manifested by a sharp rise of the curve at $L \to 0$. A similar result is obtained when the homogeneity of the field is varied but the symmetry is maintained (by bringing polycrystalline rods closer to both ends of the sample). The intensity of the effect of conversion by the field inhomogeneities decreases in this case by $\sim$20 dB from its initial value, while the intensity of the spin Mandel'shtam-Brillouin effect remains unchanged, thus confirming the nature of the latter.

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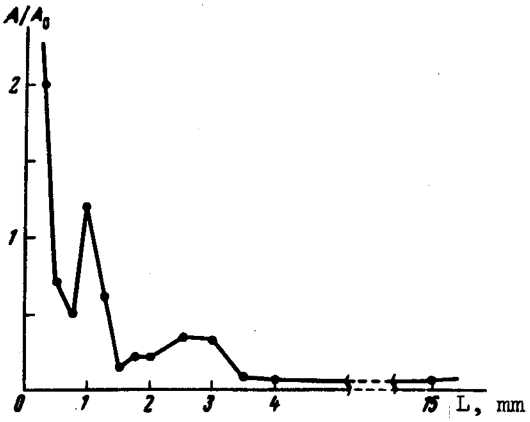

Fig. 2. Ratio of the intensity A of the first-order spin Mandel'shtam-Brillouin effect to the intensity $A_0$ of the conversion on the field inhomogeneities, as a function of the symmetry of the internal field in the sample. L - distance between the nearest faces of the investigated sample and the polycrystalline rod.

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# EXPERIMENTAL INVESTIGATION OF THE DIFFERENTIAL CROSS SECTION OF ELASTIC SCATTERING OF EXCITED ATOMS BY ELECTRONS OF A GAS-DISCHARGE PLASMA

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The investigation referred to in the title was performed in the following manner: Radiation from a single-mode helium-neon laser ($\lambda$ = 6328 Å) was absorbed in a gas-discharge tube with neon (solid arrow in Fig. 1) and produced a "Bennett peak" in the distribution of the atoms Ne($3s_2$) (i.e., Ne atoms at the $3s_2$ level) with respect to the velocity v. When Ne($3s_2$) collides with the plasma electrons, Ne(j) atoms at the level j are produced (dashed arrow in Fig. 1), having a different distribution with respect to v. Modulation of the laser light makes this fraction of the atoms at j alternating and facilitates its measurement by determining the emission in the $j \to i$ transitions (wavy arrow of Fig. 1). The line contour[1] of the modulated $j \to i$ radiation is given by

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[1] Our experiment is analogous to that of [1], except that we measured the line contour, whereas the integrated line intensity was measured in [1].

(for observation collinear with the laser beam)

$$I(\omega) \propto \int_{-\infty}^{\infty} \frac{\Gamma_{jl}/\pi}{\Gamma_{jl}^2 + (\omega - \omega_{jl} - k_{jl}v)^2}\, q(v)\, dv\,, \tag{1}$$

$$q(v) = \int_{-\infty}^{\infty} A(v', v)\, W_{\mathrm{B}}(v')\, dv'; \qquad W_{\mathrm{B}}(v) = \frac{(\Gamma_{mn}/\pi)\, e^{-v^2/\bar{v}^2}}{\Gamma_{mn}^2 + (\omega_o - \omega_{mn} - k_{mn}v)^2} \tag{2}$$

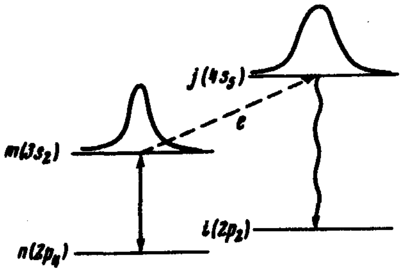

Fig. 1. Level and transition scheme. The horizontal lines denote the levels; the curves over the lines show the velocity-distribution increments of W(v) and q(v) due to the absorption of the laser field.

$W_{\mathrm{B}}(v)$ describes the "Bennett peak"; A(v', v) is the probability of the $3s_2 \to j$ transition with a velocity change $v' \to v$ in collisions with the electron; q(v) is the part of N(j) produced by the laser field and by the inelastic atom-electron scattering. If the width of A(v', v) is much larger than $\Gamma_{mn}/k_{mn}$ or $\Gamma_{ji}/k_{ji}$, then the I(ω) plot duplicates that of A(v', v) (with v recalculated to account for the Doppler shifts).

