TABLE I. Conductivity and thermoelectric power of the alkali metals.

	Li	Na	K	Rb	Cs
r_s	3.22	3.96	4.87	5.18	5.57
m^*/m	1.45	0.98	0.93	0.89	0.83
β	0.634	0.703	0.78	0.80	0.834
$N(\epsilon_F)/N_0(\epsilon_F)$	0.837	0.90	0.935	0.945	0.965
τ/τ_0	1.43	1.23	1.14	1.12	1.07
σ/σ_0	1.70	1.37	1.22	1.19	1.11
S/S_0	0.81	0.91	0.99	1.01	1.05

the thermoelectric power is a second-order phenomenon and hence the second derivative of part of the integrand appears. (Blatt took the conductivity to be proportional to $N\tau$, further invalidating his calculations; the conductivity is proportional to $N\tau v^2$ and v is replaced by $\hbar^{-1}(d\epsilon/dk)$. A similar mistake was made in his formula for the thermoelectric power.)

The modified results are shown in Table I, the last three rows being different from Blatt's results. It is to be noted that σ/σ_0 for lithium is 1.70, whereas Blatt found a value 1.07. This represents a considerable change in the conductivity.

The author would like to express his thanks to the Admiralty for permission to publish this work.

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Cyclotron Resonance in Tin and Copper

E. FAWCETT
Division of Pure Physics, National Research Council, Ottawa, Canada

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THE recent measurements of cyclotron resonance absorption in semiconductors[1] have stimulated interest in the possibility of observing this phenomenon in metals.[2,3] In normal metals at microwave frequencies the theoretical treatment is complicated by the intervention of anomalous skin effect conditions when the condition $\omega\tau \gg 1$ is satisfied (ω being the angular frequency and τ the relaxation time of the electrons). When the dc magnetic field is applied perpendicular to the metal surface, the equations describing the behavior of a free-electron model are formally analogous to those describing the anomalous skin effect in the absence of a field, and Azbel' and Kaganov[4] and Chambers[3] have shown that in this case the surface impedance is independent of the field in the extreme anomalous limit. The more interesting case when the magnetic field is parallel to the surface and the metal is in the extreme anomalous region has been analyzed recently by Azbel' and Kaner.[5] They find that when $\omega\tau \gg 1$, the resistance plotted as a function of the field should exhibit a series of resonance peaks, which occur when the cyclotron resonance frequency is near the subharmonics of the microwave frequency. For all $\omega\tau$, the resistance should decrease uniformly with increasing field for sufficiently large fields.[6] The preliminary measurements on tin and copper presented below appear to be consistent with this description. A brief report on this work has already appeared.[7]

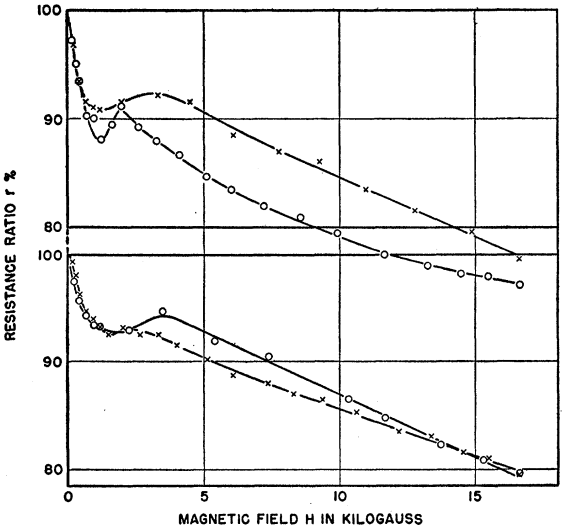

FIG. 1. Cyclotron resonance absorption in tin at 4.2°K for plane polarized radiation near 24 kMc/sec and magnetic field parallel to the metal surface. Specimen orientation—$\theta = 59°$, $\phi = 43°$; upper curves—$J \parallel X$, lower curves—$J \parallel Y$; ○—$H \parallel J$, ×—$H \perp J$; $\omega\tau = 27$.

The resistance is measured calorimetrically by a method similar to one described previously.[8] The specimen, in the form of a disk, is suspended in a vacuum chamber immersed in liquid helium, and faces the open end of a square wave guide. Microwaves at a frequency of 24 kMc/sec may be propagated in the wave guide in either of the two principal modes so that the direction of current flow is either parallel or perpendicular to the magnetic field, which is applied as nearly as possible parallel to the surface of the specimen. A link of high thermal resistance is provided between the specimen and the helium bath so that the specimen temperature rises, with a fairly short time constant, by an amount proportional to the heat generated by the incident microwaves, which under constant current conditions is a measure of the resistance. The rise in temperature is measured by means of a carbon composition thermometer attached to the back of the specimen. Spurious heating of the thermometer by microwaves leaking from the wave guide past the edge of the specimen is prevented by suitably disposed circular choking grooves. The values of $\omega\tau$ were calculated from the measured dc resistances of the specimens at 4.2°K using Chambers'[9] values of the effective number of free electrons per atom in tin and copper.

