On the Albedo of Slow Neutrons

Halpern, Lueneburg and Clark[1] have recently given a rigorous solution of the integrodifferential equation describing the diffusion of thermal neutrons in paraffin. Although the method used by these authors is very elegant and involves the overcoming of serious mathematical difficulties, the criticism given by them of our interpretation[2] of the experimental results does not seem to be correct.

The definition of albedo as "reflection coefficient for neutrons impinging on a plane surface limiting a large paraffin block" is not quite unique. We introduced, therefore, what we called "experimental albedo" by formula (10) of our paper in the *Physical Review*,[3] All measurements of the albedo are to be compared with this definition, and to the same definition the relationship

$$\beta = 1 - 2/(N)^{\frac{1}{2}}$$

refers, as proved in Fermi's paper.

Halpern, Lueneburg and Clark have instead calculated a different quantity viz., the reflection coefficient defined as the ratio of the number of reflected neutrons to the number of incident neutrons. Our definition rests on the measurement of the activity of a thin detector; now this activity is not simply a measure of the number of incident neutrons, but it also depends on their angular distribution, neutrons falling normally on the detector being less effective than neutrons falling at a large incidence angle (the probability of capture is proportional to $1/\cos\vartheta$). Since the angular distributions of the incident and reflected neutrons are different, the difference between Halpern's result and ours is easily explained.[4]

We must therefore maintain, that the average number of impacts of a thermal neutron in paraffin as given in our papers is correct, apart from the uncertainty of the experimental data.

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[1] O. Halpern, R. Lueneburg and O. Clark, Phys. Rev. **53**, 173 (1938).
[2] E. Amaldi, E. Fermi, Phys. Rev. **50**, 899 (1936); E. Fermi, Ricerca Scient. **7**, 13 (1936).
[3] See e.g. our paper, reference 2, page 910, column 2, line 11.
[4] It may be pointed out that in a paper by Wick, Lincei Rend. **23**, 775 (1936) the whole problem was based on the same integrodifferential equation as in Halpern's paper and a result in accordance with Fermi was obtained by a numerical method. The reflection coefficient, as defined by Halpern a.o., was also considered under the assumption of a cosine distribution of the incident neutrons, and a result in full accord with Halpern's result for this case was obtained.

Evidence of a Periodic Deviation from the Schottky Line for Tungsten

In the course of a study in this laboratory of the surface ionization of salts on tungsten it was found desirable to reinvestigate the thermionic emission of tungsten at high fields. Use was made of the thermionic cell designed by Clemens and Phipps.[1] Emission data were obtained over the range of temperature, 1560°K to 1940°K, and over the range of field at the surface of the filament, 1800 to 260,000 volts per cm. When the resulting values of log i were

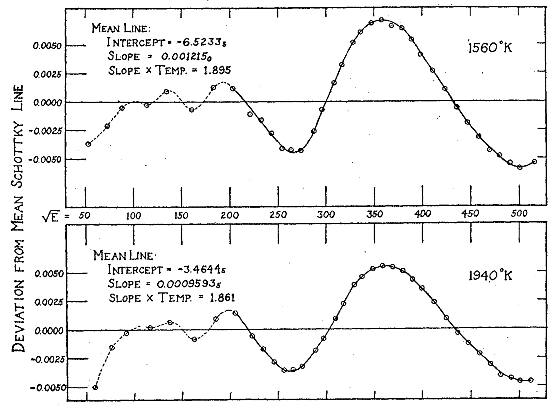

FIG. 1. Deviation from a mean straight line of the logarithm of the emission current from tungsten, at 1560°K and 1940°K, *vs.* the square root of E, the field at the filament surface in volts per cm.

plotted against $E^{\frac{1}{2}}$ in order to test Schottky's relation, and the mean straight line was calculated by the method of least squares, it was found that the experimental points consistently fluctuate about the mean straight line, as shown in the sample curves given in Fig. 1, in which the deviation is given in the same units as log i. It is seen that the magnitude of the deviations from linearity is small, so that the deviations can be observed only with very precise measurements.

In order to determine whether an inherent condition in the cell or in the circuit might have been responsible for the deviations, the experimental conditions were varied as follows: four different thermionic cells were employed in which filament diameters of 2 mil, 1 mil, and 0.5 mil were variously used: and in the course of the work two different experimental circuits were employed. In each case the resulting emission curves (six to nine isotherms for each 1 and 2 mil filament) showed the same deviation, the period and amplitude of the deviation curve increasing with increasing field. For a given cell and filament the maxima and minima in the deviation curves appeared at the same values of field strength for each isotherm. For different sized filaments the positions of the maxima and minima were shifted slightly.[2] The amplitude of the deviation curves decreases only slightly with increasing temperature.

A theoretical interpretation of these results is being undertaken by Professor H. M. Mott-Smith of the department of physics. To aid in this attempt it has been found desirable to obtain similar emission data for metals other than tungsten. At present we are attempting to do this and also to extend our measurements with tungsten to fields of the order of 10^6 volts per cm in an attempt to reach another maximum in the deviation curve and also possibly to reach the region of transition to field currents.

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[1] Clemens and Phipps, Rev. Sci. Inst. **8**, 133 (1937).
[2] This may be attributed to uncertainties in the calculation of the conversion factor from applied voltage to field at the filament surface.