

FIG. 1. a) Fermi-resonance doublets of class  $A_1$  polariton with combination tone in  $\text{LiNbO}_3$  crystal (scattering geometry  $\gamma(zz)\gamma$ ;  $k_p$  in  $x, y$  plane;  $\theta$  is the scattering angle inside the crystal; crystal temperature  $100^\circ\text{K}$ ); b) polariton frequency  $\omega_p$  plotted against  $\theta$  in the Fermi resonance region ( $536\text{ cm}^{-1}$ —combination tone,  $523\text{ cm}^{-1}$ —middle of gap; gap width  $\approx 7\text{ cm}^{-1}$ ; for greater detail see [5]).

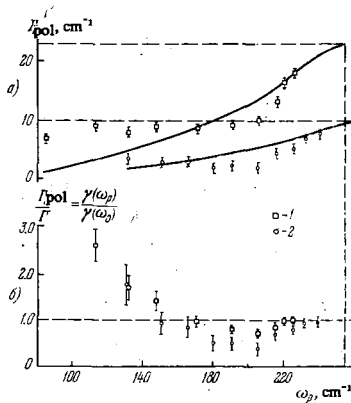


FIG. 2. a) Measured polariton line width  $\Gamma_{\text{pol}}$  as a function of frequency  $\omega_p$  of class  $A_1$  polariton in  $\text{LiNbO}_3$  crystal (solid line— $\Gamma(\omega)$  at  $\gamma(\omega\text{TO}) = \text{const}$ ; the measurements were made by a special technique using a specially shaped diaphragm (to be published)); b) ratio  $\gamma(\omega)/\gamma(\omega\text{TO})$  as a function of the frequency  $\omega$  in  $\text{LiNbO}_3$ . 1)  $290^\circ\text{K}$ ,  $\omega_{\text{TO}} = 255\text{ cm}^{-1}$ ,  $\gamma(\omega\text{TO}) = 23.5^{-1}$ ; 2)  $100^\circ\text{K}$ ,  $\omega_{\text{TO}} = 260\text{ cm}^{-1}$ ,  $\gamma(\omega\text{TO}) = 10\text{ cm}^{-1}$ .

quencies. If the dielectric constant of the crystal has the form

$$\epsilon(\omega) = \epsilon_\infty - \frac{(\epsilon_0 - \epsilon_\infty) \omega_{\text{TO}}^2}{\omega^2 - \omega_{\text{TO}}^2 + i\gamma(\omega)\omega},$$

in the conventional notation for the polariton-frequency range under study, then according to [9], the width of the line formed on RSL by a polariton with wave vector  $k$  and frequency  $\omega$  is given by

$$\Gamma(\omega) = \frac{\gamma(\omega)(\epsilon_0 - \epsilon_\infty)\omega_{\text{TO}}^2\omega^2}{\epsilon_\infty(\omega_{\text{TO}}^2 - \omega^2)^2 + (\epsilon_0 - \epsilon_\infty)\omega_{\text{TO}}^2\omega^2}.$$

It follows from this equation that study of polariton RSL line widths enables us to reconstruct the  $\gamma(\omega)$  dependence and, consequently, by using also the  $\omega = \omega(k)$  dependence, to reconstruct completely the complex dielectric constant  $\epsilon(\omega)$ . Figure 2 presents results of such an investigation for a lithium niobate crystal at various temperatures. We note in the above connection that studies of  $\gamma(\omega)$  with  $\omega \ll \omega_{\text{TO}}$  for crystals with  $\omega_{\text{TO}} \gg \omega_{\text{D}}$  ( $\omega_{\text{D}}$  is the Debye frequency), where we might expect relationships of the type of Urbach's rule for  $\gamma(\omega)$ , would be of special interest.

We note in conclusion that the tensor  $\chi_{ijl} = 0$  in centrally symmetrical crystals (CSC) and that the usual

method with RSL on polaritons cannot be used to reconstruct  $\epsilon(\omega)$ . However, the situation changes if we revert to RSL by surface polaritons under conditions such that the CSC under study is bounded along at least one of its interfaces by a medium that does not have an inversion center. Since the electromagnetic field in a surface polariton at distances on the order of its wavelength is nonzero on both sides of the interface and, consequently, also in the region in which  $\chi_{ijl} \neq 0$ , the intensity of RSL by the surface polariton is found to be significant and, as indicated by the calculations of [13], quite sufficient for experimental observations of the effect. This conclusion is also in agreement with the results of [14], in which RSL was observed experimentally for the first time on a surface polariton in a medium without an inversion center (GaAs; sapphire substrate). Naturally, the peaks corresponding to excitation of bulk polaritons were most strongly in evidence in the RSL spectrum of [14], and this interfered with observation of the effect. But in the "inverted" situation discussed in [13], in which the absence of an inversion center is guaranteed by the choice of substrate, no bulk polaritons of the CSC should be excited at all.

