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The purpose of this note is to combine existing information on the $^{237}U(n,f)$ cross section to determine if some consistency can be obtained for the neutron induced fission excitation of ^{237}U.

The neutron induced fission cross section of the 6.8 day ^{237}U was measured directly by McNally et al.[1] in 1968 using the Pommard nuclear device test. At the same time critical assembly measurements were done at Los Alamos using the Flattop assembly[2]. A previous measurement was also made at LASL in 1954 with two different neutron sources, each peaked near 200 keV. The results were 0.66 ± 0.10 b and 0.70 ± 0.07 b[3] for the (n,f) cross section. More recently Younes and Britt[4] have reanalyzed direct reaction charged particle data of Cramer and Britt[5] that had determined the fission probability of the ^{238}U compound nucleus as a function of nuclear excitation energy. They have combined fission probabilities with calculated neutron absorption cross sections, including corrections for the differences in angular momentum between the direct and neutron induced reactions. From this analysis they have extracted equivalent $^{237}U(n,f)$ cross sections. The technique for extracting surrogate (n,f) cross sections from (t,pf) data has been demonstrated in a recent publication for the test case $^{235}U(n,f)$[6]. In addition to this experimental information, Lynn and Hayes[7] have recently done a new theoretical study of the fission cross sections for a series of isotopes in this region. A summary plot of the data is shown in Fig. 1. Below 0.5 MeV the McNally, Cowan, and Younes-Britt results are in reasonable agreement. The average cross section in the Younes-Britt results, for En = 0.1 to 0.4 MeV, is 0.80 times the McNally values which is well within the errors of the McNally experiment. Above 0.5 MeV the McNally results diverge toward higher values. It should be noted that this divergence begins approximately at the ^{237}Np threshold and that ^{237}Np is the daughter of the 6.8 day ^{237}U decay.

The Flattop critical assembly measurements were performed on a fraction of the same target material that was used in the Pommard test. Steady state irradiations were done at two irradiation positions; in the reactor core and in a tamper region located some 14.67 cm from the core. The relative flux curves for these two irradiation positions are shown in Fig 2. In these critical assembly measurements no attempt was made to determine the absolute cross section directly. Instead all results were reported as a ratio to a ^{235}U standard sample that was measured simultaneously. The measurements for both critical assembly irradiation positions were done over a 30-day period to permit in-growth of ^{237}Np from the beta decay of ^{237}U. From the t = 0 intercept of this curve the ratio of the ^{237}U/^{235}U cross sections could be obtained (integrated over the critical assembly neutron spectrum). The results were:

	$\sigma^{237}U(n,f)/\sigma^{235}U(n,f)$
Flattop - Tamped	0.391 +/- 0.012
Flattop - Core	0.537 +/- 0.029

The Pommard experiment was a heroic effort involving multi-Curie samples of a radioactive target that had been produced in a high flux nuclear reactor, chemically purified and isotopically separated. The nuclear device test was, obviously, a “one shot” measurement. Various flux monitors were used to insure accurate analysis of the data. The major backgrounds were from an exponentially decaying electromagnetic pulse and from the in-growth of the fissile ^{237}Np daughter. The authors attempted to correct for these backgrounds.

McNally et al note that their data are in reasonable agreement with the previous measurements at 200 keV.[3] They then compared to the critical assembly data[2] by averaging their cross section for ^{237}U over the tamped Flattop spectrum and doing the same with the known ^{235}U(n,f) cross section. The value obtained for the ratio was:

$$\sigma^{237}U(n,f)/\sigma^{235}U(n,f) = 0.62$$

Thus, there is an apparent discrepancy between this value (0.62) from the Pommard data and the value of 0.391 from the critical assembly measurement.

In their analysis Lynn and Hayes have renormalized the Pommard data over the entire energy range to be consistent with the tamped critical assembly information. By doing this they were able to show fair agreement between their model calculations of the ^{237}U(n,f) cross section and the renormalized experimental data.

