λ_p, μ	P_p, kW/cm²	
	e = o + o	e = e + o
0.69	15	100
1.06	28	32
2.36	120	125
5.3	600	610

The transparency in a wide spectral range, the high value of the nonlinear susceptibility, satisfaction of the phase-synchronism conditions for parametric generation in the wavelength band from 1 to 18 μ, and the possibility of effectively converting sum and difference frequencies, all make GaSe a very interesting material for nonlinear optics.

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SINGULARITIES OF THE SOUND ATTENUATION COEFFICIENT IN A PHASE TRANSITION OF ORDER 2.5

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The anomalies that the thermodynamic quantities of metals acquire as a result of a change in the topology of the Fermi surface $\varepsilon(p) = \varepsilon_F$ are customarily called a phase transition of order 2.5 [1, 2] (I. Lifshitz [1]).

In this paper we consider the singularities of the absorption coefficient of high-frequency sound ($k\ell \gg 1$, $k = \omega/s$ is the wave vector of the sound, ω is its frequency, s is its velocity, and ℓ is the mean free path of the electrons) near the phase-transition point defined by the condition $\varepsilon_F = \varepsilon_c$, where ε_c is the critical value of the energy at which the topology of the equal-energy surfaces changes.

We investigated two variants: (a) appearance (or vanishing) of the cavity of the Fermi surface (for simplicity, a sphere) at $z = (\varepsilon_F - \varepsilon_c = 0)$

$$p^2/2m = z \qquad (z > 0), \tag{1}$$

(b) "breaking of the neck" (see [2]).

According to the results of [3], when $k\ell \gg 1$ the electrons that take part in the absorption of sound are those located on the "strip"

$$(v(p)k) = 0, \quad \epsilon(p) = \epsilon_F, \tag{2}$$

where $\vec{v} = (\partial\varepsilon/\partial\vec{p})$ is the electron velocity.

Each "strip" makes the following contribution to the sound attenuation coefficient:

$$\Gamma \approx \frac{\pi\omega}{(2\pi\hbar)^3 \rho s} \int_0^{2\pi} \frac{|\Lambda_i'|^2 d\phi}{v^2(\phi)\varkappa(\phi)}, \tag{3}$$

ρ is the density of the metal, $\mathcal{K}$ is the Gaussian curvature of the Fermi surface, and $|\Lambda|^2$ is a quantity that depends quadratically on the components of the tensor λ_{ik}, which connects the change of the energy of the electron with the deformation tensor [4].

Formula (3) can be obtained by classical means (by solving the kinetic equation) and by quantum means (by calculating the probability of phonon absorption) [3]. The results of the classical and quantum methods coincide under the following customarily prevailing conditions[1]):

$$\hbar\omega \ll |z|, \quad \hbar k \ll p_F, \tag{4}$$

where p_F is the characteristic momentum of the Fermi surface (for a sphere it is equal to its radius: $p_F = \sqrt{2m|z|}$).

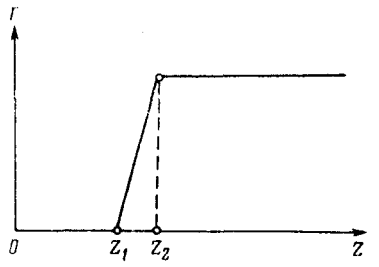

Fig. 1. Dependence of Γ on z. In the case of the appearance (vanishing) of a new cavity

$$z_1 = \frac{ms^2}{2} - \frac{\hbar\omega}{2}, \quad z_2 = \frac{ms^2}{2} + \frac{\hbar\omega}{2},$$

when the neck is broken

$$z_1 = \frac{m_3 s^2}{2} - \frac{\hbar\omega}{2}, \quad z_2 = \frac{m_3 s^2}{2} + \frac{\hbar\omega}{2}.$$

The inequalities (4), in addition, explain the rarely noted circumstance that Γ is independent of the radius of the "strip" (for a sphere this means that Γ does not depend on the number of the electrons in the cavity), $v^2 = p_F^2/m^2$, and $\mathcal{K} = 1/p_F^2$ (see [3]). Therefore the appearance (or vanishing) of the cavity or the breaking of the neck should lead to a noticeable change in the absorption coefficient.