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I. M. Khalatnikov. *Phase Transitions in He<sup>3</sup>*. Superfluidity is a characteristic property of quantum fluids consisting of Bose particles (for example, of He<sup>4</sup> atoms). Quantum fluids consisting of Fermi particles (for exam-

ple, liquid He<sup>3</sup>) do not exhibit this property at low temperatures. But at ultralow temperatures (of the order of 10<sup>-3</sup>°K) we have reason to expect the production of bound pairs of Fermi particles (like Cooper electron pairs in superconductors). Such pairs will form a Bose condensate, and the property of superfluidity may appear as a result.

During the past year, two phase transitions have been observed in liquid He<sup>3</sup> at equilibrium with solid He<sup>3</sup> (pressure about 33 atm): an A transition at T = 2.65 × 10<sup>-3</sup>°K and a B transition at T ≈ 2 × 10<sup>-3</sup>°K.

Heat-capacity investigations have shown that the A transition is a second-order phase transition (a heat-capacity jump is observed), and that release of a latent heat of transition on the order of 15 erg/mole is observed in the B transition. As the pressure is lowered, the temperature of the A transition decreases (p<sub>min</sub> = 10 atm, T<sub>min</sub> = 2 × 10<sup>-3</sup>°K). In a magnetic field, the A transition splits into two phase transitions, A<sub>1</sub> and A<sub>2</sub>. The temperature difference for these transitions is proportional to the magnitude of the applied magnetic field. Study of the NMR and static susceptibility indicates that the A phase has a large internal field, which could be explained if atoms with parallel spins were paired. The resulting pair would have a spin S = 1. It then follows that the orbital momentum L of the pair is odd (evidently equal to 1). The magnetic properties of the phases can be understood qualitatively if the condensate is anisotropic in the A phase and isotropic in the B phase.

The appearance of superfluidity in the A and B phases

was very recently demonstrated experimentally. The resonance vibration amplitude of a string immersed in liquid He<sup>3</sup> increased sharply with decreasing temperature in the new phases.

Thus, liquid He<sup>3</sup> presents physics with a totally new object—a superfluid, anisotropic magnetic quantum fluid.

The discovery of this phenomenon can, without fear of exaggeration, be called the most important event in physics during recent years.

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## Scientific Session of the Division of General Physics and Astronomy, USSR Academy of Sciences (19-20 December 1973)

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A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on December 19 and 20, 1973 at the conference hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. Z. R. Mustel', Supernova Outbursts and Transformations of Elements.
2. Yu. N. Efremov, S. B. Novikov, and P. V. Shcheglov, Development of Ground-Based Optical Astronomy and its Prospects.\*
3. V. S. Letokhov, Selective Laser Irradiation of Matter.
4. D. N. Mirlin, Optical Studies of Surface Vibrations in Ionic Dielectrics and Semiconductors.
5. G. A. Askar'yan, V. A. Namiot, and M. S. Rabinovich, Use of Ultracompression of Matter by Light Reaction Pressure to Obtain Microcritical Masses of Fissile Elements, Ultrastrong Magnetic Fields, and Particle Acceleration.

We publish below brief contents of three of the papers.

V. S. Letokhov, Selective Laser Irradiation of Matter. Recent progress in broadening the range of laser wavelengths and in the development of methods for tuning and frequency control of lasing have enabled us to enter upon systematic study of the possibility of controlling selective chemical reactions with laser radiation. This problem is of fundamental importance for the use of coherent light in chemistry, especially in photochemistry and nuclear chemistry and possibly in biology, medicine, and other fields. The basic idea is to use the difference between the absorption spectra of substances not for analysis of their composition and structure, but for selective treatment of the substances with the object of changing their composition and properties. The general statement of the problem will be found in<sup>[1]</sup>.

A mixture of molecules (atoms) A and B with very closely similar chemical properties is considered, and the problem is to obtain preferential participation of, let us say, molecule A in a chemical reaction. As a coefficient of selectivity we might take the ratio of the number of reacted molecules A to the number of molecules B at equal initial concentrations:  $S = ([N_A])/([N_B]) - 1$ .  $S = 0$  in the absence of selectivity, and  $S \gg 1$