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L. V. LANSHINA and M. I. SHAKHPARONOV

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Abstract

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L. V. LANSHINA and M. I. SHAKHPARONOV

THE FINE STRUCTURE OF THE RAYLEIGH LINE OF LIGHT SCATTERING AND THE PROPAGATION VELOCITY OF HYPERACOUSTIC OSCILLATIONS IN WATER

(Presented by Academician V. V. Shuleikin, 26 X 1960)

Studies of the fine structure of the Rayleigh line in water were previously carried out by Venkateswaran (^{1}) and by Rank, McCartney, and Saucier (^{2}). Measuring the shift $\Delta\nu$ (cm^{-1}) of the Mandelstam-Brillouin (M.-B.) components relative to the center of the Rayleigh triplet and using the formula $\frac{\Delta\nu}{\nu} = 2n\frac{v}{c}\sin\frac{\theta}{2}$, Venkateswaran found that the propagation velocity of hypersonic oscillations v in water at 30° is 1509 ± 25 m/sec, i.e., coincides with the propagation velocity of ultrasound v_0. For the ratio of the intensity of the central component to the intensities of the M.-B. components, Venkateswaran obtained $I_c/2I_{\text{M.-B.}} = 0.36$. Rank et al. confined themselves to measurements of the polarization of the components of the triplet and to determining the value of the ratio $I_c/2I_{\text{M.-B.}}$; they obtained $I_c/2I_{\text{M.-B.}} = 0.14$. According to Landau and Placzek, $I_c/2I_{\text{M.-B.}} = (c_p - c_v)/c_v$; for water, calculation by this formula gives the value $I_c/2I_{\text{M.-B.}} = 0.0068$.

The measurements of Venkateswaran and of Rank, McCartney, and Saucier had a number of methodological shortcomings. A critical analysis of the methodological aspect of these works is given in the review article by I. L. Fabelinskii (^{3}). We add that in the measurements of the fine structure of the Rayleigh line of water and of a number of other liquids, as follows from the text of paper (^{1}), the temperature was maintained with an accuracy of $\pm 5°$. Such fluctuations sharply reduce the resolving power of a Fabry-Perot interferometer, leading to a broadening of the lines by an amount equal to 1/4 of an interference order at a distance between the interferometer plates of 5 mm. Evidently, for these reasons Venkateswaran did not observe the positive dispersion $\Delta v \approx 150$ m/sec in benzene and $\Delta v \approx 120$ m/sec in carbon tetrachloride, discovered by I. L. Fabelinskii and confirmed for benzene by our measurements.

In water and in aqueous solutions of methyl alcohol and acetone, according to data obtained by us earlier (^{5}), a negative dispersion of hyperacoustic oscillations of the order of 2-5% was detected. Since the magnitude of the dispersion was close to the mean square experimental error, it seemed advisable to study

Figure 2

Figure 1: Figure 2

additionally the fine structure of the Rayleigh line (λ 4358 Å) scattered by water at various temperatures. After some modernization of the experimental setup (we placed the Fabry–Perot interferometer after the spectrograph, cemented a special wedge-shaped plate onto the Wollaston prism to equalize the propagation conditions of the x- and r-components, etc.), it proved possible to improve the quality of the photographs and thereby increase the accuracy of the measurements.

The experimental conditions and the method of interpreting the photographs were the same as in ([4], [5]). In addition, all photographs were interpreted by us by the method of unilateral bands ([6]). The distance between the plates of the Fabry–Perot interferometer was 5 mm.

For the article by A. V. Lanishina and M. I. Shakhparonov, p. 830

Fig. 1. Interference orders of the z-component of the Rayleigh line (λ 4358 Å), scattered by water at 4°

For the article by I. V. Volkov, V. F. Esipov, and P. V. Shchelov, p. 840

Fig. 1. Electron-telescopic photograph of the NGC 7000 nebula with an exposure of 1 min.

