LA-UR -85-1659

RECEIVED BY OSTI JUN 07 1985

CONF-850507--25

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LA-UR--85-1659

DE85 012703

SUBMITTED TO: The International Conference on Nuclear Data for Basic and Applied Science, Santa Fe, N.M., May 13-17, 1985

Los Alamos

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FORM NO 836 R4
ST NO 2629 5/81

COMPARISONS OF FOUR REPRESENTATIONS OF THE PROMPT NEUTRON SPECTRUM FOR THE SPONTANEOUS FISSION OF ^{252}Cf

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Abstract We compare four representations of the prompt neutron spectrum for the spontaneous fission of ^{252}Cf with recent differential and integral measurements.

INTRODUCTION

Because of its importance as a neutron standard, we present comparisons of measurements and calculations of the prompt fission neutron spectrum N(E) for the spontaneous fission of ^{252}Cf. In particular, we test four representations of N(E) against recent experimental measurements of the differential spectrum and threshold integral cross sections. These representations are the Maxwellian spectrum, two versions of the Watt spectrum, the NBS spectrum,[1] and the Los Alamos spectrum of Madland and Nix.[2] For the Maxwellian spectrum, we obtain the value of the Maxwellian temperature T_M by least-squares adjustments to the experimental differential spectrum of Poenitz and Tamura[3] and also that of Boldeman et al.[4] Similarly, for the Watt spectrum we perform least-squres adjustments to obtain the Watt temperature T_W with the other parameter of the Watt spectrum, the average kinetic energy per nucleon E_f, determined from experiment. For the Los Alamos spectrum, least-squares adjustments determine the nuclear level-density parameter a, which is the single unknown parameter that appears. The NBS spectrum has been previously constructed by adjustments to eight earlier differential spectrum measurements. With these representations of the spectrum so determined, we calculate 15 threshold integral cross sections for each representation, using ENDF/B-V cross sections generally, and compare the calculated values with the measured values of Grundl et al.[5] and Kobayashi et al.[6]

DIFFERENTIAL AND INTEGRAL COMPARISONS

We consider first the differential spectrum of Poenitz and Tamura. Our least-squares adjustments with respect to this experiment give the following adjusted parameter values and minimum values of χ^2 per degree of freedom: Maxwellian (T_M = 1.429 MeV, χ^2 = 1.20), Watt (T_W = 0.897 MeV, χ^2 = 2.33), Modified Watt (T_W = 0.897 MeV, χ^2 = 1.57), and Los Alamos (a = A/9.15 MeV^{-1}, χ^2 = 0.55). Here the Modified Watt spectrum is the average of two

Watt spectra representing separately neutron emission from equitemperature fragments of the light and heavy fragment mass peaks. The values of E_f^L and E_f^H are again determined from experiment. The NBS spectrum yields a value of χ^2 = 1.92. The ratios of these spectra and the experimental spectrum to the Maxwellian spectrum are shown in Fig. 1. Clearly, the Los Alamos spectrum agrees best with the experiment, both in overall shape agreement and by factors exceeding two in χ^2.

Secondly, we consider the differential spectrum of Boldeman et al. Our least-squares adjustments with respect to this experiment give the following corresponding values: Maxwellian (T_M = 1.420 MeV, χ^2 = 8.24), Watt (T_W = 0.926 MeV, χ^2 = 31.70), Modified Watt (T_W = 0.922 MeV, χ^2 = 23.42), and Los Alamos (a = A/9.50 MeV^{-1}, χ^2 = 11.59). The NBS spectrum yields a value of χ^2 = 6.09. The ratios of these spectra and the experimental spectrum to the Maxwellian spectrum are shown in Fig. 2. Here the NBS spectrum agrees best with experiment in terms of χ^2. However, the Maxwellian and Los Alamos spectra yield χ^2 values that are within a factor of two of the minimum value.

Figure 3 shows 15 ratios of calculated to experimental integral cross sections, as a function of the effective threshold energy of the reaction, for each of the spectra that have been adjusted with respect to the Poenitz and Tamura measurement, plus the NBS spectrum. We infer that the Maxwellian spectrum is too hard in the tail region and that the two Watt spectra are too soft. The NBS spectrum is slightly hard and the Los Alamos spectrum is slightly soft. The corresponding ratios for spectra adjusted with respect to the Boldeman et al. experiment, plus the NBS spectrum, are shown in Fig. 4. Similar inferences are made here except that the Los Alamos spectrum is just slightly hard and it gives the best overall agreement with experiment.

