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R MATRIX ANALYSIS OF ^{239}Pu NEUTRON CROSS-SECTIONS IN THE ENERGY RANGE 0 eV to 1000 eV

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RESUME

Ce rapport décrit les résultats de travaux d'analyse des sections efficaces neutroniques expérimentales de ^{239}Pu dans le domaine des résonances résolues effectués à ORNL en utilisant le code multiniveaux-multivoies SAMMY. Les paramètres des résonances ont été obtenus dans le domaine d'énergie 0 eV à 1000 eV. La liste des paramètres de résonances est donnée de même que quelques propriétés statistiques de ces paramètres. Des comparaisons tabulées et graphiques entre les sections efficaces expérimentales et calculées sont faites. Les résultats de l'analyse sont disponibles à la banque de données de l'AEN dans le format ENDF/B-V et seront utilisés dans les bibliothèques de données évaluées JEF2 et ENDF/B-VI.

ABSTRACT

The report is a description of the analysis of the ^{239}Pu neutron cross-sections in the resolved resonance region at ORNL using the multilevel-multichannel Reich-Moore code SAMMY. The resonance parameters were obtained in the energy range 0 eV to 1000 eV. The table of the resonance parameters is given with some statistical properties of the parameters. Tabulated and graphical comparisons between the experimental data and the calculated cross-sections are given. The results are available in ENDF/B-V format and will be used in the evaluated data library JEF2 and ENDF/B-VI.

I - INTRODUCTION

In order to improve the representation of the ^{239}Pu cross-sections by using a multilevel-multichannel formalism and to extend the resolved resonance range up to 1 keV, ^{239}Pu cross-sections measurements were analyzed with the resonance analysis Bayesian code SAMMY using the Reich-Moore R-matrix formalism. Preliminary results have been presented in the report ORNL/TM-10098[1] in which more informations could be found concerning the purpose of the analysis, the data analyzed[2-9] and the method of the analysis. The aim of the present report is to present : 1) the new set of resonance parameters obtained from a complementary work performed in 1987 by using an up-dated version of SAMMY ; 2) some properties of the resonances parameters in comparison to the results obtained at Saclay in 1973[10] ; 3) detailed graphical and tabular comparisons between the cross-sections calculated from the resonance parameters and the experimental data analyzed. A more extensive study of the resonance properties and a discussion of their significance will be submitted for a journal publication.

II - THE RESONANCE PARAMETERS

The list of the resonance parameters is given in Table I. The cross-sections in the energy range 0 eV to 1 keV are described by 393 resonances including 4 bound levels and 3 resonances in the energy range above 1 keV. It is hoped that the parameters of the 7 fictitious outside resonances represent correctly the contributions of the truncated external levels to the range of interest, in such a way that the cross-sections could be properly described in the energy range 0 eV to 1 keV without the need of a smooth-file contribution and by using a constant effective radius R' = 0.948 f. The value of R' is strongly correlated to the parameters of the fictitious resonances at - 150 eV and at 1100 eV and to the accuracy of the normalization coefficients of the experimental transmissions analyzed ; it is known with about 2 % accuracy.

The new set of resonance parameters is improved in comparison to the values published in ORNL/TM-10098 in regard to the following points :

1) more experimental data have been included in the thermal region and all the data were normalized to the ENDF/B-VI standard values at 2200 m/s. The standard values at 2200 m/s are reproduced by the resonance parameter within the error bars (see Table IX),

2) some energy range above 300 eV containing broad resonances with large fission widths have been reanalyzed in regard to the spin assignment. An attempt has been made to assign the spin 0^+ to all the broad resonances, since the fully open fission channel is a 0^+ fission channel. In the new set of parameters, only 4 broad resonances remain in the 1^+ spin group, against 20 in the previous set. This situation is more realistic than the previous one,

3) some difficulties due to the exponential tail of the resolution function were encountered in the analysis of the high energy range of the data. The so-called exponential folding width was previously taken as a constant in SAMMY. A careful least square shape analysis of some isolated resonances or well defined group of resonances has shown that this parameter varies roughly like $1/\sqrt{E}$ in the HARVEY transmission data. After up-dating SAMMY to take into account this variation, the transmission fits were greatly improved leading to more accurate values of the neutron widths,

4) some bias was introduced in the parameters of the high energy range analyzed, due to a lack of accuracy in SAMMY for the calculation of the DOPPLER and resolution broadening when the channel width of the experimental data is large compared to the natural width of the resonances. That was particularly true for WESTON[6] fission cross-sections. The up-dated version of SAMMY allows an accurate calculation in each case by using an input parameter for the definition of the number of calculated points in each resonance,

5) above 500 eV no systematic search was made on the capture widths in the previous analysis. That was done in the new set of parameters and realistic values of $\Gamma\gamma$ were obtained for most of the well defined resonances.

III - SOME COMMENTS ON THE RESONANCE PARAMETERS

III.1 - The resonance spin

The repartition between the two possible spin 0^+ and 1^+ is roughly the same than in reference 10. The fission width distribution (fig. 6) shows an evidence of two families of resonances corresponding to two different average fission widths. One family is caracterized by a small average value of about 30 meV and the other by a large value of about 2500 meV. The first family should correspond to a partially open 1^+ fission channel and the second to the 0^+ fully open fission channel. One estimates from the fission width distribution that almost all of the resonances having a fission width larger than 300 meV are 0^+ resonances, and about 95 % of the resonances having a fission width smaller than 300 meV are 1^+ resonances. Several authors have assigned the spin 0^+ to some of the narrow resonances, mainly from scattering measurements[11,12,13]. There is few differences between the spin assignments made in the present work and those found in the litterature. These differences should not be considered as a new tentative of spin attributions ; they correspond to resonances located mainly in energy regions where the shape of the cross-sections is rather complicated and where the best solution was probably not found.

III.2 - The level spacing

The spacing stairstep histogram, shown on figure 1, is linear in the energy range 0 eV to 480 eV with an average level spacing of 2.40 eV. Between 480 eV and 1000 eV the spacing stairstep is still linear but with an average level spacing of 2.71 eV, which means that, compared to the energy range 0 eV to 480 eV, there is a constant fraction of 17 % of missed levels in the energy range 480 eV to 1000 eV. That is due to the expected effect of the resolution in the experimental data when the neutron energy increases. A non negligible fraction of the levels could also be missed in the low energy part of the data, as it will be shown in the next section from the neutron width distribution.

III.3 - The neutron widths and the s-wave strength function

The cumulative reduced neutron width stairstep histogram is shown on figure 2. The s-wave strenght function in the energy range 0 eV to 1000 eV is given by the average slope of the histogram, and is equal to the following walue :

$$So = \left(\sum_{E_1}^{E_2} g\, \Gamma^\circ_n\right)/(E_2-E_1) = (1.145 \pm 0.082) \times 10^{-4}$$

With $E_1 = 0$ eV and $E_2 = 1000$ eV

The local values of the strength function fluctuate strongly as it is shown on table II. The largest value, $(1.992 \pm 0.446) \times 10^{-4}$, is obtained in the 500 eV to 600 eV interval and the smallest value, $(0.723 \pm 0.159) \times 10^{-4}$, in the 400 eV to 500 eV interval. The errors are the sampling errors. These strong fluctuations suggest a non statistical effect in the entrance channel.

Table II shows the comparison with the results obtained at Saclay (10) from similar transmission data in the energy range 0 eV to 600 eV. The Saclay neutron widths were used as prior informations in SAMMY with error values ranging from 20 to 50 %. There is an overall agreement between ORNL and Saclay results. However, one should note some local deviations, particularly in the energy range 300 eV to 400 eV and 500 eV to 600 eV where the Saclay strength function is 6 % to 7 % smaller. These differences are due to the very wide 0^+ resonances at 365.40 eV and 510.51 eV which were not used in Saclay analysis. As a matter of fact, the multilevel Breit- Wigner formalism used in Saclay analysis was much less accurate for the representation of the 0^+ resonances than the SAMMY Reich-Moore multilevel-multichannel formalism used in the present work. The agreement is excellent for the narrow resonances for which the multilevel Breit-Wigner formalism is equivalent to the Reich-Moore formalism. A comparison is given in Table III for the individual $g\Gamma n$ value of the narrow resonances in the energy range 500 eV to 600 eV.

The integral distributions of the reduced neutron widths are shown in fig. 3 for the energy range 0 eV to 480 eV and in fig. 4 for the energy range 0 eV to 1000 eV. Though the fraction of missed levels is larger in the second sample than in the first, both distributions have the same behaviour. The experimental distribution is poorly fitted by the Porter-Thomas distribution. Apparently about 15 % of small $g\Gamma_n^o$ values are missing in the energy range 0 eV to 470 eV and a correct value of the average s-wave level spacing could be (2.10 $\pm$ 0.20) eV.

III.4 - The fission widths

At least one fully open fission channel is available for the low energy neutron induced reaction on ^{239}Pu. It is a 0^+ fission channel corresponding to the fondamental rotational band of ^{240}Pu compound nucleus. Since the average level spacing of the 0^+ resonances is about 9 eV, the corresponding average fission width, $\langle\Gamma_f\rangle = D/2\pi$, could be as large as 1.5 eV, justifying that one should a priori assign the spin 0^+ to the broad resonances. Some other 0^+ collective states could exist in the sectrum of the highly deformed nucleus, justifying that at least two 0^+ fission channels should be used in the Reich-Moore calculations. As for the 1^+ transition states, they could not be found in the low lying collective states of the even-even compound nucleus. Since the fission widths of the 1^+ resonances are relatively important, a 1^+ fission channel must be found not too far from the neutron binding energy. This evidence brought J.J GRIFFIN[14] to consider a 1^+ transition state by combining the collective states formed from the mass-assymmetry and bending vibrations. As a matter of fact, the situation is not as bad as it was foreseen by GRIFFIN in 1965 in view of the experimental results of FRASER et al.[11] on the ^{239}Pu resonance spin assignments. The average fission width of the 1^+ resonance is much smaller than the one expected at this time ; in more recent works[22], it was found to be smaller than 40 meV, which corresponds to a fission threshold at about 300 keV above the neutron binding energy, when GRIFFIN was looking for a fission channel at less than 500 keV below the neutron binding energy.

The integral distributions of the total fission widths in the energy ranges 0 eV to 480 eV and 0 eV to 1 keV are shown on figures 5 and 6. They are similar to those already published in reference 10. The existence of two families of resonances is obvious. As mentioned above, the shape of the distribution was used for a prior assignment of the resonance spins. One should also note that the width of the $(n,\gamma f)$ process, which was found to be equal to about 3 meV by several authors[15,16], is not negligible compared to the average fission width of the 1^+ resonances. A constant value of 3 meV was substracted to all the fission widths in figures 5 and 6. A quite good description of the shape of the distributions is obtained by a sum of two χ^2 distribution, $P(\nu,x)$, with the average parameters given in Table IV. The average value of the fission widths of the narrow resonances obtained in the energy range 0 eV to 1000 eV is 37.0 meV (or 34.0 meV without the $(n,\gamma f)$ process). For the broad resonances, the average value is 2800 meV which corresponds to an effective number of fission channels,

$N_{eff} = 2\pi <\Gamma f>/<D>$, of about 2. According to this quite large value, in addition to the fully 0^+ open channel, more than one partially open 0^+ channel could exist with average fission widths of several hundred meV. Therefore, the splitting of the 0^+ fission widths in only two components is questionable and has probably no physical meaning, more especially as equivalent solution could be found by rotation of the fission vectors in the channel space configuration. In this regard, the results obtained in the energy range 0 eV to 200 eV in reference 10, for the 0^+ fission channel properties, could be revised.

The 1^+ fission component corresponds to a subthreshold fission. An intermediate structure, due to a double humped fission barrier, could exist in this component. A detailed study of the average 1^+ fission widths is found in reference 10 where it was concluded that the small value of the average fission width of the narrow resonances in the 110 eV energy interval centered at 610 eV cannot be explained by the usual Porter-Thomas fluctuations of the parameters. The results of the present work confirm the small average value in the energy interval 550 eV to 660 eV as it is shown on Table V. But such non statistical behaviour is not apparent on Table VI where the average parameters are given in energy interval of 100 eV from 0 eV to 1000 eV.

III.5 - The capture widths

The capture width appears explicitly in the reduced R-matrix expression of the Reich-Moore formalism. The derivative of all the cross-sections can be calculated with respect to the capture widths and search on the capture width could be made even if the cross-section sample analyzed does not include experimental capture data. In this case, if the results obtained for the capture widths are consistent (reasonable fluctuations about a constant average value for all the resonances in all energy intervals), one could expect than the cross-section sample analyzed is also consistent and that adequate width and shape of the resolution function have been used. In the present work, experimental capture cross-sections were used only below 30 eV.

In the 0 eV to 1000 eV energy range, search on Γ_γ have been made on 64 % of the identified resonances. The fluctuations observed in the results could be as large as 40 % with respect to the average value. These fluctuations are present mainly in the small or not well resolved resonances, in correlation with the corresponding poor accuracy obtained on the fission widths. The average values over 100 eV energy intervals are shown on Table VI. Below 500 eV, the data are quite consistent and one obtains $\langle\Gamma_\gamma\rangle$ = 41.14 meV, in very good agreement with the result obtained in reference 10. Above 500 eV, the data are still consistent, but the average value of 45.75 meV is 10 % higher ; that is mainly due to the increasing number of non resolved multiplets when the neutron energy increases.

III.6 - The correlation matrices

Due to computer time and space, the full correlation matrix for the nearly 1600 parameters used for the calculation of the cross-sections in the energy range 0 eV to 1000 eV was not obtained. The SAMMY calculations were performed separately in the 9 energy intervals shown on Table XI. The totality of the parameters were used in each energy interval, but the Bayes equations were solved only for the resonance parameters of the energy interval analyzed. The partial correlation matrices are available and should be associated to the parameters of Table I for the evaluation of the error bars. Some sample of correlation matrices are given in Table VII and Table VIII for the energy range 30 eV to 153 eV and 770 eV to 900 eV. The errors on the resonance parameters are quite small ; they should be increased to take into account some systematic experimental effects not included in SAMMY and the difficulties in fitting the data for small or not well resolved resonances.

IV - THE CROSS-SECTIONS

IV.1 - The thermal range

The cross-sections at 0.0253 eV are supposed to be known with an accuracy better than 1 %, (0.25 % for fission, 0.8 % for capture and 0.5 % for total cross-sections) ; they were obtained by the ENDF/B-VI standard evaluation group from an experimental data base including all the available experimental data and the correlation coefficients for all the fissile isotopes[17]. Since recommendations have been made to avoid the use of a background file in the evaluated data files, one should reproduce these highly accurate values by the evaluated resonance parameters. That is also a way to show that the evaluated thermal values have a real meaning in terms of at least one set of R-matrix resonance parameters, which was not obvious a priori. For this purpose, a SAMMY fit was performed in the energy range 0.01 eV to 5 eV using as input the resonance parameters obtained by fitting the higher energy region up to 1 keV. The experimental data base was GWIN et al. fission, capture and absorption cross-sections[2,4,7] published in 1971, 1976 and 1984, and SPENCER et al. transmission data[8]. All the data were renormalized in the energy range 0.02 eV to 0.06 eV to an average cross-section value equivalent to the new standard value at 0.0253 eV. A renormalization of the energy scale on SPENCER transmission data was also performed by a preliminary fit on the 0.29 eV resonance for each separated data set. The adjustment on the standard values in SAMMY calculations was obtained by varying only the parameters of 3 negative energy resonances and the parameters of the 0.29 eV resonance. The cross-sections obtained at 0.0253 eV from the resonance parameters are shown on Table IX. They agree very well with the experimental standard values.

The average cross-sections in the energy range 0.02 eV to 0.65 eV over the 0.29 eV resonance are shown on Table X. ORNL-RPI data are consistent within about 1 % with the calculated values. Data from DERUYTER[18] and WAGEMANS[5], which were not included in the SAMMY fit, are also shown on Table X. When normalized on the same thermal standard value, they are 2 % to 3 % larger over the 0.29 eV resonance. New results have been obtained recently by WAGEMANS et al.[19], showing an agreement better than 1 % with GWIN 1984 data. These new WAGEMANS results should be in very good agreement with the present evaluation.

Figures 7 and 8 illustrate the results of the SAMMY fit in the low energy region.

IV.2 - Cross-sections in the resolved resonance region

a) Background and normalization problems

In ORELA transmission measurements, the normalization coefficients are known with better than 1 % accuracy. The error due the background corrections is also very small. Therefore, the scattering radius and the contribution of the non identified external resonances should be carefully chosen to avoid a non realistic variation of the background and normalization correction parameters in the SAMMY calculations. Starting from guessed parameters for the external resonance contributions and a realistic value of 9.50 f for the scattering radius, a preliminary SAMMY fit was performed on the experimental transmissions in 9 energy intervals by letting free the normalization and background parameters. The values obtained for these parameters are shown on Table XI. The background corrections are very small, as expected. But the normalization corrections vary from - 2 % in the lower energy range to 5 % in the higher energy range, which is an indication that one should decrease the contribution of the external resonances. Starting from a new set of external resonance parameters, chosen to minimize the above corrections, a second series of SAMMY fit was performed leading to the corrections parameters shown on Table XII. These corrections were considered small enough to provide a good starting point for the definitive fit including the fission data.

Some a priori informations on the normalization and the background are also needed for the experimental fission cross-sections. The fission cross-sections are generally normalized on the same standard at thermal energy. But discrepancies could appear even at energies not far from the normalization region, as it was shown above in the low energy range when comparing ORELA and GEEL data (see Table X). In the present work, only GWIN 1984[7], WESTON 1984[6] and BLONS 1973[3] fission data have been considered in the resolved resonance region. The 1984 ORELA data are known to be obtained with very good experimental background conditions. BLONS 1973 data were obtained in better resolution conditions (longer flight path and sample cooled down at liquid nitrogen temperature) ; but an accurate evaluation of a quite large background in the experimental data was difficult both in the fission rate measurements and in the neutron flux measurements[20]. Starting from this prior informations (small corrections on WESTON data and larger corrections on BLONS data), and with the covariance matrices obtained in the second fit of the transmissions mentioned above, a serie of SAMMY fits were performed on WESTON 1984 and BLONS 1973 fission data with a search on the normalization and background corrections. The results are shown on Table XIII, suggesting the following comments :

- a rather stable normalization correction of 1.2 % on average and small background corrections are obtained on WESTON data. The agreement between the calculated and experimental cross-sections is excellent (better than 0.5 %). BLONS normalization corrections, about 5 % on average, vary strongly and are strongly correlated to a rather high background correction ; in spite of the fact that large variations were allowed on the correction parameters, larger deviations are observed between the calculated cross-sections and the experimental data,

- the last line is an example of results which should be obtained if the same constraints are applied to BLONS and WESTON data (small variations allowed on the normalization and background corrections). The correction parameters obtained for BLONS data are surprisingly very small but the discrepancy between the calculated and the experimental cross-sections is very important (more than 10 %). The conclusion is that, at least in the energy range considered, it is impossible to find a consistent fit of HARVEY, WESTON and BLONS data without allowing a large variation of the background correction in BLONS data,

- the search on normalization and background corrections was made before renormalizing WESTON data on the new thermal standard. The renormalization results in an increase of 0.85 % on WESTON fission and the average variation of WESTON normalization on Table XIII should decrease to 0.37 %.

In conclusion, WESTON 1984 fission and HARVEY transmissions are consistent with no or small normalization and background adjustment. BLONS data are not consistent with WESTON and HARVEY data and need important correlated normalization and background adjustment. In the energy range 30 eV to 1000 eV, the final SAMMY runs were performed on the renormalized WESTON fission and on HARVEY transmission with the external resonance parameters obtained in the preliminary calculations and no background or normalization adjustment. In the energy range below 30 eV, GWIN 1984 data were also included in the fit. The resonance parameters obtained are representative of ORELA cross-section measurements.

b) Presentation of some results

Table XIV shows the average fission cross-sections calculated with the resonance parameters and the values proposed by the ENDF/B-VI standard evaluation group[17]. The standard values were obtained from a large experimental data base including all the correlated standard cross-sections. The small error bars on the standard values are due to a statistical processing of a large number of experimental data and it seems that the systematic errors were also considered by the standard evaluation group as statistical errors with zero mean. The calculated cross-sections and WESTON cross-sections are on average 3.5 and 3.1 % smaller than the proposed standard values ; BLONS data are on average 1.7 % larger. As it has been explained above, the systematic errors on WESTON data are quite small, when they could be very large on BLONS data. That is in complete disagreement with the results of the standard evaluation group, especially concerning the very small error bars obtained. The authors of the present work have the feeling that many of the experimental fission cross-sections suffer of an underestimation of the experimental background, leading to systematic overestimate of the cross-sections. That is particularly true for BLONS data. The proposed standard values could be wrong by about + 3 % in the resolved resonance region, which is in conflict with the claimed 0.7 % to 0.8 % accuracy.

Because of the poor statistical accuracy, large statistical uncertainties and contamination by chemical or isotopical impurities, the direct capture or absorption measurements were not included in the SAMMY fit. Accurate absorption cross-sections should be calculated by the parameters obtained from the analysis of the transmission and fission experimental data. Table XV shows the average calculated values of the capture, absorption and alpha compared to GWIN 1976 data. Below 500 eV the calculated absorption agree quite well with GWIN 1976 data. Above 500 eV, they are on average 4.5 % lower, and the calculated alpha values are also on average 4.5 % lower. In the energy range 100 eV to 1000 eV, the calculated alpha values agree very well with WESTON and TODD 1972 evaluation [21].

