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FAST NEUTRON CROSS SECTIONS

Corrections to LA-1714 and a Correlation of 3 Mev Values

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LA-2122
PHYSICS AND MATHEMATICS

LOS ALAMOS SCIENTIFIC LABORATORY
OF THE UNIVERSITY OF CALIFORNIA LOS ALAMOS NEW MEXICO

REPORT WRITTEN: March 1, 1957

REPORT DISTRIBUTED: June 11, 1957

FAST NEUTRON CROSS SECTIONS

Corrections to LA-1714 and a Correlation of 3 Mev Values

By

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Contract W-7405-ENG. 36 with the U. S. Atomic Energy Commission

Most of the early Los Alamos fission cross-section measurements have been summarized in LA-1714.[1] For the measurements between 2 and 10 Mev neutron energy, a "long counter"[2] was used to measure relative neutron flux. Early measurements[3] on the efficiency of the long counter versus neutron energy showed that resonances in the total neutron cross section of carbon resulted in changes in the long counter efficiency near these resonance energies. The data in LA-1714 were corrected for these sharp resonance effects -- shown by the dotted line in Fig. 1 of this report.

In more recent measurements[4] on the long counter efficiency in which comparisons were made with the (n, p) scattering cross section, additional variations in efficiency were found which varied slowly with neutron energy but were still correlated with the total neutron cross section of carbon. Because of these variations in efficiency (shown in Fig. 1 of this report), there are errors in the fission cross sections reported in LA-1714. These errors are as large as 20% at 7 Mev.

The policy has been to replace the old fission cross-section measurements whenever newer data are obtained with better experimental techniques. However, because of the wide distribution of the material in LA-1714 it seemed advisable to issue this report giving corrections to these data. The corrections shown in this report were made by multiplying the existing fission excitation curves by a long counter correction found from Fig. 1. Since

these data were almost entirely based upon the absolute cross section of U^{235} at 1.25 Mev,[5] the efficiency curve was normalized to unity at this energy, and since the sharp resonance effects had been removed previously, only the solid curve corrections were applied.

The corrections become appreciable only above 2 Mev. When the data points were few, the original data were corrected and are shown in the graphs, where the solid line indicates the best values from LA-1714. In some cases where there are a limited number of data points, they are shown. See, for example, the curves for U^{236} and U^{238}. When many measurements were involved, only a smooth curve of averaged data was corrected. This resulted in some fine structure being deleted (e.g., in Th^{232}, U^{236}, and U^{238}) but the correction is not sufficiently certain to warrant its application to detailed points. LA-1714 can be referred to for possible detailed features. Recent measurements from Harwell[6] have been included on the curves for U^{233}, U^{235}, and Pu^{239}.

Huizenga[7] has described in ANL-5150 a study of fission cross sections as a function of the parameter Z^2/A (using for A the atomic weight of the compound nucleus). A correlation resulted which suggested the possibility of predicting unmeasured cross sections. At the time that LA-1714 was prepared, corrections were applied to the earlier measurements used by Huizenga, which resulted in essentially eliminating the smooth correlation shown in ANL-5150. However, H. H. Barschall[8] has shown that if the fission cross sections for a neutron energy of 3 Mev are plotted against $\frac{Z^{4/3}}{A}$, where A is the atomic weight of the bombarded nucleus, a smooth correlation again appears which may be useful in the prediction of fission cross-section values. In this report the radium data[9] and those for Pu^{240} (Ref. 10) have been included in addition to the corrected values from LA-1714. Table I lists the data used to plot the correlation shown in Fig. 9. The significance, if any,

of the parameter $\frac{Z^{4/3}}{A}$ is not clear.

It is emphasized that the cross-section values shown in this report are not the best which exist. However, in an attempt to bring attention to errors in the published fission cross sections of LA-1714 and to correct these errors, the appropriate correction has been applied and should result in more accurate values from this particular set of measurements. The most recent compilation of cross-section values appears in an article in "Progress in Nuclear Energy."[11] Fission cross sections for U^{233}, U^{235}, U^{238}, and Pu^{239} from this article have been reproduced in LA-2114.

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TABLE I

$\frac{Z^{4/3}}{A}$ AND FISSION CROSS-SECTION VALUES FOR A NEUTRON ENERGY OF 3.0 MEV FOR VARIOUS NUCLEI

Bombarded Nucleus	$\frac{Z^{4/3}}{A}$	σ_f(3 Mev), barns
Ra^{226}	1.7312	0.0003
Th^{232}	1.7376	0.13
Pa^{231}	1.7709	1.28
U^{233}	1.7816	1.84
U^{234}	1.7739	1.52
U^{235}	1.7664	1.21
U^{236}	1.7589	0.82
U^{238}	1.7441	0.54
Np^{237}	1.7768	1.43
Pu^{239}	1.7873	1.9
Pu^{240}	1.7798	1.66
Am^{241}	1.7976	1.9