In addition, in order not to be bound by the conditions (4), we calculate the absorption coefficient by the quantum method, and following [5], we naturally do not neglect the quantity $\hbar\omega$ in comparison with the quantity $|z|$:

$$\Gamma = \int |M|^2 (n_p - n_{p+\hbar k}) \delta(\epsilon_p + \hbar\omega - \epsilon_{p+\hbar k}) d^3p, \tag{5}$$

ε_p is the energy of the electron with momentum $\vec{p}$, n_p is the Fermi distribution function, and $|M|^2$ is the matrix element of the transition [3] (it can be related with the quantity $|\Lambda|^2$) and will be assumed for simplicity to be independent of $\vec{p}$. We consider first the anomalies of the absorption of sound at $T = 0$, when $n_p = 1$ at $\varepsilon(\vec{p}) < \varepsilon_F$ and $n_p = 0$ at $\varepsilon > \varepsilon_F$.

a) It is seen from (1) and (5) that the appearance (or vanishing) of a cavity on the Fermi surface is accompanied by the following anomalies of the sound absorption coefficient (Fig. 1):

$$\Gamma = \begin{cases} 0 & (z \leqslant z_1), \\ \eta(z - z_1) & (z_1 \leqslant z \leqslant z_1 + \hbar\omega), \\ \eta\hbar\omega & (z \geqslant z_1 + \hbar\omega), \end{cases} \tag{6}$$

where

$$z_1 = \frac{ms^2}{2}\left(1 - \frac{\hbar\omega}{2ms^2}\right)^2; \quad \eta = \frac{2\pi m^2 s |M|^2}{\hbar\omega}, \tag{7}$$

[1]) In addition, of course, $T \ll |z|$ (T is the temperature).

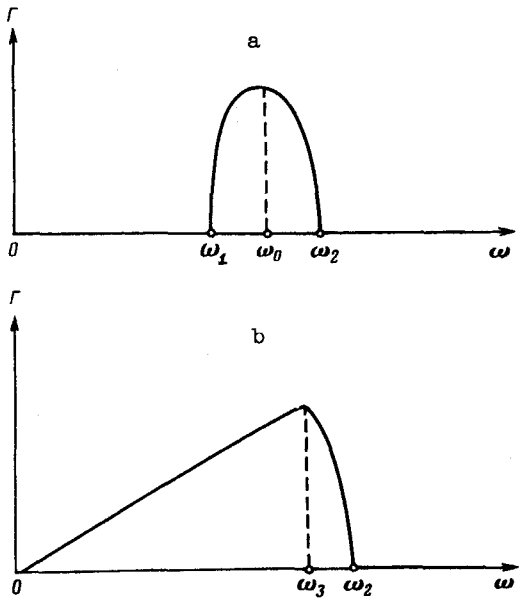

Fig. 2. Dependence of Γ on ω: $\omega_0 = 2ms^2/\hbar$; $\omega_{1,2} = \omega_0 \pm \Delta$; $\omega_3 = \Delta - \omega_0$; $\Delta = (8zms^2)^{1/2}/\hbar$. Figure 2a corresponds to $0 < z < ms^2/2$, and Fig. 2b corresponds to $z > ms^2/2$.

i.e., two closely located kinks should appear on the $\Gamma = \Gamma(z)$ curve. Since $\hbar\omega$ is much smaller than the characteristic electronic energies, the two kinks coalesce into a jump of the function $\Gamma(z)$, and since $\hbar\omega \ll ms^2$ for realistically attainable sound frequencies, we have $z_1 \simeq ms^2/2 - \hbar\omega/2$. The shift of the singularity with respect to $z = 0$ is due to the fact that satisfaction of the conservation laws following absorption of a phonon by an electron begins with the electron threshold energy (in fact, the condition $z > z_1$ is the Cerenkov-radiation condition $v > s$).

b) The breaking of the neck is accompanied by a more complicated anomaly, the character of which depends on the direction of sound propagation. Thus, if $\vec{k}$ is perpendicular to the axis of the neck, then $\Gamma(z)$ is a continuous function; if the vector $\vec{k}$ is directed along the axis of the neck, then the singularity of $\Gamma(z)$ is the same as when a new cavity appears (see (6)).

