Figure 2 shows the experimental dependence of the amplitudes of the main and stimulated echoes on the intervals τ_1 and τ_2, respectively. Within the limits of errors, the experimental points lie on straight lines, indicating that diffusion processes do not make a noticeable contribution to the damping of the echo signals. This confirms the assumption made above that the diffusion is effectively limited by the small dimensions of the metal particles. Neglecting the diffusion terms in the expressions for $v_1(\tau_1)$ and $v_2(\tau_2)$, we obtain from the experimental plots of Fig. 2 $T_1 = (1.06 \pm 0.15)$ μsec and $T_2 = (1.03 \pm 0.10)$ μsec. Together with the value $T_2^* = (1.13 \pm 0.10)$ μsec obtained from the measurements of the width of the stationary absorption line (the peak width of the resonance line of our sample is $\delta H = 58 \pm 5$ mG), these data indicate that $T_1 = T_2 = T_2^*$, and are thus a direct experimental confirmation of the validity of an important premise of the theory of [5], that the relaxation times of the longitudinal and transverse components of the spin magnetization of CE are equal.

We note in conclusion that for bulky metals the diffusion of CE leads to an exceedingly rapid damping of the echo signals. This is probably why they observed in [6] only the free-induction signals that follow directly the microwave pulses, and could not measure the echo signals in bulky samples of lithium and sodium. At the same time, further research on the spin echo of CE in samples of intermediate dimensions, $d \simeq 5 - 10$ μ, affords a direct method of measuring the diffusion velocity of CE.

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CONNECTION BETWEEN THE WAVE FRONTS OF THE REFLECTED AND EXCITING LIGHT IN STIMULATED MANDEL'SHTAM-BRILLOUIN SCATTERING

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In stimulated Mandel'shtam-Brillouin scattering (SMBS) the back-scattered light propagates usually in the same solid angle as the exciting radiation [1]. It has never been ascertained whether this fact is connected only with the geometry of the experiment or whether it has a deeper meaning. To answer this question, we have compared the wave fronts of the reflected and exciting light.

The experimental setup is shown in Fig. 1. The wave front of the ruby-laser radiation is distorted by the plate P, made by etching polished glass in fluoric acid. The laser beam has a divergence 0.14 × 1.3 mrad. The divergence of the light passing through the plate is 3.5 mrad. This light enters a hollow glass light pipe of square cross section, placed in a cell with methane gas[1].

[1]The methane is at room temperature and 125 atm pressure. Under these conditions, the gain due to the SMBS is approximately 0.09 cm/MW and the gain line width is ∿20 MHz [3].

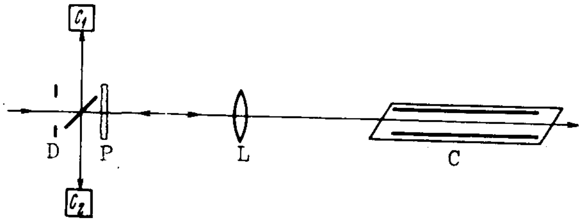

Fig. 1

Fig. 2

Fig. 1. Experimental setup: D - diaphragm (6 × 6 mm); P - plate 1.3 mm thick, with surface roughnesses ~150 μ high and ~1 μ deep (see [2] concerning the optical properties of such a plate), distance between plate and diaphragm 10 cm; L - lens of 10 cm diameter and focal length 100 cm; C - cell with light pipe; cell length 96 cm, light pipe length 94 cm, cross section 4 × 4 mm; C_1 and C_2 - systems for the measurement of the parameters of the laser and reflected light.

Fig. 2. Spectrograms of exciting (left) and scattered (right) radiation. The dispersion of the Fabry-Perot etalon is 3.33×10^{-2} cm^{-1}.

Since the radiation is incident on the light-pipe walls at glancing angles, the coefficient of Fresnel reflection from them is close to unity. This ensures constancy of the pump intensity along the cell. To prevent lasing, the cell windows are inclined 45°.