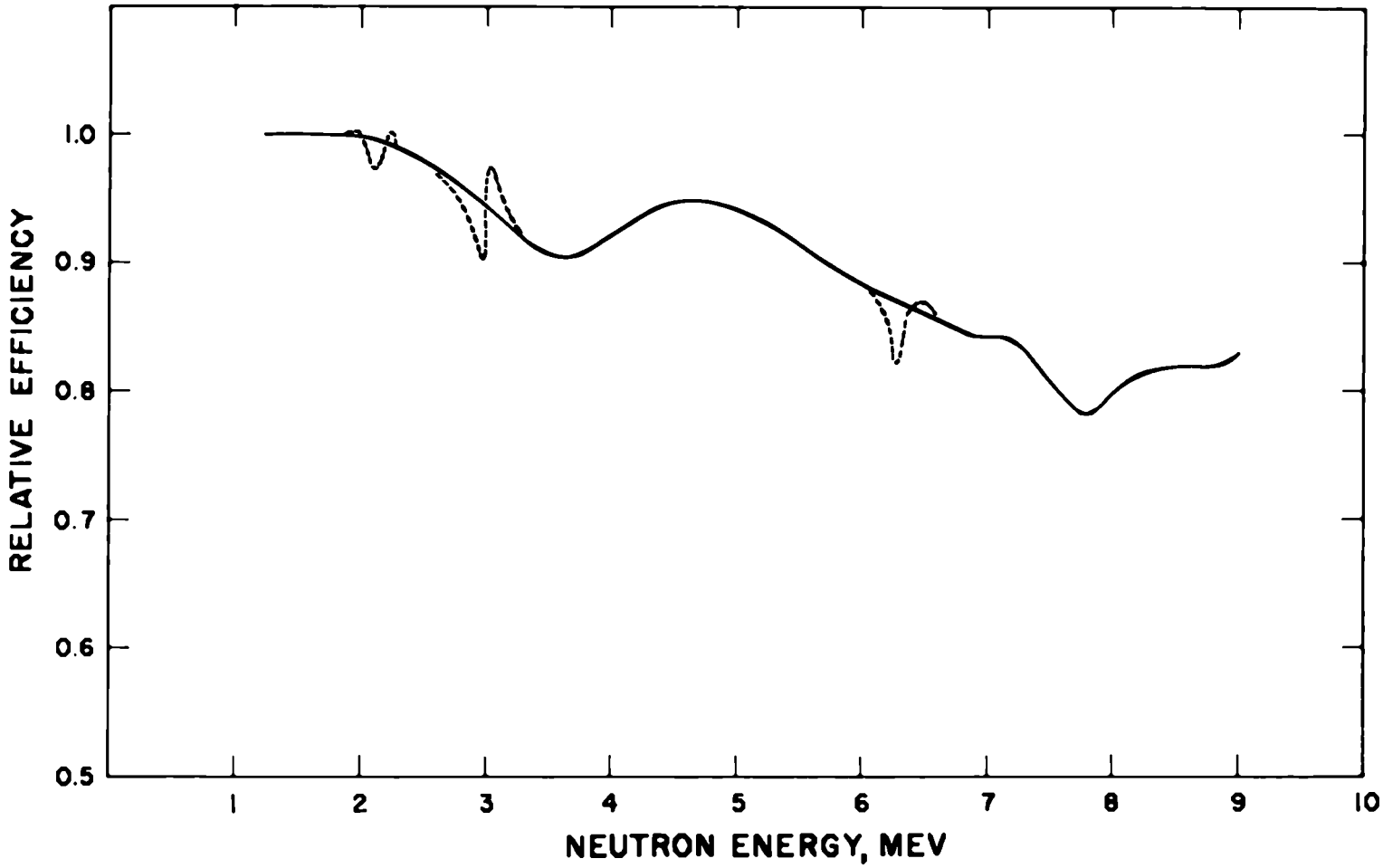

Fig. 1 The relative efficiency of the long counter neutron detector.