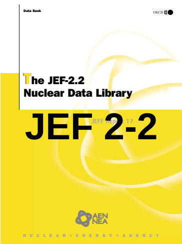
The fission and capture resonance integrals are compared to ENDF/B-V on Table XVI. The fission and capture integrals calculated from the present evaluation are respectively 1.95 % and 5.03 % smaller than ENDF/B-V values.

Figure 9 to figure 21 provide a detailed graphical comparison between the results of several measurements and the corresponding quantities as computed from the resonance parameters of Table I. The curves represent the calculated values ; the crosses or the vertical bars (error bars) represent the measured values. Figure 9 shows the results in the energy range 6 eV to 30 eV ; the upper part of the figure represents HARVEY et al. transmission ratios of the 0.0064 and 0.0180 atom/b samples ; the data for the thin sample were displaced by 0.5 for clarity of the display ; the lower part shows GWIN 1984 and WESTON 1984 fission data ; WESTON 1984 were displaced by two decades. Figure 10 to figure 21 show the data in the energy range 30 eV to 1000 eV. The upper part of the figures represent HARVEY et al. transmission ratios for the 0.0064, 0.0180 and 0.0787 atom/b samples ; the data for the thin sample and the medium sample are displaced by 0.25 and 0.5 respectively. The lower part of the figure shows WESTON 1984 and BLONS 1973 fission data ; BLONS data were displaced by two decades. Most of the figure indicate that BLONS fission cross-sections are much larger than WESTON values in the resonance valleys, suggesting a remaining background of about 2 barns at 40 eV (figure 10), 1.5 barn at 150 eV (figure 13), 0.7 barn at 500 eV (figure 17) and 850 eV (figure 20) in BLONS data.

Figure 22 shows an example of the differences between the shape of the fission cross-sections calculated from ENDF/B-V and in the present evaluation. ENDF/B-V calculations were displaced by one decade. The experimental data are from WESTON 1984. This figure illustrates the improvement obtained of the representation of the fission cross-sections shape by the REICH-MOORE code SAMMY, compared to the BREIT-WIGNER representation in ENDF/B-V. Similar comparisons are shown in the same energy interval for the capture cross-section on figure 23. In the valleys between resonances there are large differences between SAMMY calculations and ENDF/B-V calculations ; the ENDF/B-V representation often results in an unphysical structure as would be expected because of the non physical formalism used : between resonances the cross-sections are mostly determined by the "smooth background" file 3. More comparisons between SAMMY calculations and ENDF/B-V representation could be found in ORNL/TM-10098.

V - SUMMARY AND CONCLUSIONS

Several sets of ^{239}Pu neutron cross-section data, both recent and old, have been analyzed using R-matrix theory combined with Bayesian equations, a technique which provides a powerful tool for cross-section evaluation procedures. This analysis provides a consistent and precise description of various sets of fission, capture, and transmission data. The evaluation also provides an accurate method for cross-section interpolation at the valleys between resonances where the capture and fission cross-sections are exceedingly small, making accurate measurements difficult, and where the single-level formalisms grossly misrepresent the data. The present analysis is a great improvement over previous evaluations in that it provides a good and consistent representation of the high resolution transmission ratios of Harvey et al. and the high accuracy recent fission measurement of Weston and Todd and Gwin et al.



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-1.5002E+02 1.0000E+00 4.2894E-01 4.4516E-02 1.9172E-01 0.0000E+009439 2151
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 4.1736E+01 1.0000E+00 9.3502E-04 3.9475E-02 5.9249E-02 0.0000E+009439 2151
 4.4531E+01 1.0000E+00 6.1318E-03 4.0162E-02-4.2461E-03 0.0000E+009439 2151
 4.7534E+01 0.0000E+00 4.6984E-03 3.1464E-02 4.8148E-01-1.2739E-079439 2151
 4.9576E+01 0.0000E+00 4.1515E-03 4.2000E-02-1.0493E+00 4.9827E-039439 2151
 5.0144E+01 1.0000E+00 3.2536E-03 2.2649E-02-4.8501E-03 0.0000E+009439 2151
 5.2648E+01 1.0000E+00 9.4602E-03 4.4199E-02-8.7811E-03 0.0000E+009439 2151
 5.5704E+01 1.0000E+00 1.5078E-03 3.8263E-02 2.3565E-02 0.0000E+009439 2151
 5.6924E+01 0.0000E+00 1.1362E-02 4.2000E-02-2.2043E+00 2.5304E-029439 2151
 5.9291E+01 1.0000E+00 4.4449E-03 3.6777E-02 9.5812E-02 0.0000E+009439 2151
 6.1621E+01 0.0000E+00 2.7411E-02 4.2000E-02 7.0977E+00 6.6792E-039439 2151
 6.3170E+01 1.0000E+00 6.2939E-04 3.7383E-02 7.0308E-02 0.0000E+009439 2151
 6.5454E+01 0.0000E+00 4.0071E-03 2.4113E-02 4.5020E-01-2.1169E-169439 2151
 6.5793E+01 1.0000E+00 9.6909E-03 6.4784E-02 1.0596E-01 0.0000E+009439 2151
 7.4167E+01 1.0000E+00 3.2109E-03 3.2080E-02-2.8841E-02 0.0000E+009439 2151
 7.4885E+01 0.0000E+00 2.8770E-03 4.2000E-02 1.2527E-03-3.4027E-019439 2151
 7.5034E+01 1.0000E+00 2.0886E-02 4.2752E-02-8.6432E-02 0.0000E+009439 2151
 7.9085E+01 1.0000E+00 4.2916E-05 4.2000E-02 6.0000E-03 0.0000E+009439 2151
 8.0872E+01 0.0000E+00 4.6193E-03 4.2000E-02 1.8596E+00-1.7602E-039439 2151
 8.2774E+01 1.0000E+00 3.3118E-04 4.7000E-02 5.0000E-03 0.0000E+009439 2151
 8.5507E+01 0.0000E+00 4.8833E-02 5.1000E-02-1.8444E+00 3.0442E-039439 2151
 8.5618E+01 1.0000E+00 8.1945E-03 2.6352E-02 5.6947E-03 0.0000E+009439 2151
 9.0850E+01 1.0000E+00 1.2209E-02 3.4209E-02 7.1466E-03 0.0000E+009439 2151
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<u>Table I</u>

Energy, angular momentum, capture width, neutron width, fission width (channel 1), fission width (channel 2) of 239 Pu resonances in ENDF/B-V format.

14130245

9.3079E+01	1.0000E+00	6.7496E-04	3.7726E-02	-2.8135E-03	0.0000E+00	9439	2151
9.5509E+01	1.0000E+00	2.0784E-03	6.4127E-02	-3.2108E-02	0.0000E+00	9439	2151
9.6465E+01	0.0000E+00	6.6349E-03	4.2000E-02	1.5003E+00	-2.1350E-01	9439	2151
9.9399E+01	0.0000E+00	2.7133E-02	4.2000E-02	-1.3268E-01	9.9451E+00	9439	2151
1.0314E+02	1.0000E+00	1.6464E-03	3.4626E-02	7.0250E-03	0.0000E+00	9439	2151
1.0546E+02	1.0000E+00	4.7159E-03	4.3650E-02	4.8470E-03	0.0000E+00	9439	2151
1.0683E+02	1.0000E+00	9.9439E-03	3.8191E-02	-2.0920E-02	0.0000E+00	9439	2151
1.1055E+02	1.0000E+00	4.9620E-04	5.3818E-02	2.0372E-02	0.0000E+00	9439	2151
1.1442E+02	0.0000E+00	2.3513E-03	4.2000E-02	-1.4574E+00	3.0317E-01	9439	2151
1.1532E+02	1.0000E+00	2.1667E-04	4.2000E-02	1.6000E-01	0.0000E+00	9439	2151
1.1619E+02	0.0000E+00	1.0055E-02	3.2644E-02	-1.3959E-01	-4.9309E-02	9439	2151
1.1900E+02	1.0000E+00	1.6904E-02	4.1217E-02	-4.0865E-02	0.0000E+00	9439	2151
1.2118E+02	1.0000E+00	2.5735E-03	3.6094E-02	2.5628E-02	0.0000E+00	9439	2151
1.2362E+02	1.0000E+00	5.8035E-04	7.4979E-02	-6.4558E-02	0.0000E+00	9439	2151
1.2639E+02	1.0000E+00	1.7424E-03	4.6630E-02	-9.9365E-03	0.0000E+00	9439	2151
1.2772E+02	1.0000E+00	5.3777E-04	3.8339E-02	1.0836E-02	0.0800E+00	9439	2151
1.3177E+02	0.0000E+00	3.5654E-02	4.2000E-02	3.9491E+00	-9.8495E-03	9439	2151
1.3398E+02	1.0000E+00	5.8612E-03	3.9457E-02	-3.5603E-03	0.0000E+00	9439	2151
1.3694E+02	0.0000E+00	1.1038E-02	3.3704E-02	3.1863E-04	-9.0161E-02	9439	2151
1.3945E+02	1.0000E+00	9.1096E-05	4.2000E-02	-1.9300E-02	0.0000E+00	9439	2151
1.4316E+02	1.0000E+00	3.2586E-03	2.8137E-02	4.6288E-02	0.0000E+00	9439	2151
1.4367E+02	1.0000E+00	4.5743E-03	4.0390E-02	3.0756E-02	0.0000E+00	9439	2151
1.4647E+02	1.0000E+00	7.3904E-03	4.0647E-02	7.9677E-03	0.0000E+00	9439	2151
1.4741E+02	0.0000E+00	4.9775E-03	4.2000E-02	2.4105E+00	1.6162E-03	9439	2151
1.4844E+02	1.0000E+00	3.3534E-04	5.0929E-02	3.3148E-02	0.0000E+00	9439	2151
1.4965E+02	1.0000E+00	1.6047E-03	3.6497E-02	2.4128E-02	0.0000E+00	9439	2151
1.5717E+02	1.0000E+00	1.2000E-03	4.2000E-02	6.0000E-03	0.0000E+00	9439	2151
1.5717E+02	0.0000E+00	3.0422E-02	3.6197E-02	1.7249E-01	6.0745E-01	9439	2151
1.6215E+02	1.0000E+00	1.1077E-04	3.5600E-02	1.5400E-02	0.0000E+00	9439	2151
1.6471E+02	1.0000E+00	2.8060E-02	4.5008E-02	-7.6748E-03	0.0000E+00	9439	2151
1.6729E+02	1.0000E+00	6.1724E-03	4.4296E-02	6.6839E-02	0.0000E+00	9439	2151
1.7007E+02	1.0000E+00	1.2681E-04	4.2000E-02	3.0000E-03	0.0000E+00	9439	2151
1.7067E+02	1.0000E+00	4.2811E-04	4.0684E-02	4.7647E-02	0.0000E+00	9439	2151
1.7081E+02	0.0000E+00	3.4950E-03	4.2000E-02	-3.5961E-02	1.6240E+00	9439	2151
1.7132E+02	1.0000E+00	2.5000E-05	4.2000E-02	3.0000E-03	0.0000E+00	9439	2151
1.7617E+02	1.0000E+00	2.1751E-03	4.9109E-02	3.1918E-02	0.0000E+00	9439	2151
1.7741E+02	1.0000E+00	3.6415E-03	4.3445E-02	6.6894E-03	0.0000E+00	9439	2151
1.7909E+02	1.0000E+00	1.2554E-03	3.3928E-02	9.0926E-03	0.0000E+00	9439	2151
1.8383E+02	1.0000E+00	1.5833E-03	3.7542E-02	1.3836E-02	0.0000E+00	9439	2151
1.8476E+02	0.0000E+00	1.9189E-02	4.2000E-02	-2.3374E+00	9.5844E-02	9439	2151
1.8847E+02	1.0000E+00	6.4878E-04	4.4492E-02	1.4782E-02	0.0000E+00	9439	2151
1.9084E+02	1.0000E+00	1.6801E-03	4.1694E-02	-1.0894E-02	0.0000E+00	9439	2151
1.9129E+02	0.0000E+00	1.1621E-03	4.2000E-02	4.0540E-02	3.1684E+00	9439	2151
1.9540E+02	0.0000E+00	5.3000E-02	2.2136E-02	-6.4097E-01	3.3884E-04	9439	2151
1.9692E+02	1.0000E+00	3.9107E-03	3.9005E-02	1.4582E-02	0.0000E+00	9439	2151
1.9961E+02	1.0000E+00	9.0316E-03	4.7353E-02	7.1593E-02	0.0000E+00	9439	2151
2.0363E+02	1.0000E+00	1.7014E-03	2.3061E-02	2.2087E-02	0.0000E+00	9439	2151
2.0407E+02	0.0000E+00	6.2883E-02	5.6078E-02	1.4505E-01	3.1181E-01	9439	2151
2.0760E+02	1.0000E+00	7.2268E-03	4.5715E-02	6.6815E-03	0.0000E+00	9439	2151
2.1100E+02	0.0000E+00	3.2460E-03	4.2000E-02	-1.0688E-01	1.3248E+00	9439	2151
2.1350E+02	1.0000E+00	3.6061E-04	3.8250E-02	3.2153E-02	0.0000E+00	9439	2151
2.1465E+02	0.0000E+00	9.2960E-03	4.2000E-02	1.1171E+01	-2.2798E-01	9439	2151
2.1550E+02	1.0000E+00	4.6000E-05	4.2000E-02	3.4000E-02	0.0000E+00	9439	2151
2.1677E+02	1.0000E+00	6.2371E-03	3.7331E-02	5.6296E-03	0.0000E+00	9439	2151
2.1971E+02	1.0000E+00	3.5379E-03	3.8558E-02	2.1292E-02	0.0000E+00	9439	2151
2.2047E+02	1.0000E+00	7.7322E-03	3.9047E-02	-1.1407E-02	0.0000E+00	9439	2151
2.2341E+02	1.0000E+00	3.3835E-03	3.3574E-02	4.8768E-03	0.0000E+00	9439	2151
2.2513E+02	1.0000E+00	1.7305E-03	5.6842E-02	2.0835E-02	0.0000E+00	9439	2151
2.2651E+02	0.0000E+00	1.0648E-02	4.2000E-02	-1.4870E+00	-2.6981E+00	9439	2151
2.2814E+02	1.0000E+00	1.7830E-03	3.8809E-02	-1.6512E-02	0.0000E+00	9439	2151
2.3021E+02	0.0000E+00	5.5265E-03	4.2000E-02	3.0363E+00	-2.8453E-02	9439	2151
2.3165E+02	1.0000E+00	1.2738E-02	3.7519E-02	6.5179E-03	0.0000E+00	9439	2151

Table I (continued)

14130246

2.3284E+02	1.0000E+00	3.7327E-04	4.2000E-02	2.7000E-02	0.0000E+00	9439	2151
2.3358E+02	0.0000E+00	9.6568E-03	4.2000E-02	4.2457E+00	-2.8025E-01	9439	2151
2.3457E+02	1.0000E+00	1.0249E-02	3.5178E-02	7.3032E-03	0.0000E+00	9439	2151
2.3931E+02	1.0000E+00	5.5360E-03	4.1249E-02	-1.2130E-02	0.0000E+00	9439	2151
2.4084E+02	1.0000E+00	3.3300E-05	4.2000E-02	3.4000E-02	0.0000E+00	9439	2151
2.4314E+02	1.0000E+00	6.6481E-03	3.8573E-02	-6.0311E-02	0.0000E+00	9439	2151
2.4777E+02	1.0000E+00	7.9692E-04	4.4827E-02	1.3831E-01	0.0000E+00	9439	2151
2.4912E+02	1.0000E+00	1.5001E-02	3.7481E-02	-5.0291E-03	0.0000E+00	9439	2151
2.5149E+02	1.0000E+00	2.9429E-02	3.4239E-02	1.0272E-02	0.0000E+00	9439	2151
2.5485E+02	1.0000E+00	3.0236E-03	4.4110E-02	3.7139E-02	0.0000E+00	9439	2151
2.5616E+02	0.0000E+00	1.6291E-03	4.1500E-02	8.7585E-01	1.0050E-03	9439	2151
2.5638E+02	1.0000E+00	5.5758E-03	4.2042E-02	-1.0544E-02	0.0000E+00	9439	2151
2.5926E+02	1.0000E+00	2.6400E-04	4.1500E-02	-3.6000E-02	0.0000E+00	9439	2151
2.6243E+02	0.0000E+00	8.2926E-02	4.2000E-02	-2.4749E+00	2.8448E+00	9439	2151
2.6301E+02	1.0000E+00	2.2718E-03	3.5444E-02	-8.0545E-03	0.0000E+00	9439	2151
2.6449E+02	1.0000E+00	1.6500E-04	4.1500E-02	2.1000E-02	0.0800E+00	9439	2151
2.6936E+02	1.0000E+00	1.2132E-03	4.1473E-02	-5.5479E-02	0.0000E+00	9439	2151
2.6984E+02	1.0000E+00	4.0898E-03	2.4755E-02	1.8413E-02	0.0000E+00	9439	2151
2.7291E+02	1.0000E+00	2.6410E-02	4.1396E-02	-4.2369E-02	0.0000E+00	9439	2151
2.7506E+02	0.0000E+00	3.8795E-02	4.2000E-02	8.7455E-02	8.6368E-01	9439	2151
2.7588E+02	1.0000E+00	2.2399E-02	4.1850E-02	5.5478E-02	0.0000E+00	9439	2151
2.7619E+02	0.0000E+00	2.8489E-02	4.2000E-02	9.5666E+00	1.7832E-02	9439	2151
2.7986E+02	1.0000E+00	7.9042E-03	3.4171E-02	-2.8023E-02	0.0000E+00	9439	2151
2.8322E+02	1.0000E+00	2.7522E-02	3.9368E-02	5.9778E-03	0.0000E+00	9439	2151
2.8602E+02	1.0000E+00	2.0000E-04	4.1500E-02	1.0000E-02	0.0000E+00	9439	2151
2.8832E+02	1.0000E+00	9.3300E-05	4.1500E-02	-3.4000E-02	0.0000E+00	9439	2151
2.9184E+02	0.0000E+00	2.0972E-02	4.2000E-02	-6.3065E+00	1.6089E-02	9439	2151
2.9266E+02	1.0000E+00	3.5651E-03	2.7408E-02	2.1283E-02	0.0000E+00	9439	2151
2.9305E+02	0.0000E+00	5.0446E-04	4.2000E-02	1.0624E-04	-6.5534E-01	9439	2151
2.9680E+02	1.0000E+00	3.3737E-03	4.8793E-02	-3.2621E-02	0.0000E+00	9439	2151
2.9892E+02	1.0000E+00	1.0437E-02	5.0867E-02	2.7311E-02	0.0000E+00	9439	2151
3.0215E+02	1.0000E+00	1.8857E-02	4.7527E-02	-5.0214E-02	0.0000E+00	9439	2151
3.0858E+02	1.0000E+00	3.2501E-03	3.1956E-02	1.2687E-01	0.0000E+00	9439	2151
3.0935E+02	1.0000E+00	1.4019E-02	4.9404E-02	2.3430E-02	0.0000E+00	9439	2151
3.1122E+02	0.0000E+00	1.3702E-03	4.2000E-02	1.2968E+00	1.0069E-03	9439	2151
3.1150E+02	1.0000E+00	2.4156E-04	4.2000E-02	3.2000E-03	0.0000E+00	9439	2151
3.1397E+02	1.0000E+00	1.4691E-02	3.8948E-02	-1.0075E-02	0.0000E+00	9439	2151
3.1701E+02	1.0000E+00	5.6432E-03	3.8972E-02	2.1074E-02	0.0000E+00	9439	2151
3.2374E+02	1.0000E+00	1.8908E-02	8.3202E-02	-2.8154E-02	0.0000E+00	9439	2151
3.2422E+02	0.0000E+00	1.7234E-02	4.2000E-02	-2.1428E+00	-2.4099E+00	9439	2151
3.2566E+02	1.0000E+00	8.3350E-03	3.4172E-02	-1.9135E-02	0.0000E+00	9439	2151
3.2991E+02	0.0000E+00	5.3047E-03	4.2000E-02	1.6450E+00	-4.0261E-01	9439	2151
3.3430E+02	1.0000E+00	5.6422E-03	4.6151E-02	8.9325E-03	0.0000E+00	9439	2151
3.3631E+02	1.0000E+00	1.4868E-02	4.5412E-02	-1.5871E-02	0.0000E+00	9439	2151
3.3834E+02	1.0000E+00	8.2000E-03	4.6842E-02	9.0499E-03	0.0000E+00	9439	2151
3.3963E+02	1.0000E+00	3.5036E-03	3.7815E-02	-1.6211E-02	0.0000E+00	9439	2151
3.4357E+02	1.0000E+00	1.6496E-02	3.5660E-02	2.0438E-02	0.0000E+00	9439	2151
3.4670E+02	0.0000E+00	1.0124E-02	4.2000E-02	-1.6845E-02	-1.1729E+00	9439	2151
3.5070E+02	1.0000E+00	2.1826E-02	3.8264E-02	3.0509E-02	0.0000E+00	9439	2151
3.5321E+02	1.0000E+00	3.9208E-03	3.6900E-02	1.5518E-02	0.0000E+00	9439	2151
3.5533E+02	1.0000E+00	3.5879E-04	4.2984E-02	1.6149E-02	0.0000E+00	9439	2151
3.6041E+02	1.0000E+00	1.1892E-03	7.7364E-02	-3.6870E-02	0.0000E+00	9439	2151
3.6172E+02	1.0000E+00	1.9142E-04	4.2500E-02	3.2000E-03	0.0000E+00	9439	2151
3.6540E+02	0.0000E+00	6.5964E-02	4.2000E-02	-2.8316E+01	7.5408E-01	9439	2151
3.6865E+02	1.0000E+00	2.6704E-04	4.2000E-02	1.5000E-02	0.0000E+00	9439	2151
3.6991E+02	0.0000E+00	3.7997E-03	4.1500E-02	1.2442E-03	1.0750E+00	9439	2151
3.7075E+02	1.0000E+00	3.0899E-03	7.3990E-02	2.7377E-02	0.0000E+00	9439	2151
3.7334E+02	0.0000E+00	3.0379E-03	4.2000E-02	2.7824E+00	1.7154E+00	9439	2151
3.7546E+02	1.0000E+00	2.7482E-03	2.9938E-02	2.8069E-03	0.0000E+00	9439	2151
3.7753E+02	1.0000E+00	1.7901E-03	4.0499E-02	-1.8794E-02	0.0000E+00	9439	2151
3.7848E+02	1.0000E+00	1.0435E-03	5.5527E-02	8.3916E-03	0.0000E+00	9439	2151
3.8282E+02	1.0000E+00	3.5140E-04	4.2566E-02	1.1424E-02	0.0000E+00	9439	2151

