Drift of Adsorbed TH on W Filaments Heated with d.c.

A study (soon to be reported) of the surface structure produced on tungsten lamp filaments during long heating with direct current has suggested that W ions drift over the wire surface toward the negative terminal. Such migration can be demonstrated directly, for the case of Th adsorbed on W, in a simple electron-optical tube.

A loop of 1 mil thoriated wire 6 mm long is mounted on 30-mil leads at the center of a spherical bulb 3 inches in diameter coated inside with willemite. The anode, a wire ring near the mouth of the bulb, is made a few thousand volts positive, and the emitted electrons form on the screen a magnified orthogonal image of the loop; the screen is kept near anode potential by secondary emission. A 10-mil Ni wire, welded to one filament lead and projecting between the ends of the loop, casts an electrical shadow which permits distinguishing the emission from the two ends, and also prevents evaporation of Th from one end across to the other. With the anode floating, the filament is first flashed and then is heated, from a 2 v d.c. supply, for 20 or 30 minutes at a low activating temperature. The electron image, observed briefly at a low temperature where Th is immobile, is then brightest opposite the negative end of the loop, with a sharp cutoff toward the lead and a gradual decrease toward the center. The positive side of the screen is dark. With 60-cycle a.c. heating, the activation is always symmetrical about the center of the wire. These observations have been repeated in a similar tube, with a loop of 2 mil thoriated wire.

The processes involved in activation of a short filament are obviously manifold, but the net result, that Th accumulates preferentially at the negative end, strongly indicates a drift of ions in the electric field. Ionization in the space is ruled out by the low voltage of the heating supply, the shadow-caster stops evaporation from one end to the other, and thermionic emission from either end is at the worst limited by space charge to a value too low to give appreciable cooling.

This experimental arrangement is not adapted for yielding values for either the mobility or the activation energy for migration under the influence of a field. Deposit of Th on an isothermal length of smooth undoped filament (preferably a single crystal), by evaporation from an external source, at present seems a promising technique for future study of the effect.

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On the Form of the β-Spectrum of Ra E in the Vicinity of the Upper Limit and the Mass of the Neutrino

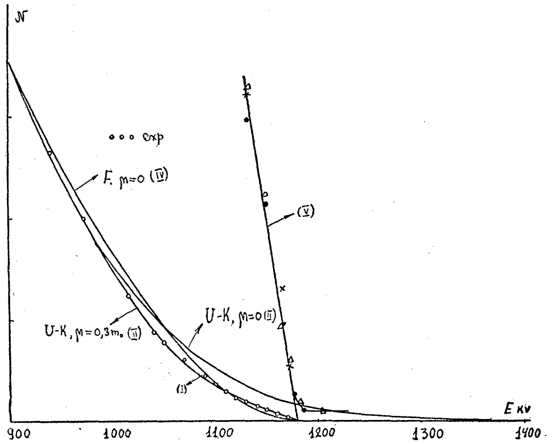

FIG. 1.

The spectrum of the β-particles emitted by Ra E has often been studied and at the present time[1] it is established that the form of the spectrum over a wide range may be accounted for satisfactorily by the formula of Uhlenbeck and Konopinski. However the spectrum in the immediate neighborhood of the upper limit has been studied in much less detail. Nevertheless the results of Lyman's[2] measurements and those described in this note indicate that the form of the spectrum in this region departs considerably from that predicted by theory. The study of the energy distribution of the electrons in the neighborhood of the spectral limit is for a number of reasons accompanied by considerable difficulty, chief of which is the low intensity of the radiation in this part of the spectrum. The choice of apparatus and the sensitivity of the method of registering the electrons are therefore of prime importance. In the experiments described below, the method of electron focusing in a uniform magnetic field has been used. The electrons were registered by the method of coincident discharges in Geiger-Müller counters. It was necessary to guard against electrons scattered from the walls of the apparatus and from the diaphragm entering the counters. This was attained by separating out a narrow beam of electrons ($\phi=10°$) and by a special system of traps.

