The results obtained thus show that the tunneling effect between $\sim 10^{-5}$ cm thick superconducting films can be explained satisfactorily by the present theory of superconductivity, and the ratio $2\Delta/kT_c$ is not a universal constant. The ratio $2\Delta/kT_c$ obtained on thin films is close to the value determined by other methods on bulk specimens. However, while results of investigations on bulk specimens indicate the existence of strong anisotropy of Δ in a number of metals, no noticeable anisotropy was found in the investigation of the tunnel effect in thin films of superconductors. For example, although the anisotropy of Δ in tin is as much as $\sim 30\%$, according to measurements on the heat capacity[5] and on the absorption of ultrasonics,[6] the $\sigma(V)$ dependence is close to that which follows from an isotropic model. It is possible that this arises because the thickness of the films studied was much smaller than the coherence distance of the electrons of the superconductor.

In conclusion, I express my thanks to P. L. Kapitza and A. I. Shal'nikov for their interest in this work.

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THE SPECIAL ROLE OF OPTICAL BRANCHES IN THE MÖSSBAUER EFFECT

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1. Recently two experimental groups have detected an anomalous temperature behavior of the Mössbauer effect in SnO_2[1] (radiator Sn^{119}) and Dy_2O_3[2] (radiation Dy^{161}). It appeared that in these materials the effect exists at high temperatures, and its fall-off with increasing T occurs much more slowly than would be expected starting from the actual values of the Debye temperature and a simple theoretical description of the effect.[3]

In the present note we give the results of an analysis of the effect of optical branches of the crystal on the magnitude of the Mössbauer effect, which makes it possible in particular to explain the observed regularities.

2. The probability of the Mössbauer effect in a crystal of arbitrary symmetry, when the radiator is one of the atoms in the elementary cell (j), is given by the expression[4]

$$W_j = \exp\{-Z_j\}, \qquad (1)$$

$$Z_j = R\frac{v_0}{(2\pi)^3}\sum_\alpha \int_* \frac{|\mathbf{qV}_j(\mathbf{f}, \alpha)|^2}{\hbar\omega(\mathbf{f}, \alpha)}[2\bar{n}(\mathbf{f}, \alpha) + 1]\, d^3f \qquad (2)$$

(where the notation is all the same as in [4]).

If we use the orthonormality of the complex amplitudes $V_j^\xi(\mathbf{f}, \alpha)$, one can show that for any atom in the cell and for arbitrary direction of the γ quantum we have the relation

$$(2\pi)^{-3} v_0 \sum_\alpha \int_* |\mathbf{qV}_j(\mathbf{f}, \alpha)|^2 d^3f = 1. \qquad (3)$$

It then follows from (2) and (3) that at T = 0 the effect is determined by the average over branches and phase space of the value of $1/\omega(\mathbf{f}, \alpha)$, where the probability density distribution is given by the quantity $|\mathbf{q}\cdot\mathbf{V}_j(\mathbf{f}, \alpha)|^2$.

This result enables us to draw the important conclusion that the probability of the Mössbauer effect will be the larger the greater the relative magnitude of the amplitude of oscillation of the atom in the highest-lying optical branches in the fundamental region of the phase space of the reciprocal lattice.

Let us compare crystals with one and with several atoms in the unit cell, which have similar characteristic acoustic frequencies (that is, similar Debye temperatures). If we have the same radiator in both cases, it follows from (2) and (3) that the Mössbauer effect in the polyatomic lattice will, in general, occur with higher probability.

The presence of optical branches in the crystal can markedly change the temperature dependence of the effect. In fact, the temperature excitation of optical phonons begins at much higher temperatures compared with acoustic phonons. Therefore, if the role of optical branches in vibrations of the atoms of the j-th type is significant, W_j drops with temperature more slowly compared with the monatomic lattice with the same Debye temperature.

In the limiting case where the optical branches play a predominant role, W_j changes slowly with temperature, so long as kT does not become of the order of the characteristic energy of the optical phonons.

3. To find the frequency spectrum and relative values of the amplitudes of oscillation for different branches, one must solve the eigenvalue problem for the dynamical matrix $C_{jj'}^{\alpha\beta}(\mathbf{f})$.[5] Let us consider a lattice with two atoms in the elementary cell. If for simplicity we assume that the dynamical matrix can be reduced to diagonal form simultaneously for all values of $\mathbf{f}$ and j, j', then the qualitative analysis of the vibration problem can be carried through completely.

As $\mathbf{f} \to 0$ for the acoustic branch which corresponds to polarization along the ξ axis, we have

$$V_1^\xi / V_2^\xi = \sqrt{m_1 / m_2}, \tag{4}$$

while for an optical phonon with the same direction of polarization:

$$V_1^\xi / V_2^\xi = -\sqrt{m_2 / m_1}. \tag{4'}$$

If $m_1 \gg m_2$, we see that for a heavy atom the contribution to Z_j in (2) for small $\mathbf{f}$ is due mainly to the acoustical branch, while for the light atom it is mainly from the optical branch. Which situation will hold for arbitrary $\mathbf{f}$ depends essentially on the nature of the interaction between the atoms. If the interaction between the heavy atoms is greater than all other interactions, so that the inequality

$$|C_{11}^{\xi\xi}(\mathbf{f})| \gg |C_{12}^{\xi\xi}(\mathbf{f})|, \quad |C_{22}^{\xi\xi}(\mathbf{f})| \tag{5}$$

holds in the fundamental part of phase space, then with increasing $\mathbf{f}$ the heavy atom "slips over" into the optical branches. Since the phase volume corresponding to small wave vectors is small, Z_j for the heavy atom will be determined for the most part by the optical branches. As a consequence, we get a large Mössbauer effect for a heavy radiator at T = 0, and a weak dependence of the effect on temperature.

The results found give a good qualitative explanation of the observed temperature dependence of the effect.[1,2] Though the elementary cell in SnO_2 and Dy_2O_3 contains more than two atoms, it is obvious that all the arguments remain unchanged.

If the predominant interaction is that between different atoms or the interaction between light atoms, then as $\mathbf{f} \to 0$, just as for arbitrary $\mathbf{f}$, in the optical branches the predominant vibration will be that of the light atom. As a result, in such a lattice one will observe a weaker temperature dependence even for the light radiator. The case of a cubic lattice, which is considered in detail in [6], taking account of the interaction with nearest neighbors, corresponds to just this variant.

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POLARIZATION OF LAMBDA HYPERONS GENERATED ON LIGHT NUCLEI BY NEGATIVE 2.8-Bev/c PIONS

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MANY experimental investigations[1,3] were devoted to the polarization of Λ hyperons generated in π^-p and π^--nucleus collisions at pion energies greater than 2 Bev. In a preliminary communication[1] we reported a freon bubble chamber[4] investigation of the transverse polarizations of the Λ particles produced in the reactions

$$\pi^- + A \to \Lambda + K + A' + n\pi, \tag{1}$$

$$\pi^- + A \to \Sigma^0 + K + A' + n\pi, \quad \Sigma^0 \to \Lambda + \gamma \tag{1'}$$