of 1.5 million Oe.

[1] N. B. Brandt, E. A. Svistova, Yu. G. Kashirskii, and L. V. Lyn'ko, ZhETF Pis. Red. 7, 12 (1968) [JETP Lett. 7, 7 (1968)].
[2] N. B. Brandt, E. A. Svistova, Yu. G. Kashirskii, and L. V. Lyn'ko, Zh. Eksp. Teor. Fiz. 56, 65 (1969) [Sov. Phys.-JETP 29 (1969)].
[3] G. A. Baraff, Phys. Rev. 137, A842 (1965).
[4] G. E. Smith, G. A. Baraff, and I. M. Rowell, ibid. 135, 4A, 1118 (1964).
[5] N. B. Brandt, E. A. Svistova, and G. Kh. Tabieva, ZhETF Pis. Red. 4, No. 1 (1966) [JETP Lett. 4, 17 (1966)].

OBSERVATION OF INTERFERENCE OF CONVERSION AND OF THE PHOTOEFFECT UPON ABSORPTION OF 26-keV GAMMA QUANTA BY Dy_2O_3

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Yu. Kagan and A. M. Afanas'ev called our attention to the existence of an interesting physical phenomenon, consisting in the possibility of interference between processes of internal conversion and the photoeffect upon interaction of resonant Mossbauer radiation with atoms. Indeed, the final electronic states coincide for these two processes. Then, provided the projection of the nuclear spin remains unchanged during the internal conversion process, the photoeffect and the conversion become physically indistinguishable processes, and interference between the two should take place in the general case.

In the theory developed by Kagan, Afanas'ev, and Voitovetskii [1] it is shown that this interference should in principle be manifest in the energy dependence of both the cross section $\sigma_{\gamma e}$ of the γ - e reaction and the total cross section σ_t of the absorption of resonant gamma quanta. With this, σ_t is given by

$$\sigma_t = \sigma_{ph} + f_a\sigma_0[(1 + \beta_\gamma x)/(1 + x^2)]. \tag{1}$$

Here σ_{ph} is the photoabsorption cross section, f_a the probability of the Mossbauer effect in the absorber, σ_0 the resonance cross section, $x = 2(E_\gamma - E_a)/\Gamma_a$ (E_γ is the gamma-quantum energy, E_a and Γ_a the position and width of the absorption line, respectively), and finally β_γ is a numerical coefficient which determines the relative contribution of the interference term to the total cross section.

The quantity β_γ depends in an essential manner on the multipolarity of the nuclear transition. For almost all transitions except E1, this coefficient is very small. In the case of E1 transitions, however, β_γ is expressed directly in terms of the known quantities and is given by the formula

$$\beta_\gamma = 2\sqrt{(1/3)[(2I + 1)/(2I_0 + 1)]\alpha/(\alpha + 1)(\sigma_{ph}/\sigma_0)}, \tag{2}$$

where I_0 and I are the spins of the ground and excited states of the nucleus and α is the internal-conversion coefficient.

According to the results of [1], an interference term of the same nature is present also in the total cross section of the γ-e reaction and should be manifest in an asymmetrical character of the shape of the Mossbauer line, measured by registering the electrons. Naturally, however, the part of $\sigma_{\gamma e}$ which is symmetrical in the velocity no longer contains a term corresponding to the ordinary resonance scattering of the gamma quanta, thus increasing the relative contribution of the interference term. The energy dependence of the γ-e reaction is given by (1), in which σ_0 should be replaced by $\sigma_0^{(2)}$ (the conversion cross section at resonance) and the parameter β_γ replaced by $\beta_e = [(\alpha + 1)/\alpha]\beta_\gamma$.

An estimate of the parameters β_γ and β_e (see the table) shows that the gamma absorption cross section of almost all the Mossbauer nuclei with E1 transition contains a strongly pronounced interference term.

Nucleus	Dy^{161}		Gd^{155}	Np^{237}	Ta^{181}
E_γ, keV	25.7	74.6	86.5	59.5	6.25
β_γ	0.077	0.152	0.048	0.075	0.291
β_e	0.108	0.386	0.164	0.145	0.297

