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THE TOTAL NEUTRON CROSS SECTION OF NORMAL URANIUM IN THE ENERGY RANGE FROM 20 TO 1600 KEV

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THE TOTAL NEUTRON CROSS SECTION OF NORMAL URANIUM IN THE ENERGY RANGE FROM 20 TO 1600 KEV

INTRODUCTION

Four series of experiments have been carried out in the past in which the total neutron cross section of uranium was determined: the measurements of the Minnesota group,[1] the measurements of Group P-3 at Los Alamos,[2] the photo-neutron experiments at Argonne,[3] and measurements by Frisch at Los Alamos.[4] The disagreement between the results of the various experimenters is far outside the statistical errors of the measurements, the first two sets of data giving much lower values than the latter two. In view of the importance of an accurate knowledge of the uranium cross section, it was decided to carry out further experiments at the University of Wisconsin, covering a wider continuous energy range.

METHOD

The measurements were performed in the same manner as those described by Adair, et al.[5] Neutrons were obtained by bombarding a lithium target by protons accelerated by the Wisconsin electrostatic generator. At low energies, the observations were carried out at an angle of 115° with respect to the incident protons, while, at higher energies, the neutrons in the forward direction were used. The Li target had a stopping power of 25 kev at the Li(p, n) threshold. Most of the energy spread of the neutrons was due to the finite target thickness. The spread amounts to about 15 kev for observations at 115°, while it is about 25 kev for the forward direction. The neutrons were detected by means of $B^{10}F_3$ counter.

Two samples of normal uranium were used, both circular disks, 1-3/4 inches in diameter. One was one cm thick and contained 0.0479×10^{24} atoms/cm^2, the other was 2 cm thick containing 0.0957×10^{24} atoms/cm^2. The measurements were simple transmission experiments in a geometry such that the cross section for scattering through angles greater than 20° was measured.

Cross sections were computed assuming an exponential decrease of neutron intensity in the sample.

The cross sections were corrected for background and for scattering into the detector (3 percent) assuming isotropic scattering.

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Diffraction scattering was not taken into account,* nor could the increased sensitivity of the counter for inelastically scattered neutrons be corrected for.

Neutron energies were computed from the known value of the Li(p, n) threshold, i.e., 1.882 Mev. Neutron energies are taken as those half-way between the maximum and minimum value of the neutron energy spread caused by the finite target thickness.

RESULTS

In Fig. 1, the total cross section of uranium in barns is plotted against neutron energy in kev. Circles represent data taken at 115° with respect to the incident protons; all other symbols represent measurements taken in the forward direction. Different symbols show different runs. The one-cm thick sample was used at energies below 900 kev, while the 2-cm sample was used above this energy. The point taken at the lowest energy (17 kev) is less reliable than the point at higher energy, since the room background at this energy is very high and not accurately known. At each energy, at least 7000 counts were taken; in many cases, the cross sections are based on more than 20,000 counts. The resulting statistical error is about ± 0.7 barns at the lowest energies, ± 0.5 barns up to one Mev and ± 0.2 barns above one Mev. Within the statistical error, the total cross section of uranium appears to be a smooth function of the energy.

DISCUSSION

Figure 2 shows the data from this investigation and the previously measured ones.(2)(3)(4) The results of the present experiments differ from those of previous measurements by more than the expected experimental error. The discrepancy with the photoneutron measurements is particularly disturbing, since these were carried out in a very similar geometry and with a similar detector. Errors introduced by inelastic scattering and diffraction scattering should therefore be the same in both measurements. Furthermore,

*If only elastic scattering occured, the correction for diffraction scattering would increase the cross section by 15% at 1.5 Mev and by 7% at 500 kev.

