Nuclear Data for Science and Technology (1988 MITO), 141- 143, Copyright © 1988 JAERI.

MEASUREMENT OF ^{232}Th AND ^{234}U FISSION CROSS-SECTIONS BY FAST NEUTRONS

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Abstract: Experimental results $^{232}Th/^{235}U$ and $^{234}U/^{235}U$ fission cross-section ratios are represented in this paper.

(fission cross-section, fast neutrons, Van-de-Graaf accelerator)

Introduction

This paper presents the experimental data on ^{232}Th and ^{234}U fission cross-section measurement, which can be useful for nuclear constants generation required for thorium cycle reactor design. Regardless of a series of Refs./1-6/ published recently, where these cross-sections were measured with satisfactory accuracy, we have attempted to eliminate certain disagreement in separate energy ranges. In our work the technique was applied, which was used earlier for investigation of a wide range of nuclei from ^{231}Pa to ^{249}Cf /7/.

The experimental procedure

$^{232}Th/^{235}U$ and $^{234}U/^{235}U$ fission cross-section ratios have been measured directly in the experiment. The measurements have been conducted at the Van-de-Graaf accelerators. The neutron sources were the Li(p,n)-, T(p,n)- and D(d,n)-reactions on solid targets. The energy resolution was (30-45 keV) for E_n <1,7 MeV and (60-170 keV) for E_n=1,8-7,4 MeV.

The fissile layers with the diameter 10-15 mm were applied to thin (0.1 mm) aluminium backings. Table 1 represents the characteristics of the fissible layers.

The fission fragments were detected with a twin ionization chambers allowing the concurent measurement of two fission cross-section ratios. The fragments registration efficiency was about 98-99%.

Table 1. Masses and Isotopic Composition of Fissile Layers

Isotope	Mass, mg	Isotope composition, at %
^{232}Th	0.678	100
^{232}Th*	0.260	99.2 ^{235}U-0.724±0.011
^{232}Th*	0.425	99.6 ^{235}U-0.359±0.006
^{234}U*	0.110	93.3 ^{235}U-6.70±0.06
^{234}U	0.393	98.04 ^{238}U-1.58; ^{235}U-0.13
^{235}U	0.266	99.9955
^{235}U	0.416	99.9955

* The layers were used for calibration in the isotopic impurity method.

The ionization chamber with the layers ^{232}Th and ^{234}U containing the known impurities ^{235}U (Table 1) was located in a slow neutron flux (with cadmium ratio ~25) to determine the mass ratio of fissile layers. The measurement of ^{235}U fission rates ratios in the layers ^{232}Th and ^{235}U, ^{234}U and ^{235}U enabled the ratio of fissile nuclei numbers to be determined. Then the fission cross-section ratios for neutron with the energy E_n= 1.5, 2.0, 2.5 and 3.0 MeV (Table 2) were measured for the same fissile layers. The energy dependence measurement data for fission cross-section ratios obtained with the layers ^{232}Th and ^{234}U of a high enrichment subsequently were normalized to these calibration values.

The neutron background components were measured experimentally. The back-

Table 2. Calibration Values of Fission Cross-Section Ratios

E_n, MeV	$^{232}Th/^{235}U$	$^{234}U/^{235}U$
1.0	-	0.9120±0.0146
1.5	0.0679±0.0014	1.1122±0.0178
2.0	0.0992±0.0015	1.1921±0.0185
2.5	0.0989±0.0019	1.1909±0.0181
3.0	0.1199±0.0020	1.2464±0.0200

ground of neutrons scattered on the target device material were measured by doubling the effective thickness of the material with the subsequent extrapolation to the zero thickness (the correction was 0.1-1% for the major part of energy range and increased to 4-6% in the fission threshold range). The experimental room background did not exceed 0.3-0.7%. The neutron background of the concurent (p,n)- and (d,n)-reactions was measured by replacing the target with deuterium and tritium free template. The maximum correction for the (p,n)-reaction was 5.5% for E_n=3.5 MeV and reduce to 1-0.1% for E_n=3-2 MeV. For the (d,n)-reaction the correction for a "parasitic" reaction background was 0.4-2% for E_n = 3.6-5.4 MeV and increased up to the values 6.5% (^{234}U) and 11.4% (^{232}Th) for E_n=7.4 MeV.

Certain corrections have been applied in the course of calculation: for the energy dependence of fission chamber efficiency taking into account a momentum produced by the neutron and angular fission anisotropy; for inelastic neutron scattering on backing of the layers; for the difference of neutron fluxes through the fissile layers; for the effect of fissile impurities.

The Experimental Results

The resulting data are shown in Figs. 1-4.

