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"Fission Cross Section Measurements of Cm-247, Cf-250 and Es-254 from 0.1 eV to 80 keV"*

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Fission cross section measurements were made with the RINS system [1] over the neutron energy range from approximately 0.1 eV to 80 keV upon samples of Cm-247, Cf-250 and Es-254. The Cm-247 measurement was undertaken to complete the RINS fission cross section measurement sequence of the curium isotopes [2-3], Es-254 was measured because it is a very heavy odd-odd nucleus which might show interesting nuclear structure effects in its fission cross section, and Cf-250 was measured to account for its buildup as a daughter product from the 276-day halflife Es-254.

These measurements utilized 3.2±0.2, 0.15±0.01 and 0.21±0.01 microgram samples, respectively, of Cm-247, Cf-250 and Es-254 which were electroplated onto hemispherical fission chamber electrodes [4]. The Es-254 sample was chemically separated (primarily to remove its daughter product Cf-250) and RINS measurements commenced approximately 48 hours after separation to minimize Cf-250 buildup. These measurements were made simultaneously in the same fission chamber with a reference sample of U-235, and the fission cross sections were normalized to the ENDF/B-V U-235 cross section in the 0.1-to-10 keV energy region. These are the first reported fission measurements in this energy region for Cf-250 and Es-254 and below 20 eV for Cm-247. The measured fission cross sections are shown in Figures 1, 2 and 3, respectively, for Cm-247, Cf-250 and Es-254. The Cm-247 in our sample was 29% abundant with the other major constituents being Cm-244 and Cm-246. The data in Figure 1 have not been corrected yet for the effect of the other curium isotopes; the major impurities, the even-even species, will provide only minor interferences to the Cm-247 signal. Only 1-sigma counting statistical errors are shown in these figures; an overall systematic error of less than 10% is estimated for all three cross sections.

The smooth curve in Fig. 1 is the RINS resolution-broadened cross section for the Cm-247 measurement of Moore & Keyworth [5]. The RINS measurement is in excellent agreement with their data over the strong resonance group near 70 eV but is about 30% larger at higher energies; the source of this disagreement is not known but is characteristic of other comparisons of RINS measurements with the

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higher energy average data from the Moore & Keyworth experiments [2-3]. Five low-energy resonanaces are observed at approximately 1.2, 3.2, 4.5, 9 and 19 eV; all but the 4.5-eV resonance have been reported by Belanova et al. from total cross section measurements [6].

The Cf-250 cross section exhibits a strong resonance at 0.6 eV with a peak cross section of about 200 barns. There also appears to be broad structure near 50 eV with a peak of the order of 3 barns. Assuming a 1/v dependence and extrapolating the cross section from the 2-to-10 eV region, a thermal cross section of about 95 barns is obtained.

The cross section for Es-254 is very different from that obtained from all other nuclei measured by RINS. The cross section shows no resonance structure below 4 eV and only small structure near 6, 18, 60 and 400 eV. This is very surprising because a heavy odd-odd nucleus like Es-254 would be expected to have very strong resonances with a level spacing somewhat less that that of U-235. The lack of structure may be the result of the fission widths exceeding the level spacing, thus producing a continuum with a few weak clusters of strength. An extrapolation of the RINS data to thermal energy is in good agreement with the measured value (shown as the open square).

These measurements demonstrate the power of the RINS method for measuring the fission cross of very small samples of highly active nuclei.

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Figure Captions

Figure 1. Fission cross section of Cm-247 over the neutron energy range from approximately 0.1 eV to 80 keV. No corrections have been applied for the effect of the other isotopes in the Cm-247 sample.

Figure 2. Fission cross section (times the square root of energy) of Cf-250 over the neutron energy range from approximately 0.1 to 80 keV.

Figure 3. Fission cross section of Es-254 over the neutron energy range from approximately 0.1 to 80 keV.