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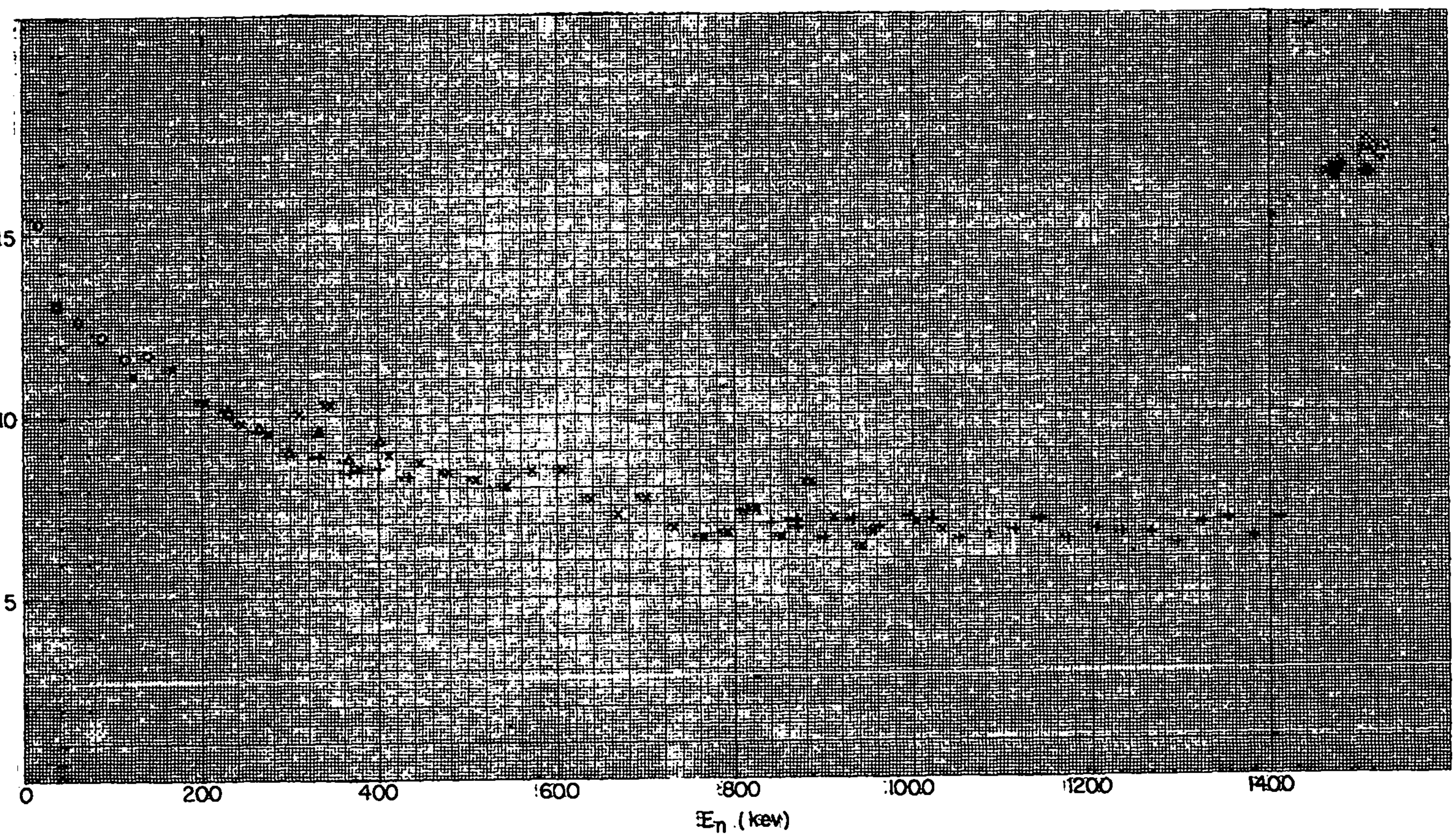

Fig. 1. Total cross section of uranium versus neutron energy.

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Frisch's measurements, using a hydrogen recoil detector, agree with the photo-neutron data, which would indicate that at low energies, at least, inelastic scattering does not introduce any appreciable error. The fact that the present measurements give higher cross sections than those of Group P-3 at Los Alamos at 200, 600, and 1500 kev is also difficult to understand. Since a hydrogen threshold detector was used at Los Alamos, any effects of inelastic scattering should give higher cross sections for the Los Alamos data. Diffraction scattering would lower the Los Alamos data, since a somewhat poorer geometry was used, but it seems unreasonable that this effect should be large enough at low energies to produce the observed difference.

