Triple fission of the spontaneously fissioning isomer ^{238}U

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A scintillation-ionization chamber and time-of-flight analysis of the events have been used to determine the branching ratio for triple fission involving the emission of a long-range α particle of the spontaneously fissioning isomer ^{238}U. The result is 1 triple fission per 49 ± 14 double fissions of the isomer. This figure is more than 10 times the branching ratio for the triple fission of ^{238}U from a nonisomeric state.

In this letter we report an experimental study of triple fission involving the emission of a long-range α particle of the spontaneously fissioning isomer ^{238}U. The unusual properties of such isomers are explained in the model of a double-humped fission barrier.[1] They have been analyzed in detail in several reviews (e.g., Refs. 2 and 3).

The isomer was excited in the reaction $^{238}U(n,n')$ at an average neutron energy of 4.5 MeV. The neutrons were produced in the reaction $D(n,n)$[3] in the interaction of a deuteron beam from a pulsed electrostatic accelerator (pulse repetition frequency of 2 MHz)[4] with a deuterium target .

The layer of fissioning material was prepared from a uranium sample depleted in the isotope 235 to a concentation 200 times that in a natural mixture of isotopes. The thickness of the layer was 5.1 mg/cm^2, and the total amount of material was about 1 mg.

The fission fragments were detected by a scintillation method. The long-range α particles were detected by an ionization method. The detector was a set of three coaxial chambers. The layer of fissile material was placed in the inner chamber, which was a scintillation chamber (the fission chamber). The cylindrical wall of this chamber was made of aluminum foil 25 μm thick. The scintillation chamber was surrounded by a cylindrical grid. An annular collecting electrode was introduced in the gap between the grid and the wall of the scintillation chamber, so that this part of

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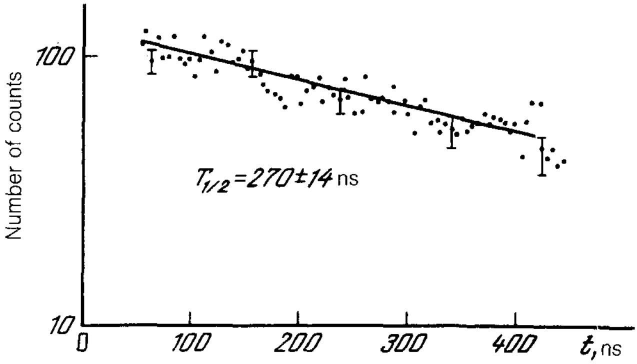

FIG. 1. Diagram used in determining the decay half-life.

the detector constituted the first ionization chamber. An annular collecting electrode was also introduced between the grid and the wall of the detector, forming a second ionization chamber here.

The fission fragments were detected in the fission chamber, and the long-range α particles were detected in the first and second ionization chambers. The working gas was spectroscopically pure xenon held at a pressure of 2 kg/m^2.

The efficiency of the detection of the fission fragments was about 100%, and that of the detection of the long-range α particles was about 10%.

The electronic event detection system was organized as a set of three spectrometric channels: a fission-chamber channel and two ionization-chamber channels. A coincidence of the signals in all three channels was evidence of the presence of a triple-fission event. Prompt-fission events were detected at the time of the flash of the pulsed beam; delayed (isomer) fission events were detected in the pause between pulses.

Background events (random coincidences and fission events caused by neutrons scattered by equipment in the measurement cabin) constituted less than 2% of the events.

In some control measurements carried out to check the operating stability of the apparatus we determined the relative probability for the prompt triple fission of ^{238}U by fast neutrons: 1 triple fission per 752 ± 56 double prompt fissions, in agreement with the results reported by other investigators (e.g., Ref. 5).

In this experiment we have substantially refined the decay half-life of the fissile isomer ^{238}U (270 ± 14 ns Fig. 1) and its yield $[(1.50 \pm 0.03) \times 10^{-4}]$ for an average neutron energy of 4.5 MeV. In coincidence with about 6.5×10^3 events of a double fission of the isomer, we detected 13 cases of the emission of a long-range α particle. We were thus able to determine the branching ratio for the triple fission of the spontaneously fissionable isomer: 1 triple fission per 49 ± 14 double fissons. This figure is more than an order of magnitude greater than the branching ratio for the triple fission of the nucleus ^{238}U from a nonisomeric state.

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