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PRELIMINARY RESULTS ON THE FISSION CROSS SECTIONS OF Th^{232} and U^{235} FOR 14 MEV NEUTRONS

Work done by:

George Everhart

A. Hemmendinger

G. A. Jarvis

R. F. Taschek

Report written by:

G. A. Jarvis

[redacted]

Abstract

The fission cross sections of Th^{232} and U^{235} have been measured relative to U^{238} for 14 Mev neutrons. The absolute cross sections were determined to be 0.242 $\pm$ 0.020 barn for Th^{232} and 1.63 $\pm$ 0.12, assuming a value of 0.846 $\pm$ 0.051 for U^{238}.

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Preliminary Results on the Fission Cross Sections of Th^{232} and U^{235} for 14 Mev Neutrons

Introduction

The absolute fission cross section of U^{238} for neutrons in the 13 to 18 Mev range has recently been measured[1], using the fast neutrons from the $T(D,n)He^4$ source operating in conjunction with the Los Alamos electrostatic generator. It is the purpose of this report to present some preliminary results obtained for the fission cross sections of Th^{232} and U^{235} in the 14 Mev neutron energy range.

Once the absolute fission cross section has been established for some material at a given neutron energy, the extension of fission measurements to other materials can most easily be done by using a comparison method wherein atoms of the two materials are exposed to the same neutron flux under identical conditions of geometry, etc., so that the unknown cross section depends primarily on the relative number of fissions observed, the relative number of atoms involved, and of course, the known cross section of one of the materials.

Method

The device chosen for comparing the fission properties of Th^{232} and U^{235} with U^{238} was a flat foil fission chamber, the essential features of which are shown in Fig. 1. Four foils each of U^{238} and Th^{232}(or U^{235}) were assembled in an array such that the same average neutron exposure per fissionable atom obtained for both types of foils. The active material was coated over an area 4 cm diameter on one mil thick platinum discs of somewhat greater diameter. The foils were clamped at the edges between stainless steel rings and held approximately 0.25 cm apart with insulating spacers. The array of foils was supported from the back side of the chamber upon three Kovar to glass seals, which also served to make electrical correction to the accelerating potential and to the two preamplifiers. The insulating spacers and the pressurizing gasket were of polythene, a non-hydrogeneous material used to minimize scattering of neutrons into the foils. The accelerating potential of about 2,000 volts per cm was connected for electron collection and the resulting fission pulses were amplified by model 100 amplifiers. The chamber was filled with argon to a pressure of 100 lbs. per square inch. The chamber was lined with 15 mil cadmium to minimize fissions in U^{235} due to thermal neutrons.

For these experiments the target was modified to operate as a thick target in order to take advantage of the high flux of 14 Mev neutrons obtainable from the broad 200 kev resonance of the $T(D,n)He^4$ reaction. To do this the deuteron beam energy, target input foil thickness, lengtn of deuteron path in target and pressure of target gas were adjusted so that the beam was just stopped in the target gas. Due to the high total cross section (around 5 barns) of the $T(D,n)He^4$ reaction in the neighborhood of the resonance[2], one has an approximately spherical source of

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nearly monoergic high energy neutrons. With the target operating in this manner, total neutron fluxes of the order of 5×10^8 per second were readily obtained.

Before each experiment was started, integral bias curves were taken for both fission pulse collection systems and care was taken to set the discriminator bias settings to corresponding points on the flat portions of the bias curves.

The active material contained in each type of foil was as follows:

Type of Foil	Mass of Active Material	Contamination
U^{238}	7.636 mg	25 to extent of 1/30,000
Th^{232}	7.562	-----
U^{235}	2.702	28 to extent of 0.792 mg

Cross Section of Th^{232} for 14 Mev Neutrons

In this experiment an almost equal number of atoms of Th^{232} and U^{238} were exposed to the high flux of 14 Mev neutrons for a period of about one hour. The following results were obtained:

Type of Foil	Number of Fissions	Number of Atoms
U^{238}	17,369	1.946×10^{19}
Th^{232}	5,039	1.973×10^{19}

The ratio of cross sections is therefore:

$$\frac{\sigma_{U^{238}}}{\sigma_{Th^{232}}} = \frac{17,369}{5,039} \times \frac{1.973 \times 10^{19}}{1.946 \times 10^{19}} = 3.50 \pm 07$$

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Since the cross section for U^{238} at 14 Mev is 0.846 ± 0.051 barns, we get for Th^{232}

$$\sigma_{Th^{232}} = 0.242 \pm 0.020 \text{ barns.}$$

Cross Section of U^{235} for 14 Mev Neutrons

The throium foils were replaced by U^{235} foils and several exposures made, the results of which are in the following table:

Fissions in U^{238} Foils	Fissions in U^{235} Foils	Time for Run	Ratio of Fissions (U^{235}/U^{238})	Distance Foils to Target	$\sigma U^{238}/\sigma U^{235}$
20,667	16,507	162 m	0.7990	10 cm	0.521
3,113	2,366	-----	0.7600	28 cm	0.546
6,817	5,389	-----	0.7800	28 cm	0.519

A background run was made with the tritium in the target being replaced by hydrogen, other things being the same, this gave,

