change the parameters A^0 and γ^0. A comparison of the measured (continuous line) and calculated (dark points) relations for two-channel scattering (Fig. b) shows sufficiently good agreement, making it possible to assume that the values of the parameters of the potential energy surface ($A^* = 230$ eV, $\gamma^* = 3.8$ Å^{-1}) and of the probability ($p = 0.4$) are reliable. Some discrepancy in the region of the peak is apparently due to the approximate character of the calculation, and in particular to the neglect of the existence of distributions of the quantities Δq_∞ and θ^*, due to the real population of the vibrational levels of the excited and de-activated molecules.

In conclusion, we summarize the main results.

1. We measured the differential scattering cross section of the molecules N_2 in the ground and metastable states. We observed for the first time effects connected with impact de-activation of $N_2(A^3\Sigma_u^+)$.

2. We reconstructed the surface of the potential energy of the interaction of $N_2(X^1\Sigma_g^+)$ with $N_2(A^3\Sigma_u^+)$ and obtained its intersection with the surface for the ground-state molecules.

3. The results enable us to estimate the total cross section for impact deactivation of the $A^3\Sigma_u^+$ state of N_2, namely $Q \approx 3.3$ Å^2; this value disagrees with $Q \approx 1$ Å^2 obtained in [6].

[1] Yu.N. Belyaev, V.B. Leonas, and A.V. Sermyagin, Collected abstracts of V I.C.P.E.A.C., Leningrad, Nauka, 1967, p. 643.
[2] A.P. Kalinin, V.B. Leonas, and A.V. Sermyagin, Vestnik, Moscow State Univ., Phys. Ser., No. 3, 245 (1971).
[3] A. Salop, D.C. Lorents, and I.R. Peterson, J. Chem. Phys. 54, 1187 (1971).
[4] A.P. Kalinin and V.B. Leonas, Dokl. Akad. Nauk SSSR 197, 393 (1971).
[5] V.B. Leonas, A.V. Sermyagin, and N.V. Kamyshov, Chem. Phys. Lett. 8, 282 (1971).
[6] I.R. Sheridan and I.R. Peterson, J. Chem. Phys. 51, 3574 (1969).

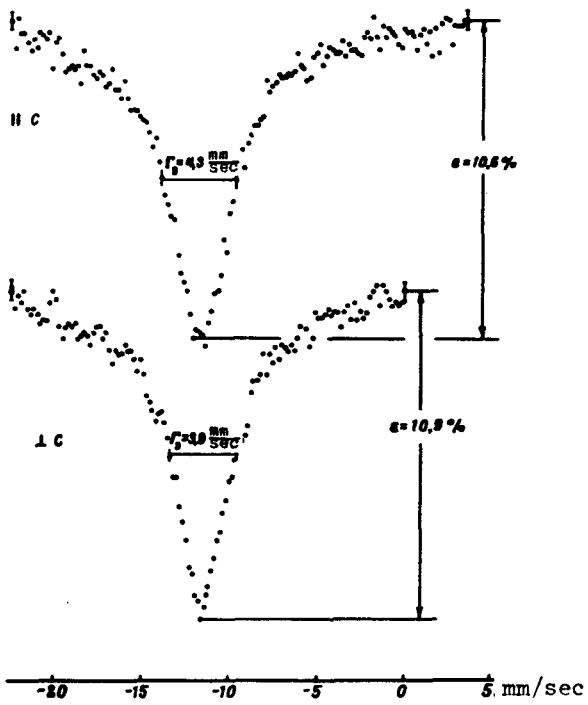
ANISOTROPY OF THE MOSSBAUER EFFECT IN ANTIMONY SINGLE CRYSTALS

I.A. Avenarius, R.N. Kuz'min, and A.A. Opalenko
Physics Department, Moscow State University

Submitted 10 September 1971
ZhETF Pis. Red. 14, No. 9, 484 - 487 (5 November 1971)

Of greatest interest in the investigation of the Mossbauer-effect anisotropy in pure elements are single crystals of tin, tellurium, and antimony. Single crystals of tin and tellurium were investigated in [1 - 4]. We report here the results of a study of the anisotropy of the probability of resonant absorption of 37.2-keV γ quanta by Sb^{121} nuclei in antimony single crystals at liquid-nitrogen temperature.