The variation with the magnetic field H of the resistance, expressed as a percentage r of its value in zero field, for an electropolished single crystal of tin is shown in Fig. 1. The angles θ and ϕ describing the orientations of the tetrad and dyad axes of the crystal with respect to the normal to its surface are defined in reference 8. The upper and lower curves correspond to current flow J in the X direction parallel to the projection of the tetrad axis in the surface and the perpendicular Y direction, respectively. For both orientations and for both the transverse case ($H\perp J$) and the longitudinal case ($H\|J$), the behavior is characterized by an initial rapid decrease of resistance, followed by a "resonance peak" and a linear decrease at a rather slower rate in high fields. If the field at the turning point is identified with the cyclotron resonance field H_c in the expression $eH_c/m^*c=\omega$, the values of the effective mass m^* range from 0.23 m_0 to 0.43 m_0. For a second tin specimen of a different orientation having $\omega\tau=20$, there was some evidence of an additional peak at a lower field, possibly a subharmonic resonance. For both specimens the resistance at high fields decreases much less rapidly than is implied by the expression $r=(2/3\omega\tau)\{2\pi H_c/H\}^{\frac{1}{3}}$ to which Azbel's[6] Eq. (7) reduces when $\omega\tau\gg 1$ and $H\gg H_c$. This may be due to the complex geometry of the Fermi surface of tin[8] or to a pronounced anisotropy of the relaxation time, either of which might considerably modify the behavior.

Figure 2 shows the results for an electropolished single crystal of copper. Here the X direction is the intersection with the metal surface of a plane containing the normal and two of the tetrad axes, one of which makes an angle of 28° with the normal. The absence of a resonance peak is to be expected when $\omega\tau\sim 1$ (see Fig. 1 of reference 5). The decrease at high fields is not inconsistent with Azbel's formulation for this value of $\omega\tau$ if we take $m^*\sim 1.5\ m_0$,[10] but the anisotropy of the effect is surprisingly marked for a cubic monovalent metal such as copper.

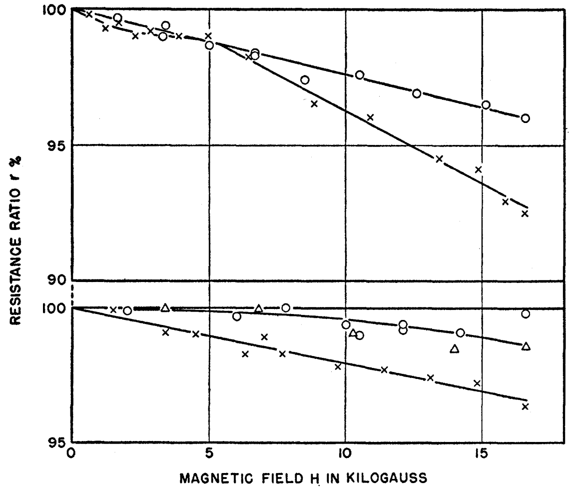

FIG. 2. Cyclotron resonance absorption in copper at 4.2°K for plane polarized radiation near 24 kMc/sec and magnetic field parallel to the metal surface. Specimen orientation—see text; upper curves—$J\|X$, lower curves—$J\|Y$; ○—$H\|J$, ×—$H\perp J$; $\omega\tau=1.05$.

The author is indebted to Dr. R. G. Chambers for a stimulating correspondence and for drawing his attention to the work of Azbel, and Kaner.[5]

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Need for Upward Revision of λ_g/λ_s and its Consequences*

JESSE W. M. DUMOND, *California Institute of Technology, Pasadena, California*

AND

E. RICHARD COHEN, *Atomics International, Canoga Park, California*

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THE conversion constant, $\Lambda(=\lambda_g/\lambda_s)$, from the Siegbahn nominal scale of x-units to milliangstroms has been extensively measured in Sweden by comparing, with a concave ruled grating spectrograph, certain x-ray lines with certain standard reference lines obtained from hydrogen-like spark spectra whose wavelengths were computed by means of a theoretical formula for the Lyman series. The work of Tyrén[1] is an outstanding example. Bearden[2] and others, on the other hand, have determined Λ by absolute measurements of the diffraction angles of certain x-ray lines in grazing incidence on plane gratings. The grating constants were either measured directly (by comparator measurements of a counted number of lines) or calibrated directly with optical spectra whose wavelengths in angstroms were known without resort to theoretical