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SPONTANEOUSLY FISSIONING ISOMER WITH HALF-LIFE 10^{-7} SEC

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In several recently observed cases of isomerism of transuranic elements, the de-excitation of the isomer state was via fission [1-3], with a half-life ranging from fractions of a millisecond to several minutes. The nature of these states has not been explained as yet. In analogy with usual isomerism, it can be assumed that the number of such states increases with a decrease in their lifetime. Therefore a search for spontaneously fissioning isomers with half-lives in the microsecond and nanosecond regions is of great interest.

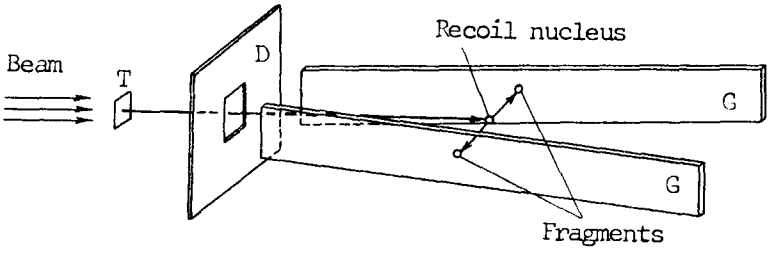

Fig. 1

We used for this purpose the apparatus shown in Fig. 1. A beam of heavy ions accelerated by the 150-cm cyclotron of the JINR Nuclear Reactions Laboratory is incident on target T. The nuclei knocked out of the target, which receive a large momentum, are collimated by the diaphragm and move along glass detectors G, which register the fragments of the nuclei fissioning in flight.

Targets of Th^{232}, U^{235}, and U^{238} were bombarded with C^{12} ions having energies from 60 to 82 MeV. The fission fragments traveling between the detectors were registered in the reaction $U^{238} + C^{12}$. From the distribution of the tracks along the detectors, we found the half-life of the spontaneously fissioning nucleus to be $(0.8 \pm 0.3) \times 10^{-7}$ sec. Inasmuch as all the isotopes formed in this reaction had a much larger lifetime, the observed half-life is obviously connected with the isomer state of the nucleus.

The excitation function of the reaction that leads to the spontaneously fissioning isomer state (Fig. 2) has a form characteristic of reactions with formation of a compound nucleus and evaporation of several nucleons. Apparently, several neutrons are evaporated and Cf isotopes are produced. No α particle is likely to be evaporated with the neutrons,

since the excitation function has a small width, although the experimental errors do not make the conclusions in this respect unambiguous. There is likewise no proton evaporation, which would lead to Bk isotopes, since no spontaneous fission having the same period was observed in the reaction $U^{238} + N^{15}$, which leads to Bk isotopes by evaporation of an α particle and several neutrons.

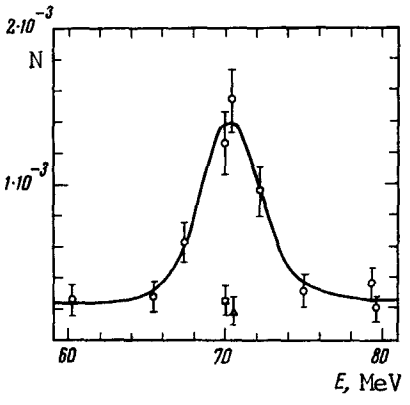

Fig. 2. Excitation functions of the $U^{238} + C^{12}$ reaction leading to spontaneously fissioning isomer. o - Effect, Δ - background, N - number of tracks per Maxwell, E - ion energy.

Comparison of the excitation function with the known data [4] on the production of the ground state of Cf isotopes in the reaction $U^{238}(C^{12}, xn)Cf$ allows us to assume that the observed spontaneously-fissioning isomer belongs to the isotope Cf^{246}. The cross section of the reaction $U^{238}(C^{12}, 4n)Cf^{246m}$ at the maximum of the excitation function (at 70 ± 2 MeV) is $(1.2 \pm 0.5) \times 10^{-32}$ cm^2. By comparison, the maximum cross section of the reaction with production of Cf^{246} in the ground state (at 68 MeV) is 3×10^{-29} cm^2 [4].

The half-life of Cf^{246} relative to spontaneous fission is 2.1×10^3 years. This means an increase by a factor 10^{18} in the probability of spontaneous fission for the isomer state.

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STATISTICAL SCATTERING AND THE OREAR FORMULA

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An important role is played in large-angle scattering of strongly-interacting high-energy particles by statistical processes and the diffraction associated with them [1].