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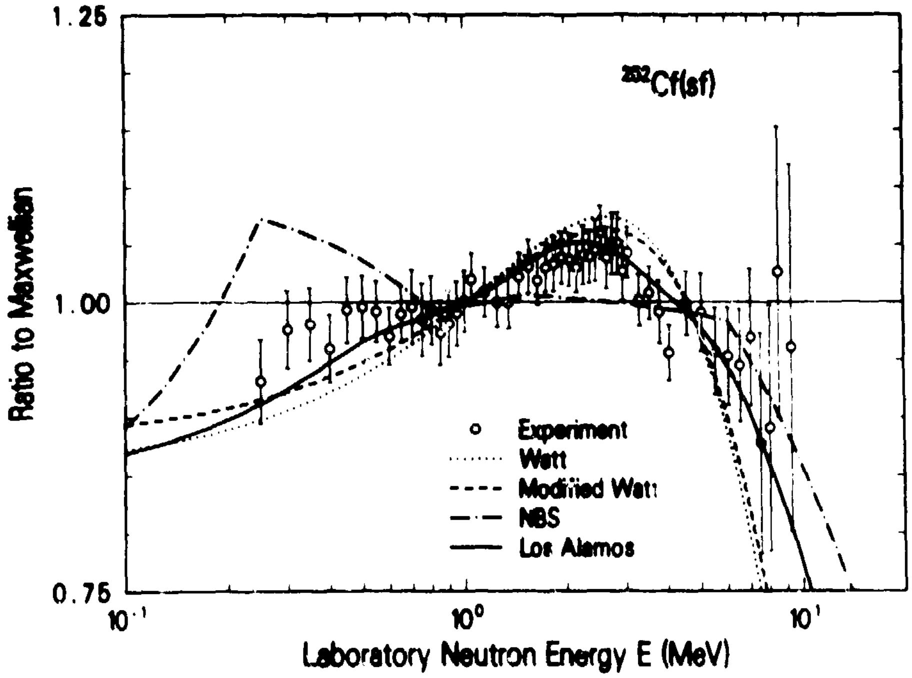

FIGURE 1 Differential spectrum comparisons for adjustments to the Poenitz and Tamura experiment (Ref. 3).

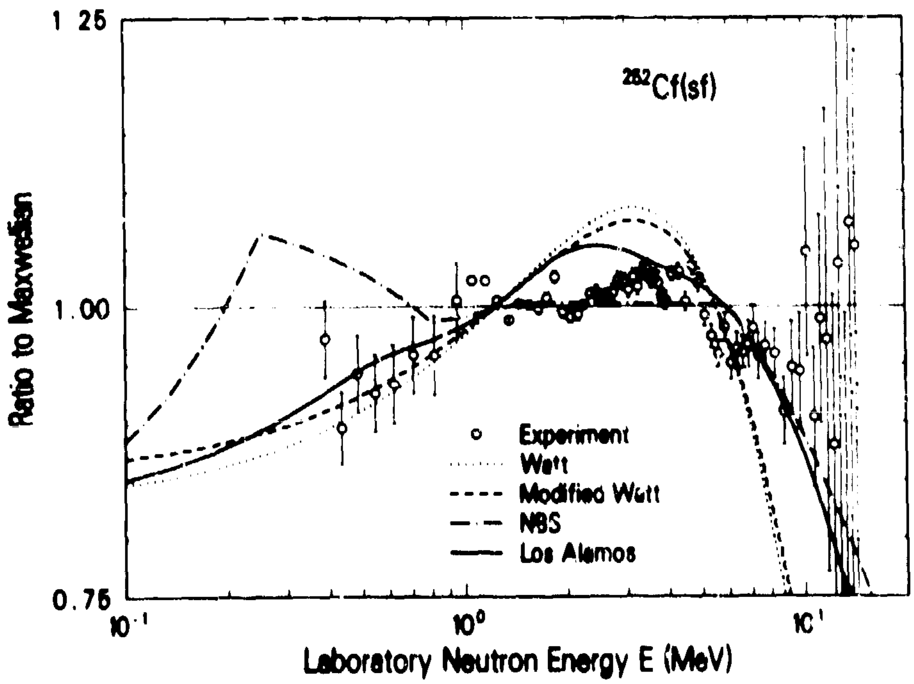

FIGURE 2 Differential spectrum comparisons for adjustments to the Boldeman et al. experiment (Ref. 4).

