LETTER TO THE EDITOR

CLARIFICATION OF "CONTRIBUTION TO THE THEORY OF COLLECTIVE OSCILLATIONS IN POLAR LIQUIDS"

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IN connection with my paper[1], I received a number of letters containing questions regarding the gist of the paper, and also containing conclusions that do not follow from the paper, particularly a conclusion that the waves considered in the paper can probably get over long distances. I therefore consider it necessary to make the following clarifying comments.

1. The waves considered in[1] are essentially connected with the presence of a structural frame of the liquid (and are analogous to some degree to optical phonons). For simplicity we considered longitudinal waves (relative to the wave vector **k**) connected with the rotations of the dipole moments of the molecules (without displacement of the center of gravity of the molecule and without change in the absolute magnitude of its dipole moment). It is assumed that the potential energy of the rotation of the molecule-dipole in the liquid frame is small compared with the characteristic sound energy Ms^2 (M - molecule mass, s - speed of sound). Under this assumption, the wave dispersion is linear.

If we forego this assumption, then the Lagrangian density should contain a term proportional to the square of the density of the dipole moment, and the wave dispersion should be nonlinear. In particular, the wave would have an activation frequency $\omega_0 = \omega(k \rightarrow 0)$, equal in order of magnitude to $\omega_0 \sim s/a$, where a is the molecules of the frame (for water $\omega_0 \sim 3 \times 10 \times 10^{12}\ \text{sec}^{-1}$).

2. The damping decrement of the waves under consideration is determined by the relaxation time τ of the dipole moments of the molecules of the structure frame of the liquid. In[1] we chose, for a tentative estimate of the order of magnitude of τ, the relaxation time of the dipole moments of the molecule in the solid phase at the melting temperature. For ice at melting temperature the value of τ, determined from the experimental data on the dispersion of the transverse dielectric constant, is[2] $\tau \sim 2 \times 10^{-6}$ sec. Therefore in the case of water we can expect for the wave damping length a value on the order of $l \sim \tau\, \partial\omega/\partial k \sim 1/2$ cm, corresponding to a decrease in the wave energy by a factor of 100 along a path of 1 cm. (If the wave has an activation frequency ω_0, then in the longwave region the wave energy will decrease with increasing distance from the source even more rapidly.)

Thus, we can expect the existence of dipole-moment waves that attenuate weakly over one wavelength. It is to be expected, however, that these waves cannot propagate over distances of any appreciable size.

[1] I. A. Akhiezer, Zh. Eksp. Teor. Fiz. 53, 372 (1967) [Sov. Phys.-JETP 26, 249 (1968)].

[2] P. Debye, Polar Molecules, Dover, 1929. (Russ. transl., Gostekhizdat, 1931, p. 151).

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