[1] G. K. Walters and W. M. Fairbank, Phys. Rev. 103, 262 (1956).
[2] J. G. Daunt and C. V. Heer, Phys. Rev. 79, 46 (1950).
[3] B. N. Esel'son, Berezniak and Kaganov, Dokl. Akad. Nauk SSSR 111, 568 (1956).
[4] Abraham, Weinstock and Osborne, Phys. Rev. 76, 864 (1949).

Translated by R. T. Beyer
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Fine Structure of the α-Spectra of U^{234} and U^{238}

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FOR THE STUDY OF the fine structure of the α-spectra of long-lived isotopes such as U^{238} and Th^{232}, magnetic spectrometers are practically useless because of their low sensitivity. To solve such problems it is therefore advisable to use pulsed ionization chambers, which exceed the sensitivity of magnetic spectrometers by several orders of magnitude. (The product of source area and solid angle is greater.)

Although they are more sensitive, ionization chambers are somewhat inferior to magnetic spectrometers in resolution. As a rule, the half-width of the lines of the α-spectra of a pulse ionization chamber, which determines its energy resolution, is 50–70 kev. This high value of this quantity is ascribable to circuit noise, in addition to other causes. We were able[1] to reduce the mean square value of the circuit noise to 6.8 kev, which is 3.2 kev less than the best work abroad[2]. In addition, the method of electrical collimation worked out in our laboratory permitted complete utilization of the sensitivity of the apparatus. The resultant apparatus had a line half-width of 30 kev and good sensitivity.

We used this apparatus to study the energy spectra of the α-particles of U^{234} and U^{238}. A natural mixture of uranium isotopes was used as a source of α-particles. The results obtained are shown in Figs. 1 and 2. Figure 1 shows the energy spectrum of the α-particles from U^{234}. Along with the basic group of 4.77 Mev α-particles there is a clearly

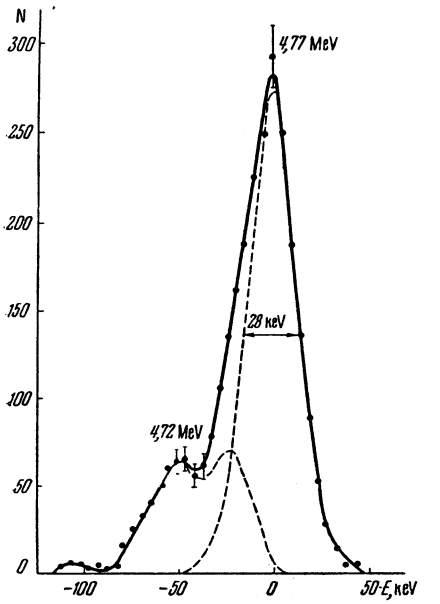

FIG. 1

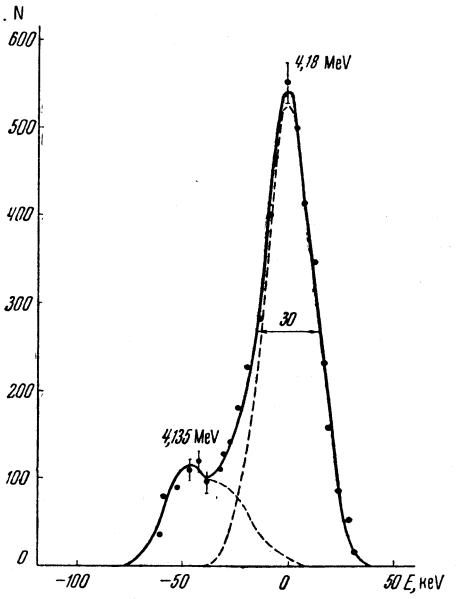

FIG. 2

defined 4.72 Mev group corresponding with the transition to the first rotational level of Th^{230}. The intensities of these two lines are 72 and 28% respectively. These data are in good agreement with the data found by Goldin, Tretyakov and Novikov[3].