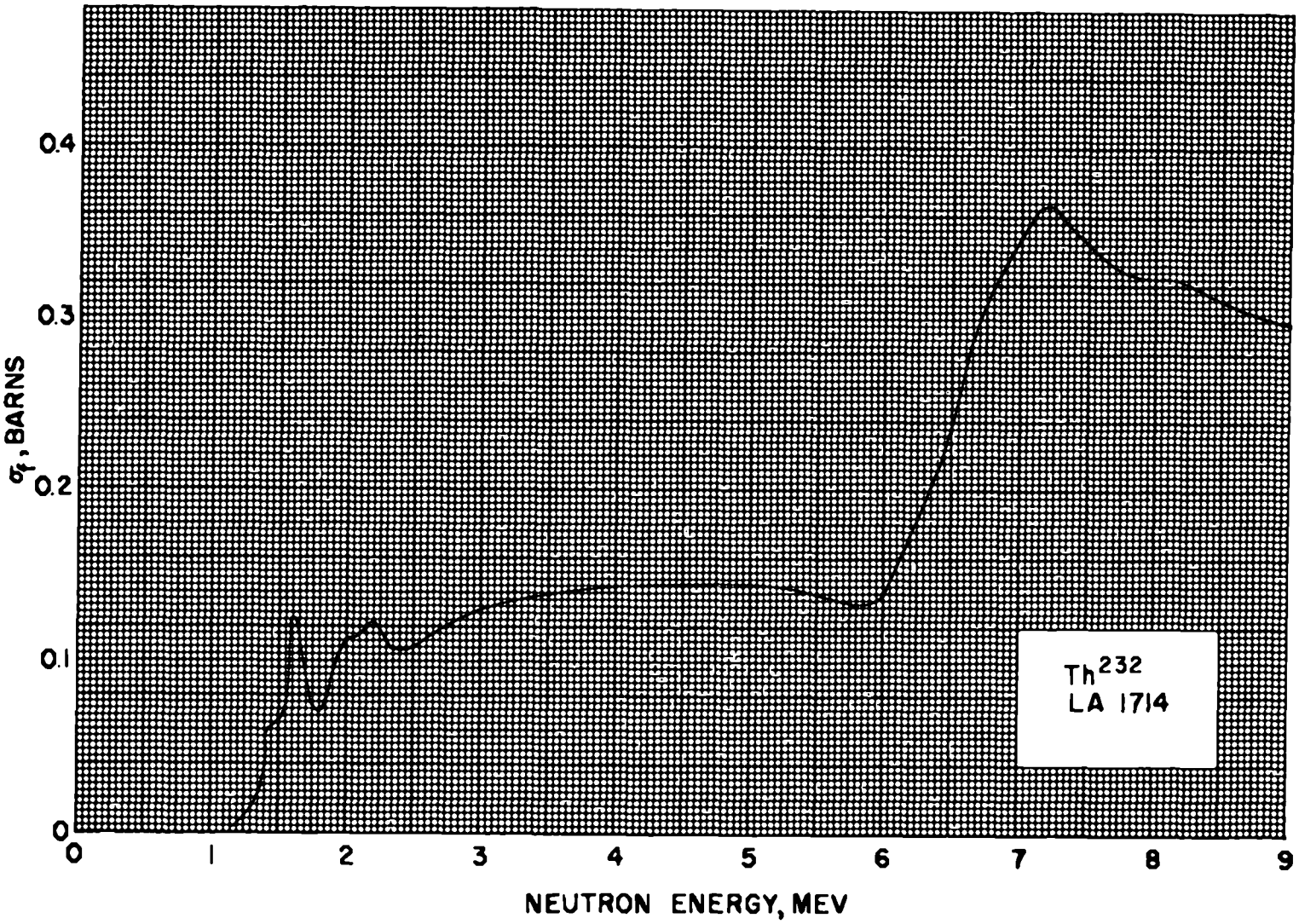

Fig. 2 Fission cross section for Th^{232}.

