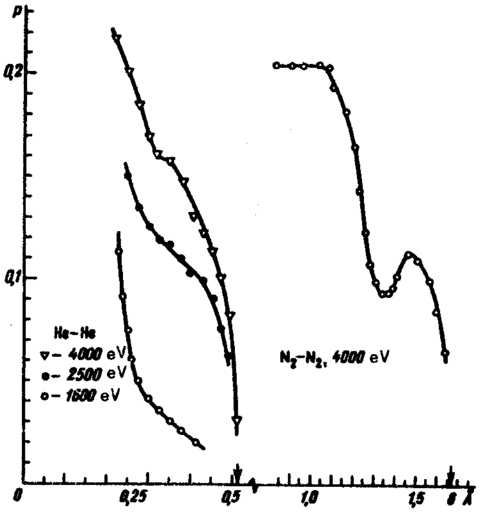

Fig. 2

Of considerable interest are the differential cross sections for atom-atom ionization, obtained here for the first time. For the systems He-He and N_2-N_2, Fig. 2 shows the dependence of the probability of electron loss by the fast particle, P on the impact distance b (here $P = \sigma^+(\theta)/[\sigma^0(\theta) + \sigma^+(\theta)]$, and $\theta(b)$ was assumed to be the same for both types of particles). The next to last column of the table gives the threshold values of b_n marked by arrows in Fig. 2.

The absolute values of P(b) depend on the velocity (Fig. 2); moreover, in the case of Xe-Xe in the investigated range of angles (albeit in the corresponding interaction energy 1 - 100 eV), it was impossible to register any ions. Assuming the values of $\theta(b)$ to be the same, the interaction energy at the ionization threshold $U(b_n)$ exhibits a distinct correlation with the ionization potential: $U(b_n) = E_u$. Attention is called to the presence of a structure on the P(b) curves. The N_2-N_2 system is the most remarkable in this respect; from the values of U(b) it is possible to assume that the second increase of P(b) is apparently connected with the opening of a channel for double ionization of fast particles. Using the measured values of $\sigma^+(\theta, E)$ it is possible to extrapolate the behavior of $\sigma^+(\theta)$, to estimate the ionization cross section σ_{0I}, which was measured earlier by a number of workers (for a bibliography, see [6]); a comparison of these values (at 4000 eV) with the data in the last column of the table reveals a reasonable agreement.

The $\sigma^+(\theta, E)$ and P(b) plots obtained in the present work make it possible to evaluate critically various theoretical approaches to the description of ionization process in atomic collisions and to choose the most suitable one.

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SRS IN RUBIDIUM VAPOR WITH FREQUENCY VARIATION NEAR RESONANCE

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Although stimulated Raman scattering (SRS) has already been obtained by several workers in alkali-metal vapors [1 - 4], the dependence of its threshold on the wavelength of the exciting radiation has not been studied until recently. To this end, we excited SRS in rubidium vapor by means of a laser with adjustable frequency. We obtained both the anti-Stokes SRS connected with the atomic transitions $5^2P_{3/2} \rightarrow 5^2P_{1/2}$ [3, 4] and the hitherto unobserved Stokes SRS connected with the inverse transition. To populate the initial level, we used the emission from another laser with adjustable frequency, tuned to the frequency of the corresponding resonant line of rubidium.

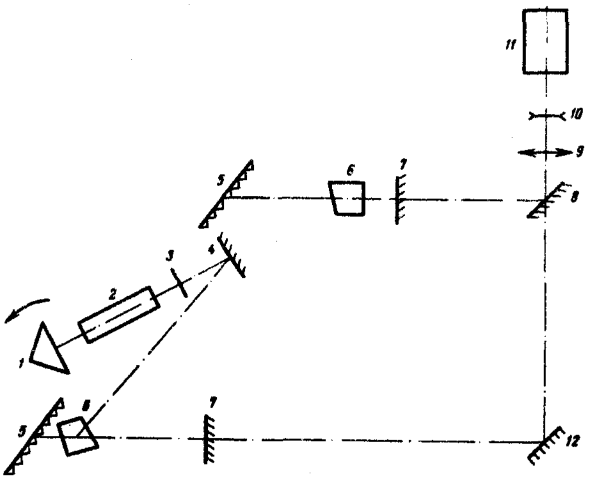
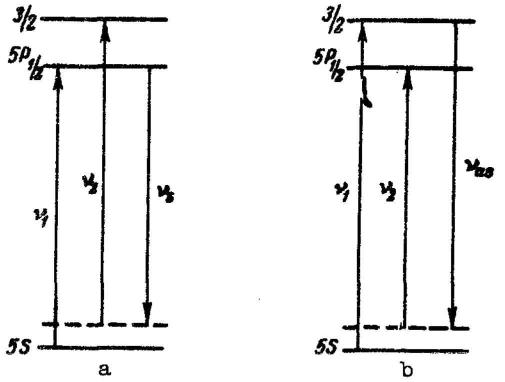


Fig. 1. Diagram of experimental setup.



a

b

Fig. 2. Scheme of transitions: a) Stokes SRS, b) anti-Stokes SRS.

