of using an absorber of unseparated Dy_2O_3.

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PARAMAGNETIC RESONANCE IN METALLIC ALUMINUM

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A number of experimental and theoretical papers[1-9] have been devoted to paramagnetic resonance in the conduction electrons of a metal. However, most of the investigations have been made on alkali metals where the electron resonance line is sufficiently narrow, due to the weak spin-orbit interaction. The difficulty of observing paramagnetic resonance in "classical" metals, in which the spin-orbit interaction is strong, is increased because impurities can lead to a sharp reduction in the spin relaxation time and thus to a broadening of the absorption curve.

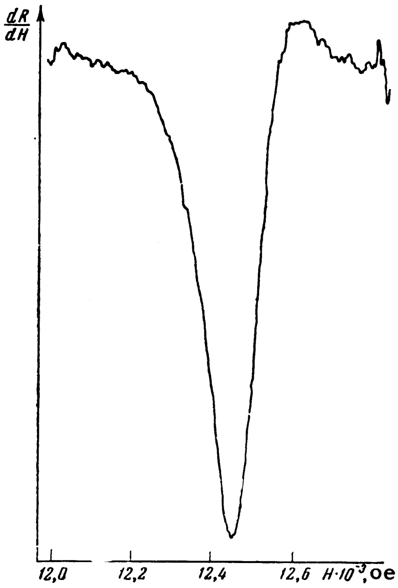
In this note we describe experiments on the observation of electron paramagnetic absorption in single crystal aluminum with a residual resistance of 6.7×10^{-5},* corresponding to an electron mean free path $\sim 2 \times 10^{-2}$ cm.

The specimen, in the form of a 10 mm diameter disc of thickness ~ 3 mm, was electropolished and served as the base of a cylindrical resonance cavity in which H_{011} mode oscillations were excited. The perfection of the surfaces was such that at T = 4.2° K several cyclotron resonance oscillations were fairly clearly observed.

The dependence of absorption on magnetic field was studied with a high sensitivity spectrometer, working at a frequency of 3.6×10^{10} cps in the temperature range 300 — 4.2° K.

A broad symmetrical line was visible at temperatures of 300 and 77° K. The intensity of the line depended weakly on temperature, indicating the electronic character of the absorption. At hydrogen temperatures the absorption line has pronounced asymmetry which increases somewhat as the temperature is reduced to 4.2° K.

Figure 1 shows the dependence of the derivative of the surface impedance, dR/dH, on magnetic field H at T = 4.2° K. The results of the investigation refer to a specimen in which the fourfold axis was perpendicular to the surface of the specimen. The line width, determined at the half height of the derivative, does not change over the interval 20 — 4° K and equals 140 oe, corresponding to a spin relaxation time $\tau_{sp} \approx 5 \times 10^{-10}$ sec.



One can deduce from the fact that the line width is weakly dependent on temperature, while according to B. I. Aleksandrov's measurements an appreciable change in the dc resistance of aluminum is still observed, that the spin relaxation time is determined by impurities with strong spin-orbit coupling. This deduction is also confirmed by measurements on aluminum with a large impurity content, for which the value $\tau_{sp} \approx 5 \times 10^{-11}$ sec was found.

The absence of anisotropy in the line width and g-factor (equal to 2.06) can also be explained by the strong line broadening produced by impurities.

The shape of the absorption line, which has been studied very thoroughly by other authors,[5] is not understood. It was shown for the alkali metals that the positive part of the derivative dR/dH is considerably larger than the negative.

Examination of the shape of the absorption curve shows that for aluminum and copper the negative part of the derivative is considerably greater than the positive. This can be explained formally by particles with opposite sign of spin taking part in the paramagnetic resonance. It seems likely that Dyson's theory[6] is not fully applicable to our case, since $\mu H \lesssim kT$ and τ_{sp} is of the same order of magnitude as the collision time.

Since the electron mean free path is greater than the radius of the electron orbit in the magnetic field, a dependence of the signal strength on the inclination of the magnetic field relative to the specimen surface is observed in the experiments. The change in signal amplitude is in qualitative agreement with the theory of Azbel', Gerasimenko, and Lifshitz.[7]

*We are grateful to B. I. Aleksandrov for providing the initial specimen, prepared in his laboratory.

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SMALL-ANGLE SCATTERING OF 0.8- AND 2.8-Mev NEUTRONS

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WHEN studying the scattering of neutrons with an average energy of about 2 Mev in the region of angles smaller than 8 — 10°, we discovered, besides Schwinger scattering,[1] an additional contribution to the scattering cross section of U and Pu nuclei.[2,3] In this work we have tried to establish the energy dependence of the indicated effect in the angle interval of 3 to 25°. The work was carried out with a fast-neutron reactor. Measurements were made in two energy intervals with average energies of 0.8 and 2.8 Mev. The neutrons, with an average energy of 0.8 Mev, were separated out of a broad spectrum of reactor neutrons by radiotechnical collimation of the recoil protons.[4] The measurements at an average energy of 2.8 Mev were made with a threshold detector (as was done in references 2 and 3). The performance of the collimation system used for the measurements is presented in Fig. 1.

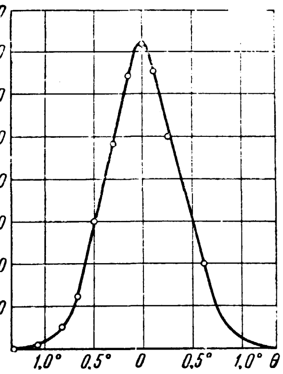

FIG. 1

Measurements were made in the 3 — 8° interval both to the left and to the right of the neutron beam; agreement of the two measurement results was observed. Figures 2 and 3 present the results of the measurements. The quantity $\gamma^2 \cot^2(\theta/2)$, which is the cross section for Schwinger scattering, was computed from the experimental points; $\gamma = \frac{1}{2}\mu_n(\hbar/mc)(ze^2/\hbar c)$, $\mu_n = 1.91$. As is evident from the graphs, the results of the measurements for neutrons of about 0.8 Mev agree with the theory of Schwinger scattering within the limits of error. At an energy of ~ 2.8 Mev, as was also reported in