Table I (continued)

3.8471E+02	1.0000E+00	5.8363E-03	2.8604E-02	-2.7195E-02	0.0000E+00	9439	2151
3.8709E+02	1.0000E+00	2.2000E-04	4.2000E-02	1.5000E-02	0.0000E+00	9439	2151
3.8716E+02	0.0000E+00	3.5605E-03	4.2164E-02	4.7994E+00	-1.7975E+00	9439	2151
3.8998E+02	1.0000E+00	1.4433E-03	4.2542E-02	-1.3333E-02	0.0000E+00	9439	2151
3.9196E+02	1.0000E+00	1.0048E-03	6.0011E-02	3.1391E-02	0.0000E+00	9439	2151
3.9489E+02	1.0000E+00	6.8060E-03	5.1216E-02	-4.1151E-02	0.0000E+00	9439	2151
3.9735E+02	1.0000E+00	1.9223E-03	2.9428E-02	3.5285E-02	0.0000E+00	9439	2151
4.0207E+02	1.0000E+00	1.9064E-02	3.5091E-02	-1.8498E-01	0.0000E+00	9439	2151
4.0465E+02	1.0000E+00	2.2508E-02	3.8624E-02	-7.0010E-02	0.0000E+00	9439	2151
4.0652E+02	1.0000E+00	1.2395E-03	4.9859E-02	-1.0746E-02	0.0000E+00	9439	2151
4.0750E+02	1.0000E+00	8.1896E-04	3.0365E-02	1.4928E-01	0.0000E+00	9439	2151
4.0919E+02	1.0000E+00	1.1475E-03	6.1567E-02	-2.8898E-02	0.0000E+00	9439	2151
4.1279E+02	1.0000E+00	9.0126E-03	3.8622E-02	3.6871E-02	0.0000E+00	9439	2151
4.1616E+02	1.0000E+00	2.8995E-03	5.0431E-02	-6.2725E-03	0.0000E+00	9439	2151
4.1810E+02	1.0000E+00	1.2120E-03	5.8268E-02	-1.7538E-02	0.0000E+00	9439	2151
4.2024E+02	0.0000E+00	9.3578E-03	4.2000E-02	2.5013E-01	2.9407E+00	9439	2151
4.2033E+02	1.0000E+00	5.6119E-03	4.1683E-02	-2.8474E-02	0.0000E+00	9439	2151
4.2554E+02	0.0000E+00	1.8162E-02	4.2000E-02	1.5616E-01	8.4277E+00	9439	2151
4.2614E+02	1.0000E+00	2.8591E-04	4.1500E-02	2.1281E-02	0.0000E+00	9439	2151
4.3012E+02	1.0000E+00	3.4268E-03	5.8598E-02	6.4205E-01	0.0000E+00	9439	2151
4.3335E+02	1.0000E+00	6.2387E-04	4.1171E-02	-4.3066E-03	0.0000E+00	9439	2151
4.3394E+02	0.0000E+00	1.5106E-02	4.1500E-02	2.4012E+00	-2.8654E+00	9439	2151
4.3825E+02	1.0000E+00	2.8784E-03	3.7270E-02	-6.6911E-03	0.0000E+00	9439	2151
4.3930E+02	1.0000E+00	3.1583E-03	4.9825E-02	2.8784E-03	0.0000E+00	9439	2151
4.4072E+02	1.0000E+00	3.4403E-04	4.6000E-02	-1.3310E-01	0.0000E+00	9439	2151
4.4301E+02	0.0000E+00	2.1570E-02	3.8456E-02	-1.2445E-01	3.3484E-01	9439	2151
4.5033E+02	1.0000E+00	9.4711E-04	4.3623E-02	-3.9766E-02	0.0000E+00	9439	2151
4.5187E+02	1.0000E+00	1.4517E-02	2.8075E-02	2.4180E-03	0.0000E+00	9439	2151
4.5515E+02	1.0000E+00	4.1173E-04	4.0407E-02	-2.1127E-01	0.0000E+00	9439	2151
4.5631E+02	0.0000E+00	7.8792E-02	3.6237E-02	2.9552E-01	-8.1143E-02	9439	2151
4.5788E+02	1.0000E+00	7.1136E-03	6.3012E-02	-1.5855E-01	0.0000E+00	9439	2151
4.5938E+02	1.0000E+00	4.7598E-03	2.8197E-02	2.4155E-02	0.0000E+00	9439	2151
4.6179E+02	1.0000E+00	2.2596E-03	5.2287E-02	-1.1471E-01	0.0000E+00	9439	2151
4.6322E+02	1.0000E+00	6.3813E-04	2.8071E-02	2.4438E-02	0.0000E+00	9439	2151
4.6613E+02	1.0000E+00	7.6466E-05	4.6000E-02	3.6000E-02	0.0000E+00	9439	2151
4.6853E+02	0.0000E+00	2.1789E-02	4.6000E-02	-3.5998E+00	1.1033E-02	9439	2151
4.7366E+02	1.0000E+00	4.2038E-03	3.5486E-02	-3.2196E-03	0.0000E+00	9439	2151
4.7568E+02	0.0000E+00	2.9948E-02	4.6000E-02	3.9750E-03	3.0670E+00	9439	2151
4.7645E+02	0.0000E+00	3.7158E-03	4.6000E-02	3.6874E+00	5.5021E+00	9439	2151
4.7972E+02	1.0000E+00	1.5340E-04	4.6000E-02	2.0848E-02	0.0000E+00	9439	2151
4.8472E+02	1.0000E+00	2.4821E-03	2.7136E-02	-4.7428E-03	0.0000E+00	9439	2151
4.8829E+02	0.0000E+00	1.9272E-02	4.7300E-02	-1.7915E-02	7.8337E-01	9439	2151
4.9192E+02	0.0000E+00	3.7979E-02	4.6000E-02	1.6432E+00	1.1171E+00	9439	2151
4.9469E+02	1.0000E+00	5.1839E-03	3.9308E-02	-6.4862E-02	0.0000E+00	9439	2151
4.9622E+02	1.0000E+00	6.5329E-04	4.8004E-02	1.2668E-02	0.0000E+00	9439	2151
5.0112E+02	1.0000E+00	3.7758E-03	2.6656E-02	4.1372E-02	0.0000E+00	9439	2151
5.0345E+02	1.0000E+00	1.2322E-02	9.9586E-02	9.2351E-02	0.0000E+00	9439	2151
5.0646E+02	1.0000E+00	3.3210E-04	4.6000E-02	-1.2319E-01	0.0000E+00	9439	2151
5.1019E+02	0.0000E+00	5.7382E-05	4.6000E-02	7.2586E-01	3.0265E+00	9439	2151
5.1027E+02	1.0000E+00	3.2888E-02	4.2112E-02	-1.7123E-01	0.0000E+00	9439	2151
5.1051E+02	0.0000E+00	1.2835E-01	4.6000E-02	3.4115E-01	1.5967E+00	9439	2151
5.1571E+02	1.0000E+00	4.2593E-06	4.6000E-02	-1.2261E-02	0.0000E+00	9439	2151
5.1728E+02	1.0000E+00	6.4621E-05	4.6000E-02	5.9301E-02	0.0000E+00	9439	2151
5.1869E+02	1.0000E+00	6.9900E-04	4.6000E-02	-1.1083E-01	0.0000E+00	9439	2151
5.2085E+02	1.0000E+00	1.5203E-02	4.9896E-02	-3.1998E-02	0.0000E+00	9439	2151
5.2484E+02	1.0000E+00	3.8058E-02	2.3575E-02	-8.4195E-03	0.0000E+00	9439	2151
5.2586E+02	0.0000E+00	2.5121E-01	4.6000E-02	1.0661E+01	-5.3749E-01	9439	2151
5.2671E+02	1.0000E+00	1.1222E-03	4.6000E-02	2.4853E-03	0.0000E+00	9439	2151
5.2805E+02	1.0000E+00	1.4672E-03	4.6000E-02	1.9862E-02	0.0000E+00	9439	2151
5.2920e+02	1.0000e+00	8.0000e-04	4.6000e-02	3.0000e-03	0.0000e+00	9439	2151
5.3122e+02	1.0300e+00	5.5543e-02	4.0000e-02	-2.6800e-02	0.0000e+00	9439	2151
5.3140e+02	0.0000e+00	3.4500e-05	4.6000e-02	-1.6238e+00	5.0650e-02	9439	2151

Table I (continued)

5.3983E+02	1.0000E+00	1.2450E-02	2.2845E-02	2.5999E-03	0.0000E+00	9439	2151
5.4122E+02	1.0000E+00	1.4803E-03	4.6000E-02	-3.3950E-02	0.0000E+00	9439	2151
5.4218E+02	1.0000E+00	5.2424E-03	4.6000E-02	6.4731E-01	0.0000E+00	9439	2151
5.4376E+02	1.0000E+00	1.1828E-02	5.7182E-02	-8.8155E-03	0.0000E+00	9439	2151
5.4642E+02	0.0000E+00	3.5053E-02	4.6000E-02	-2.4185E-02	1.4113E+00	9439	2151
5.5034E+02	1.0000E+00	1.1620E-02	5.3797E-02	9.5329E-03	0.0000E+00	9439	2151
5.5426E+02	1.0000E+00	1.3317E-02	5.9412E-02	9.0566E-03	0.0000E+00	9439	2151
5.5492E+02	0.0000E+00	1.1328E-01	4.6000E-02	1.1063E+00	-5.7076E-01	9439	2151
5.5628E+02	1.0000E+00	1.2002E-03	5.5904E-02	-1.1926E-02	0.0000E+00	9439	2151
5.5984E+02	1.0000E+00	2.6992E-02	7.0403E-02	1.3442E-02	0.0000E+00	9439	2151
5.6348E+02	1.0000E+00	3.3288E-02	1.4685E-01	-4.1980E-01	0.0000E+00	9439	2151
5.6473E+02	1.0000E+00	7.2644E-03	7.5984E-02	3.2000E-03	0.0000E+00	9439	2151
5.6649E+02	1.0000E+00	9.4380E-03	5.8559E-02	-3.2000E-03	0.0000E+00	9439	2151
5.7178E+02	1.0000E+00	8.6654E-03	4.7945E-02	-6.1017E-02	0.0000E+00	9439	2151
5.7467E+02	0.0000E+00	1.5206E-01	3.5832E-02	5.2064E-02	1.3320E-01	9439	2151
5.7653E+02	1.0000E+00	4.2218E-02	3.5426E-02	7.7052E-03	0.0000E+00	9439	2151
5.7871E+02	1.0000E+00	1.8094E-03	4.6000E-02	3.2000E-03	0.0000E+00	9439	2151
5.7977E+02	1.0000E+00	6.5872E-03	4.1194E-02	6.2153E-03	0.0000E+00	9439	2151
5.8555E+02	1.0000E+00	6.6106E-04	4.6000E-02	-2.9789E-02	0.0000E+00	9439	2151
5.8882E+02	1.0000E+00	1.1549E-02	5.7995E-02	9.4038E-03	0.0000E+00	9439	2151
5.9069E+02	1.0000E+00	4.6689E-04	4.6000E-02	3.6000E-02	0.0000E+00	9439	2151
5.9432E+02	1.0000E+00	1.6489E-03	5.3638E-02	1.0280E-02	0.0000E+00	9439	2151
5.9797E+02	0.0000E+00	3.0921E-02	4.6000E-02	3.9821E-02	5.5067E+00	9439	2151
5.9806E+02	1.0000E+00	8.1858E-03	2.6659E-02	-3.2555E-03	0.0000E+00	9439	2151
6.0474E+02	1.0000E+00	2.4029E-02	2.8362E-02	-2.7223E-03	0.0000E+00	9439	2151
6.0841E+02	1.0000E+00	9.7412E-03	2.4688E-02	-6.5632E-03	0.0000E+00	9439	2151
6.1004E+02	1.0000E+00	1.6009E-02	4.0333E-02	-5.9591E-03	0.0000E+00	9439	2151
6.1358E+02	1.0000E+00	5.5900E-03	3.4360E-02	-9.9296E-03	0.0000E+00	9439	2151
6.2160E+02	1.0000E+00	1.1235E-02	2.7340E-02	-4.5020E-03	0.0000E+00	9439	2151
6.2335E+02	1.0000E+00	8.8691E-03	4.5845E-02	7.4690E-03	0.0000E+00	9439	2151
6.2594E+02	1.0000E+00	7.3702E-03	2.2785E-02	-6.3839E-03	0.0000E+00	9439	2151
6.2895E+02	1.0000E+00	1.4510E-03	4.9006E-02	8.6448E-03	0.0000E+00	9439	2151
6.3358E+02	0.0000E+00	7.0841E-02	4.6000E-02	3.1626E-01	-3.8620E+00	9439	2151
6.3726E+02	1.0000E+00	4.3648E-03	8.2511E-02	1.3378E-02	0.0000E+00	9439	2151
6.4004E+02	1.0000E+00	8.5361E-03	2.7856E-02	8.6604E-03	0.0000E+00	9439	2151
6.4265E+02	1.0000E+00	2.3000E-04	4.6000E-02	1.0000E-02	0.0000E+00	9439	2151
6.4318E+02	0.0000E+00	5.4166E-03	4.6000E-02	9.1065E-03	3.5287E+00	9439	2151
6.4574E+02	1.0000E+00	5.9810E-03	2.9757E-02	4.4286E-03	0.0000E+00	9439	2151
6.4717E+02	0.0000E+00	4.5993E-03	4.6000E-02	1.6613E+00	9.4069E-02	9439	2151
6.4734E+02	1.0000E+00	4.0000E-04	4.6000E-02	1.0000E-02	0.0000E+00	9439	2151
6.5137E+02	1.0000E+00	2.5000E-04	4.6000E-02	1.0000E-02	0.0000E+00	9439	2151
6.5340E+02	1.0000E+00	2.0000E-04	4.6000E-02	1.0000E-02	0.0000E+00	9439	2151
6.5871E+02	0.0000E+00	4.1921E-02	4.8647E-02	-3.9061E-02	1.8988E-02	9439	2151
6.5936E+02	1.0000E+00	5.1496E-02	8.4387E-02	-1.3846E-02	0.0000E+00	9439	2151
6.6254E+02	1.0000E+00	3.7482E-04	4.6000E-02	3.0000E-02	0.0000E+00	9439	2151
6.6717E+02	1.0000E+00	2.0563E-03	4.0921E-02	-6.5085E-03	0.0000E+00	9439	2151
6.6991E+02	1.0000E+00	3.5813E-03	3.2364E-02	4.8724E-03	0.0000E+00	9439	2151
6.7215E+02	1.0000E+00	1.5913E-02	3.4909E-02	4.9918E-03	0.0000E+00	9439	2151
6.7357E+02	1.0000E+00	8.6380E-04	4.6000E-02	3.0000E-02	0.0000E+00	9439	2151
6.7507E+02	1.0000E+00	2.3780E-03	7.6728E-02	5.3295E-02	0.0000E+00	9439	2151
6.7630E+02	1.0000E+00	1.0991E-03	4.2325E-02	1.8186E-01	0.0000E+00	9439	2151
6.8172E+02	0.0000E+00	4.9330E-03	4.6000E-02	6.4356E-05	-1.0112E+00	9439	2151
6.8214E+02	1.0000E+00	2.7152E-03	6.9320E-02	-1.3699E-01	0.0000E+00	9439	2151
6.8395E+02	0.0000E+00	4.5058E-02	4.6000E-02	4.3979E-03	-3.3919E+00	9439	2151
6.8469E+02	1.0000E+00	7.9817E-03	4.3445E-02	2.7857E-03	0.0000E+00	9439	2151
6.8657E+02	1.0000E+00	5.6809E-04	4.0261E-02	3.2000E-03	0.0000E+00	9439	2151
6.8852E+02	1.0000E+00	1.4211E-02	2.2480E-02	7.3940E-03	0.0000E+00	9439	2151
6.9268E+02	1.0000E+00	5.5770E-03	7.8776E-02	1.1700E-01	0.0000E+00	9439	2151
6.9369E+02	0.0000E+00	8.9194E-03	4.9865E-02	6.9986E-01	1.1078E-02	9439	2151
7.0117E+02	0.0000E+00	5.8130E-03	4.6000E-02	1.5564E-02	-2.7122E+00	9439	2151
7.0708E+02	1.0000E+00	2.5879E-03	5.5755E-02	1.5755E-02	0.0000E+00	9439	2151
7.0768E+02	1.0000E+00	9.5335E-03	3.7637E-02	1.0996E-02	0.0000E+00	9439	2151

Table I (continued)

7.1050E+02	1.0000E+00	1.9000E-04	4.6000E-02	3.6000E-02	0.0000E+009439	2151
7.1320E+02	1.0000E+00	9.3806E-03	4.0634E-02	1.7198E-02	0.0000E+009439	2151
7.1401E+02	1.0000E+00	6.0112E-03	4.9313E-02	3.4838E-02	0.0000E+009439	2151
7.1747E+02	1.0000E+00	1.1297E-02	2.4333E-02	5.8322E-03	0.0000E+009439	2151
7.1884E+02	1.0000E+00	7.1714E-03	3.9242E-02	3.4041E-03	0.0000E+009439	2151
7.2082E+02	1.0000E+00	1.8779E-04	4.6000E-02	3.6000E-02	0.0000E+009439	2151
7.2785E+02	1.0000E+00	2.9752E-03	3.5089E-02	-1.5316E-02	0.0000E+009439	2151
7.3319E+02	1.0000E+00	8.1226E-03	8.4635E-02	1.2200E-02	0.0000E+009439	2151
7.3339E+02	0.0000E+00	1.9288E-02	4.6000E-02	-8.9511E-01	-1.4801E+009439	2151
7.3489E+02	1.0000E+00	6.6728E-04	4.6000E-02	3.0000E-02	0.0000E+009439	2151
7.3795E+02	0.0000E+00	2.5630E-02	4.6000E-02	1.1393E+00	2.1880E-029439	2151
7.3956E+02	1.0000E+00	4.4709E-03	7.5214E-02	1.2009E-01	0.0000E+009439	2151
7.4464E+02	1.0000E+00	1.1790E-02	4.6341E-02	2.0374E-02	0.0000E+009439	2151
7.4705E+02	1.0000E+00	1.3434E-02	4.6054E-02	9.1451E-03	0.0000E+009439	2151
7.4931E+02	1.0000E+00	1.0560E-03	5.0108E-02	5.5687E-03	0.0000E+009439	2151
7.5080E+02	1.0000E+00	1.9244E-03	5.3543E-02	1.1738E-02	0.0000E+009439	2151
7.5343E+02	1.0000E+00	3.9481E-02	3.4281E-02	8.7146E-03	0.0000E+009439	2151
7.5536E+02	1.0000E+00	1.4469E-03	4.6000E-02	2.9547E-02	0.0000E+009439	2151
7.5769E+02	0.0000E+00	7.5608E-02	4.6000E-02	-3.6041E-02	2.5714E+009439	2151
7.5808E+02	1.0000E+00	3.0587E-03	5.7300E-02	3.2203E-02	0.0000E+009439	2151
7.6475E+02	1.0000E+00	7.5953E-03	7.0799E-02	-1.4739E-02	0.0000E+009439	2151
7.6713E+02	1.0000E+00	3.0315E-03	3.9258E-02	2.2226E-02	0.0000E+009439	2151
7.7386E+02	1.0000E+00	6.3369E-03	4.5620E-02	1.2965E-02	0.0000E+009439	2151
7.7577E+02	0.0000E+00	3.2323E-03	4.6000E-02	5.2535E-01	1.0591E-029439	2151
7.7767E+02	1.0000E+00	1.0023E-02	6.1353E-02	4.7888E-02	0.0000E+009439	2151
7.8102E+02	1.0000E+00	1.9041E-03	3.9142E-02	2.8013E-02	0.0000E+009439	2151
7.8180E+02	1.0000E+00	1.3458E-02	4.1921E-02	4.3533E-02	0.0000E+009439	2151
7.8262E+02	1.0000E+00	2.0658E-03	4.4550E-02	1.6331E-02	0.0000E+009439	2151
7.8470E+02	1.0000E+00	2.3098E-03	5.2689E-02	6.5944E-03	0.0000E+009439	2151
7.8714E+02	1.0000E+00	9.4892E-03	5.1000E-02	1.9364E-02	0.0000E+009439	2151
7.9050E+02	1.0000E+00	1.1595E-03	4.9238E-02	5.5356E-02	0.0000E+009439	2151
7.9577E+02	1.0000E+00	8.0436E-03	3.6299E-02	4.3475E-02	0.0000E+009439	2151
7.9797E+02	0.0000E+00	1.3331E-01	4.6000E-02	-4.6100E+00	5.1266E+009439	2151
8.0095E+02	1.0000E+00	3.4193E-03	5.0639E-02	5.7010E-02	0.0000E+009439	2151
8.0503E+02	0.0000E+00	3.9599E-02	4.6000E-02	-8.3486E-01	1.3220E+019439	2151
8.0531E+02	1.0000E+00	6.5917E-04	4.6000E-02	3.6000E-02	0.0000E+009439	2151
8.0702E+02	1.0000E+00	7.8059E-03	5.8322E-02	1.8236E-02	0.0000E+009439	2151
8.1099E+02	1.0000E+00	7.5843E-04	4.6000E-02	3.6893E-02	0.0000E+009439	2151
8.1664E+02	1.0000E+00	1.3312E-02	2.5821E-02	9.4502E-03	0.0000E+009439	2151
8.2066E+02	1.0000E+00	5.8822E-03	2.3415E-02	1.3918E-02	0.0000E+009439	2151
8.2381E+02	0.0000E+00	1.8351E-02	4.6000E-02	-1.3966E+00	1.0232E+009439	2151
8.2520E+02	1.0000E+00	6.0492E-03	4.9624E-02	-9.6419E-02	0.0000E+009439	2151
8.2977E+02	1.0000E+00	2.8890E-02	6.1145E-02	4.0558E-02	0.0000E+009439	2151
8.3191E+02	0.0000E+00	2.6920E-03	4.6000E-02	1.4328E+00	1.1770E+009439	2151
8.3300E+02	1.0000E+00	1.6856E-03	4.6000E-02	2.6591E-01	0.0000E+009439	2151
8.3613E+02	1.0000E+00	2.3836E-03	4.6226E-02	3.2000E-03	0.0000E+009439	2151
8.4351E+02	0.0000E+00	1.3100E-01	4.6000E-02	5.0285E-01	8.5366E+009439	2151
8.4375E+02	1.0000E+00	1.3815E-03	4.6000E-02	3.9432E-02	0.0000E+009439	2151
8.4556E+02	1.0000E+00	5.4191E-03	5.1553E-02	-5.3643E-02	0.0000E+009439	2151
8.4820E+02	1.0000E+00	6.3836E-03	6.1252E-02	7.0237E-02	0.0000E+009439	2151
8.5360E+02	0.0000E+00	1.8952E-02	4.6000E-02	1.4052E+00	1.2244E+009439	2151
8.5398E+02	1.0000E+00	6.1233E-04	3.8858E-02	7.7711E-02	0.0000E+009439	2151
8.5593E+02	1.0000E+00	2.0332E-03	3.4158E-02	1.3753E-01	0.0000E+009439	2151
8.5870E+02	1.0000E+00	3.2987E-03	7.9075E-02	2.7146E-01	0.0000E+009439	2151
8.6147E+02	1.0000E+00	3.2282E-03	4.1419E-02	2.8908E-01	0.0000E+009439	2151
8.6594E+02	1.0000E+00	1.9196E-03	4.6000E-02	1.3762E-01	0.0000E+009439	2151
8.6745E+02	1.0000E+00	3.8798E-03	5.2426E-02	1.2870E-01	0.0000E+009439	2151
8.7014E+02	1.0000E+00	3.9928E-03	3.0070E-02	4.0866E-02	0.0000E+009439	2151
8.7440E+02	1.0000E+00	1.8112E-02	3.5951E-02	2.4064E-02	0.0000E+009439	2151
8.7565E+02	1.0000E+00	1.5052E-02	3.0047E-02	1.4188E-02	0.0000E+009439	2151
8.7858E+02	1.0000E+00	4.1016E-03	4.0254E-02	3.2301E-03	0.0000E+009439	2151
8.8553E+02	1.0000E+00	1.1981E-02	4.8934E-02	1.0864E-02	0.0000E+009439	2151