Cm247 Fission Cross Section

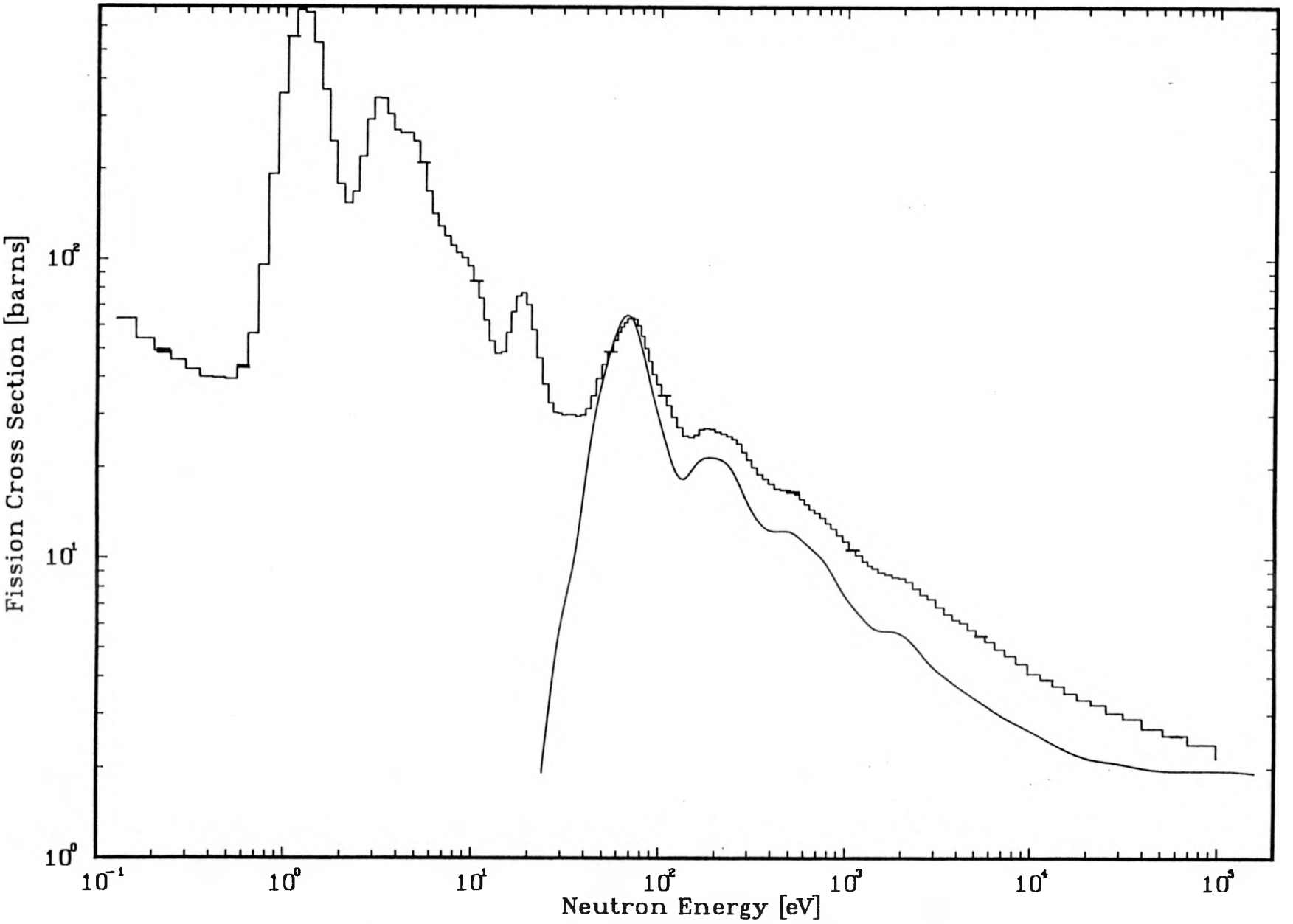

FIGURE 1.

