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Total Fast Neutron Cross Sections of Co, Ga, Se, Cd, Te, Pt, Au, Hg, and Th†

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The total neutron cross sections of Co, Ga, Se, Cd, Te, Pt, Au, Hg, and Th were measured as a function of neutron energy from 0.1 to 3 Mev. An estimate of the error caused by neutrons scattered into the detector was made by measuring the apparent cross section as a function of sample diameter. The results give additional evidence that, neglecting resonance structure, total neutron cross-section curves have characteristic shapes which change slowly with atomic weight.

IT has been pointed out[1] that if total neutron cross sections divided by the nuclear geometrical area are plotted as a function of the neutron energy and of the atomic weight, the result is a smooth surface containing broad maxima and minima. This regular behavior of the total neutron cross sections of various elements has created interest in measuring the cross sections of hitherto uninvestigated elements to see if they conform to these regularities. The present experiment was undertaken to supplement existing data.

Total cross sections were measured by transmission experiments as described by Miller *et al.*[2] Fast neutrons for energies above about 1 Mev were produced by bombarding a zirconium-tritium target with protons from an electrostatic generator. Below 1 Mev a lithium target was used. Cylindrical samples about one inch in diameter of the elements studied were placed midway between the neutron source and the detector; the distance from source to detector was fourteen inches. With the exception of the measurements on Te, Au, and Se above 1.5 Mev, neutrons were detected by a hydrogen recoil (pulse) ionization chamber. The high energy Te, Au, and Se data were taken with a scintillation detector using a stilbene phosphor mounted on an RCA 5819

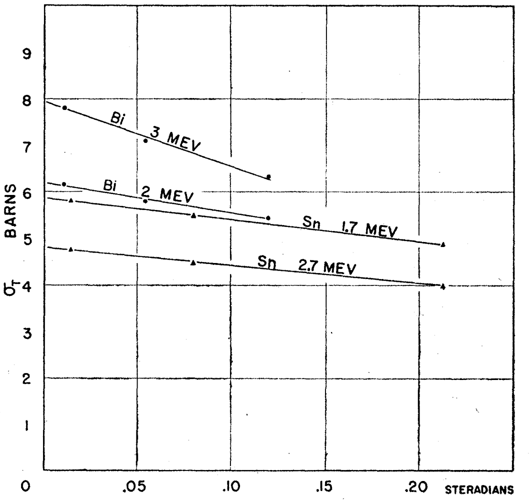

FIG. 1. Variation of the apparent total neutron cross section of Sn and Bi as a function of the solid angle subtended by the sample at the source and at the detector.

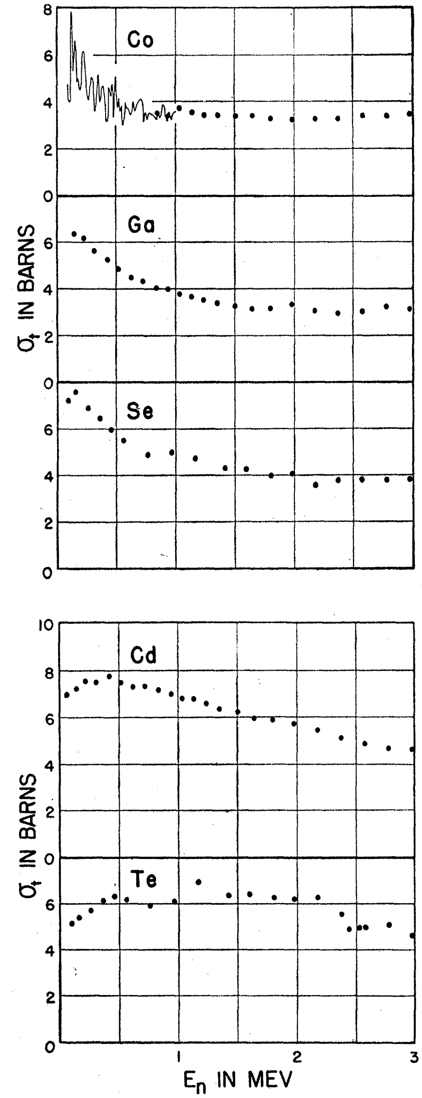

FIG. 2. Total neutron cross sections of Co, Ga, Se, Cd, and Te.

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[1] H. H. Barschall, Phys. Rev. 86, 431 (1952).

[2] Miller, Adair, Bockelman, and Darden, Phys. Rev. 88, 83 (1952).

