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SPECTRUM OF LIGHT SCATTERED BY DENSITY AND ANISOTROPY FLUCTUATIONS IN LIQUID NITROBENZENE

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In all liquids, the spectrum of light scattered by density fluctuations consists of a linearly-polarized Rayleigh triplet, which fits within a frequency interval narrower than 1 cm^{-1} , and a continuous depolarized spectrum (the wing of the Rayleigh line), which extends to 150 cm^{-1} [1].

The frequency dependence of the intensity in the depolarized-scattering spectrum is divided roughly into two regions, one adjacent to the unshifted line ($0 - 25 \text{ cm}^{-1}$) and the remaining region [1,2].

The region directly adjacent to the unshifted line - the narrow or diffuse wing, considered in detail by Starunov [2] - is characterized by a different width and intensity. Its maximum coincides with the unshifted line. In liquids with anisotropic molecules, which are relatively viscous at room temperature (glycerin, triacetin, salol, acetic acid, etc.) the diffuse wing is very narrow [1].

Of special interest is nitrobenzene - a liquid whose molecules have a very large anisotropy, and whose viscosity is ~ 2 centipoise. The thermal scattering spectrum of this liquid has not yet been investigated.

The use of a gas laser ($\lambda = 6328 \text{ \AA}$) as the light source affords a qualitatively different opportunity for simultaneously investigating the narrow diffuse wing and the fine-structure lines.

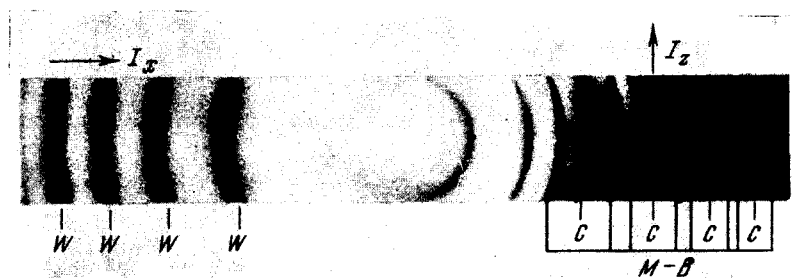


Fig. 1. Spectrum of thermal scattering of light in nitrobenzene. M-B - Mandel'shtam-Brillouin components, C - central component, W - diffuse wing. Fabry-Perot interferometer dispersion region - 0.50 cm^{-1} .

Figure 1 shows the thermal-scattering interference spectrum of nitrobenzene. The ap-

paratus was the same as used by Mash et al. [3] but the scattered light passed through a Wollaston prism ¹⁾ oriented in such a way that one of its principal planes was perpendicular to the scattering plane (Z-polarization) and the other parallel to it (X-polarization). Therefore on the right side of the figure (I_z) we see the fine structure spectrum, on which is superimposed part of the diffuse wing, and on the left side we see only the diffuse wing.

The data obtained show that the diffuse wing superimposed on the fine-structure components is depolarized, and the Rayleigh triplet in nitrobenzene is linearly polarized.

Estimates made earlier show that in nitrobenzene almost half the integral intensity of the wing is located in the part that is superimposed on the frequency region occupied by the fine-structure lines [1].

Measurements of the actual width of this part of the wing in nitrobenzene have shown that it amounts to $\sim 0.20 \text{ cm}^{-1}$. The anisotropy relaxation time corresponding to this width is $\tau \approx 5 \times 10^{-11} \text{ sec}$.

It must therefore be assumed that nitrobenzene, when used as the working medium in a light modulator based on the Kerr effect, is characterized by two times, one equal to $5 \times 10^{-11} \text{ sec}$, and the other smaller than 10^{-12} sec , and that both processes characterized by these times should play approximately equal roles ²⁾.

It must be emphasized that in liquids where a narrow and intense wing exists, the Rayleigh triplet is "raised" wholly or in part, in accordance with the intensity distribution in the wing. Therefore the distribution of the intensity among the components of the triplet is strongly distorted (Fig. 2). It is meaningful to measure the intensity ratio in the Rayleigh triplet (the Landau-Placzek ratio) if the influence of the depolarized scattering is suitably excluded.

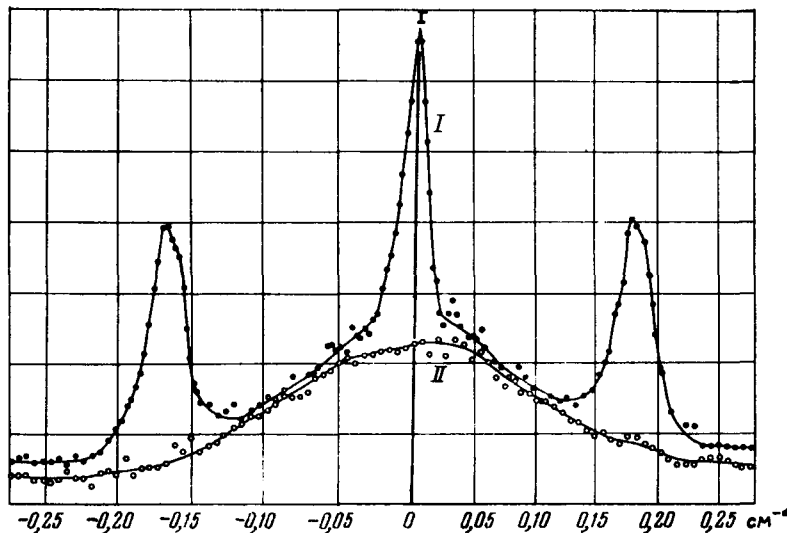


Fig. 2

In the present investigation this was done with polarization resolution of the spectrum by the method described by Fabelinskii [1]. Figure 2 shows the intensity distribution in the