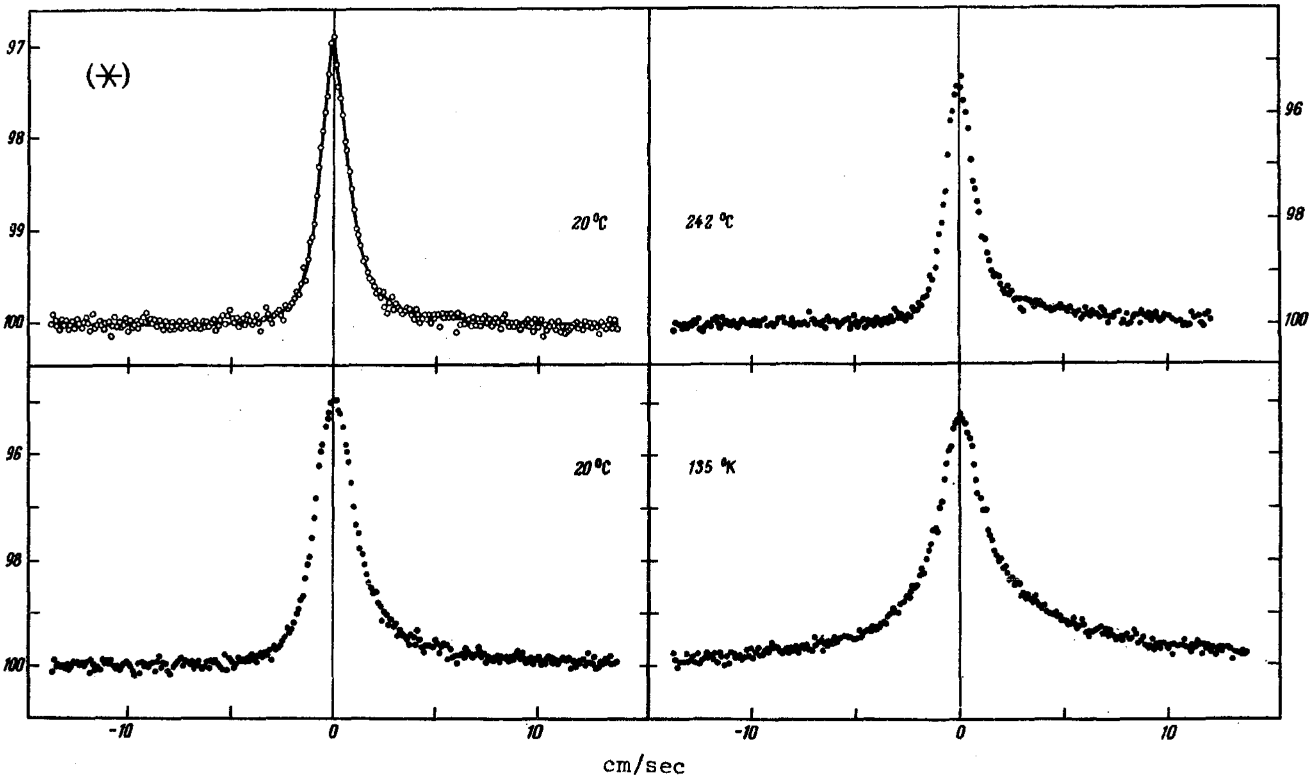
As seen from the table, the largest effect should be expected in experiments in which conversion electrons are registered. We note, however, that the usual Mossbauer measurements of the intensity of gamma quanta passing through an absorber are experimentally simpler than experiments in which conversion electrons are registered.

We have therefore started our investigation of the interference between conversion and photoeffect by studying the absorption line shape, choosing as the object Dy^{161} with a transition energy 25.7 keV. We present here the results of this investigation. We note here that recently Sauer, Matthias, and Mossbauer published results of experiments on resonance absorption of gamma quanta in Ta^{181} and observed a sharp asymmetry of the absorption line. Recognizing that $\beta_\gamma = 0.291$ for Ta^{181}, there is no doubt that the indicated asymmetry is connected precisely with the interference phenomenon investigated in the present paper.

The source used by us was Gd_2O_3 enriched to 97% with Gd^{160} and irradiated in a reactor. The source was at room temperature and was moved with constant acceleration by an electrodynamic vibrator fed from an electronic block with feedback. The error signal (the difference between the velocity signal and the standard sawtooth signal) was less than 0.1% of the standard signal in the entire employed velocity range (up to 15 cm/sec). The Mossbauer spectra were obtained with a 512-channel analyzer (NTA-512) operating in the time mode.

The asborber was polycrystalline powdered Dy_2O_3 enriched to 90% with Dy^{161}. Two absorbers were used, with thicknesses 18 and 117 mg/cm^2, respectively.

The measured spectra are shown in the figure, where the spectrum marked with the asterisk pertains to the thin absorber, and the remaining three to the thick one. As seen from the figure, all the spectra have a clearly pronounced asymmetric character, the asymmetry being much stronger for the thick absorber. The solid curve on the spectrum of the thin absorber was calculated in accordance with the theory of Kagan, Afanas'ev, and Voitovetskii for the



Mossbauer absorption spectra in $D_2^{161}O_3$. The number of pulses per velocity channel is 3.3 x 10^6 for the spectrum (*) and 1.8 x 10^6 for all others.

parameter value β_γ = 0.077 and is in good agreement with the experimental data. We note that the small value of β_γ is the reason why the interference between the conversion and the photoabsorption is relatively weak (although noticeable at good statistics).

It is possible, however, to intensify this effect artificially enough to make it visually observable. This is attained by simply increasing the absorber thickness. Indeed, in the case of a thin absorber, and also in the case of a thick one at velocities v satisfying the condition $\sigma|1 + \beta_\gamma v| \ll 1 + v^2$, the absorption increases in proportion to the increase of the effective absorber thickness σ. On the other hand, when v = 0 the absorption practically reaches saturation starting with a certain effective thickness σ. At the same time, at larger velocities, the absorption still continues to increase with increasing σ. We used this circumstance to increase the contribution of the interference term, which becomes most strongly manifest at velocities different from zero.

Thus, the present results, as well as the results of [2], show the presence of interference betwen the photoeffect and conversion when resonant gamma quanta interact with Mossbauer atoms, and also manifestation of this interference in experiments on ordinary Mossbauer absorption in the case when the corresponding nuclear transition is E1, meaning that the predictions of [1] can be regarded as definitely proved.

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[1] Yu. Kagan, A. M. Afanas'ev, and V. K. Voitovetskii, ZhETF Pis. Red. 8, 342 (1968)[sic!]

[2] C. Sauer, E. Matthias, and R. L. Mossbauer, Phys. Rev. Lett. 21, 961 (1968)

In the article by V. D. Gorobchenko et al., Vol. 9, No. 4, the first literature reference [1] should read: "... ZhETF Pis. Red. 9, 155 (1969)[JETP Lett. 9, 91 (1969)]."