By placing the first counter with its narrow slit at the focus it was possible to eliminate almost completely the entry of scattered electrons. The source was a thin nickel strip on which 0.3—1.0 mC of Ra E were deposited. The spectrum was studied in detail from $E=1030$ kv to $E_m=1180$ kv. The results are represented in Fig. 1(I) and it will be seen that the energy intervals were very narrow. The random error of the individual points on the curve were very small and the measurements of the magnetic field constitute the main error. A noticeable feature in Fig. 1 is the sharp change in the curve at an energy of about 1120 kv after which the number of electrons decreases practically linearly. This part of the curve is reproduced on a larger scale in the same figure for the sake of clarity (V). The results of repeated experiments are indicated by different signs. The insignificant number of electrons observed at $E>E_m$ is undoubtedly due to scattered electrons and indicates that the experimental conditions were satisfactory.

The spectra computed according to the formula:

$$P \sim W\cdot(W^2-1)^{\frac{1}{2}}\cdot(W_0-W)^3\cdot[(W_0-W)^2-(\mu/m)^2]^{\frac{1}{2}}\cdot f(Z, W).$$

which follows from the theory of Konopinski and Uhlenbeck are given in Fig. 1. Curve II refers to the case $\mu=0$

and $W_0=3.69m_0c^2$ and curve III to the case $\mu=0.3m_0$ and $W_0=3.69m_0c^2$. It is clear that curve III agrees excellently with the experimental results. It may be noted that the remainder of the experimental spectrum also fits the Uhlenbeck-Konopinski theory satisfactorily when $\mu=0.3m_0$. The curve IV of Fig. 1 has been computed according to Fermi's formula, from the experimental value of the spectral limit $(W_0)_{\text{exp}}=3.31m_0c^2$ while μ was taken equal to zero. This curve clearly does not agree with that found experimentally.

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[1] A. Alichanian and A. Zavelsky, Comptes rendus d. Acad. d. L'URSS. 17, 467 (1937).

[2] Lyman, Phys. Rev. 51, 1 (1937).

The Shape of the β-Spectrum of Th C and the Mass of the Neutrino

In the preceding letter of A. I. Alichanian, A. I. Alichanow and B. S. Dželepow it was shown that the intensity curve of Ra E cuts the axis of abscissa at a certain angle.

It was of importance therefore to investigate whether the shape of the Ra E spectrum is typical for all radioactive elements. The end of the spectrum of Th C was accordingly studied by the magnetic focusing method with registration by means of coincidences. The apparatus was the same as that used for Ra E.[1] A narrow beam of electrons with an angle of spread $\phi=10°$ was focused onto the slit of the first counter ($d\sim0.8$ mm). A considerable number of diaphragms and traps prevented scattered electrons from entering the counting system. An active deposit of Th(B+C+C″) (1.0–1.5 mC) was deposited on an aluminum strip 0.3 mm wide and 5 mm long.

The end of the spectrum is represented in Fig. 1(I). There is a distinct break in the curve at $E=2130$ kv, similar to that observed in the spectrum of Ra E, after which the curve falls off practically linearly to the very limit. The small number of coincidences observed for $H>H_m$ is due partly to Compton electrons liberated from the walls of the vessel by γ-rays, and partly to scattered electrons and random coincidences. It is clear, however, that this background does not depend on the strength of the magnetic field. The remainder of the Th C spectrum down to $E=1275$ kv is given in the same figure (V). By constructing the Konopinski-Uhlenbeck plot from this spectrum (assuming the mass of the neutrino $\mu=0$) we found the extrapolated limit $W_0=6.18$ with the help of which the K−U spectrum for $\mu=0$ was constructed (curve II). Curve III was computed according to Fermi's theory with $\mu=0$ from the experimentally determined spectral limit for the total energy of disintegration. Finally curve IV has been computed according to the Konopinski-Uhlenbeck theory, for $\mu=0.8m_0$ from the formula

