when the lead became superconducting. These results seem to cast doubt upon the general validity of the supposed fundamental property of superconductors, namely, the zero value for the magnetic induction, B, within a substance when it is in the superconducting state.

Because of the fundamental nature of this experiment, we investigated the problem under isothermal conditions which facilitate precision measurements and eliminate errors due to temperature gradients. A lead sphere, one inch in diameter, was studied at *ca.* 4.2°K through the measurement of the induced electromotive force, between the axis and the periphery of the sphere, as a function of the applied magnetic field, H, in the direction of the axis of rotation, the rotational speed being maintained constant. Thus far, two speeds have been used: 200 r.p.m. and 350 r.p.m. The results were entirely in accord with the concept of the inability of a magnetic field to reside within a superconductor. As H was increased from zero, the induced voltage remained zero until the field reached a value $H=\frac{2}{3}H_c$. In the transition range, the voltage increased linearly with the field up to the critical field, $H=H_c$, attaining at this point a value in agreement with that deduced from the laws of electromagnetic induction for a conductor of permeability unity. Thus at 200 r.p.m. and at 4.180°K, corresponding to $H_c=552$ oersteds, the measured e.m.f. was 91 microvolts. The e.m.f. *versus* field curve was reversible except for a small hysteresis corresponding to a "frozen-in" flux of about 8 percent of the value obtaining within the specimen at $H=H_c$.

Auxiliary experiments in which the sphere was cooled in the presence of a magnetic field, in contrast to our aforementioned experiments, confirmed the transition to a state wherein the magnetic induction is zero. Under these conditions, the measured e.m.f. was only 17 percent of the value to be expected of a normal conductor, and was 7 percent of the e.m.f. observed at $H=H_c$. In addition, qualitative experiments involving temperature changes under conditions of constant rotational speed and applied magnetic field resulted in e.m.f. changes of the type to be expected from the variation of B with temperature.

The e.m.f. *versus* H transition curves should be entirely equivalent to those of B *versus* H. This was confirmed by measurements of B *versus* H by the conventional method described by Keeley and Mendelssohn.[3] All of our data are consistent and give values of H_c in very close agreement with the carefully determined critical data of Daunt and Mendelssohn.[4]

More extensive measurements, covering higher rotational speeds, will be reported in detail in the near future.

[1] W. V. Houston and C. F. Squire, Science **109**, 439 (1949).
[2] W. Meissner and R. Ochsenfeld, Naturwiss. **21**, 787 (1933).
[3] T. C. Keeley and K. Mendelssohn, Proc. Roy. Soc. London **A154**, 378 (1936).
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Thompson Scattering and the Hole Theory

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IT is well known that the original Dirac theory and the "hole" theory give identical values for the scattering (electromagnetic waves) cross section of an (isolated) electron—in the "original" theory the negative energy states are assumed to be all vacant whereas in the hole theory they are all occupied. The type of divergence, however, of the electron self-energy is different in the two cases. Recently, while examining the problem of the effect of radiation field on the electromagnetic shift of the s-level of the H-atom, we were led, incidentally, to consider how the scattering cross section for a free electron becomes modified when it belongs to an assembly of a degenerate Fermi-Dirac gas. It was immediately obvious that the cross section for this case is affected differently according to whether the original theory or the hold theory is used. For instance, in the non-relativistic case (Thompson scattering) the scattering cross section is practically unaffected in the original theory whereas this is not so in the hole theory. In the case of the hole theory, the scattering cross section tends to vanish for photons of wave-length λ_0, where λ_0 is the minimum de Broglie wave-length for the fermi distribution for the degenerate electron gas.

We were, therefore, greatly interested to see a recent note by Halpern and Hall[1] on the coherent scattering of radiation and negative energy states. They have considered the scattering cross section of neutral atoms originally calculated by Waller, assuming the negative energy state to be unoccupied, and find that, in the case of the hole theory, the results of Waller need modification. As Halpern and Hall conclude, the results obtained indicate that not only the proof concerning the equivalence of the two versions of the theory is erroneous, but also that the two theories lead to different predictions concerning experimental results. The point that the hole theory and the original theory do not lead to identical results has been often overlooked. It is therefore worth while to draw attention to the fact that even for Thompson scattering the results are identical only when we consider an isolated electron, but they are different if the electron is the constituent of a degenerate gas. (In the case of non-degeneracy the difference is negligible.)

[1] O. Halpern and H. Hall, Phys. Rev. **75**, 910 (1949).

Quadrupole Moment of Sb^{121} and Sb^{123}

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IN order to find the value of the quadrupole moment of Sb^{121} and Sb^{123}, the hyperfine structure of the spectrum of Sb II was studied. This was excited in an aluminum hollow cathode discharge tube which was filled with neon of a few mm Hg pressure. The cathode contained some powdered antimony and was cooled with water. The fine structure was examined by the use of two glass Lummer plates (thickness=10 mm and 4.7 mm), a quartz Lummer plate (thickness=4.4 mm), and a Fabry-Pérot etalon.

$\lambda 5640(5p6s^3P_2-5p6p^3S_1)$ was found to have the following structure: 0(10), 0.072(8), 0.222(8)*, 0.315(6), 0.351(6), 0.403(4)*, 0.484(7)*, 0.616(7)*, 0.672(2), 0.736(3) cm^{-1}, where numbers in brackets represent visually estimated intensities. The approximate structure of this line was calculated by Badami by assuming the nuclear spins[1] $I=5/2$ for Sb^{121} and $I=7/2$ for Sb^{123}. Comparison of the observed structure with the calculated one shows that the components marked with * are blends and are not suited for determining the hyperfine levels. From the observed structure we obtain the hyperfine separations of the term $5p6s^3P_2(Sb^{121})$:

$$F_{\frac{7}{2}\frac{9}{2}}-F=0.315\ cm^{-1}$$
$$F_{\frac{1}{2}\frac{3}{2}}-F=0.736+\text{total separation of } 5p6p^3S_1$$
$$=0.736+0.135=0.871\ cm^{-1}.$$

If we assume that the position of the hyperfine structure levels of a term is represented by $E=E_0+(A/2)C+C(C+1)$ where A and B are the fine structure constant and the quadrupole constant respectively and $C=F(F+1)-I(I+1)-J(J+1)$, we obtain from the above mentioned separations the values of the constants:

$$5p6s^3P_2(Sb^{121}):\quad A=0.0674,\quad B=-0.000086.$$

The value of the quadrupole moment Q can be calculated by the formula which is due to Casimir[2]:

$$=\frac{BZ_iH}{\delta R'}I(2I-1)44370\cdot10^{-24}\ cm^2,$$