a laser with moving crystal should make it possible in the future, on the one hand, to formulate the principles of continuous operation of a solid-state laser with a moving crystal, and, on the other, explain the spike character of the generation of most contemporary solid-state lasers.

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## LATTICE STABILITY IN THE PHONONLESS MECHANISM OF SUPERCONDUCTIVITY

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Following the paper by Little [1], several recent papers have considered the phononless superconductivity mechansims, particularly in three-dimensional systems [2,3].

The interaction that leads to superconductivity has in these papers, in final analysis, the standard form [4]

$$H_{int} = \frac{f}{2(2\pi)^3} \sum_{\vec{p}_1+\vec{p}_2=\vec{p}_3+\vec{p}_4} a^+_{\vec{p}_1\sigma_1} a^+_{\vec{p}_2\sigma_2} a_{\vec{p}_3\sigma_2} a_{\vec{p}_4\sigma_1} , \qquad (1)$$

where the effective interaction constant f is negative and the summation is confined to the region

$$(\epsilon(p_i) - \epsilon_F) < \Delta E.$$

$\Delta E$ depends on the concrete mechanism of the investigation and in the models under investigation [3] its order of magnitude is that of the width of the band of d-electrons in a transition metal or the excitation energy of the impurity atoms.

The superconducting transition temperature is given by the usual formula

$$T_c = 1.14\ \Delta E\ e^{-1/\lambda}, \qquad (2)$$

where $\lambda = |f|mP_0/2\pi^2$ is the dimensionless constant of interaction (1) and $P_0$ is the Fermi momentum.

According to Geilikman's estimates $\Delta E \sim 0.1 - 1$ eV and $\lambda \sim 1$. In this case $T_0$ turns out to be of the order of $10^3 - 10^4$ °K, and this is the reason for the interest in these models.

In the usual superconductivity mechanism with a Froehlich electron-phonon interaction constant g (the corresponding dimensionless constant is $\zeta = g^2mP_0/2\pi^2$) there exists the natural limitation

$$\zeta < \tfrac{1}{2}, \tag{3}$$

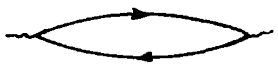
which follows from the lattice stability condition [5].

We consider the conditions for lattice stability in the presence of additional direct electron-electron interaction (1).

The electron-phonon interaction leads to renormalization of the bare phonon frequency $\omega_0$ [5]

$$\omega(k) = \omega_0(k)\sqrt{1 + g^2\Pi(k)}. \tag{4}$$

Here $\Pi(K) \simeq \Pi_0(K)$ is the polarization operator, represented by the simplest diagram



In the limit when $k \ll 2P_0$

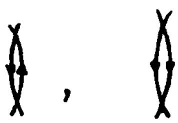
$$g^2\Pi_0(k) = -\frac{g^2 mP_0}{2\pi^2}2 = -2\zeta. \tag{5}$$

From the condition that the renormalized frequency (4) be real we obtain the criterion (3).

In the presence of the direct electron-electron interaction (1) on top of the electron-phonon interaction, formula (4) remains in force. However, in the calculation of the polarization operator $\Pi(K)$ the simplest diagram will not do, and it is necessary to sum the chain

where the 4-point vertex is connected with the interaction (1).

Generally speaking, each loop can be made more elaborate by arbitrary inserts of the type



However, since the interaction in the 4-point vertex is limited to a region of width $\Delta E$ near the Fermi surface, all such inserts contain an extra small parameter $\Delta E/\epsilon_F \lesssim 0.1$ and can be neglected.

As a result, the polarization operator takes the form

$$\Pi(k) = \frac{\Pi_0(k)}{1 - f\tilde{\Pi}_0(k)}, \tag{6}$$

where $\tilde{\Pi}_0(k)$ coincides with $\Pi_0(K)$ when $k \lesssim \Delta E(P_0)/\epsilon_F$ and is equal to $\Delta E\Pi_0(K)/\epsilon_F$ when $k > (\Delta E)P_0/\epsilon_F$.

Substituting (6) in (4) we arrive at a natural generalization of the lattice stability criterion (3)

$$\zeta + \lambda < \tfrac{1}{2}. \tag{7}$$

Thus, regardless of the concrete mechanism of the additional electron-electron interaction (1), the condition for lattice stability imposes a limitation on its constant $\lambda$. This limitation must be taken into account in estimates of the possible values of the critical temperature.

In most metals $\zeta \sim 1/3 - 1/5$. Hence, according to (7), $\lambda \lesssim 1/4 - 1/6$. We then obtain, for the values $\Delta E \sim 0.1$ eV given by Geilikman [3], $T_c \sim 10 - 10^3$ °K. It is also obvious that, in contrast to ordinary superconductivity, we can hope to obtain here high critical temperatures in substances having only weak electron-phonon interaction.

We can estimate the temperature $T_K$ at which the lattice instability appears for the first time.

Using temperature Green's functions [4], we obtain for this temperature the expression (for $T_K \ll \epsilon_F$)

$$T_k = \frac{2\sqrt{3}}{\pi} \epsilon_F \sqrt{\frac{2}{1 - 2\lambda} - \frac{1}{\zeta}}. \tag{8}$$

We see that when $\lambda > \lambda_{cr} = 1/2 - \zeta$ the value of $T_K$ increases very rapidly and certainly exceeds the critical temperature of the superconducting transition.

In conclusion, we thank V. L. Ginzburg and L. V. Keldysh for a discussion of the work.

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## A POSSIBLE EXPERIMENT FOR FINDING SUPERCONDUCTORS WITH DIFFERENT PAIR MULTIPLICITY

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It has been assumed in many papers that certain superconductors can be in the triplet state, or generally in a state with $l \neq 0$ (cf. e.g. [1, 2]). It is obviously necessary now to check these assumptions experimentally, but this is not so simple. One possible experiment for finding superconductors with different $l$ may be the Josephson tunneling. Indeed, the angular-momentum conservation law forbids the Josephson effect for structures consisting of superconductors with pairs in different orbital states. This is seen mathematically already from the fact that the Josephson current is proportional to [1)]

$$\iint d\Omega_1 d\Omega_2 |T_{kq}|^2 \Delta^+(\vec{k})\Delta(\vec{q}) \sim t_{l_1} d_{l_1 l_2} \delta_{m_1 m_2},$$

where we have put $\Delta(\Omega) \sim Y_{lm}(\Omega)$ and carried out the expansion