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RATIO OF THE THERMAL FISSION CROSS SECTIONS OF 23 AND 25

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ABSTRACT

The ratio of the fission cross sections of 23 and 25 for thermal neutrons has been determined to be 0.90 ± 0.015. From the reported value $\sigma_f(25)$ = 542 barns, one gets $\sigma_f(23)$ = 488 barns. This quantity together with $\sigma_a(23)$ = 566 barns, gives α (23) = 0.16.

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RATIO OF THE THERMAL FISSION CROSS SECTIONS OF 23 AND 25

The ratio of the fission cross sections of 23 and 25 for thermal neutrons has been measured by a comparison method. Thin foils of the materials were placed in a double ionization chamber, and their relative counting rates were observed when the chamber was exposed to the highly thermalized neutrons at the center of a large graphite block near the cyclotron. The composition of the foils was determined from a combination of direct weighing, α - counting, and mass-spectrometric analysis.

Foil Contents

In the experiment one 23 foil was compared with a 25 foil which in turn was compared with another 25 foil. The foils were prepared by Mary Miller by depositing the fluoride on 2-mil Pt foils by electrolysis and then igniting to the oxide, U_3O_8. All three foils were weighed on a micro-balance, and their activities were measured in a nitrogen-filled ionization chamber. The materials from which the foils were prepared were analyzed with a mass spectrometer by Williams and Custer. The pertinent data on the foils are given in the following table:

Material	Foil No.	Diameter cm	Wt. of Oxide mg	Activity	Analysis
25	E16B2	3.1	1.562 ± 0.01	3.42 x 10^4 c/min	63.2% 25
25	E16B35	5.0	3.992 ± 0.01	8.31 "	"
25	HB1	5.0	2.026 ± 0.01	5.65 x 10^5 α/sec	97.2% 23 2.8% 28

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The counting rates of the 25 foils were measured in a 2π ionization chamber, and a correction was made for the thickness of the foils. The specific activity of the material has been accurately determined in the same chamber by measurements on about 25 samples and was found to be 2.609 x 10^4 counts/ minute/ mg of metal.

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The activity of the 23 foil is the total number of disintegrations per second as determined from measurements in a demultiplier chamber, the geometry of which has been measured directly by standard foils. The probable error in these measurements is 0.5 o/o.

The isotopic concentrations are expressed as relative weights. The probable error in the ratios of these quantities is approximately 0.3 o/o.

From the data on the 25 foils, the number of 25 nuclei in each foil, n_{25}, can be computed in two ways: 1) from the weights and the isotopic concentrations and 2) from the α - activity and the isotopic concentrations. The results of these computations are given in the following table:

Foil	$n_{25} \times 10^{-18}$		
	From wts. and analysis	From α's and analysis	Average
E16B2	2.142	2.133	2.137 ± 0.015
E16B35	5.475	5.467	5.471 ± 0.03

The half-life of 23 has been found by Linenberger to be $(1.63 \pm .05) \times 10^5$ years. This together with the rate of disintegration of the 23 foil gives a value of n_{23} since practically all the activity is due to the 23. Another value of n_{23} can be obtained from the weight of the foil and the mass spectrometric data. These are given in the following table:

$n_{23} \times 10^{-18}$		
From α's and Half-life	From weight and analysis	Average
4.195	4.304	4.25 ± 0.05

Comparison Measurements

The comparisons were made in a double parallel-plate ionization chamber, which was constructed of aluminum with lucite electrode supports. The three electrodes were 8.6 cm diameter and 0.1 cm thick and were spaced one cm apart. The foils were placed on the central electrode, which was held at a potential of -1000 volts. The fission particles were counted by electron collection on the outer

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electrodes. The chamber was filled to a pressure of 60 cm of Hg with a mixture of 90 o/o A and 10 o/o CO_2. With this arrangement, long flat plateaus were obtained.

The chamber was placed in the center of a cubical hole, three feet on a side, in the approximate center of a graphite block, 11 ft x 7 ft x 6 ft 8 in, placed near the cyclotron. In this position the cadmium ratio for a 25 detector is about 10^4.

The ratio of the fission counting rates for E16B2 and E16B35 was 0.390 $\pm$ 0.002, which agrees well with the ratio of the numbers of nuclei in the two foils, 0.394. This provides a check on the consistency of the data on these foils. The ratio of the counting rates of HB1 and E16B35 was 0.698 $\pm$ 0.003. From the expression

$$\sigma_f(23) / \sigma_f(25) = (C_{23} \times n_{25}) / (C_{25} \times n_{23}).$$

C_{23} - counts from 23 foil.

C_{25} - counts from 25 foil.

n_{23} - number of 23 nuclei in 23 foil.

n_{25} - number of 25 nuclei in 25 foil.

the value of $\sigma_f(23) / \sigma_f(25)$ is found to be 0.90 $\pm$ 0.015.

Discussion

The value of $\sigma_f(25)$ for thermal neutrons has been reported to be 542 barns.[1)] From the ratio $\sigma_f(23) / \sigma_f(25) = 0.90$, one obtains $\sigma_f(23) = 488$ barns. This is the effective cross section for thermal neutrons. Since the cross sections of 23 and 25 do not have the same energy dependence in the thermal region, the ratio

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of the cross sections at a particular neutron energy is not the same as the ratio of the effective cross sections. The value of $\sigma_f(23)$ varies as $1/v$ in the thermal region,[2] but $\sigma_f(25)$ varies more rapidly.[3] If one assumes that the neutron energy distribution in the graphite block is Maxwellian with a temperature equal to that of the graphite, then it is possible to calculate the ratio of the cross sections for neutrons of a particular velocity. Such a calculation for neutrons of velocity equal to 2200 meters per second gives a ratio of 0.88.

The total absorption cross section of 23 for thermal neutrons has been measured by Fermi, Hinton, and King and was found to be 566 barns.[4] From this quantity and the value of $\sigma_f(23)$ found in this experiment, one gets

$$\sigma(23) = \sigma_r(23) / \sigma_f(23) = \left[\sigma_a(23) - \sigma_f(23)\right] / \sigma_f(23) = 0.16$$

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2) McDaniel, LA 190.

3) Anderson, McDaniel, and Sutton, LA 158.

4) LAMS 228 - F Division Progress Report for March, 1945.

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