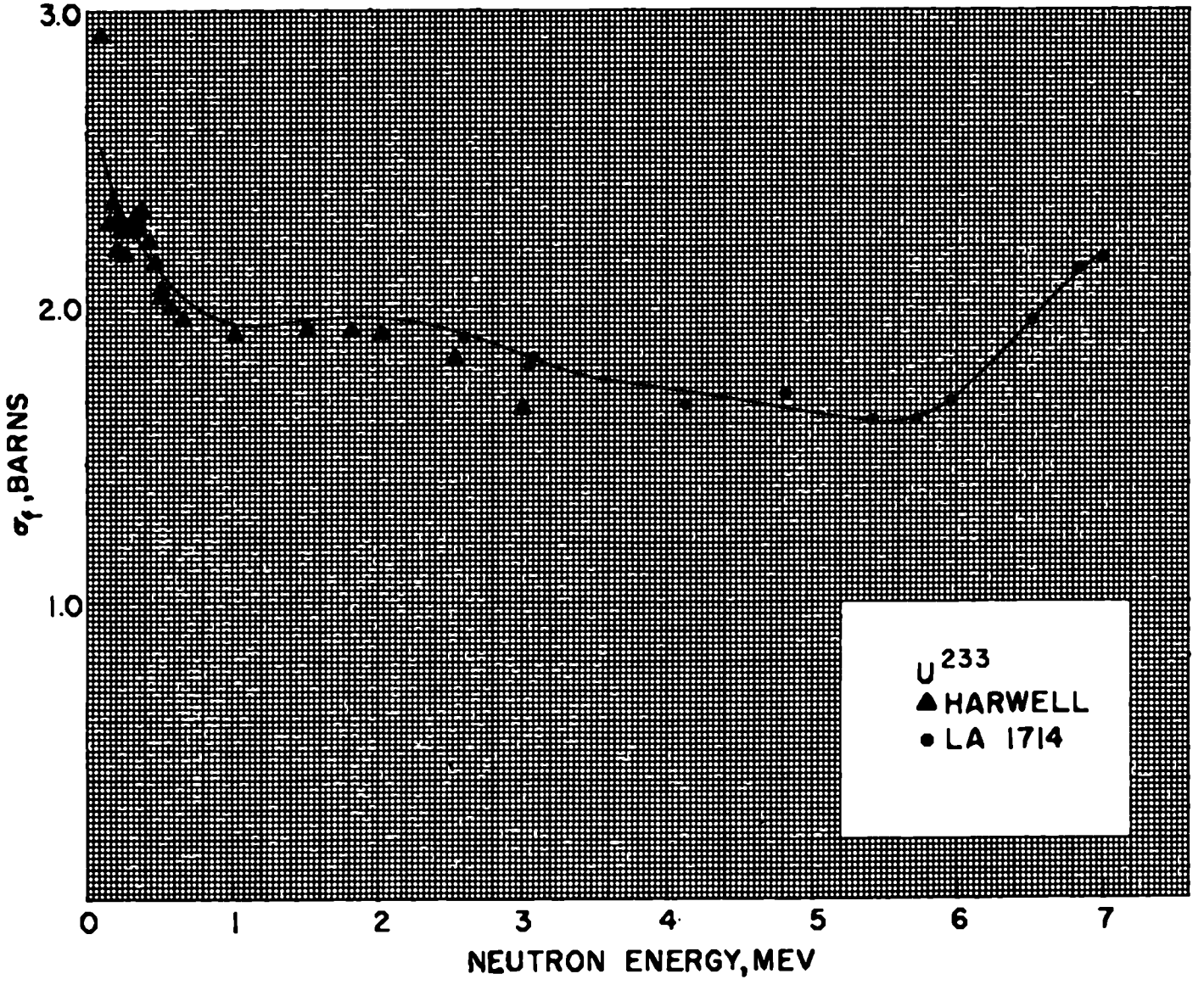

Fig. 3 Fission cross section for U^{233}.

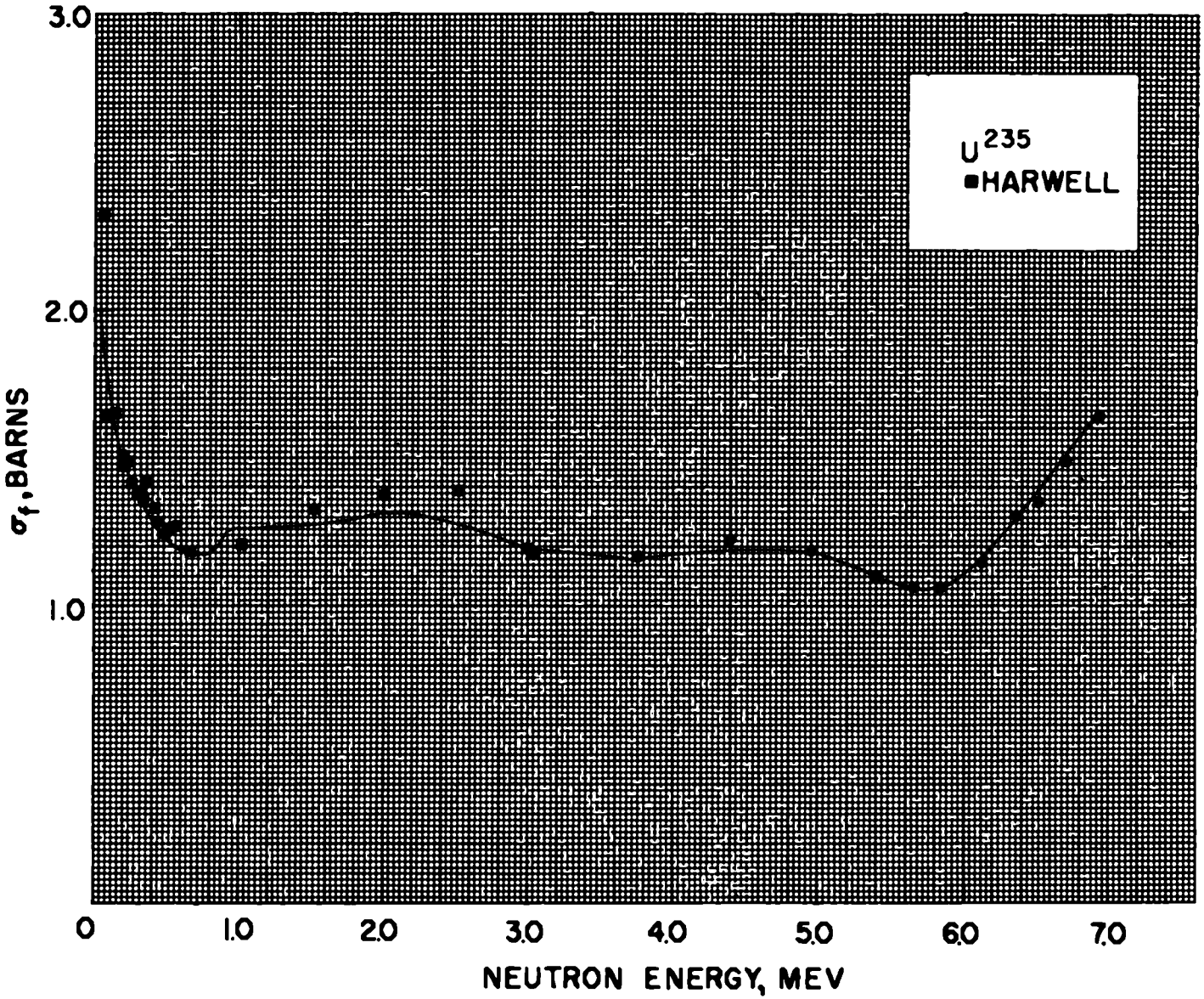

Fig. 4 Fission cross section for U^{235}.