Figure 2 shows the energy spectrum of the α-particles of U^{238}. In this case, too, a fine structure was revealed. The fine structure line is separated from the fundamental by 45 kev. The ratio of intensity of the fundamental to the fine structure line is 4. The half-width of the lines is about 30 kev.

An analysis of the curves has shown that they cannot be represented by the sum of two gaussians, corresponding to a fundamental group and a fine structure group. The existence of a third group of α-particles had to be assumed with an energy lying between the fundamental and the fine structure group. This is reasonable since immediately after emitting a low-energy α-particle the nucleus emits a conversion electron. Half of the total number of emitted conversion electrons, falling in the working volume of the chamber, produce additional ionization. Consequently, half of the pulses v_α from the α-particles of the fine structure line are registered simultaneously with the pulses v_e from the conversion electrons, and what we get is the sum of the pulses, equal to $v_\alpha + v_e$, corresponding so to speak to a group of α-particles of intermediate energy $E = E_\alpha + E_e$. The other half of the pulses is registered as α-particle pulses of energy E_α. Our analysis of the curves shows the existence of such lines. The separation between the lines is about 30 kev, which corresponds to the kinetic energy of the electrons emitted from the L-shell of the atom.*

The intensities of the groups are identical which shows that the conversion is practically 100%.

It should be noted that number of authors[4-6] have studied the fine structure of the α-spectrum of U^{238} by an indirect method, viz., by studying the conversion electrons accompanying α-decay, using electron sensitive emulsions impregnated with a uranium salt. From the data of the above authors, the intensity of the transition to the first excited level amounts fo 23 ± 3%. After finishing our measurements it became known (private communication from J. Teillac) that the fine structure of the α-decay had been studied by Valladas using an ionization chamber with ion collection. He plotted the energy spectrum of the α-particles of U^{238} by means of the coincidences of the α-particles and the γ-radiation accompanying conversion, thereby avoiding registering the fundamental group of α-particles. His results agree with ours.

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* The mean energy going into the formation of one ion pair by electrons is the same as for α-particles.

[1] Bochagov, Kocharov, and Krishin, "Signal to Noise Ratio in Pulse Ionization Chambers," Pribori i Tekhnika Eksperimenta (in press).

[2] D. W. Engelkemeir, L. B. Magnusson, Rev. Sci. Instr. **26**, 295 (1955).

[3] L. L. Goldin, E. F. Tretyakov, G. I. Novikov, Report of the Session of the Academy of Sciences of the U.S.S.R. on the Peaceful Uses of Atomic Energy, July 1–5, 1955.

[4] B. B. Zajac, Phil. Mag. **43**, 264 (1952).

[5] D. C. Dunlavey and G. T. Seaborg, Phys. Rev. **87**, 165 (1952).

[6] G. Albouy and J. Teillac, Compt. rend. **234**, 829 (1952).

Translated by C. V. Larrick
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On the Theory of Skin Effect in Metals

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IN ANY THEORY of skin effect in metals one usually assumes $B = H$ since the magnetic susceptibility of metals is very slight ($\chi \sim 10^{-6}$). However, it is easy to see that neglect of the spin paramagnetism of the free electrons would lead to a substantial error in determining the coefficient of electromagnetic wave transmission through a sufficiently thick film. As was shown in Ref. 1, this is due to the damping of the magnetic moment due to spin paramagnetism at a depth

$$\delta_{\text{eff}} \sim v\,[t_0 T_{\text{sp}} / 3\,(1 + \omega T_{\text{sp}})]^{1/2}$$

(v is the limiting Fermi electron velocity, ω is the electromagnetic field frequency, T_0 and T_{sp} are the electron free path times without and with spin transfer). Since the usual skin layer depth is

$$\delta \sim \sqrt{c^2 / 2\pi\omega\sigma}, \quad \text{then}$$

$$\delta / \delta_{\text{eff}} \gtrsim (c / vt_0)\sqrt{m / 2\pi ne^2} \sim 10^{-14}\,\text{sec} / t_0 \ll 1$$

(n, m, and e are the density, effective mass, and