Fissions in U^{238} Foils	Fissions in U^{235} Foils	Time for Run
229	193	12 minutes

Applying this correction to the first run in the above table, the ratio of fission cross sections becomes:

$$\sigma U^{238}/\sigma U^{235} = 0.520 \pm 0.005 ,$$

and the absolute cross section of U^{235} for 14 Mev neutrons becomes

$$\sigma U^{235} = 1.63 \pm 0.12 \text{ barns.}$$

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Since the U^{235} foils contained an appreciable quantity of U^{238}, the calculation of the cross section ratio was slightly more involved than for the Th^{232} foils. The ratio was obtained from the formula:

$$C_{U^{235}}/C_{U^{238}} = \frac{N'_{U^{238}}\,\sigma_{U^{238}} + N'_{U^{235}}\,\sigma_{U^{235}}}{N_{U^{238}}\,\sigma_{U^{238}}}$$

where

$C_{U^{235}}$ = number of fission counts from U^{235} foils,

$C_{U^{238}}$ = number of fission counts from U^{238} foils,

$N_{U^{238}}$ = number of U^{238} atoms on U^{238} foils,

$N'_{U^{238}}$ = number of U^{238} atoms on U^{235} foils,

$N'_{U^{235}}$ = number of U^{235} atoms on U^{235} foils.

In view of the large number of fissions observed the statistical errors for the fission cross section ratios were negligible. The most likely sources of errors would seem to be due to possible incorrect settings of the discriminator bias voltages and to fission in U^{235} due to epithermal neutrons. Further experiments will be necessary to determine the magnitude of these effects.

<u>References</u>

[1] G. A. Jarvis, LAMS-777.

[2] R. F. Taschek, LAMS-662.

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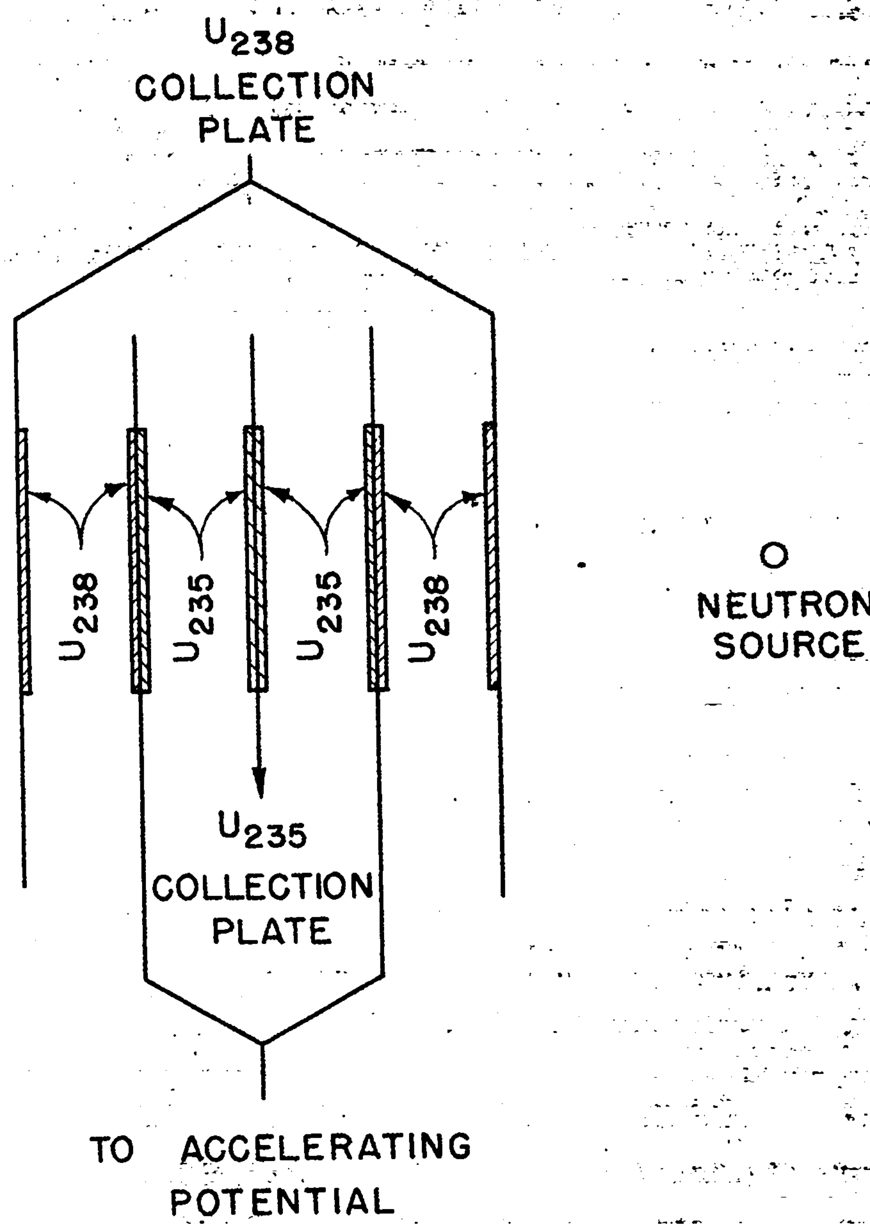

FIG 1

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