ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E7 - 3043

ЛАБОРАТОРИЯ ЯДЕРНЫХ РЕАКЦИЙ

G.N. Flerov, V.I. Kuznetsov, N.K. Skobelev

ON SPONTANEOUS FISSION OF ISOTOPE 102^{254}

1966

E7 - 3043

G.N. Flerov, V.I. Kuznetsov, N.K. Skobelev

ON SPONTANEOUS FISSION OF ISOTOPE 102^{254}

Submitted to At. En.

The synthesis and the properties of the isotope 102^{254} were first reported in 1958 [1]. Measurements made by Ghiorso et al. showed that the 102^{254} half-life was 3 sec [1]. The alpha particle energy was found to be 8.3 MeV [2]. It was pointed out that the isotope 102^{254} undergoes spontaneous fission with partial half-life of about 6 sec [3]. This value was in disagreement with the Ghiorso [4] and Swiatecki-Dorn's [5] predictions. Such an increase of the 102^{254} spontaneous fission rate was accounted for by Johansson [6] who predicted also the half-lives for a number of other isotopes (in particular, for the isotope 102^{256}).

The results of the works performed in the Laboratory of Nuclear Reactions of the JINR on the investigation of the 102^{256} properties [7,8] have not proved the Johansson's predictions. In paper [9] it was shown that in reactions $U^{238}+Ne^{20}$ ($Z_{comp.nucl.}=102$) and $U^{238}+O^{16}$ ($Z_{comp.nucl.}=100$) a spontaneously fissioning isomer ($Z \leq 100$) with $T_{1/2}\approx 3{,}5$ sec is produced, the decay of which could be taken (in ref. [2]) for spontaneous fission of the isotope 102^{254}.

Experiments on the study of the 102^{254} properties were therefore repeated in the Laboratory of Nuclear Reactions by two independent methods [10,11]. It was shown that the isotope 102^{254} undergoes alpha decay with half-life of about 60 sec and alpha particle energy $E_{\alpha}=(8{,}11\pm 0{,}03)$ MeV. The excitation functions for reactions $U^{238}(Ne^{22},6n)102^{254}$, $Am^{243}(N^{15},4n)102^{254}$ [10] and $Pu^{242}(O^{16},4n)102^{254}$ [11] were studied and the cross sections for producing 102^{254} were measured.

To determine the partial the half-life for spontaneous fission it is necessary to measure the fraction of the decays due to spontaneous fission in one of the above reactions (i.e. determine σ_{sf} for spontaneous fission).

To this end a U^{238} target was bombarded with Ne^{22} ions on a sloping target probe [8,12]. The target thick was 800 $\mu g/cm^2$ what corresponded to the ion beam effective thickness of 3.8 mg/ cm^2 (for uranium metal). The Ne^{22} ion energy was maximum about 130 MeV. Energy losses of Ne^{22} ions in the uranium layer were about 9 MeV. Two independent 2-hour experiments were made for the following time cycles of the apparatus: the time of irradiation was 3.5 min, the total time of measurement by 4 detectors was chosen to be 3.5 min. In order to decrease the background due to spotaneus fission of 102^{256} the counters were delayed by 16 sec. The fission fragments were detected by mica. A total of 20 fragment tracks per an integral flux of $3.34 \cdot 10^{17}$ Ne^{22} ions was registrated.

The background due to spontaneous fission of the isotope Fm^{256} from reaction $U^{238}(Ne^{22}, p3n)\, Mv^{256} \xrightarrow{K-capture} Fm^{256}$ must be excluded. The amount of Fm^{256} and, consequently, the cross section for reaction $U^{238}(Ne^{22}, p3n)Mv^{256}$ was determined from the number of fission fragments registrated by special mica detectors which were placed in contact with the target at the end of each experiment. The averaged cross section calculated by us for this reaction ($\sigma \approx 2 \cdot 10^{-34} cm^2$) is somewhat less than that obtained from the data of ref. /13/.