$^{232}Th/^{235}U$ (Figs. 1,2). The neutron energy range 0.7-7.4 MeV has been studied. The statistical error for E_n>1.5 MeV was

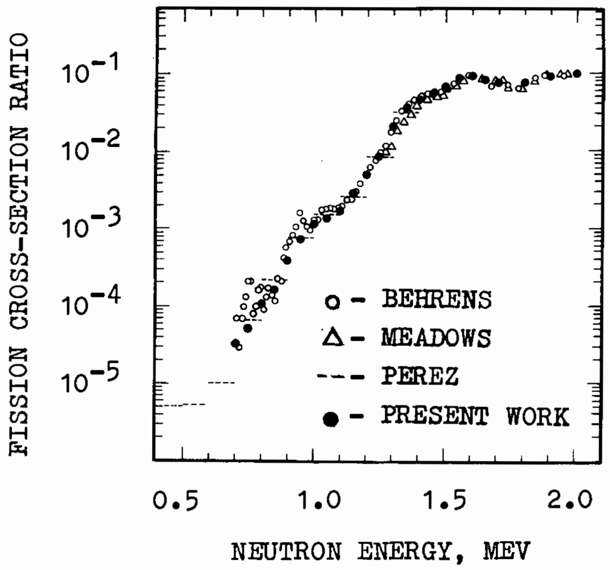

Fig.1. $^{232}Th/^{235}U$ fission cross-section ratio (sub-threshold area E_n)

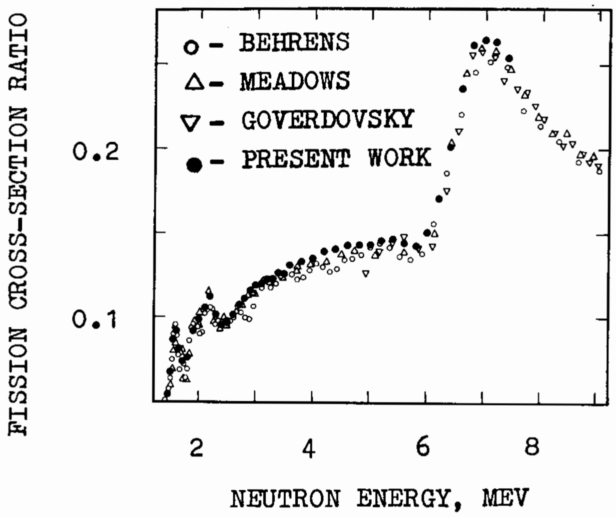

Fig.2. $^{232}Th/^{235}U$ fission cross-section ratio

0.6-1%. The total error in the region E_n>5 MeV grows up to 3-5% relative to the correction for background.

The present work results are in a good agreement with the data by Behrens /1/ and Meadows /3/ in the form of energy dependence over the whole energy range consided, but by 3-5% higher, than these results for E_n>3.5 MeV.

$^{234}U/^{235}U$ (Figs. 3,4) This ratio was measured in the neutron energy range E_n = 0.13-7.4 MeV with accuracy about 1.5% in the main part of the energy region inve-

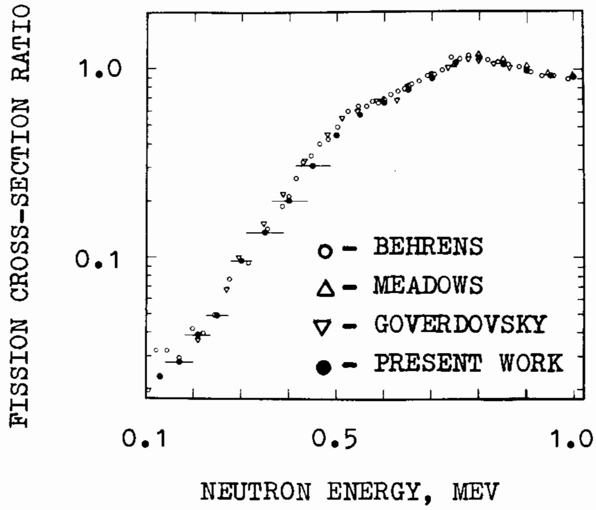

Fig.3. $^{234}U/^{235}U$ fission cross-section ratio (sub-threshold area E_n)

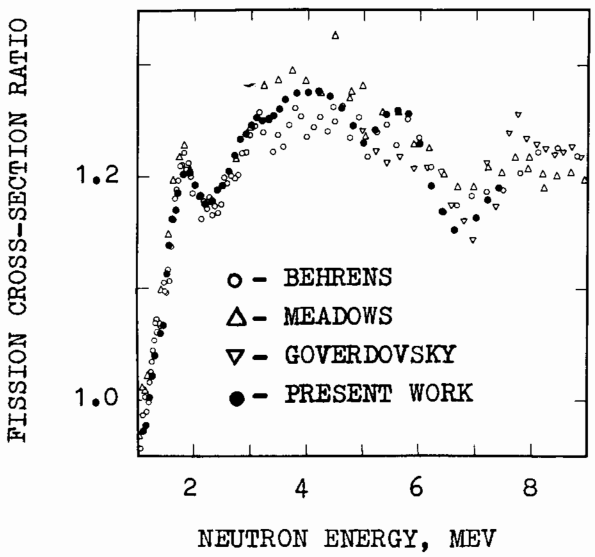

Fig.4. $^{234}U/^{235}U$ fission cross-section ratio

stigated. The present work results demonstrate a good agreement with the data of Behrens /2/, Meadows /4/ and Goverdovsky /6/. The attained agreement of the results enables the ^{234}U fission cross-section to be evaluated with an accuracy meeting the practical requirements.

Acknowledgements

The authors wish to thank E.Yu. Baranov, M.P. Klemyshev, Yu.M. Turchin for their assistance in the work and A.A.Goverdovsky, M.F. Mitrofanov for the contribution to the preparation of the experiment.

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