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COMISION DE ENERGIA ATOMICA DE CUBA

TITULO:

MEASUREMENT ~~FO~~ OF THE FISSION CROSS-SECTION RATIO FOR $^{237}Np/^{235}U$ AROUND 14 MeV NEUTRON ENERGIES.

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Clasificación temática del INIS

A 33-50 FISSION

DESCRIPTORES

NEUTRON GENERATORS
FISSION CHAMBERS
URANIUM 235
NEPTUNIUM 237
FAST FISSION

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Measurement of the fission cross-section ratio for $^{237}Np/^{235}U$ around 14 MeV neutron energies*,**

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* Dedicated to Prof.Berényi on his 60th birthay.

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MEASUREMENT OF THE FISSION CROSS-SECTION RATIO FOR $^{237}Np/^{235}U$ AROUND 14 MEV NEUTRON ENERGIES.

Resumen La relación de las secciones eficaces de fisión $^{237}Np/^{235}U$ para neutrones de energías de la región de 14 MeV fue medida con una camara de ionización back-to-back. Los neutrones fueron producidos con un acelerador de 180 kV usando la reacción $T(d,n)^4He$. No se encontró dependencia significativa de la relación de las secciones eficaces con la energía.

Abstract Fission cross-section ratio was determined for $^{237}Np/^{235}U$ around 14 MeV neutron energies with a back-to-back ionization chamber. Neutrons were produced by a 180 kV accelerator using $T(d,n)^4He$ reaction. No significant energy dependence was found in the cross section ratio.

INTRODUCTION.

The ^{237}Np fission cross-section is often used in dosimetry. For such a purpuse, an accurate knowledge of the ^{237}Np to ^{235}U fission cross-section ratio is necessary. These data are also required for a systematic study of fission cross-sections.

A number of ratio measurements have been reported in the range of 13.5-15 MeV. Behrens et.al.[1] have measured the fission cross-section ratio of ^{237}Np to ^{235}U as a function of neutron energy using fission chamber, threshold cross-section method and time of flight technique.

Fission cross-section ratio ^{237}Np/ ^{235}U has been determined by Várnagy et. al.[2] using solid state nuclear track detectors in combination with the jumping spark counting evaluation technique. Carlson et.al.[3] have reported a relative measurement of ^{237}Np/ ^{235}U.

Fast neutron fission cross-section measurements for ^{237}Np has been reviewed by Cross et.al.[4] and Lapenas [5]. Alkhazov et.al.[6] measured the σ value for $^{237}Np(n,f)$ at 14.8 MeV by time correlated associated particle method. The $\sigma(^{237}Np(n,f))$ was measured with absolute method by White et.al.[7] and by Moat[8]. These absolute data can be converted to the ^{237}Np/ ^{235}U ratios using evaluated $^{235}U(n,f)$ cross-sections from ENDF/B-V [9].

The analysis of the ^{237}Np/ ^{235}U fission cross-section ratios around 14 MeV shows discrepancies in the magnitude of the reported data.

At 14.1 MeV the value of White et.al.[7] is higher by about 8% than that of Behrens et.al.[1]. The trend in the data observed by Carlson et.al.[3] agrees with that of Behrens et.al.[1] around 14 MeV. The Adamov et.al.[10] value at 14.7 MeV is higher by about 10% than that of Behrens et.al.[1]. The Varnagy's[2] data within the limits of errors are in good agreement with the Lapenas[5] data, but they are sistematically higher than the data of Behrens et.al.[1]. The Alkhazov et.al.[6] value at 14.8 MeV is higher by about 3% than the Varnagy's[2] value at the same energy.

The aim of this work was to measure the $^{237}Np/\ ^{235}U$ fission cross-section ratio with a back-to-back chamber to clear up the discrepancies in the previous data.

EXPERIMENTAL PROCEDURE.

A schematic drawing of the experimental arrangement is shown in Fig.1.