The account of the contributions from spontaneous fission of isotopes 102^{256} and Fm^{256} shows that spontaneous fission of 102^{254} can explain not more than half of the effect observed. In that case the cross section for the 102^{254} production by spontaneous fission is estimated to be $\bar{\sigma}_{sf} \le 2 \cdot 10^{-35} cm^2$.

Using this value and averaging σ_a for reaction $U^{238}(Ne^{22}, 6n)\, 102^{254}$ in this energy region /10/, T_{sf} can be estimated by the formula:

$$T_{sf} = T_a \cdot \frac{\bar{\sigma}_a}{\bar{\sigma}_{sf}} \qquad \text{where} \qquad \frac{\bar{\sigma}_a}{\bar{\sigma}_{sf}} \ge 1,5 \cdot 10^3$$

Hence, the half-life for spontaneous fission of 102^{254} will be $T_{sf} \ge 25$ hours.

It should be noted that the value obtained is only the lower limit of the half-life for spontaneous fission of 102^{254}. This value is somewhat lower than that of recently predicted by Viola and Seaborg /14/.

The value of the spontaneous fission half-life of isotope 102^{256} /8/ and the limiting value of the half-life for 102^{254} do not contradict the hypothesis about the effect of the $N = 152$ neutron subshell on the half-lives of even-even isotopes of heavy elements (Fig. 1).

The extrapolation of these regularities into the region of the element 104 isotopes gives longer half-lives for alpha decay and spontaneous fission of isotope 104^{256} as compared to isotope 104^{260} /15/.

In conclusion the authors express their gratitude to the coworkers of the U-300 cyclotron's group for providing the successful operation of the accelerator. Thanks are also due to the V. Perelygin's group coworkers for preparing the mica detectors.

References

1. A. Ghiorso, T. Sikkeland, I.R. Walton, G.T. Seaborg. Phys. Rev. Lett. 1, 18 (1958).

2. A. Гиорсо. Атомная энергия. 7, 338 (1958).

3. E.K. Hyde. The Nuclear Properties of the Heavy Elements, v. III, p. 77, Prentice-Hall Inc. New Jersey (1964).

4. A. Ghiorso. Proceedings of the International Conference on the Peaceful Uses of Atomic Energy (1955), v. 7, p. 15 United Nation, New York (1956).

5. D. Dorn. Phys. Rev. 121 , 1740 (1961).

6. S. Johansson. Report UCRL - 10474, September 25, 1962.

7. Е.Д. Донец, В.А. Щеголев, В.А. Ермаков, Атомная энергия, 16 ,195 (1964).

8. В.А. Друин, Н.К. Скобелев, Б.В. Фефилов, Г.Н. Флеров, Препринт ОИЯИ Р-1580, Дубна 1964.

9. В.А. Друин, Н.К. Скобелев, Б.В. Фефилов, В.И. Кузнецов, Ю.В. Лобанов, Ю.Ц. Оганесян. Препринт ОИЯИ Р-1651, Дубна 1964.

10. Е.Д. Донец, В.А. Щеголев, В.А. Ермаков. Атомная энергия, 20 223 (1966).

11. В.Л. Михеев, В.И. Илющенко, М.Б. Миллер, С.М. Поликанов, Препринт ОИЯИ Р-2839, Дубна 1966; Атомная энергия (в печати).

12. В.И. Кузнецов, Н.К. Скобелев, Г.Н. Флеров. Препринт ОИЯИ. Р-2435, Дубна 1965; Ядерная физика 4, 279 (1966).

13. В.А. Друин. Препринт ОИЯИ Р-874, Дубна 1962.

14. V.E. Viola, G.T. Searborg, J. Inorg. Nucl. Chem., 28, n.3, 741 (1966).

15. Г.Н. Флеров, Ю.Ц. Оганесян, Ю.В. Лобанов, В.И. Кузнецов, В.А. Друин, В.П. Перелыгин, К.А. Гаврилов, С.П. Третьякова, В.М. Плотко. Атомная энергия, 17, 310 (1964).

