TEMPERATURE DEPENDENCE OF THE EFFECT OF TRANSFORMATION OF ELECTROMAGNETIC ENERGY INTO ACOUSTIC IN THE ABSENCE OF CONSTANT MAGNETIC FIELD

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In /I/ the temperature dependence of the effect of transformation was experimentally investigated in the interval of temperatures from 4,2 - IOO K in metal films which thickness d satisfies $d \gtrsim \ell$,where ℓ is the mean free path of the electrons.Our aim is to present a theory which may be useful in the explanation of the experimental results /I/.We assume that the only temperature sensitive parameter is the mean free path of the electrons.

The problem is reduced to a coupled system of equations:the kinetic equation of the conductivity electrons, the Maxwell equations and the equation of the theory of elasticity /2/.General expressions for the amplitude of the acoustic waves in the bulk metal samples were obtained in /3,4/,where the frequency dependence of the effect of transformation was investigated in detail for the cases of specular / $p=1$ / and diffuse / $p=0$ / reflection of the electrons from the surface of the sample.Here,these results are analysed as functions of ℓ and they are presented graphically.

In the case of normal skin-effect / $\ell \ll \lambda$ /,the transformation of electromagnetic energy into acoustic is more effective for larger ℓ ,which is a consequence of the fact that if ℓ is greater,the electrons have more time to interact with the electromagnetic field / Fig.I /.When the frequency ω is increased,the thickness of the skin layer is reduced and starting from some relatively large ℓ ,the surface mechanism becames predominant / Fig.Ic-d/.

In the case of anomalous skin-effect / $\ell \gg \lambda$ /, the role of ℓ is taken by the skin depth δ_{sk} .Because of this, the transformation governed by volume forces saturates with further increase of l .The transformation regulated by surface forces is less effective if l is increased,because the number of collisions with the surface is reduced.The saturation in this case /fig.Id/ comes from the fact,that when $\omega \gg \nu$,the role of l is played by the path of the electrons for one period of the electromagnetic wave $\frac{V_F}{\omega}$ / $\nu \equiv \frac{1}{\tau}$ is the collison rate of the electrons, V_F is the Fermi velocity/.

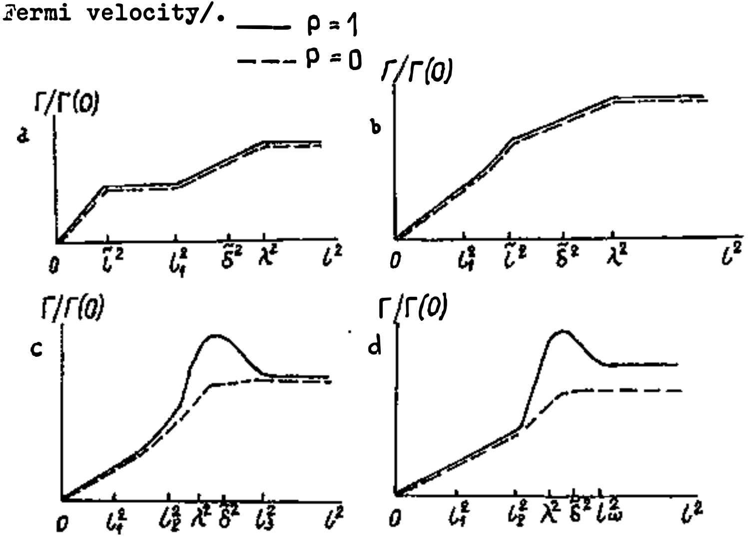

Fig.I The dependence of the coefficient of transformation Γ on the free path l of the electrons:a/ $\omega \ll \frac{s^2}{\delta_0^2 V_F}$ b/ $\frac{s^2}{\delta_0 V_F} \ll \omega \ll \frac{s}{\delta_0}\left(\frac{s}{V_F}\right)^{1/2}$ c/ $\frac{s}{\delta_0}\left(\frac{s}{V_F}\right)^{1/2} \ll \omega \ll \frac{s}{\delta_0}$ d/ $\frac{s}{\delta_0} \ll \omega \ll \frac{V_F}{\delta_0}$; $l_1 = \frac{s^2}{\omega V_F}$ $\tilde{l} = \frac{\omega V_F \delta_0^2}{s^2}$, $\tilde{\delta} = \left(\frac{\delta_0^2 V_F}{\omega}\right)^{1/3}$, $\lambda = \frac{s}{\omega}$, $l_2 = \frac{\lambda^2}{l}$

One can see from the graphs that the maximum is a result of the surface mechanism of transformation.

References

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