The fission detector was a low-mass, double ionization chamber filled with argon gas of about 10^5 Pa. The cylindrical fission chamber was made of 0.5 mm aluminium. Both parts of the chamber were operated at 500 V with a plate separation of 6 mm. This chamber was place at a distance of 7 cm from the beam spot on the tritium target.

The irradiation of fissile samples were performed by fast neutrons produced in the $^3H(d,n)^4He$ reaction using a 180 KeV accelerator. The intencity of the analyzed D^+ beam was about 70 μA. The energy of neutrons was changed by the emission angle, i.e. the chamber was placed at different directions to the deuteron beam of about 10mm diam. The neutron energies and their spreads are given in Table 3 for the geometrical arrangement shown in Fig.1.

The fissile sample were prepared at the Hlopin Institute in Leningrad(USSR) where, their isotopic compositions and thicknesses (summarized in table 1) have been determined. The ^{235}U and ^{237}Np, as tetrafluorides, were deposited onto Al holders(0.2 mm Thick and 40 mm diameter).

A rather good separation of the alpha particles and the fission fragments can be observed in the experimental spectrum (Fig.2).

In order to obtein the total number of fission events in the deposits, a correction was performed for the loss of pulses under the base line by extrapolation of the fragment pulse-height spectrum to zero energy.

To determine the channel number corresponding to zero pulse height, the linearity of the systems was measured by a pulse generator.

A correction for the fission fragment absorved in the layer of fissionable nuclides was introduced.

Pair of ^{237}Np/ ^{235}U samples were placed back-to-back in the chamber. Two orientations were possible: first, when the ^{237}Np sample was placed near the neutron source, and second, when the ^{235}U sample was placed in the same position.

At each neutron energy, measurement of the relative fission rate were made with both of these orientations.

When the results from the two orientations were averaged, the effect of geometry, neutron scattering in the support plates between the deposits and the momentum transfer were elimited.

The contributions of the thermal and epithermal neutron background to the fission event events in the case of ^{235}U has been determined by experiment using the $^{164}Dy(n,\gamma)^{165}Dy$ reaction and the cadmium difference method. It was found that the background neutrons increased the cross section of $^{235}U(n,f)$ with about 1%. This effect is caused mainly by the epithermal neutrons in our experimental arrangement.

RESULT AND DISCUSSION.

The results obteined in this experiment are given in table 3. Table 2 list the corrections to the data and the magnitudes of errors. Root-mean-square errors were used in every case. The error of fission cross-section ratios is mainly due to the uncertainty in the determination of the total amounts of ^{237}Np and ^{235}U isotopes.

Our results in comparison with some previous data are shown in Fig.3.

At it can be seen in the figure no significant energy dependence has been found in the fission cross-section ratio for $^{237}Np/\ ^{235}U$ around 14 MeV. The cross-section ratio obtained in this experiment is in good agreement with the result of Behrens and is lower in average with about 8% and 15% from those given by Várnagy et.al. and Lapenas, respectively.

ACKNOWLEDGEMENT

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TABLE 1. Isotopic composition and masses of the fissile samples.

Sample	Isotopic composition(%)			mass(μg)
U	^{234}U	^{235}U	^{236}U	481
	0.001	99.9955	0.0036	
Np	^{237}Np	^{239}Pu	^{241}Am	418
	99.9917	.0078	0.0005	

TABLE 2. Range of correction factors and error.

Effect	Range of correction (%)	Range of Error (%)
statistical.	-	0.6 - 0.8
extrapolation of fission spectrum to zero bias.	2 - 4	0.4 - 0.8
fission fragment loss in sample deposits.	1.8	0.18
mass ratio.	-	4.24
forward-backward anisotropy.	negligible	-
thermal and epithermal neutrons.	1	-
fission due to other isotopes.	negligible	-
total	4.0 - 5.4	4.3 - 4.4

TABLE 3. Cross-section ratio $^{237}Np/^{235}U$

Angle	Neutron energy (MeV)	$\sigma_{nf}(^{237}Np/^{235}U)$
0^0	14.80 ± 0.17	0.999 ± 0.043
30^0	14.70 ± 0.15	1.054 ± 0.046
60^0	14.45 ± 0.12	1.042 ± 0.045
90^0	14.12 ± 0.08	1.021 ± 0.044
120^0	13.75 ± 0.10	1.006 ± 0.043

Pie de figuras.