Fig. 2. Photograph of the NGC 7000 nebula with an exposure of 60 min., obtained on Kodak 103 aE photoemulsion

For the article by N. A. Toropov, A. I. Boikov, A. F. Nevinsky, and S. K. Aninintis, p. 882

Fig. 2. X-ray diffraction pattern of a solid solution with 7.5% $3SrO \cdot SiO_2$, obtained by the asymmetric method

DAN, vol. 137, No. 4

The shift $\Delta\nu$ of the M.–B. component of the Rayleigh line scattered by water can be determined more accurately than for many other liquids, since anisotropic scattering and scattering by isobaric density fluctuations in water are very small. Owing to the weakness of the central component, the M.–B. components are well resolved.

Figure 1 shows one (typical) photograph obtained by us of the fine structure of the Rayleigh line in water at 4°. Figure 2 shows

Fig. 2. Microphotogram of one of the interference orders of the z-component of the Rayleigh line (λ 4358 Å) scattered by water at 4°

Fig. 3. Intensity distribution in the triplet of the Rayleigh line scattered by water at 4°

Figure 3

Figure 2: Figure 3

a microphotogram of one of the interference orders, taken with an MF-4 microphotometer. Figure 3 presents the intensity distribution after the corresponding processing of the blackening curve.

Table 1

Measurements of the velocity of propagation of hypersonic vibrations in water at 4°.
Wavelength of the exciting light λ 4358 Å. Velocity of ultrasound $v_0 = 1437$ m/sec.
Refractive index $n = 1.3420$

Photograph No.	$\Delta\nu$, cm^{-1}	v, m/sec	$I_c/2I_{\text{M.-B.}}$	Temp. of experiment, °C	Δt of air, °C	ΔP, mm Hg
1	0.208	1432	0.065	4.2 ± 2.0	+2.0	0.0
2	0.210	1447	0.045	4.6 ± 2.0	0.0	0.0
3	0.210	1447	0.065	4.6 ± 2.0	+2.0	0.0
4	0.209	1440	0.051	4.4 ± 1.0	+1.0	−0.3
5	0.212	1460	0.029	3.5 ± 1.0	+1.0	−1.0
Mean	0.210	1445 ± 8	0.051 ± 0.01	4.1	–	–

Table 1 contains the results of the interpretation of photographs of the Rayleigh triplet scattered by water at 4°. The last column of the table gives the intervals of variation of atmospheric pressure ΔP during the exposure, which in these experiments was 6 h.

Table 2 gives the values of v, v_0, and $I_c/2I_{\text{M.-B.}}$ at 4, 15, 25, 40, and 50°. Our experiments show that, within the accuracy of the experiment, dispersion of the velocity of hypersonic vibrations (wavelength $\Lambda = 2.3 \cdot 10^{-5}$ cm, frequency $f = 0.6 \cdot 10^{10}$ Hz) in water is apparently absent.

The values we obtained for the ratio $I_c/2I_{\text{M.-B.}}$ are closer to the theoretical ones than the values given in works (^{1,2}). The temperature depend-

Table 2

Liquid	t, °C	v_0	v	$I_c/2I_{\text{M.-B.}}$
H_2O	4	1437	1445 ± 8	0.051 ± 0.01
H_2O	15	1471	1450 ± 20	0.076 ± 0.02

Liquid	t, °C	v_0	v	$I_c/2I_{\text{M.-B.}}$
H_2O	25	1497	1470 ± 37	0.058 ± 0.01
H_2O	40*	1515	1530	
H_2O	50	1522	1543 ± 20	0.058 ± 0.02
$CH_3OH - H_2O$	25	1575	1575 ± 30	0.43 ± 0.1

* One photograph.

No dependence of $I_c/2I_{\text{M.-B.}}$ is observed. The observed intensities of the central component I_c, apparently, are mainly due to slight parasitic scattering of light from the walls of the cuvette, which cannot be completely eliminated.

In connection with the results of measurements of the hypersound velocity v in water, we again carried out measurements of v in solutions containing 15 mol.% CH_3OH in water. Table 2 contains the results of these measurements as well.

Within the measurement accuracy available at the present time, apparently, it may be considered that no dispersion of the propagation velocity of hypersonic waves is observed in aqueous solutions of methyl alcohol.

Moscow State University
named after M. V. Lomonosov

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