\theta = \theta_B$. The effect of anomalous transmission of the resonant γ rays should become manifest in the angular dependence of the ratio $T_{res}(\theta) = N_{res}(\theta)/N_\infty(\theta)$, in which the angular dependence of the non-resonant absorption is eliminated.

The anomalous transmission was first observed for γ rays of Sn^{119} in single-crystal tin [2]. The authors used a γ-ray beam with divergence 300", which naturally did not make it possible to obtain the $T_{res}(\theta)$ curve. In [2] are given only the $N_\infty(\theta)$ and $N_{res}(\theta)$ curves, and it is indicated that these curves imply the presence of a small decrease of the resonant absorption in the region $\theta = \theta_B$ compared with absorption at θ far from θ_B.

In the present investigation we studied the anomalous transmission under much better conditions of angular solution (∿7"), and obtained a $T_{res}(\theta)$ curve with a clearly pronounced peak of anomalous transmission in the region $\theta = \theta_B$.

Experimental conditions. The measurements were performed with a two-crystal Mossbauer diffractometer. The source was Co^{57} in stainless steel, with activity ∿70 μCi, mounted on a vibrator which made it possible to set the source in motion at a constant velocity. The γ rays from the source were incident on a germanium crystal collimator (reflecting plane (220)). The angular divergence of the beam reflected from the germanium in the Bragg position was ∿7". The second investigated crystal, Fe + 3% Si (thickness 54 μ) was oriented near the reflecting position (110) in the Laue geometry. The dimension of the section of the Fe + 3% Si crystal exposed to the γ beam was 3 × 1 mm. The intensity of the 14.4-keV γ rays passing through the crystal were measured with a NaI(Tl) crystal with dimensions 5 × 10 × 0.1 mm. All the measurements were performed at room temperature. Preliminary measurements verified the perfection of the illuminated part of the crystal. At a source velocity $v = v_\infty$, we measured the dependence of the intensity of the γ rays passing through the crystal on the angle of rotation of the crystal in the region of θ_B. This curve (Fig. 1) reveals an intense peak due to the Borrmann effect at $\theta = \theta_B$. The experimental half-width of the peak is 16". Thus, our crystal is close to ideal.

In the principal measurements, for a number of angular positions of the Fe + 3% Si crystal, we measured the intensity of the γ beam passing through the crystal at two source velocities, $v = v_\infty$ (N_∞) and $v = 0.31$ cm/sec (N_{res}). The velocity $v = 0.31$ cm/sec corresponds to the energy of one of the six transitions of the magnetic hyperfine splitting of Fe^{57} in Fe + 3% Si. The crystal was magnetized in the [100] direction perpendicular to the scattering plane. Under these conditions, γ rays of only one polarization take part in the excitation of the transition $-1/2 \rightarrow -1/2$ (for this polarization, the magnetic vector is perpendicular to the scattering plane). It is precisely for this polarization that total suppression of the nuclear absorption of the γ rays takes place. The normal absorption factor (under conditions when θ is far from θ_B and $v = v_{res}$) for γ rays with this polarization is $\mu t = (\mu t)_{el} + (\mu t)_{nuc} = 2.8 + 2.7 = 5.5$. The duration of a single measurement (for each of the two velocities) was 4000 sec. From these measurements we determined for each angle the value of $T_{res}(\theta) = N_{res}(\theta)/N_\infty(\theta)$. (We first subtracted from the values of N_{res} and N_∞ the background, which amounted to ∿60 counts in 4000 sec.)

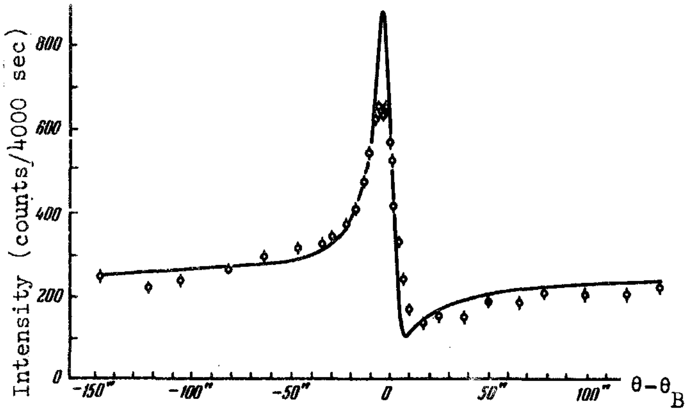

Fig. 1. Angular dependence of the nonresonant ($v = v_\infty$) transmission of 14.4-keV γ rays of Fe^{57} in single-crystal Fe + 3% Si. Solid line - theoretical curve for ideal crystal.