Table I (continued)

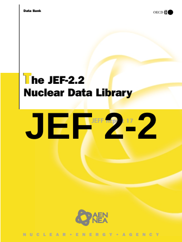
8.8711E+02	0.0000E+00	9.4216E-03	4.6000E-02	8.4171E+00	-6.2861E-04	9439	2151
8.9191E+02	1.0000E+00	6.8314E-02	2.7803E-02	3.8696E-03	0.0000E+00	9439	2151
8.9586E+02	1.0000E+00	8.3745E-03	5.5581E-02	5.4718E-01	0.0000E+00	9439	2151
8.9660E+02	0.0000E+00	7.2308E-04	4.6000E-02	1.6696E+00	-4.2150E-02	9439	2151
8.9712E+02	1.0000E+00	7.4058E-03	6.0508E-02	7.7251E-02	0.0000E+00	9439	2151
9.0376E+02	1.0000E+00	1.0116E-02	3.6837E-02	-1.7509E-02	0.0000E+00	9439	2151
9.0447E+02	0.0000E+00	4.7275E-02	4.6000E-02	-4.8613E+00	1.2864E+00	9439	2151
9.0602E+02	1.0000E+00	4.1094E-03	4.1315E-02	-1.4001E-02	0.0000E+00	9439	2151
9.0851E+02	1.0000E+00	3.3634E-03	3.3162E-02	8.7105E-03	0.0000E+00	9439	2151
9.1094E+02	0.0000E+00	1.3092E-02	4.6000E-02	4.5577E+00	1.2542E-01	9439	2151
9.1266E+02	0.0000E+00	3.6954E-02	4.6000E-02	4.1538E-01	2.2307E+00	9439	2151
9.1619E+02	1.0000E+00	4.9970E-03	3.1397E-02	1.8934E-01	0.0000E+00	9439	2151
9.1994E+02	1.0000E+00	9.8750E-03	4.6000E-02	-1.7047E-01	0.0000E+00	9439	2151
9.2068E+02	1.0000E+00	9.9360E-03	4.6000E-02	2.1015E-02	0.0000E+00	9439	2151
9.2315E+02	1.0000E+00	2.5063E-02	3.0074E-02	5.8082E-03	0.0000E+00	9439	2151
9.2626E+02	0.0000E+00	7.4775E-03	4.6000E-02	6.8854E-01	1.0000E-02	9439	2151
9.2795E+02	1.0000E+00	3.8254E-03	4.6000E-02	2.6911E-02	0.0000E+00	9439	2151
9.2970E+02	1.0000E+00	1.3965E-03	4.6000E-02	2.5008E-01	0.0000E+00	9439	2151
9.3296E+02	1.0000E+00	1.2051E-02	5.1340E-02	-9.7008E-03	0.0000E+00	9439	2151
9.3759E+02	1.0000E+00	1.1269E-03	4.6000E-02	1.7540E-02	0.0000E+00	9439	2151
9.3823E+02	0.0000E+00	4.1517E-02	4.6000E-02	3.7460E+00	-1.3470E+00	9439	2151
9.3975E+02	1.0000E+00	1.3012E-02	7.9316E-02	1.3732E-01	0.0000E+00	9439	2151
9.4121E+02	1.0000E+00	9.3576E-03	6.8998E-02	5.0948E-02	0.0000E+00	9439	2151
9.4415E+02	1.0000E+00	8.2166E-03	6.1207E-02	2.3708E-02	0.0000E+00	9439	2151
9.4642E+02	1.0000E+00	7.9685E-03	5.3889E-02	-2.9670E-03	0.0000E+00	9439	2151
9.5170E+02	1.0000E+00	5.8144E-03	3.7289E-02	1.7635E-02	0.0000E+00	9439	2151
9.5500E+02	1.0000E+00	8.0271E-03	3.7606E-02	9.8835E-02	0.0000E+00	9439	2151
9.5890E+02	1.0000E+00	4.1059E-02	5.4297E-02	4.0545E-02	0.0000E+00	9439	2151
9.6637E+02	1.0000E+00	2.8623E-02	4.1617E-02	1.4251E-01	0.0000E+00	9439	2151
9.7185E+02	0.0000E+00	6.2197E-02	4.6000E-02	9.0917E-01	1.0358E-03	9439	2151
9.7442E+02	1.0000E+00	5.4043E-02	2.5735E-02	3.7846E-02	0.0000E+00	9439	2151
9.7813E+02	1.0000E+00	2.6224E-03	4.6000E-02	5.1269E-03	0.0000E+00	9439	2151
9.8063E+02	0.0000E+00	7.6450E-02	4.6000E-02	-4.2388E-01	1.3149E+00	9439	2151
9.8540E+02	1.0000E+00	7.7898E-02	3.1807E-02	-1.8559E-02	0.0000E+00	9439	2151
9.8956E+02	1.0000E+00	1.8919E-03	4.5565E-02	4.3517E-02	0.0000E+00	9439	2151
9.9051E+02	1.0000E+00	5.6616E-03	5.2874E-02	2.3628E-01	0.0000E+00	9439	2151
9.9428E+02	1.0000E+00	1.8441E-02	4.2773E-02	4.3104E-02	0.0000E+00	9439	2151
9.9795E+02	1.0000E+00	3.4997E-02	4.6000E-02	-1.5474E-01	0.0000E+00	9439	2151
9.9870E+02	1.0000E+00	3.4639E-02	4.6000E-02	-6.3158E-02	0.0000E+00	9439	2151
1.0050E+03	1.0000E+00	7.7227E-02	4.6000E-02	1.1953E-03	0.0000E+00	9439	2151
1.0100E+03	0.0000E+00	1.8505E-01	4.6000E-02	-4.9203E+00	2.0852E-02	9439	2151
1.1000E+03	1.0000E+00	1.2200E+00	4.6000E-02	4.6000E-02	0.0000E+00	9439	2151

Table I (continued)

Energy range (eV)	So x 10^4		So (narrow) x 10^4	
	ORNL	SACLAY	ORNL	SACLAY
0 - 100	1.470	1.520 (- 3.4 %)	1.046	1.068 (- 2.0 %)
100 - 200	1.103	1.072 (+ 2.9 %)	0.787	0.777 (+ 1.3 %)
200 - 300	1.531	1.515 (+ 1.0 %)	1.093	1.087 (+ 0.6 %)
300 - 400	0.912	0.856 (+ 6.5 %)	0.765	0.764 (+ 0.1 %)
400 - 500	0.723	0.741 (- 2.4 %)	0.413	0.423 (- 2.4 %)
500 - 600	1.992	1.864 (+ 6.9 %)	1.387	1.379 (+ 0.6 %)
600 - 700	0.807			
700 - 800	0.786			
900 - 1000	1.290			
0 - 600	1.289	1.261 (+ 2.2 %)	0.915	0.916 (- 0.1 %)
0 - 1000	1.141			

TABLE II

^{239}Pu s-wave strenght functions in several energy intervals in the incident neutron energy range 0 eV to 1000 eV. The values calculated from the resonance parameters of Table I (ORNL) are compared to the values obtained in reference 10 (SACLAY). The figures between parenthesis are the percentage deviations between ORNL and SACLAY. So (narrow) are the values obtained from the resonances for which the fission width is smaller than 300 meV (mainly 1^+ resonances). The discrepancies of 6.5 % and 6.9 % in the energy ranges 300 eV to 400 eV and 500 eV to 600 eV are due to the inadequacy of the Breit-Wigner formalism used at SACLAY to represent accurately the shape of the broad resonances (0^+ resonances).



Resonance Energy (eV)	Γn (meV) SACLAY	Γn (meV) ORNL	Resonance Energy (eV)	Γn (meV) SACLAY	Γn (meV) ORNL
500.50	3.40 ± 0.90	3.78	562.84	35.73 ± 2.68	33.29
502.96	11.87 ± 0.90	12.32	564.03	6.53 ± 1.07	7.26
509.74	52.13 ± 2.70	57.39	565.81	9.47 ± 0.80	9.44
520.22	14.93 ± 1.21	15.20	571.11	8.60 ± 0.60	8.67
524.21	30.60 ± 3.22	25.12	574.00	159.00 ± 4.02	152.10
530.52	42.52 ± 3.41	55.54	575.77	39.80 ± 3.75	42.22
539.17	11.40 ± 2.01	12.45	579.04	6.87 ± 0.60	6.59
543.08	11.73 ± 2.01	11.83	588.09	11.27 ± 0.80	11.55
549.67	11.80 ± 1.01	11.62	593.52	2.13 ± 0.34	1.65
559.16	27.20 ± 1.61	26.99	597.35	8.60 ± 1.01	8.19

TABLE III

Comparison between the neutron widths obtained in the present evaluations (ORNL) with those obtained in reference 10 (SACLAY) in the energy range 500 eV to 600 eV. The average value agrees within 1.5 %.

Energy range (eV)	Spin	N	$\langle \Gamma_f \rangle$	ν
0 - 480	0^+ 1^+	62 154	3.000 0.030	1.3 1.0
0 - 1000	0^+ 1^+	105 300	2.800 0.034	1.5 0.0

TABLE IV

Parameters of the χ^2 distribution $P(\nu,x)$ used in figure 5 and figure 6. N is the number of levels used for the normalization of the distributions. The average fission widths are given in eV. A value of 3.0 meV was substracted to the fission widths to take into account the n(γ,f) reaction.

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Energy range (eV)	Average fission widths (meV)		
	ORNL (EXP)	SACLAY (EXP)	SACLAY (THE)
0 - 110	31.75 (32)	35.3 (29)	41.0
110 - 220	23.92 (35)	38.1 (26)	30.0
220 - 330	26.20 (37)	33.8 (27)	22.0
330 - 440	25.23 (35)	60.2 (25)	43.0
440 - 550	50.36 (30)	41.4 (19)	38.0
550 - 660	8.28 (31)	7.2 (23)	5.4
0 - 660	27.36 (200)	36.13 (149)	30.0

TABLE V

^{239}Pu average fission widths of the narrow resonances (mainly 1^+ resonances) for 6 energy intervals in the incident neutron energy range 0 to 600 eV, as obtained in the present work (ORNL) and in reference 10 (SACLAY). The numbers between parenthesis are the number of resonances in the averaged sample. A value of 3 meV corresponding to the n(γ, f) process has been substracted to all the average values. SACLAY (TH) are the values obtained by fitting the fission width distributions (10) in the corresponding energy ranges. These values are more in agreement with ORNL (EXP) than SACLAY (EXP), because they take into account the small values which are missing in the SACLAY (EXP) samples.

Energy range (eV)	Average fission widths (meV)	Average capture widths (meV)
0 - 100	37.22 (29)	39.66 (29)
100 - 200	26.66 (32)	41.15 (30)
200 - 300	26.28 (35)	39.59 (29)
300 - 400	23.40 (30)	44.55 (27)
400 - 500	52.55 (27)	40.98 (27)
500 - 600	31.15 (31)	48.06 (21)
600 - 700	25.40 (28)	43.75 (23)
700 - 800	25.52 (30)	46.26 (25)
800 - 900	75.28 (26)	45.57 (21)
900 - 1000	68.44 (27)	45.13 (19)
0 - 1000	37.05 (295)	
0 - 500		41.14 (142)
500 - 1000		45.75 (109)

TABLE VI

^{239}Pu average fission widths and capture widths obtained from the parameters of the narrow resonances (mainly 1^+ resonances) in the energy range 0 eV to 1000 eV. The figures between parenthesis are the number of resonances in the averaged samples.

			26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
107	9.6068E-04	.000	-1	5	1	2	-4	3	5	3	0	0	-2	-3	0	0	2	1	-1	1	-2	-5	0	0	0	-1	0
108	0.7376	.023	2	-19	21	2	0	2	3	2	3	0	-3	-2	-4	-2	7	4	-1	9	-7	-1	-2	3	1	1	-2
109	5.8823E-02	.012	0	16	-6	0	-6	-1	-2	-2	-1	1	1	1	2	1	-4	-2	1	-5	5	1	2	-1	0	0	1
110	0.9406	.033	2	-26	26	2	-2	3	4	3	4	0	-6	-2	-5	-2	8	5	-2	11	-9	-2	-3	3	1	1	-2
111	1.6221E-03	.000	0	-85	4	1	12	-1	-7	-5	0	0	2	1	1	0	-5	-3	1	-3	5	3	2	-1	0	1	0
112	0.7103	.017	-3	37	15	2	-64	1	5	4	-3	1	-2	-1	4	2	-4	-2	1	-9	4	-3	4	-2	-1	-1	3
113	0.1934	.009	-1	11	-43	0	22	0	-1	-1	-1	-2	-2	2	2	1	0	-1	-1	-1	-1	-1	-1	0	0	-1	2
114	1.294	.015	-6	3	-15	5	-9	5	11	7	-4	2	-2	-6	5	3	-4	-3	1	-9	8	-6	4	-2	-1	-2	3
115	3.5824E-03	.000	0	0	0	0	0	3	3	-1	0	1	-2	-1	0	0	0	0	0	0	0	0	1	0	0	0	0
116	9.6247E-03	.029	0	0	0	0	0	-8	-13	-13	-1	-9	2	-6	0	-1	2	1	0	2	-2	-2	-1	0	0	0	0
117	2.0278E-03	.000	0	0	0	0	0	-2	-4	-4	0	-11	3	-1	-1	0	2	1	0	2	-1	-2	0	0	0	0	0
118	1.672	.043	0	-2	-4	0	-4	-5	-7	1	1	-2	-20	20	-1	-1	2	1	1	4	-6	0	-4	0	-1	0	-2
119	0.2504	.031	0	2	0	0	3	-11	-5	6	-2	-12	-20	20	3	0	0	0	0	2	-4	2	-1	1	0	0	1
120	0.3991	.070	-1	-3	-3	0	-4	-9	-11	3	1	-2	-23	30	-1	-1	3	1	1	5	-5	0	-6	0	-1	0	-4
121	7.9960E-04	.000	0	0	0	0	0	2	2	0	0	1	1	-4	1	-2	2	2	-1	2	-2	2	-1	1	1	1	-1
122	0.8094	.026	1	0	-1	1	-1	4	7	2	0	4	-5	-9	4	-2	4	3	-6	5	-5	9	-8	1	0	2	-4
123	0.1484	.016	0	1	1	0	2	-6	-5	-1	-1	-2	7	8	-1	-1	0	0	4	5	-3	-5	3	1	1	-1	2
124	0.2071	.029	1	0	-1	1	-1	6	7	2	0	4	-6	-9	4	-2	3	3	-4	1	-3	9	-7	1	0	2	-4
125	1.6556E-03	.000	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	-1	1	1	0	0	0	0	0	0	0
126	2.283	.061	0	0	1	0	0	0	1	0	0	-1	0	-1	1	-1	4	3	-1	5	-5	1	-2	1	1	1	-1
127	1.0568E-02	.016	0	0	1	0	1	-1	0	1	-1	0	1	1	1	-6	4	3	2	9	-7	1	-6	1	1	1	-1
128	0.2039	.072	0	1	2	0	2	-2	-1	1	-1	-1	2	3	2	-7	4	4	4	13	-11	3	-7	2	2	2	-2
129	1.3148E-03	.000	0	0	0	0	-1	0	0	-1	0	2	-1	0	-1	12	-5	-7	-4	-6	3	-2	0	-1	-2	0	0
130	1.960	.031	-2	0	2	0	0	-2	-2	0	0	6	1	3	-2	13	-15	-19	4	-6	3	-6	-2	-2	-2	0	-1
131	2.6395E-02	.013	-1	-1	0	0	-1	-1	-1	-1	1	6	-1	1	-2	16	-16	-18	0	-10	8	-5	1	-3	-3	-1	0
132	1.310	.041	-2	-1	2	0	0	-3	-3	-1	1	8	0	4	-3	17	-24	-28	7	-10	9	-8	-1	-5	-4	0	-1
133	1.1217E-03	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	-1	-1	-1	0	0	-1	0	0	0	0
134	1.451	.042	-1	-1	-2	0	-1	0	-1	0	0	2	0	-1	0	0	-8	-3	2	-13	4	0	-2	0	-3	0	-6
135	1.9744E-02	.012	0	0	0	0	0	0	0	0	0	1	0	0	0	1	-4	-2	0	-7	1	0	-4	0	-2	0	-3
136	0.3362	.048	-1	0	-2	0	-1	-1	-1	1	0	3	0	-1	0	0	-10	-6	3	-18	5	0	-3	0	-4	0	-8
137	8.8267E-04	.000	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	1	1	0	2	0	0	0	1
138	1.144	.026	0	-1	-1	0	0	0	0	0	0	1	0	0	0	2	-3	-3	-1	-8	0	-1	-6	0	-1	1	-4
139	5.6138E-02	.012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	-1	2	-1	0	-1	0	1	0	2
140	0.1690	.035	0	0	-1	0	0	-1	0	0	0	1	0	0	0	3	-3	-4	-2	-9	-1	-1	-8	1	-2	1	-6
141	7.8697E-04	.000	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	-1	-1	-3	0	-4	1	1	1	-2
142	0.7159	.019	0	0	2	0	2	-1	0	0	-1	-1	0	1	0	2	3	-2	-5	-2	-9	-3	-15	3	4	6	-3
143	0.1256	.013	1	0	-1	0	0	1	1	0	0	1	0	-1	0	0	1	1	-1	3	2	0	3	0	0	-2	5
144	0.5601	.027	0	0	2	0	1	-1	0	0	-1	-1	0	1	1	2	2	-2	-6	-3	-8	-2	-13	2	3	5	-5
145	1.9056E-03	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
146	2.663	.049	1	0	0	0	1	0	0	0	0	-1	0	0	0	1	4	1	-6	2	-7	-2	-7	0	8	3	7
147	8.1610E-03	.016	0	0	0	0	1	0	0	0	0	0	0	0	0	1	3	1	-2	2	-5	-1	-5	0	6	2	7
148	1.094	.054	1	0	0	0	1	-1	0	0	0	-1	0	1	0	2	7	2	-5	5	-10	-2	-11	0	12	6	11
149	8.3115E-04	.000	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	-1	0	-1	0	-1	-1	0
150	0.6201	.015	1	0	1	0	2	2	3	-1	0	0	-1	0	1	1	1	-1	-1	0	-4	-2	-6	-12	-21	-13	-5
151	0.1882	.011	0	0	-1	0	-1	-1	0	1	0	1	0	0	-1	0	0	0	0	0	3	-1	4	8	13	6	1
152	0.8946	.022	1	0	1	0	2	2	2	-1	0	0	-1	0	1	1	1	-1	-1	0	-5	-1	-6	-13	-22	-13	-5
153	1.1284E-03	.000	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	-1	-1	-1	-1	-3	-2	-1
154	1.076	.030	2	0	0	0	1	2	3	-1	0	1	-2	-1	0	2	5	1	-3	3	-6	-4	-5	-1	-9	-8	-6
155	2.7354E-02	.011	0	0	0	0	0	1	1	0	0	1	0	0	0	1	1	0	-1	1	-1	-1	-1	-1	-6	-3	-2
156	0.8519	.033	2	0	0	0	1	2	4	-1	0	1	-2	-1	0	2	6	1	-3	4	-7	-5	-5	0	-9	-8	-6
157	2.5561E-03	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
158	3.439	.046	1	0	1	0	1	2	3	0	0	1	-1	-1	0	1	3	0	-1	2	-3	-3	-2	0	-5	-6	-2
159	1.0340E-02	.018	1	0	1	0	1	2	3	-1	0	1	-1	-1	0	1	4	0	-2	3	-4	-4	-2	0	-6	-6	-3
160	3.082	.048	1	0	1	0	1	3	5	-1	0	2	-2	-2	0	2	5	0	-2	4	-6	-6	-3	1	-8	-9	-6
161	1.3572E-03	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
162	1.854	.040	0	0	1	0	0	1	1	0	0	1	-1	-1	0	0	1	0	0	1	-1	-2	0	1	-1	-3	0
163	2.0280E-02	.012	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	1	-1	-1	0	1	0	-2	0
164	0.4467	.045	0	0	1	0	1	2	2	0	0	1	-1	-1	0	1	3	0	-1	2	-2	-3	0	2	-2	-4	-1
165	2.425	.068	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	-1	-1	0	0	0	-1	0
167	1.1075E-02	.021	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	-1	1	-1	-1	0	2	0	-1	0
168	0.7685	.071	0	0	0	0	0	1	1	0	0	1	-1	-1	0	1	3	1	-1	2	-2	-2	0	3	0	-2	0
169	1.1243E-03	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0

TABLE VII

Part of the covariance matrix obtained from SAMMY fit in the energy range 30 eV to 150 eV. The absolute and relative errors on the parameters are also given (colums 2 and 3). The numbers in colum 1 and line 1 of the table are the parameter numbers as they appear on Table VII bis. The correlation coefficients are given in percentage units. The correlation coefficients are significant only for the neighbouring resonances.