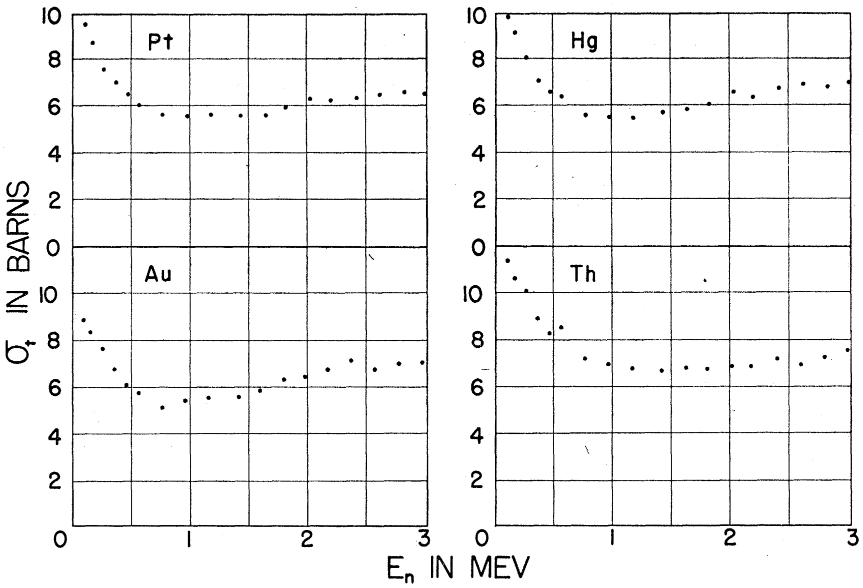

FIG. 3. Total neutron cross sections of Pt, Au, Hg, and Th.

photomultiplier tube. Background, which was measured by shielding the detector from the source by a paraffin cone, was less than 2 percent with the recoil counter and less than 10 percent with the scintillation detector. The recoil counter background was produced by neutrons reflected from the floor and walls of the room while the background of the scintillation counter was due primarily to x-rays from the electrostatic generator. The data for neutron energies below 200 kev were taken at 115° with respect to the incident proton beam. All other measurements were made with neutrons produced at 0° to the incident protons.

Before cross sections could be determined, it was necessary to correct the measured transmissions for the effect of neutrons scattered into the detector by the sample. The correction was made assuming that the neutrons were scattered isotropically. However, angular distributions[3] of scattered neutrons calculated from the continuum model show a strong forward maximum which becomes more pronounced with increasing energy and increasing atomic weight. Therefore, the isotropic correction was expected to be too small, and an experiment was undertaken to determine the magnitude of the resultant error. The experiment consisted of measuring the apparent transmission of samples of Sn and Bi as a function of the solid angle subtended by the sample at the source and detector. The apparent transmission increased with sample size because of the increase in the number of neutrons scattered into the detector. Figure 1 gives the apparent cross sections of Sn and of Bi for three different samples of the same thickness but different diameters. Assuming that the theoretical angular distributions of reference 3 are valid, the calculated apparent cross sections are very nearly a linear function of the solid angle subtended by the sample at the source and detector for the range of sample sizes used. Hence it is reasonable to assume that a straight line extrapolation of the data of Fig. 1 to 0 steradians will give the true cross sections.

As Sn and Bi are typical of medium and heavy elements, the in-scattering error for the elements measured can be estimated from the Sn and Bi data. At 3 Mev for 1-in. samples and a source-to-detector distance of 14 in., the measured cross section would be 4 percent low for the case of Bi and about 2 percent low for Sn. The isotropic correction was about $\frac{1}{2}$ percent so the data shown in Figs. 2 and 3 are probably low as much as 3 percent for the heavy elements at the highest energy.

Figures 2 and 3 give the total cross section of Co, Ga, Se, Cd, Te, Pt, Au, Hg, and Th as a function of neutron energy. No effort was made to resolve individual resonances. The resolution was determined by the target thickness and was about 25 kev for the data taken with tritium targets and 50 kev for the Li target work.

The measured cross sections fit smoothly on the surface giving cross section as a function of atomic weight and neutron energy shown in reference 1.

We wish to thank Dr. J. H. Coon and Dr. C. W. Zabel of the Los Alamos Scientific Laboratory for the loan of most of the samples used in the experiments.

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[3] Final Report of the Fast Neutron Data Project, January 31, 1951, Atomic Energy Commission Report NYO-636 (unpublished).