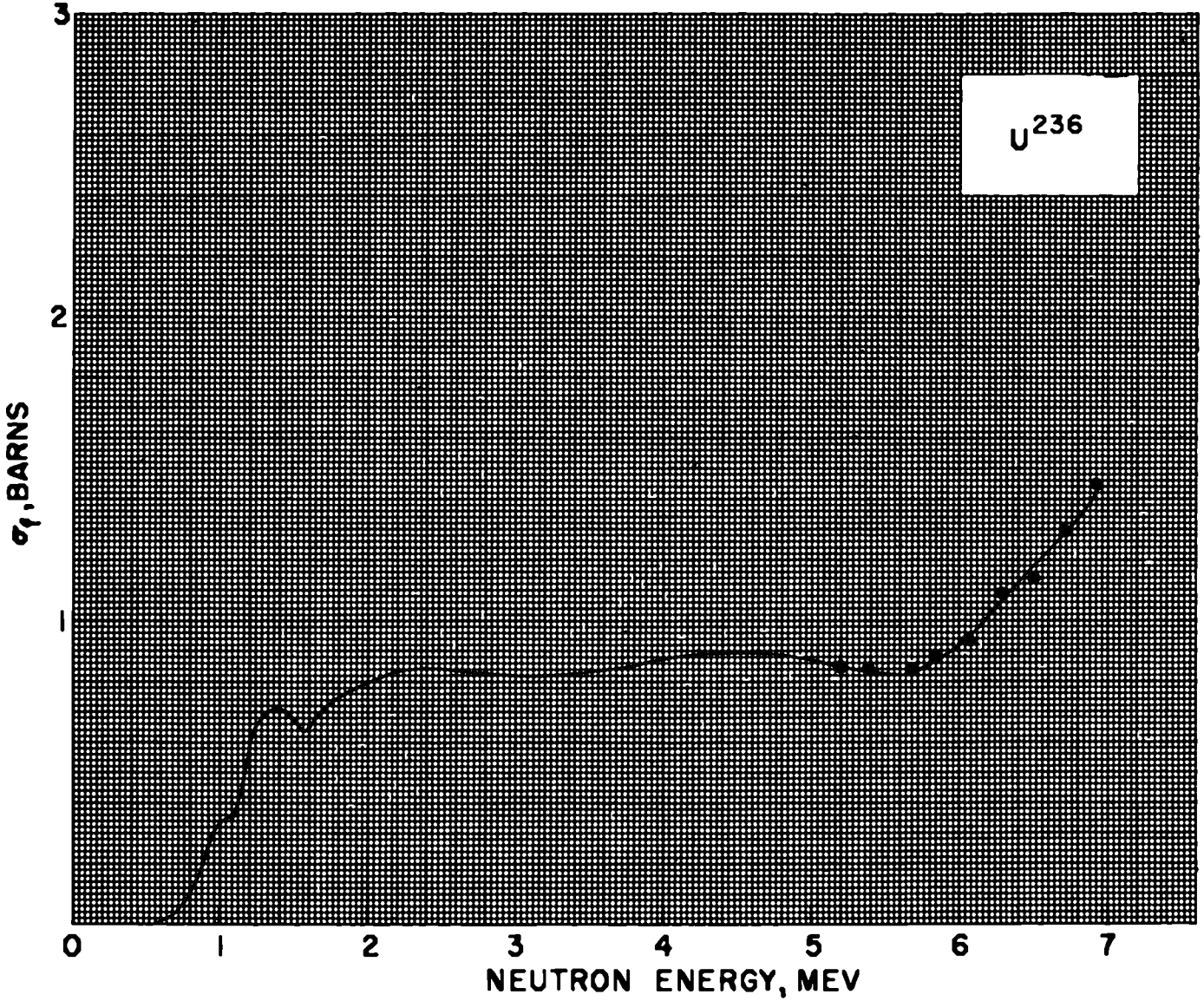

Fig. 5 Fission cross section for U^{236}.