Fig. 1. Scattering-free irradiation arrangement used in the present work.

Fig. 2. A pulse-height distribution of the fission fragments.

fig. 3. Cross-section ratio for $^{237}Np/ ^{235}U$ around 14 MeV.

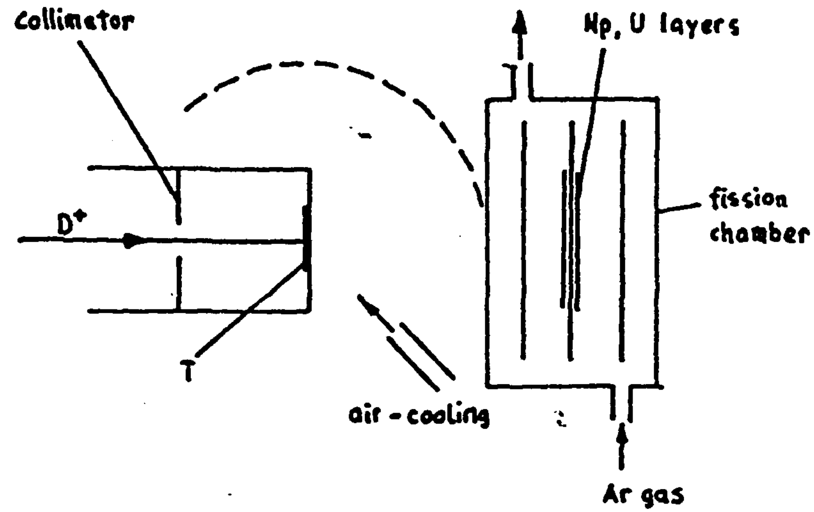
Collimator
Np, U layers
D+
fission
chamber
T
air-cooling
Ar gas

Fig. 1

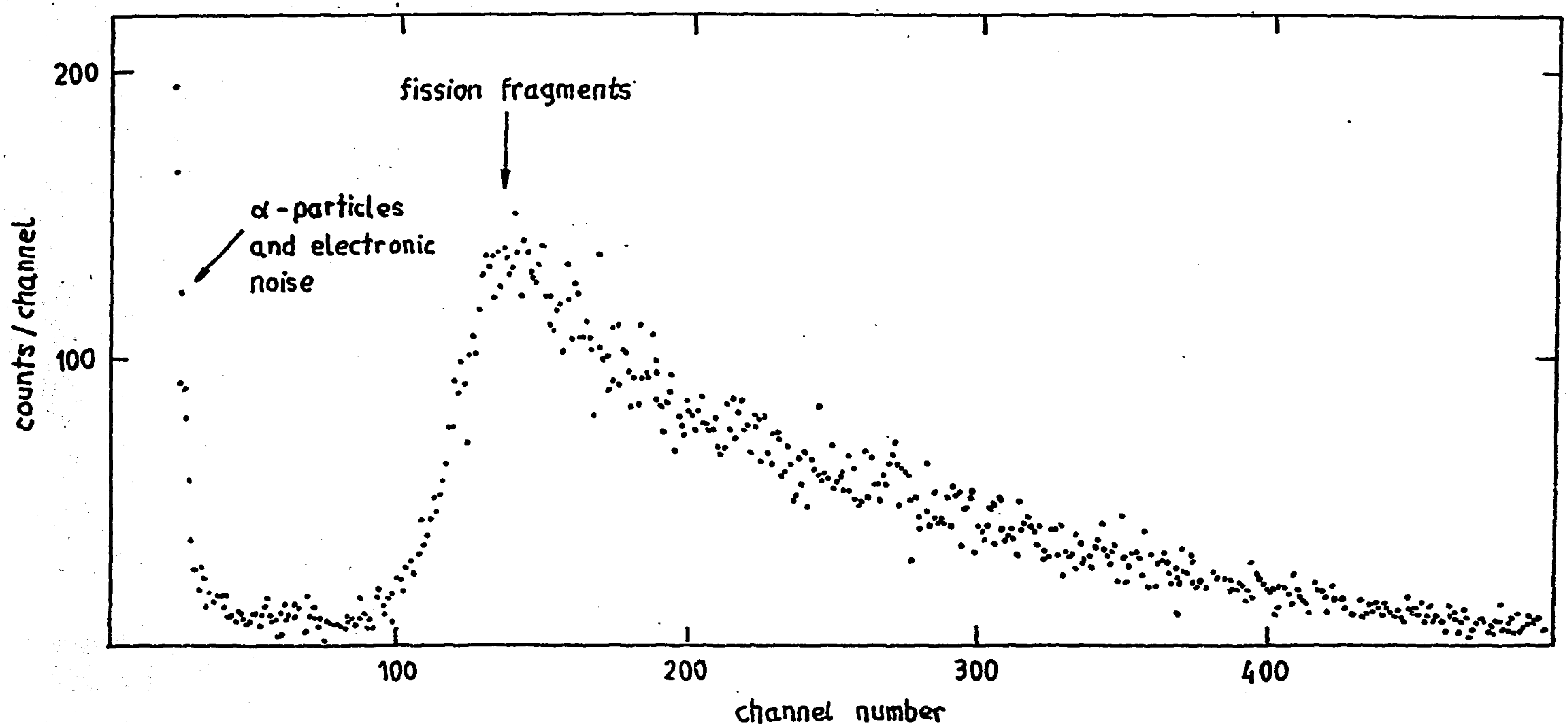
fission fragments
α-particles and electronic noise
200
100
100
200
300
400
counts / channel
channel number

