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# AMZ, A MULTI-GROUP LIBRARY OF CONSTANTS FOR THE EXPANDA CODE GENERATED BY THE NJOY CODE ON THE BASIS OF ENDF/B-IV

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ABSTRACT

A library of multi-group constants in 70 energy groups with 37 isotopes for fast reactor calculations is described. Cross-sections, transfer matrices and self-shielding factors were generated with the NJOY code and with the RGENDF interface program on the basis of evaluated data from ENDF/B-IV. The library is being issued in a format suitable for the EXPANDA code. Comparisons with the JFS-2 library and test results for fourteen standard critical assembly problems are presented.

# CONTENTS

# 1. INTRODUCTION

The purpose of this report is to describe the AMZ library of multi-group constants which was generated by the NJOY code [1] and by the RGENDF interface program and is based on evaluated nuclear data from ENDF/B-IV [2] and issued in a format suitable for the EXPANDA code [3].

In the following sections, descriptions are given of the processing methods and codes used and of the specifications and content of the AMZ library, comparisons are made between the multi-group cross-sections of the AMZ, JFS-2 [4] and JFS-1 [5, 6] libraries and the test results obtained with AMZ and JFS-2 and processed with the EXPANDA code for fourteen standard critical assembly problems are presented.

# 2. PROCESSING METHODS

Using evaluated data from ENDF/B-IV, the cross-sections and transfer matrices for 37 isotopes were generated with the NJOY code.

When being processed with NJOY, after they had been reconstructed with a tolerance of 0.5% (with the exception of $^{238}U$ and $^{240}Pu$, for which the accuracy was 1%), the multi-group data were calculated to Legendre order $P_o$ at three temperatures (300, 900 and 2100 K) and for various values of $\sigma_o$ (background reference cross-section) using a structure with 70 energy groups from the JAERI set [4] and a weighting spectrum produced by the MC2 code [7], which are shown in Table 1 and Fig. 1 respectively.

To obtain the weighting spectrum, a critical assembly of a unit cell of plutonium oxide $(UPu)O_2$ according to LCCEWG [8] was used, represented by infinite cylindrical geometry ($B_g^2$ = 7.8E-4). The composition and dimensions of this cell are shown in Table 2. Since it was known that MC2 could provide two weighting spectra, one with 70 groups and the other with 2100, and that the latter took into consideration the effects of self-shielding, preference was given in this case to the 70-group spectrum, since these effects are taken into account when processing with NJOY.

In calculation of the multi-group data, the mean cross-section of the material i, of the reaction x, of the group g, at a temperature T and for a given value of $\sigma_o$ is defined in NJOY as

$$\sigma_{xg}^{i}\ (T,\sigma_o) = \frac{\int_g \sigma_x^i(E,T)\ \ \phi^i(E,T,\sigma_o)\ dE}{\int_g \phi^i(E,T,\sigma_o)\ dE} \quad , \qquad (1)$$

whereby the flux $\phi^i$ is calculated by

$$\phi^i(E,T,\sigma_o) = \frac{S(E)}{\sigma_t^i(E,T) + \sigma_o} \quad , \qquad (2)$$

where S(E) is the weighting spectrum, $\sigma_t^i(E,t)$ is the total microscopic cross-section and $\sigma_o$ is a parameter into which the effects of composition can be introduced (cf. Ref. [9]). The transfer cross-sections are calculated by

$$\sigma_{e,g\rightarrow g'} = \frac{\int_g dE \int_{g'} dE'\ \sigma_e(E)\ F_e(E\rightarrow E')\ S(E)}{\int_g S(E)\ dE} \quad , \qquad (3)$$

where g and g' are the initial and final energy groups and $F_e(E\rightarrow E')$ is the Legendre component of the transfer probability of energies from E to E'.

The structure and format of the data produced in this way with the GROUPR module of the NJOY code are not, however, suitable for EXPANDA. It has therefore been necessary to draw up the RGENDF interface program which, in addition to formatting the data, calculates the following:

(a) The inelastic cross-section, taking the (n,2n) reaction into account, by means of the expression

$$\sigma'_{in} = \sigma_{in} + 2\,\sigma_{n,2n} \quad ; \qquad (4)$$

(b) The capture cross-section, by

$$\sigma_c = \sigma_t - \sigma_e - \sigma'_{in} - \sigma_f \quad , \qquad (5)$$

whereby this value is equivalent to the sum of all the captures ($\gamma$, p, d, $\alpha$, ...) subtracted from a portion of the (n,2n) reaction*/ so that the total cross-section remains unaltered;

(c) The removal cross-section, by summation of the elastic cross-sections of neutrons emigrating from each group g to other groups, namely

$$\sigma^g_{er} = \sum_{g' \neq g}^{G} \sigma_{e,g \to g'} \quad ; \qquad (6)$$

(d) The inelastic scattering matrix, by summation of the inelastic matrices of the excited and continuum states;

(e) The self-shielding factors, by the expression

$$f^g_x(T,\sigma_o) = \frac{\sigma^g_x\,(T,\sigma_o)}{\sigma^g_x\,(300,\infty)} \quad . \qquad (7)$$

The input and output units, preparation of input data and two examples of data for the RGENDF program are shown in Appendix I.

## 3. SPECIFICATIONS AND CONTENT OF THE AMZ LIBRARY

Table 3 shows the materials processed with NJOY and RGENDF at 300, 900 and 2100 K to make up the AMZ library. Of the data for the various

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*/ Translator's Note: This passage has, as far as possible been translated literally, since the meaning of the original is not clear.

isotopes shown, only those for Ga and Sn were based on ENDL/78 [10], since they were not in ENDF/B-IV, while the lumped fission products FP(PU239) and FP(U235) were obtained from JFS-2.

The table also permits the identification of materials in accordance with ENDF/B-IV (or ENDL/78) and JAERI and gives the variable MSF, which shows which values of $\sigma_o$ were adopted when drawing up the tables of self-shielding factors. The structure of the library used by EXPANDA, which is based on Ref. [11], and the values of $\sigma_o$ used are explained in Appendix II.

It should be noted that the self-shielding factors provided in the AMZ library for the two atomic density ratios of the two resonant nuclei are identical. This is because the NJOY code is not structured for calculating the cross-sections dependent on mutual interference between resonant nuclei.

## 4. COMPARISONS BETWEEN THE MULTI-GROUP DATA OF THE AMZ, JFS-2 AND JFS-1 LIBRARIES

In order to evaluate the data contained in the AMZ library, the infinite-dilution multi-group cross-sections and the self-shielding factors produced were compared with those generated in JFS-2, which was based on evaluated data adjusted by the least-squares method. This library was in turn compared with JFS-1 in order to ascertain the differences caused by adjustment, since the two libraries were generated on the basis of the same evaluated nuclear data. In order for the reasons for the differences found between the data of the three libraries to be better understood, the process used in drawing up JFS-2 on the basis of JFS-1 is described.

Using the data of JFS-1, most of which were based on the UKNDL library [12], standard problem tests were carried out by the JAERI group with a view to gauging their applicability in fast reactor calculations. Large discrepancies were found between the calculated and experimental values of $k_{eff}$ and of the spectral indices. In order to minimize these discrepancies it was necessary once again to re-evaluate the nuclear data for most of the nuclides and, using the sensitivity study, to adjust the cross-sections on the basis of the least-squares method [4].

In re-evaluation of nuclear data, the data of UKNDL for the nuclides C, O, Na, Al, Cr, Mn, Fe, Ni and Mo were rejected and replaced by those of ENDF/B-IV. The nuclides $^{9}Be$, Si, $^{232}Th$, $^{233}U$, $^{234}U$ and $^{242}Pu$, which were also based on ENDF/B-IV, were incorporated into the new library. Data for $^{241}Pu$ above 10 keV were replaced by those of ENDF/B-III. By means of the sensitivity study, the following were adjusted: the resonance parameters of the nuclides $^{235}U$, $^{238}U$, $^{239}Pu$ and $^{241}Pu$; the fission cross-sections of $^{235}U$ and $^{239}Pu$ and the capture cross-section of $^{238}U$ between 3.6 keV and 1.4 keV; and the inelastic cross-section of $^{238}U$. With these modifications the JFS-2 library was produced [4].

The two libraries of the JAERI group, the contents of which are presented in Tables 4 and 5, were produced by processing with the codes PROFGROUCH-G and G-II [13, 14] and TIMS-1 [15]. The first code, which uses a combined weighting spectrum with 1/E and the fission spectrum, with a border at 1 MeV, generated the multi-group constants of light and intermediate nuclides in the whole energy range and of heavy nuclei only in the smooth region above the resonance region. The constants of heavy nuclei in this region were generated with TIMS-1, through which the weighting spectrum was calculated numerically, thereby solving the neutron moderation equation. In this processing operation, the inelastic, capture and removal elastic scattering cross-sections received different treatments in relation to those used in the RGENDF program. The removal cross-section was calculated by

$$\sigma_{er}^{g}(\sigma_o,T) = \frac{\int_{\Delta E'} \sigma_e(E,T)\ \phi(E,\sigma_o,T)\ \frac{E_L-\alpha E}{1-\alpha}\ dE}{\int_{\Delta E_g} \phi(E,\sigma_o,T)\ dE} , \qquad (8)$$

whereby $\Delta E' = \frac{E_L}{\alpha} - E_L$ e $\alpha = \left(\frac{A-1}{A+1}\right)^2$ , and

where $E_L$ is the energy below the integration range $\Delta E_g$, $\sigma_e(E,T)$ is the elastic scattering cross-section, $\phi(E, \sigma_o,T)$ is the flux and A is the atomic mass of the resonant isotope. In the calculation of inelasticity, a single portion of the (n,2n) reaction was taken into account, while capture was determined by adding the partial captures, without the (n,2n) reaction being taken into consideration [4, 5, 6, 16].

In the comparisons performed in this study, calculations were made of the percentage deviations between the multi-group data, at infinite dilution and at 300 K, taking as the basis the JFS-2 library, by means of the expressions

$$DJA^g = \frac{\sigma_A^g - \sigma_B^g}{\sigma_B^g} \times 100 \qquad (9)$$

$$DJJ^g = \frac{\sigma_C^g - \sigma_B^g}{\sigma_B^g} \times 100 \qquad (10)$$

where the subscripts A, B and C refer to the cross-sections of the libraries AMZ, JFS-2 and JFS-1 respectively, and g refers to the energy group. The most pronounced percentage deviations, which are commented on below, are shown in Tables 6 and 21.

When analysing the discrepancies, the nuclides were grouped in order to emphasize the differences resulting from adjustment of nuclear data and differences due to different methods of processing being used in the generation of libraries. The comparisons were performed, in the first analysis case, between JFS-1 and JFS-2 and, in the second, between AMZ and JFS-2.

In the first analysis case, where comparisons were made of multi-group data for the nuclides in the JFS-1 and JFS-2 libraries $^{235}U$, $^{238}U$, $^{239}Pu$ and $^{241}Pu$, which were based on the same evaluated data of UKNDL, the following percentage deviations were found exclusively in the region in which the evaluation was performed:

$^{235}U$ - The fission (Table 6) and capture cross-sections generally compare well to within $\pm$ 10%, while in certain groups large differences of the order of 40% are found. The average differences found in the elastic and removal cross-sections, for which higher values are found in JFS-2, are -15% and -20% respectively;

$^{238}U$ - For capture (Table 7) the deviations vary between -26% and 45%, while for the elastic and removal cross-sections, for which in most groups lower data are found in JFS-2, the differences can reach orders of 30% and 180% respectively. The deviations in the inelastic cross-sections are on average 30%;

$^{239}Pu$ - The discrepancies for the fission cross-section (Table 8) vary from -34% to 74%, while for capture they vary from -60% to 70%. The differences in the elastic and removal cross-sections are generally comparable, within a range of $\pm$ 20%, except for certain groups for which they attain 93% and 128% respectively;

$^{241}Pu$ - The data are generally lower in JFS-2, and the calculated deviations can reach relatively high levels in the following reactions: fission (Table 9) and elastic scattering 77%; capture 190%; and removal 360%.

It was also noted that the data for the mean cosine of the scattering angle ($\bar{\mu}$) of the nuclides $^{235}U$, $^{238}U$ and $^{239}Pu$ are nil in JFS-1 for energies below 6 keV (group 31), while in JFS-2 they are of the order of $10^{-3}$.

The second analysis case is divided into two categories of isotope pertaining to the AMZ and JFS-2 libraries: isotopes generated on the basis of the same and of different evaluated data.

The nuclides $^{9}Be$, C, O, Na, Al, Si, Cr, Mn, Fe, Ni, Mo, $^{232}Th$, $^{233}U$, $^{234}U$ and $^{242}Pu$, which are based on the same evaluated data of ENDF/B-IV, generally have deviations of less than 10% in all nuclear reactions, with the exception of elastic removal. These differences, which occur in certain groups of the epithermal region, can be attributed to the different methods of reconstructing the evaluated data and the different weighting spectra used in the processing of these isotopes. In the case of elastic removal data, for the calculation of which different treatments were applied, the discrepancies remain in the regions of -20% and -30% for energies above and below 1 keV (group 37) respectively. Differences which may arise from the different versions of evaluated data from ENDF/B-IV being used for generating AMZ and JFS-2 were also noted when it was found that values of $\bar{\mu}$ in the range between 10 keV (group 28) and 500 keV (group 13) had relatively large differences for the following isotopes: O, -222%; Mn (Table 10), 389%; and $^{232}$Th, 1148%. Also, the version on which AMZ was based has nil values for inelastic scattering of $^{9}$Be, which never occurs in JFS-2 and thereby leads to deviations in capture as large as 2505% in the fast region (Table 11).

Of the nuclides $^{11}$B, $^{236}$U, $^{10}$B, Cu and $^{240}$Pu, the data for which were based on UKNDL where the generation of JFS-2 is concerned, only the last three are commented on, since they are elements of importance in analyses of critical assemblies and also because they show the greatest differences:

$^{10}$B - The cross-sections compare well, to within -10%, over the whole energy range for the elastic scattering and removal cross-sections and below 1 MeV (group 10) for the other reactions. Above 1 MeV, capture (Table 12), which is the principal reaction, shows differences as great as 178%.

Cu - The data are in most groups lower in JFS-2 and certain diviations can be relatively large in the following reactions: in capture 500%, in removal and $\bar{\mu}$ 180% and in elastic scattering (Table 13) 122%.

$^{240}$Pu - The elastic scattering and removal reactions, with values higher in JFS-2 in most groups, show, on average, differences of the order of -20% and -40% respectively. In inelastic scattering (Table 14), the differences are as much as 80% and rise until the beginning of the threshold is relatively near. For fission above 5 keV (group 30) and capture (Table 15) above 60 keV (group 21), where the data are generally higher in JFS-2, the discrepancies remain around -40%. Below these energies, where the opposite situation obtains, the deviations are, on average, 30% for capture and 200% for fission. Moreover, for fission between 17 eV (group 53) and 600 eV (group 40), JFS-2 has nil cross-sections, whereas in AMZ they are of the order of $10^{-1}$.

With respect to the isotopes $^{235}U$, $^{238}U$, $^{239}Pu$ and $^{241}Pu$, which were generated on the basis of UKNDL and adjusted by the least-squares method in the elaboration of JFS-2, the differences observed were relatively large in the cross-sections of all reactions, especially fission, capture and inelastic scattering - and, consequently, also in elastic removal - in the resonance regions, as was to be expected. For these four isotopes the elastic cross-section has, on average, discrepancies of around 20%. The percentage deviations of the other most important reactions are:

$^{235}U$ - For energies above 1 keV (group 37), fission (Table 16) shows differences of less than 10%, whereas below this energy the discrepancies vary between -22% and 62%. For capture the average deviations are of the order of $\pm$ 20%. For inelastic scattering (Table 17), the cross-sections compare well, to within 10%, throughout the energy range, except near the beginning of the threshold where the data of JFS-2 are twenty times lower than those of AMZ.

$^{238}U$ - For fission below 500 keV (group 13) JFS-2 has nil cross-sections, whereas in AMZ they are of the order of $10^{-6}$. Except for the first fast groups, for capture (Table 18), where the differences are relatively large, the deviations generally remain within 10%, although in certain groups in the resonance region they are $\pm$ 40%.

$^{239}Pu$ - The fission data (Table 19) compare well, to within $\pm$ 10%, above the resonance region. In this region the difference vary between -32% and 88%. For capture, where the data of JFS-2 are generally lower, the deviations are, on average, of the order of 20%, increasing around 1 eV (group 64) and reaching levels as high as approximately 200%. The differences with inelastic scattering is, on average, -30%.

$^{241}Pu$ - The fission cross-sections (Table 21) compare well, to within $\pm$ 10%, for energies above 10 keV (group 28). Below this energy, the differences vary between -33% and 58%. The capture data remain, on average, within the region of -20%.

Because of the different treatments used in the generation of the AMZ and JFS-2 libraries, when calculating the inelastic and capture cross-sections, taking the (n,2n) reaction into account, considerable discrepancies were found in the first fast groups of these two reactions for all heavy nuclei and some light ones, such as Cr and Mo, where the value of the (n,2n) reaction is relatively large (see Tables 15 and 18). It was also noted that the inelastic reaction of most isotopes analysed showed considerable percentage deviations around the beginning of the threshold, where the variation in the cross-section with energy is at a miximum. This may have been caused by different interpolation methods having been used in the processing codes when generating AMZ and JFS-2 on the basis of evaluated nuclear data. Such differences should not, however, be important for criticality calculations, since they occur where the cross-section is much lower (100 times or more) than its mean value (Tables 14 and 17).

The comparisons of the self-shielding factors pertaining to the same nuclides mentioned above were only performed superficially because of the large amount of information in existence. In analysing the differences it was found that, outside the resonance region for each of the nuclides, the percentage deviations calculated for JFS-1/JFS-2 and AMZ/JFS-2 were similar (of the same order of magnitude) to those found when a comparison is made between infinite-dilution multi-group data. However, this did not occur in the resonance region, especially for the factors relating to elastic removal, where relatively large deviations were noted, which in most cases were considerably higher (factors of eight or more). This fact points towards some special treatment in calculation of self-shielding factors or adjustments performed in the elaboration of JFS-2 which have not been described in the literature.

## 5. CRITICAL ASSEMBLY CALCULATIONS

Fourteen standard critical assembly problems selected from those of the Cross-Section Evaluation Working Group (CSEWG) [17] were processed with EXPANDA, a one-dimensional diffusion code using the AMZ library to gauge its applicability in fast reactor calculations.

Since the differences observed between the multi-group data of the AMZ and JFS-2 libraries were relatively large, it was necessary to process the same critical assemblies with EXPANDA, on this occasion using JFS-2, in order to test the effects of these differences on values of $k_{eff}$ and of the spectral indices obtained with the two libraries. For the basic conditions of the two processing operations to be the same, it was necessary to introduce into JFS-2 the new multi-group data for the nuclides $^{238}Pu$, $^{233}Pa$, Mg, $^{93}Nb$, Pb, V, Ti, Ga and Sn produced for AMZ and constants for the critical assemblies.

Of the assemblies selected, eight had plutonium fuel and the others uranium, and their characteristics (Table 22) varied in terms of size between 12 and 4000 litres and of the ratio of concentrations of fertile and fissile isotopes between 0.05 and 8.6. All the assemblies were calculated on the assumption of spherical geometry, except for ZPPR-2, for which the calculations were performed on the assumption of cylindrical geometry. The specifications of the assemblies, which were obtained from Ref. [17], are presented in Appendix III.

The calculated and corrected values of $k_{eff}$ are shown in Table 23 and Fig. 2. The correction factors applied to the calculated values, which include corrections for heterogeneity, transport and two dimensions, were obtained from Ref. [18]. Table 23 shows two corrected values of $k_{eff}$ introduced for JFS-2, the first of which was calculated in the present study, while the second was obtained from Refs [4, 16]. The differences between these two values may have been caused by the differences in the numbers of mesh points selected for each cell region analysed and in the maximum numbers of mesh points and permitted regions in each version of EXPANDA and by the presence of the new nuclides inserted into our version of JFS-2.

From the results obtained it will be seen that, despite the large variety in the characteristics of the critical assemblies analysed, the AMZ and JFS-2 libraries can predict the values of $k_{eff}$ well, except for the assemblies ZPR-3-6F, ZPR-3-12 and ZPR-3-11 in respect of AMZ and for VERA-11A and ZPR-3-6F in respect of JFS-2, where the eigenvalues differ from unity by more than 1%. It is also found that the two libraries underestimate the eigenvalues, mainly for assemblies with fertile-fissile isotope concentration ratios in the range 4.6-6.5 or for cores larger than 400 litres, and that better mean values of $k_{eff}$ can be obtained from assemblies with Pu fuel. The mean percentage deviations calculated for AMZ and JFS-2 are of the order of 0.7% and 0.5% respectively, which indicates a slight improvement of 0.2% in the results of JFS-2.

