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DISPERSION AND ABSORPTION OF SOUND IN WATER AND IN ACETONE

E. V. Tiganov
P. N. Lebedev Physics Institute, USSR Academy of Sciences
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We have measured the absorption and the velocity of hypersound and ultrasound in the same samples of water and acetone, and measured the Landau-Placzek ratio in acetone.

Special attention was paid here to the question whether negative dispersion of the velocity of sound in water and acetone actually exists. An answer to this question is of fundametal importance to the problem of intermolecular interaction in liquids. From the theoretical point of view, negative dispersion is possible [1,2] and its magnitude is determined by the relation

$$\frac{\Delta v}{v} = \frac{q^2}{2v^2} f^*, \qquad (1)$$

where q is the wave number of the sound and f* is a constant characterizing the intermolecular interaction.

In a molecular aggregate with elastic forces acting between the molecules we have $f^* < 0$ and the sound dispersion is negative.

A large negative dispersion of the velocity of sound in acetone was obtained in an early investigation [3] but was not confirmed subsequently [2].

Recent experiments [4] again provided experimental indications that negative dispersion of the velocity of sound exists in acetone and in water.

We determined the velocity of hypersound by measuring the positions of the fine-structure components of a Rayleigh line excited by a He-Ne gas laser (λ = 6328 Å), using a setup described earlier [5]. The amplitude coefficients of sound absorption were determined from the widths of the fine-structure components at $f \sim 4 \times 10^9$ Hz in both liquids. We measured in the same liquid samples the velocity of ultrasound at $f \sim 2.8$ MHz using the apparatus described in [6].

The temperature was measured accurate to 0.1 - 0.2°C. The hypersound measurement accuracy was 0.1 - 0.2% and included the error in measuring the positions of the Mandel'shtam-Brillouin components and in reading the scattering angle (90° ± 0.3°).

The measurement results, shown in Table I, allow us to conclude that, within the limits of experimental accuracy, no dispersion of the velocity of sound is observed in water or acetone. Measurement of the velocity of hypersound in water at frequency $f = 6.31 \times 10^9$ Hz likewise disclosed no dispersion of the velocity of sound.

Table I

Substance	t, °C	n [1]	$\Delta\nu$, cm^{-1}	f x 10^9 Hz	hypersound, v, m/sec	ultrasound, v, m/sec	$\delta\nu \times 10^3$ cm^{-1}
Water	20	1.332	0.1474 ± 0.0002	4.42	1486 ± 1.3	1486 ± 1.0	6 ± 1.6
Acetone	20	1.358	0.1202 ± 0.0003	3.60	1190 ± 2.5	1190 ± 2	4 ± 1.6

1) The refractive indices of both liquids were extrapolated to λ = 6328 Å.

If we assume that the linear dimensions of the molecular aggregate are smaller than 10^{-7} cm, then this experimental result agrees with the theory [2,3].

From the measured value of the coefficient of hypersound absorption α we calculated the hypersound values of α/f^2 for water and acetone, and compared them with the ultrasound values of the same quantity in Table II.

Table II

Substance	f, Hz	$(\alpha/f^2) \times 10^{17}$	Literature
Water	2.5×10^8	25	[8]
	1.92×10^8	21.2	[9]
	4.4×10^9	19 ± 5	Present work
Acetone	1.0×10^8	25.7	[9]
	3.6×10^9	25 ± 10	Present work

The results in Table II indicate that in water and acetone the sound frequency $f \sim 4 \times 10^9$ Hz is at the very beginning of the region of relaxation of bulk viscosity.

We measured for acetone the integral intensities of the central component I_c and of the Mandel'shtam-Brillouin components I_{M-B} and found that $I_c/2I_{M-B} = 0.40 \pm 0.05$.

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ION CYCLOTRON RESONANCE IN A DENSE PLASMA WITH HOT ELECTRONS

L. V. Dubovoi, V. D. Dyatlov, and V. P. Fedyakov

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Comparison of the data obtained in [1,2] shows that the efficiency of heating of plasma ions by cyclotron resonance is greatly enhanced with increasing temperature T_e of the electronic component of the plasma. In this paper we report results of an experimental investigation of the properties of a dense plasma with preheated electrons in the ion cyclotron resonance region. The experiments were made in a magnetic mirror trap. The electrons were heated by a direct turbulent discharge. The main parameters of the apparatus and the method of producing the plasma with the hot electrons were described earlier in [3]. At the instant when the heating of the electrons was terminated, and at an initial hydrogen pressure 4×10^{-4} mm Hg, a plasma with energy density $nT_e \cong 5 \times 10^{16}$ eV/cm^3 ($n_e \sim 4 \times 10^{13}$ cm^{-3}, $T_e \sim 1$ keV) was produced in a quartz chamber 100 cm long and 10 cm in diameter, with diaphragms of 7.0 cm diameter to limit the diameter of the current pinch.

Figure 1 shows the time dependences of nT_e, obtained from the measurements of the diamagnetic effect in the plasma, for mirror ratios $\beta = 1.4$, 2.7, and 4.3.

The nT_e decay is exponential, the kink on the obtained curves corresponds to the termination of the discharge current, and the increased rate of nT_e decay when the current passes through the plasma is apparently connected with the presence of anomalous diffusion.

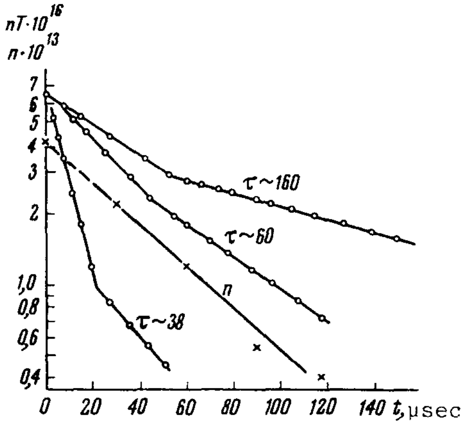

Fig. 1. Plasma decay at different trap mirror ratios: $\beta = 4.3$, $\tau = 160$ μsec; $\beta = 2.7$, $\tau = 60$ μsec; $\beta = 1.44$, $\tau = 38$ μsec.

In the first part of the investigation, the cyclotron absorption of the energy of the probing high frequency fields was used to measure the parameters of the ionic component of the plasma. The rapidly alternating field needed to excite the ion cyclotron wave was produced with the aid of four-section Stix coils [1] with a spatial period $2\lambda = 40$ cm, placed in the homogeneous part of the magnetic field B_0 of the