However, the surrogate data of Younes and Britt has a much flatter shape than does the reported Pommard data. In particular the Pommard data shows a rise in cross section in the region above the ^{237}Np fission cross section threshold at $E_n \approx 400$ keV. This rise may be physical, but it is also possible that it is due to an improper subtraction of the ingrowth of the ^{237}Np daughter contaminant. To test the plausibility of this idea, the McNally and Younes-Britt data sets were normalized together in the region from 0.1 to 0.4 MeV, below the ^{237}Np threshold, by multiplying the McNally set by a factor 0.8. Then a postulated contaminant contribution was added. Fig. 3 shows the result of reducing the Pommard data by the factor 0.8 and adding an additional 25% contribution from the ^{237}Np(n,f) reaction. From these results it can be seen that a contamination correction larger than originally made by McNally et al can account for the differences in the shape of the cross sections at higher energies.

To test whether this hypothesis can also account for the apparent discrepancy with the critical assembly data, we have folded the tamped Flattop spectrum with: the ENDF ^{235}U(n,f) cross section, the Pommard experimental data, the Younes-Britt surrogate data and the Lynn-Hayes calculated cross section. These results were normalized to the ^{235}U(n,f) cross section and are:

σ^{237}U(n,f)/σ^{235}U(n,f)	Pommard	Younes-Britt	Lynn-Hayes
New folded value	0.61	0.430	0.255
"Literature" value	0.62	0.391	0.391

With this procedure we were able to reproduce the Pommard literature value. The results also imply that the surrogate reaction cross section is in good agreement (<10%) with the critical assembly measurement while the Pommard data and the Lynn-Hayes value (which has a shape similar to the reported Pommard data) are in substantially poorer agreement with the critical assembly data.

In test cases, the surrogate approach has been shown to give good experimental agreement, with accurately measured direct neutron cross sections for ^{235}U(n,f).[5] In the currently reported results nothing has been adjusted or optimized for the ^{237}U(n,f) case. We believe that the surrogate reaction is a better representation of the true ^{237}U(n,f) cross-section than the direct measurement that was performed under very difficult experimental conditions. Other surrogate reaction results from (t,pf) data in a series of Th, U and Pu isotopes will be contained in a paper currently being prepared.

Acknowledgments

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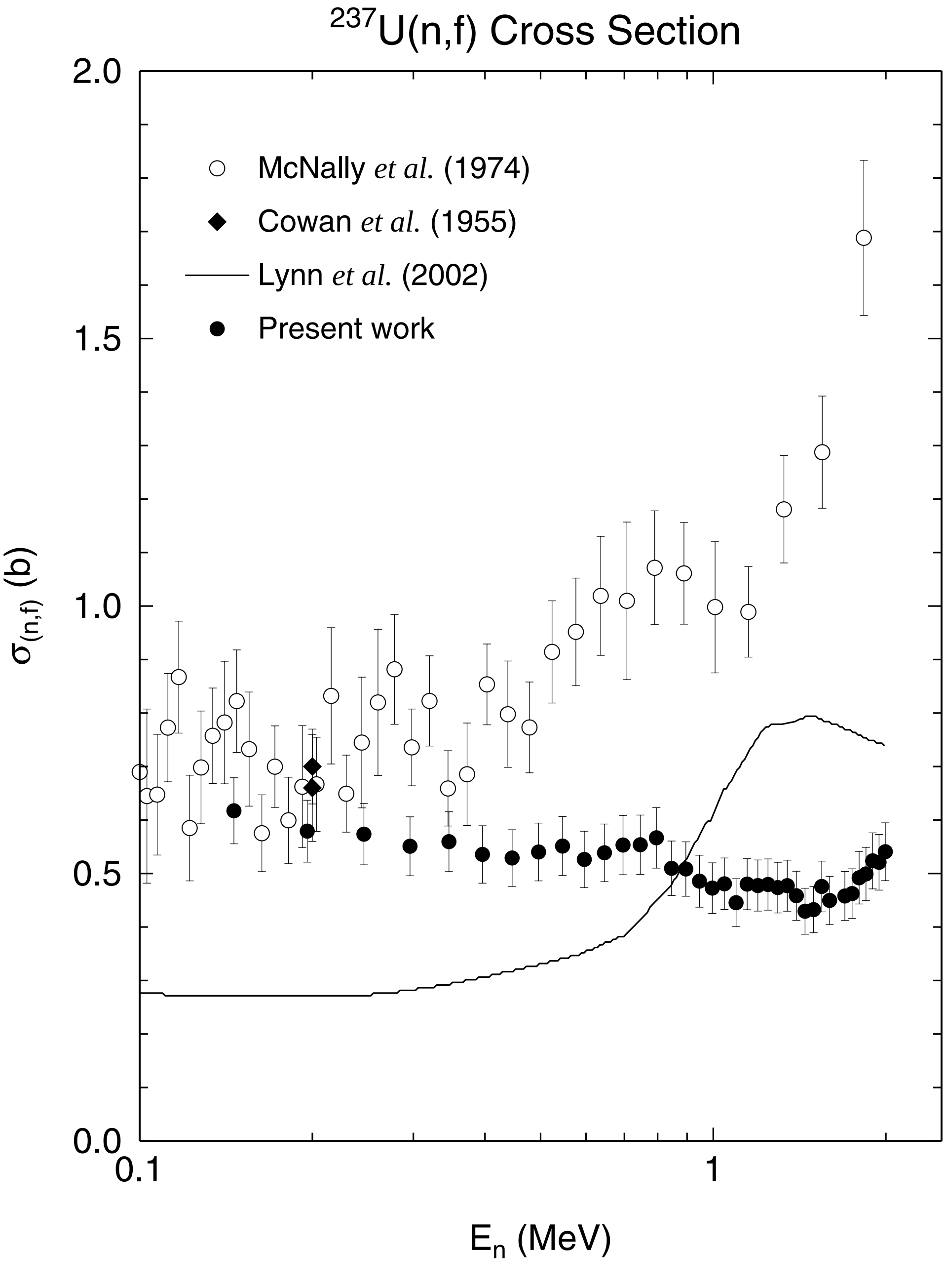

