If the ratio of the liquid volume to the free-surface area is infinite, then the entire surface is covered by the gas phase at $T > T_c$ and by the liquid at $T < T_c$. There is no region of phase stratification. This region appears if the indicated ratio is finite. The width ΔT of the temperature interval near T_c, in which two surface phases coexist on the surface of the liquid layer of thickness z at large values of z, is given by the formula

$$\frac{\Delta T}{T_c} = -\frac{N_s - n_s}{zn}\frac{T_c}{\epsilon_0}.$$

At finite z, the derivative $\partial\sigma/\partial T$ is continuous.

To observe surface condensation in measurements of surface tension, the accuracy must be sufficient to observe the kink on the $\sigma(T)$ curve. We note in this connection that a much more strongly pronounced singularity should be observed in the temperature dependence of the velocity of the surface second sound [4], which should experience a large discontinuity at the condensation point.

We are grateful to I.M. Lifshitz for a discussion of the work and for valuable remarks.

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SUPERCONDUCTIVITY IN NON-EQUILIBRIUM WITH REPULSION BETWEEN PARTICLES

D.A. Kirzhnits and Yu.V. Kopaev
P.N. Lebedev Physics Institute, USSR Academy of Sciences
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In the fundamental formulas of superconductivity theory, the coupling constant enters in combination with the quantity $1 - 2n$, where n is the occupation number of the fermion states. This suggests that superconductivity can appear in such "non-superconducting" systems in which both factors have an unusual sign, namely, repulsion between particles predominates, but on the other hand an inverted level population is produced[1)].

In the simplest metallic model, the time τ_R of recombination of the electrons and holes, which leads to the vanishing of the population inversion, is so short that to produce the inversion, if at all possible, continuous pumping would be necessary. This creates a number of complicated problems. We discuss below a model in which the time τ_R has been appreciably increased and one can expect superconductivity to appear as a result of a single action of the pump pulse.

[1)] We have learned that similar arguments were advanced also by A.G. Aronov and V.L. Gurevich.

1. The proposed model pertains to the superconducting type and is characterized by the presence of a dielectric gap and a shift of the extrema of the bands (Fig. 1). Both factors cause τ_R to reach tremendous values, up to 10^{-5} sec [1]. We assume for simplicity that (a) the system is quasi-two-dimensional and the density of its states does not depend on the energy, (b) the parameters of both bands are identical, (c) the chemical potential μ characterizing the population inversion resulting from the electrons "thrown" from band 2 to band 1 is large in comparison with the width of ω_p of the region of action of the repulsion (Coulomb) interaction. These limitations are immaterial and do not change the qualitative conclusions.

The model Hamiltonian of the system is

$$H = \sum_{i,k} \epsilon_i a^+_{i,k} a_{i,k} + \gamma_0 \sum_i B_i^+ B_i + \gamma_1 \sum_{i \neq j} B_i^+ B_j, \quad B_i \equiv \sum_k a_{i,k} a_{i,-k},$$

where i, j = 1, 2 are the numbers of the band, the pairing of the electrons with electrons or holes from another band is neglected, γ_0 and γ_1 are the intraband and interband coupling constants, respectively ($\gamma_0 > 0$), $\varepsilon_1 = E_g + k^2/2m$, and $\varepsilon_2 = -E_g - (k - k_0)^2/2m$.

2. The usual test of the normal state of the system for stability [2] yields the following equation for the poles of the vertex parts in the "particle-particle" channel

$$1 + \gamma_0 \ln \frac{E_g^2 - \omega^2}{\omega_p^2} + (\gamma_0^2 - \gamma_1^2) \ln \frac{\omega - E_g}{\omega_p} \ln \frac{\omega + E_g}{-\omega_p} = 0. \quad (1)$$

Imaginary values of ω (superconducting instability) correspond to the region shown shaded in Fig. 2 and appear only if the dielectric gap is narrow enough. At $E_g = 0$ and $|\delta_1| \ll \gamma_0$ (corresponding to a large value of τ_R) we have, in particular,

$$\omega = \pm i \Delta_0 \exp(-\sqrt{\gamma_1^2/\gamma_0^4 - \pi^2/4}), \quad \Delta_0 \equiv \omega_p \exp(-1/\gamma_0).$$

When $\gamma_0 < 0$, the instability in question vanishes in accordance with the results of [3].

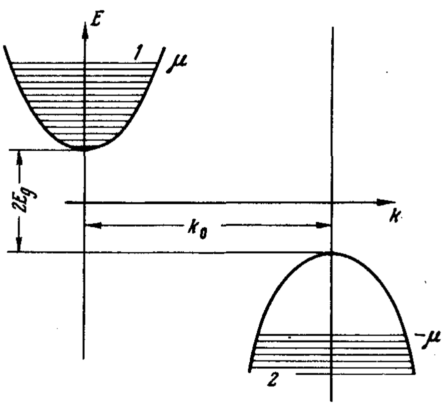

Fig. 1

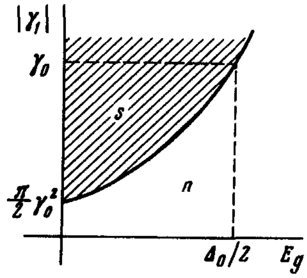

Fig. 2

It is convenient to describe the resultant superconductivity in the language of the Gor'kov equations for the ordinary and anomalous Green's functions[2]) G_i and F_i