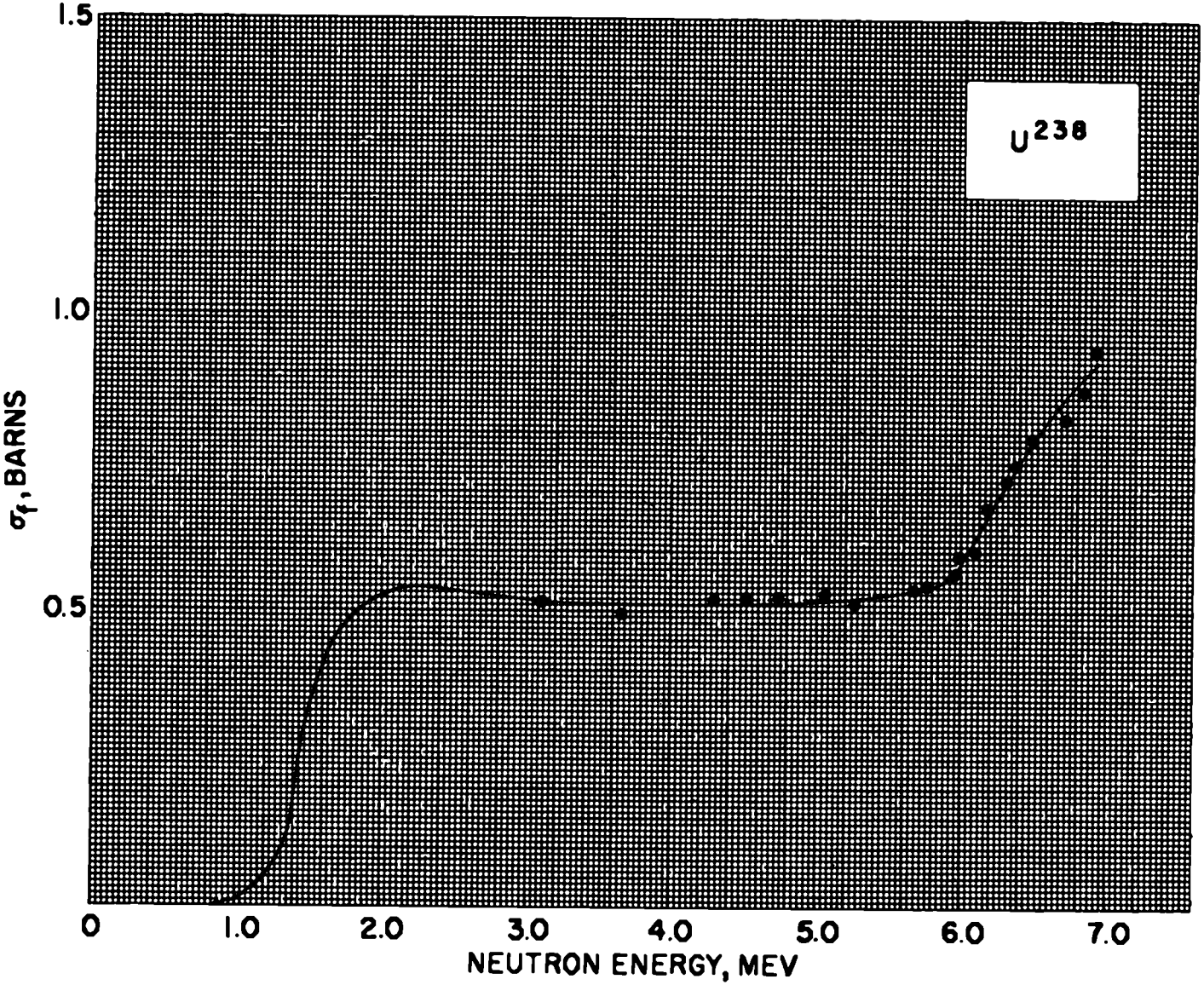

Fig. 6 Fission cross section for U^{238}.