The central reaction rates for fission with $^{233}U$, $^{238}U$, $^{239}Pu$ and $^{240}Pu$, for capture with $^{238}U$ relative to fission in $^{235}U$ and for capture in $^{238}U$ relative to fission in $^{239}Pu$ were also determined for both libraries using the EXPANDA code. The ratios between the respective calculated and experimental values (C/E) and their dependences on the ratio between the concentrations of fertile and fissile isotopes (fertile/fissile) are shown in Tables 24 and 29 and Figs 3 and 4 respectively.

In the two indices relating to capture in $^{238}U$, $C(^{238}U)/f(^{235}U)$ and $C(^{238}U)f/(^{239}Pu)$, large differences are found between the mean percentage deviations calculated for AMZ and JFS-2 for U cores. The other calculated indices show that the values obtained from AMZ are slightly higher than those of JFS-2. It is also found that the C/E values of the fission rates $^{238}U/^{235}U$ and $^{240}Pu/^{235}U$ in the two libraries show considerable fluctuations around unity, which suggests some systematic error in measurements of the fission rates of fertile materials. Compared with the experimental data, the spectral indices calculated for the two libraries have relatively large discrepancies, with percentage deviations reaching values of the order of 6%.

## 6. CONCLUSIONS

The greatest differences between the multi-group data of the AMZ and JFS-2 libraries were found for nuclides adjusted by the least-squares method in the generation of JFS-2. These differences are believed to be responsible for the discrepancies between the calculated values of $k_{eff}$ and the spectral indices of the two libraries, which are of the order of 0.2% and 2% respectively.

Despite the considerable variety in the characteristics of the critical assemblies analysed, AMZ predicts the values of $k_{eff}$ well, except in the case of certain assemblies for which the eigenvalues differ from unity by a little more than 1%. In relation to the spectral indices, significant discrepancies were noted between calculated and experimental data, which may have been caused partly by inconsistent treatment in heterogenization of cells.

Finally, it can be stated that values of $k_{eff}$ for fast reactor calculations with various dimensions can be obtained using the AMZ library with an error of ~0.7%, which is approximately the uncertainty found in the calculation procedures.

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Table 1. Structure of the JAERI set with 70 energy groups

| GROUP | ENERGY UPPER | | ENERGY LOWER | ΔU | GROUP | ENERGY UPPER | | ENERGY LOWER | ΔU |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 10.5 | (MeV) | 8.3 | 0.2351 | 36 | 1.66 | (keV) | 1.29 | 0.2522 |
| 2 | 8.3 | (MeV) | 6.5 | 0.2445 | 37 | 1.29 | (keV) | 1.0 | 0.2546 |
| 3 | 6.5 | (MeV) | 5.1 | 0.2426 | 38 | 1000 | ( eV) | 773 | 0.2575 |
| 4 | 5.1 | (MeV) | 4.0 | 0.2429 | 39 | 773 | ( eV) | 598 | 0.2567 |
| 5 | 4.0 | (MeV) | 3.1 | 0.2549 | 40 | 598 | ( eV) | 465 | 0.2516 |
| 6 | 3.1 | (MeV) | 2.5 | 0.2151 | 41 | 465 | ( eV) | 360 | 0.2559 |
| 7 | 2.5 | (MeV) | 1.9 | 0.2744 | 42 | 360 | ( eV) | 278 | 0.2585 |
| 8 | 1.9 | (MeV) | 1.4 | 0.3054 | 43 | 278 | ( eV) | 215 | 0.2570 |
| 9 | 1.4 | (MeV) | 1.1 | 0.2412 | 44 | 215 | ( eV) | 166 | 0.2587 |
| 10 | 1.1 | (MeV) | 0.8 | 0.3185 | 45 | 166 | ( eV) | 129 | 0.2522 |
| 11 | 0.8 | (MeV) | 0.63 | 0.2389 | 46 | 129 | ( eV) | 100 | 0.2546 |
| 12 | 0.63 | (MeV) | 0.50 | 0.2311 | 47 | 100 | ( eV) | 77.3 | 0.2575 |
| 13 | 0.50 | (MeV) | 0.4 | 0.2231 | 48 | 77.3 | ( eV) | 59.8 | 0.2567 |
| 14 | 0.4 | (MeV) | 0.31 | 0.2549 | 49 | 59.8 | ( eV) | 46.5 | 0.2516 |
| 15 | 0.31 | (MeV) | 0.25 | 0.2151 | 50 | 46.5 | ( eV) | 36.0 | 0.2559 |
| 16 | 0.25 | (MeV) | 0.2 | 0.2231 | 51 | 36.0 | ( eV) | 27.8 | 0.2585 |
| 17 | 0.2 | (MeV) | 0.15 | 0.2877 | 52 | 27.8 | ( eV) | 21.5 | 0.2570 |
| 18 | 0.15 | (MeV) | 0.12 | 0.2231 | 53 | 21.5 | ( eV) | 16.6 | 0.2587 |
| 19 | 0.12 | (MeV) | 0.1 | 0.1823 | 54 | 16.6 | ( eV) | 12.9 | 0.2522 |
| 20 | 100 | (keV) | 77.3 | 0.2575 | 55 | 12.9 | ( eV) | 10.0 | 0.2546 |
| 21 | 77.3 | (keV) | 59.8 | 0.2567 | 56 | 10.0 | ( eV) | 7.73 | 0.2575 |
| 22 | 59.8 | (keV) | 46.5 | 0.2516 | 57 | 7.73 | ( eV) | 5.98 | 0.2567 |
| 23 | 46.5 | (keV) | 36.0 | 0.2559 | 58 | 5.98 | ( eV) | 4.65 | 0.2516 |
| 24 | 36.0 | (keV) | 27.8 | 0.2585 | 59 | 4.65 | ( eV) | 3.60 | 0.2559 |
| 25 | 27.8 | (keV) | 21.5 | 0.2570 | 60 | 3.60 | ( eV) | 2.78 | 0.2585 |
| 26 | 21.5 | (keV) | 16.6 | 0.2587 | 61 | 2.78 | ( eV) | 2.15 | 0.2570 |
| 27 | 16.6 | (keV) | 12.9 | 0.2522 | 62 | 2.15 | ( eV) | 1.66 | 0.2587 |
| 28 | 12.9 | (keV) | 10.0 | 0.2546 | 63 | 1.66 | ( eV) | 1.29 | 0.2522 |
| 29 | 10.0 | (keV) | 7.73 | 0.2575 | 64 | 1.29 | ( eV) | 1.0 | 0.2546 |
| 30 | 7.73 | (keV) | 5.98 | 0.2567 | 65 | 1.0 | ( eV) | 0.773 | 0.2575 |
| 31 | 5.98 | (keV) | 4.65 | 0.2516 | 66 | 0.773 | ( eV) | 0.598 | 0.2567 |
| 32 | 4.65 | (keV) | 3.60 | 0.2559 | 67 | 0.598 | ( eV) | 0.465 | 0.2516 |
| 33 | 3.60 | (keV) | 2.78 | 0.2585 | 68 | 0.465 | ( eV) | 0.360 | 0.2559 |
| 34 | 2.78 | (keV) | 2.15 | 0.2570 | 69 | 0.360 | ( eV) | 0.278 | 0.2585 |
| 35 | 2.15 | (keV) | 1.66 | 0.2587 | 70 | 0.278 | ( eV) | 0.215 | 0.2570 |

Table 2. Composition (atoms/barn-cm) and dimensions of plutonium cell $(UPu)O_2$

| Material | Core<br>Radius = 0.30289 | Coolant<br>Density = 0.02784 |
|---|---|---|
| $^{239}Pu$ | 0,00101 | - |
| $^{240}Pu$ | 0,00041 | - |
| $^{241}Pu$ | 0,00019 | - |
| $^{242}Pu$ | 0,000112 | - |
| $^{235}U$ | 0,000018 | - |
| $^{236}U$ | 0,00723 | - |
| O | 0,01804 | - |
| Cr | - | 0,00298 |
| Fe | - | 0,00623 |
| Ni | - | 0,00526 |
| Mo | - | 0,00026 |
| Na | - | 0,00808 |

Table 3. Content of the AMZ library

| N | ISOTOPE | IDENTIFICATION ENDF/B-IV | IDENTIFICATION JAERI | MFS |
|---|---|---|---|---|
| 1 | U-235 | 1261 | 925 | 1 |
| 2 | U-238 | 1262 | 928 | 2 |
| 3 | PU-239 | 1264 | 949 | 1 |
| 4 | PU-240 | 1265 | 940 | 1 |
| 5 | B-10 | 1273 | 105 | 0 |
| 6 | B-11 | 1160 | 115 | 0 |
| 7 | C-12 | 1274 | 6 | 2 |
| 8 | O-16 | 1276 | 8 | 2 |
| 9 | NA-23 | 1156 | 11 | 2 |
| 10 | AL-27 | 1193 | 13 | 2 |
| 11 | CR | 1191 | 24 | 2 |
| 12 | MN-55 | 1197 | 25 | 2 |
| 13 | FE | 1192 | 26 | 2 |
| 14 | NI | 1190 | 28 | 2 |
| 15 | CU | 1295 | 29 | 2 |
| 16 | MO | 1287 | 42 | 2 |
| 17 | PU-242 | 1161 | 942 | 2 |
| 18 | PU-241 | 1266 | 941 | 1 |
| 19 | AM-241 | 1056 | 951 | 2 |
| 20 | SI | 1194 | 14 | 2 |
| 21 | U-233 | 1260 | 923 | 2 |
| 22 | U-236 | 1163 | 926 | 2 |
| 23 | BE-9 | 1289 | 4 | 2 |
| 24 | FP(PU239) | 1999 | 999 | 0 |
| 25 | TH-232 | 1296 | 902 | 2 |
| 26 | H-1 | 1269 | 1 | 2 |
| 27 | FP(U235) | 1995 | 995 | 0 |
| 28 | U-234 | 1043 | 924 | 2 |
| 29 | PU-238 | 1050 | 948 | 2 |
| 30 | PA-233 | 1297 | 913 | 2 |
| 31 | MG | 1280 | 12 | 2 |
| 32 | NB-93 | 1189 | 41 | 2 |
| 33 | PB | 1288 | 82 | 2 |
| 34 | V | 1196 | 23 | 2 |
| 35 | TI | 1286 | 22 | 2 |
| 36 | GA-NAT | 7540 | 31 | 2 |
| 37 | SN-NAT | 7850 | 50 | 2 |

Table 4. Content of the JFS-1 library

| N | ISOTOPE | IDENTIFICATION ENDF/B-IV | IDENTIFICATION JAERI | MSF |
|---|---|---|---|---|
| 1 | U-235 | 1261 | 925 | 1 |
| 2 | U-238 | 1262 | 928 | 2 |
| 3 | PU-239 | 1264 | 949 | 1 |
| 4 | PU-240 | 1265 | 940 | 1 |
| 5 | B-10 | 1273 | 105 | 0 |
| 6 | B-11 | 1160 | 115 | 0 |
| 7 | C-12 | 1274 | 6 | 2 |
| 8 | O-16 | 1276 | 8 | 2 |
| 9 | NA-23 | 1156 | 11 | 1 |
| 10 | AL-27 | 1193 | 13 | 2 |
| 11 | CR | 1191 | 24 | 2 |
| 12 | MN-55 | 1197 | 25 | 1 |
| 13 | FE | 1192 | 26 | 2 |
| 14 | NI | 1190 | 28 | 2 |
| 15 | CU | 1295 | 29 | 2 |
| 16 | MO | 1287 | 42 | 1 |
| 17 | U-234 | 1043 | 924 | 1 |
| 18 | PU-241 | 1266 | 941 | 0 |

Table 5. Content of the JFS-2 library

| N | ISOTOPE | IDENTIFICATION ENDF/B-IV | IDENTIFICATION JAERI | MSF |
|---|---|---|---|---|
| 1 | U-235 | 1261 | 925 | 1 |
| 2 | U-238 | 1262 | 928 | 2 |
| 3 | PU-239 | 1264 | 949 | 1 |
| 4 | PU-240 | 1265 | 940 | 1 |
| 5 | B-10 | 1273 | 105 | 0 |
| 6 | B-11 | 1160 | 115 | 0 |
| 7 | C-12 | 1274 | 6 | 2 |
| 8 | O-16 | 1276 | 8 | 2 |
| 9 | NA-23 | 1156 | 11 | 2 |
| 10 | AL-27 | 1193 | 13 | 2 |
| 11 | CR | 1191 | 24 | 2 |
| 12 | MN-55 | 1197 | 25 | 2 |
| 13 | FE | 1192 | 26 | 2 |
| 14 | NI | 1190 | 28 | 2 |
| 15 | CU | 1295 | 29 | 2 |
| 16 | MO | 1287 | 42 | 2 |
| 17 | PU-242 | 1161 | 942 | 2 |
| 18 | PU-241 | 1266 | 941 | 1 |
| 19 | AM-241 | 1056 | 951 | 2 |
| 20 | SI | 1194 | 14 | 2 |
| 21 | U-233 | 1260 | 923 | 2 |
| 22 | U-236 | 1163 | 926 | 2 |
| 23 | BE-9 | 1289 | 4 | 2 |
| 24 | FP(PU239) | 1999 | 999 | 0 |
| 25 | TH-232 | 1296 | 902 | 2 |
| 26 | H-1 | 1269 | 1 | 2 |
| 27 | FP(U235) | 1995 | 995 | 0 |
| 28 | U-234 | 1043 | 924 | 2 |

Table 6. Comparisons between multi-group data of $^{235}U$

Fission

| GR | JFS-1 | DJJ | JFS-2 | GR | JFS-1 | DJJ | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 1.80719E+00 | 0 | 1.80719E+00 | 36 | 7.31070E+00 | 1 | 7.20720E+00 |
| 2 | 1.61844E+00 | 0 | 1.61844E+00 | 37 | 8.81970E+00 | 11 | 7.89820E+00 |
| 3 | 1.12448E+00 | 0 | 1.12448E+00 | 38 | 8.92200E+00 | -8 | 9.70480E+00 |
| 4 | 1.11930E+00 | 0 | 1.11930E+00 | 39 | 9.96400E+00 | -4 | 1.04390E+01 |
| 5 | 1.18623E+00 | 0 | 1.18623E+00 | 40 | 1.33630E+01 | 44 | 9.23120E+00 |
| 6 | 1.25644E+00 | 0 | 1.25644E+00 | 41 | 1.33380E+01 | 10 | 1.21180E+01 |
| 7 | 1.30556E+00 | 0 | 1.30556E+00 | 42 | 1.44700E+01 | -18 | 1.76790E+01 |
| 8 | 1.27417E+00 | 0 | 1.27417E+00 | 43 | 1.56030E+01 | -8 | 1.69610E+01 |
| 9 | 1.23555E+00 | 0 | 1.24320E+00 | 44 | 2.14590E+01 | 5 | 2.02760E+01 |
| 10 | 1.19044E+00 | 1 | 1.17250E+00 | 45 | 1.96210E+01 | -20 | 2.46640E+01 |
| 11 | 1.13911E+00 | 1 | 1.12600E+00 | 46 | 1.48030E+01 | 0 | 1.48690E+01 |
| 12 | 1.14880E+00 | 0 | 1.14990E+00 | 47 | 2.00600E+01 | 0 | 2.01480E+01 |
| 13 | 1.19646E+00 | 1 | 1.18350E+00 | 48 | 2.09430E+01 | -1 | 2.12910E+01 |
| 14 | 1.25654E+00 | 0 | 1.24510E+00 | 49 | 5.68090E+01 | 0 | 5.73500E+01 |
| 15 | 1.32140E+00 | 1 | 1.29920E+00 | 50 | 2.90610E+01 | 0 | 2.93400E+01 |
| 16 | 1.38230E+00 | 2 | 1.35220E+00 | 51 | 5.31770E+01 | 0 | 5.34760E+01 |
| 17 | 1.46036E+00 | 1 | 1.43290E+00 | 52 | 4.15530E+01 | -2 | 4.24190E+01 |
| 18 | 1.54144E+00 | 1 | 1.51480E+00 | 53 | 6.76130E+01 | 0 | 6.81960E+01 |
| 19 | 1.60773E+00 | 3 | 1.54600E+00 | 54 | 3.45520E+01 | -5 | 3.65330E+01 |
| 20 | 1.69074E+00 | 4 | 1.62310E+00 | 55 | 4.38970E+01 | -8 | 4.77530E+01 |
| 21 | 1.80379E+00 | 1 | 1.76950E+00 | 56 | 9.81420E+01 | 3 | 9.47640E+01 |
| 22 | 1.92915E+00 | 3 | 1.85590E+00 | 57 | 2.92950E+01 | 0 | 2.92700E+01 |
| 23 | 2.06994E+00 | 7 | 1.92560E+00 | 58 | 9.22280E+00 | -25 | 1.23740E+01 |
| 24 | 2.22164E+00 | 4 | 2.13210E+00 | 59 | 9.80530E+00 | -5 | 1.04000E+01 |
| 25 | 2.38169E+00 | 2 | 2.32790E+00 | 60 | 3.06160E+01 | 1 | 3.02250E+01 |
| 26 | 2.61152E+00 | 6 | 2.45950E+00 | 61 | 1.07110E+01 | 13 | 9.45560E+00 |
| 27 | 2.93896E+00 | 13 | 2.57890E+00 | 62 | 1.43320E+01 | -9 | 1.57780E+01 |
| 28 | 3.23794E+00 | 15 | 2.80080E+00 | 63 | 1.73700E+01 | -10 | 1.93690E+01 |
| 29 | 2.84540E+00 | -8 | 3.10950E+00 | 64 | 7.34090E+01 | 1 | 7.20410E+01 |
| 30 | 3.29120E+00 | -4 | 3.44440E+00 | 65 | 5.23960E+01 | -10 | 5.84760E+01 |
| 31 | 3.69290E+00 | -4 | 3.86600E+00 | 66 | 5.82160E+01 | -3 | 6.06150E+01 |
| 32 | 4.08740E+00 | -1 | 4.15090E+00 | 67 | 7.66570E+01 | 0 | 7.70750E+01 |
| 33 | 4.67710E+00 | -2 | 4.81740E+00 | 68 | 1.14170E+02 | 11 | 1.02450E+02 |
| 34 | 5.83440E+00 | 7 | 5.43130E+00 | 69 | 1.84460E+02 | 18 | 1.55730E+02 |
| 35 | 6.39970E+00 | 4 | 6.14480E+00 | 70 | 1.99460E+02 | 5 | 1.89700E+02 |