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RESONANCE ENERGY	CAPTURE WIDTH	NEUTRON WIDTH	FISSION WIDTH CHANNEL1	FISSION WIDTH CHANNEL2
3.23276E+01(1)	4.2850E+01(2)	8.4410E-01(3)	8.1644E+00(4)	-1.2763E+02(5)
4.75362E+01(6)	3.2116E+01(7)	4.6977E+00(8)	4.7951E+02(9)	-1.2741E-04(10)
4.95701E+01(11)	4.2000E+01	4.1105E+00(12)	-1.0522E+03(13)	5.3343E+00(14)
5.69259E+01(15)	4.2000E+01	1.1248E+01(16)	-2.1899E+03(17)	2.8973E+01(18)
6.16096E+01(19)	4.2000E+01	2.7340E+01(20)	7.0756E+03(21)	6.8264E+00(22)
6.54791E+01(23)	2.7269E+01(24)	4.2072E+00(25)	4.7212E+02(26)	-2.1169E-13
7.49717E+01(27)	4.2000E+01	2.8344E+00(28)	1.2358E+00(29)	-3.2693E+02(30)
8.08674E+01(31)	4.2000E+01	4.5849E+00(32)	1.8700E+03(33)	-1.6794E+00(34)
8.55081E+01(35)	5.1000E+01	6.8769E+01(36)	-1.8560E+03(37)	3.1327E+00(38)
9.64781E+01(39)	4.2000E+01	6.4325E+00(40)	1.4622E+03(41)	-2.1756E+02(42)
9.93364E+01(43)	4.2000E+01	2.7552E+01(44)	-1.1557E+02(45)	9.9647E+03(46)
1.14409E+02(47)	4.2000E+01	2.3356E+00(48)	-1.4801E+03(49)	2.9161E+02(50)
1.16191E+02(51)	3.3299E+01(52)	1.0063E+01(53)	-1.3613E+02(54)	-5.0190E+01(55)
1.31771E+02(56)	4.2000E+01	3.5899E+01(57)	3.9934E+03(58)	-1.0513E+01(59)
1.36942E+02(60)	3.4718E+01(61)	1.1005E+01(62)	3.5063E-01(63)	-9.0487E+01(64)
1.47393E+02(65)	4.2000E+01	5.0545E+00(66)	2.4293E+03(67)	1.6683E+00(68)
3.54863E+01(69)	4.1016E+01(70)	2.6934E-01(71)	3.4108E+00(72)	
3.83360E+01	3.6558E+01	1.0259E-02	0.0000E+00	
4.14603E+01(73)	4.9118E+01	3.3937E+00(74)	-6.0765E+00(75)	
4.17339E+01(76)	3.9475E+01	9.2768E-01(77)	6.0619E+01(78)	
4.45312E+01(79)	4.0145E+01(80)	6.1192E+00(81)	-4.2232E+00(82)	
5.01445E+01(83)	2.4507E+01(84)	3.1800E+00(85)	-5.3664E+00(86)	
5.26498E+01(87)	4.3545E+01(88)	9.5464E+00(89)	-8.5185E+00(90)	
5.57040E+01(91)	3.8258E+01(92)	1.5087E+00(93)	2.3121E+01(94)	
5.92916E+01(95)	3.7807E+01(96)	4.4840E+00(97)	9.3520E+01(98)	
6.31697E+01(99)	3.9349E+01(100)	6.3546E-01(101)	7.2130E+01(102)	
6.57930E+01(103)	6.5258E+01(104)	9.6837E+00(105)	1.0506E+02(106)	
7.41671E+01(107)	3.2974E+01(108)	3.2268E+00(109)	-2.9399E+01(110)	
7.50286E+01(111)	4.3276E+01(112)	2.1243E+01(113)	-8.3082E+01(114)	
7.90850E+01	4.2000E+01	4.2916E-02	6.0000E+00	
8.27735E+01(115)	4.7000E+01	3.3203E-01(116)	5.0000E+00	
8.96173E+01(117)	2.6761E+01(118)	8.2809E+00(119)	5.7076E+00(120)	
9.08502E+01(121)	3.3291E+01(122)	1.2315E+01(123)	6.8851E+00(124)	
9.30789E+01(125)	3.8461E+01(126)	6.7282E-01(127)	-2.7397E+00(128)	
9.55102E+01(129)	6.2868E+01(130)	2.0897E+00(131)	-3.1239E+01(132)	
1.03165E+02(133)	3.4717E+01(134)	1.6443E+00(135)	6.9248E+00(136)	
1.05458E+02(137)	4.4006E+01(138)	4.7194E+00(139)	4.8289E+00(140)	
1.06834E+02(141)	3.6887E+01(142)	1.0094E+01(143)	-1.9800E+01(144)	
1.10551E+02(145)	5.1602E+01(146)	4.9245E-01(147)	1.9352E+01(148)	
1.15320E+02	4.2000E+01	2.1667E-01	1.6000E+02	
1.19001E+02(149)	4.1345E+01(150)	1.6914E+01(151)	-4.0270E+01(152)	
1.21179E+02(153)	3.7883E+01(154)	2.5640E+00(155)	2.6495E+01(156)	
1.23622E+02(157)	7.0664E+01(158)	5.7353E-01(159)	-6.0176E+01(160)	
1.26392E+02(161)	4.5699E+01(162)	1.7379E+00(163)	-9.5489E+00(164)	
1.27721E+02(165)	3.9550E+01(166)	5.3574E-01(167)	1.0774E+01(168)	
1.33984E+02(169)	3.8724E+01(170)	5.8374E+00(171)	-3.3855E+00(172)	
1.39450E+02	4.2000E+01	9.0429E-02(173)	-1.9300E+01	
1.43156E+02(174)	2.7962E+01(175)	3.2510E+00(176)	4.5142E+01(177)	
1.43676E+02(178)	4.2279E+01(179)	4.5660E+00(180)	3.1873E+01(181)	
1.46471E+02(182)	3.9564E+01(183)	7.4138E+00(184)	7.6543E+00(185)	
1.48441E+02(186)	5.0687E+01(187)	3.3268E-01(188)	3.2550E+01(189)	
1.49645E+02(190)	3.6069E+01(191)	1.6005E+00(192)	2.3525E+01(193)	

TABLE VII bis

SAMMY input resonance parameters in the energy range 30 eV to 150 eV. The figures between parenthesis are the number of the parameter for the interpretation of the covariance matrix of Table VII. The resonances with two fission channels are 0^+, the others are 1^+.

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			26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
27	119.1	.085	44	100																							
28	90.42	.076	44	-1	100																						
29	0.4413	.000	-2	-11	11	100																					
30	0.5239	.056	-1	-1	-3	35	100																				
31	509.4	.061	2	0	-1	12	53	100																			
32	6.2809E-02	.100	0	0	0	1	0	0	100																		
33	0.2732	.000	-1	-1	-1	-16	-18	-22	0	100																	
34	6.7102E-02	.093	0	-1	0	1	-5	-9	0	5	100																
35	161.5	.097	0	-1	0	-6	-8	-2	0	-25	-1	100															
36	4.204	.100	0	0	0	0	-1	-1	0	-1	0	0	100														
38	3.532	.077	0	0	0	1	0	0	0	0	0	0	0	4	100												
39	0.1735	.027	0	0	0	-1	1	0	0	0	0	0	0	-3	17	100											
40	0.9463	.073	1	1	-1	-2	1	0	0	0	0	0	0	9	70	-18	100										
41	8.4766E-03	.000	0	0	0	-1	0	0	0	0	0	0	0	0	-2	0	0	100									
42	4.473	.073	0	0	0	0	0	0	0	0	0	0	0	1	0	-3	-2	9	100								
43	0.2349	.024	1	1	0	-2	1	1	0	0	0	0	0	0	2	0	0	-13	23	100							
44	3.453	.072	1	1	0	-2	1	1	0	0	0	0	0	1	0	-3	-1	9	72	-19	100						
45	3.1123E-02	.000	0	0	0	1	0	0	0	0	0	0	0	0	0	0	-1	1	-3	0	-3	100					
46	3.777	.096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	-2	-1	0	-2	100				
47	0.1186	.062	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	44	2	100			
48	2.759	.098	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	2	0	0	12	6	7	100		
49	1.1337E-02	.000	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	1	-3	0	-2	48	-6	58	4	100	
50	0.3376	.025	0	0	0	-1	0	0	0	0	0	0	0	0	0	2	1	0	2	3	3	-30	4	-20	-4	-2	100
51	2.129	.049	1	1	0	-2	1	1	0	0	0	0	0	0	-1	0	1	-1	0	2	2	10	19	-7	-19	-3	-53
52	3.4002E-02	.000	0	0	0	-1	0	0	0	0	0	0	0	0	-1	1	1	1	-1	1	0	13	-2	20	1	41	28
53	4.352	.098	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	3	2	0	-2	7	2
54	0.1366	.046	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1	-18	-1	-24	0	-51	-33
55	1.601	.098	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	-2	-2	-1	2	-4	-3
56	2.0224E-02	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
57	4.954	.094	0	0	0	1	0	0	0	0	0	0	0	0	0	-1	-1	0	0	-1	-1	2	1	0	-1	3	-1
58	0.1066	.046	1	1	0	-2	1	0	0	0	0	0	0	0	-1	1	2	1	0	1	3	-1	-1	1	1	-1	-2
59	0.6525	.099	0	0	0	-1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	-1	-1	-1	1	-2	1
60	8.6672E-03	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	0	0	0
61	3.876	.076	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0	0	-1	-1	1	0	-1	0	1	-2
62	0.2436	.026	0	0	0	-2	0	0	0	0	0	0	0	0	0	1	2	1	1	2	2	-1	0	2	1	1	0
63	1.398	.072	1	1	0	-2	1	1	0	0	0	0	0	0	-1	1	2	1	0	2	2	0	0	1	0	2	2
64	4.0096E-02	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0
65	4.718	.096	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0	0	-1	-1	0	0	-1	0	0	-1
66	7.6199E-02	.066	1	0	0	-1	0	0	0	0	0	0	0	0	-1	1	2	1	0	2	3	-1	0	2	1	1	2
67	5.386	.097	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	1	1
68	1.1035E-02	.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1	-1	-1	0	0	0	0	0	0
70	0.2435	.030	-1	0	-1	1	-1	0	0	0	0	0	0	0	1	-1	-2	0	0	-1	-1	0	0	0	0	0	0
71	3.412	.078	0	0	-1	1	0	0	0	0	0	0	0	0	0	-1	-1	0	0	0	-1	1	0	0	0	1	0
72	2.1399E-02	.000	-2	1	-2	0	-1	1	0	0	0	0	0	0	1	-1	-2	0	0	0	-1	0	0	0	0	0	-1
74	0.2005	.059	0	1	-1	0	0	1	0	-1	0	0	0	0	1	-1	-1	0	0	0	0	0	0	0	0	0	0
75	5.211	.091	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0
76	1.0280E-02	.000	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	4.586	.079	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
78	0.2221	.028	1	1	-1	1	0	0	0	0	0	0	0	0	0	-1	-1	0	0	-1	-1	1	0	0	0	0	-1
79	1.405	.077	1	1	0	1	0	0	0	0	0	0	0	0	0	-1	-1	0	0	-1	-1	1	0	-1	0	0	0
82	0.2988	.022	-1	-1	0	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	0.5683	.040	0	-1	1	0	-1	-1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
84	1.0751E-02	.000	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85	1.893	.081	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	0.1722	.029	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	0.9688	.070	0	-1	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	1.3483E-02	.000	0	-1	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
89	4.088	.082	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0.2124	.035	0	0	0	-3	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE VIII

Part of the covariance matrix obtained from SAMMY fit in the energy range 770 eV to 900 eV. The absolute and relative errors on the parameters are also given (column 2 and 3). The numbers in column 1 and line 1 of the table are the parameter numbers as they appear on Table VIII bis. The correlation coefficients are given in percentage unit. The correlation coefficients are significant only for the neighbouring resonances.

RESONANCE ENERGY	CAPTURE WIDTH	NEUTRON WIDTH	FISSION WIDTH CHANNEL1	FISSION WIDTH CHANNEL2
7.75803E+02(1)	4.6000E+01	3.1120E+00(2)	5.5000E+02(3)	1.0506E+01(4)
7.98048E+02(5)	4.6000E+01	1.2923E+02(6)	-4.3500E+03(7)	4.9921E+03(8)
8.05155E+02(9)	4.6000E+01	3.7984E+01(10)	-8.1783E+02(11)	1.2127E+04(12)
8.23847E+02(13)	4.6000E+01	1.7639E+01(14)	-1.3606E+03(15)	1.0058E+03(16)
8.32010E+02(17)	4.6000E+01	2.5443E+00(18)	1.3982E+03(19)	1.1759E+03(20)
8.43493E+02(21)	4.6000E+01	1.2944E+02(22)	4.9173E+02(23)	8.4202E+03(24)
8.53594E+02(25)	4.6000E+01	1.8846E+01(26)	1.3528E+03(27)	1.2504E+03(28)
8.87136E+02(29)	4.6000E+01	8.3263E+00(30)	8.2654E+03(31)	-6.2822E-01(32)
8.96254E+02(33)	4.6000E+01	7.0838E-01(34)	1.7034E+03(35)	-4.2120E+01(36)
7.73862E+02(37)	4.4159E+01(38)	6.4070E+00(39)	1.3345E+01(40)	
7.77676E+02(41)	6.0368E+01(42)	1.0098E+01(43)	4.8778E+01(44)	
7.81010E+02(45)	3.8949E+01(46)	1.9253E+00(47)	2.8146E+01(48)	
7.81799E+02(49)	4.1921E+01	1.3564E+01(50)	4.4024E+01(51)	
7.82624E+02(52)	4.4376E+01(53)	2.0906E+00(54)	1.6413E+01(55)	
7.84698E+02(56)	5.1784E+01(57)	2.3700E+00(58)	6.7385E+00(59)	
7.87133E+02(60)	5.0209E+01(61)	9.6296E+00(62)	2.0102E+01(63)	
7.90507E+02(64)	4.8383E+01(65)	1.2155E+00(66)	5.6518E+01(67)	
7.95768E+02(68)	3.6422E+01(69)	8.0355E+00(70)	4.3344E+01(71)	
8.00945E+02(72)	5.1134E+01(73)	3.4013E+00(74)	5.6778E+01(75)	
8.05310E+02	4.6000E+01	6.5917E-01	3.6000E+01	
8.07022E+02(76)	5.8290E+01(77)	7.7730E+00(78)	1.8181E+01(79)	
8.10990E+02	4.6000E+01	7.5843E-01	3.6893E+01	
8.16637E+02(80)	2.5473E+01(81)	1.3349E+01(82)	9.5951E+00(83)	
8.20665E+02(84)	2.3409E+01(85)	5.8878E+00(86)	1.3916E+01(87)	
8.25197E+02(88)	4.7868E+01(89)	6.1452E+00(90)	-9.7611E+01(91)	
8.29775E+02(92)	6.0559E+01(93)	2.8921E+01(94)	4.0794E+01(95)	
8.32992E+02(96)	4.6000E+01	1.6650E+00(97)	2.6052E+02(98)	
8.36129E+02(99)	4.5399E+01(100)	2.4013E+00(101)	3.2000E+00	
8.43750E+02	4.6000E+01	1.3815E+00	3.9432E+01	
8.45554E+02(102)	5.1712E+01(103)	5.4336E+00(104)	-5.3842E+01(105)	
8.48200E+02(106)	6.0602E+01(107)	6.4507E+00(108)	7.1090E+01(109)	
8.53980E+02	3.8858E+01	6.1233E-01	7.7711E+01	
8.55933E+02(110)	3.4142E+01(111)	2.0436E+00(112)	1.3695E+02(113)	
8.58697E+02(114)	7.8322E+01(115)	3.3481E+00(116)	2.7378E+02(117)	
8.61455E+02(118)	4.1098E+01(119)	3.2640E+00(120)	2.8491E+02(121)	
8.65940E+02	4.6000E+01	1.9196E+00	1.3762E+02	
8.67435E+02(122)	5.1736E+01(123)	3.9141E+00(124)	1.2992E+02(125)	
8.70138E+02(126)	3.0374E+01(127)	3.9895E+00(128)	4.0585E+01(129)	
8.74405E+02(130)	3.5872E+01(131)	1.8118E+01(132)	2.4283E+01(133)	
8.75652E+02(134)	3.0138E+01(135)	1.5053E+01(136)	1.4136E+01(137)	
8.78580E+02	4.0254E+01	4.1192E+00(138)	3.2301E+00	
8.85529E+02(139)	4.7425E+01(140)	1.2070E+01(141)	1.1370E+01(142)	
8.91911E+02(143)	2.8214E+01(144)	6.8306E+01(145)	4.0662E+00(146)	
8.95865E+02(147)	5.3739E+01(148)	8.3651E+00(149)	4.9374E+02(150)	
8.97113E+02(151)	5.7773E+01(152)	7.3439E+00(153)	7.5119E+01(154)	

TABLE VIII bis

SAMMY input resonance parameters in the energy range 770 eV to 900 eV. The figures between parenthesis are the number of the parameters for the interpretation of the covariance matrix of Table VIII. The resonances with two fission channels are 0^+, the other are 1^+.

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	Calculated values (barn) 300 K	Calculated values (barn) 0K	Proposed standard values (barn) (17)
Fission	747.34	746.66	747.99 ± 1.87
Capture	270.49	270.03	271.43 ± 2.14
Scattering	8.85	8.83	7.88 ± 0.97
Absorption	1017.83	1016.69	1019.42 ± 4.00
Total	1026.68	1025.52	1027.30 ± 5.00
GF	1.0543		1.0563 ± 0.0022
GA	1.0786		1.0782 ± 0.0024

TABLE IX

^{239}Pu cross-sections at 0.0253 eV.

References	0.02 to 0.06 eV EXP	0.02 to 0.06 eV CALCULATED	0.02 to 0.65 eV EXP	0.02 to 0.65 eV CALCULATED
GWIN71 FISS	631.41		843.71	
GWIN76 FISS	631.41		838.39	
GWIN84 FISS(*)	631.41	631.59(+0.03 %)	837.18	838.46(+0.15 %)
DERUYTER70 FISS	631.41		859.43	
WAGEMANS80 FISS	631.41		862.56	
GWIN71 CAPTURE	243.84	243.12(-0.30 %)	524.75	517.79(-1.34 %)
GWIN76 ABSORP(*)	875.90	874.71(-0.14 %)	1359.96	1356.25(-0.27%)
SPENCER84 TOT(*)	883.20	883.47(+0.03 %)	1361.69	1367.96(+0.46%)

(*) These data had the largest weight in the thermal-fit. The values between the parenthesis give the percentage deviations between the calculated data and the experimental data

TABLE X

^{239}Pu average fission cross-sections (in barn) at low energies. The value of 631.4 barns for all the experimental fission data in the energy range 0.02 eV to 0.06 eV corresponds to the renormalization of all the experiments to (748.0 ± 1.0) barns at 0.0253 eV. The calculated values were obtained from the resonances parameters of Table I.