We present the final formulas for A(v', v) in the Born-Behthe approximation [2] for a Maxwellian electron velocity distribution

$$A(v', v) = \frac{1}{a\bar{v}}[1 - \Phi(y)]; \quad y = \frac{|v - v'|}{a\bar{v}}; \quad a\bar{v} = 2\frac{m_e}{m_a}\bar{v}_e, \tag{3}$$

$$A(v', v) = \frac{2}{\epsilon d\bar{v}}\left\{e^{-\epsilon}\left[1 - \Phi\left(\frac{\epsilon}{4y} - y\right)\right] - \left[1 - \Phi\left(\frac{\epsilon}{4y} + y\right)\right]\right\} \tag{4}$$

$$\bar{v} = \sqrt{2k_{\mathrm{B}}T/m_a}; \quad \bar{v}_e = \sqrt{2k_{\mathrm{B}}T_e/m_e}; \quad \epsilon = (E_j - E_{3s_2})/k_{\mathrm{B}}T_e.$$

Formulas (3) and (4) correspond to optically forbidden and allowed $3s_2 \to j$ transitions; Φ(z) is the probability integral; $m_e$ and $m_a$ are the electron and atom masses. In the derivation of (3) and (4) it was assumed that $\varepsilon \ll 1$.

The width σ of the kernel (3) at half-height is given by the formula

$$\sigma = 0.954\, a\bar{v} = 1{,}908\frac{m_e}{m_a}\bar{v}_e, \tag{5}$$

which has a simple interpretation: the atom receives a momentum $m_a\sigma$ approximately equal to double the momentum $m_e\bar{v}_e$ of the "mean thermal" electron. The width of the kernel (4) is

$$\sigma = 1.043\,\epsilon a\bar{v} = 2.086\frac{m_e}{m_a}\bar{v}_e = 1.043\frac{4(E_j - E_{3s_2})}{m_a\bar{v}_e}, \tag{6}$$

i.e., it is smaller than in (5) by an approximate factor $\varepsilon \ll 1$. The interpretation of (6) is different: the momentum acquired by the atom, $m_a\sigma \simeq \varepsilon 2m_e v_e = 4(E_j - 3E_{3s_2})/\bar{v}_e$, is determined by the energy transferred to the internal degrees of freedom.

Owing to the large value of $\bar{v}_e$, the width of the kernel may amount to an appreciable fraction of v ($\bar{v}_e \sim 10^8$ cm/sec; $\alpha \sim 0.1$).

From (1) we readily obtain the following estimate of the line half-width

$$\delta \cong \Gamma_{ji} + k_{ji}\left[\frac{1}{2}\sigma + \frac{\Gamma_{mn}}{k_{mn}}\right]. \qquad (7)$$

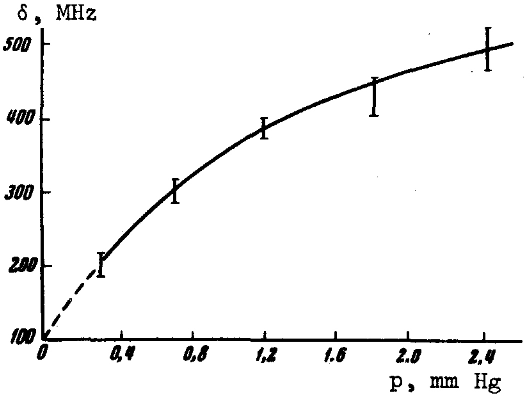

Fig. 2. Line half-width δ vs the pressure p. Dashed curve - extrapolation to p = 0.