The plate P is illuminated by a beam of rectangular cross section, shaped by diaphragm D. Large-aperture lens L produces an image of the illuminated region at the entrance to the light pipe, the size of the image being equal to the dimension of the entrance aperture of the light pipe. As a result, the entire laser radiation, registered by the measuring system C_1, enters the light pipe after passing through the plate P and the lens. The system C_2 registers the reflected light, which also passes through the lens and the plate.

The ruby laser operates on one axial mode, and its radiation at the entrance to the cell has a maximum power ~1.3 MW at a pulse duration at half-height ~110 nsec. The laser is decoupled from the cell by an optical isolator built around on a Faraday cell.

The spectrum of the reflected line reveals one line (Fig. 2), the shift of which relative to the laser-emission line corresponds to scattering through 180°.

The photograph of Fig. 3a shows the distribution of the laser radiation in the far zone. The photograph of the far zone of the reflected radiation is shown in Fig. 3b. We see that the reflected radiation, after passing through the plate P, has practically the same divergence as the laser light. This is also confirmed by the fact that the ratio of the intensities determined by processing the negatives 3b and 3a is equal to the value of the reflection coefficient (~25%) obtained from calorimetric measurements.

A different picture is observed if the cell with methane is replacec by a flat mirror (see Fig. 3c). In this case the divergence of the reflected light greatly exceeds the divergence of the laser emission and equals 6.5 mrad.

Passage through the etched plate makes the coherent-light beam highly inhomogeneous in its cross section, owing to interference between the waves traveling in different directions [2]. To determine the influence of these inhomogeneities on the SMBS process, we photographed the far zone of the reflected light in the absence of the plate (Fig. 3d). In this case the

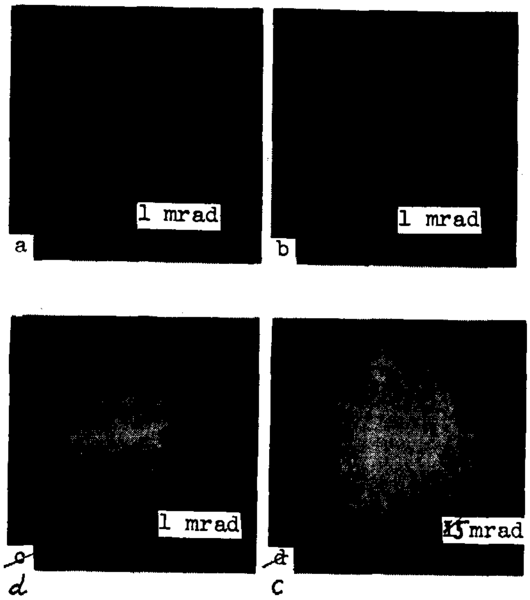

Fig. 3. Photographs of the distribution in the far zone: a - laser radiation, b - scattered radiation, c - light reflected by a flat mirror, d - scattered light in the absence of plate P. The photographs were obtained by the procedure of [4].

divergence of the scattered radiation greatly exceeds that of the exciting light.

The experimentally observed "correction" of the wave front of the backscattered radiation, effected with the same phase plate that had distorted the initial laser wave, can be explained if it can be demonstrated that the scattered field (signal) $E_S(r_\perp, z)$ in the plane $z = z_0$ coincides (apart from a factor) with the complex-conjugate laser field $E_L^*(r_\perp, z)$:

$$E_s(r_\perp, z_0) \approx \text{const}\, E_L^*(r_\perp, z_0). \tag{1}$$

The plane $z = z_0$ is perpendicular here to the average direction of the beam and is located near the plate on the side of the scattering cell. We present semiquantitative arguments favoring satisfaction of (1).

It is easy to show that the dependence of the gain and of the reactive component of the nonlinear polarizability on the scattering angle θ can be neglected when θ is varied in the experiment from 0 to 3×10^{-3}. Therefore the propagation of the signal wave $E_S(r_\perp, z) = \exp[ik_S z]\varepsilon_S(r_\perp, z)$ in the $(-z)$ direction can be described by the parabolic equation

$$\frac{\partial \epsilon_s}{\partial z} + \frac{i}{2k_s}\Delta_\perp \epsilon_s + \frac{1}{2} g(r_\perp, z)\epsilon_s = 0, \tag{2}$$

where the gain $g(r_\perp, z)$ is determined, by virtue of the foregoing, simply by the local value of the intensity of the laser field, $g(r_\perp, z) = A|E_L(r_\perp, z)|^2$. The most important aspect of the analysis is that the laser field $E_L(r_\perp, z) = \exp(ik_L z)\varepsilon_L(r_\perp, z)$ satisfies (if we neglect the terms with gain) an equation that is the complex conjugate of (2).

