Thermal-Neutron Fission Cross Section of Pu^{240}†

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A thermal-neutron fission cross section of 4.4±0.5 barns for isotopically pure Pu^{240}, formed by the β^- decay of U^{240}, has been measured in the thermal column of the Materials Testing Reactor.

THE measurement of the fission cross section of Pu^{240} is dependent upon the availability of an isotopically pure sample of this isotope, since fissions from small amounts of Pu^{239} or Pu^{241} would overshadow those occurring in the Pu^{240}. The quantities of Pu^{240} necessary for the measurement can be obtained by chemically separating it from either of two sources: as the alpha-decay daughter of Cm^{244} or through the β^--decay chain of U^{240} and Np^{240}. In the results reported here, it was obtained by the latter method from a sample of uranium that had suffered a short but very intense neutron irradiation. After the irradiation nearly all of the U^{239} formed must be allowed to decay to Np^{239}, then the uranium is purified, and Pu^{240} is grown and eventually separated from the uranium.

Approximately nine hours after the formation of the uranium samples, containing U^{238}, the 6.7-day U^{237} and 14.1-hour U^{240}, the following chemistry was performed: separation of the uranium from plutonium, neptunium, and all fission products by use of anion-exchange resin, ether extractions, precipitation of lanthanum fluoride from uranium VI, and the reduction and coprecipitation of uranium IV with lanthanum fluoride.[1] In the final step of the chemical purifications uranium was left as the chloride complex in a column of anion-exchange resin. At time intervals up to three days the Pu^{240} was removed from the uranium and Np^{237} by reduction and elution of the plutonium from the anion resin with $10M$ hydrochloric acid made $0.5M$ with hydroiodic acid. Further chemical separations of the plutonium resulted in pure samples of Pu^{240}.

The Pu^{240} thus obtained was combined and volatilized *in vacuo* onto a platinum plate and the plate attached to a graphite shuttle which was then seated into an ionization-type fission counter. Measurements of the fission counting rate were made in a thermal-neutron flux of approximately 5×10^{10} neutrons/cm^2 second. The fission counter was the double-chamber type with one chamber, containing an isotopically pure Pu^{239} standard, acting as a flux monitor. In the second chamber alternate counts were taken on the Pu^{240} sample, blank background plates, and Pu^{239} and U^{235} standards. The counting rates of the various samples were measured at different discriminator voltages over the counter plateau. The weights of Pu^{240} and of Pu^{239} deposited on the plates were determined by their alpha-disintegration rates and using a half-life of 6580 years[2] for Pu^{240} and 24 360 years[3] for Pu^{239}. Comparing the ratio between the weights and net fission counting rates of Pu^{240} and Pu^{239} yields a slow-neutron fission cross section of 4.4±0.5 barns for Pu^{240}, using 750 barns for the thermal-neutron fission cross section of Pu^{239}.[4]

A small fraction of the Pu^{240} sample was removed from the platinum counting plate and mass-analyzed to determine if Pu^{239} contamination was responsible for the observed fissions. Since an upper limit of only 0.1% was found for the 239 mass, it is very unlikely that Pu^{239} contributed any of the fissions in the Pu^{240} sample.

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Note added in proof.—The authors have recently received a letter from Dr. B. R. Leonard and co-workers, with their kind permission to publish the pertinent information, reporting measurements of the fission cross section of Pu^{240} at two neutron energies in the thermal region and an investigation of the fission cross section in the energy region around the known 1-ev resonance in the total cross section. Their values, obtained in the thermal region are consistent, within the limits of error, with the 4.4 b reported here; however, from the resonance data they have derived a thermal value of 0.05 b using the Breit-Wigner one-level formula.

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[1] Manfred Lindner, University of California Radiation Laboratory (Livermore) Report UCRL-4377, 1954 (unpublished), p. 42.

[2] Inghram, Hess, Fields, and Pyle, Phys. Rev. **83**, 1250 (1951).

[3] J. C. Wallmann, Ph.D. thesis, University of California (unpublished).

[4] *Neutron Cross Sections*, Atomic Energy Commission Report AECU-2040 (Technical Information Division, Department of Commerce, Washington, D. C., 1952), second edition (1955).