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PART I

NUCLEAR-PHYSICAL CONSTANTS

FISSION CROSS-SECTION OF $^{232}Th^{*}$ FOR 0.6–1.3 MeV NEUTRONS

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The detector used in measuring the relative shape of the fission cross-section curve was a thin-walled (~1 mm Al) multilayer ionization chamber into which was placed about 6 grams of thorium which had previously been carefully purified from possible uranium admixtures. The assembly of thorium oxide layers, ~2 mg/cm^2 in thickness, applied on aluminium foils (0.1 mm), was divided into two halves between which was placed the monitoring chamber containing a double layer of natural uranium. The working space of the detector, i.e. the area filled by the fissionable material, had the shape of a cylinder the diameter and height of which came to 6 cm. Because of the considerable thickness of the layers and the fact that about 30% of the fission events are not recorded, there was the risk of an undesirable sensitivity in the detector to the anisotropic angular distribution of the fission fragments, the character of which depends strongly on E [1,2] (see Fig. 1). Test experiments with rotation of the detector and increase of the discriminator threshold showed that the distortions brought about by the effect referred to are unimportant.

Measurements were carried out on FEI[*] electrostatic generators using the T(p,n) reaction on solid tritium targets, the thickness of the active layer being 0.4 mg/cm^2 (Ti). The distance from the source to the middle plane of the active part of the detector, where the monitoring chamber layer was placed, was 12 cm. The total energy spread ΔE (the width of the neutron spectrum at the base), due to the broadening of the proton energy in the target and the final angular resolution of the detector, increases with E, from 0.07 to 0.10 MeV. In the region that interests us, that of E_n = 0.6–1.3 MeV neutrons, the total energy spread amounts to 0.07 MeV.

The number of thorium fissions experimentally determinable for one monitor reading R is proportional to the ratio of the fission cross-sections of Th and natural uranium, averaged with respect to the spectrum of neutrons that produce fissions in the corresponding layers of the fissionable materials. The error in R, calculated from the scatter of the individual measurements, does not exceed 5% in the plateau region. Below the threshold

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*/ Institute of Physics and Energetics.

there predominates a statistical error which reaches 15% when $E = 0.6$ MeV. The final energy resolution of the experiment may be estimated by considering the effective neutron energy, for which σ_f is equal to the mean value of the cross-section averaged over the neutron spectrum within the limits of ΔE. The effective neutron energy for Th and U will differ slightly because of the difference in the dependence of σ_f over the interval ΔE and because of the way in which the fissionable material is arranged in the chamber relative to the neutron source. This was taken into consideration in plotting the relative dependence of the fission cross-section of ^{232}Th ($\sigma_f^{Th} \sim R.\sigma_f^U$) in Fig. 1, where the effective neutron energy was plotted along the abscissa. Fission cross-sections of natural uranium were found from the corresponding data for ^{238}U [3,4,5,6] and ^{235}U [5].

The dependence of $\sigma_f^{Th} \sim R.\sigma_f^U$ on E was normalized through comparison with the only published data available [7]. The present experiment in the uninvestigated energy region far below the threshold, where σ_f is several orders of magnitude lower than the cross-section measured in [7], was carried out partly at the cost of a lower energy resolution. It is precisely for this reason that measurements were necessary in the region of neutron energies relatively remote from the threshold, where a comparatively slow change of σ_f ($E = 1.8$–2.0 and 2.5–3.0 MeV) can be observed and the discrepancy in the energy resolution has an insignificant effect. Fig. 1 gives the dependence σ_f (E) in millibarns, as obtained in the present work, normalized in such a manner that in the regions of E referred to, the difference from the results of [7], shown on the same Figure, are minimal. Taking into account what was stated previously, we can accept the agreement of the compared data for the entire overlapping range of E as completely satisfactory.

In Table 1 we give the values of the fission cross-section for E_n from 0.6 to 1.3 MeV. The dependence of the fission cross-section of ^{232}Th on the neutron energy right up to $E = 2$–2.5 MeV is irregular in character. This phenomenon is obviously due to the fact that the compound nucleus of the (n,n') reaction is predominant in the decay process. In particular, the origin of the step-like structure in the σ_f (E) curve at $E = 0.75$ and 1.05 MeV is definitely linked with the competition of Γ_n, inasmuch as the discontinuities in σ_f with respect to energy coincide with the positions of the excited levels of the residual nucleus of ^{232}Th - 0.725 (0^+), 0.775 (2^+), 0.788 (2^+) and 1.045 (1^-), 1.095 (3^-) [8] - which can be arrived at by emission of neutrons from the compound nucleus of ^{233}Th.

Table 1

Neutron energy E_n (keV)	585	645	690	705	735	760	780	800	825	845	870	895
Fission cross-section σ_f (millibarns)	0,0065	0,020	0,029	0,043	0,065	0,082	0,III	0,II3	0,I24	0,I76	0,280	0,427
Neutron energy E_n (keV)	9I5	940	960	985	I005	I035	I055	I080	II05	II30	II50	II75
Fission cross-section σ_f (millibarns)	0,680	0,820	I,000	I,I40	I,350	I,9I0	I,760	2,020	I,950	2,500	2,500	3,770
Neutron energy E_n (keV)	I200	I225	I245	I270	I295							
Fission cross-section σ_f (millibarns)	4,830	6,260	8,070	I0,300	I5,300							

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