Energy range (eV)	Thick sample (0.0747 at/b)		Medium sample (0.01825 at/b)		Thin sample (0.00646 at/b)	
	NORM	BG	NORM	BG	NORM	BG
100 - 153	0.979	0.0012	0.994	0.0043	0.994	0.0048
153 - 210	0.977	0.0005	0.994	0.0032	1.003	-0.0016
210 - 253	0.984	0.0005	0.991	0.0047	0.988	0.0089
253 - 305	0.996	0.0002	0.999	0.0027	0.995	0.0043
305 - 447	0.989	0.0024	0.993	0.0037	1.002	-0.0032
447 - 617	1.000	0.0020	0.998	0.0043	0.997	0.0029
617 - 770	1.010	0.0018	0.997	0.0075	0.997	0.0039
770 - 900	1.029	-0.0018	1.007	-0.0009	1.009	-0.0046
900 - 1000	1.052	-0.0015	1.010	0.0031	1.000	0.0007

TABLE XI

Normalization (NORM) and background (BG) corrections obtained in the first preliminary SAMMY runs of HARVEY transmission data.

Energy range (eV)	NORM	BG
30 - 150	0.995	- 0.00050
150 - 300	0.993	- 0.00099
300 - 450	0.997	- 0.00003
450 - 600	0.997	0.00096
600 - 770	0.990	0.00066
770 - 900	1.000	0.00210
900 - 1000	1.000	0.00190

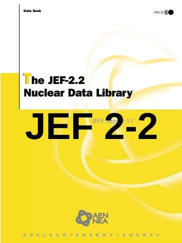
TABLE XII

Normalization (NORM) and background (BG) corrections obtained in the second preliminary SAMMY runs of HARVEY thick sample transmission data.

Energy range (eV)	Normalization		Background (barn)		(EXP-CAL)/CAL	
	WESTON	BLONS	WESTON	BLONS	WESTON	BLONS
30 - 150	0.9895	0.9996	-0.190	1.713	- 0.55 %	+ 0.5 %
150 - 300	0.9865	0.9432	0.005	1.233	- 0.27 %	- 1.0 %
300 - 450	0.9822	0.9279	-0.024	1.012	- 0.20 %	- 1.6 %
450 - 600	0.9763	0.9317	0.104	0.964	- 0.13 %	- 2.0 %
600 - 770	0.9887	0.9566	0.062	0.742	+ 0.17 %	- 1.1 %
780 - 900	0.9944	0.9347	0.150	0.875	- 0.11 %	- 0.1 %
900 - 1000	1.0040	0.9133	0.171	1.159	- 0.46 %	+ 1.4 %
750 - 900	0.9874	1.0071	0.162	0.005	+ 0.30 %	+ 10.5 %

TABLE XIII

Normalization and background corrections resulting from a SAMMY fit including HARVEY transmissions, WESTON fission and BLONS fission. The input error on the background correction was 0.05 b for WESTON and 0.5 b for BLONS. In the fit corresponding to the last line, BLONS background input error was also 0.05 b.



Energy range (keV)	Calculated values	WESTON84	BLONS73	Proposed standard
0.1-0.2	18.135	18.095(-3.1%)	18.93(+1.4%)	18.66±0.13
0.2-0.3	17.312	17.441(-2.7%)	17.79(-0.5%)	17.88±0.12
0.3-0.4	8.080	8.130(-3.6%)	8.91(+5.7%)	8.43±0.06
0.4-0.5	9.389	9.337(-2.5%)	9.71(+1.5%)	9.57±0.07
0.5-0.6	15.062	15.170(-2.6%)	15.51(-0.3%)	15.56±0.11
0.6-0.7	4.129	4.192(-6.4%)	4.63(+3.8%)	4.46±0.04
0.7-0.8	5.323	5.385(-4.5%)	5.94(+5.5%)	5.63±0.04
0.8-0.9	4.729	4.765(-4.5%)	5.11(+2.6%)	4.98±0.04
0.9-1.0	8.228	8.165(-1.7%)	8.57(+3.3%)	8.30±0.07
0.1-1.0	10.043	10.075(-3.1%)	10.57(+1.7%)	10.39

TABLE XIV

^{239}Pu average fission cross-sections (barns) in the energy range 100 eV to 1000 eV. The calculated values were obtained from the resonance parameters of Table I. The figures between parenthesis are the percentage deviation from the proposed standard data (17).

Energy range (eV)	Calculated values			GWIN 1976 DATA	
	CAPT.	ABSORP.	ALPHA	ABSORP.	ALPHA
7.3 - 16.0	79.01	194.82	0.682	208.00	0.74
16.0 - 37.5	21.10	44.79	0.891	46.50	0.89
37.5 - 50.0	48.43	69.27	2.389	83.15	2.96
50.0 - 100.0	34.29	91.25	0.602	92.84	0.63
100.0 - 200.0	15.74	33.88	0.868	33.66	0.87
200.0 - 300.0	16.01	33.32	0.925	34.69	0.94
300.0 - 400.0	9.65	17.73	1.194	18.31	1.16
400.0 - 500.0	3.89	13.28	0.414	13.56	0.44
500.0 - 600.0	10.76	25.82	0.714	26.64	0.72
600.0 - 700.0	6.47	10.60	1.566	11.57	1.54
700.0 - 800.0	4.81	10.13	0.904	10.52	0.97
800.0 - 900.0	3.53	8.26	0.746	9.30	0.82
900.0 - 1000.	5.06	13.29	0.615	13.23	0.70

TABLE XV

^{239}Pu capture and absorption cross-sections (barns) and alpha values calculated from the resonances parameters of Table I and compared to GWIN experimental data.

Energy range (eV)	Fission (barn)		Capture (barn)	
	ENDF/B-V	Present evaluation	ENDF/B-V	Present evaluation
0.5 - 5.0	86.02	85.67	32.21	28.64
5.0 - 10.0	26.03	25.06	20.14	19.04
10.0 - 50.0	100.25	96.84	78.66	77.38
50.0 - 100.0	40.32	40.42	27.23	25.66
100.0 - 301.0	19.98	19.67	19.52	17.94
301.0 - 1000.0	10.15	10.04	8.54	8.34
0.5 - 1000.0	282.76	277.62	186.30	177.00

TABLE XVI

^{239}Pu fission and capture integrals in several energy ranges calculated from the resonance parameters of Table I and compared to ENDF/B-V data.

By adding the ENDF/B-V value above 1 keV are obtains for the present evaluation :

RI fission 298.75 barns
RI capture 184.80 barns

The corresponding ENDF/B-V values are :

RI fission 303.82 barns
RI capture 194.10 barns

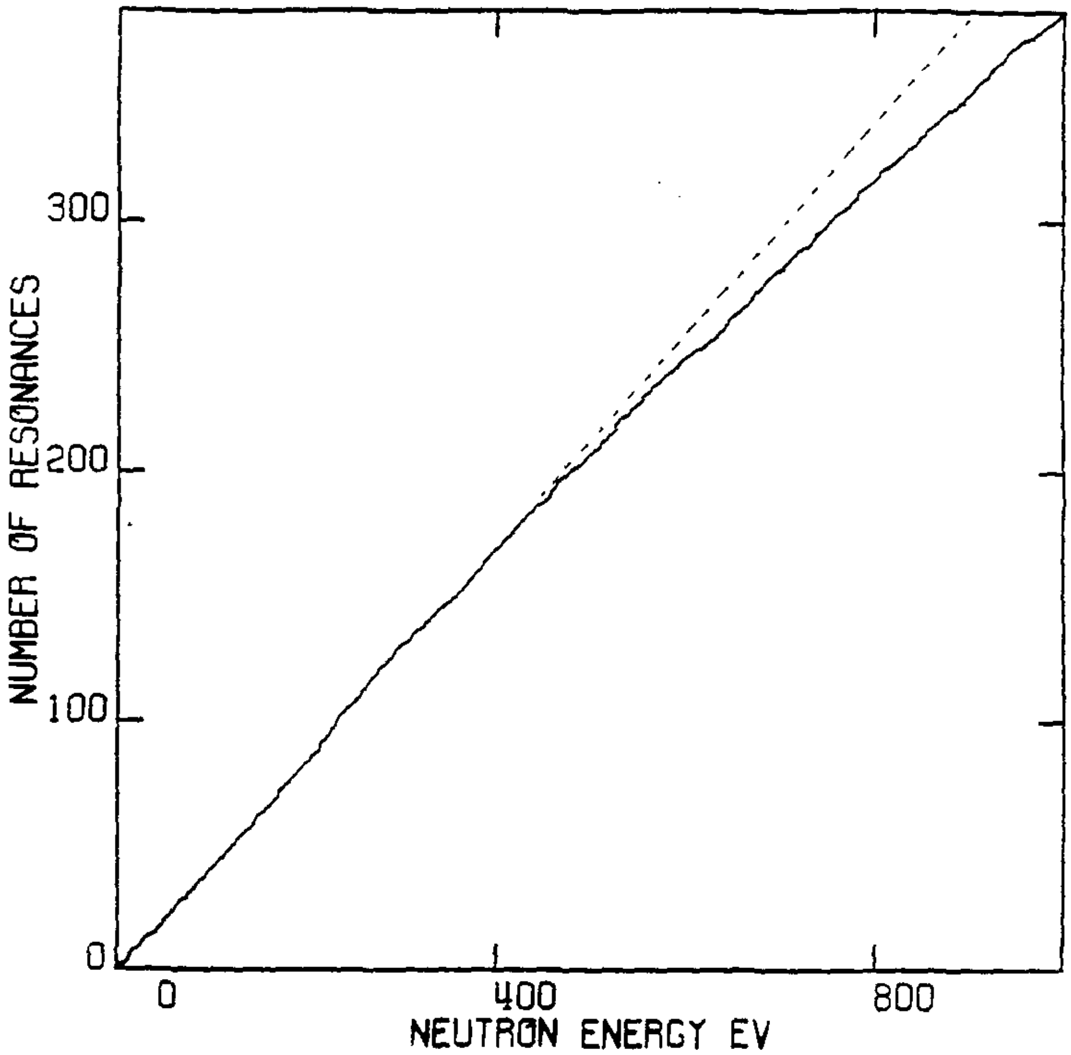
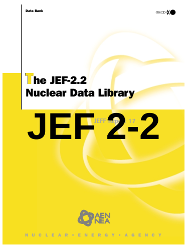
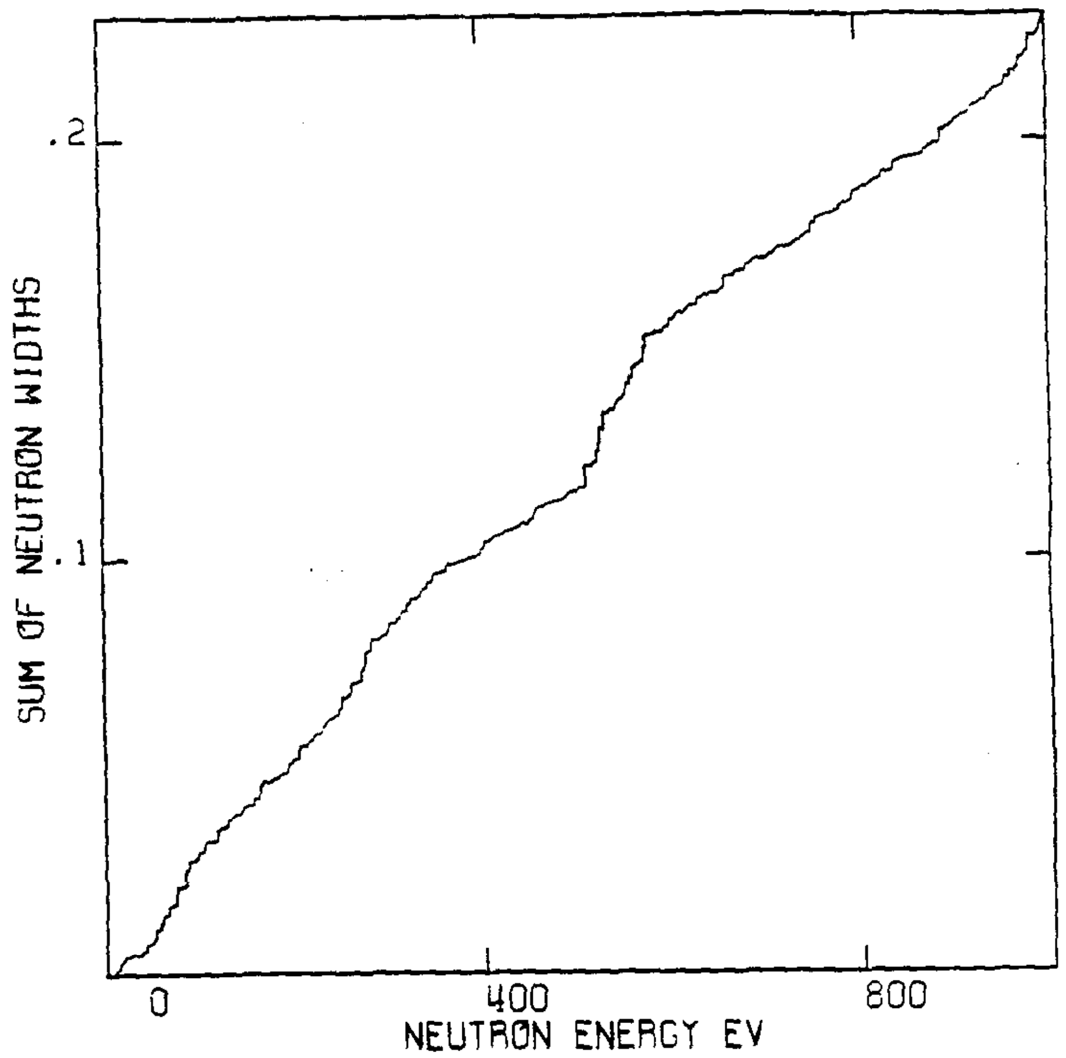


FIGURE 1

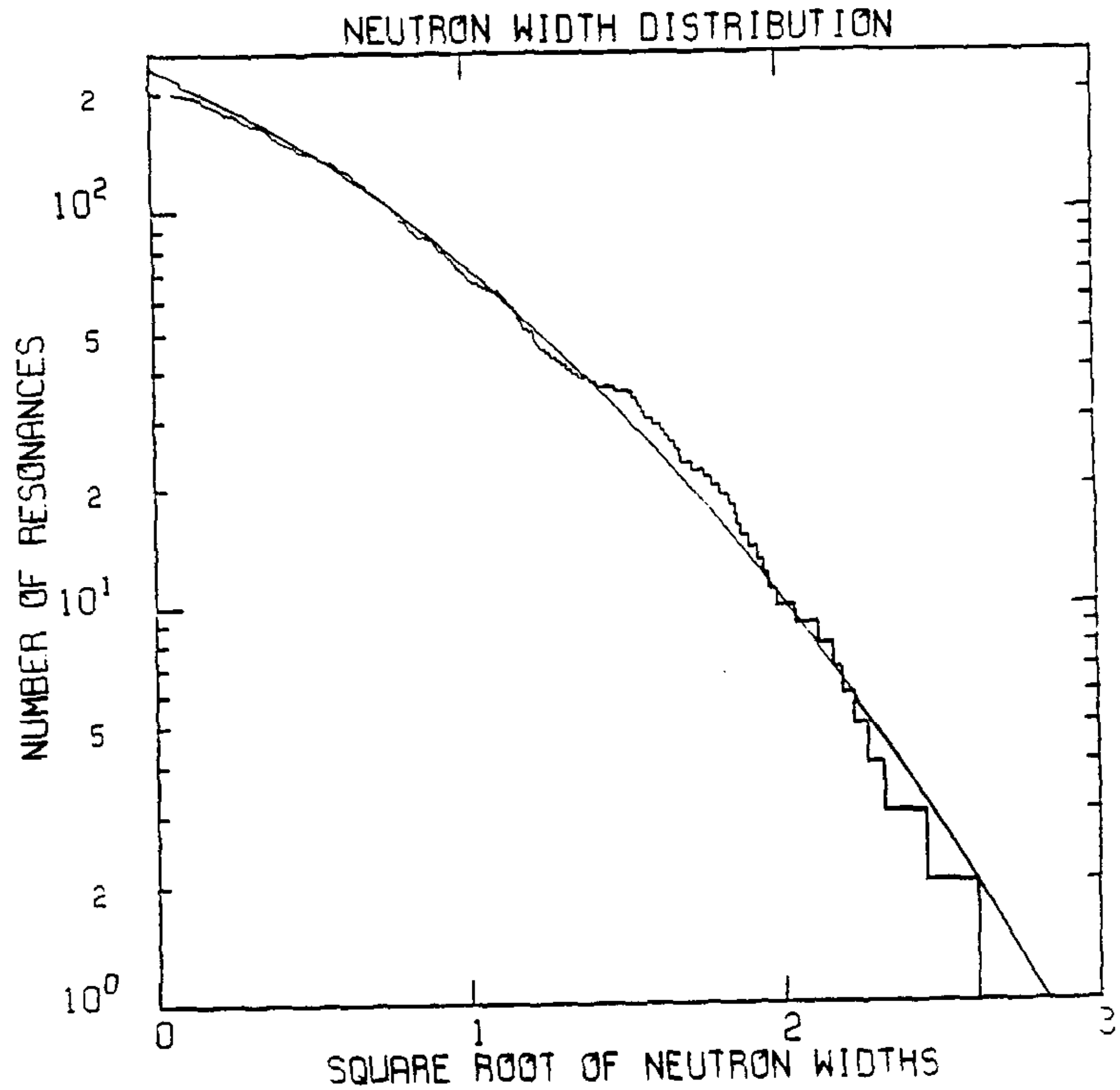
Spacing stairstep histogramm in the neutron energy range 0 eV to 1000 eV. The dashed line correspond to an average level spacing of 2.40 eV. Compared to the energy range 0 eV to 4.80 eV, 17 % of levels are missing in the energy range 480 eV to 1000 eV.





<u>Figure 2</u>

$\sum_{0}^{E} 2g\Gamma_n^0$ histogram in the energy range 0 eV to 1000 eV, showing strong fluctuations in the local s-wave strength functions.



<u>Figure 3</u>

Histogram of the integral distribution of the reduced neutron widths for the resonances of the energy range 0 eV to 480 eV. The curve is the Porter-Thomas distribution normalized to 230 resonances, assuming that about 30 small $2g\Gamma_n^o$ values could be missed.

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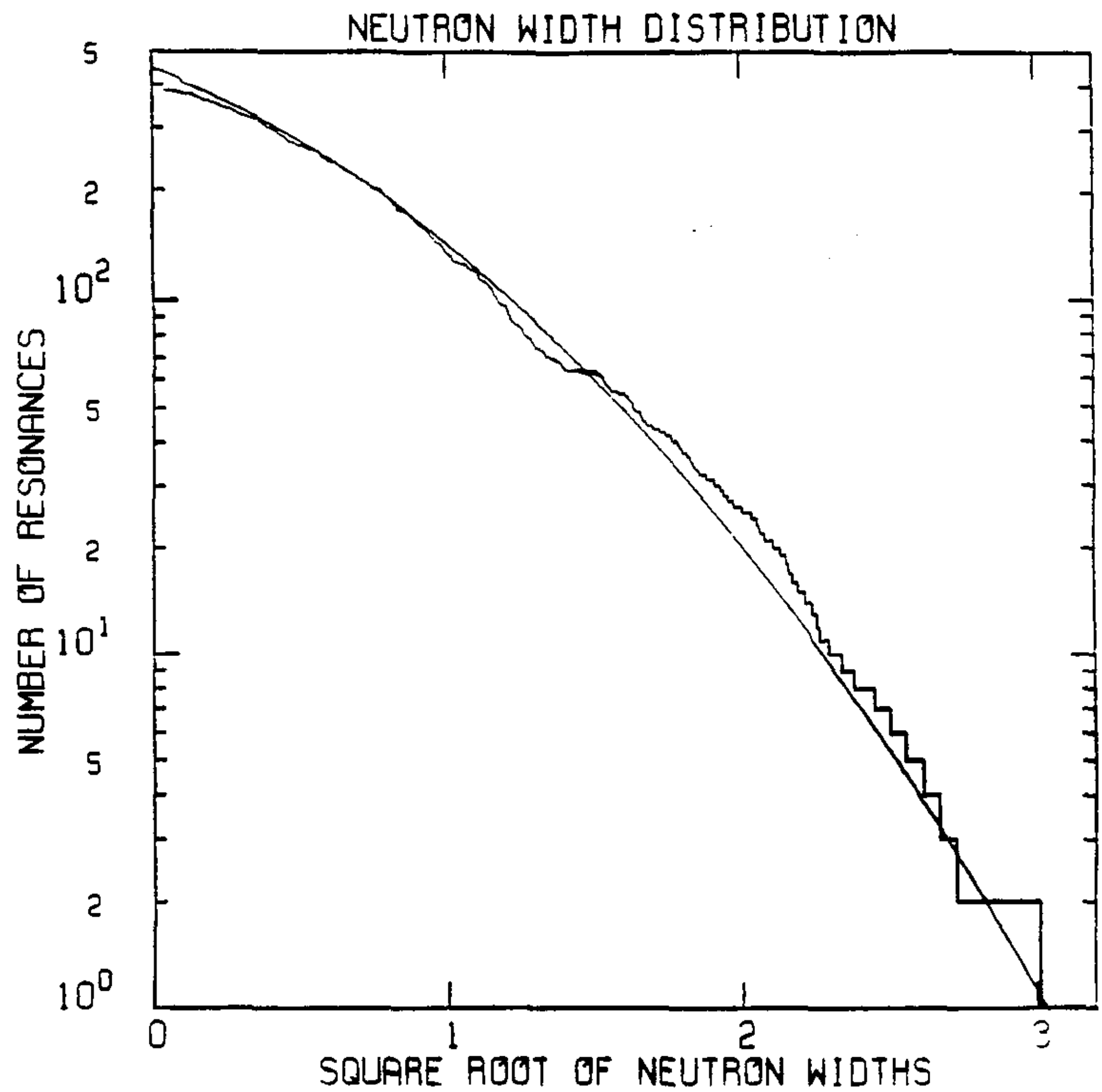

Figure 4

Histogram of the integral distribution of the reduced neutron widths for the resonances of the energy range 0 eV to 1000 eV. The curve is the Porter-Thomas distribution normalized to 480 resonances, assuming that 65 small $2g\Gamma_n^0$ values could be missed.