We have investigated (using a Fabry-Perot interferometer, thickness 75 mm, real resolution 80 MHz) the contour of the 5589.3 Å $4s_5 - 2p_2$ line, at different neon pressures p. The measured values of the half-width are shown in Fig. 2. Extrapolation to zero pressure[2]) yields

$$\delta = 100 \pm 20 \text{ MHz} = (0{,}63 \pm 0{,}15)\cdot 10^9 \text{ sec}^{-1}. \qquad (8)$$

Let us compare (7) and (8). Using the data for the radiative widths $\Gamma_{k\ell} = (\Gamma_k + \Gamma_\ell)/2$ [3, 4], we find

$$\Gamma_{4s_5} + k_{ji}\sigma = 160 \pm 40 \text{ MHz} = (1{,}01 \pm 0{,}25)\cdot 10^9 \text{ sec}^{-1}. \qquad (9)$$

The value of $\Gamma_{4s_5}$ is unknown, but the transition from $4s_5$ to the ground state is forbidden, and $\Gamma_{4s_5}$ can in no way be of the order of $10^9$ sec$^{-1}$. We therefore assume that the anomalously large value of δ is due to scattering of the atoms by the electrons, i.e., to the term $k_{ji}\sigma$. The transition $3s_2 \rightarrow 4s_5$ is forbidden and we can use formula (5). For $T_e = 10^5$°K (the only poorly-defined parameter in (5) is $\sqrt{T_e}$) we have $k_{ji}\sigma$ = 148 MHz, which agrees well with (9).

Insofar as we know, the results so far constitute the only direct data on the differential cross section of inelastic scattering of excited atoms. All the earlier data pertain to the ground state, and from the point of view of collision theory the proposed method offers unique possibilities. The data obtained are of interest also for the theory of Doppler broadening of spectral lines and the analysis of a number of nonlinear phenomena in gases [5 - 7].

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[2]) The reason for the nonlinear dependence of δ on p is not perfectly clear; this may be partly due to the change of the atom velocity following the collisions with Ne(1p), and also with the fact that the ratio $\delta/(k_{ji}\bar{v})$ is finite. These assumptions require a detailed verification. The curve of Fig. 2 is presently regarded only as a means of extrapolating to p = 0.

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# ANOMALOUS DISSIPATION OF MICROWAVE ENERGY IN A COLLISIONLESS PLASMA

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A number of recent investigations [1 - 3] are devoted to various aspects of the anomalous interaction of microwaves with a collisionless plasma, namely, the heating of the electronic component [1], absorption of microwave energy in a plasma [2], and decay of a bounded plasma [3]. A common property of the foregoing phenomena was the fact that the frequency of the Coulomb collisions of the electrons with the ions, $\nu_{ei} \sim 10^5 - 10^6$ sec$^{-1}$, was lower by 3 - 4 orders of magnitude than the effective collision frequency $\nu_{eff}$ needed to give rise to the observed dissipative effects. Theoretical investigations of instability of a plasma in a microwave field [4 - 7] give grounds for assuming that the anomalous increase in the dissipation of the microwave energy is due to the onset of parametric instability in the plasma. Measurements [3] of the threshold value of the electric field of the wave in anomalous decay, as a function of the plasma density, have shown qualitative agreement with the theory of [5], viz., the threshold intensity decreased by 2 - 3 orders of magnitude when the plasma electron density n approached a critical value $n_0$ at which the Langmuir electron frequency equals the circular frequency of the external field, $\omega_{Le} = \omega_0$.

The purpose of the present investigation was to study simultaneously the effects of wave absorption and electron heating in a uniform plasma layer.

The experiment was performed with a plasma stream of uniform density [3] crossing a rectangular waveguide perpendicular to the broad wall, with an ion translational velocity $10^7$ cm/sec. To this end, a length of 15 cm of one of the broad walls of the waveguide was replaced by a conducting grid. The waveguide was excited in the 10 cm band at the $H_{10}$ mode, in which the direction of the electric-field force lines coincided with the direction of motion of the plasma stream through the waveguide. As is well known, the electric field intensity varies only along the broad wall of the guide: $E(x) = E_0 \cos(\pi x/a)$ (a is the dimension of the broad wall). Cutoff of wave propagation in the plasma-filled waveguide begins at a density $n = 0.6 n_0$ (in the presence of anomalous dissipation). We note immediately that the concentration of the ions in the plasma stream remained unchanged even at high level of microwave energy dissipation in the plasma. The absence of anomalous decay under these conditions will be explained below. The duration of the microwave power pulse was $3 \times 10^{-6}$ sec. The anomalous distribution assumed its steady-state value within a time $\Delta t \sim 10^{-7}$ sec.