

# Letters to the Editor

## MEASUREMENT OF THE ENERGY LOSSES OF FAST ELECTRONS IN MATTER

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**E**LECTRONS lose energy in passing through matter. The energy loss is due to the interaction of the electrons with nuclei and with shells of atoms of the stopping material. For electrons of intermediate energy the most probable energy losses are due to ionization of atoms of the material.

Using the Landau theory,<sup>1</sup> taking account of the Fermi corrections<sup>2</sup> for polarization of the medium, we can write the most probable energy loss for a relativistic electron as follows:<sup>3</sup>

$$-\Delta W = 0.1537 \frac{\sum Z}{\sum A} D \left( 19.43 + \ln \frac{D}{\rho} \right) \text{Mev},$$

where  $Z$  is the atomic number of the stopping materials,  $A$  is the mass number,  $\rho$  is the density, and  $D$  is the surface density.

In the present note we describe results of experiments carried out to determine the most probable energy losses of 18-Mev electrons. The experimental arrangement is shown in Fig. 1.

By means of a 90° magnetic monochromator the primary electron beam is made monoenergetic to within  $\pm 0.2\%$  ( $\sim \pm 40$  kev). The energy losses are determined from the displacement of the maxima

in the energy spectra obtained by means of the magnetic analyzer 4 with the sample placed in front of the beam in the experimental chamber 3 and with the sample removed. The accuracy of the measurements is  $\pm 40$  kev.

Typical curves are shown in Fig. 2. In this case

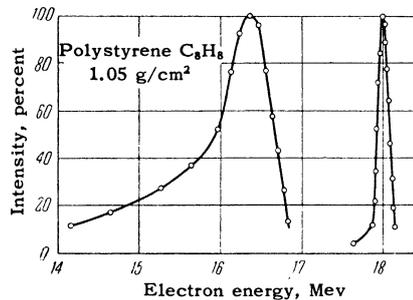


FIG. 2

the samples are targets of aluminum, polystyrene  $(C_8H_8)_n$  and Plexiglas  $(C_4H_8O_2)_n$ . The results of the measurements are shown in the table, where we compare our data with the results obtained by Goldwasser<sup>3</sup> and with theory. Here  $\Delta W$  is the loss predicted by the Landau theory with the Fermi correction,  $(\Delta W)_G$  is the loss measured by Goldwasser, and  $(\Delta W)_0$  is the result obtained in present experiment.

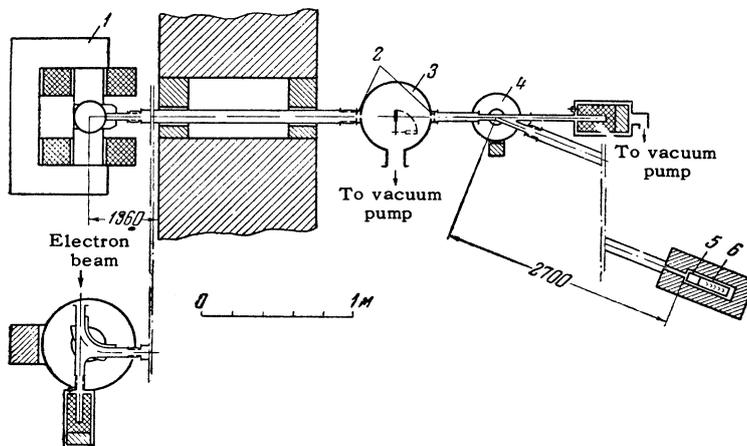
|              | Al    | $(C_8H_8)_n$ | $(C_4H_8O_2)_n$ |
|--------------|-------|--------------|-----------------|
| $D$          | 0.81  | 1.055        | 0.559           |
| $\rho$       | 2.694 | 1.055        | 1.130           |
| $\Delta W$   | 1.09  | 1.65         | 0.96            |
| $\Delta W_G$ | 0.99  | 1.61         | —               |
| $\Delta W_0$ | 1.04  | 1.65         | 0.92            |

An examination of these results indicates good agreement between the theoretical and experimental values.

<sup>1</sup> L. Landau, J. Phys. (U.S.S.R.) **8**, 204 (1944).

<sup>2</sup> E. Fermi, Phys. Rev. **57**, 485 (1940).

FIG. 1. 1—magnetic monochromator, 2—lead collimators, 3—experimental chamber, 4—magnetic analyzer, 5—Cerenkov radiator, 6—photomultiplier.



<sup>3</sup>Goldwasser, Mills, and Hanson, Phys. Rev. **88**, 1137 (1952).