Fig. 1 Reported values for the ^{237}U(n,f) cross sections.

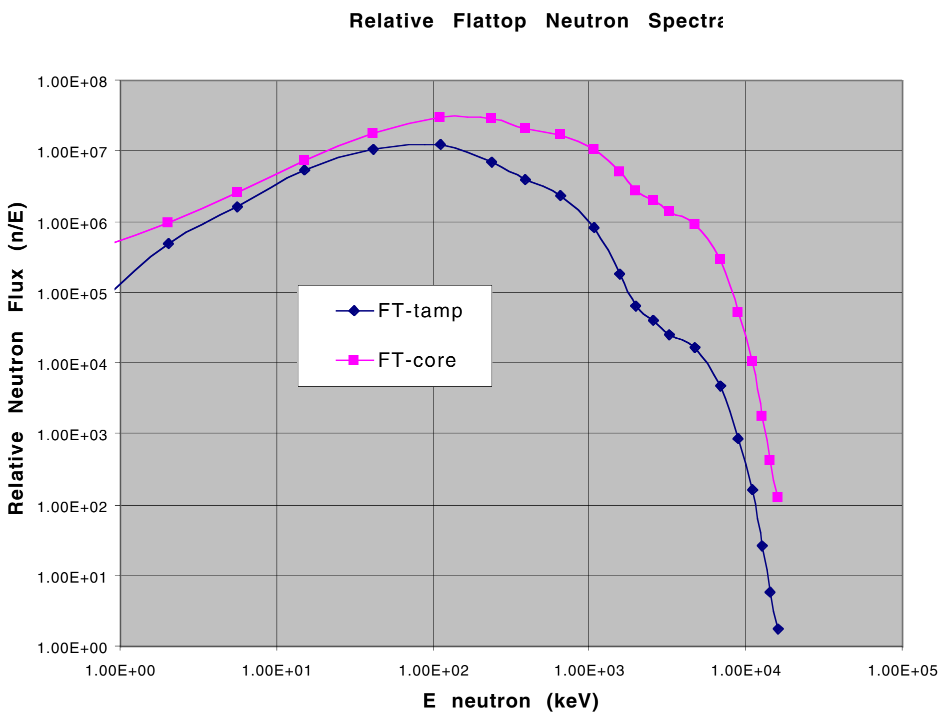

Fig 2 Relative Flattop neutron spectra.

