ANGULAR DISTRIBUTION OF FISSION FRAGMENTS OF Am^{241} BY NEUTRONS

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ANGULAR DISTRIBUTION OF FISSION FRAGMENTS OF Am^{241} BY NEUTRONS

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Among odd-odd fissioning nuclei, angular distributions of fragments have been measured only for fission by neutrons of Np^{237}. It was shown ([1]) that, in the region of the fission threshold, the anisotropy is comparatively small and changes little when the neutron energy is varied. This result agrees with the assumption that fission of odd-odd compound nuclei proceeds through a large number of closely spaced intermediate states and that the observed angular distribution is a superposition of many partial distributions.

In this case a statistical treatment of the process is valid. The partial angular distributions of fission fragments are determined by the total angular momentum of the fissioning nucleus I and the projection K of this momentum on the axis of symmetry of the nucleus. If it is assumed ([2]) that the distribution of intermediate states in K has a Gaussian character:

$$F(K) \sim \exp\left(-K^2/2K_0^2\right),$$

then the observed anisotropy is

$$\sigma(0^\circ)/\sigma(90^\circ) = 1 + I_{\max}^2/8K_0^2,$$

where $I_{\max}$ is the maximum angular momentum introduced into the nucleus by the incident neutron.

Measurements ([3]) carried out for nuclei of different parity types over a wide range of neutron energies made it possible to determine the dependence of K_0 on the excitation energy of the fissioning nucleus. These measurements showed that, at low excitation energies, the smallest value of K_0 is found for even-even nuclei, and the largest for odd-odd nuclei, which is evidently explained by the different possibilities for the formation of paired nucleon configurations (and, consequently, for a decrease of K_0) in nuclei of different parity types. Attention is drawn, however, to the fact that, with increasing excitation energy, the value

Fig. 1

Figure 1: Fig. 1

of K_0 for the odd-odd compound nucleus Np^{238} did not approach the values of K_0 for nuclei of other parity types.

We have carried out measurements of the angular distributions of fission fragments produced by neutrons in Am^{241}—a nucleus of the same parity type as Np^{237} and having the same intrinsic spin 5/2.

The experiment was carried out on an electrostatic accelerator ([4]). The neutron source was a solid TiT target bombarded by protons, whose diameter was 5 mm. The neutron-energy spread was ± 30 keV. The neutron flux was measured with two long counters calibrated against a standard neutron source.

A layer of Am^{241} about 1 mg/cm^2 thick and 6 mm in diameter was deposited electrolytically on a platinum backing 0.1 mm thick. The distance from the accelerator target to the layer was 25 mm. Fission fragments were recorded simultaneously by four round glass detectors ([5]), each 20 mm in diameter, placed at a distance of 50 mm from the layer at angles of 0, 30, 60, and 90° to the direction of the neutron flux. The layer of fissionable material and the detectors were located in a common thin-walled evacuated vessel.

Each measurement consisted of two series carried out in different quadrants, which made it possible to obtain directly $\sigma(0^\circ)/\sigma(90^\circ)$ and $\sigma(30^\circ)/\sigma(60^\circ)$. Special measurements were made to determine the relative efficiency of the middle detectors with respect to the outer ones.

Corrections for energy and angular ($\sim 12^\circ$) resolution were introduced into the measurement results. The influence of neutrons scattered by the walls of the room was taken into account by varying the distance from the accelerator target to the layer of fissile material (according to the deviation from the $1/R^2$ law). It did not exceed 2%. The fraction of neutrons scattered by the measuring chamber was determined by calculation and was $\sim 5\%$.

Fig. 1. Dependence of the fission anisotropy on neutron energy

The small magnitude of the anisotropy at the accuracy of measurements attained by us ($\sim 2\%$) made it possible to retain only two terms in the expansion of the angular distributions in powers of the cosine,

$$\sigma_f(\vartheta) = \sigma_f(90^\circ)\left[1 + a\cos^2\vartheta\right].$$

The measurement results are shown in Fig. 1. As can be seen from the figure, the fission anisotropy in the threshold region is quite small and depends only weakly on neutron energy.

Fig. 2

Figure 2: Fig. 2

Fig. 2. Dependence of k_0^2 on the excitation energy for nuclei of different parity types.
I—even-even nuclei, II—even-odd nuclei, III—odd-odd nuclei.
a—Am^{242}—data of the present work; b—Np^{238}—data of Ref. ([3])

Measurements of the angular distributions at neutron energies of 4.0 and 5.0 MeV made it possible to determine the values of K_0 at the corresponding excitations of the compound nucleus Am^{242}. The results are shown in Fig. 2 together with the data for Np^{238} ([3]). As in Ref. ([3]), in the present case we took as the threshold neutron energy that at which the fission cross section reached 10% of the fission cross section on the plateau, and assumed that

$$I_{\max} \simeq \sqrt{5E_n}\,(\mathrm{MeV})^{1/2}.$$

It is seen that the agreement is quite satisfactory, except for the value of K_0 for Np^{238} obtained from measurements at a neutron energy of 5.5 MeV; however, the possibility of a correct determination of this value, in view of the proximity of the threshold of the $(n, n'f)$ process, is doubtful. If this single value is excluded, then the dependence of K_0 on the excitation energy for odd-odd fissioning nuclei exhibits a noticeable tendency to approach the analogous dependences for nuclei of other parity types.

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