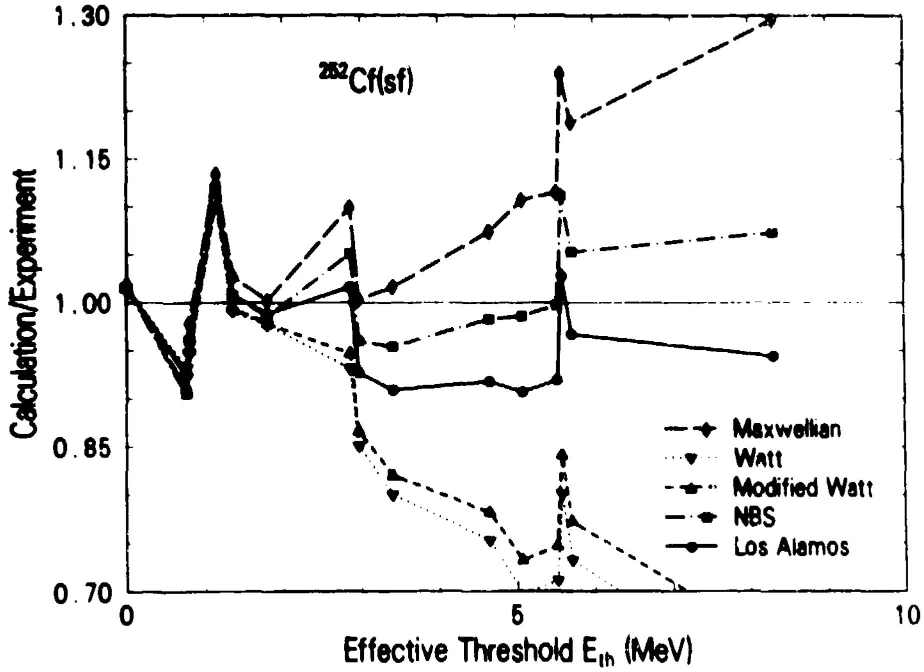

FIGURE 3 Integral cross-section comparisons for spectra adjusted to the Poenitz and Tamura experiment (Ref. 3).

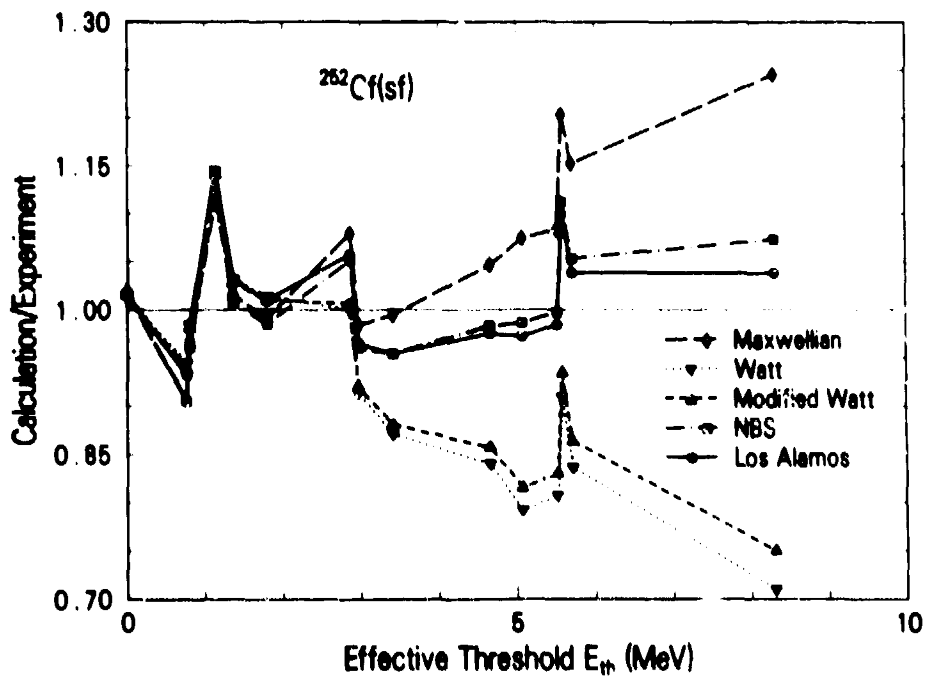

FIGURE 4 Integral cross-section comparisons for spectra adjusted to the Boldeman et al. experiment (Ref. 4.)