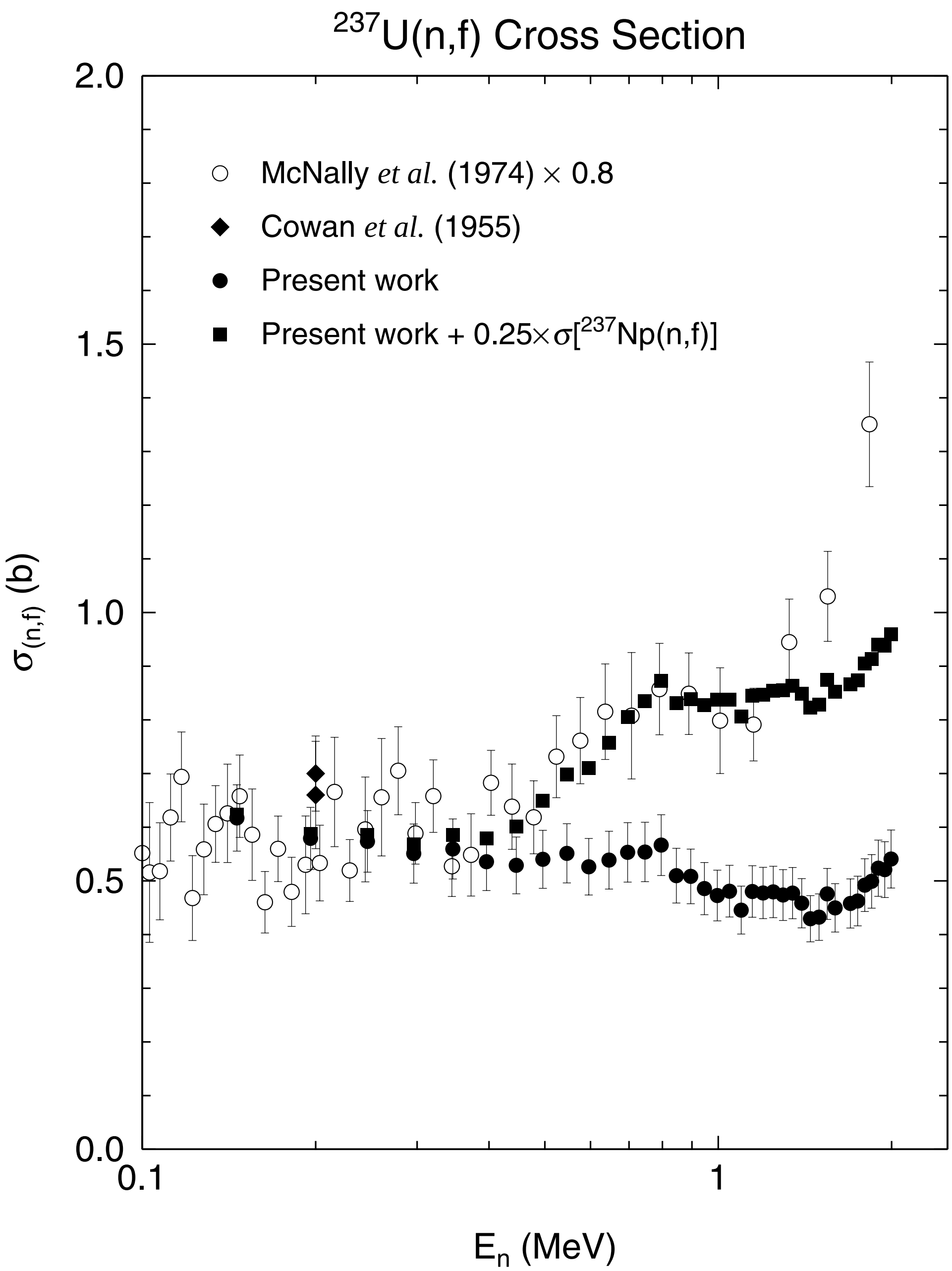

Fig. 3 Comparison of data sets with renormalization and postulated ^{237}Np contaminant added.