Table 7. Comparisons between multi-group data of $^{238}U$

Capture

| GR | JFS-1 | DJJ | JFS-2 | GR | JFS-1 | DJJ | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 7.92067E-03 | 0 | 7.92067E-03 | 36 | 1.36690E+00 | -13 | 1.58040E+00 |
| 2 | 9.92035E-03 | 0 | 9.92035E-03 | 37 | 2.16080E+00 | 0 | 2.17500E+00 |
| 3 | 1.26541E-02 | 0 | 1.26541E-02 | 38 | 2.51640E+00 | -20 | 3.18510E+00 |
| 4 | 1.47673E-02 | 0 | 1.47673E-02 | 39 | 2.06950E+00 | -26 | 2.64600E+00 |
| 5 | 1.59289E-02 | 0 | 1.59289E-02 | 40 | 3.35080E+00 | -10 | 3.74150E+00 |
| 6 | 2.44110E-02 | 0 | 2.44110E-02 | 41 | 2.19820E+00 | -18 | 2.70070E+00 |
| 7 | 3.99011E-02 | 0 | 3.99011E-02 | 42 | 3.99800E+00 | -10 | 4.44300E+00 |
| 8 | 6.51811E-02 | 0 | 6.51811E-02 | 43 | 6.97420E+00 | 8 | 6.45280E+00 |
| 9 | 9.79414E-02 | -19 | 1.21940E-01 | 44 | 1.32600E+01 | -13 | 1.54180E+01 |
| 10 | 1.61960E-01 | 19 | 1.35040E-01 | 45 | 2.31320E+00 | -6 | 2.47370E+00 |
| 11 | 1.55246E-01 | 20 | 1.29370E-01 | 46 | 4.39020E+01 | 0 | 4.38390E+01 |
| 12 | 1.33331E-01 | 7 | 1.23590E-01 | 47 | 4.94600E+00 | 0 | 4.89340E+00 |
| 13 | 1.26808E-01 | 7 | 1.18470E-01 | 48 | 3.71630E+01 | -15 | 4.38360E+01 |
| 14 | 1.25030E-01 | 1 | 1.23750E-01 | 49 | 9.12600E-02 | -26 | 1.24300E-01 |
| 15 | 1.38143E-01 | 4 | 1.31830E-01 | 50 | 1.46340E+02 | -11 | 1.64900E+02 |
| 16 | 1.54821E-01 | 9 | 1.41770E-01 | 51 | 1.88290E+00 | -9 | 2.07740E+00 |
| 17 | 1.79069E-01 | 17 | 1.51890E-01 | 52 | 2.24670E+00 | 14 | 1.95510E+00 |
| 18 | 2.11771E-01 | 26 | 1.67040E-01 | 53 | 2.29110E+02 | -3 | 2.37890E+02 |
| 19 | 2.42358E-01 | 36 | 1.77570E-01 | 54 | 3.07300E-01 | -13 | 3.53390E-01 |
| 20 | 2.81387E-01 | 45 | 1.93750E-01 | 55 | 4.36700E-01 | -16 | 5.25980E-01 |
| 21 | 3.35896E-01 | 37 | 2.44360E-01 | 56 | 1.11510E+00 | 5 | 1.05490E+00 |
| 22 | 3.93319E-01 | 29 | 3.03800E-01 | 57 | 5.08180E+02 | 0 | 5.06490E+02 |
| 23 | 4.42552E-01 | 27 | 3.47540E-01 | 58 | 2.88310E+00 | -16 | 3.46800E+00 |
| 24 | 4.86508E-01 | 18 | 4.12010E-01 | 59 | 8.50060E-01 | -4 | 8.88500E-01 |
| 25 | 5.25492E-01 | 14 | 4.59460E-01 | 60 | 5.61170E-01 | -5 | 5.94800E-01 |
| 26 | 5.67860E-01 | 11 | 5.10400E-01 | 61 | 4.74210E-01 | -6 | 5.08200E-01 |
| 27 | 6.60510E-01 | 18 | 5.59020E-01 | 62 | 4.49470E-01 | -7 | 4.85300E-01 |
| 28 | 7.53810E-01 | 21 | 6.19060E-01 | 63 | 4.53370E-01 | -7 | 4.91700E-01 |
| 29 | 7.82470E-01 | 9 | 7.11390E-01 | 64 | 4.74470E-01 | -7 | 5.15600E-01 |
| 30 | 9.28480E-01 | 16 | 7.97600E-01 | 65 | 5.06120E-01 | -8 | 5.55700E-01 |
| 31 | 1.04050E+00 | 12 | 9.24750E-01 | 66 | 5.57300E-01 | -6 | 5.98200E-01 |
| 32 | 1.03700E+00 | -5 | 1.10180E+00 | 67 | 5.79500E-01 | -12 | 6.64500E-01 |
| 33 | 1.16110E+00 | 1 | 1.14550E+00 | 68 | 9.00000E-01 | 25 | 7.19300E-01 |
| 34 | 1.43910E+00 | -1 | 1.45440E+00 | 69 | 9.00000E-01 | 12 | 8.01100E-01 |
| 35 | 1.33610E+00 | -17 | 1.62630E+00 | 70 | 9.00000E-01 | 0 | 9.01900E-01 |

Table 8. Comparisons between multi-group data of $^{239}$Pu

Fission

| GR | JFS-1 | DJJ | JFS-2 | GR | JFS-1 | DJJ | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 2.38942E+00 | 0 | 2.38942E+00 | 36 | 4.51640E+00 | -12 | 5.16950E+00 |
| 2 | 2.14396E+00 | 0 | 2.14396E+00 | 37 | 5.28990E+00 | 3 | 5.08950E+00 |
| 3 | 1.84830E+00 | 0 | 1.83360E+00 | 38 | 8.31200E+00 | 29 | 6.39930E+00 |
| 4 | 1.86690E+00 | 2 | 1.81300E+00 | 39 | 6.65430E+00 | 48 | 4.47010E+00 |
| 5 | 1.96390E+00 | 3 | 1.89900E+00 | 40 | 1.16270E+01 | -4 | 1.21170E+01 |
| 6 | 1.97970E+00 | 1 | 1.94800E+00 | 41 | 8.71700E+00 | 5 | 8.29590E+00 |
| 7 | 1.99933E+00 | 0 | 1.99930E+00 | 42 | 1.04080E+01 | 0 | 1.04770E+01 |
| 8 | 1.94060E+00 | 0 | 1.94060E+00 | 43 | 2.56230E+01 | 45 | 1.75680E+01 |
| 9 | 1.81490E+00 | 1 | 1.79330E+00 | 44 | 1.98580E+01 | 16 | 1.71100E+01 |
| 10 | 1.70580E+00 | 0 | 1.68960E+00 | 45 | 1.37130E+01 | -27 | 1.88810E+01 |
| 11 | 1.61390E+00 | 0 | 1.62480E+00 | 46 | 2.13160E+01 | 9 | 1.94090E+01 |
| 12 | 1.62120E+00 | 0 | 1.62590E+00 | 47 | 4.17900E+01 | -16 | 4.99690E+01 |
| 13 | 1.62630E+00 | 3 | 1.57260E+00 | 48 | 1.04530E+02 | 58 | 6.60880E+01 |
| 14 | 1.60290E+00 | 2 | 1.56850E+00 | 49 | 7.26590E+01 | 1 | 7.19130E+01 |
| 15 | 1.61000E+00 | 4 | 1.54370E+00 | 50 | 1.06340E+01 | -4 | 1.11630E+01 |
| 16 | 1.60000E+00 | 4 | 1.53030E+00 | 51 | 3.40070E+00 | 22 | 2.76860E+00 |
| 17 | 1.62000E+00 | 6 | 1.52370E+00 | 52 | 6.14640E+01 | 24 | 4.93890E+01 |
| 18 | 1.68000E+00 | 9 | 1.54050E+00 | 53 | 3.72700E+01 | 13 | 3.28000E+01 |
| 19 | 1.73000E+00 | 14 | 1.51560E+00 | 54 | 1.02800E+02 | 11 | 9.24500E+01 |
| 20 | 1.72000E+00 | 10 | 1.55500E+00 | 55 | 1.74140E+02 | -10 | 1.95100E+02 |
| 21 | 1.71000E+00 | 6 | 1.60080E+00 | 56 | 7.47370E+01 | 6 | 7.01100E+01 |
| 22 | 1.72000E+00 | 8 | 1.58070E+00 | 57 | 2.46020E+01 | -5 | 2.59100E+01 |
| 23 | 1.79000E+00 | 15 | 1.54990E+00 | 58 | 7.17500E+00 | -6 | 7.69300E+00 |
| 24 | 1.78000E+00 | 9 | 1.63020E+00 | 59 | 7.28330E+00 | -17 | 8.85000E+00 |
| 25 | 1.75820E+00 | 1 | 1.74030E+00 | 60 | 8.74000E+00 | -21 | 1.10700E+01 |
| 26 | 1.87910E+00 | 4 | 1.75750E+00 | 61 | 1.13540E+01 | -21 | 1.44600E+01 |
| 27 | 1.90170E+00 | 8 | 1.75870E+00 | 62 | 1.54190E+01 | -20 | 1.92900E+01 |
| 28 | 2.00730E+00 | 8 | 1.85030E+00 | 63 | 2.14770E+01 | -14 | 2.52600E+01 |
| 29 | 2.17040E+00 | 7 | 2.01630E+00 | 64 | 3.06820E+01 | -6 | 3.28300E+01 |
| 30 | 2.25010E+00 | 2 | 2.19760E+00 | 65 | 4.57850E+01 | 6 | 4.29500E+01 |
| 31 | 2.59180E+00 | 6 | 2.38990E+00 | 66 | 7.69390E+01 | 39 | 5.52200E+01 |
| 32 | 2.58780E+00 | 2 | 2.52240E+00 | 67 | 1.56600E+02 | 74 | 8.96700E+01 |
| 33 | 2.87900E+00 | -1 | 2.92980E+00 | 68 | 5.42050E+02 | 59 | 3.40800E+02 |
| 34 | 3.42860E+00 | 7 | 3.17750E+00 | 69 | 2.33560E+03 | 0 | 2.34300E+03 |
| 35 | 3.59990E+00 | 20 | 2.97580E+00 | 70 | 1.85160E+03 | -34 | 2.81100E+03 |

Table 9. Comparisons between multi-group data of $^{241}$Pu

Fission

| GR | JFS-1 | DJJ | JFS-2 | GR | JFS-1 | DJJ | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 2.36542E+00 | 9 | 2.16533E+00 | 36 | 9.46416E+00 | 0 | 9.44870E+00 |
| 2 | 2.10972E+00 | 9 | 1.92476E+00 | 37 | 9.83466E+00 | 13 | 8.63360E+00 |
| 3 | 1.65162E+00 | 9 | 1.50153E+00 | 38 | 1.01559E+01 | -5 | 1.07730E+01 |
| 4 | 1.57972E+00 | 10 | 1.43050E+00 | 39 | 1.13434E+01 | 13 | 9.97600E+00 |
| 5 | 1.58320E+00 | 7 | 1.47565E+00 | 40 | 1.71109E+01 | 42 | 1.20340E+01 |
| 6 | 1.66174E+00 | 5 | 1.57219E+00 | 41 | 2.13105E+01 | 24 | 1.70760E+01 |
| 7 | 1.78134E+00 | 2 | 1.74473E+00 | 42 | 2.18347E+01 | -7 | 2.36560E+01 |
| 8 | 1.82971E+00 | 4 | 1.74393E+00 | 43 | 2.82005E+01 | 71 | 1.65400E+01 |
| 9 | 1.74738E+00 | 6 | 1.64456E+00 | 44 | 3.14490E+01 | 21 | 2.59850E+01 |
| 10 | 1.63814E+00 | 9 | 1.49400E+00 | 45 | 3.23442E+01 | 27 | 2.54630E+01 |
| 11 | 1.61637E+00 | [illegible] | 1.48500E+00 | 46 | 1.81570E+01 | -51 | 3.75650E+01 |
| 12 | 1.61707E+00 | [illegible] | 1.45900E+00 | 47 | 5.74257E+01 | 77 | 3.23010E+01 |
| 13 | 1.56133E+00 | [illegible] | 1.53000E+00 | 48 | 5.14[illegible]3E+01 | 56 | 3.29400E+01 |
| 14 | 1.76045E+00 | 7 | 1.64500E+00 | 49 | 3.76442E+01 | -7 | 4.07740E+01 |
| 15 | 1.87628E+00 | 4 | 1.80300E+00 | 50 | 3.32050E+01 | -2 | 3.39960E+01 |
| 16 | 2.01639E+00 | 8 | 1.85100E+00 | 51 | 6.94591E+01 | 7 | 6.35590E+01 |
| 17 | 2.21305E+00 | 13 | 1.94400E+00 | 52 | 7.89282E+01 | -6 | 8.42460E+01 |
| 18 | 2.53721E+00 | 23 | 2.05400E+00 | 53 | 4.82742E+01 | -23 | 6.30200E+01 |
| 19 | 2.81629E+00 | 35 | 2.07500E+00 | 54 | 2.95008E+02 | 3 | 2.86060E+02 |
| 20 | 3.01903E+00 | 41 | 2.12900E+00 | 55 | 6.66336E+01 | -23 | 8.71100E+01 |
| 21 | 3.32371E+00 | 47 | 2.25700E+00 | 56 | 1.92006E+02 | 24 | 1.54060E+02 |
| 22 | 3.71607E+00 | 60 | 2.31400E+00 | 57 | 3.33365E+02 | 33 | 2.49240E+02 |
| 23 | 4.24531E+00 | 72 | 2.46100E+00 | 58 | 1.66079E+02 | -39 | 2.73440E+02 |
| 24 | 4.53475E+00 | 69 | 2.68000E+00 | 59 | 2.61831E+02 | -5 | 2.76460E+02 |
| 25 | 4.70697E+00 | 58 | 2.97800E+00 | 60 | 3.59227E+01 | -8 | 3.92720E+01 |
| 26 | 4.83102E+00 | 54 | 3.12000E+00 | 61 | 2.27026E+01 | -18 | 2.78200E+01 |
| 27 | 4.97810E+00 | 52 | 3.26500E+00 | 62 | 1.83517E+01 | -24 | 2.43260E+01 |
| 28 | 5.19164E+00 | 51 | 3.43722E+00 | 63 | 1.69559E+01 | -28 | 2.37100E+01 |
| 29 | 5.41063E+00 | 48 | 3.64820E+00 | 64 | 1.69460E+01 | -33 | 2.55150E+01 |
| 30 | 5.53015E+00 | 33 | 4.14030E+00 | 65 | 1.89241E+01 | -37 | 3.04800E+01 |
| 31 | 5.85766E+00 | 35 | 4.31860E+00 | 66 | 2.52893E+01 | -41 | 4.33220E+01 |
| 32 | 6.17795E+00 | 17 | 5.26640E+00 | 67 | 4.72943E+01 | -37 | 7.59560E+01 |
| 33 | 6.36685E+00 | 13 | 5.62560E+00 | 68 | 1.54790E+02 | -22 | 1.99380E+02 |
| 34 | 7.09576E+00 | 2 | 6.93170E+00 | 69 | 7.13239E+02 | -8 | 7.82760E+02 |
| 35 | 8.32381E+00 | 14 | 7.29660E+00 | 70 | 1.38472E+03 | -2 | 1.42560E+03 |

Table 10. Comparisons between multi-group data of Mn

$\bar{\mu}$

| GP | AMZ | DJA | JFS-2 | GP | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 8.60858E-01 | 0 | 8.63826E-01 | 36 | 1.22400E-02 | 0 | 1.22400E-02 |
| 2 | 7.85500E-01 | 0 | 7.86124E-01 | 37 | 1.22400E-02 | 0 | 1.22400E-02 |
| 3 | 7.26572E-01 | 0 | 7.26400E-01 | 38 | 1.22400E-02 | 0 | 1.22400E-02 |
| 4 | 6.65696E-01 | 0 | 6.63990E-01 | 39 | 1.22400E-02 | 0 | 1.22400E-02 |
| 5 | 5.79545E-01 | 0 | 5.77456E-01 | 40 | 1.22400E-02 | 0 | 1.22400E-02 |
| 6 | 5.09615E-01 | 0 | 5.07936E-01 | 41 | 1.22400E-02 | 0 | 1.22400E-02 |
| 7 | 4.23956E-01 | 5 | 4.02099E-01 | 42 | 1.22400E-02 | 0 | 1.22400E-02 |
| 8 | 2.83705E-01 | 11 | 2.55135E-01 | 43 | 1.22400E-02 | 0 | 1.22400E-02 |
| 9 | 1.78986E-01 | 2 | 1.74604E-01 | 44 | 1.22400E-02 | 0 | 1.22400E-02 |
| 10 | 1.60562E-01 | -1 | 1.63018E-01 | 45 | 1.22400E-02 | 0 | 1.22400E-02 |
| 11 | 1.87729E-01 | 0 | 1.88215E-01 | 46 | 1.22400E-02 | 0 | 1.22400E-02 |
| 12 | 1.83646E-01 | 13 | 1.61196E-01 | 47 | 1.22400E-02 | 0 | 1.22400E-02 |
| 13 | 1.73718E-01 | 33 | 1.30458E-01 | 48 | 1.22400E-02 | 0 | 1.22400E-02 |
| 14 | 1.63236E-01 | 56 | 1.04638E-01 | 49 | 1.22400E-02 | 0 | 1.22400E-02 |
| 15 | 1.54054E-01 | 78 | 8.62132E-02 | 50 | 1.22400E-02 | 0 | 1.22400E-02 |
| 16 | 1.43591E-01 | 111 | 6.78774E-02 | 51 | 1.22400E-02 | 0 | 1.22400E-02 |
| 17 | 1.34101E-01 | 142 | 5.52627E-02 | 52 | 1.22400E-02 | 0 | 1.22400E-02 |
| 18 | 1.22144E-01 | 220 | 3.81470E-02 | 53 | 1.22400E-02 | 0 | 1.22400E-02 |
| 19 | 1.14322E-01 | 200 | 3.80093E-02 | 54 | 1.22400E-02 | 0 | 1.22400E-02 |
| 20 | 1.03897E-01 | 217 | 3.27396E-02 | 55 | 1.22400E-02 | 0 | 1.22400E-02 |
| 21 | 9.37945E-02 | 389 | 1.91560E-02 | 56 | 1.22400E-02 | 0 | 1.22400E-02 |
| 22 | 8.49915E-02 | 343 | 1.91647E-02 | 57 | 1.22400E-02 | 0 | 1.22400E-02 |
| 23 | 7.09549E-02 | 339 | 1.61580E-02 | 58 | 1.22400E-02 | 0 | 1.22400E-02 |
| 24 | 6.45940E-02 | 239 | 1.90008E-02 | 59 | 1.22400E-02 | 0 | 1.22400E-02 |
| 25 | 5.07465E-02 | 314 | 1.22400E-02 | 60 | 1.22400E-02 | 0 | 1.22400E-02 |
| 26 | 4.27842E-02 | 249 | 1.22400E-02 | 61 | 1.22400E-02 | 0 | 1.22400E-02 |
| 27 | 2.75632E-02 | 125 | 1.22400E-02 | 62 | 1.22400E-02 | 0 | 1.22400E-02 |
| 28 | 1.69154E-02 | 38 | 1.22400E-02 | 63 | 1.22400E-02 | 0 | 1.22400E-02 |
| 29 | 1.22400E-02 | 0 | 1.22400E-02 | 64 | 1.22400E-02 | 0 | 1.22400E-02 |
| 30 | 1.22400E-02 | 0 | 1.22400E-02 | 65 | 1.22400E-02 | 0 | 1.22400E-02 |
| 31 | 1.22400E-02 | 0 | 1.22400E-02 | 66 | 1.22400E-02 | 0 | 1.22400E-02 |
| 32 | 1.22400E-02 | 0 | 1.22400E-02 | 67 | 1.22400E-02 | 0 | 1.22400E-02 |
| 33 | 1.22400E-02 | 0 | 1.22400E-02 | 68 | 1.22400E-02 | 0 | 1.22400E-02 |
| 34 | 1.22400E-02 | 0 | 1.22400E-02 | 69 | 1.22400E-02 | 0 | 1.22400E-02 |
| 35 | 1.22400E-02 | 0 | 1.22400E-02 | 70 | 1.21407E-02 | -79 | 5.81267E-02 |

Table 11. Comparisons between multi-group data of $^{9}Be$

| Capture | | | | Inelastic | | | |
|---|---|---|---|---|---|---|---|
| GP | AMZ | DJA | JFS-2 | GP | AMZ | DJA | JFS-2 |
| 1 | 5.90456E-01 | 2505 | 2.26586E-02 | 1 | 0. | 0 | 5.66710E-01 |
| 2 | 6.10406E-01 | 1659 | 3.46922E-02 | 2 | 0. | 0 | 5.76296E-01 |
| 3 | 6.27106E-01 | 1044 | 5.47725E-02 | 3 | 0. | 0 | 5.72081E-01 |
| 4 | 6.14677E-01 | 714 | 7.54442E-02 | 4 | 0. | 0 | 5.39783E-01 |
| 5 | 5.54526E-01 | 483 | 9.49833E-02 | 5 | 0. | 0 | 4.58661E-01 |
| 6 | 2.69736E-01 | 168 | 1.00463E-01 | 6 | 0. | 0 | 1.66022E-01 |
| 7 | 7.19530E-02 | 19 | 6.07300E-02 | 7 | 0. | 0 | 8.80275E-03 |
| 8 | 2.46000E-02 | 0 | 2.44280E-02 | 8 | 0. | 0 | 5.05220E-04 |
| 9 | 6.96800E-03 | 0 | 6.96820E-03 | 9 | 0. | 0 | 0. |
| 10 | 2.54900E-03 | -4 | 2.65605E-03 | 10 | 0. | 0 | 0. |
| 11 | 2.33000E-04 | 0 | 2.30977E-04 | 11 | 0. | 0 | 0. |
| 12 | 1.00000E-04 | 0 | 1.00000E-04 | 12 | 0. | 0 | 0. |
| 13 | 1.00000E-04 | 0 | 1.00000E-04 | 13 | 0. | 0 | 0. |
| 14 | 1.00000E-04 | 0 | 1.00000E-04 | 14 | 0. | 0 | 0. |
| 15 | 1.00000E-04 | 0 | 1.00000E-04 | 15 | 0. | 0 | 0. |
| 16 | 1.00000E-04 | 0 | 1.00000E-04 | 16 | 0. | 0 | 0. |
| 17 | 1.00000E-04 | 0 | 1.00000E-04 | 17 | 0. | 0 | 0. |
| 18 | 1.00000E-04 | 0 | 1.00000E-04 | 18 | 0. | 0 | 0. |
| 19 | 1.00000E-04 | 0 | 1.00000E-04 | 19 | 0. | 0 | 0. |
| 20 | 1.00000E-04 | 0 | 1.00000E-04 | 20 | 0. | 0 | 0. |
| 21 | 1.00000E-04 | 0 | 1.00000E-04 | 21 | 0. | 0 | 0. |
| 22 | 1.00000E-04 | 0 | 9.99959E-05 | 22 | 0. | 0 | 0. |
| 23 | 1.00000E-04 | 0 | 1.00000E-04 | 23 | 0. | 0 | 0. |
| 24 | 1.00000E-04 | 0 | 1.00000E-04 | 24 | 0. | 0 | 0. |
| 25 | 1.00000E-04 | 0 | 1.00000E-04 | 25 | 0. | 0 | 0. |
| 26 | 1.00000E-04 | 0 | 1.00000E-04 | 26 | 0. | 0 | 0. |
| 27 | 1.00000E-04 | 0 | 1.00000E-04 | 27 | 0. | 0 | 0. |
| 28 | 1.00000E-04 | 0 | 1.00000E-04 | 28 | 0. | 0 | 0. |
| 29 | 1.00000E-04 | 0 | 1.00000E-04 | 29 | 0. | 0 | 0. |
| 30 | 1.00000E-04 | 0 | 1.00000E-04 | 30 | 0. | 0 | 0. |
| 31 | 1.00000E-04 | 0 | 1.00000E-04 | 31 | 0. | 0 | 0. |
| 32 | 1.00000E-04 | 0 | 1.00000E-04 | 32 | 0. | 0 | 0. |
| 33 | 1.00000E-04 | 0 | 1.00000E-04 | 33 | 0. | 0 | 0. |
| 34 | 1.00000E-04 | 0 | 1.00000E-04 | 34 | 0. | 0 | 0. |
| 35 | 1.00000E-04 | 0 | 1.00000E-04 | 35 | 0. | 0 | 0. |