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284

**MEASUREMENT OF THE INTENSITY RATIO OF THE TRANSITIONS TO THE FIRST EXCITED LEVELS OF DAUGHTER NUCLEI IN THE DECAY OF  $U^{238}$  AND  $U^{234}$**

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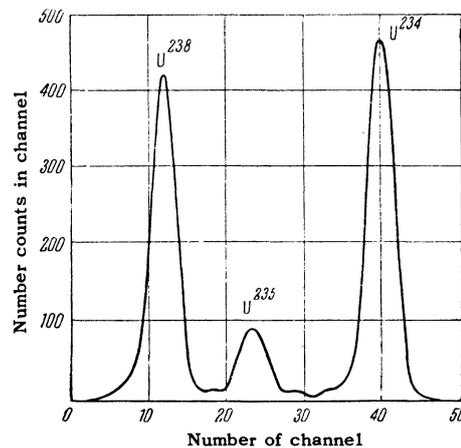
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THE ratio of the intensities of the transitions to the first excited levels was measured by us with a pulse ionization chamber with a screen connected for coincidence with a scintillation counter with a NaI crystal. The latter registered the x-rays accompanying the  $\alpha$  decay to the first excited levels of the daughter nuclei. In plotting the  $\alpha$  spectra without coincidences, the lines corresponding to the transitions to the first excited level and to the ground state are incompletely resolved. Data on the transition intensities<sup>1</sup> obtained in this manner are therefore insufficiently accurate. Transitions to the ground state are not registered if coincidences with x-ray L-quanta are introduced, so that it becomes possible to determine reliably the relative intensities of the transitions to the first excited levels.

The  $\alpha$  spectrum of a natural mixture of uranium isotopes, plotted in coincidence with x-ray L radiation, yielded the following information: 1) the number of pulses  $N_1$  corresponding to the transition of  $U^{234}$  to the first excited level of  $Th^{230}$  is 1815; 2) the number of pulses  $N_2$  corresponding to the transition of  $U^{238}$  to the first excited level  $Th^{234}$  is 1640. It is necessary to subtract from  $N_2$  approximately 30 pulses, due to the decay of  $U^{235}$ . The calculations performed have shown that the errors in the intensities, due to the presence of two conversion lines  $L_{II}$  and  $L_{III}$  (different absorption, Auger effect, etc.) and to conversions on the M and N shells, are quite insignificant and result in a total correction of 0.7%. Taking



this correction into account, we obtain for the intensity ratio  $N_2/N_1 = 0.91 \pm 0.04$ . The populations of the same levels were investigated previously by Teillac<sup>2,3</sup> by a method in which the conversion electrons were registered in thick photoemulsions. These measurements yielded a value of 0.75 for  $N_2/N_1$ . However, owing to the poor distribution of the groups of  $\alpha$  particles and the small number of registered events, the accuracy of this ratio was small ( $\sim 25\%$ ).

The intensity of the transition to the first excited level in the decay of  $U^{234}$ , measured with a magnetic spectrometer, amounts to 28%.<sup>4</sup> We therefore obtain a value of 25.5% for the intensity of the analogous transition in the decay of  $U^{238}$ . (The accuracy of this value is determined essentially by the accuracy of the measurements made by Gol'din, Tret'yakov, and Novikova,<sup>4</sup> which, unfortunately, was not stated by the authors.) Investigations in which the photoemulsion method was used<sup>3,5</sup> yielded a value of  $(23 \pm 3)\%$ . It can be shown that in these investigations the number of conversion electrons due to the  $U^{235}$  decay was incorrectly computed. This value should have been computed, since the  $U^{235}$  line was not separated from the  $U^{238}$  line. It was thought that each  $U^{235}$  decay was accompanied by a conversion electron. Investigations performed recently in our laboratory and in others on the  $\alpha$  decay of  $U^{235}$  make it possible to state that the number of conversion electrons of energy within  $U^{234}$  conversion-electron energy range is only approximately half the number of the  $U^{235}$  decays. Taking this into account, the results of references 3 and 5 can be reduced to a value of  $(25 \pm 3)\%$ .

<sup>1</sup>Kocharov, Komar, and Korolev, JETP **36**, 68 (1959), Soviet Phys. JETP **9**, 48 (1959).

<sup>2</sup>J. Teillac, Compt. rend. **230**, 1056 (1950).

<sup>3</sup>J. Teillac and G. Albouy, Compt. rend. **236**, 829 (1952).