The dependence of $|M|^2$ on the sound frequency cannot be obtained in the general case, but at relatively low phonon momenta $|M|^2 \sim k^2/\omega \sim \omega$ (see [5]), and this makes it possible to determine the $\Gamma(\omega)$ dependence at different values of z (see Fig. 2).

When $T \neq 0$, the singularities, naturally, smooth out, for example, in the case when a new cavity of the equal-energy surface appears we have from (1) and (5)

$$\Gamma = \eta T \ln \frac{1 + \exp\left(\frac{z - z_1}{T}\right)}{1 + \exp\left(\frac{z - z_1 - \hbar\omega}{T}\right)}, \qquad (8)$$

from which we see that the character of the temperature smearing depends on the relation between $\hbar\omega$, ms^2, and T. Since, however, all the quantities ($\hbar\omega$, ms^2, T) are much smaller than ε_F, the absorption coefficient changes quite abruptly.

The phase transition of order 2.5 should be accompanied not only by singularities of the sound absorption coefficient, but should also affect the dispersion of the metal phonons, since a change takes place in the topology of the geometric locus of the points of the Migdal - Kohn singularities (see [5, 6]).

In conclusion, the authors thank I.M. Lifshitz for interest in the work and for stimulating discussions.

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INVESTIGATION OF MAGNETIC TRANSITION IN MANGANESE ARSENIDE UNDER THE INFLUENCE OF LIGHT PULSES

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Investigations of magnetic phase transitions in manganese arsenide as functions of the temperature and pressure [1, 2] have established that a transition takes place from the α-ferromagnetic state into the β-paramagnetic state when the sample is heated above 318°K, as well as, say, at room temperature and a pressure of 2.2 kbar. As shown by x-ray [3] and neutron-diffraction [4] investigations, the α → β transition is accompanied by an orthorhombic distortion of the nickel arsenide structure of manganese arsenide (transition into a structure of the MnP type). The displacements from the equilibrium positions in the crystal lattice, which the ions experience as a result of the α → β transition, are apparently connected with an electronic transition of the Jahn-Teller type. When the temperature increases, the degree of distortion of the crystal lattice decreases, and above 400°K the distortions are eliminated completely [5]. It is known also that the β → α transition takes place when a strong magnetic field is applied [6, 7]. An analysis of the singularities of the α → β transition has given grounds for assuming that this transformation can be observed under the influence of sufficiently strong electromagnetic fields, and in particular under the influence of light pulses in the visible band.

We have investigated experimentally the changes occurring in the magnetization of manganese arsenide under the influence of light pulses. The experimental setup is shown in Fig. 1. In the experiment, the sample was placed between the poles of an electromagnet. A measuring coil was wound directly on the sample or else was placed on the central part of the electromagnet core. Light pulses of 3.5 msec duration were produced by an IFK-500 photographic flash lamp with pulse energy ∿500 J. The sample was prepared in the form of a plate measuring 20 × 10 × 1 mm by pressing powdered manganese arsenide and subsequent annealing in vacuum at 600°C for 1 hr. The remaining details of the setup can be seen in Fig. 1. The sample was placed in an electromagnetic field of intensity ∿100 Oe.

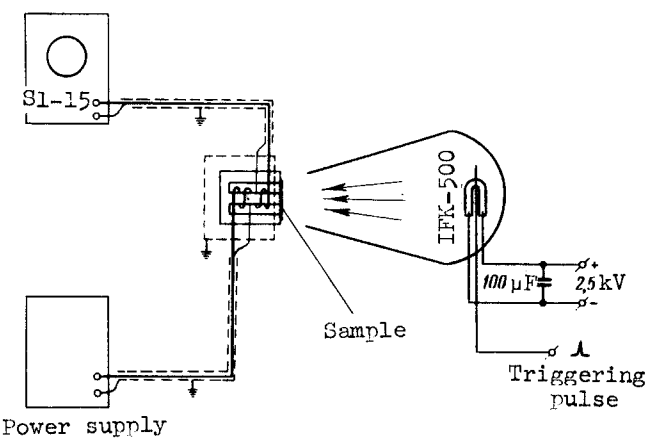

Fig. 1. Experimental setup.

Figure 2 shows the time variation of the light intensity in the pulse (a) and the corresponding change of the emf induced in the measuring coil (b) as a result of the magnetic transition.

Figure 3 shows the change of the area of the voltage pulses, which are induced in the measuring coil and are