OBSERVATION OF FOCUSED ELECTRON BEAMS IN A METAL

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We have performed the experiment proposed in [1], aimed at producing and observing in a metal with a large mean free path of electron beams starting from a definite point of the sample and focused by a longitudinal magnetic field in another point of the sample. The apparatus is thus an analog of a β spectrometer with longitudinal focusing. The sources and collectors for the electron beams were electric contacts of small size.

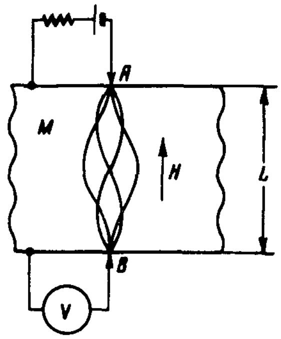

Fig. 1. Diagram of experiment

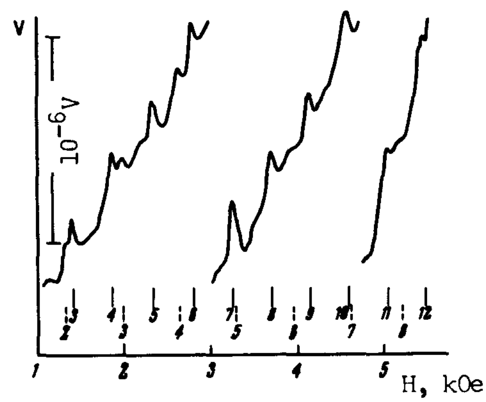

Fig. 2. Plot of V(H). For compactness, the curve is divided into three sections which are arbitrarily displaced along the ordinate axis.

The experimental set-up is shown in Fig. 1. Two thin points A and B of tin wire 60 μ in diameter were soldered to a single-crystal plate M of high purity and of thickness L = 0.4 mm. The contact diameter was of the order of a micron. The experiment was carried out at 2°K. A 200 mA current was made to flow through the circuit of point A. The voltage difference between point B and a supplementary lead soldered to the sample was recorded with a galvanometric amplifier V and an automatic recorder. The sample was placed in a magnetic field H, which could be varied in magnitude and in direction.

In the absence of a magnetic field, the measured voltage V was quite small, in view of the large conductivity of the sample. When the magnetic field was turned on, a signal appeared in the circuit of point B, and its magnitude increased abruptly when the direction of the field approached the line AB. By observing the magnitude of the signal it was possible to establish the direction of the field along the line AB accurate to several minutes. In our experiment the direction AB was close to the [100] direction, being inclined from the latter by about 5° to the [001] axis and 6° to the [010] axis.

The dependence of the signal on the intensity of the magnetic field directed along AB is shown in Fig. 2. In addition to the overall increase in the signal, approximately proportional to H^2, the curve shows series of periodically repeating maxima. The most intense series with peaks of height $\sim 10^{-7}$ V is denoted by the solid bars in the lower part of the figure, while another series, less intense, is designated by dashed bars.

The observed singularities on the V(H) curve can be attributed to the focusing of definite groups of electrons, accelerated by the electric field near the point A toward the point B, where they produce a voltage burst. The magnitude of the effect is in satisfactory agreement with estimates made in [1]. Upon focusing, the electrons execute an integral number of revolutions (while moving along helices) during the time of motion between points A and B. Figure 1 shows schematically the trajectories of the electrons for n = 1. The value of the number n is indicated in Fig. 2 next to the bars designating the positions of the peaks.

It is still impossible to identify with any assurance the sections of the Fermi surface of tin responsible for the appearance of the observed peaks. Generally speaking, the motion of an electron with given p_H along the direction of H (p_H is the component of the electron momentum in the H direction) in one revolution is equal to $(c/eH)(\partial S/dp_H)$, where S is the area of intersection of the plane p_H = const with the Fermi surface. Accordingly, the singularities on the V(H) curve arise in the presence of singularities of the function dS/dp_H, especially in the presence of elliptic turning points on the Fermi surface.

We thank P. L. Kapitza for interest in the work.

[1] Yu. V. Shavrin, JETP 48, 984 (1965), Soviet Phys. JETP 21 (1965), in press.

ERRATA

In "Letters to the Editor" vol. 1, No. 2, p. 69, line 13 (Russian page 46), replace 1.5 kOe by 15 kOe.