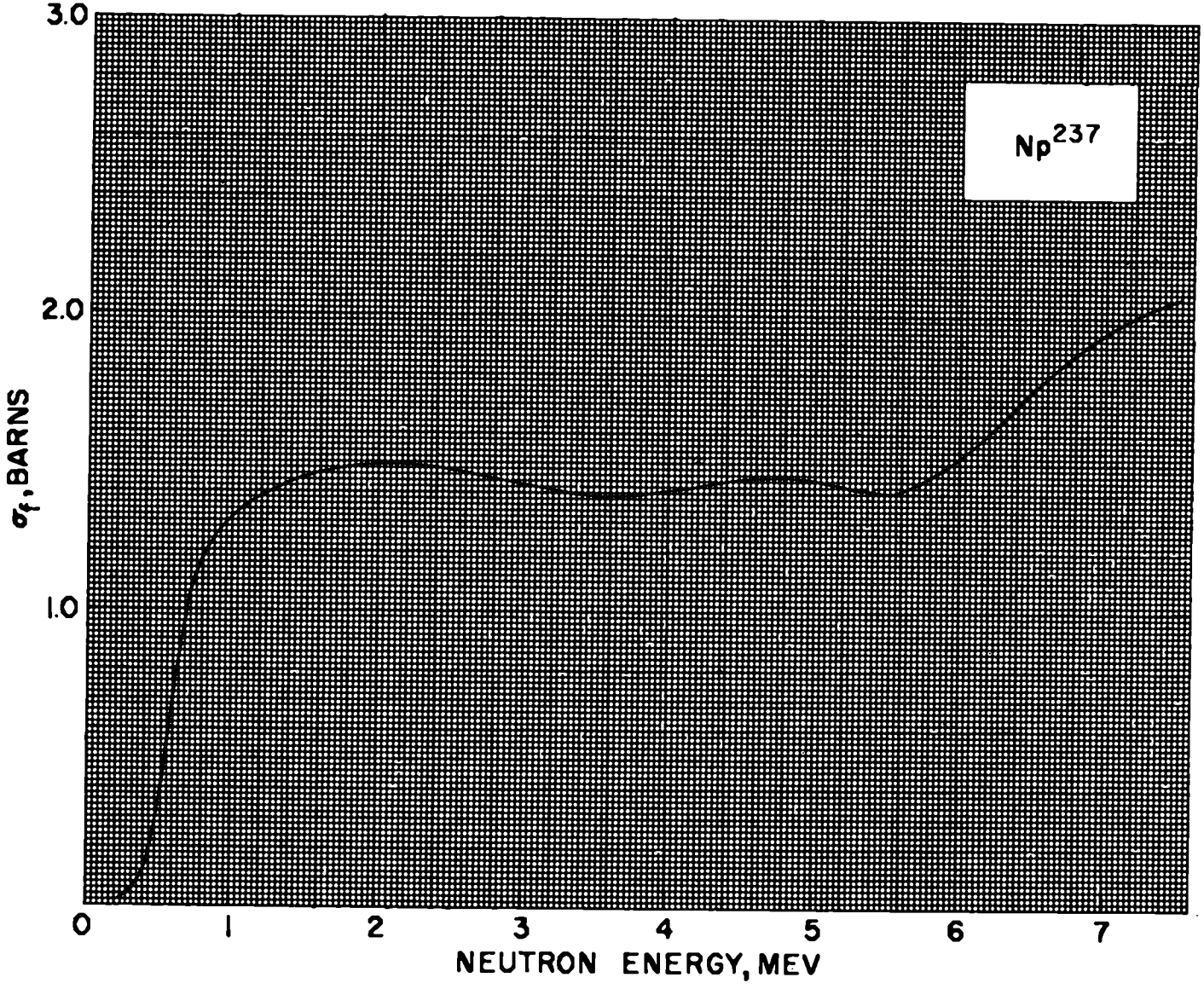

Fig. 7 Fission cross section for Np^{237}.

