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

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

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 $f'_{\parallel}/f'_{\perp} = 0.73 \pm 0.09$.

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

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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

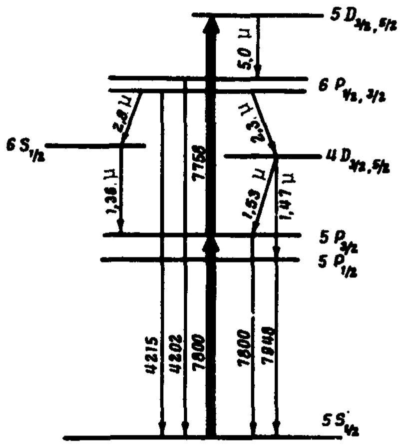

Fig. 1. Term scheme of rubidium atoms.

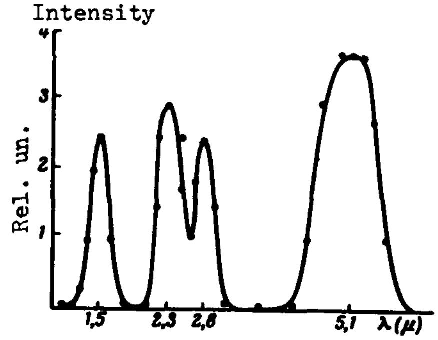

Fig. 2. IR scattering spectrum.

made it possible to establish the channels of the atomic transitions and the scattering mechanisms, namely stimulated cascade generation and induced parametric scattering following two-photon excitation of the rubidium atoms. The results can be used to explain the phenomena observed in [1 - 8].

The rubidium vapor was excited with a laser using a solution of 1, 3, 3, 1', 3', 3'-hexamethylindotricarbocyanine iodide in ethanol, with a power density 20 MW/cm^2 and a pulse duration 20 nsec. The laser radiation was focused (f = 550 mm) on a cell with rubidium vapor (ℓ = 70 mm). The distribution of the intensity in the spectra of the transmitted radiation and of the radiation scattered backward or at right angle was registered with the aid of an STE-1 spectrophotograph or an IKM-1 monochromator with an IR photoreceiver based on InSb. The laser radiation was linearly polarized and its spectrum was in the 775 - 785 nm and overlapped the wavelengths of the rubidium transitions $5S_{1/2}$ - $5P_{3/2}$ and $5P_{3/2}$ - $5D_{3/2,5/2}$ (Fig. 1). The rubidium cell had sapphire windows and could be heated with air to 350°C.

The main experimental results are the following.

1. At an exciting radiation power density on the order of 10 MW/cm^2, intense directional radiation was observed in the spectrum of the light transmitted through the vapor, with wavelengths 4202, 4215, and 7948 Å, corresponding to the $6P_{1/2,3/2}$ - $5S_{1/2}$ and $5P_{1/2}$ - $5S_{1/2}$ transitions of the rubidium atom. The threshold of the appearance of all these lines was approximately the same. The intensity of the 4202 and 4215 Å blue lines increased with increasing rubidium vapor pressure from 10^{-3} to 1 mm Hg and with decreasing divergence of the exciting radiation, even if the power of the exciting radiation was decreased somewhat thereby. The intensity of the 7948 Å red line at a fixed excitation power reaches the optimal value at a vapor pressure on the order of 10^{-1} mm Hg.

2. It was established that there were no blue lines in the back-skattered radiation (their intensity was lower by at least two orders of magnitude than in the forward direction), whereas the intensity of the red lines remained approximately the same as in the forward direction. Directed radiation with λ = 7800 Å ($5P_{3/2}$ - $5S_{1/2}$ transition) was observed also in the backward direction, and could not be observed in the forward direction against the background of the powerful exciting radiation.

3. Directed intense radiation was observed also in the transverse direction. To observe it, the laser radiation was focused with a cylindrical lens on the cell with the rubidium vapor so as to fill the entire cross section of the cell, and the observation was at right angle to the exciting beam in the direction of the longest part of the excitation region. Under these conditions, likewise, only the 7800 and 7948 Å red lines were observed.

4. An IKM-1 monochromator (dispersion 0.18 μ/mm at λ = 10 μ) with a photoreceiver based on InSb was used to investigate the spectrum of the induced emission in the IR region. The signal from the photoreceiver located behind the exit slit of the monochromator was amplified and registered with an oscilloscope (the line contour was plotted point by point). The exciting radiation, together with the radiation in the blue and red lines, was reliably cut off with a silicon plate. New lines were observed at 1.5, 2.3, 2.8, and 5.1 μ, corresponding to the following transitions of the rubidium atom (Fig. 1): $5D_{3/2,5/2}$ - $6P_{1/2,3/2}$, $6P_{1/2,3/2}$ - $6S_{1/2}$, $6P_{1/2,3/2}$ - $4D_{3/2,5/2}$, and $4D_{3/2,5/2}$ - $5P_{1/2,3/2}$. The intensities of all these lines were approximately equal.

Summarizing, we can draw the following conclusions with respect to the mechanism of the observed phenomena.

The absence of blue lines in the backward and transverse directions allows us to conclude that the main role in the appearance of these lines is played by four-photon parametric processes with absorption of two pump photons and with emission of a blue and IR photon. To the contrary, the emission of the red lines is obviously connected with the appreciable population of the $5D_{3/2,5/2}$ states, cascade generation on all the low-lying levels $6P_{1/3,3/2}$, $6S_{1/2}$, $4D_{3/2,5/2}$, and inverted population of the states $5P_{3/2}$ and $5P_{1/2}$ relative to the ground state. It is possible that a contribution to the population of the $5P_{1/2}$ level is made also by electronic stimulated Raman scattering from the $5P_{3/2}$ level [9]. The absence of generation on the $5D_{3/2,5/2}$ - 5P transition is apparently due to the small oscillator strength of this transition (it is lower by one order of magnitude than for the 5D - 6P transitions).

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