Z component (curve I) and in the X component (curve II). The ordinates of the latter are multiplied by $4/3$ (the coefficient of depolarization of the wing excited by linearly polarized

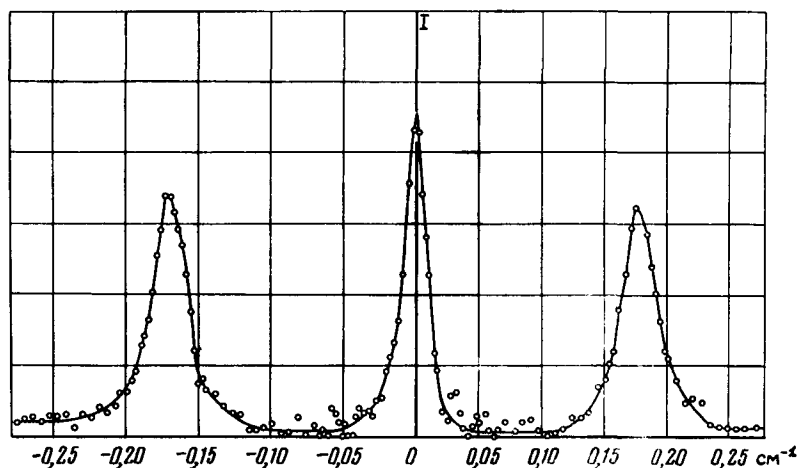


Fig. 3

light is equal to $3/4$). The difference between the ordinates of curves I and II yields a curve (Fig. 3) which is practically free of the influence of the depolarized scattering.

Results of measurements of the speed of hypersound and the width of the Mandel'shtam-Brillouin components in nitrobenzene ¹⁾ at 20°C.

Hypersound frequency f , 10^9 cps	Speed, m/sec		Speed dispersion, $\Delta v/vf \times 10^2$	MBC half-width, $\delta v \times 10^3$ cm^{-1}	Absorption, $\alpha \times 10^{-3}$ cm^{-1}	Relaxation time of bulk viscosity coef. $\tau_{\eta} \times 10^{10}$, sec	Speed at infinite frequency, v_{∞} , m/sec	Landau-Placzek ratio $I_C/2I_{M-B}$
	Ultra-sound	Hyper-sound						
5.31 ± 0.01	1473	1535 ± 3	4	22 ± 4 15 ± 2	13.5 ± 2.3 9.2 ± 1.3	0.26 ± 0.04 0.44 ± 0.11	1595 ± 20 1546 ± 24	0.49 ± 0.06

¹⁾ In the calculations of the relaxation parameters (α , τ_{η} , v_{∞}) we used data taken from [4,5]. The upper figures were obtained by calculation from the velocity-dispersion data, and the lower from the widths of the Mandel'shtam-Brillouin components using the formulas of Mash et al. [3]

Using the curve of Fig. 3, we determined the hypersound speed, the widths of the Mandel'shtam-Brillouin components, and the Landau-Placzek ratio. The measurement results and the relaxation parameters calculated from them are listed in the table. The discrepancy between the values calculated from the dispersion of the speed of sound and the width of the Mandel'shtam-Brillouin components can be attributed to the large error in the measurement of the MBC width or to the use of simplified formulas with a single τ for the calculation in [3].

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1) A quarter-wave plate is located behind the Wollaston prism to make the linear polarization of the light circular and thereby eliminate the unequal light-propagation conditions in the apparatus.

2) If the diffuse wing (Fig. 1) has a complex structure, then a relaxation time longer than 5×10^{-11} sec is possible.

OBSERVATION OF QUANTUM SIZE EFFECTS IN BISMUTH FILMS BY THE METHOD OF TUNNEL SPECTROSCOPY

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In an earlier paper by Orgin et al. [1] it was reported that quantum size effects were observed in bismuth films of thickness commensurate with the effective de Broglie wavelength of the carriers. In [1] the quantization of the energy spectrum of the carriers was manifest in an oscillatory dependence of the kinetic and galvanomagnetic coefficients on the film thickness.

In this communication we report the results of an experimental investigation of tunnel systems containing size-quantized bismuth films. It is shown in the theoretical papers [2-4] that the current-voltage characteristics of such a system should reveal a number of specific features that yield information on the structure of the carrier energy spectrum.

The measurements were made on Bi (thin film) - dielectric - Bi (thick film), Bi (thin film) - dielectric - Ag, and Bi (thin film) - dielectric - Bi (thin film) systems. We attempted to use vacuum rather than a solid dielectric for the gap, to eliminate as much as possible parasitic effects connected, for example, with tunneling through the "trap" levels in the dielectric. The dielectric employed

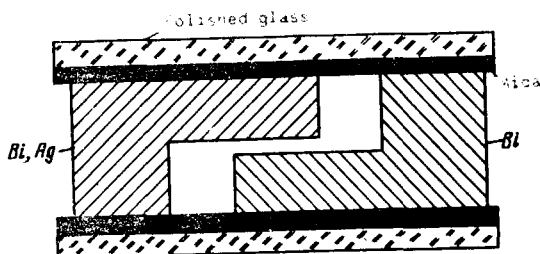


Fig. 1

was the interelectrode gap produced by assembling two independently prepared samples with an appropriate difference in the thickness of the sputtered layers (Fig. 1).