Table 12. Comparisons between multi-group data of $^{10}B$

Capture

| GR | AMZ | DJA | JFS-2 | GR | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 2.62222E-01 | -19 | 3.27395E-01 | 36 | 1.55655E+01 | -6 | 1.66817E+01 |
| 2 | 2.99971E-01 | -31 | 4.38375E-01 | 37 | 1.77005E+01 | -6 | 1.89444E+01 |
| 3 | 4.04953E-01 | -18 | 4.95295E-01 | 38 | 2.01041E+01 | -6 | 2.15442E+01 |
| 4 | 4.08312E-01 | 18 | 3.43378E-01 | 39 | 2.28949E+01 | -6 | 2.44873E+01 |
| 5 | 3.05184E-01 | 92 | 1.58342E-01 | 40 | 2.60165E+01 | -6 | 2.77819E+01 |
| 6 | 3.58436E-01 | 178 | 1.29091E-01 | 41 | 2.95584E+01 | -6 | 3.15372E+01 |
| 7 | 4.10083E-01 | 14 | 3.56773E-01 | 42 | 3.36395E+01 | -6 | 3.58570E+01 |
| 8 | 4.01069E-01 | 2 | 3.91596E-01 | 43 | 3.82110E+01 | -6 | 4.07661E+01 |
| 9 | 2.09381E-01 | -24 | 2.77336E-01 | 44 | 4.35586E+01 | -6 | 4.63609E+01 |
| 10 | 2.30609E-01 | -1 | 2.34211E-01 | 45 | 4.95785E+01 | -5 | 5.26268E+01 |
| 11 | 3.76717E-01 | -1 | 3.81065E-01 | 46 | 5.62225E+01 | -5 | 5.97215E+01 |
| 12 | 6.21373E-01 | 9 | 5.68229E-01 | 47 | 6.38562E+01 | -5 | 6.78955E+01 |
| 13 | 8.28378E-01 | 13 | 7.32767E-01 | 48 | 7.26653E+01 | -5 | 7.72419E+01 |
| 14 | 9.34841E-01 | 3 | 9.06932E-01 | 49 | 8.27332E+01 | -5 | 8.77094E+01 |
| 15 | 1.10353E+00 | 0 | 1.10251E+00 | 50 | 9.40331E+01 | -5 | 9.96509E+01 |
| 16 | 1.28573E+00 | 1 | 1.27174E+00 | 51 | 1.07949E+02 | -4 | 1.13399E+02 |
| 17 | 1.49353E+00 | 0 | 1.48863E+00 | 52 | 1.21847E+02 | -5 | 1.29037E+02 |
| 18 | 1.70841E+00 | 0 | 1.72536E+00 | 53 | 1.39011E+02 | -5 | 1.46874E+02 |
| 19 | 1.88350E+00 | -1 | 1.91809E+00 | 54 | 1.58468E+02 | -5 | 1.66868E+02 |
| 20 | 2.07701E+00 | -2 | 2.13478E+00 | 55 | 1.79849E+02 | -5 | 1.89526E+02 |
| 21 | 2.32985E+00 | -3 | 2.42683E+00 | 56 | 2.04123E+02 | -5 | 2.14898E+02 |
| 22 | 2.61908E+00 | -4 | 2.75650E+00 | 57 | 2.31819E+02 | -4 | 2.43221E+02 |
| 23 | 2.94804E+00 | -5 | 3.11829E+00 | 58 | 2.66933E+02 | -2 | 2.74794E+02 |
| 24 | 3.32572E+00 | -5 | 3.52785E+00 | 59 | 3.02076E+02 | -2 | 3.10630E+02 |
| 25 | 3.77519E+00 | -5 | 3.99828E+00 | 60 | 3.41406E+02 | -2 | 3.51678E+02 |
| 26 | 4.27109E+00 | -7 | 4.61219E+00 | 61 | 3.88727E+02 | -2 | 3.98130E+02 |
| 27 | 4.86480E+00 | -8 | 5.31765E+00 | 62 | 4.42311E+02 | -1 | 4.50844E+02 |
| 28 | 5.51898E+00 | -6 | 5.90842E+00 | 63 | 4.98618E+02 | -2 | 5.09635E+02 |
| 29 | 6.26011E+00 | -6 | 6.68906E+00 | 64 | 5.58076E+02 | -3 | 5.75921E+02 |
| 30 | 7.13626E+00 | -5 | 7.56921E+00 | 65 | 6.56932E+02 | 0 | 6.53498E+02 |
| 31 | 8.12508E+00 | -6 | 8.65013E+00 | 66 | 7.40945E+02 | 0 | 7.43090E+02 |
| 32 | 9.21696E+00 | -6 | 9.90722E+00 | 67 | 8.38631E+02 | 0 | 8.43429E+02 |
| 33 | 1.04956E+01 | -7 | 1.12863E+01 | 68 | 9.52062E+02 | 0 | 9.57846E+02 |
| 34 | 1.20787E+01 | -6 | 1.28566E+01 | 69 | 1.09439E+03 | 0 | 1.09552E+03 |
| 35 | 1.36867E+01 | -6 | 1.46496E+01 | 70 | 1.23200E+03 | 0 | 1.23058E+03 |

Table 13. Comparisons between multi-group data of Cu

Elastic

| GR | AMZ | DJA | JFS-2 | GR | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 1.91859E+00 | 5 | 1.82111E+00 | 36 | 4.32143E+00 | -28 | 6.07773E+00 |
| 2 | 2.09869E+00 | 8 | 1.93914E+00 | 37 | 5.05827E+00 | -22 | 6.56140E+00 |
| 3 | 2.17407E+00 | 10 | 1.97545E+00 | 38 | 5.67867E+00 | -17 | 6.89905E+00 |
| 4 | 2.10465E+00 | 10 | 1.90077E+00 | 39 | 6.69026E+00 | -14 | 7.78887E+00 |
| 5 | 1.97664E+00 | 13 | 1.73546E+00 | 40 | 2.04631E+01 | 22 | 1.66660E+01 |
| 6 | 1.91044E+00 | 9 | 1.74492E+00 | 41 | 6.35510E+00 | -4 | 6.66151E+00 |
| 7 | 1.99746E+00 | 3 | 1.93571E+00 | 42 | 6.84482E+00 | 0 | 6.86955E+00 |
| 8 | 2.21311E+00 | -9 | 2.45105E+00 | 43 | 7.27708E+00 | 2 | 7.10657E+00 |
| 9 | 2.81649E+00 | -2 | 2.88099E+00 | 44 | 7.46291E+00 | 7 | 6.96574E+00 |
| 10 | 3.33076E+00 | 0 | 3.36210E+00 | 45 | 7.76009E+00 | 10 | 7.04676E+00 |
| 11 | 3.72530E+00 | -3 | 3.84757E+00 | 46 | 7.99231E+00 | 12 | 7.10688E+00 |
| 12 | 4.16131E+00 | -2 | 4.28876E+00 | 47 | 8.18769E+00 | 14 | 7.14383E+00 |
| 13 | 4.31050E+00 | -7 | 4.65499E+00 | 48 | 8.35142E+00 | 16 | 7.18277E+00 |
| 14 | 4.50543E+00 | -8 | 4.93698E+00 | 49 | 8.46880E+00 | 17 | 7.21679E+00 |
| 15 | 5.12547E+00 | 2 | 4.98542E+00 | 50 | 8.59878E+00 | 18 | 7.24625E+00 |
| 16 | 5.33160E+00 | 1 | 5.26266E+00 | 51 | 8.69279E+00 | 19 | 7.27256E+00 |
| 17 | 5.36695E+00 | 5 | 5.06520E+00 | 52 | 8.76041E+00 | 20 | 7.29531E+00 |
| 18 | 5.88575E+00 | 14 | 5.13340E+00 | 53 | 8.81798E+00 | 20 | 7.31340E+00 |
| 19 | 5.91978E+00 | 19 | 4.95990E+00 | 54 | 8.86306E+00 | 20 | 7.32803E+00 |
| 20 | 6.64074E+00 | 17 | 5.65506E+00 | 55 | 8.81313E+00 | 20 | 7.34184E+00 |
| 21 | 7.46183E+00 | 2 | 7.29942E+00 | 56 | 8.57797E+00 | 16 | 7.35281E+00 |
| 22 | 7.75051E+00 | 1 | 7.61036E+00 | 57 | 8.53845E+00 | 15 | 7.36125E+00 |
| 23 | 8.34859E+00 | 23 | 6.77946E+00 | 58 | 8.55649E+00 | 16 | 7.36791E+00 |
| 24 | 1.08815E+01 | 43 | 7.59249E+00 | 59 | 8.56875E+00 | 16 | 7.37312E+00 |
| 25 | 1.49144E+01 | 54 | 9.63732E+00 | 60 | 8.57823E+00 | 16 | 7.37731E+00 |
| 26 | 1.62054E+01 | 85 | 8.73640E+00 | 61 | 8.58630E+00 | 16 | 7.38080E+00 |
| 27 | 1.36565E+01 | 51 | 9.01811E+00 | 62 | 8.59246E+00 | 16 | 7.38309E+00 |
| 28 | 1.04957E+01 | -3 | 1.09071E+01 | 63 | 8.59703E+00 | 16 | 7.38452E+00 |
| 29 | 2.14923E+01 | 122 | 9.66463E+00 | 64 | 8.60067E+00 | 16 | 7.38664E+00 |
| 30 | 8.92629E+00 | -13 | 1.03144E+01 | 65 | 8.60468E+00 | 16 | 7.38797E+00 |
| 31 | 1.91191E+01 | 0 | 1.91978E+01 | 66 | 8.60712E+00 | 16 | 7.38896E+00 |
| 32 | 1.00533E+01 | -17 | 1.22387E+01 | 67 | 8.60943E+00 | 16 | 7.38966E+00 |
| 33 | 6.13531E+00 | -34 | 9.31708E+00 | 68 | 8.61168E+00 | 16 | 7.38995E+00 |
| 34 | 2.16191E+01 | -5 | 2.29118E+01 | 69 | 8.61401E+00 | 16 | 7.39015E+00 |
| 35 | 4.57879E+01 | 15 | 3.96270E+01 | 70 | 8.61443E+00 | 16 | 7.39026E+00 |

Table 14. Comparisons between multi-group data of $^{240}Pu$

Inelastic

| GR | AMZ | DJA | JFS-2 | GR | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 6.92598E-01 | -25 | 9.25541E-01 | 36 | 0. | 0 | 0. |
| 2 | 1.27863E+00 | 3 | 1.23616E+00 | 37 | 0. | 0 | 0. |
| 3 | 1.61973E+00 | -5 | 1.70919E+00 | 38 | 0. | 0 | 0. |
| 4 | 1.64990E+00 | -6 | 1.76167E+00 | 39 | 0. | 0 | 0. |
| 5 | 1.65000E+00 | 0 | 1.66163E+00 | 40 | 0. | 0 | 0. |
| 6 | 1.65000E+00 | 3 | 1.59770E+00 | 41 | 0. | 0 | 0. |
| 7 | 1.65000E+00 | 4 | 1.56273E+00 | 42 | 0. | 0 | 0. |
| 8 | 1.64920E+00 | 18 | 1.35586E+00 | 43 | 0. | 0 | 0. |
| 9 | 1.61604E+00 | 49 | 1.08185E+00 | 44 | 0. | 0 | 0. |
| 10 | 1.55780E+00 | 81 | 8.57968E-01 | 45 | 0. | 0 | 0. |
| 11 | 1.50947E+00 | 41 | 1.07041E+00 | 46 | 0. | 0 | 0. |
| 12 | 1.50760E+00 | 23 | 1.22565E+00 | 47 | 0. | 0 | 0. |
| 13 | 1.48239E+00 | 10 | 1.33655E+00 | 48 | 0. | 0 | 0. |
| 14 | 1.40020E+00 | 9 | 1.28411E+00 | 49 | 0. | 0 | 0. |
| 15 | 1.31387E+00 | 11 | 1.18123E+00 | 50 | 0. | 0 | 0. |
| 16 | 1.23413E+00 | 15 | 1.07188E+00 | 51 | 0. | 0 | 0. |
| 17 | 1.09922E+00 | 21 | 9.08379E-01 | 52 | 0. | 0 | 0. |
| 18 | 9.07696E-01 | 31 | 6.88999E-01 | 53 | 0. | 0 | 0. |
| 19 | 7.41206E-01 | 50 | 4.90887E-01 | 54 | 0. | 0 | 0. |
| 20 | 5.45103E-01 | 117 | 2.50255E-01 | 55 | 0. | 0 | 0. |
| 21 | 2.93567E-01 | 470 | 5.14654E-02 | 56 | 0. | 0 | 0. |
| 22 | 7.39068E-02 | 1158 | 5.87142E-03 | 57 | 0. | 0 | 0. |
| 23 | 3.02509E-03 | 0 | 0. | 58 | 0. | 0 | 0. |
| 24 | 0. | 0 | 0. | 59 | 0. | 0 | 0. |
| 25 | 0. | 0 | 0. | 60 | 0. | 0 | 0. |
| 26 | 0. | 0 | 0. | 61 | 0. | 0 | 0. |
| 27 | 0. | 0 | 0. | 62 | 0. | 0 | 0. |
| 28 | 0. | 0 | 0. | 63 | 0. | 0 | 0. |
| 29 | 0. | 0 | 0. | 64 | 0. | 0 | 0. |
| 30 | 0. | 0 | 0. | 65 | 0. | 0 | 0. |
| 31 | 0. | 0 | 0. | 66 | 0. | 0 | 0. |
| 32 | 0. | 0 | 0. | 67 | 0. | 0 | 0. |
| 33 | 0. | 0 | 0. | 68 | 0. | 0 | 0. |
| 34 | 0. | 0 | 0. | 69 | 0. | 0 | 0. |
| 35 | 0. | 0 | 0. | 70 | 0. | 0 | 0. |

Table 15. Comparisons between multi-group data of $^{240}Pu$

Capture

| GR | AMZ | DJA | JFS-2 | GR | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | -1.82541E-01 | -1410 | 1.39307E-02 | 36 | 3.16799E+00 | 34 | 2.36250E+00 |
| 2 | -3.63844E-02 | -303 | 1.78396E-02 | 37 | 3.76051E+00 | 32 | 2.84640E+00 |
| 3 | 1.02370E-02 | -53 | 2.19044E-02 | 38 | 5.96671E+00 | 23 | 4.84530E+00 |
| 4 | 1.51210E-02 | -41 | 2.57372E-02 | 39 | 4.10315E+00 | 40 | 2.91620E+00 |
| 5 | 2.35160E-02 | -13 | 2.72849E-02 | 40 | 6.73672E+00 | 33 | 5.03460E+00 |
| 6 | 3.37050E-02 | -21 | 4.27559E-02 | 41 | 6.70118E+00 | 10 | 6.07420E+00 |
| 7 | 4.67690E-02 | -33 | 6.98747E-02 | 42 | 1.01725E+01 | 10 | 9.19500E+00 |
| 8 | 6.65770E-02 | -40 | 1.12584E-01 | 43 | 6.53464E+00 | 32 | 4.93770E+00 |
| 9 | 9.84260E-02 | -48 | 1.72494E-01 | 44 | 9.12073E+00 | -2 | 9.33920E+00 |
| 10 | 1.14405E-01 | -59 | 2.82508E-01 | 45 | 2.14182E+01 | 11 | 1.91640E+01 |
| 11 | 1.37280E-01 | -49 | 2.72963E-01 | 46 | 3.40941E+01 | 1 | 3.34460E+01 |
| 12 | 1.51609E-01 | -34 | 2.32260E-01 | 47 | 2.72416E+01 | 33 | 2.04160E+01 |
| 13 | 1.60976E-01 | -27 | 2.21525E-01 | 48 | 9.84253E+01 | 7 | 9.14810E+01 |
| 14 | 1.64743E-01 | -25 | 2.21426E-01 | 49 | 2.66770E-01 | 22 | 2.17950E-01 |
| 15 | 1.75514E-01 | -27 | 2.42512E-01 | 50 | 1.74549E+02 | -9 | 1.93630E+02 |
| 16 | 1.86989E-01 | -31 | 2.71290E-01 | 51 | 5.01085E-01 | 25 | 3.99550E-01 |
| 17 | 2.04717E-01 | -34 | 3.11389E-01 | 52 | 3.42018E-01 | -8 | 3.72360E-01 |
| 18 | 2.26995E-01 | -37 | 3.66278E-01 | 53 | 9.67574E+01 | 6 | 9.11540E+01 |
| 19 | 2.52641E-01 | -40 | 4.21726E-01 | 54 | 2.45712E-01 | 25 | 1.94860E-01 |
| 20 | 2.81799E-01 | -42 | 4.89875E-01 | 55 | 2.72287E-01 | 29 | 2.10520E-01 |
| 21 | 3.29145E-01 | 0 | 3.31957E-01 | 56 | 4.18479E-01 | 26 | 3.30650E-01 |
| 22 | 4.03054E-01 | 14 | 3.52652E-01 | 57 | 7.27641E-01 | 20 | 6.04230E-01 |
| 23 | 4.92769E-01 | 30 | 3.78128E-01 | 58 | 1.48083E+00 | 23 | 1.19620E+00 |
| 24 | 6.33705E-01 | 56 | 4.04646E-01 | 59 | 2.97144E+00 | 16 | 2.54390E+00 |
| 25 | 7.97958E-01 | 87 | 4.26199E-01 | 60 | 6.33386E+00 | 5 | 6.01700E+00 |
| 26 | 9.31855E-01 | 56 | 5.95530E-01 | 61 | 1.63534E+01 | 3 | 1.58470E+01 |
| 27 | 1.03929E+00 | 50 | 6.91130E-01 | 62 | 5.13024E+01 | 0 | 5.16590E+01 |
| 28 | 1.14395E+00 | 54 | 7.40500E-01 | 63 | 2.27245E+02 | -18 | 2.79880E+02 |
| 29 | 1.25977E+00 | 55 | 8.11860E-01 | 64 | 8.49096E+03 | -68 | 2.67820E+04 |
| 30 | 1.39813E+00 | 50 | 9.29260E-01 | 65 | 2.46689E+03 | -16 | 2.96950E+03 |
| 31 | 1.56262E+00 | 54 | 1.01430E+00 | 66 | 4.33599E+02 | 3 | 4.16950E+02 |
| 32 | 1.68859E+00 | 67 | 1.00530E+00 | 67 | 2.39506E+02 | 5 | 2.25950E+02 |
| 33 | 1.82274E+00 | 61 | 1.13050E+00 | 68 | 1.79907E+02 | 4 | 1.72450E+02 |
| 34 | 2.59307E+00 | 65 | 1.56490E+00 | 69 | 1.56560E+02 | 5 | 1.48060E+02 |
| 35 | 2.72776E+00 | 35 | 2.00900E+00 | 70 | 1.47937E+02 | 7 | 1.37210E+02 |