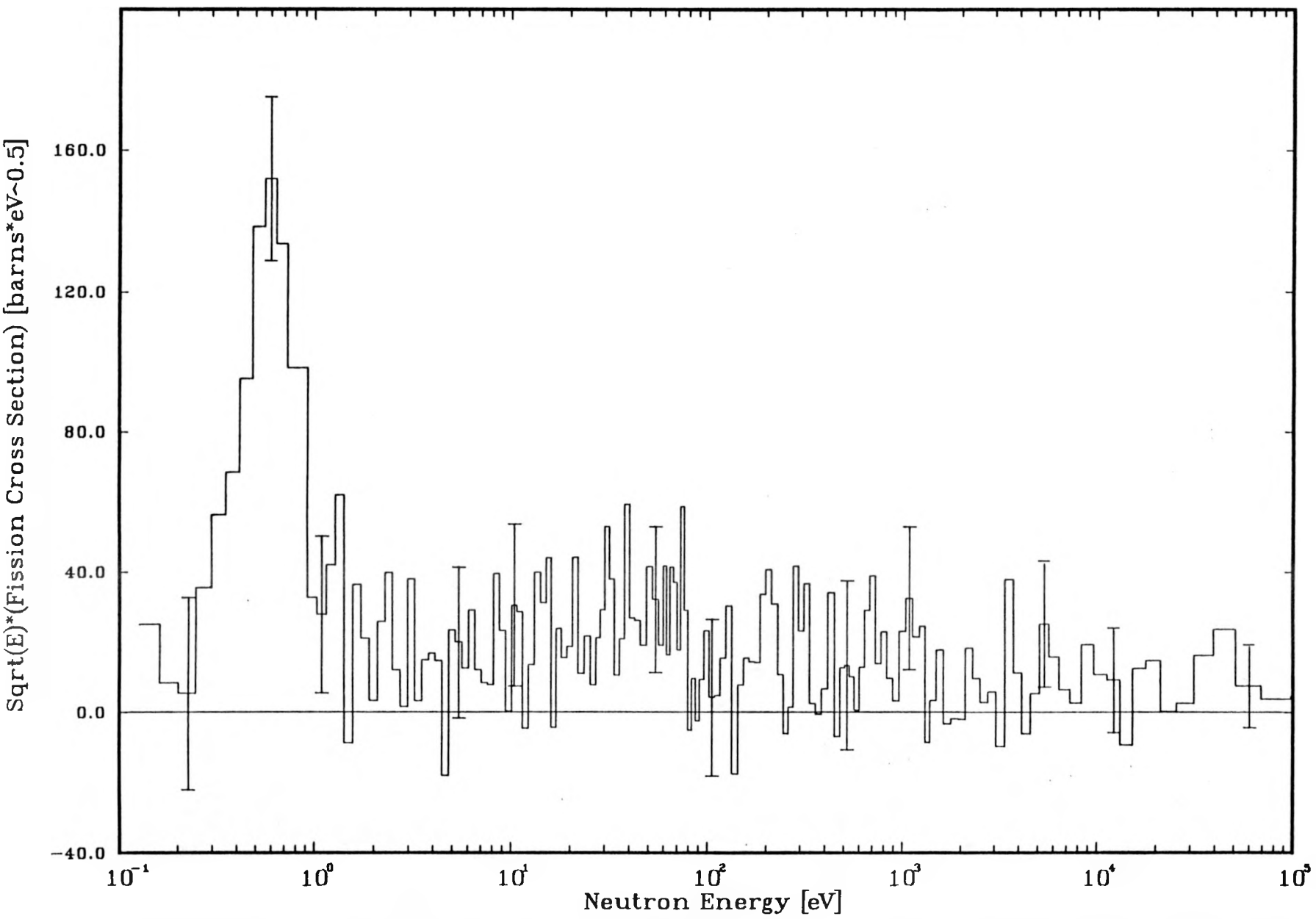
Cf250 Fission Cross Section
Sqrt(E)*(Fission Cross Section) [barns*eV^0.5]
160.0
120.0
80.0
40.0
0.0
-40.0
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
Neutron Energy [eV]

FIGURE 2.