REFERENCES

(1) J. H. Williams, CF-507 (1943).
(2) H. H. Barschall, V. F. Weisskopf, LA-169 (1944).
(3) W. H. Zinn, CP-2638 (1945).
(4) D. H. Frisch, LA-256 (1945).
(5) Adair, Barschall, Bockelman, and Sala, Phys. Rev. 75, 1124 (1949).

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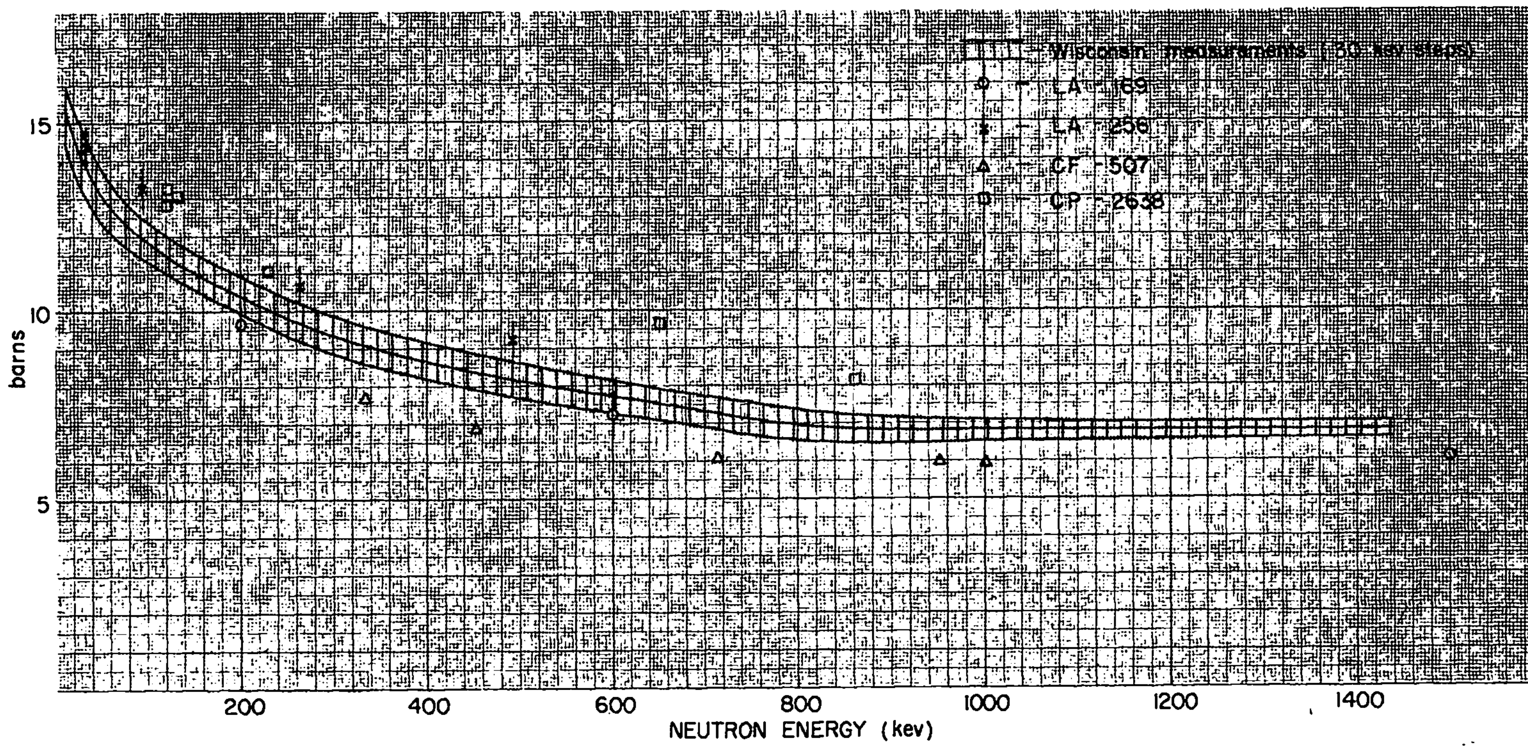

Fig. 2. Summary of data on total cross section of uranium (Refs. 1, 2, 3 and 4, and present investigation).

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