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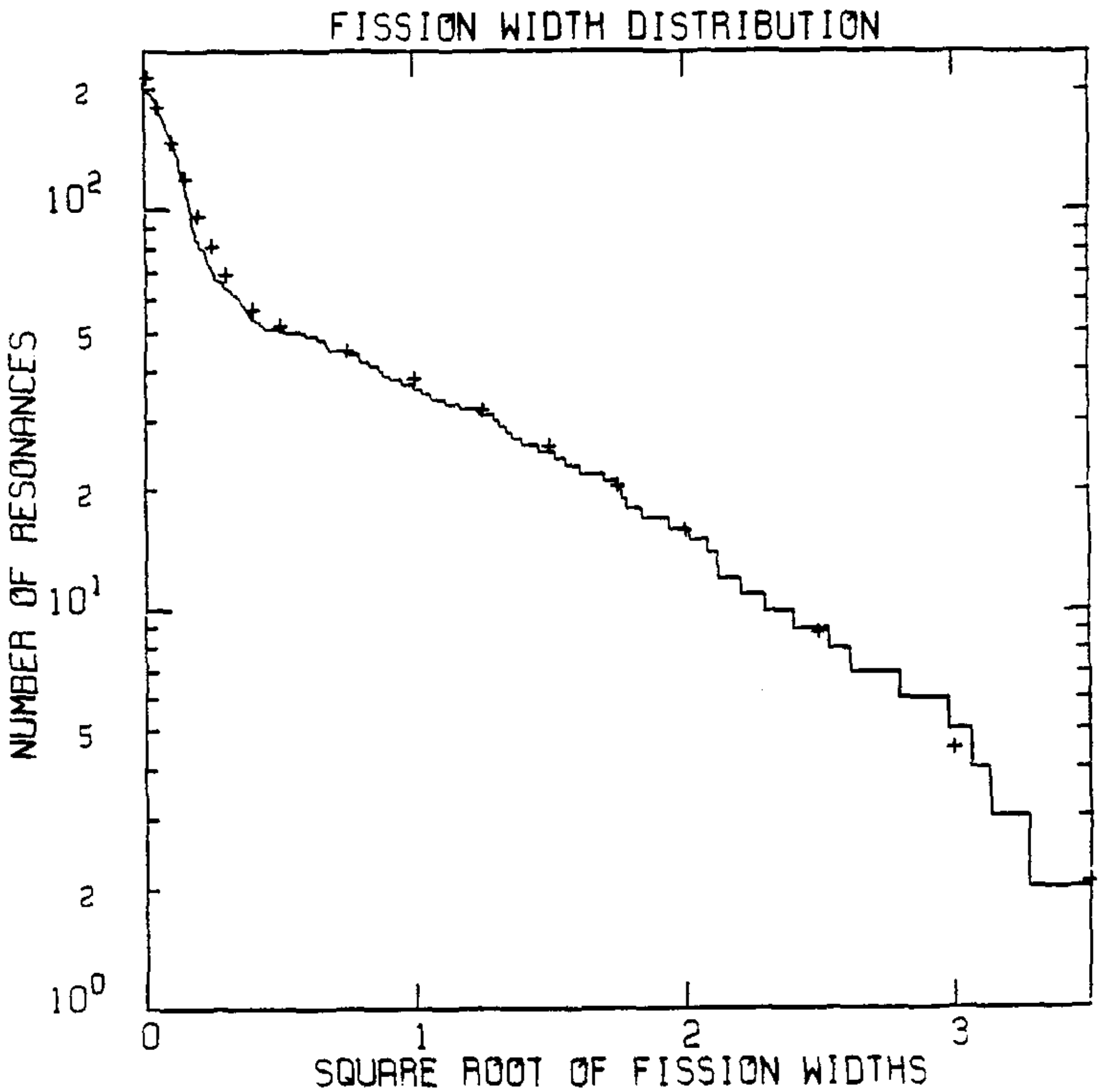
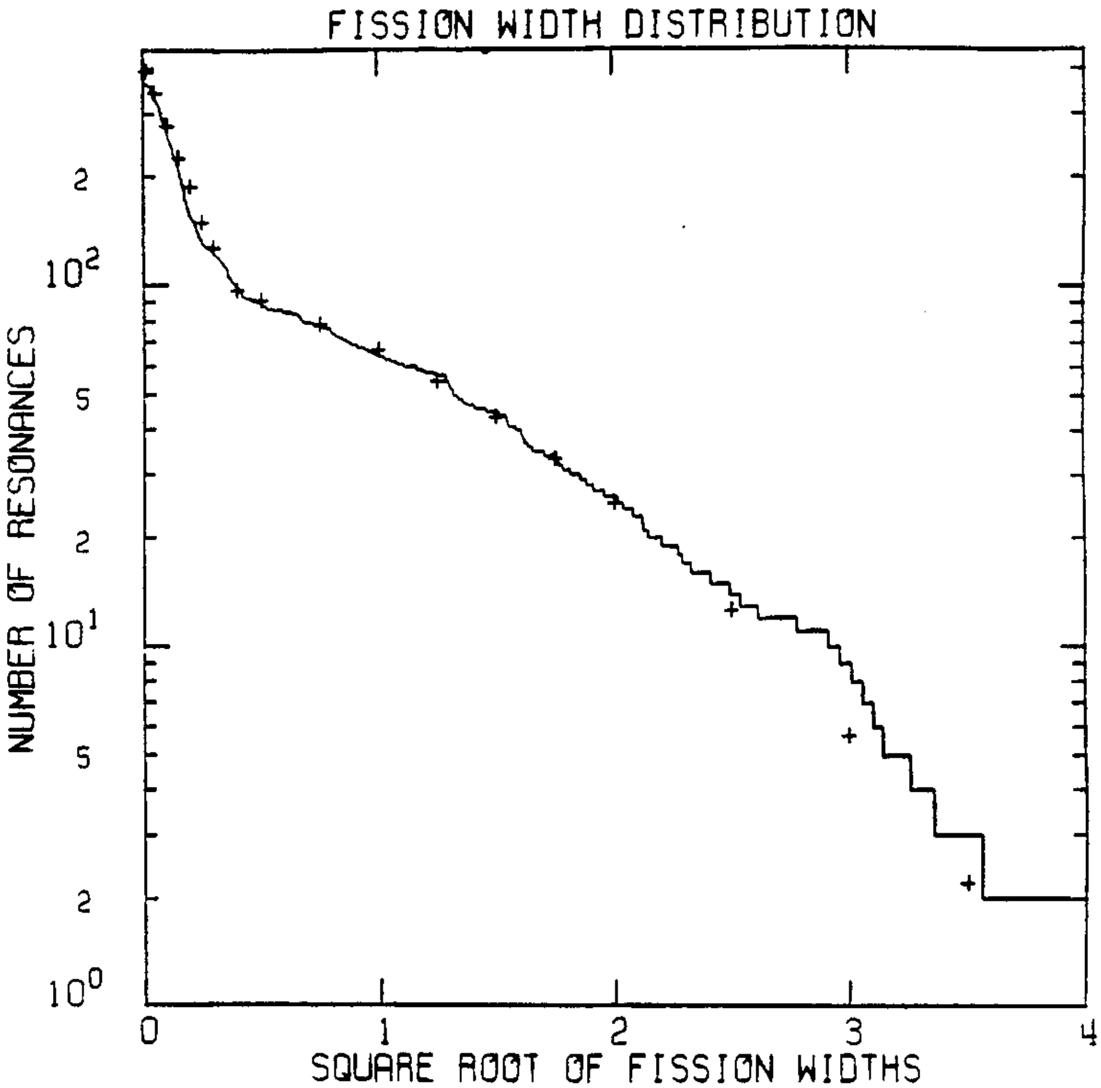


Figure 5

Integral distribution of the fission widths for the resonances of the energy range 0 eV to 480 eV. The particular shape of the distribution corresponds to a sum of two χ^2 distributions, $P(\nu,x)$, representative of the 1^+ fission channel (small average value of the fission widths) and of the 0^+ fission channels (large average values of the fission widths). The crosses correspond to a sum of two distributions with the parameters given in table VI.



<u>Figure 6</u>

Integral distribution of the fission widths for the resonances of the energy range 0 eV to 1000 eV. The particular shape of the distribution corresponds to a sum of two X^2 distributions, $P(\nu,x)$, representative of the 1^+ fission channel (small average value of the fission widths) and of the 0^+ fission channels (large average values of the fission widths). The crosses correspond to a sum of two distributions with the parameters given in table VI.

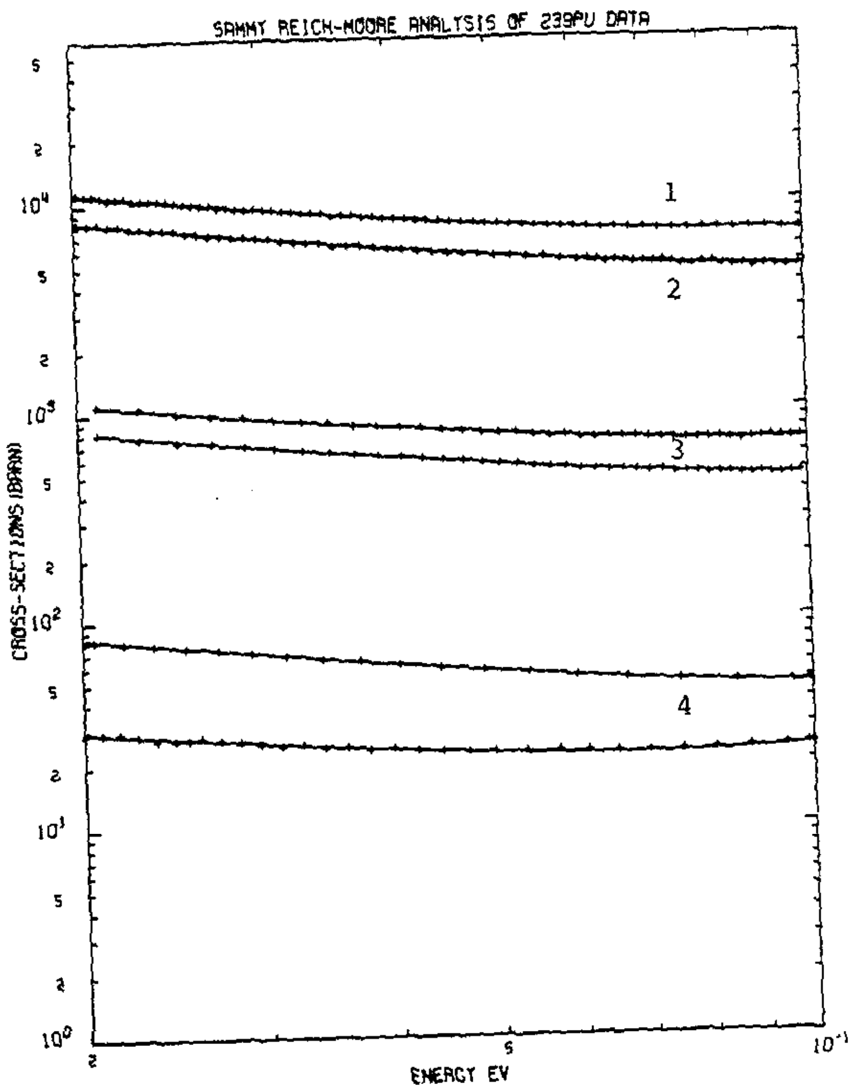


Figure 7

Comparison between the calculated cross-sections (curve) and the experimental data (cross) in the energy range 0.02 eV to 0.10 eV.

1 SPENCER total cross-section x 10

2 GWIN 1984 fission cross-section x 10

3 GWIN 1976 fission and absorption cross-section

4 GWIN 1971 fission and capture cross-section x 0.1

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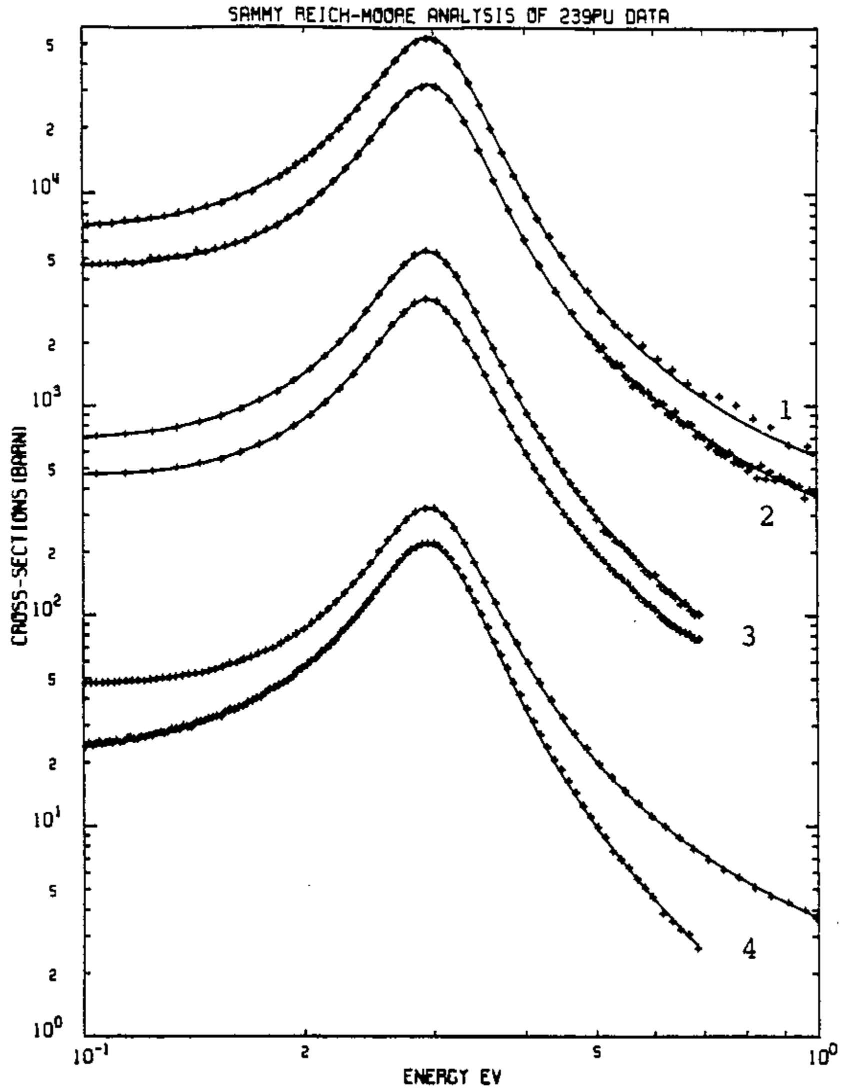


Figure 8

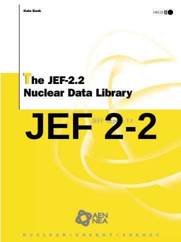
Comparison between the calculated cross-sections (curve) and the experimental data (cross) in the energy range 0.10 eV to 1.0 eV.

1 SPENCER total cross-sections x 10

2 GWIN 1984 fission cross-sections x 10

3 GWIN 1976 fission and absorption cross-sections

4 GWIN 1971 fission and capture cross-section x 0.1



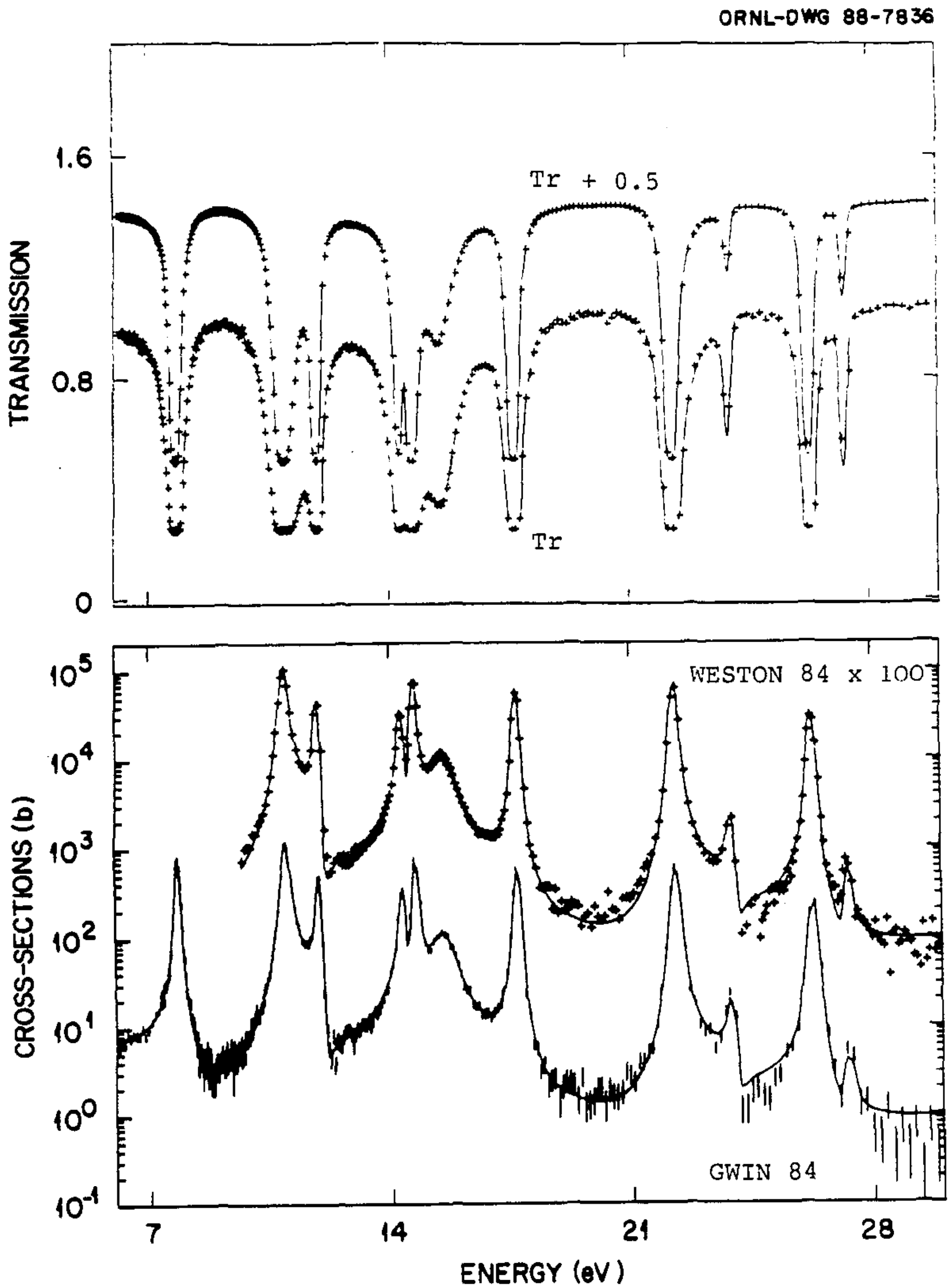


Figure 9

Experimental and calculated data in the energy range 6 eV to 30 eV.

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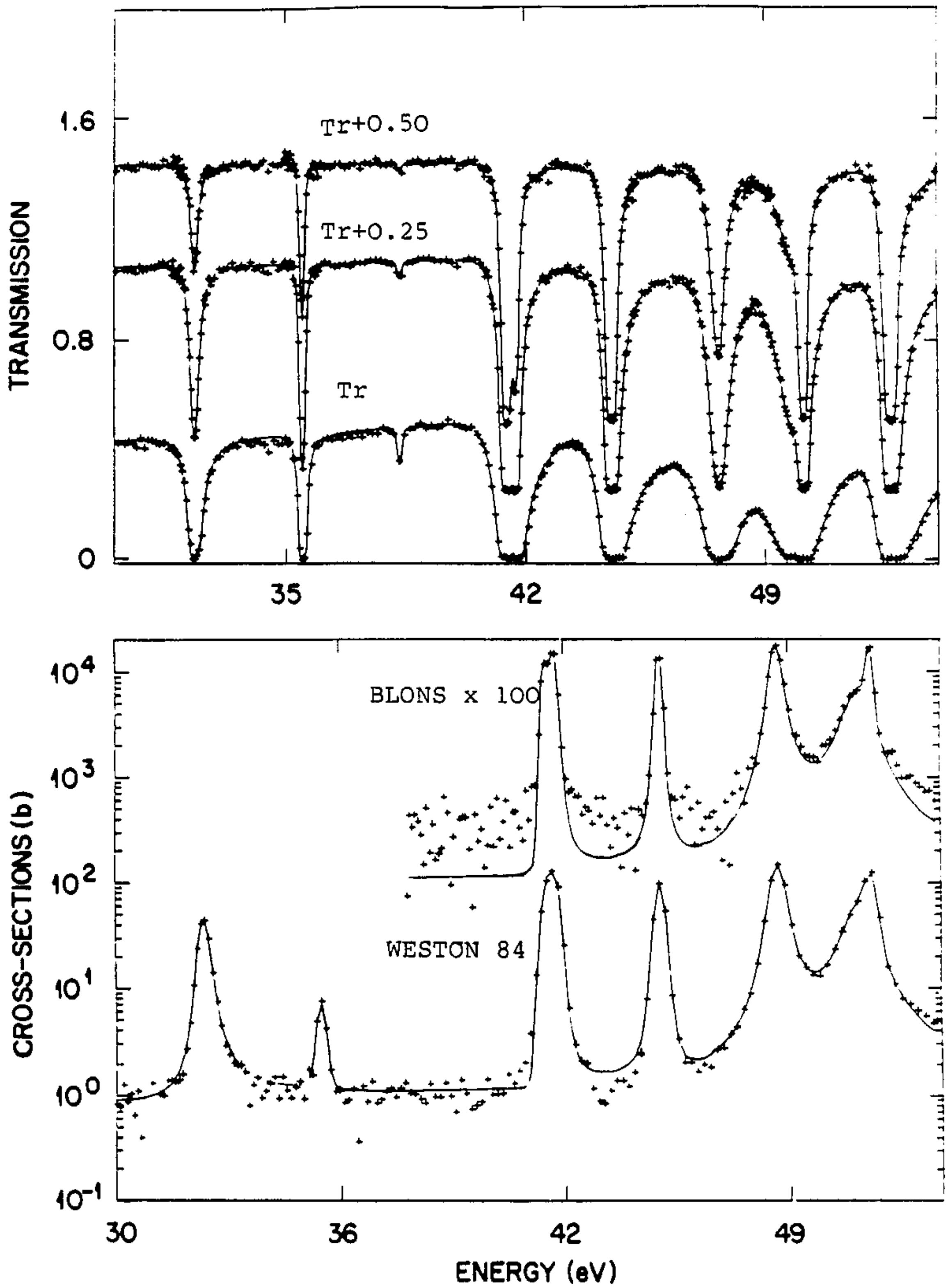
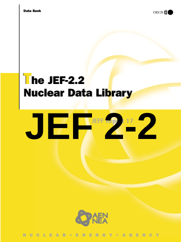


Figure 10

Experimental and calculated data on the energy range 30 to 50 eV.