Table 16. Comparisons between multi-group data of $^{235}U$

Fission

| GR | AMZ | DJA | JFS-2 | GR | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 1.78687E+00 | -1 | 1.80719E+00 | 36 | 7.18301E+00 | 0 | 7.20720E+00 |
| 2 | 1.59661E+00 | -1 | 1.61844E+00 | 37 | 8.31790E+00 | 5 | 7.89620E+00 |
| 3 | 1.13143E+00 | 0 | 1.12448E+00 | 38 | 8.04087E+00 | -17 | 9.70460E+00 |
| 4 | 1.11940E+00 | 0 | 1.11930E+00 | 39 | 1.14709E+01 | 9 | 1.04390E+01 |
| 5 | 1.16498E+00 | 0 | 1.16623E+00 | 40 | 1.50149E+01 | 62 | 9.23120E+00 |
| 6 | 1.25140E+00 | 0 | 1.25644E+00 | 41 | 1.32512E+01 | 9 | 1.21160E+01 |
| 7 | 1.27687E+00 | -2 | 1.30556E+00 | 42 | 1.37188E+01 | -22 | 1.76790E+01 |
| 8 | 1.25925E+00 | -1 | 1.27417E+00 | 43 | 2.19062E+01 | 29 | 1.69610E+01 |
| 9 | 1.25439E+00 | 0 | 1.24320E+00 | 44 | 1.96130E+01 | -3 | 2.02760E+01 |
| 10 | 1.19034E+00 | 1 | 1.17250E+00 | 45 | 2.11179E+01 | -14 | 2.46640E+01 |
| 11 | 1.13483E+00 | 0 | 1.12600E+00 | 46 | 2.29696E+01 | 54 | 1.48690E+01 |
| 12 | 1.15619E+00 | 0 | 1.14990E+00 | 47 | 2.35062E+01 | 16 | 2.01480E+01 |
| 13 | 1.19515E+00 | 0 | 1.18350E+00 | 48 | 2.64250E+01 | 24 | 2.12910E+01 |
| 14 | 1.22914E+00 | -1 | 1.24510E+00 | 49 | 5.78705E+01 | 0 | 5.73500E+01 |
| 15 | 1.29212E+00 | 0 | 1.29920E+00 | 50 | 3.10951E+01 | 5 | 2.93400E+01 |
| 16 | 1.32113E+00 | -2 | 1.35220E+00 | 51 | 6.32062E+01 | 18 | 5.34760E+01 |
| 17 | 1.40461E+00 | -1 | 1.43290E+00 | 52 | 4.26205E+01 | 0 | 4.24190E+01 |
| 18 | 1.49488E+00 | -1 | 1.51480E+00 | 53 | 7.53166E+01 | 10 | 6.81960E+01 |
| 19 | 1.55574E+00 | 0 | 1.54600E+00 | 54 | 3.40827E+01 | -6 | 3.65330E+01 |
| 20 | 1.62042E+00 | 0 | 1.62310E+00 | 55 | 5.24145E+01 | 9 | 4.77530E+01 |
| 21 | 1.78236E+00 | 0 | 1.76950E+00 | 56 | 1.02010E+02 | 7 | 9.47640E+01 |
| 22 | 1.84426E+00 | 0 | 1.85590E+00 | 57 | 2.66505E+01 | -8 | 2.92700E+01 |
| 23 | 1.89611E+00 | -1 | 1.92560E+00 | 58 | 1.17339E+01 | -5 | 1.23740E+01 |
| 24 | 2.06162E+00 | -3 | 2.13210E+00 | 59 | 1.03703E+01 | 0 | 1.04000E+01 |
| 25 | 2.17339E+00 | -6 | 2.32790E+00 | 60 | 3.24973E+01 | 7 | 3.02250E+01 |
| 26 | 2.23635E+00 | -9 | 2.45950E+00 | 61 | 9.69249E+00 | 2 | 9.45560E+00 |
| 27 | 2.50190E+00 | -2 | 2.57890E+00 | 62 | 1.60510E+01 | 1 | 1.57780E+01 |
| 28 | 2.66404E+00 | -4 | 2.80080E+00 | 63 | 1.66188E+01 | -14 | 1.93690E+01 |
| 29 | 3.02669E+00 | -2 | 3.10950E+00 | 64 | 5.91529E+01 | -17 | 7.20410E+01 |
| 30 | 3.32537E+00 | -3 | 3.44440E+00 | 65 | 5.79961E+01 | 0 | 5.84760E+01 |
| 31 | 3.81361E+00 | -1 | 3.86600E+00 | 66 | 6.14574E+01 | 1 | 6.06150E+01 |
| 32 | 4.52031E+00 | 8 | 4.15090E+00 | 67 | 7.78030E+01 | 0 | 7.70750E+01 |
| 33 | 4.90087E+00 | 1 | 4.81740E+00 | 68 | 1.12275E+02 | 9 | 1.02450E+02 |
| 34 | 5.40521E+00 | 0 | 5.43130E+00 | 69 | 1.73100E+02 | 11 | 1.55730E+02 |
| 35 | 6.21238E+00 | 1 | 6.14460E+00 | 70 | 1.86074E+02 | -1 | 1.89700E+02 |

Table 17. Comparisons between multi-group data of $^{235}U$

Inelastic

| GR | AMZ | DJA | JFS-2 | GR | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 1.05470E+00 | -2 | 1.07980E+00 | 36 | 0. | 0 | 0. |
| 2 | 1.19010E+00 | -10 | 1.32498E+00 | 37 | 0. | 0 | 0. |
| 3 | 1.70382E+00 | -3 | 1.77040E+00 | 38 | 0. | 0 | 0. |
| 4 | 1.82524E+00 | 0 | 1.82860E+00 | 39 | 0. | 0 | 0. |
| 5 | 1.81207E+00 | 0 | 1.81650E+00 | 40 | 0. | 0 | 0. |
| 6 | 1.78365E+00 | 0 | 1.77420E+00 | 41 | 0. | 0 | 0. |
| 7 | 1.74749E+00 | 0 | 1.74520E+00 | 42 | 0. | 0 | 0. |
| 8 | 1.64154E+00 | 4 | 1.57280E+00 | 43 | 0. | 0 | 0. |
| 9 | 1.48436E+00 | 3 | 1.43080E+00 | 44 | 0. | 0 | 0. |
| 10 | 1.35657E+00 | 0 | 1.35790E+00 | 45 | 0. | 0 | 0. |
| 11 | 1.29363E+00 | 0 | 1.29260E+00 | 46 | 0. | 0 | 0. |
| 12 | 1.13209E+00 | 0 | 1.14070E+00 | 47 | 0. | 0 | 0. |
| 13 | 1.03420E+00 | 0 | 1.03670E+00 | 48 | 0. | 0 | 0. |
| 14 | 8.87621E-01 | 0 | 8.95340E-01 | 49 | 0. | 0 | 0. |
| 15 | 7.77028E-01 | 0 | 7.69990E-01 | 50 | 0. | 0 | 0. |
| 16 | 6.66282E-01 | 1 | 6.59400E-01 | 51 | 0. | 0 | 0. |
| 17 | 5.65545E-01 | 2 | 5.49990E-01 | 52 | 0. | 0 | 0. |
| 18 | 4.65168E-01 | 3 | 4.49080E-01 | 53 | 0. | 0 | 0. |
| 19 | 4.05657E-01 | 3 | 3.93090E-01 | 54 | 0. | 0 | 0. |
| 20 | 2.55536E-01 | -13 | 2.93530E-01 | 55 | 0. | 0 | 0. |
| 21 | 1.25313E-01 | -32 | 1.85920E-01 | 56 | 0. | 0 | 0. |
| 22 | 5.62868E-02 | 5 | 5.33810E-02 | 57 | 0. | 0 | 0. |
| 23 | 3.06504E-02 | 0 | 3.08540E-02 | 58 | 0. | 0 | 0. |
| 24 | 2.05396E-02 | 0 | 2.05120E-02 | 59 | 0. | 0 | 0. |
| 25 | 1.26267E-02 | 149 | 5.06110E-03 | 60 | 0. | 0 | 0. |
| 26 | 6.61301E-03 | 1694 | 3.68590E-04 | 61 | 0. | 0 | 0. |
| 27 | 1.86253E-03 | 0 | 0. | 62 | 0. | 0 | 0. |
| 28 | 0. | 0 | 0. | 63 | 0. | 0 | 0. |
| 29 | 0. | 0 | 0. | 64 | 0. | 0 | 0. |
| 30 | 0. | 0 | 0. | 65 | 0. | 0 | 0. |
| 31 | 0. | 0 | 0. | 66 | 0. | 0 | 0. |
| 32 | 0. | 0 | 0. | 67 | 0. | 0 | 0. |
| 33 | 0. | 0 | 0. | 68 | 0. | 0 | 0. |
| 34 | 0. | 0 | 0. | 69 | 0. | 0 | 0. |
| 35 | 0. | 0 | 0. | 70 | 0. | 0 | 0. |

Table 18. Comparisons between multi-group data of $^{238}U$

Capture

| GP | AMZ | DJA | JFS-2 | GP | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | -1.46656E+00 | -18615 | 7.92067E-03 | 36 | 1.61373E+00 | 2 | 1.58040E+00 |
| 2 | -7.14288E-01 | -7300 | 9.92035E-03 | 37 | 2.36238E+00 | 8 | 2.17500E+00 |
| 3 | -9.65102E-04 | -107 | 1.26541E-02 | 38 | 3.44232E+00 | 8 | 3.18510E+00 |
| 4 | 1.05568E-02 | -28 | 1.47673E-02 | 39 | 2.76528E+00 | -2 | 2.84600E+00 |
| 5 | 1.76239E-02 | 10 | 1.59289E-02 | 40 | 4.34952E+00 | 15 | 3.76180E+00 |
| 6 | 2.80997E-02 | 15 | 2.44110E-02 | 41 | 2.57995E+00 | 6 | 2.70070E+00 |
| 7 | 4.36109E-02 | 9 | 3.99011E-02 | 42 | 4.86303E+00 | 9 | 4.44300E+00 |
| 8 | 7.01808E-02 | 7 | 6.51811E-02 | 43 | 7.55754E+00 | 17 | 6.45280E+00 |
| 9 | 1.00104E-01 | -17 | 1.21940E-01 | 44 | 1.80297E+01 | 16 | 1.54160E+01 |
| 10 | 1.20007E-01 | -11 | 1.35040E-01 | 45 | 3.63505E+00 | 46 | 2.47370E+00 |
| 11 | 1.18847E-01 | -8 | 1.29370E-01 | 46 | 3.28110E+01 | -25 | 4.38390E+01 |
| 12 | 1.11299E-01 | -9 | 1.23590E-01 | 47 | 3.15871E+00 | -35 | 4.89340E+00 |
| 13 | 1.07666E-01 | -9 | 1.18420E-01 | 48 | 3.56313E+01 | -18 | 4.38360E+01 |
| 14 | 1.09862E-01 | -11 | 1.23750E-01 | 49 | 1.32488E-01 | 6 | 1.24300E-01 |
| 15 | 1.16785E-01 | -9 | 1.31830E-01 | 50 | 9.88359E+01 | -40 | 1.64900E+02 |
| 16 | 1.32550E-01 | -6 | 1.41770E-01 | 51 | 2.38931E+00 | 15 | 2.07740E+00 |
| 17 | 1.49356E-01 | -1 | 1.51890E-01 | 52 | 1.43456E+00 | -26 | 1.95510E+00 |
| 18 | 1.66242E-01 | 0 | 1.67040E-01 | 53 | 3.21283E+02 | 35 | 2.37890E+02 |
| 19 | 1.87193E-01 | 2 | 1.77570E-01 | 54 | 3.74855E-01 | 6 | 3.53390E-01 |
| 20 | 2.01341E-01 | 3 | 1.93750E-01 | 55 | 4.93411E-01 | -6 | 5.25960E-01 |
| 21 | 2.55383E-01 | 4 | 2.44360E-01 | 56 | 1.00603E+00 | -4 | 1.05490E+00 |
| 22 | 3.28091E-01 | 7 | 3.03800E-01 | 57 | 4.55287E+02 | -10 | 5.06490E+02 |
| 23 | 3.82547E-01 | 10 | 3.47540E-01 | 58 | 2.85731E+00 | -17 | 3.46800E+00 |
| 24 | 4.25254E-01 | 3 | 4.12010E-01 | 59 | 8.97295E-01 | 0 | 8.88500E-01 |
| 25 | 4.82143E-01 | 4 | 4.59460E-01 | 60 | 6.05449E-01 | 1 | 5.94800E-01 |
| 26 | 5.39433E-01 | 5 | 5.10400E-01 | 61 | 5.10700E-01 | 0 | 5.08200E-01 |
| 27 | 6.07843E-01 | 8 | 5.59020E-01 | 62 | 4.82204E-01 | 0 | 4.85300E-01 |
| 28 | 6.71113E-01 | 8 | 6.19060E-01 | 63 | 4.85206E-01 | -1 | 4.91700E-01 |
| 29 | 7.30339E-01 | 2 | 7.11390E-01 | 64 | 5.02999E-01 | -2 | 5.15600E-01 |
| 30 | 8.34620E-01 | 4 | 7.97600E-01 | 65 | 5.46370E-01 | -1 | 5.55700E-01 |
| 31 | 9.48890E-01 | 2 | 9.24250E-01 | 66 | 5.92721E-01 | 0 | 5.98200E-01 |
| 32 | 1.05631E+00 | -4 | 1.10180E+00 | 67 | 6.50799E-01 | -2 | 6.64500E-01 |
| 33 | 1.19397E+00 | 4 | 1.14550E+00 | 68 | 7.21719E-01 | 0 | 7.19300E-01 |
| 34 | 1.50521E+00 | 3 | 1.45440E+00 | 69 | 8.06145E-01 | 0 | 8.01100E-01 |
| 35 | 1.55714E+00 | -4 | 1.62630E+00 | 70 | 9.04711E-01 | 0 | 9.01900E-01 |

Table 19. Comparisons between multi-group data of $^{239}Pu$

Fission

| GP | AMZ | DJA | JFS-2 | GP | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 2.36615E+00 | 0 | 2.38942E+00 | 36 | 4.30205E+00 | -16 | 5.16950E+00 |
| 2 | 2.18759E+00 | 2 | 2.14396E+00 | 37 | 5.57847E+00 | 9 | 5.08950E+00 |
| 3 | 1.73589E+00 | -5 | 1.83300E+00 | 38 | 6.71908E+00 | 4 | 6.39530E+00 |
| 4 | 1.73256E+00 | -4 | 1.81300E+00 | 39 | 4.73740E+00 | 5 | 4.47010E+00 |
| 5 | 1.80760E+00 | -4 | 1.88800E+00 | 40 | 1.42321E+01 | 17 | 1.21170E+01 |
| 6 | 1.88384E+00 | -3 | 1.94800E+00 | 41 | 8.43422E+00 | 1 | 8.29590E+00 |
| 7 | 1.95150E+00 | -2 | 1.99930E+00 | 42 | 9.85733E+00 | -5 | 1.04770E+01 |
| 8 | 1.91315E+00 | -1 | 1.94060E+00 | 43 | 2.13331E+01 | 21 | 1.75680E+01 |
| 9 | 1.80234E+00 | 0 | 1.79330E+00 | 44 | 1.88773E+01 | 10 | 1.71100E+01 |
| 10 | 1.70813E+00 | 1 | 1.68960E+00 | 45 | 1.72917E+01 | -8 | 1.88810E+01 |
| 11 | 1.65926E+00 | 2 | 1.62480E+00 | 46 | 2.01761E+01 | 3 | 1.94090E+01 |
| 12 | 1.59922E+00 | -1 | 1.62590E+00 | 47 | 4.14532E+01 | -17 | 4.99690E+01 |
| 13 | 1.57496E+00 | 0 | 1.57260E+00 | 48 | 7.30646E+01 | 10 | 6.60860E+01 |
| 14 | 1.54606E+00 | -1 | 1.56850E+00 | 49 | 7.71696E+01 | 7 | 7.19130E+01 |
| 15 | 1.50805E+00 | -2 | 1.54370E+00 | 50 | 1.26298E+01 | 13 | 1.11630E+01 |
| 16 | 1.48442E+00 | -2 | 1.53030E+00 | 51 | 3.92074E+00 | 41 | 2.76860E+00 |
| 17 | 1.49119E+00 | -2 | 1.52370E+00 | 52 | 4.30927E+01 | -12 | 4.93890E+01 |
| 18 | 1.54898E+00 | 0 | 1.54050E+00 | 53 | 2.88758E+01 | -11 | 3.28000E+01 |
| 19 | 1.58051E+00 | 4 | 1.51560E+00 | 54 | 1.04409E+02 | 12 | 9.24500E+01 |
| 20 | 1.56038E+00 | 0 | 1.55500E+00 | 55 | 1.65125E+02 | -15 | 1.95100E+02 |
| 21 | 1.62611E+00 | 1 | 1.60080E+00 | 56 | 5.22405E+01 | -25 | 7.01100E+01 |
| 22 | 1.60595E+00 | 1 | 1.58070E+00 | 57 | 2.88251E+01 | 11 | 2.59100E+01 |
| 23 | 1.59891E+00 | 3 | 1.54990E+00 | 58 | 8.08921E+00 | 5 | 7.69300E+00 |
| 24 | 1.61918E+00 | 0 | 1.63020E+00 | 59 | 8.73484E+00 | -1 | 8.85000E+00 |
| 25 | 1.64911E+00 | -5 | 1.74030E+00 | 60 | 1.05251E+01 | -4 | 1.10700E+01 |
| 26 | 1.68734E+00 | -3 | 1.75750E+00 | 61 | 1.35917E+01 | -6 | 1.44600E+01 |
| 27 | 1.74511E+00 | 0 | 1.75870E+00 | 62 | 1.74596E+01 | -9 | 1.92900E+01 |
| 28 | 1.82653E+00 | -1 | 1.85030E+00 | 63 | 2.28147E+01 | -9 | 2.52600E+01 |
| 29 | 2.02355E+00 | 0 | 2.01630E+00 | 64 | 2.92982E+01 | -10 | 3.28300E+01 |
| 30 | 2.03113E+00 | -7 | 2.19760E+00 | 65 | 4.71732E+01 | 9 | 4.29500E+01 |
| 31 | 2.27912E+00 | -4 | 2.38990E+00 | 66 | 7.71790E+01 | 39 | 5.52300E+01 |
| 32 | 2.46055E+00 | -2 | 2.52240E+00 | 67 | 1.68839E+02 | 68 | 6.96700E+01 |
| 33 | 3.30507E+00 | 12 | 2.92950E+00 | 68 | 5.96017E+02 | 74 | 3.40600E+02 |
| 34 | 3.37945E+00 | 6 | 3.17750E+00 | 69 | 2.38139E+03 | 1 | 2.34300E+03 |
| 35 | 3.23279E+00 | 8 | 2.97580E+00 | 70 | 1.99983E+03 | -32 | 2.81100E+03 |

Table 20. Comparisons between multi-group data of $^{239}Pu$

Inelastic

| GR | AMZ | DJA | JFS-2 | GR | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 6.15854E-01 | -10 | 6.91886E-01 | 36 | 0. | 0 | 0. |
| 2 | 8.73103E-01 | -18 | 1.06834E+00 | 37 | 0. | 0 | 0. |
| 3 | 1.54142E+00 | 8 | 1.41743E+00 | 38 | 0. | 0 | 0. |
| 4 | 1.66098E+00 | 15 | 1.43530E+00 | 39 | 0. | 0 | 0. |
| 5 | 1.66035E+00 | 24 | 1.33390E+00 | 40 | 0. | 0 | 0. |
| 6 | 1.64051E+00 | 31 | 1.24940E+00 | 41 | 0. | 0 | 0. |
| 7 | 1.55679E+00 | 34 | 1.16140E+00 | 42 | 0. | 0 | 0. |
| 8 | 1.41191E+00 | 25 | 1.12350E+00 | 43 | 0. | 0 | 0. |
| 9 | 1.24858E+00 | 13 | 1.10350E+00 | 44 | 0. | 0 | 0. |
| 10 | 1.05541E+00 | -2 | 1.08340E+00 | 45 | 0. | 0 | 0. |
| 11 | 8.84700E-01 | -17 | 1.07090E+00 | 46 | 0. | 0 | 0. |
| 12 | 7.46371E-01 | -28 | 1.04000E+00 | 47 | 0. | 0 | 0. |
| 13 | 6.15949E-01 | -35 | 9.52530E-01 | 48 | 0. | 0 | 0. |
| 14 | 5.40925E-01 | -34 | 8.31360E-01 | 49 | 0. | 0 | 0. |
| 15 | 4.97452E-01 | -32 | 7.37610E-01 | 50 | 0. | 0 | 0. |
| 16 | 4.69014E-01 | -29 | 6.67830E-01 | 51 | 0. | 0 | 0. |
| 17 | 4.09918E-01 | -30 | 5.92330E-01 | 52 | 0. | 0 | 0. |
| 18 | 3.57242E-01 | -32 | 5.25550E-01 | 53 | 0. | 0 | 0. |
| 19 | 3.16189E-01 | -34 | 4.81890E-01 | 54 | 0. | 0 | 0. |
| 20 | 2.79257E-01 | -35 | 4.34580E-01 | 55 | 0. | 0 | 0. |
| 21 | 2.54533E-01 | -35 | 3.92270E-01 | 56 | 0. | 0 | 0. |
| 22 | 2.40279E-01 | -33 | 3.63130E-01 | 57 | 0. | 0 | 0. |
| 23 | 2.37090E-01 | -33 | 3.59190E-01 | 58 | 0. | 0 | 0. |
| 24 | 2.27702E-01 | -34 | 3.47910E-01 | 59 | 0. | 0 | 0. |
| 25 | 2.14564E-01 | -35 | 3.31470E-01 | 60 | 0. | 0 | 0. |
| 26 | 1.96331E-01 | -36 | 3.07620E-01 | 61 | 0. | 0 | 0. |
| 27 | 1.61518E-01 | -40 | 2.69310E-01 | 62 | 0. | 0 | 0. |
| 28 | 1.19325E-01 | -42 | 2.07760E-01 | 63 | 0. | 0 | 0. |
| 29 | 5.00584E-02 | -8 | 5.45320E-02 | 64 | 0. | 0 | 0. |
| 30 | 0. | 0 | 0. | 65 | 0. | 0 | 0. |
| 31 | 0. | 0 | 0. | 66 | 0. | 0 | 0. |
| 32 | 0. | 0 | 0. | 67 | 0. | 0 | 0. |
| 33 | 0. | 0 | 0. | 68 | 0. | 0 | 0. |
| 34 | 0. | 0 | 0. | 69 | 0. | 0 | 0. |
| 35 | 0. | 0 | 0. | 70 | 0. | 0 | 0. |