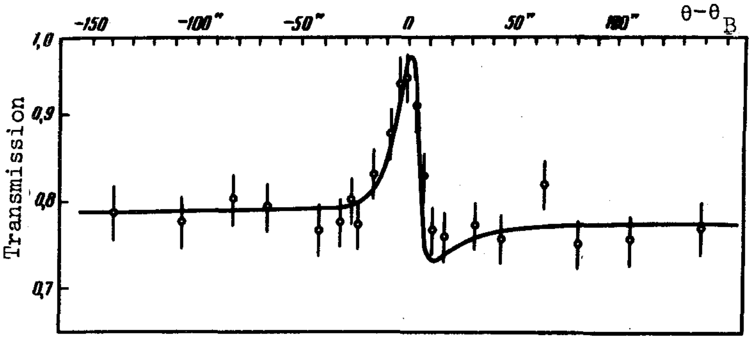

Fig. 2. Angular dependence of the resonant ($v = v_{res}$) transmission of 14.4-keV γ rays of Fe^{57} in single-crystal Fe + 3% Si, $T_{res}(\theta) = N_{res}(\theta)/N_\infty(\theta)$. Solid line - theoretical curve for ideal crystal.

Results and discussion. The quantity $T_{res}(\theta)$ characterizes the angular characterizes the angular dependence of the transmission, due only to nuclear resonant absorption. We note that $T_{res} = 1 - \varepsilon(\theta)$, where $\varepsilon(\theta) = [N_\infty(\theta) - N_{res}(\theta)]/N_\infty(\theta)$ is the usual magnitude of the resonant-absorption effect.

Figure 2 shows the results of measurements of $T_{res}(\theta)$, obtained after averaging over four series of measurements. The solid line was obtained on the basis of the theory of [1], and in its calculation we integrated over the angle and over the energy for the γ rays incident on the crystal. The agreement between the experimental results and the theory is good. We note two main features of the obtained $T_{res}(\theta)$ curve: 1) The $T_{res}(\theta)$ curve has a clearly pronounced peak at $\theta = \theta_B$ with half-width ∿20". The resonant absorption of the γ rays far from θ_B amounts to ∿23%, and in the region of θ_B it drops to ∿5%. We thus see obviously a sharp decrease of the nuclear resonant absorption of the γ rays. The absorption coefficient μ_{nuc} far from θ_B is 500 cm^{-1} and decreases to 60 cm^{-1} near θ_B, i.e., by a factor 8.4. The incomplete suppression of the nuclear absorption (ε = 5% and not zero at $\theta = \theta_B$) is due mainly to the insufficiently small angular divergence of the γ rays incident on the crystal. 2) The $T_{res}(\theta)$ dependence has a somewhtt asymmetrical dispersion form, and the T_{res} levels to the right and to the left of θ_B are different. This is due to the fact that the crystal investigated by us is not thick enough. According to the theory [1], diffraction is accompanied, besides absorption by the wave state, also by formation of the strongly absorbable state, which is not completely absorbed in our crystal and produces the asymmetry of $T_{res}(\theta)$.

For our Fe + 3% Si crystal, the ratio of the amplitudes of the scattering of the γ rays by nuclei and electrons is $f_{nuc}/f_{el} \simeq 0.08$. Therefore the wave field in the crystal is formed mainly as a result of the diffraction by electrons. We are presently carrying out measurements on an α-Fe_2O_3 crystal made of enriched iron (~85% Fe^{57}). In this case $f_{nuc}/f_{el} \simeq 10$ and the effect of normal transmission of the resonant γ rays is due mainly to diffraction by the nuclei.

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ACCELERATION OF COSMIC ELECTRONS AND POSSIBLE MECHANISM OF FORMATION OF THE SPECTRUM OF METAGALACTIC X-RADIATION

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The problem of the mechanism whereby the cosmic-electron spectrum is produced has by now become very important. On the one hand, it is closely connected with the problem of the origin of cosmic rays, and on the other it is of independent significance, since the electrons are the sources of the background radiation of the universe. Apparently, the diffuse x-radiation of the metagalaxy is produced by Compton scattering of relativistic electrons by radiation of longer wavelength (relict, infrared, etc.). The spectrum of the diffuse x-radiation of the metagalaxy has been investigated in sufficient detail. For photons in the energy interval $1.5 < E < 40$ keV, it is described by the expression $I(E) < E^{-\alpha}$ at $\alpha \simeq 0.7 - 0.8$. At $E \simeq 40$ keV, the spectrum experiences a kink, after which α becomes equal to 1.2 - 1.3. At low energies, there is only one experimental point at E = 280 eV. The high value of the x-ray flux at this point has led a number of authors [1, 2] to the conclusion that there exists one more kink in the energy region below 1 keV. However, the available experimental data are not sufficient to make the conclusion unambiguous [3]. Most authors [2 - 4] have reached the conclusion that the kink at $E \simeq 40$ keV is due to the kink in the spectrum of the electrons responsible for the x-radiation. The spectrum of these electrons corresponds to the spectrum of the electrons of our galaxy, which was determined both on the basis of radio-emission data and by direct measurements [5, 6]. However, the mechanism of formation of this spectrum was not considered.