Crystalline antimony has rhombohedral syngony, space group $R\bar{3}m$, and lattice parameters $a = 4.4928$ Å and $\alpha = 57°12'$ at liquid-nitrogen temperature [4]. Each unit cell has two atoms located on the spatial diagonal [111] of the rhombohedron, which is the inversion of the threefold axis C. Each atom has three nearest neighbors at a distance 2.87 Å, and is bound to them covalently, forming a folded layer. The shortest distance between atoms of different layers is 3.47 Å, and the binding forces between layers are much weaker. Therefore the greatest strength of the crystal is observed in the (111) planes parallel to the folded layers of the atoms, and the crystal is relatively easily damaged in directions perpendicular to these layers. Antimony exhibits



anisotropy of physical properties. The linear-expansion coefficient in the temperature range 78 - 90° has values $\alpha_{\parallel} = 15.48 \times 10^{-6}$ and $\alpha_{\perp} = 5.27 \times 10^{-6}$.

The Mossbauer spectra were obtained for single crystals grown by zone melting. The absorbers had two orientations: The γ radiation propagated parallel to the C axis in the first absorber, 37.5 mm/cm^2 thick, and perpendicular to the C axis in the second 23.2 mg/cm^2 thick. The experiments were performed on an electrodynamic setup with constant acceleration, and the γ source was the compound $BaSn^{121}O_3$, with line width Γ = 1.6 ± 0.1 mm/sec. The γ quanta were registered with a scintillation counter with NaI(Tl) crystal 0.2 mm thick, using the emission peak. The source and absorber were kept at liquid-nitrogen temperature in a low-temperature chamber, and the absorber was set in motion.

The Mossbauer spectra of antimony single crystals of two orientations are shown in the figure, with indication of the magnitude of the effect ε and of the line width Γ_e. The isomer shift relative to the $BaSn^{121}O_3$ source was the same for both orientations, δ = -11.6 ± 0.1 mm/sec. The experimental values of f' are listed in the table.

Direction of gamma quanta in crystal	Crystal thickness mg/cm^2	Area under curve, corrected for bacground	Probability of resonant absorption, f'
∥ C	37.5 ± 0.3	$S_{\parallel}$ = 1.69 ± 0.07	$f'_{\parallel}$ = 0.117 ± 0.010
⊥ C	23.2 ± 0.4	$S_{\perp}$ = 1.51 ± 0.06	$f'_{\perp}$ = 0.160 ± 0.010

To find f' from the experimental data, we used the dependence of the area under the curve on the effective absorber thickness $C_A = n\sigma_0 f'$:

$$S = \kappa f \pi e^{-\frac{C_A}{2}}\left[I_0\left(\frac{C_A}{2}\right) + I_1\left(\frac{C_A}{2}\right)\right], \qquad (1)$$

where κ is the fraction of the resonant γ quanta among those registered, I_0 and I_1 are Bessel functions of zeroth and first order of imaginary argument, and f is the probability of resonant emission of 37.2-keV γ quanta and its value can be estimated from data on the probability of the Mossbauer effect for 23.8-keV γ quanta from Sn^{119} in the $BaSnO_3$ lattice. $f_{BaSnO_3}(Sn^{119}) = \exp[-\text{const}(23.8)^2]$ and $f_{BaSnO_3}(Sb^{121}) = \exp[-\text{const}\ (37.2)^2]$, from which we get at $f_{BaSnO_3}(Sn^{119}) = 0.72$ [5] the value $f_{BaSnO_3}(Sb^{121}) = 0.45$. This value was

