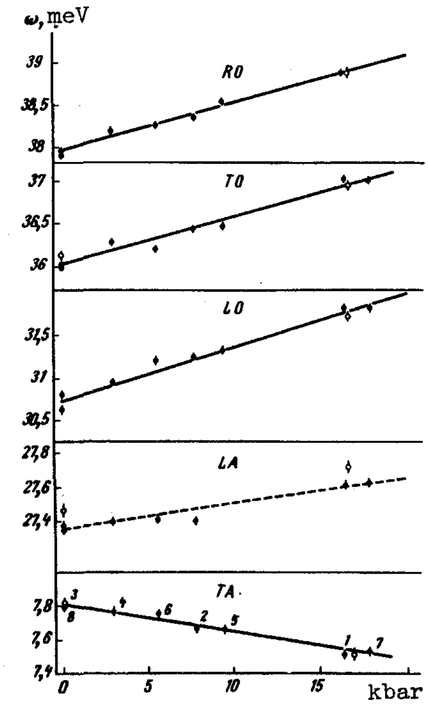

Fig. 2. Pressure dependence of the positions of the singularities of the germanium lattice vibration spectrum. The numbers on the TA curve show the sequence of the experiments.

thermal expansion also causes a shift of the lattice vibration frequencies. For germanium, the corresponding neutron-diffraction measurements were made in the interval 100 - 700°K [13]. For all the vibration modes, $(\partial \ln\omega/\partial T)_P = (-7.5 \pm 0.8) \times 10^{-5}$ deg^{-1}, which is much higher than the value d lnω/dT that can be calculated from the obtained values of $(d \ln\omega/dP)_T$ and the coefficient of thermal expansion. This contradiction can be eliminated by assuming that germanium is subject to an appreciable change of ω as a result of the contribution from the phonon-phonon interaction (see [4]). The values of $(\partial \ln\omega/\partial T)_V$ calculated from our data and from [13] are -11×10^{-5}, -7×10^{-5}, and -5×10^{-5} deg^{-1} for TA, LA, and TO, RO singularities, respectively. Observation of a large value of $(\partial \ln\omega/\partial T)_V$ and the complicated character of the shift of the spectrum under pressure are undoubtedly of interest. It is obvious that the lattice-vibration spectrum of the germanium and of similar substances deserves further study.

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ELECTRON SHOCK WAVES IN A COLLISIONLESS PLASMA

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Attention was called recently to the fact that the spreading of a bunch of hot electrons in a collisionless plasma can be strongly retarded by collective effects [1].

At high hot-electron densities, the main role is played by the following processes: The spreading of the cloud of hot electrons should be accompanied by an opposing current of hot electrons, so as to cancel out the charge, since the ions do not have time to move [2]. In this case the cold electrons can be slowed down by the effect of anomalous resistance.

It can be shown that under these conditions the spreading of the bunch of hot electrons can lead to the formation of a stationary moving jump of the density of the hot electrons. The conditions on this jump can be obtained from the conservation laws, just as for a shock wave.

The motion of the cold electrons in the electric field produced by the hot ones will be described just as in the theory of anomalous resistances. For not too large values of the electric field, the current velocity is $u = \alpha c_s$ (c_s - velocity of ion sound, α - a constant that depends on the detailed forms of the ion and electron distribution functions, for which we assume the asymptotic value $\alpha \simeq (m/M)^{1/4}$ [3]).

The temperature of the cold electrons varies in accord with the equation

$$\frac{3}{2}\frac{dT_x}{dt} = e\frac{\partial \phi}{\partial x} u .$$

This yields for the current velocity

$$3\frac{M}{\alpha^2}\frac{du}{dt} = e\frac{\partial \phi}{\partial x} . \tag{1}$$

The density of the cold electrons n_c is determined from the continuity equation

$$\frac{\partial n_x}{\partial t} + \frac{\partial}{\partial x}(n_x u) = 0.$$

For the density of the hot electrons, which is much lower than the plasma density, we can obtain, by using the quasineutrality condition, the equations:

$$\frac{\partial n_h}{\partial t} = n_0 \frac{\partial u}{\partial x} ,$$

$$n_h = \int_{-\infty}^{\infty} f\left(\frac{mv^2}{2} - e\phi\right)dv . \tag{2}$$

Eliminating u from (1) and (2) we obtain the nonlinear wave equation

$$\frac{\partial}{\partial t}\left(\frac{dn_h}{d\phi}\frac{\partial \phi}{\partial t}\right) = n_0 \frac{e\alpha^2}{3M}\frac{\partial^2 \phi}{\partial x^2} , \tag{3}$$

describing the spreading of the cloud of hot electrons. The "sound velocity" corresponding to Eq. (3) is of the form $[(e\alpha^2/3M)n_0^{-1}(d\phi/dn_h)]^{1/2}$ and the analog of the Riemann solution is

$$\phi = \phi\left(x - \sqrt{\frac{e\alpha^2}{3M}\frac{1}{n_0}\frac{d\phi}{dn_h}}\,t\right) + .$$

When $d(d\phi/dn_h)/dn_h > 0$ or $d^2n_h/d\phi^2 < 0$, the slope of the wave front increases without limit.

Leaving aside for the time being the question of the width of the stationary "shock" wave, let us determine the velocity of this wave. From (1) and (2) we can obtain the conservation laws and the velocity of the jump

$$D = a v_o \sqrt{\frac{m}{3M}\,\frac{n_o}{n_{oh}}}\,, \qquad \frac{mv_o^2}{2} = e\phi_{max}\,. \tag{4}$$

Here v_0 is the maximum velocity of the particles for the given distribution function.

The lower bound of the width of the jump, $(M/m)^{1/2}r_{de}$, can be obtained by stipulating that the spectrum of the ion-acoustic oscillations have time to become established within the jump.

As already noted, the condition for the formation of the "shock wave" imposes limitations on the $n(\phi)$ dependence, which is determined from the velocity distribution functions of the hot particles. Thus, for example, for a Maxwellian distribution $d(d\phi/dn_h)/dn_h < 0$ no stationary wave is formed, and the front spreads out in accordance with the self-similar solution (x/t). For distribution functions having a steeper decrease (for example, for a Maxwellian distribution in the form of a step), we have

$$n_h \sim \left(e\phi + \frac{mv_o^2}{2}\right)^{1/2}, \quad \frac{\partial^2 n_h}{\partial\phi^2} < 0$$

and a discontinuity is formed. In the general case, the distribution functions can lead to a complicated $n(\phi)$ dependence, when both steepening and spreading can occur on different sections of the front. In principle, the shape of the front can yield information concerning the form of the distribution function of the hot electrons. Thus, the propagation of heat in a collisionless plasma will be realized by the foregoing mechanism and can be accompanied by the formation of a wave with a steep front. A similar effect may turn out to be quite important for plasma heating by a powerful relativistic beam.

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FACTORIZATION OF AN N-POINT DUAL AMPLITUDE

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Considerable progress was made recently in the study of the N-point Veneziano amplitudes B_N. Mandelstam [1] and Olesen [2, 3] have shown that B_N can be factored if the intersections of the Regge trajectories depend bilinearly on the additive "quantum numbers" b_i of the external particles.