Table 21. Comparisons between multi-group data of $^{241}Pu$

Fission

| GR | AMZ | DJA | JFS-2 | GR | AMZ | DJA | JFS-2 |
|---|---|---|---|---|---|---|---|
| 1 | 2.28030E+00 | 5 | 2.16533E+00 | 36 | 9.13575E+00 | -3 | 9.44870E+00 |
| 2 | 2.06735E+00 | 7 | 1.92476E+00 | 37 | 1.01808E+01 | 17 | 8.63380E+00 |
| 3 | 1.58739E+00 | 5 | 1.50153E+00 | 38 | 1.15533E+01 | 7 | 1.07720E+01 |
| 4 | 1.51136E+00 | 5 | 1.43050E+00 | 39 | 1.36963E+01 | 37 | 9.97600E+00 |
| 5 | 1.54035E+00 | 4 | 1.47565E+00 | 40 | 1.63750E+01 | 36 | 1.20340E+01 |
| 6 | 1.62619E+00 | 3 | 1.57219E+00 | 41 | 1.95529E+01 | 14 | 1.70760E+01 |
| 7 | 1.71687E+00 | -1 | 1.74473E+00 | 42 | 2.29850E+01 | -3 | 2.36560E+01 |
| 8 | 1.75485E+00 | 0 | 1.74393E+00 | 43 | 2.61542E+01 | 58 | 1.65400E+01 |
| 9 | 1.68626E+00 | 2 | 1.64458E+00 | 44 | 2.85255E+01 | 9 | 2.59850E+01 |
| 10 | 1.53683E+00 | 2 | 1.49400E+00 | 45 | 2.95756E+01 | 16 | 2.54630E+01 |
| 11 | 1.48954E+00 | 0 | 1.46500E+00 | 46 | 3.27286E+01 | -12 | 3.75650E+01 |
| 12 | 1.50386E+00 | 0 | 1.49900E+00 | 47 | 4.06358E+01 | 25 | 3.23010E+01 |
| 13 | 1.52941E+00 | 0 | 1.53000E+00 | 48 | 4.02343E+01 | 22 | 3.29400E+01 |
| 14 | 1.59060E+00 | -3 | 1.64500E+00 | 49 | 4.77728E+01 | 17 | 4.07740E+01 |
| 15 | 1.69371E+00 | -6 | 1.80300E+00 | 50 | 2.80790E+01 | -17 | 3.39960E+01 |
| 16 | 1.75215E+00 | -5 | 1.85100E+00 | 51 | 7.86444E+01 | -5 | 8.25590E+01 |
| 17 | 1.87787E+00 | -3 | 1.94400E+00 | 52 | 8.97929E+01 | 6 | 8.42460E+01 |
| 18 | 2.01905E+00 | -1 | 2.05400E+00 | 53 | 4.48281E+01 | -28 | 6.30200E+01 |
| 19 | 2.11847E+00 | 2 | 2.07500E+00 | 54 | 2.72063E+02 | -4 | 2.86060E+02 |
| 20 | 2.19047E+00 | 2 | 2.12900E+00 | 55 | 6.86790E+01 | -21 | 8.71100E+01 |
| 21 | 2.33029E+00 | 3 | 2.25700E+00 | 56 | 1.94307E+02 | 26 | 1.54080E+02 |
| 22 | 2.43567E+00 | 5 | 2.31400E+00 | 57 | 3.08673E+02 | 23 | 2.49240E+02 |
| 23 | 2.46052E+00 | 0 | 2.46100E+00 | 58 | 1.82068E+02 | -33 | 2.73440E+02 |
| 24 | 2.53364E+00 | -5 | 2.68000E+00 | 59 | 2.65868E+02 | -3 | 2.76460E+02 |
| 25 | 2.65065E+00 | -10 | 2.97800E+00 | 60 | 3.82458E+01 | -2 | 3.92720E+01 |
| 26 | 2.78686E+00 | -10 | 3.12000E+00 | 61 | 2.77574E+01 | 0 | 2.78200E+01 |
| 27 | 2.98722E+00 | -8 | 3.26500E+00 | 62 | 2.50459E+01 | 2 | 2.43260E+01 |
| 28 | 3.29076E+00 | -4 | 3.43722E+00 | 63 | 2.68280E+01 | 13 | 2.37100E+01 |
| 29 | 3.74542E+00 | 2 | 3.64870E+00 | 64 | 2.99981E+01 | 17 | 2.55190E+01 |
| 30 | 4.30340E+00 | 3 | 4.14030E+00 | 65 | 3.52854E+01 | 15 | 3.04800E+01 |
| 31 | 4.99445E+00 | 15 | 4.31880E+00 | 66 | 4.05428E+01 | -6 | 4.33220E+01 |
| 32 | 5.76669E+00 | 9 | 5.24640E+00 | 67 | 5.68185E+01 | -25 | 7.59560E+01 |
| 33 | 6.65252E+00 | 14 | 5.82560E+00 | 68 | 1.56702E+02 | -21 | 1.99380E+02 |
| 34 | 7.49544E+00 | 8 | 6.93120E+00 | 69 | 7.10004E+02 | -9 | 7.82760E+02 |
| 35 | 8.27082E+00 | 13 | 7.28860E+00 | 70 | 1.53621E+03 | 7 | 1.42560E+03 |

Table 22. Characteristics of critical assemblies

| ASSEMBLY | FUEL | FERTILE / FISSILE | APPROX. VOLUME OF CORE (L) |
|---|---|---|---|
| VERA-11A | Pu | 0,05 | 12 |
| VERA-1B | U | 0,07 | 30 |
| ZPR-3-6F | U | 1,1 | 50 |
| ZABRA-3 | Pu | 8,6 | 60 |
| ZPR-3-12 | U | 3,8 | 100 |
| SNEAK-7A | Pu | 3,0[a] | 110 |
| ZPR-3-11 | U | 7,5 | 140 |
| SNEAK-7B | Pu | 7,0 | 310 |
| ZPR-3-48 | Pu | 4,5 | 410 |
| ZEBRA-2 | U | 6,2 | 430 |
| ZPR-3-56B | Pu | 4,6 | 610 |
| ZPPR-2 | Pu | 6,5[a] | 2400 |
| ZPR-6-7 | Pu | 6,5 | 3100 |
| ZPR-6-6A | U | 5,0 | 4000 |

a/ Calculated for the inner region of the core.

Table 23. Multiplication factors ($k_{eff}$)

| FUEL | CRITICAL ASSEMBLY | EXP. 1.0000 | CALCULATED AMZ | CALCULATED JFS-2 | CORRECTED AMZ | CORRECTED JFS-2 | CORRECTED JFS-2[a/] |
|---|---|---|---|---|---|---|---|
| Pu | VERA-11A | ±0,0030 | 0,9427 | 0,9375 | 0,9934 | 0,9882 | 0,9924 |
| | ZEBRA-3 | ±0,0030 | 0,9964 | 0,9864 | 1,0084 | 0,9984 | 0,9980 |
| | SNEAK-7A | - | 0,9917 | 0,9901 | 1,0053 | 1,0037 | 1,0051 |
| | SNEAK-7B | - | 0,9994 | 0,9961 | 1,0062 | 1,0029 | 1,0044 |
| | ZPR-3-48 | ±0,0010 | 0,9811 | 0,9795 | 1,0049 | 1,0033 | 1,0031 |
| | ZPR-3-56B | ±0,0014 | 1,0023 | 0,9938 | 1,0024 | 0,9939 | 0,9967 |
| | ZPPR-2 | ±0,0006 | 0,9714 | 0,9781 | 0,9916 | 0,9983 | 1,0087 |
| | ZPR-6-7 | ±0,0010 | 0,9803 | 0,9858 | 0,9965 | 1,0020 | 1,0033 |
| | $k_{eff}$ mean | | | | 1,0011 | 0,9988 | 1,0015 |
| | $\|k_{eff}-1\|$ mean | | | | 0,0057 | 0,0041 | 0,0047 |
| U | VERA-1B | ±0,0028 | 0,9767 | 0,9749 | 1,0042 | 1,0024 | 1,0036 |
| | ZPR-3-6F | ±0,0015 | 0,9977 | 0,9975 | 1,0141 | 1,0139 | 1,0166 |
| | ZPR-3-12 | - | 1,0014 | 0,9977 | 1,0104 | 1,0067 | 1,0070 |
| | ZPR-3-11 | ±0,0025 | 1,0083 | 1,0002 | 1,0144 | 1,0063 | 1,0080 |
| | ZEBRA-2 | ±0,0020 | 0,9971 | 0,9906 | 0,9997 | 0,9932 | 0,9852 |
| | ZPR-6-6A | ±0,0005 | 0,9865 | 0,9912 | 0,9938 | 0,9985 | 1,0019 |
| | $k_{eff}$ mean | | | | 1,0061 | 1,0035 | 1,0037 |
| | $\|k_{eff}-1\|$ mean | | | | 0,0083 | 0,0063 | 0,0087 |
| ALL | $k_{eff}$ mean | | | | 1,0032 | 1,0008 | 1,0024 |
| | $\|k_{eff}-1\|$ mean | | | | 0,0068 | 0,0051 | 0,0064 |

a/ Obtained from Ref. [4].

Table 24. Ratio between fission reaction rates of $^{233}U$ and $^{235}U$

| FUEL | CRITICAL ASSEMBLY | EXPERIMENTAL (E) | CALCULATED (C) | | C/E | |
|---|---|---|---|---|---|---|
| | | | AMZ | JFS-2 | AMZ | JFS-2 |
| Pu | VERA-11A | 1,49 ±0,03 | 1,49 | 1,48 | 1,000 | 0,993 |
| | ZEBRA-3 | 1,542 ±0,019 | 1,520 | 1,505 | 0,986 | 0,976 |
| | ZPR-3-56B | 1,478 ±0,015 | 1,461 | 1,440 | 0,988 | 0,974 |
| | ZPPR-2 | 1,446 ±0,022 | 1,441 | 1,420 | 0,997 | 0,982 |
| | C/E mean | | | | 0,993 | 0,981 |
| | \|C/E -1\| mean | | | | 0,007 | 0,019 |
| U | VERA-1B | 1,433 ±0,047 | 1,485 | 1,480 | 1,036 | 1,033 |
| | ZPR-3-6F | 1,53 ±0,03 | 1,52 | 1,51 | 0,993 | 0,987 |
| | ZPR-3-12 | 1,48 ±0,03 | 1,50 | 1,49 | 1,014 | 1,007 |
| | ZPR-3-11 | 1,52 ±0,02 | 1,52 | 1,51 | 1,000 | 0,993 |
| | ZEBRA-2 | 1,453 ±0,014 | 1,460 | 1,456 | 1,005 | 1,002 |
| | C/E mean | | | | 1,010 | 1,004 |
| | \|C/E -1\| mean | | | | 0,012 | 0,012 |
| ALL | C/E mean | | | | 1,002 | 0,994 |
| | \|C/E -1\| mean | | | | 0,010 | 0,015 |

Table 25. Ratio between fission reaction rates of $^{239}Pu$ and $^{235}U$

| FUEL | CRITICAL ASSEMBLY | EXPERIMENTAL (E) | CALCULATED (C) | | C/E | |
|---|---|---|---|---|---|---|
| | | | AMZ | JFS-2 | AMZ | JFS-2 |
| Pu | VERA-11A | 1,07 ±0,02 | 1,15 | 1,15 | 1,075 | 1,075 |
| | ZEBRA-3 | 1,190 ±0,014 | 1,182 | 1,167 | 0,993 | 0,981 |
| | SNEAK-7A | 1,023 ±0,031 | 0,981 | 0,967 | 0,958 | 0,945 |
| | SNEAK-7B | 1,014 ±0,020 | 1,009 | 0,985 | 0,995 | 0,971 |
| | ZPR-3-48 | 0,976[a/] | 0,972 | 0,958 | 0,996 | 0,982 |
| | ZPR-3-56B | 1,028 ±0,010 | 0,980 | 0,962 | 0,953 | 0,936 |
| | ZPPR-2 | 0,9372 ±0,0142 | 0,9281 | 0,9091 | 0,990 | 0,970 |
| | ZPR-6-7 | 0,953[a/] | 0,926 | 0,907 | 0,972 | 0,952 |
| | C/E mean | | | | 0,992 | 0,977 |
| | \|C/E -1\| mean | | | | 0,027 | 0,042 |
| U | VERA-1B | 1,070 ±0,026 | 1,137 | 1,113 | 1,063 | 1,040 |
| | ZPR-3-6F | 1,22 ±0,03 | 1,25 | 1,24 | 1,025 | 1,016 |
| | ZPR-3-12 | 1,12 ±0,02 | 1,12 | 1,09 | 1,000 | 0,973 |
| | ZPR-3-11 | 1,19 ±0,02 | 1,17 | 1,15 | 0,983 | 0,966 |
| | ZEBRA-2 | 0,987 ±0,010 | 0,990 | 0,951 | 1,003 | 0,964 |
| | C/E mean | | | | 1,015 | 0,992 |
| | \|C/E -1\| mean | | | | 0,022 | 0,031 |
| ALL | C/E mean | | | | 1,000 | 0,982 |
| | \|C/E -1\| mean | | | | 0,025 | 0,038 |

a/ Obtained from Ref. [18].

Table 26. Ratio between fission reaction rates of $^{240}Pu$ and $^{235}U$

| FUEL | CRITICAL ASSEMBLY | EXPERIMENTAL (E) | | CALCULATED (C) | | C/E | |
|---|---|---|---|---|---|---|---|
| | | | | AMZ | JFS-2 | AMZ | JFS-2 |
| Pu | VERA-11A | 0,475 | ±0,020 | 0,495 | 0,491 | 1,042 | 1,034 |
| | ZEBRA-3 | 0,373 | ±0,005 | 0,383 | 0,377 | 1,027 | 1,011 |
| | ZPR-3-48 | 0,243[a/] | | 0,258 | 0,254 | 1,062 | 1,045 |
| | ZPR-3-56B | 0,282 | ±0,003 | 0,243 | 0,240 | 0,862 | 0,851 |
| | ZPPR-2 | 0,1704 | ±0,0026 | 0,1943 | 0,1901 | 1,140 | 1,116 |
| | C/E mean | | | | | 1,027 | 1,011 |
| | \|C/E -1\| mean | | | | | 0,062 | 0,051 |
| U | VERA-1B | 0,399 | ±0,032 | 0,477 | 0,453 | 1,195 | 1,135 |
| | ZPR-3-6F | 0,53 | ±0,02 | 0,54 | 0,51 | 1,019 | 0,962 |
| | ZPR-3-11 | 0,34 | ±0,02 | 0,36 | 0,35 | 1,059 | 1,029 |
| | ZEBRA-2 | 0,237 | ±0,004 | 0,254 | 0,245 | 1,072 | 1,034 |
| | C/E mean | | | | | 1,086 | 1,040 |
| | \|C/E -1\| mean | | | | | 0,086 | 0,059 |
| ALL | C/E mean | | | | | 1,053 | 1,024 |
| | \|C/E -1\| mean | | | | | 0,073 | 0,055 |

a/ Obtained from Ref. [18].

Table 27. Ratio between fission reaction rates of $^{238}U$ and $^{235}U$

| FUEL | CRITICAL ASSEMBLY | EXPERIMENTAL (E) | CALCULATED (C) | | C/E | |
|---|---|---|---|---|---|---|
| | | | AMZ | JFS-2 | AMZ | JFS-2 |
| Pu | VERA-11A | 0,077 ±0,002 | 0,084 | 0,084 | 1,091 | 1,091 |
| | ZEBRA-3 | 0,0461 ±0,0008 | 0,0453 | 0,0454 | 0,983 | 0,985 |
| | SNEAK-7A | 0,0449 ±0,0013 | 0,0422 | 0,0414 | 0,940 | 0,898 |
| | SNEAK-7B | 0,0328 ±0,0007 | 0,0332 | 0,0324 | 1,012 | 0,988 |
| | ZPR-3-48 | 0,0321 ±0,0016 | 0,0337 | 0,0332 | 1,050 | 1,034 |
| | ZPR-3-56B | 0,0308 ±0,0003 | 0,0298 | 0,0292 | 0,968 | 0,948 |
| | ZPPR-2 | 0,0201 ±0,0004 | 0,0221 | 0,0195 | 1,100 | 0,970 |
| | ZPR-6-7 | 0,0230 a/ | 0,0220 | 0,0213 | 0,957 | 0,926 |
| | C/E mean | | | | 1,013 | 0,980 |
| | \|C/E -1\| mean | | | | 0,050 | 0,051 |
| U | VERA-1B | 0,0665 ±0,0010 | 0,0785 | 0,0759 | 1,180 | 1,141 |
| | ZPR-3-6F | 0,078 ±0,002 | 0,077 | 0,074 | 0,987 | 0,949 |
| | ZPR-3-12 | 0,047 ±0,002 | 0,049 | 0,048 | 1,043 | 1,021 |
| | ZPR-3-11 | 0,038 ±0,001 | 0,039 | 0,038 | 1,026 | 1,000 |
| | ZEBRA-2 | 0,0320 ±0,0005 | 0,0328 | 0,0325 | 1,025 | 1,016 |
| | ZPR-6-6A | 0,02411±0,00072 | 0,02331 | 0,02276 | 0,967 | 0,944 |
| | C/E mean | | | | 1,038 | 1,012 |
| | \|C/E -1\| mean | | | | 0,053 | 0,048 |
| ALL | C/E mean | | | | 1,024 | 0,994 |
| | \|C/E -1\| mean | | | | 0,052 | 0,050 |

a/ Obtained from Ref. [18].

Table 28. Ratio between rates of capture reaction of $^{238}U$ and fission reaction of $^{235}U$

| FUEL | CRITICAL ASSEMBLY | EXPERIMENTAL (E) | CALCULATED (C) | | C/E | |
|---|---|---|---|---|---|---|
| | | | AMZ | JFS-2 | AMZ | JFS-2 |
| Pu | SNEAK-7A | 0,138 ±0,004 | 0,133 | 0,132 | 0,964 | 0,957 |
| | SNEAK-7B | 0,132 ±0,004 | 0,133 | 0,131 | 1,008 | 0,992 |
| | ZPR-3-48 | 0,131 ±0,007 | 0,133 | 0,131 | 1,015 | 1,000 |
| | ZPR-6-7 | 0,136[a/] | 0,142 | 0,138 | 1,044 | 1,015 |
| | C/E mean | | | | 1,008 | 0,991 |
| | \|C/E -1\| mean | | | | 0,026 | 0,017 |
| U | VERA-1B | 0,131 ±0,006 | 0,122 | 0,126 | 0,931 | 0,962 |
| | ZPR-3-6F | 0,104 ±0,003 | 0,095 | 0,102 | 0,913 | 0,981 |
| | ZPR-3-12 | 0,123 ±0,005 | 0,117 | 0,119 | 0,951 | 0,967 |
| | ZPR-3-11 | 0,112 ±0,005 | 0,107 | 0,112 | 0,955 | 1,000 |
| | ZEBRA-2 | 0,136 ±0,001 | 0,129 | 0,129 | 0,949 | 0,949 |
| | ZPR-6-6A | 0,1378 ±0,0041 | 0,1413 | 0,1386 | 1,025 | 1,006 |
| | C/E mean | | | | 0,954 | 0,978 |
| | \|C/E -1\| mean | | | | 0,054 | 0,025 |
| ALL | C/E mean | | | | 0,976 | 0,983 |
| | \|C/E -1\| mean | | | | 0,043 | 0,021 |

a/ Obtained from Ref. [18].