Received by Publishing Department
on November 29, 1966.

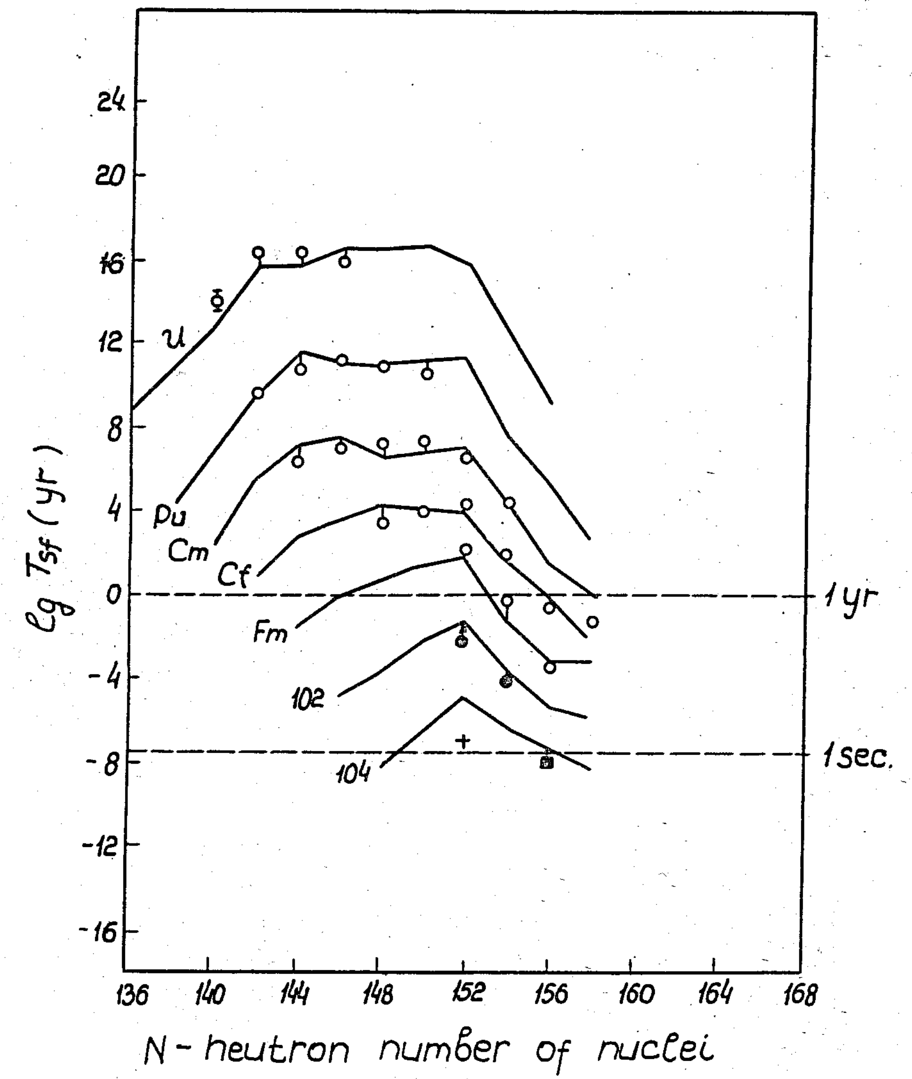

Fig. 1. Comparison of the experimental half-lives for spontaneous fission with those predicted by Viola and Seaborg /14/. (Continuous lines are the predicted values, open circles are the experimental ones. Dashed circles show the values of T_{sf} for 102^{254} (data of the present paper), 102^{256} /8/ and 104^{260} /15/. + is the value of T_{sf} for 102^{254} taken from ref /3/.