Fig 2.

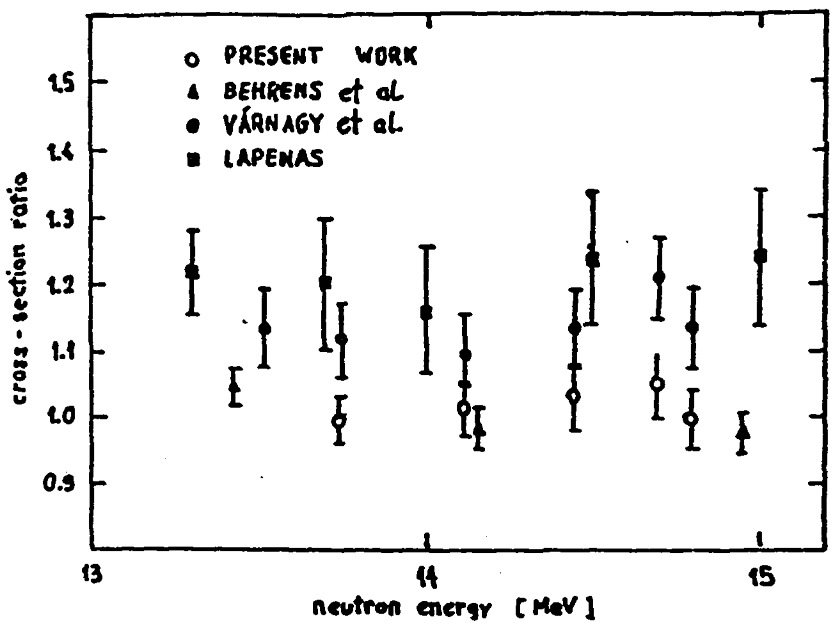
PRESENT WORK
BEHRENS et al.
VÁRNAGY et al.
LAPENAS
1.5
1.4
1.3
1.2
1.1
1.0
0.9
cross - section ratio
13
14
15
neutron energy [MeV]

Fig 2

Fig 3.

Titulo: Measurement of the fission cross-section ratio for $^{237}Np/^{235}U$ around 14 MeV neutron energies.

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