Table 29. Ratio between rates of capture reaction of $^{238}U$ and fission reaction of $^{239}Pu$

| FUEL | CRITICAL ASSEMBLY | EXPERIMENTAL (E) | CALCULATED (C) | | C/E | |
|---|---|---|---|---|---|---|
| | | | AMZ | JFS-2 | AMZ | JFS-2 |
| Pu | SNEAK-7A | 0,135 a/ | 0,133 | 0,137 | 0,985 | 1,015 |
| | SNEAK-7B | 0,129 a/ | 0,132 | 0,133 | 1,023 | 1,031 |
| | ZPR-3-48 | 0,141 a/ | 0,137 | 0,137 | 0,972 | 0,972 |
| | ZPR-6-7 | 0,1400 ±0,0028 | 0,1531 | 0,1515 | 1,094 | 1,082 |
| | C/E mean | | | | 1,019 | 1,025 |
| | \|C/E -1\| mean | | | | 0,040 | 0,039 |
| U | VERA-1B | 0,122 a/ | 0,107 | 0,114 | 0,877 | 0,934 |
| | ZPR-3-6F | 0,085 a/ | 0,076 | 0,083 | 0,894 | 0,976 |
| | ZPR-3-12 | 0,110 a/ | 0,104 | 0,109 | 0,945 | 0,991 |
| | ZPR-3-11 | 0,094 a/ | 0,091 | 0,097 | 0,968 | 1,032 |
| | ZEBRA-2 | 0,138 a/ | 0,131 | 0,136 | 0,949 | 0,986 |
| | C/E mean | | | | 0,927 | 0,984 |
| | \|C/E -1\| mean | | | | 0,073 | 0,029 |
| ALL | C/E mean | | | | 0,967 | 1,002 |
| | \|C/E -1\| mean | | | | 0,059 | 0,033 |

a/ Obtained from Ref. [18].

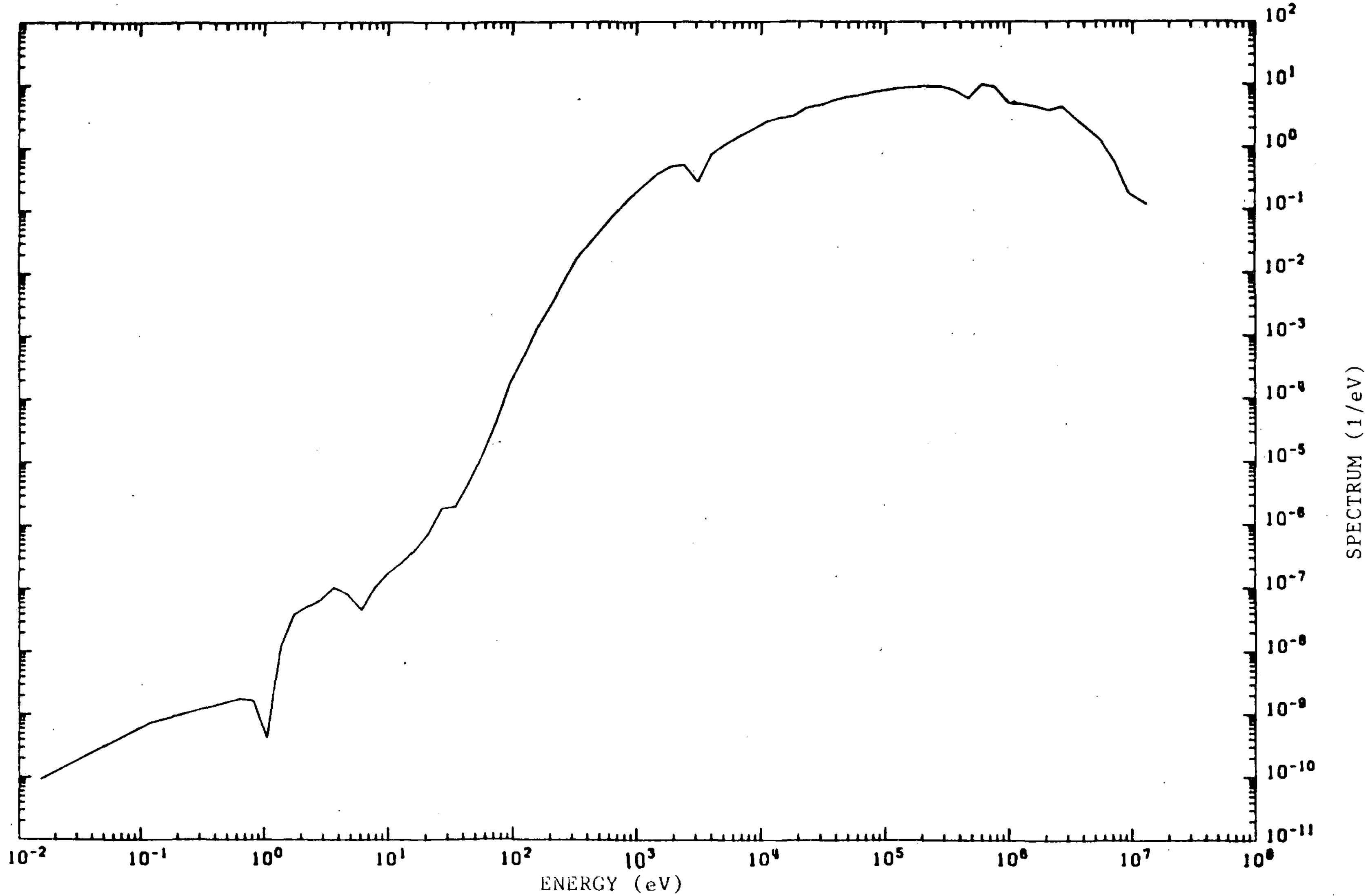


Fig. 1. Weighting spectrum with 70 energy groups generated by MC2

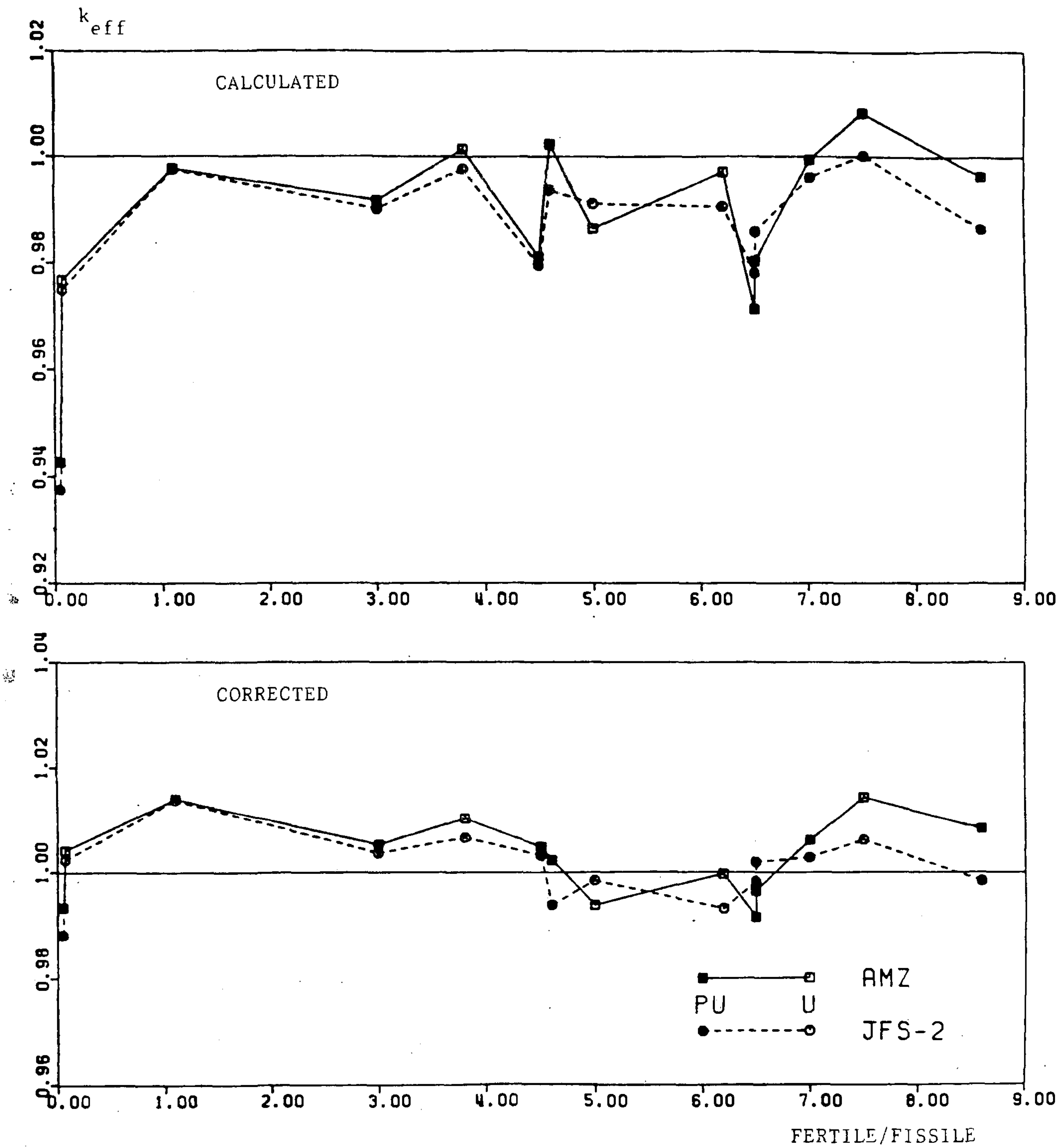


Fig. 2. Values of $k_{eff}$ versus ratio between concentrations of fertile and fissile isotopes

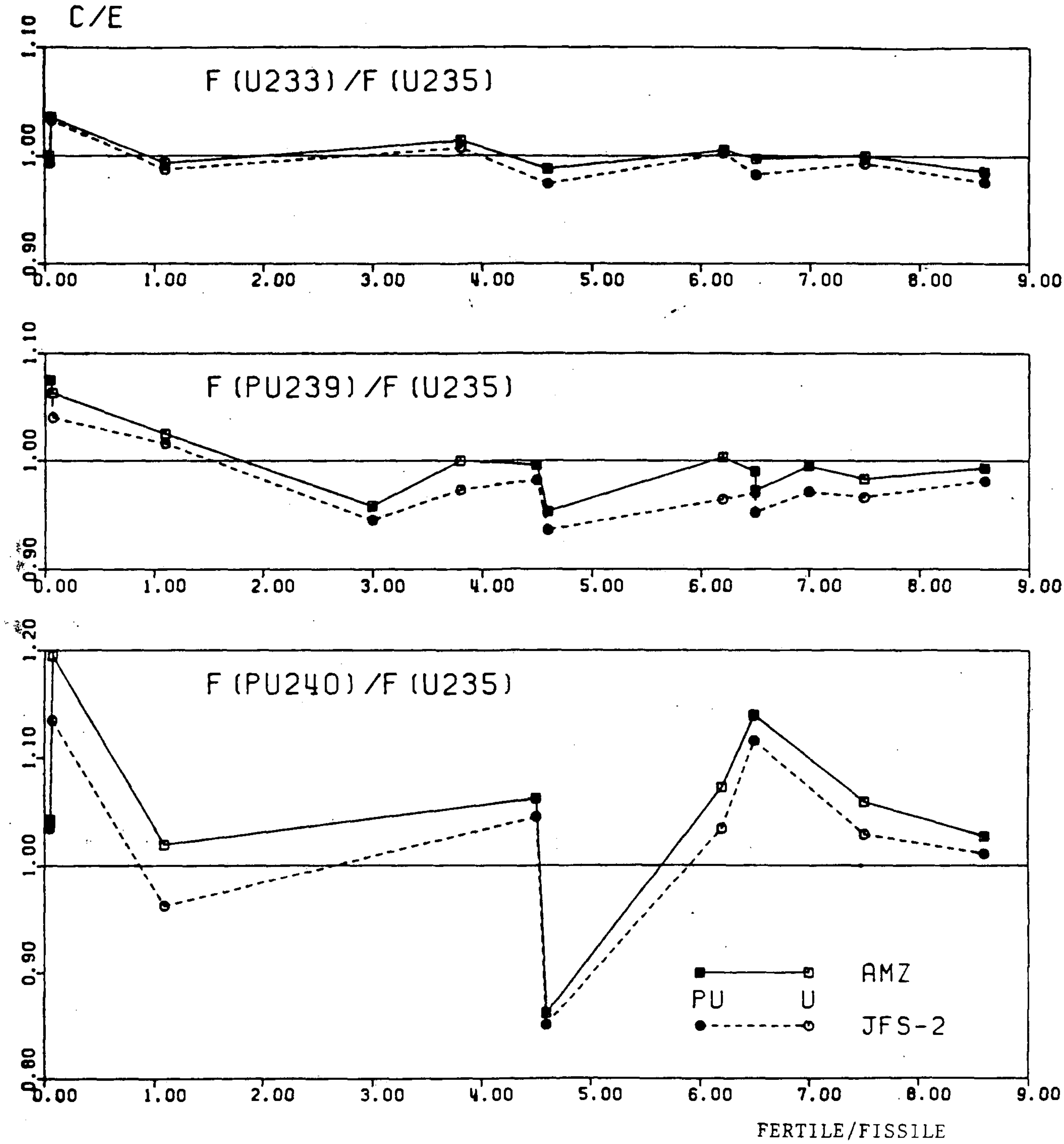


Fig. 3. C/E values of ratios between central reaction rates versus ratio between concentrations of fertile and fissile isotopes

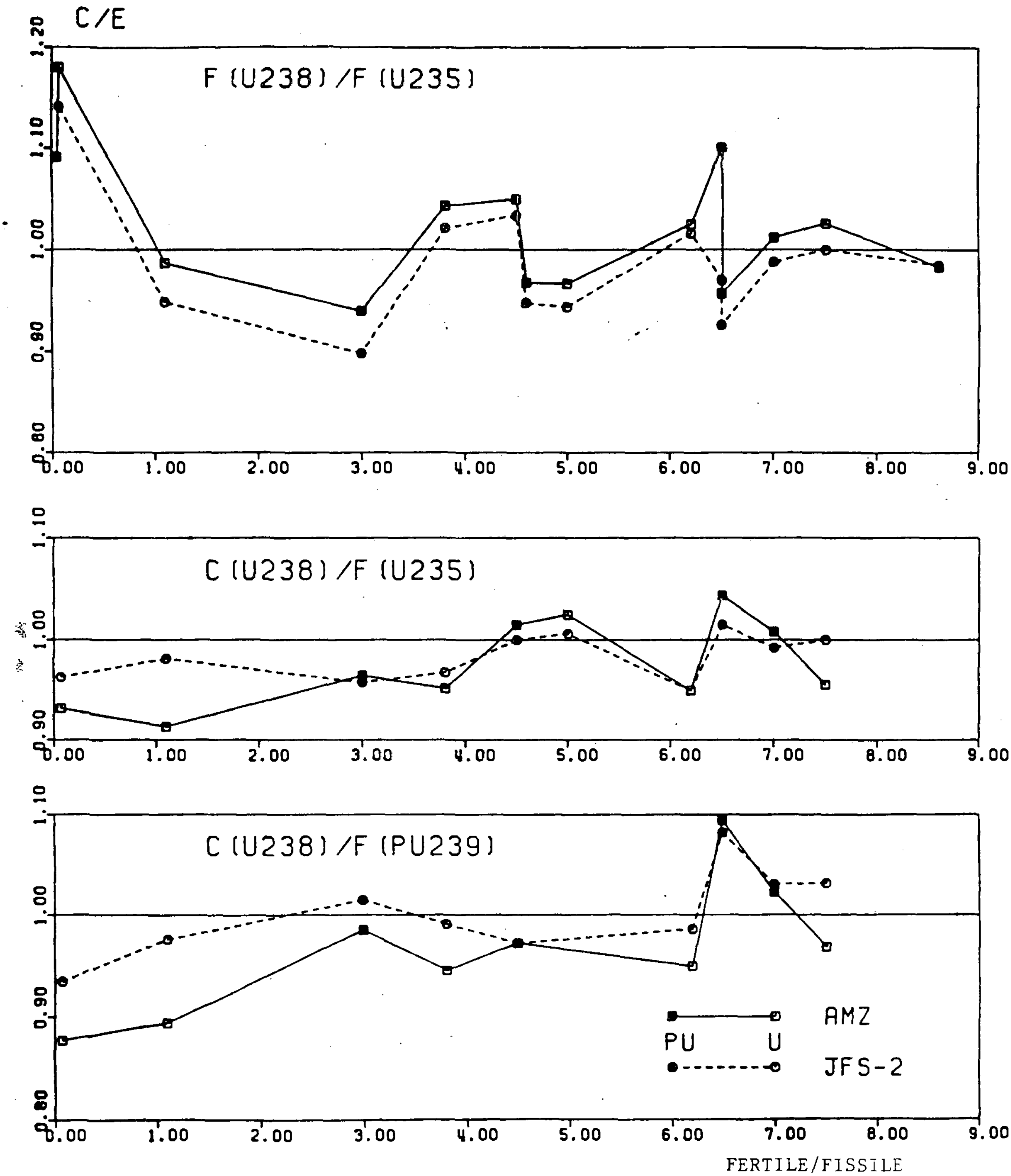


Fig. 4. C/E values of ratios between central reaction rates versus ratio between concentrations of fertile and fissile isotopes

# APPENDIX I

## THE RGENDF PROGRAM

### I.1 Input and output units

| Input | Description |
|---|---|
| 1 | Library produced by the GROUPR module of the NJOY code containing the isotopes to be processed |
| 5 | Input data |
| 7 | Library previously in existence, to be updated |

| Output | Description |
|---|---|
| 6 | Print-out |
| 8 | New AMZ library to be created |

### I.2 Input data

CARD 1 Format 5I5

JCODE = 1

NMAT Number of isotopes to be processed. A maximum of 5 isotopes may be allowed for processing owing to the limitation imposed by the memory of CDC-CYBER 170/750.

When

NMAT > 0, NMAT isotopes will form a new library or will be added to a library already in existence;

NMAT < 0, |NMAT| isotopes will be replaced in a library already in existence;

NMAT = 0, A statement of the isotopes contained in a library already in existence will be printed; in this case the other variables of the card and the other input cards, with the exception of card 7, will be omitted.

| | |
|---|---|
| NFIS | Number of isotopes to be processed containing the fission cross-section |
| NGR | Number of energy groups |
| NSIGØ | Number of values of $\sigma_o$ used |
| <u>CARD 2</u> | Format 5I5 (only if NMAT < 0) |
| (MATD (IM) IM=1, \|NMAT\|) | Identification of the isotopes, in accordance with JAERI, to be replaced in the library already in existence. |
| <u>CARD 3</u> | Format E10.5, 5I5 |
| AMAS(IM) | Atomic mass of isotope IM |
| MAT(IM) | Identification of isotope IM, in accordance with ENDF/B |
| MCODE(IM) | Identification of isotope IM, in accordance with JAERI |
| MSF(IM) | Control variable indicating which values of $\sigma_o$ are adopted for the isotope IM<br><br>MSF = 0 ; 1,E10<br>MSF = 1 ; 1,E10, 1,E-10, 1,E1, 1,E2, 1,E3, 1,E4, 1,E5<br>MSF = 2 ; 1,E10, 1,E-10, 1,E0, 1,E1, 1,E2, 1,E3, 1,E4 |
| IFIS(IM) | Control variable indicating whether the fission cross-section will be processed (= 1) or not (= 0) for the isotope IM. |
| NRF5(IM) | Control variable indicating whether reaction 18 of file 5 (normalized fission spectrum) will be processed (= 1) or not (= 0) for the isotope IM. |
| <u>CARD 4</u> | Format 2I5 |
| NRF3(IT,IM) | Number of reactions (max. 10) of file 3 of ENDF/B to be processed |
| NRF6(IT,IM) | Number of reactions (max. 10) of file 6 of ENDF/B to be processed |

| | |
|---|---|
| CARD 5 | Format 10I5 |
| (IR3(IR,IT,IM)<br>IR=1, NRF3) | Identification of reaction IR of file 3 in accordance with ENDF/B. Reaction IR=100 will always be required for calculation of $\sigma_c$. |
| CARD 6 | Format 10I5 |
| (IR6(IR,IT,IM)<br>IR=1, NRF6) | Identification of reaction IR of file 6 in accordance with ENDF/B.<br><br>With respect to the inelastic scattering matrix, the first and last excited states and the continuum state must be provided where they exist. |
| CARD 7 | Format 6A10 |
| (TIT(I),<br>I=1,6) | Title to be given to the library produced, which will only be printed |
| N.B.: (a) | When MSF=1, 2 or 3, temperatures of 300, 900 and 2100 K are considered internally by the program. When MSF=0, a single temperature (300 K) will be considered. |
| (b) | Cards 4-6 are repeated for each temperature IT. |
| (c) | Cards 3-6 are repeated for each isotope IM. |

## I.3 Examples of input data

Case 1

```
   1       5       2      70       7
95.95           1287      42       2       0       0
   6       3
   1       2       4      16     100     251
   2      16      91
   5       1
   1       2       4      16     100
   2
   5       1
   1       2       4      16     100
   2
235.117         1261     925       1       1       0
   8       5
   1       2       4      16      18     100     251     452
   2      16      51      66      91
   6       1
   1       2       4      16      18     100
   2
   6       1
   1       2       4      16      18     100
   2
239.052         1264     949       1       1       1
   8       5
   1       2       4      16      18     100     251     452
   2      16      51      76      91
   6       1
   1       2       4      16      18     100
   2
   6       1
   1       2       4      16      18     100
   2
15.9994         1276       8       2       0       0
   5       3
   1       2       4     100     251
   2      51      56
   4       1
   1       2       4     100
   2
   4       1
   1       2       4     100
   2
12.0110         1274       6       2       0       0
   5       3
   1       2       4     100     251
   2      51      91
   4       1
   1       2       4     100
   2
   4       1
   1       2       4     100
   2
AMP7CF4   OUT83
```

Case 2

```
   1    -2      0    70     1
 105   115
10.0161    1273   105     0     0     C
   5     3
   1     2      4   100   251
   2    51     67
11.0093    1160   115     0     0     0
   5     4
   1     2      4   100   251
   2    51     53    91
AMP70E4   OUT83
```

# APPENDIX II

## STRUCTURE OF THE LIBRARY USED BY EXPANDA

The library used by the EXPANDA code is drawn up in binary format with two types of record.