Es254 Fission Cross Section

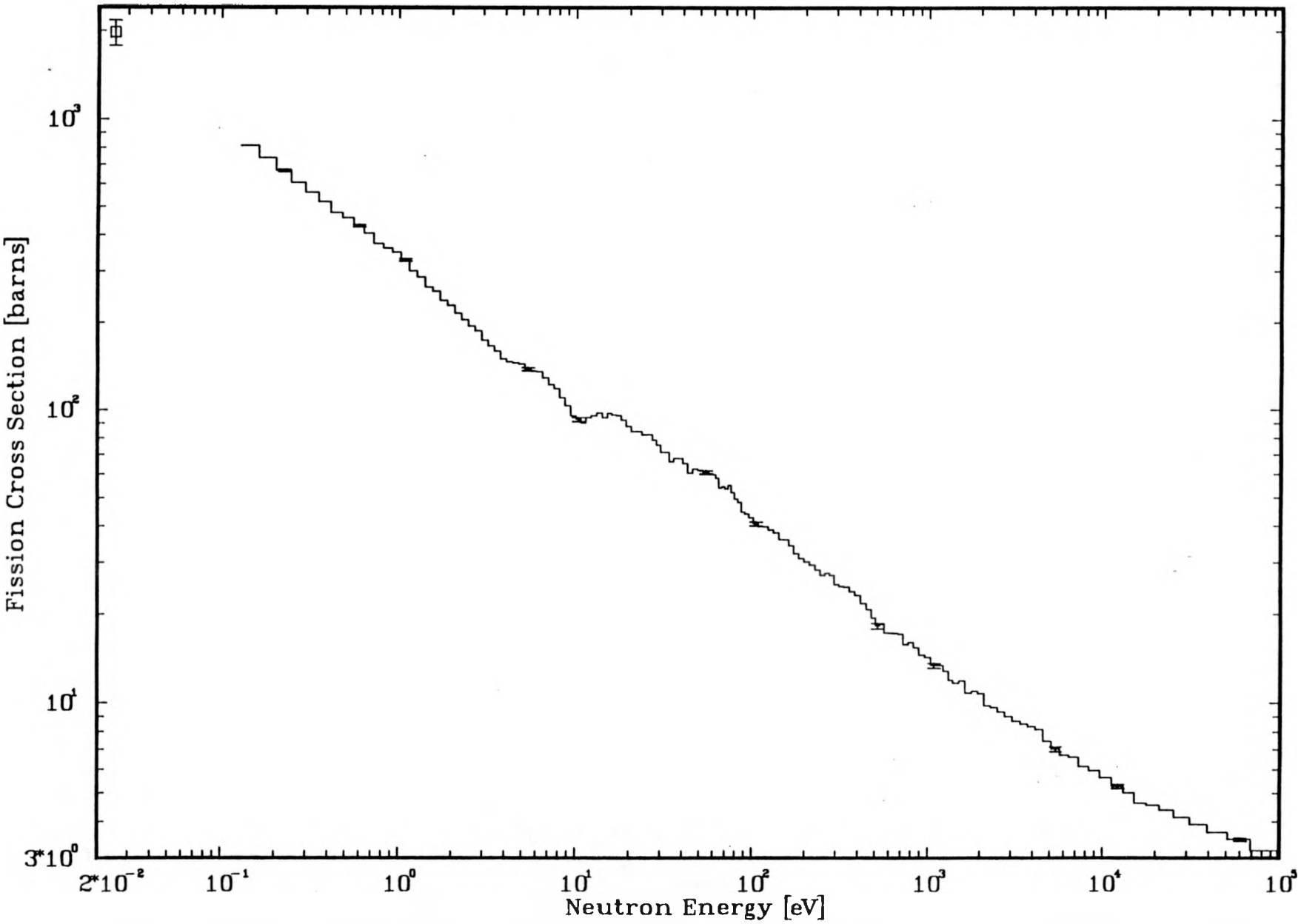

FIGURE 3.