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ANOMALOUS ABSORPTION OF SOUND NEAR THE FERROELECTRIC PHASE TRANSITION

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The absorption of ultrasonic waves (USW) near the phase transition in ferroelectrics has been the subject of a large number of experimental and theoretical papers [1 - 4]. Until recently, however, there was no good agreement between the experimental and theoretical temperature or frequency dependences of the anomalous USW absorption.

The temperature dependences of anomalous absorption, measured by us in SbSI [5], likewise agreed with the relaxation theories only very approximately [3, 4]. A theory that considered absorption due to the interaction of sound and polarization waves at the phase transition [6] was also unable to interpret well the experimental results, owing to the complexity of the mathematical derivations, although the orientation dependence of the anomalous absorption is explained in a paper to be published this year in Fiz. Tverd. Tela.

A general expression for the sound absorption coefficient,

$$\kappa \sim \omega^2 \mathrm{Re} \int_0^\infty < \delta X(t) \delta X(0) > \exp(-i\omega t)\, dt, \tag{1}$$

is contained in recent papers [7, 8] (ω is the frequency of the sound and δX describes the random force acting on the ultrasonic wave via the dipole-lattice interaction). In the case of an electrostriction coupling, the random force is proportional to the dipole-dipole interaction.

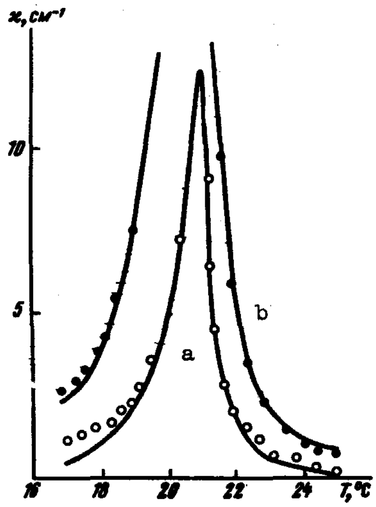
Applying formula (1), Kawasaki obtained the following relation for the USW absorption coefficient in the case of a phase transition in a ferromagnet [9]:

$$\kappa = A\omega^2 C^2(T)\left(\gamma + \frac{\lambda}{C(T)}\frac{\omega^2}{v_s^2}\right)^{-1}\left[1 + \omega^2 C(T) \Big/ \left(\gamma + \frac{\lambda}{C(T)}\frac{\omega^2}{v_s^2}\right)^2\right]^{-1}, \tag{2}$$

where C(T) is the temperature dependence of the specific heat, v_s is the speed of sound, and A, γ, and λ are coefficients that depend weakly on the temperature. In the approximation of low USW frequencies, κ is proportional to the square of the specific heat:

$$\kappa = A\omega^2 C^2(T)/\gamma. \tag{3}$$

Since Kawasaki's calculations are fairly general, it was noted by Hatta et al. [10] that such an analysis can be used also in the case of anomalous absorption in $NaNO_2$. Unfortunately, they have not yet compared the temperature



Temperature dependence of the USW absorption coefficient κ(T) of SbSI: a - at 10 MHz (light circles); b - 30 MHz (dark circles). The solid curves represent the theoretical calculations.

dependences of the USW absorption and of the specific heat.

We have attempted to compare the temperature dependence of the anomalous absorption of USW in SbSI [5] with the jump of the specific heat given in [11]. Assuming that Eq. (3) holds up to 10 MHz, we calculated κ and obtained quite good agreement with experiment (curve a in the figure). By choosing $\gamma = 3.8 \times 10^7$, $\chi = 0.1$, and $A = 3.4 \times 10^{-6}$ cgs esu, and by using formula (2), we can obtain good agreement also at 30 MHz (Fig. b). At 30 MHz the experimental points are displaced 0.4°C towards the lower temperatures, since such an error in the measurement of the absolute temperature was quite possible. In the ferroelectric phase, the experimental values of κ are somewhat larger, but this is understandable, since the domain scattering was not taken into account in this case.

Such an agreement between the experimental and theoretical results in the case of SbSI promises an interesting theoretical study of the change of the specific-heat and USW absorption in ferroelectrics.

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ELECTROPRODUCTION IN COLLIDING-BEAM EXPERIMENTS

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The process of electroproduction in colliding beam experiments ($e^{\pm}e^- \to e^{\pm}e + N$) has been frequently discussed recently, particularly at the Kiev Conference [1 - 3]. In the region of realistic energies ($\varepsilon < 5$ GeV in the foreseeable future), pair electroproduction processes ($\pi^+\pi^-$, $\mu^+\mu^-$, etc.), will apparently predominate, and these lend themselves most readily to a theoretical analysis (large-angle e^+e^- pair electroproduction was recently observed in Novosibirsk at $\varepsilon = 500$ MeV [4, 5]). To estimate the total cross sections,