The first record contains constants and control variables needed for interpreting the second data record and for processing with the EXPANDA code:

MCODE(IM), IM=1,N (N = No. of materials)

Identification of materials in accordance with JAERI

MSF(IM), IM=1,N

Control variable indicating for each material which values of $\sigma_o$ have been adopted in drawing up the tables of self-shielding factors given in the second data record.

MSF = 1, $\sigma_o$ = 0, 10, 100, 1000, 10000, 100000

MSF = 2, $\sigma_o$ = 0, 1, 10, 100, 1000, 10000

MSF = 0, no value. In this way the data contained in the tables of self-shielding factors are equalized to unity.

CHI(I), I = 1, NGR

Normalized fission spectrum

T(IT), IT = 1,3

Temperatures in degrees K
300, 900, and 2100 K

TAB1(IC), IC = 1,6

Constants for interpolation used when MSF=1

TAB2(IC), IC = 1,6

Constants for interpolation used when MSF=2

AM(IM), IM = 1,N

Atomic masses of materials

DU(I), I = 1, NGR

Lethargy width of groups

The second data record, which is divided into two parts, contains the multi-group constants and is repeated for each energy group, beginning with the highest. The first part relates to constants obtained by infinite dilution ($\sigma_o = \infty$) and at a temperature of 300 K:

$\sigma_f$, $\bar{\nu}_f$, $\sigma_c$, $\sigma_{in}$, $\sigma_e$, $\bar{\mu}$, $\sigma_{er}$,

$\sigma_e$ $(g \rightarrow g')$ , $g' = 1,30$,

$\sigma_{in}(g \rightarrow g')$ , $g' = 1,30$,

whereby each of these reactions is given as:

$\sigma_x(IM)$, IM = 1, N

The second part relates to the self-shielding factors obtained for six values of $\sigma_o$ (in accordance with the variable MSF) and at three temperatures (300, 900 and 2100 K):

$F_{f1}$, $F_{f2}$, $F_{c1}$, $F_{c2}$, $F_{e1}$, $F_{e2}$, $F_{t1}$, $F_{t2}$, $F_{r1}$, $F_{r2}$;

representing the fission, capture, elastic, total and removal reactions calculated for two atomic density ratios of two resonant nuclei. Each of these factors is given as follows:

$F_x(IS,IT,IM)$, IS = 1,6, IT = 1,3, IM = 1,N

When one of these reactions does not exist, the corresponding data contained in the tables of factors F are equalized to unity.

# APPENDIX III

## SPECIFICATIONS OF CRITICAL ASSEMBLIES IN THE FORMAT OF EXPANDA CODE INPUT DATA

### III.1 Nuclei of Pu

```
----*----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8

BENCHMARK TESTS FOR SPHERICAL NUCLEI OF Pu
                    70     0     3     0     0     0    25
925928949940006008011013024025026028029042942941014001041923924926082031050
0     0112345680 07  0 1        VERA-11A
  1  3 +1 70  0  0 29  0  2 -1 +1 +1  1 1. -5 1. -4 0.     0.    1.
  2     14     11     5
  3      2     40    80
  4     70
  5.34975.349751.0750
  6 300.  300.  300.
  8949 7.213     -3940 3.7      -4941 2.8      -5 31 4.49     -4  6 4.6204    -211
  8 26 6.084     -3 24 1.579    -3 28 6.65     -4 29 7.402    -3 82 3.5       -512
  8 50 4.3       -5923 1.0     -10925 1.0     -10928 1.0     -10               13
  8949 7.213     -3940 3.7      -4941 2.8      -5 31 4.49     -4  6 4.6204    -221
  8 26 6.084     -3 24 1.579    -3 28 6.65     -4 29 7.402    -3 82 3.5       -522
  8 50 4.3       -5                                                           23
  8 26 6.5       -3 24 1.7      -3 28 7.1      -4925 2.5      -4928 3.44      -231
 1 949 2 949 3 949
0     02235800000 10  0 0       SNEAK-7A
  2     16     16    10
  3      2     50    60
  5 .57   .57  1.0
  8 13 8.0       -6  6 2.60987  -2 24 2.2423   -3 26 7.9713   -3 25 1.109     -411
  8 42 1.65      -5 41 8.9      -6 28 1.1664   -3  8 2.18462  -2949 2.6374    -312
  8940 2.369     -4941 2.15     -5942 1.1      -6 14 9.33     -5925 5.86      -513
  8928 7.9604    -3                                                           14
  8 13 8.0       -6  6 2.60987  -2 24 2.2423   -3 26 7.9713   -3 25 1.109     -421
  8 42 1.65      -5 41 8.9      -6 28 1.1664   -3  8 2.18462  -2949 2.6374    -322
  8940 2.369     -4941 2.15     -5942 1.1      -6 14 9.33     -5925 5.86      -523
  8928 7.9604    -3                                                           24
  8  6 1.35      -5 24 1.108    -3 26 3.9549   -3 25 8.75     -5 42 1.0       -531
  8 41 8.5       -6 28 9.845    -4 14 4.53     -5925 1.624    -4928 3.99401   -232
0     0323580000 08  0 0        ZPR-3-48
  2     15     15     7
  3      2     60    80
  5 .6225.758621.5
  8949 1.645     -3940 1.06     -4941 1.1      -5942 4.0      -7925 1.6       -511
  8928 7.405     -3  6 2.077    -2 11 6.231    -3 26 1.018    -2 24 2.531     -312
  8 28 1.119     -3 42 2.06     -4 13 1.09     -4 25 1.06     -4 14 1.24      -413
  8949 1.645     -3940 1.06     -4941 1.1      -5942 4.0      -7925 1.6       -521
  8928 7.405     -3  6 2.077    -2 11 6.231    -3 26 1.018    -2 24 2.531     -322
  8 28 1.119     -3 42 2.06     -4 13 1.09     -4 25 1.06     -4 14 1.24      -423
  8925 8.3       -5928 3.969    -2 26 4.925    -3 24 1.225    -3 28 5.36      -431
  8 25 5.1       -5 14 6.0      -6                                            32
0     0423580000 07  0 0        ZPR-3-56B
  2     15     12     6
  3      2     54    80
  5 .9763 .97631.3205
  8925 1.4       -5928 6.195    -3949 1.358    -3940 1.81     -4  8 1.5       -211
  8  6 1.03      -3 11 8.669    -3 24 2.5      -3 26 1.37     -2 28 1.09      -312
  8 42 3.43      -4 25 2.2      -4923 1.0     -10924 1.0     -10924 1.0     -1013
  8925 1.4       -5928 6.195    -3949 1.358    -3940 1.81     -4  8 1.5       -221
  8  6 1.03      -3 11 8.669    -3 24 2.5      -3 26 1.37     -2 28 1.09      -322
  8 42 3.43      -4 25 2.2      -4                                            23
  8 11 7.879     -3 24 1.941    -3 26 7.824    -3 28 4.2261   -2 25 3.0       -431
```

```
----*----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

BENCHMARK TESTS FOR SPHERICAL NUCLEI OF Pu

```
                               70      0      3      0      0      0     25
9259289499400060080110130240250260280290429429410140010419239249260120220 23
0     0512345680O 08  0 1        ZPR-6-7
  1  3 +1 70  0  0 29  0  2 -1 +1 +1  1 1. -5 1. -4 0.     0.     1.
  2     12    12     8
  3      2    60    80
  4     70
  5 .58  1.5   1.6905
  6 300.  300.  300.
  8949 8.8672    -4940 1.1944    -4941 1.33     -5925 1.26      -5928 5.78036  -211
  8 42 2.357     -4 11 9.2904    -3  8 1.398    -2 26 1.297     -2 24 2.709    -212
  8 28 1.24      -3 25 2.12      -4                                              13
  8949 8.8672    -4940 1.1944    -4941 1.33     -5925 1.26      -5928 5.78036  -221
  8 42 2.357     -4 11 9.2904    -3  8 1.398    -2 26 1.297     -2 24 2.709    -222
  8 28 1.24      -3 25 2.12      -4                                              23
  8925 8.56      -5928 3.96179   -2 42 3.8      -6  8 2.4       -5 26 4.637    -231
  8 24 1.295     -3 28 5.635     -4 25 9.98     -5                               32
 1 949 2 949 3 949
0     0623580O000 10  0 0       SNEAK-7B
  2     18    16    10
  3      2    58    78
  5 .7007 .70071.5000
  8 13 1.2112    -3  6 6.31     -5 24 2.756    -3 26 9.8021    -3  1 7.1      -611
  8 12 9.5       -6 25 6.46     -5 42 1.84     -5 41 8.4       -6 28 1.4594   -312
  8  8 3.31936   -2949 1.8312   -3940 1.645    -4941 1.49      -5942 7.0      -713
  8 14 1.174     -4925 2.663    -4928 1.45794  -2                                14
  8 13 1.2112    -3  6 6.31     -5 24 2.756    -3 26 9.8021    -3  1 7.1      -621
  8 12 9.5       -6 25 6.46     -5 42 1.84     -5 41 8.4       -6 28 1.4594   -322
  8  8 3.31936   -2949 1.8312   -3940 1.645    -4941 1.49      -5942 7.0      -723
  8 14 1.174     -4925 2.663    -4928 1.45794  -2                                24
  8  6 1.35      -5 24 1.108    -3 26 3.9549   -3 25 8.75      -5 42 1.0      -531
  8 41 8.5       -6 28 9.845    -4 14 4.53     -5925 1.624     -4928 3.99401  -232
0     0723580O000 11  0 0       ZEBRA-3
  2     19    16    13
  3      2    50    80
  5 .4736 .47361.0167
  8949 3.466     -3940 1.834    -4941 1.27     -5925 2.264     -4928 3.1775   -211
  8 29 4.3702    -3 26 4.578    -3  6 4.2      -5 24 8.64      -4 42 8.0      -612
  8 25 6.4       -5 28 4.83     -4 13 1.9      -5 22 1.6       -5 14 5.4      -513
  8 23 5.0       -6923 1.0     -10924 1.0     -10926 1.0      -10               14
  8949 3.466     -3940 1.834    -4941 1.27     -5925 2.264     -4928 3.1775   -221
  8 29 4.3702    -3 26 4.578    -3  6 4.2      -5 24 8.64      -4 42 8.0      -622
  8 25 6.4       -5 28 4.83     -4 13 1.9      -5 22 1.6       -5 14 5.4      -523
  8 23 5.0       -6                                                              24
  8925 2.98      -4928 4.1269   -2 29 4.0      -6 28 3.323     -3  6 4.2      -531
  8 24 8.64      -4 42 8.0      -5 25 6.4      -5 28 4.83      -4 13 1.9      -532
  8 22 1.6       -5 14 5.4      -5 23 5.0      -6                                33
```

```
----*----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

BENCHMARK TESTS FOR CYLINDRICAL NUCLEI OF Pu

```
                               70      0      3      0      0      0     25
9259289499400060080110130240250260280290429429410140019239249260230229948951
0     0112345678O 18  0 1        ZPPR-2
  1  5 +1 70  0  0 29  0  1 -1 +1 +1  1 1. -5 1. -4 0.     0.     1.
  2     19    19    19    14     8
  3      2    40    60    76    80
  4     70
  51.61  1.61  1.23352.36252.9275
  6 300.  300.  300.  300.  300.
  7  5.92    -4  5.92    -4  5.92    -4  5.92    -4  5.92    -4                 11
  8949 8.433     -4940 1.117    -4941 1.53     -5942 1.8       -6948 6.0      -711
  8951 2.9       -6925 1.23     -5926 5.5549   -3  6 3.0       -5  8 1.3116   -212
  8 11 8.796     -3 13 3.0      -6 26 1.2576   -2 24 2.702     -3 26 1.221    -313
  8 25 2.09      -4 29 1.9      -5 42 2.31     -4 14 1.37      -4923 1.0     -1014
  8924 1.0      -10926 1.0     -10                                               15
  8949 8.433     -4940 1.117    -4941 1.53     -5942 1.8       -6946 6.0      -721
  8951 2.9       -6925 1.23     -5926 5.5549   -3  6 3.0       -5  8 1.3116   -222
  8 11 8.796     -3 13 3.0      -6 26 1.2576   -2 24 2.702     -3 29 1.221    -323
  8 25 2.09      -4 29 1.9      -5 42 2.31     -4 14 1.37      -4                24
  8949 1.2741    -3940 1.687    -4941 2.31     -5942 2.8       -6948 9.0      -731
  8951 4.3       -6925 1.15     -5928 5.1980   -3  6 2.3       -5  8 1.1761   -232
  8 11 8.564     -3 13 4.0      -6 26 1.3652   -2 24 2.523     -3 28 1.160    -333
  8 25 2.02      -4 29 2.0      -5 42 3.41     -4 14 1.16      -4                34
  8925 2.4       -5928 1.1085   -2  6 1.013    -3  8 2.01325   -2 11 6.15996  -241
  8 13 2.5472    -6 26 7.26117  -3 24 2.09004  -3 28 9.467     -4 25 1.66302  -442
  8 29 1.75472   -5 42 1.45472  -5 14 9.83776  -5  1 8.0       -6                43
  8  6 5.58      -4 26 7.5161   -2 24 1.205    -3 28 5.13      -4 25 5.98     -451
  8 29 1.3       -5 42 1.2      -5 14 9.1      -5                                52
 1 949 2 949 3 949
```

III.2 Nuclei of U

```
----*----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8

BENCHMARK TESTS FOR SPHERICAL NUCLEI OF U
                             70     0     3     0     0     0    21
925928006008011013024025026028029042014926001924023022923949940
0     01123456800 06  0 1       VERA-1B
   1  3 +1 70  0  0 29  0  2 -1 +1 +1  1 1. -5 1. -4 0.     0.    1.
   2    12     9     5
   3     2    40    80
   4    70
   5 .4785 .4785 .9863
   6 300.  300.  300.
   8925 7.349     -3926 1.4      -5924 9.2      -5928 4.55     -4  6 5.754     -211
   8  1 5.8       -5 26 6.283    -3 24 1.635    -3 28 6.89     -4923 1.0      -1012
   8949 1.0      -10940 1.0      -10                                            13
   8925 7.349     -3926 1.4      -5924 9.2      -5928 4.55     -4  6 5.754     -221
   8  1 5.8       -5 26 6.283    -3 24 1.635    -3 28 6.89     -4                22
   8925 2.5       -4928 3.44     -2 26 6.464    -3 24 1.682    -3 28 7.08      -431
  1 925 2 925 3 925
0     02235800000 07  0 0       ZPR-3-6F
   2    11     8     7
   3     2    50    80
   5 .4599 .45991.0167
   8925 6.727     -3928 7.576    -3924 6.9      -5 13 1.9019   -2 26 7.712     -311
   8 24 1.918     -3 28 8.39     -4 25 8.0      -5923 1.0      -10949 1.0     -1012
   8940 1.0       -10                                                           13
   8925 6.727     -3928 7.576    -3924 6.9      -5 13 1.9019   -2 26 7.712     -321
   8 24 1.918     -3 28 8.39     -4 25 8.0      -5                               22
   8925 8.9       -5928 4.0026   -2 13 1.359    -3 26 4.539    -3 24 1.129     -331
   8 28 4.94      -4 25 4.7      -5                                             32
0     03235800000 07  0 0       ZPR-3-12
   2    11     9     7
   3     2    50    80
   5 .5752 .57521.0167
   8925 4.516     -3928 1.6946   -2924 4.6      -5  6 2.6762   -2 26 5.704     -311
   8 24 1.419     -3 28 6.21     -4 25 5.9      -5 14 6.9      -5923 1.0      -1012
   8949 1.0       -10                                                           13
   8925 4.516     -3928 1.6948   -2924 4.6      -5  6 2.6762   -2 26 5.704     -321
   8 24 1.419     -3 28 6.21     -4 25 5.9      -5 14 6.9      -5                22
   8925 8.9       -5928 4.0026   -2 26 4.971    -3 24 1.237    -3 28 5.41      -431
   8 25 5.2       -5 14 6.0      -5                                             32
0     04235800000 06  0 0       ZPR-6-6A
   2     8     6     7
   3     2    70    80
   5 .83341.38243.0650
   8925 1.153     -3926 5.8176   -3 11 9.2904   -3  8 1.39     -2 26 1.3431    -211
   8 28 1.291     -3 24 2.842    -3 25 2.21     -4                               12
   8925 1.153     -3928 5.8176   -3 11 9.2904   -3  8 1.39     -2 26 1.3431    -221
   8 28 1.291     -3 24 2.842    -3 25 2.21     -4                               22
   8925 8.55      -5928 3.95503  -2  6 2.3      -5 26 4.4669   -3 28 5.407     -431
   8 24 1.247     -3 25 9.6      -5                                             32
0     05235800000 10  0 0       ZEBRA-2
   2    20    15    13
   3     2    52    80
   5 .7250 .88001.1322
   8925 2.526     -3928 1.5667   -2  1 3.0676   -4  8 1.544    -4 26 3.6485    -311
   8 24 8.64      -4 29 4.0      -6 42 8.0      -6 25 6.4      -5 28 4.63      -412
   8 13 1.9       -5 22 1.6      -5 14 5.4      -5 23 5.0      -6  6 3.7992    -213
   8923 1.0      -10924 1.0      -10926 1.0     -10949 1.0     -10940 1.0     -1014
   8925 2.526     -3928 1.5667   -2  1 3.0676   -4  8 1.544    -4 26 3.6485    -321
   8 24 8.64      -4 29 4.0      -6 42 8.0      -6 25 6.4      -5 28 4.83      -422
   8 13 1.9       -5 22 1.6      -5 14 5.4      -5 23 5.0      -6  6 3.7992    -223
   8925 2.98      -4928 4.1769   -2 26 3.323    -3 24 8.64     -4 29 4.0       -631
   8 42 8.0       -6 25 6.4      -5 28 4.63     -4 13 1.9      -5 22 1.6       -532
   8 14 5.4       -5 23 5.0      -6  6 4.2      -5                               33
0     06235800000 07  0 0       ZPR-3-11
   2    11     7     6
   3     2    50    80
   5 .6322 .63221.0000
   8925 4.567     -3928 3.4392   -2924 4.6      -5 26 5.681    -3 24 1.486     -311
   8 28 7.18      -4 25 2.08     -3923 1.0      -10949 1.0     -10940 1.0     -1012
   8926 1.0       -10                                                           13
   8925 4.567     -3928 3.4392   -2924 4.6      -5 26 5.681    -3 24 1.486     -321
   8 28 7.18      -4 25 2.08     -3                                              22
   8925 8.9       -5928 4.0025   -2 26 4.925    -3 24 1.196    -3 28 5.36      -431
   8 25 1.11      -4                                                            32
 1
```