$$(\omega - \epsilon_1) G_1 + \Delta F_1^+ = 1, \qquad (\omega + \epsilon_1) F_1 + \Delta G_1 = 0$$

and similarly for the functions G_2 and F_2. Here $\Delta = \int d^4p(\gamma_0 F_1 + \gamma_1 F_2)$. From this, in particular, we get the expression

$$G_1 = \frac{1}{2}(1 + \epsilon_1/E_1)/(\omega - E_1 - i\delta) + \frac{1}{2}(1 - \epsilon_1/E_1)/(\omega + E_1 + i\delta), \tag{2}$$

where $E_1 = \sqrt{\epsilon_1^2 + \Delta^2}$ and the rules for going around the poles correspond to the inverted population. The value of Δ coincides, as usual, with the imaginary part of the route of (1).

3. In the model in question, the energy of the superconducting state exceeds the energy of the normal state (at a specified quasiparticle distribution). Thus, at $\gamma_1 = \gamma_0$

$$E_s - E_n = \mathrm{sign}(\gamma_0) \int_0^{|\gamma_0|} \frac{d\gamma_0}{\gamma_0^2} \Delta^2 > 0.$$

one can expect that the system, after relaxing from a higher energy state to which it was "thrown" by the pumping action, will end up ultimately in a superconducting state.

After the end of the intraband relaxation, the remaining inverted population (see Fig. 1) vanishes after a time τ_R, and the superconductivity vanishes after a time τ_s. These times are of the same order of magnitude. In fact, the inequality $\tau_R \ll \tau_s$ is impossible, for once the inverted population vanishes the superconductivity disappears, too. The opposite inequality would bring the system to the normal state under conditions of inverted population, which, however, is unstable. Therefore the system recombines and loses superconductivity at equal rates. Accordingly, one can speak of superconductivity only as applied to time intervals that are short in comparison with τ_R (cf. [4]). The kinetic problems involved here will be the subject of a special paper.

The temperature smearing of the Fermi distributions in both bands distorts the distribution function in the region of interest to us near the extrema of the bands, by an amount on the order of $\exp(-\mu/T)$. One can therefore expect for the critical temperature a rather high value, on the order of μ. On the other hand, the critical temperature determined by the gap Δ is the largest "negative temperature" characterizing the degree of the inversion of the distribution.

In conclusion, we emphasize once more that in order for superconductivity to appear it is necessary to have a sufficiently narrow dielectric gap. In all other respects the model considered here coincides with the one usually employed in connection with the problem of the condensed exciton phase in a semiconductor [1].

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[2])Since the pairing is not on the Fermi boundary but at the extrema of the bands, the functions F do not contain the factor $\exp(-2i\mu t)$ (the corresponding chemical potential is equal to 0). This corresponds to pure imaginary routes of (1).

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INSTABILITIES AND LIGHT SCATTERING IN AN EXPANDING MULTICOMPONENT PLASMA

L.I. Rudakov
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1. When a plasma is produced by nanosecond laser pulse, a hot expanding corona is formed, in which the laser energy is absorbed. It is known that the laser beam can produce in the corona plasma instabilities that lead to the appearance of strongly epithermal plasma-density fluctuations and scattering of the incident beam [4]. In the present article we call attention to one more possible cause of the "darkening" of the plasma corona.

If the plasma consists of ions of two or more types with different z_e/M, for example thermonuclear fuel consisting of a deuterium-tritium mixture, then the ambipolar electric field $E = -(T_e/e)\nabla \ln n_e$ of the corona will accelerate the ions unevenly. In the region of the rarefied corona, where the force of friction between the ions with different z_e/M is no longer capable of equalizing the velocities, the lighter ions will start to run away forward and a two-stream motion is produced. Such a state, as is well known, is unstable. The fluctuations of the electric field and of the density can grow in it with a characteristic scale on the order of or larger than the ion Debye radius. Scattering of the ions by the turbulent electric fields leads to effective friction between the components, and some of the work of the ambipolar electric field will be consumed in their heating. One can expect the processes occurring in this case to be similar to the turbulent heating of plasma in an electric field, which has been sufficiently well investigated theoretically and experimentally [1].

2. Let us review the qualitative arguments of the theory of turbulent heating (see, e.g., [1]) as applied to the phenomenon under consideration.

In a plasma with two types of ions ($M_2 >> M_1$, $T_e >> T_1 >> T_2$) there can exist besides ordinary ion sound $\omega_1 = k(T_e/2M_1)^{1/2}$ also short-wave slow sound $\omega_2 = k(T_1/M_2)^{1/2}$ (the theory of turbulent heating is based on the existence of a small parameter m/M; the case of comparable masses can be obtained as a limiting approximation; to simplify the formulas we assume $n_1 = n_2 = n/2$ and $z_1 = z_2 = 1$). The slow sound can build up if the average velocity u of the light ions relative to the heavy ones exceeds ω_2/k. The unstable perturbations are those with wave vectors

$$k \lesssim \left(\frac{4\pi ne^2}{T_1}\right)^{1/2}, \quad \gamma_{max} \approx \left(\frac{4\pi ne^2}{T_1}\frac{M_1}{M_2}\right)^{1/2} u. \tag{1}$$

The light ions are scattered by the electric field of such a turbulence, with effective frequency