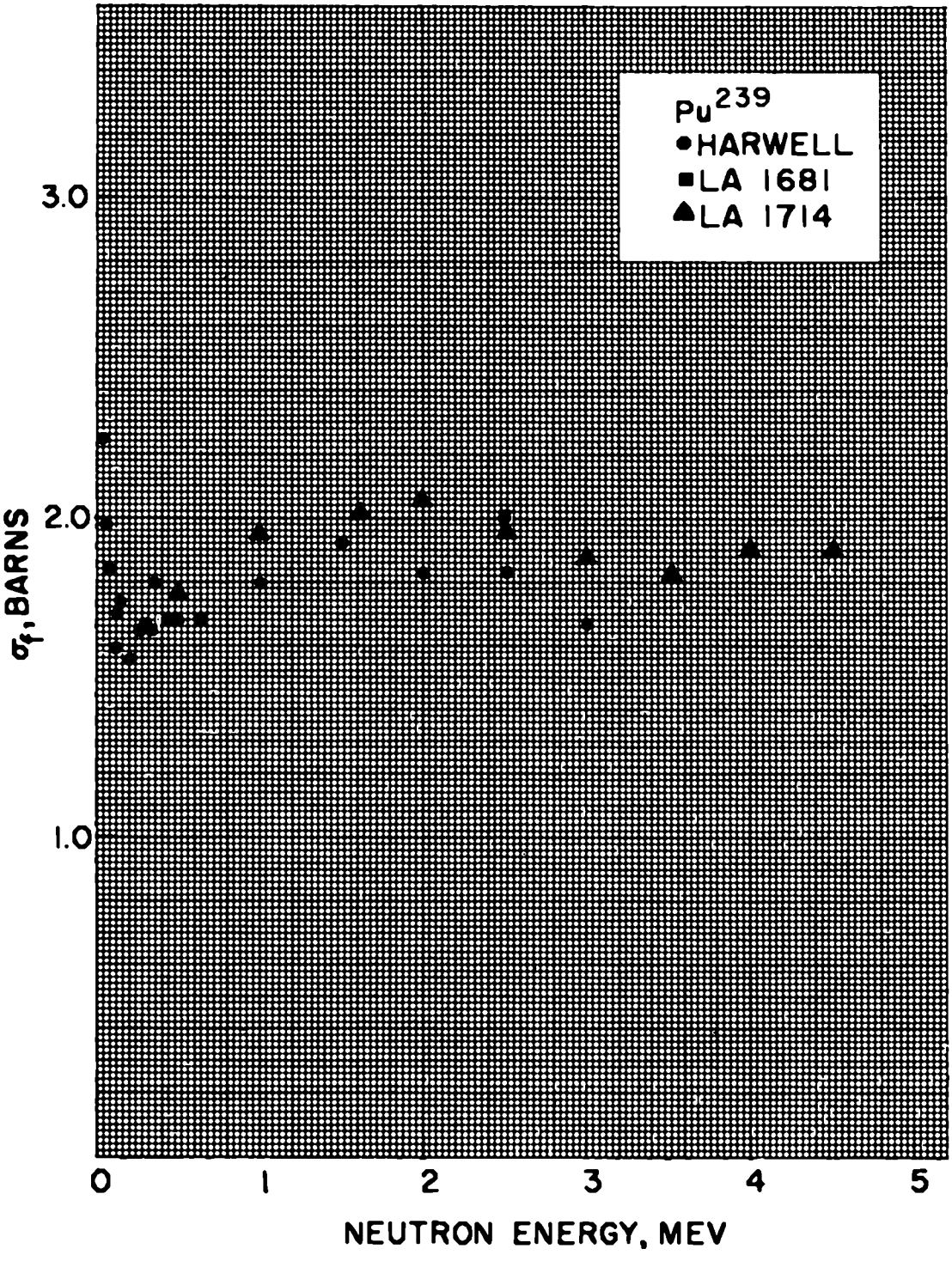

Fig. 8 Fission cross section for Pu^{239}.

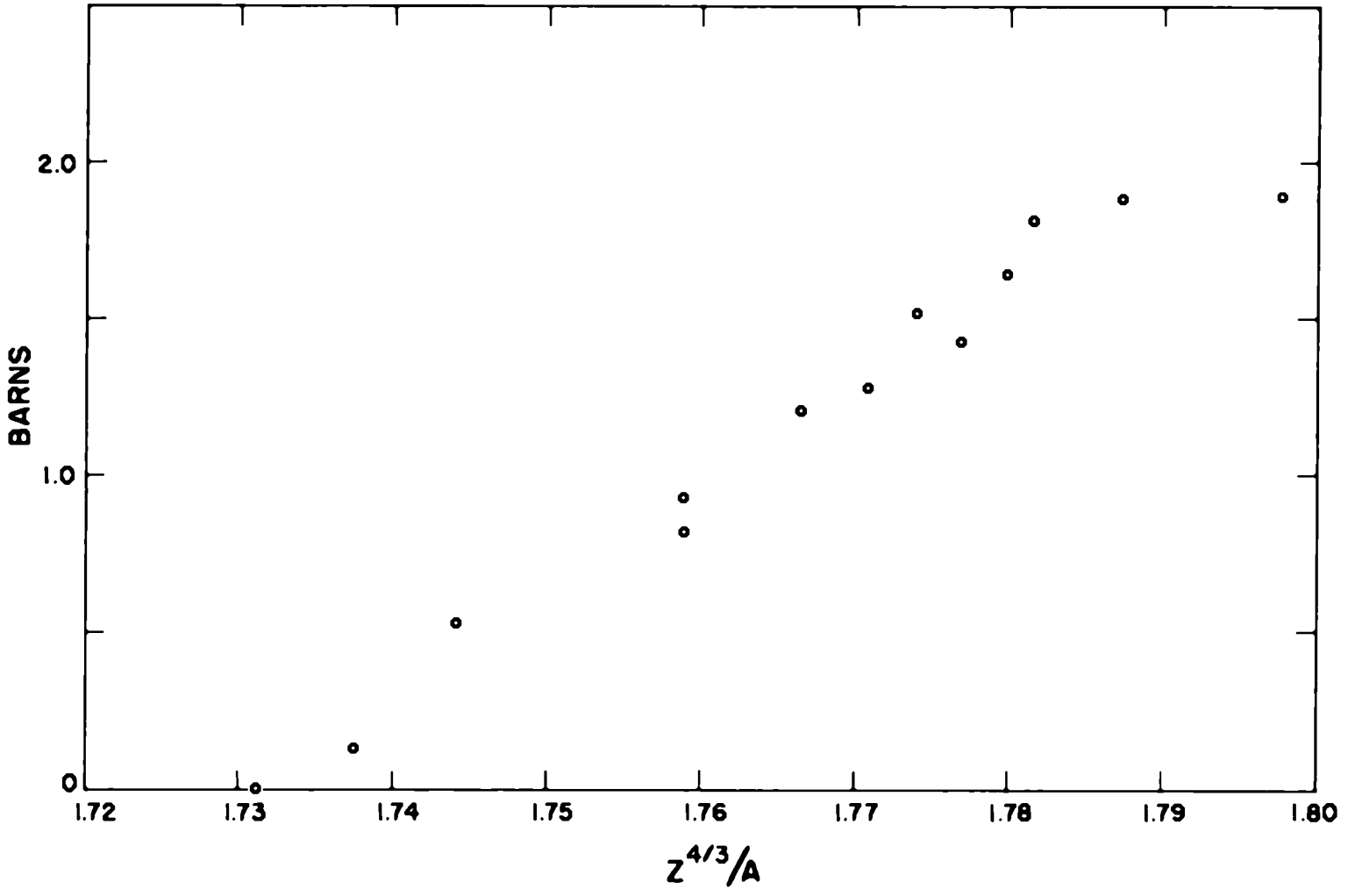

Fig. 9 Fission cross sections at 3 Mev neutron energy plotted against $Z^{4/3}/A$.