Energy of alpha particles in triple fission of the fissile isomer uranium-238

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The energy distribution of the long-range alpha particles produced in the triple fission of the spontaneously fissioning isomer uranium-238 has been measured for the first time. The mean energy of the distribution is 17.7 ± 1.3 MeV, and the width at half-maximum is 9.2 ± 1.6 MeV.

Previous measurements of the properties of the fissile isomer uranium-238 have revealed[1] a decay half-life of 267 ± 13 ns and branching ratio of 1.48 ± 0.02 with respect to spontaneous fission. Observations established that the triple fission of this isomer occurs much more frequently than does the triple fission of nearby nuclei from nonisomer states. This letter is the first report of measurements of the energy distribution of α particles in the triple fission of the fissile isomer uranium-238.

The measurements were carried out on an electrostatic accelerator in nanosecond-pulse operation with a repetition period of 500 ns. As in the earlier work, the isomer was excited in the reaction $^{238}U(n,n')$ at an average neutron energy of 4.5 MeV at the times at which the beam was present on the target. The spontaneous fission of the isomer was observed in the pause between pulses, in which the prompt-fission background was lower by a factor of about 10^6.

We used a uranium layer 3 mg/cm^2 thick deposited in a circle 15 mm in diameter on one side of a sheet of aluminum foil 25 μm thick. The content of the isotope uranium-235 in the sample was lower by a factor of about 200 than that in natural uranium.

The detector consisted of the set of two scintillation-gas volumes separated by the foil with the uranium layer. Fission fragments were detected in the volume adjacent to the uranium layer. Long-range α particles were detected in the volume on the opposite side of the foil. The foil prevented the fission fragments and the α particles from the natural radioactivity of the sample from penetrating into that volume. The volumes were filled with xenon to an absolute pressure of about 5 atm. For this particular detector geometry and for the particular energy loss in the material of the uranium layer and the foil, it was thus possible to detect long-range α particles with energies from 7 to 300 MeV. The efficiency of the α detection was calculated to be about 40%, while the efficiency of the detection of the fission fragments was calculated to be about 90%.

The fission fragments and the α particles were detected by virtue of the corresponding scintillations in the xenon. A single photomultiplier was used to detect the fission fragments. Three photomultipliers were used to detect the α particles. One of

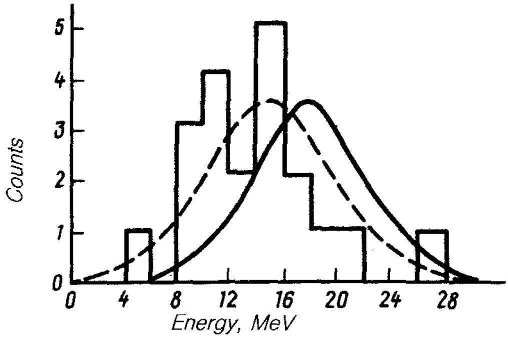

FIG. 1. Energy distributions of the α particles from the triple fission of the fissioning isomer uranium-238. Histogram—Uncorrected experimental data; dashed line— approximation of the histogram; solid line—corrected approximation.

them measured the energy of the particle, while the two others reliably discriminated the useful signal from the noise, whose level increased sharply when the detector was placed near the accelerator target. A triple-fission event was identified as the result of a quadruple coincidence of the signals from each of these photomultipliers. The threshold for the detection of the fission fragments was about 6 MeV, and that for the detection of α particles about 2 MeV.

Figure 1 shows the experimental energy distribution of the α's resulting from the triple fission of the uranium-238 (the histogram), a Gaussian distribution approximating the experimental distribution (the dashed line), and a Gaussian distribution which describes the actual energy distribution of the α particles (solid line). The experimental distribution is made up of the α particles which passed through the material of the uranium layer and the foil before detection. Accordingly, these data were corrected for the corresponding energy losses. As a result, with the actual distribution (the solid line) we can associate a mean energy of 17.7 ± 1.3 MeV and a width at half-maximum of 9.2 ± 1.6 MeV. In a previous study[2] of the triple photofission of uranium-238, the values 16.4 ± 0.2 MeV and 9.2 ± 0.2 MeV, respectively, were found.

In summary, according to the statistical accuracy as it exists—20 events of triple fission of the isomer were accumulated—the energy properties of the α particles for the triple fission of the compound nucleus are essentially the same as those for the fissile isomer uranium-238.

In these experiments. we remeasured the decay half-line of the isomer, finding 270 ± 13 ns, and also the branching radio of this isomer with respect to that for spontaneous fission, finding $(1.47 \pm 0.02) \times 10^{-4}$. These results are in complete agreement with the results of earlier measurements.[1]

[1]V. E. Makarenko *et al.*, Nucl Phys. **502**, 363 (1989).
[2]M. Verboven *et al.*, in *Proceedings of "Seminar on Fission,"* 1986 (ed. C. Wagemans), Studiecent. Kernenerg. Rapp. 586, BLC, p. 85.

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