The adjustable frequency was generated by a combination of two dye lasers. Synchronization of the pulses was ensured by exciting both lasers with a single pulse from a Q-switched ruby laser. The experimental setup is shown in Fig. 1. Here 1 is a rotating prism, 2 the ruby crystal, 3 a plane-parallel glass plate serving as the output mirror of the ruby laser, 4 a beam-splitting semitransparent mirror, 5 diffraction gratings used to vary the frequency, 6 cells with dye, 7 output mirrors of the dye lasers, 12 and 18 total-reflection and semitransparent mirrors, 9 and 10 lenses of a telescopic system to reduce the beam cross section to 2 or 3 mm, and 11 a cell with ruby vapor, 15 cm long.

The maximum radiation power incident on the cell from each laser was 350 kW. The pulse duration of each laser was 40 nsec, and the spectral width was approximately 6 cm^{-1}.

Figure 2 shows the scheme of the transitions in the case of Stokes and anti-Stokes SRS. Here ν_1 is the frequency of the radiation populating the initial level, ν_2 the frequency of the exciting radiation, and ν_s and ν_{as} the Stokes and anti-Stokes SRS frequencies.

The frequency dependence of the SRS threshold was investigated at the maximum radiation power of the frequency ν_1 (350 kW) and at a vapor pressure 0.05 mm Hg.

At a pressure higher than 0.1 mm Hg, the SRS threshold increased appreciably. This can be attributed to the fact that at high pressures the number of excited atoms in the working volume (~ 1 cm^3) approaches the maximum value determined by the spectral density of the populating radiation and by the absorption line width, which should be of the order of 1 cm^{-1} if account is taken of the level broadening under the influence of the radiation field [5]. In the high-pressure region at constant power of the populating radiation, the number of excited atoms in the working volume hardly increases with increasing pressure. At the same time, an increase of the pressure increases the radiation loss resulting from breakdown in the vapor.

We present below results of an investigation of the Stokes SRS. Figure 3 shows spectrograms demonstrating the effect of tuning the Stokes SRS frequency when the frequency of the exciting radiation is changed from 7900 Å (top) to 7720 Å (bottom). The experimental value of the SRS threshold at a 100 cm^{-1} deviation from the frequency of the resonant transition $5^2S_{1/2} - 5^2P_{3/2}$ amounted in our conditions to ~2 $\mathrm{MW/cm}^2$ (at 0.05 mm Hg). Calculation shows that this value of the threshold is in satisfactory agreement with the theoretical value of the effective scattering cross section, $d\sigma/d\Omega = 6.7 \times 10^{-21}$ cm^2, obtained using the oscillator strengths cited in [6]. When resonance is approached from the high-frequency side, up to within 30 cm^{-1}, the SRS threshold decreases, in accord with the theory, approximately in proportion to the square of the detuning. With further decrease of the detuning, however, the lowering of the threshold slowed down. At a detuning of 15 cm^{-1}, the SRS threshold was 0.14 $\mathrm{MW/cm}^2$, about double the expected value. This can apparently be attributed to the influence of other processes that come into play when the exciting-radiation frequency approaches the frequency of a resonant transition $5^2S_{1/2} - 5^2P_{3/2}$.

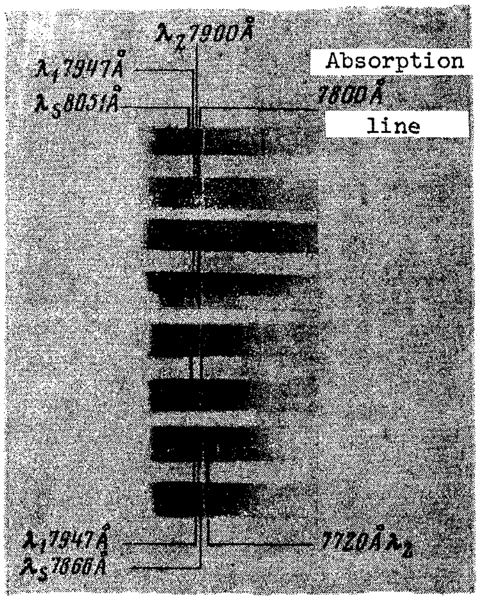


Fig. 3. Spectrogram of Stokes SRS radiation: λ_1, λ_2, λ_s) wavelengths of the populating, exciting, and Stokes radiation. The absorption spectrum of rubidium vapor is shown for comparison.

When the detuning was smaller than 10 - 15 cm^{-1}, it was difficult to observe the SRS line because it was close to the populating-radiation line. When resonance was approached from the short-wave side, an appreciable increase of the SRS threshold was observed when the frequency of the exciting radiation was close to the frequency of the two-photon transition 5S - 5D.

Similar regularities were established in investigations of the anti-Stokes SRS, but in accord with the theoretical data, the SRS threshold was noticeably higher in this case.

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