the Stark effect [6] for the state n = 3, namely $\alpha = 2.5 \times 10^{-17}$ cm^3, and with the value calculated from the known polarizability of the hydrogen atom [7] starting from the well known radius of the exciton for the state with n = 3, namely $\alpha \approx 10^{-17}$ cm^3.

In this communication we do not describe a number of extraneous phenomena observed by us, such as the long-wave shift of the exciton line under simultaneous action of the magnetic and electric fields, the excitation and variable behavior of the weak extraneous lines in the region of the yellow series of the exciton, the dependence of the ionization of the exciton on the direction of the magnetic field, and other phenomena. These influences will be the subject of a more detailed communication.

[1] E. F. Gross, B. P. Zakharchenya, and O. V. Konstantinov, Fiz. Tverd. Tela 3, 305 (1961) [Sov. Phys.-Solid State 3, 221 (1961)].
[2] A. G. Samilovich and L. L. Korenblit, Dokl. Akad. Nauk SSSR 100, 43 (1955).
[3] E. F. Gross, B. P. Zakharchenya, and P. P. Pavinskiy, Zh. Tekh. Fiz. 27, 477 (1957) [Sov. Phys.-Tech. Phys. 2, 429 (1958)]; E. F. Gross, J. Phys. Chem. Solids 8, 172 (1959).
[4] E. F. Gross, Usp. Fiz. Nauk 76, 457 (1962) [Sov. Phys.-Usp. 5, 219 (1962)].
[5] E. F. Gross and B. P. Zakharchenya, Dokl. Akad. Nauk SSSR 111, 564 (1956) [Sov. Phys.-Dokl. 1, 678 (1957)]; E. F. Gross and B. P. Zakhartchenia, J. phys. radium, No. 1, 68 (1957).
[6] E. F. Gross, B. P. Zakharchenya, and L. M. Kanskaya, Fiz. Tverd. Tela 3, 972 (1961) [Sov. Phys.-Solid State 3, 706 (1961)].
[7] H. Bethe and A. Salpeter, Quantum Mechanics of One and Two Electron Atoms, Springer, 1957.

EXPERIMENTAL OBSERVATION OF THE SUPPRESSION OF THE INELASTIC CHANNEL OF A NUCLEAR REACTION IN THE INTERACTION OF RESONANT γ RADIATION WITH NUCLEI AND ELECTRONS IN A SINGLE CRYSTAL

V. K. Voitovetskii, I. L. Korsunskii, and Yu. F. Pazhin
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In resonant interaction of γ quanta with nuclei possessing low-lying levels, the excited nucleus can decay via different channels. If the ratio of the widths of the inelastic and elastic channels $\Gamma_1/\Gamma_2 \ll 1$ then, inasmuch as the magnitude of the resonant cross sec-

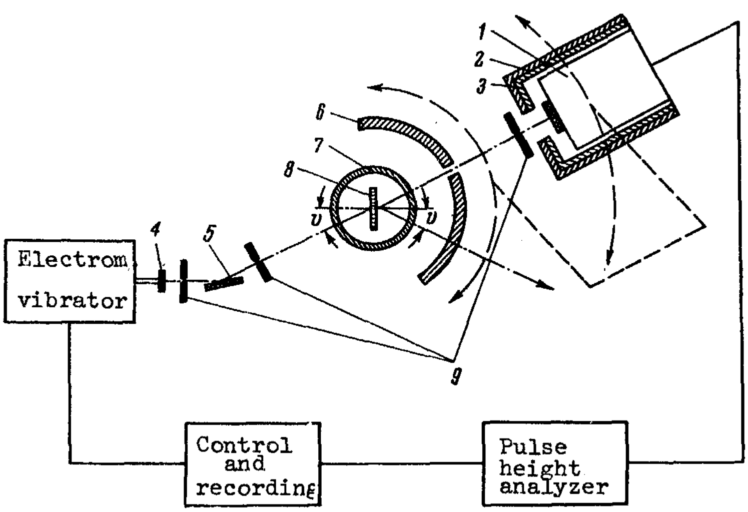

Fig. 1. Experimental setup: 1 - scintillation counter; 2 - lead screen; 3 - steel screen; 4 - $Sn^{119m}O_2$ source; 5 - monochromator; 6 - iron shield; 7 - vacuum chamber of cryostat; 8 - Sn crystal; 9 - diaphragms.

tion is large, even a very narrow layer of matter absorbs the beam of γ quanta almost completely and converts them into electrons. The character of the nuclear processes, in particular the ratio of the elastic and inelastic widths, change appreciably if the interaction between the nuclei and the γ quanta becomes collective.