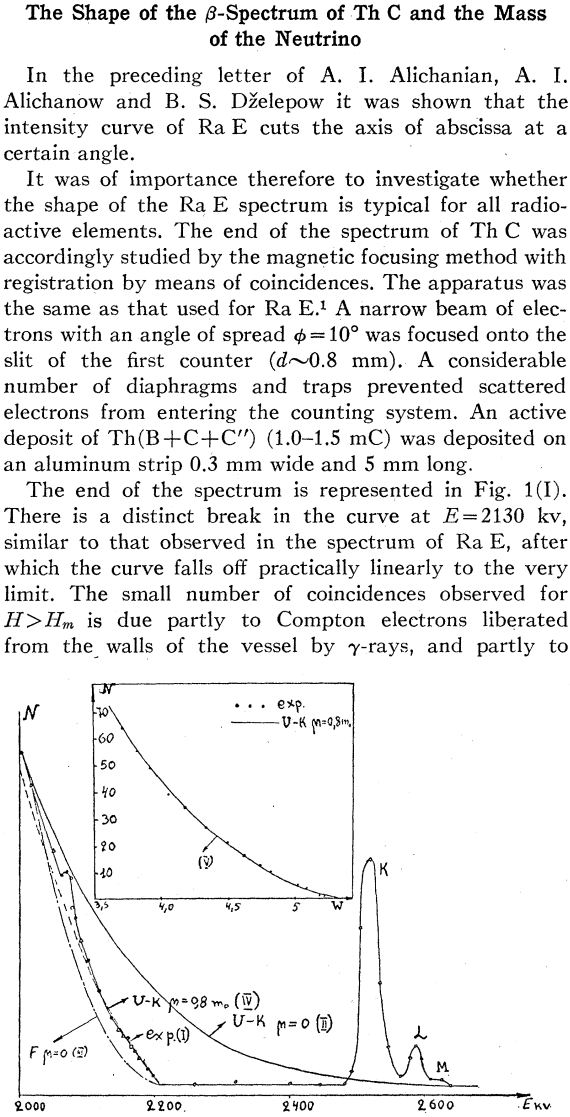

FIG. 1.

$$P\sim W(W^2-1)^{\frac{1}{2}}\cdot(W_0-W)^3\cdot[(W_0-W)^2-(\mu/m)^2]^{\frac{1}{2}}\cdot f(Z,\ W)$$

where $W_0=(W_0)_{\text{exp}}+0.8m_0c^2$. It is clear that none of the theoretical curves cited, with the exception of curve IV, agrees with the experimental spectrum. The satisfactory agreement between the latter and the Konopinski-Uhlenbeck curve for $\mu=0.8m_0$ was not confined to the immediate vicinity of the limit but extended to the rest of the spectrum. A similar analysis in the case of the Ra E spectrum showed that agreement between the theoretical and experimental curves is obtained when $\mu=0.3m_0$.

The following conclusions may be drawn from these results. The existing theory of Konopinski and Uhlenbeck describes the experimental results correctly when $\mu\neq0$. μ however is not a constant for all elements and varies with W_0.

It was found that the most suitable value of μ could be deduced from the equation:

$$(W_0)_{\text{extr}}-(W_0)_{\text{exp}}=\mu c^2$$

which gives $0.8m_0c^2$ for Th C and $0.3m_0c^2$ for Ra E. The fact, however, that μ varies from element to element means that no simple significance can be attached to this parameter.

Preliminary measurements of the end of the spectrum of Ra C showed that in this case also the shape is similar to that in the vicinity of the spectral limit of Ra E and Th C.

The three maxima observed in the figure at $E_1=2526$ kv, $E_2=2588$ kv and $E_3=2610$ kv are due to internal conversion of the γ-rays of Th C″ ($h\nu=2614$ kv) in the K, L and M levels of Th Pb. The sharpness of the lines bears witness to the high resolving power of the apparatus and the absence of disturbing factors. The relative intensities of the lines 5 : 1 : 0.2 give the relative probabilities of conversion of the γ-line 2614 kv in the K, L and M levels. The small maximum at $E=2070$ kv corresponds to the internal conversion of the γ-line $h\nu=2160$ kv found by Alichanow and W. Dželepow[2] in the positron spectrum of Th (C+C″). The present measurements yield a value of $\alpha=1.77\times10^{-3}$ for the coefficient of internal conversion of the γ-line 2614 kv whereas according to Taylor and Mott[3] the theoretical value is $\alpha=1.5\times10^{-3}$.

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[3] H. M. Taylor and N. F. Mott, Proc. Roy. Soc. 138, 665 (1932).