used to calculate the absolute values of the probability of resonant absorption, $f'_{\parallel}$ and $f'_{\perp}$. To determine the anisotropy $f'_{\parallel}/f'_{\perp}$, we plotted $S_{\parallel}/S_{\perp}$, calculated from formula (1), against $f'_{\parallel}$ for the absorber thicknesses used in this experiment, at different values of the anisotropy $f'_{\parallel}/f'_{\perp}$. A comparison of the experimental and calculated results yielded $f'_{\parallel}/f'_{\perp} = 0.73 \pm 0.09$.

Antimony single crystals have axial symmetry, and therefore the angular dependence of the probability of the Mossbauer effect for antimony can be written in the form

$$f'(\theta) = \exp\left\{-\frac{4\pi^2}{\lambda^2}[\langle x^2\rangle + (\langle z^2\rangle - \langle x^2\rangle)\cos^2\theta\right\}, \qquad (2)$$

where θ is the angle between the C axis and the propagation direction of the γ quanta, λ is the wavelength of the resonant γ quanta, $\langle z^2\rangle$ is the mean-squared displacement of the atom from the equilibrium position along the C axis, and $\langle x^2\rangle$ is the mean-squared displacement in the direction perpendicular to the C axis. For antimony at liquid-nitrogen temperature expression (2) takes the form

$$f'(\theta) = \exp\{-1.83 - 0.32\cos^2\theta\}. \qquad (3)$$

This shows that $\langle z^2\rangle > \langle x^2\rangle$.

By integrating (3) over all angles from $-\pi/2$ to $\pi/2$ we find that the probability of the resonant absorption in the polycrystal is $f' = 0.145 \pm 0.015$. To verify the correctness of the obtained anisotropy, we plotted the Mossbauer spectrum of a polycrystalline absorber. The experimental data yielded $f' = 0.15 \pm 0.01$, which agrees within the limits of experimental error with the value calculated from the obtained anisotropy $f'_{\parallel}/f'_{\perp} = 0.73 \pm 0.09$.

[1] N.E. Alekseevskii, A.P. Kir'yanov, V.I. Nizhankovskii, and Yu.A. Samarskii, ZhETF Pis. Red. 2, 269 (1965) [JETP Lett. 2, 171 (1965)].
[2] N.E. Alekseevskii and A.P. Kir'yanov, ibid. 9, 92 (1969) [9, 53 (1969)].
[3] R.N. Kuz'min, A.A. Opalenko, V.S. Shpinel', and I.A. Avenarius, Zh. Eksp. Teor. Fiz. 56, 167 (1969) [Sov. Phys.-JETP 29, 94 (1969)].
[4] T.P. Das and E.H. Hygh, Phys. Rev. 143, 452 (1966).
[5] S.M. Irkaev, R.N. Kuz'min, and A.A. Opalenko, Yadernyi γ-rezonans (Nuclear Gamma Resonance), MGU, 1970, p. 65.

INDUCED EMISSION ON A NUMBER OF TRANSITIONS OF THE RUBIDIUM ATOM FOLLOWING TWO-PHOTON EXCITATION

A.M. Bonch-Bruevich, V.A. Khodovoi, and V.V. Khromov
S.I. Vavilov Optical Institute

Submitted 13 September 1971
ZhETF Pis. Red. 14, No. 9, 487 - 490 (5 November 1971)

A number of nonlinear phenomena caused by pumping of potassium and rubidium vapor by laser radiation were reported in [1 - 8], where scattered radiation in the direction of the pump beam was observed. Some of the observed phenomena have not been reliably interpreted to this day.

We present here the results of an investigation of intense directional radiation on a number of transitions of the rubidium atom in the blue, red, and infrared regions (the IR transitions in rubidium vapor were never observed before). A comparison of the intensities of the different components of the radiation scattered forward, backward, and at right angle to the pump beam has