$$\frac{\partial \epsilon_L}{\partial z} - \frac{i}{2k_L}\Delta_\perp \epsilon_L = 0 \tag{3}$$

(it can be shown that the small difference between the coefficients k_L^{-1} and k_s^{-1} of the transverse Laplacian can be disregarded). Let us consider a system of functions $f_i(r_\perp, z)$, i = 0, 1, 2, ..., satisfying the orthogonality relation at the section $z = z_0$ and the equation that describes the propagation of the complex conjugate field of the laser:

$$\int f_i^*(r_\perp, z_0) f_j(r_\perp, z_0) dr_\perp = \delta_{ij}; \qquad \frac{\partial f_i}{\partial z} + \frac{i}{2k} \Delta_\perp f_i = 0 . \tag{4}$$

Then the orthogonality relation will hold at any section z = const. We choose a function $f_0^*(r_\perp, z)$ that coincides with the laser field: $\varepsilon_L(r_\perp, z) = Bf_0^*(r_\perp, z)$, and the remaining functions $f_i^*(r_\perp, z)$, i = 1, 2, ... are chosen arbitrarily, starting from the orthogonality condition (4). We represent the signal field in the form of an expansion

$$\varepsilon_s(r_\perp, z) = \sum_{i=0}^{\infty} C_i(z) f_i^*(r_\perp, z), \tag{5}$$

and obtain for the coefficients $C_i(z)$

$$\frac{dC_i(z)}{dz} + \frac{1}{2} \sum_{k=0}^{\infty} g_{ik}(z) C_k(z) \quad 0, \tag{6}$$

$$g_{ik}(z) = AB^2 \int dr_\perp |f_0(r_\perp, z)|^2 f_i^*(r_\perp, z) f_k(r_\perp, z). \tag{7}$$

We shall not investigate in detail the properties of the solutions of the system (6) - (7) (this should be the subject of a separate communication), and note only the following. If the diffraction of the laser field leads to appreciable oscillations of the quantity $|f_0(r_\perp, z)|^2$ over the cross section (this is precisely the situation in the experiment), the diagonal coefficient $g_{00}(z)$ which can be arbitrarily called the gain of the zeroth function) exceeds by 2 - 3 times the gains g_{ii} of the remaining functions and the values of the off-diagonal coefficients $|g_{0i}|$, $|g_{ik}|$, i, k ≠ 0. It is therefore likely that the amplitude $C_0(z)$ will increase most rapidly, and this will yield the required relation (1).

We note also that if the exciting radiation has an amplitude profile that is constant over the cross section $|f_0(r_\perp, z)|^2$ = const, then there should be no preferred production of the complex-conjugate laser-front by the signal. This agrees qualitatively with the result of the experiment without the etched plate.

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ERRATA

The following corrections are to be made in the article by V. G. Baryshevskii et al., Vol. 15, No. 2: 1) On p. 79, in the first line after formula (2), read ... $r_0 = e^2/m_e c^2$ ... instead of ... $r_0 = \ell^2/m_b c^2$... 2) In the two lines above the table on p. 80, read ..."the direction of rotation of the polarization plane"... instead of ..."the direction of the polarization plane"... 3) In the second line below the table on p. 80, read ... $|\vec{p}| = 2/26 \approx 7.69\times10^{-2}$... instead of ... $\approx 7.85\times10^{-2}$... The numerical coefficient in (5) remains unchanged.

In the article by A. A. Chaban, Vol. 15, No. 2, p. 74, line 35 from the top, read ... $\exp[i(kx \pm \omega t)]$... instead of ... $\exp[i(kx + \omega t)]$...

In the article by Ya. B. Zel'dovich et al., Vol. 15, No. 3, p. 111, frames "c" and "d" of Fig. 3 should be interchanged, and the scale in frame "c" should be 5 mrad.