In an ideal crystal, if the Bragg conditions are satisfied, a state with definite energy corresponds to a superposition of two plane waves. Under certain conditions, the excited-nucleus production amplitudes, and in the simplest cases the intensity of the electric or magnetic field, can turn out to be equal in magnitude and opposite in sign for the incident and diffracted waves. In resonant scattering of γ quanta by nuclei, the scattered wave is coherent with the primary wave [1]. Consequently, in the case under consideration, the probability of formation of an excited nucleus becomes equal to zero, and the inelastic scattering channel becomes fully suppressed. Such a result, which is paradoxical from the point of view of the usual notions of nuclear physics, can be rigorously justified by the dynamic theory of the resonant interaction of γ radiation and neutrons with a regular system of nuclei [2,3] [1)].

The suppression of the inelastic channel of the reaction, which leads to the transparency of the nuclei to resonant γ radiation, was observed by us experimentally in an investigation of Laue diffraction in a perfect single crystal of tin of natural isotopic composition.

The experimental setup is shown in Fig. 1. It employs a two-crystal spectrometer with modernized GUR-4 goniometer and a Mossbauer spectrometer with constant velocity. A Bragg-Laue arrangement of the reflecting crystals (1 - 1) is used. The 23.8-keV radiation separated by the monochromator [2)] (radiation source $Sn^{119m}O_2$) was scattered by a tin single crystal. The scattered γ-ray beam and the beam passing through the crystal were registered by a scintillation counter with a single-channel pulse-height analyzer. An NaI(Tl) crystal and an FEU-74 photomultiplier, having a high sensitivity to small noise levels, were used in the scintillation counter. The intrinsic counter background was 0.5 counts/min.

The tin single crystals used in the experiments were grown on oriented primers in optically polarized forms [5]. The Borrmann effect [6] was noticed in considerable sections of these crystals. Prolonged annealing at 224°C broadened the region of the perfect structure to cover practically the entire crystal. The experimental Mossbauer spectra of the Sn^{119m} γ radiation, obtained with this crystal by Bragg diffraction [7], as well as the relative intensities of MoK_β radiation scattered in different reflection orders [1], were close to those calculated for ideal crystals.

Figure 2 shows plots of the intensity of the transmitted (I) and scattered (II) radiations against the angle of rotation of the investigated crystal near the Bragg angle. The

[1)] The case considered in [2] is idealized, when the γ radiation interacts only with the nuclei. Under real conditions, an appreciable contribution to the formation of the wave fields (and even the major contribution if the content of the Mossbauer isotope is insignificant) is made also by scattering from the electron shells of the atoms [4].

[2)] The angular divergence of the γ-ray beam was ~5'.

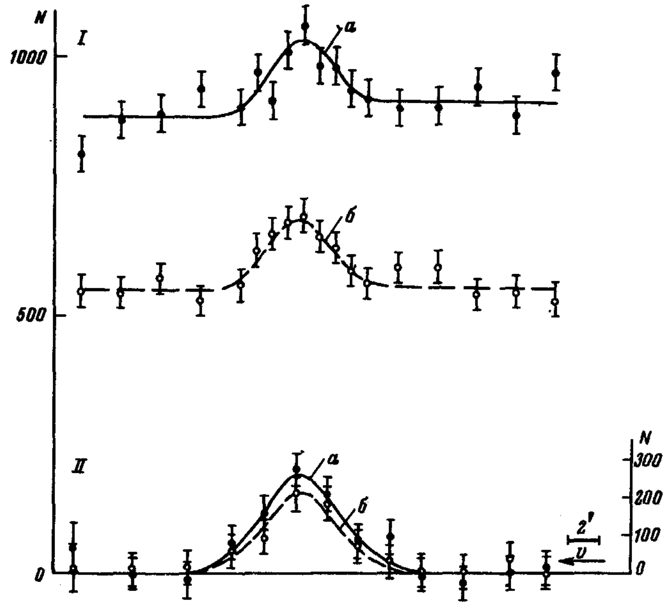

Fig. 2. Intensities of the transmitted (I) and scattered (II) radiations vs. angle of crystal rotation near the Bragg angle in Laue diffraction of γ radiation from Sn^{119m} in single-crystal tin of natural isotopic composition: a relative source and absorber velocity 10 mm/sec; b - resonant velocity (2.55 mm/sec).

scatterer temperature was 120°K. The crystal thickness was 400 μ. The reflection planes were (200). Curves Ia and IIa were obtained at a relative source-scatterer velocity far from resonance (10 mm/sec) and correspond to anomalous transmission of the γ rays by the electron shells of the atoms. Curves Ib and IIb were obtained under resonance conditions (the chemical shift for $Sn^{119}O_2$ amounts to 20.5×10^{-8} eV or 2.55 mm/sec). Each point of the experimental curves represents the total intensity of the γ radiation passing through the crystal or the scattered γ radiation.

When the angles between the incident radiation and the reflecting crystallographic plane differ greatly from the Bragg angle, the resonant absorption in the crystal amounts to (38.5 ± 2)%. The Mossbauer component passing anomalously through the crystal (part of this radiation is represented by the peaks on the curves) is absorbed much more weakly. In the region of angles corresponding to the peak on the curves (this region is limited to deviations of the average beam-incidence angle from the Bragg angle within the limits of the beam divergence) the decrease of the resonant absorption reaches on the average 10% even if the entire radiation is incident on the crystal. At a beam divergence ~5', the greater part of the radiation is incident on the crystal at angles far from the Bragg angle, and is normally absorbed on passing through the crystal, thus greatly decreasing the effective attenuation of the absorption [1)]. The attenuation of the resonant absorption at a crystal position such that the Bragg condition is satisfied for a certain part of the radiation incident on the

[1)] The effective attenuation of the absorption is influenced also by the fact that the crystal is not ideal.

crystal is direct proof of the existence of the effect of suppression of the inelastic channel of the nuclear reaction.

For a quantitative estimate of the effective suppression of the inelastic channel of the nuclear reaction, we compared the intensities of the diffracted beam off resonance and at resonance (curves IIa and IIb). In this case the influence of the radiation incident on the crystal at angles far from the Bragg angle is completely excluded. To increase the statistical accuracy, we summed the intensities of the diffracted radiation for all the angles on curves IIa and IIb. The experimental value of the resonant absorption in the diffracted beam amounts to $(22.6 \pm 6)\%$, which agrees well with the theoretical value of this quantity for single-crystal tin. Owing to the suppression of the inelastic channel of the nuclear reaction, the resonant absorption is weakened by a factor 1.7.

It should be noted that suppression of the inelastic channel of the nuclear reaction was observed in a tin single crystal having Mossbauer-effect anisotropy. When the Bragg conditions are satisfied in such a crystal, the nuclei are not nodes of the magnetic field (M1 transition in Sn^{119}), but for γ quanta having the same polarization the probability of formation of an excited nucleus is equal to zero. The observed effect does not take place in irregular systems, and consequently, we have shown experimentally for the first time that the result of a nuclear reaction depends significantly on how the nuclei are arranged in space.

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[1] V. K. Voitovetskii, I. L. Korsunskii, and Yu. F. Pazhin, Phys. Lett. 27A, 244 and 244 (1968); Zh. Eksp. Teor. Fiz. 54, 1361 (1968) [Sov. Phys.-JETP 27 (1968)].
[2] A. M. Afanas'ev and Yu. M. Kagan, Zh. Eksp. Teor. Fiz. 48, 327 (1965) [Sov. Phys.-JETP 21, 215 (1965)].
[3] Yu. M. Kagan and A. M. Afanas'ev, ibid. 49, 1504 (1965) [22, 1032 (1966)].
[4] Yu. M. Kagan, A. M. Afanas'ev, and I. P. Perstnev, ibid. 54, 1530 (1968) [27 (1968)].
[5] Yu. V. Sharvin and V. F. Gantmakher, PTE 6, 175 (1963).
[6] V. K. Voitovetskii, I. L. Korsunskii, and Yu. F. Pazhin, Phys. Lett. 27A, 207 (1968).
[7] V. K. Voitovetskii, I. L. Korsunskii, and Yu. F. Pazhin, ZhETF Pis. Red. 8, 563 (1968) [JETP Lett. 8, 343 (1968)].

OBSERVATION OF PLASMA INSTABILITY IN A STRONG ALTERNATING ELECTRIC FIELD

L. I. Grigor'eva, B. I. Smerdov, K. N. Stepanov, B. A. Fetisov, and V. V. Chechkin
Physicotechnical Institute, Ukrainian Academy of Sciences
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It was shown theoretically in [1-3] that an instability connected with excitation of small-scale high-frequency oscillations is produced in a plasma in the presence of currents perpendicular to the external magnetic field and caused by a strong alternating electric field, provided the electrons and the ions of the plasma acquire a sufficiently large relative velocity $u_\perp$. The reaction of the oscillations on the beam causes deceleration of the beam and heating of either the ions or the electrons or both, depending on the relation between $u_\perp$, T_e, and T_i [1,4,5].