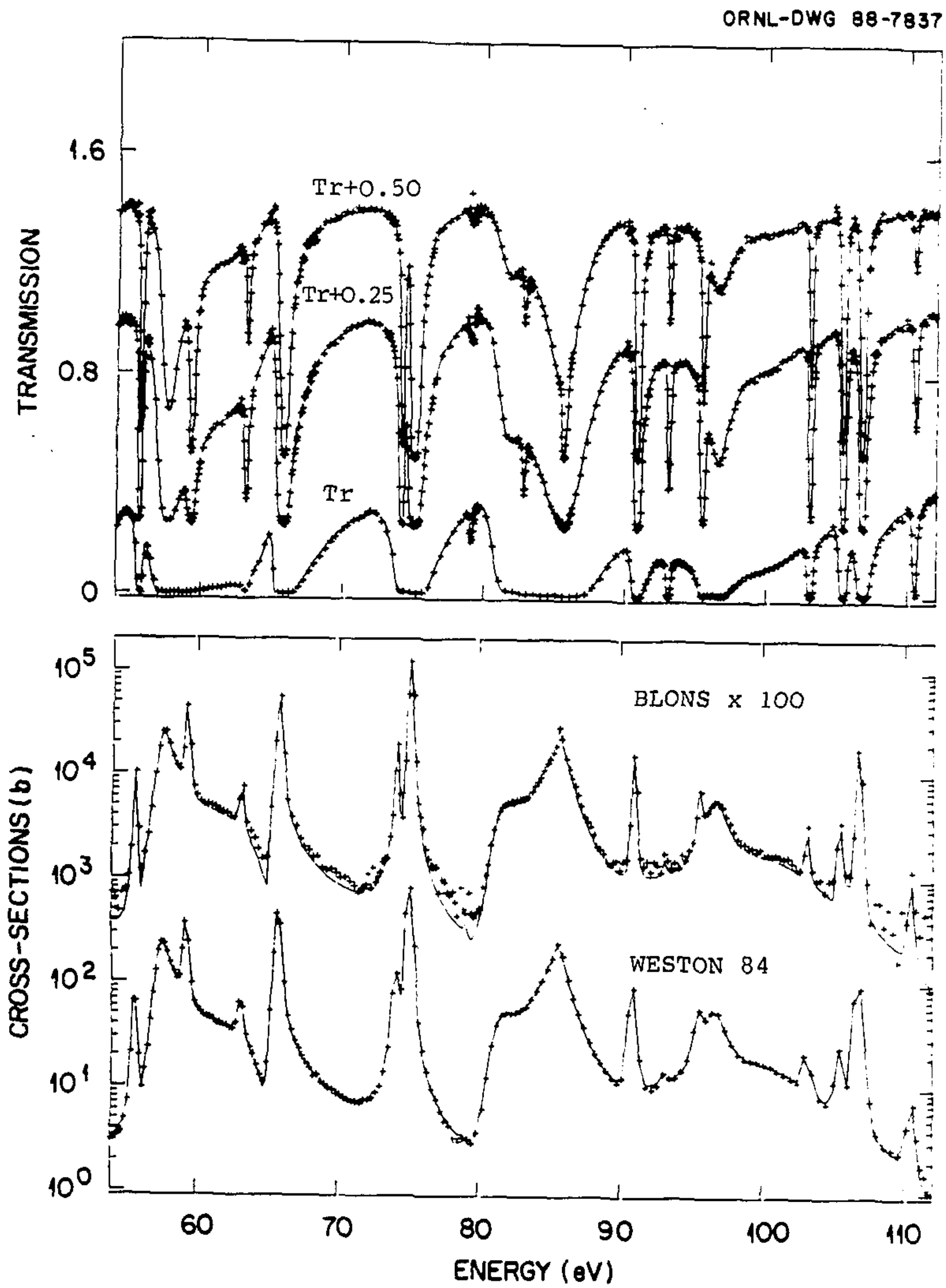


Figure 11

Experimental and calculated data in the energy range 50 eV to 110 eV.

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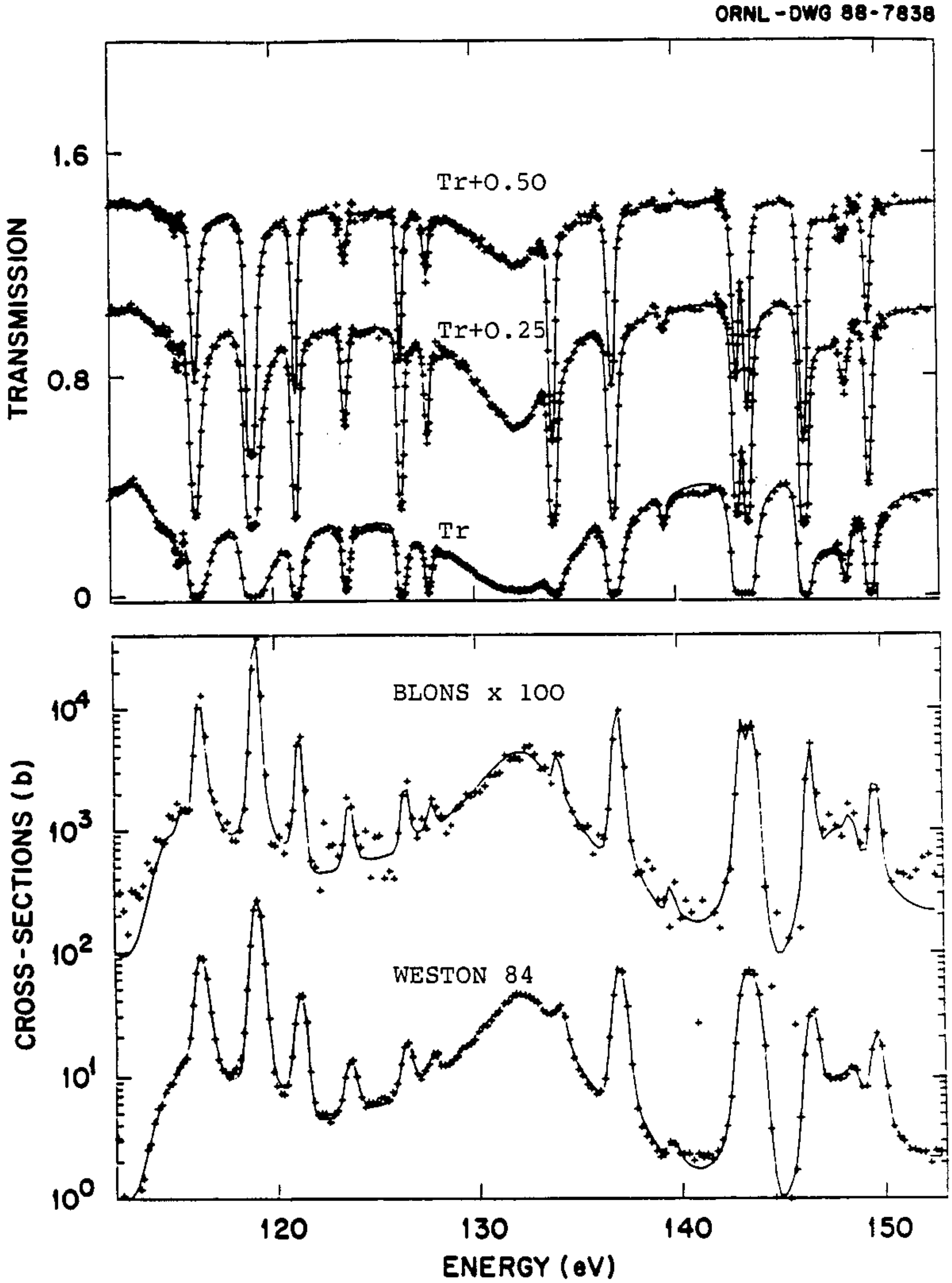
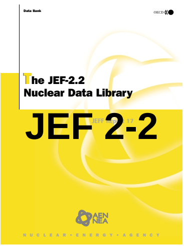


Figure 12

Experimental and calculated data in the energy range 100 eV to 153 eV.



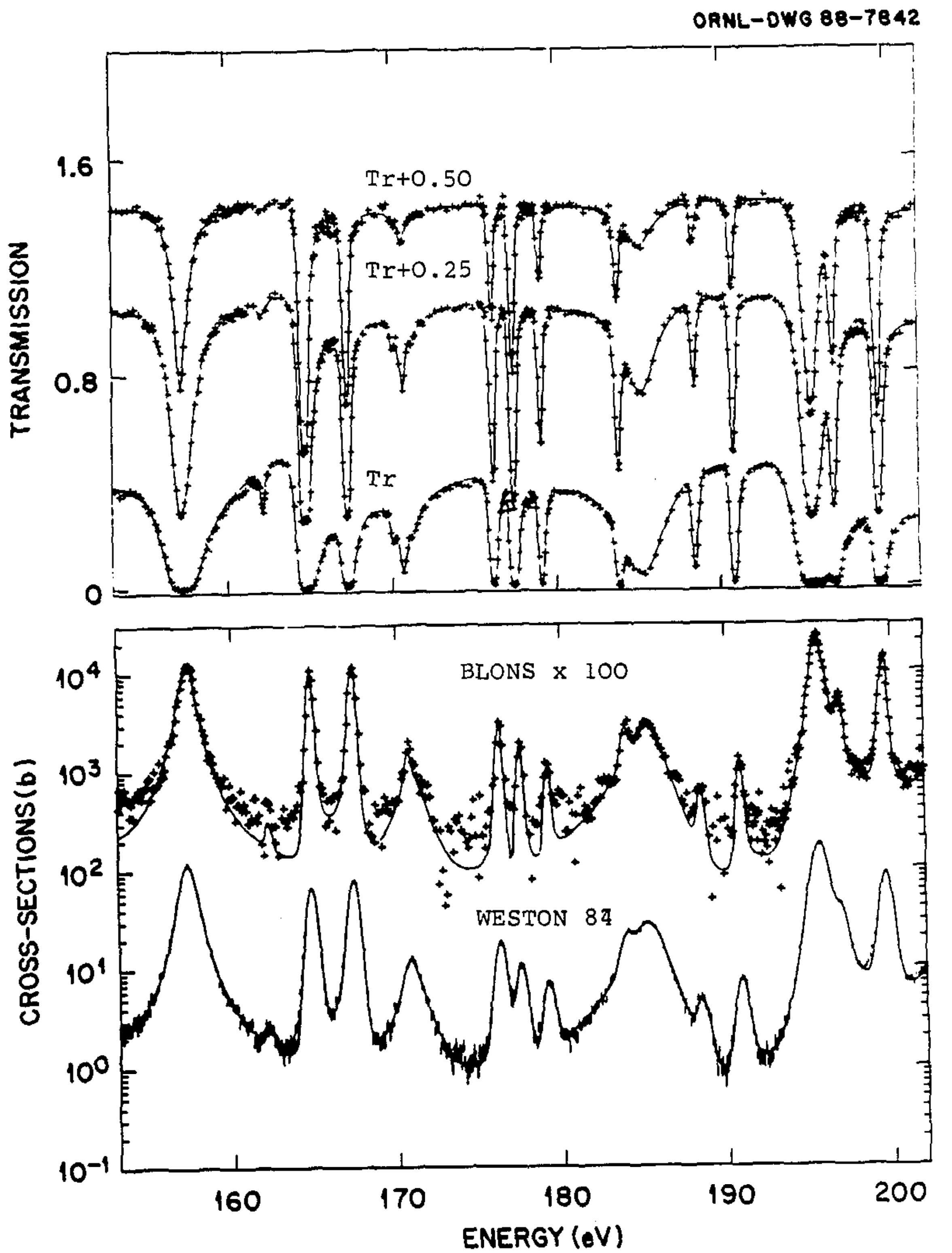


Figure 13

Experimental and calculated data in the energy range 150 eV to 210 eV.

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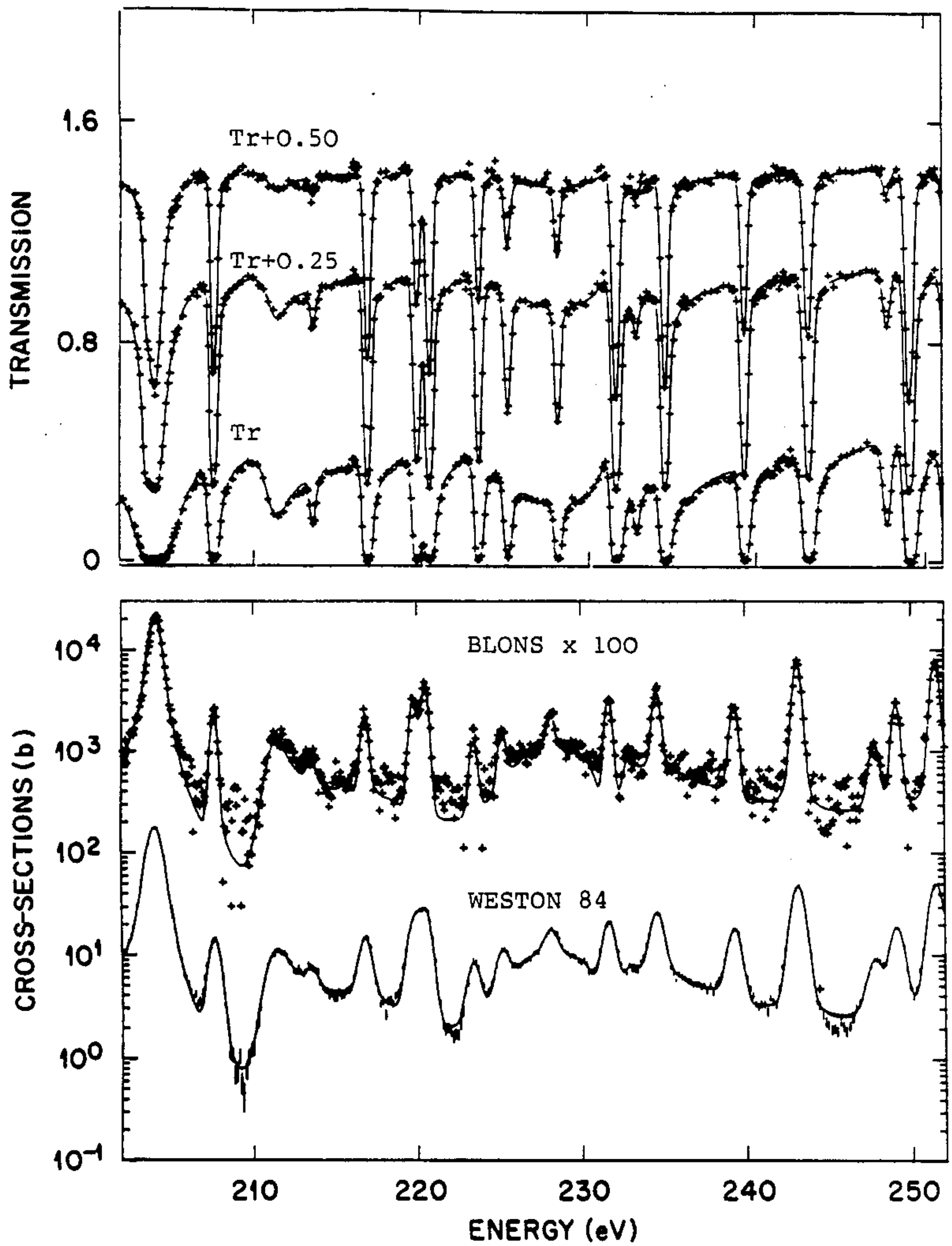
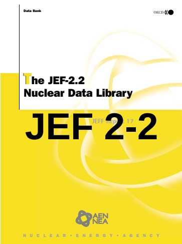


Figure 14

Experimental and calculated data in the energy range 190 eV to 253 eV.



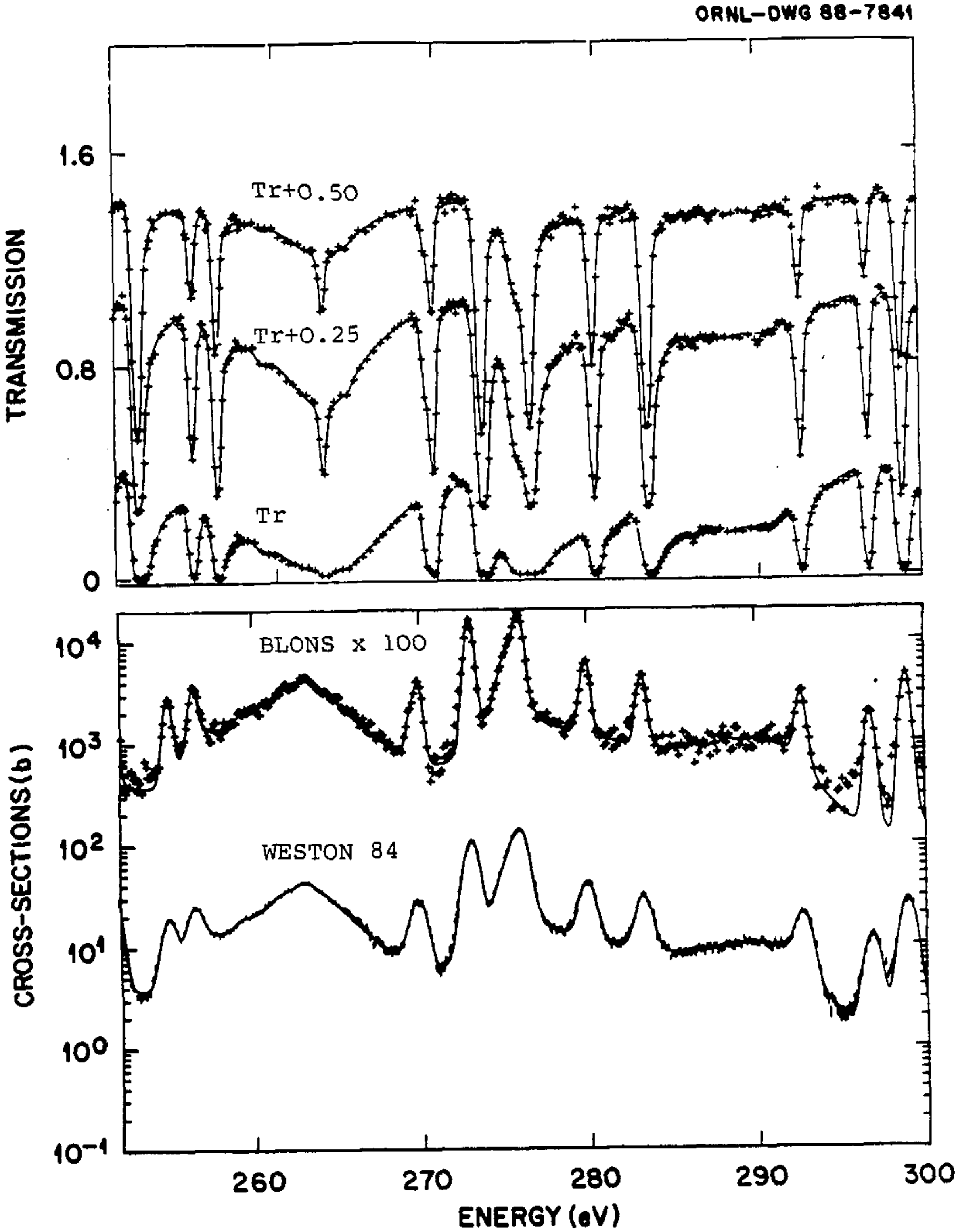


Figure 15

Experimental and calculated data in the energy range 250 eV to 300 eV.

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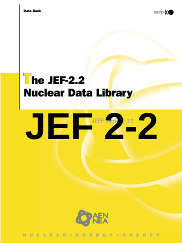

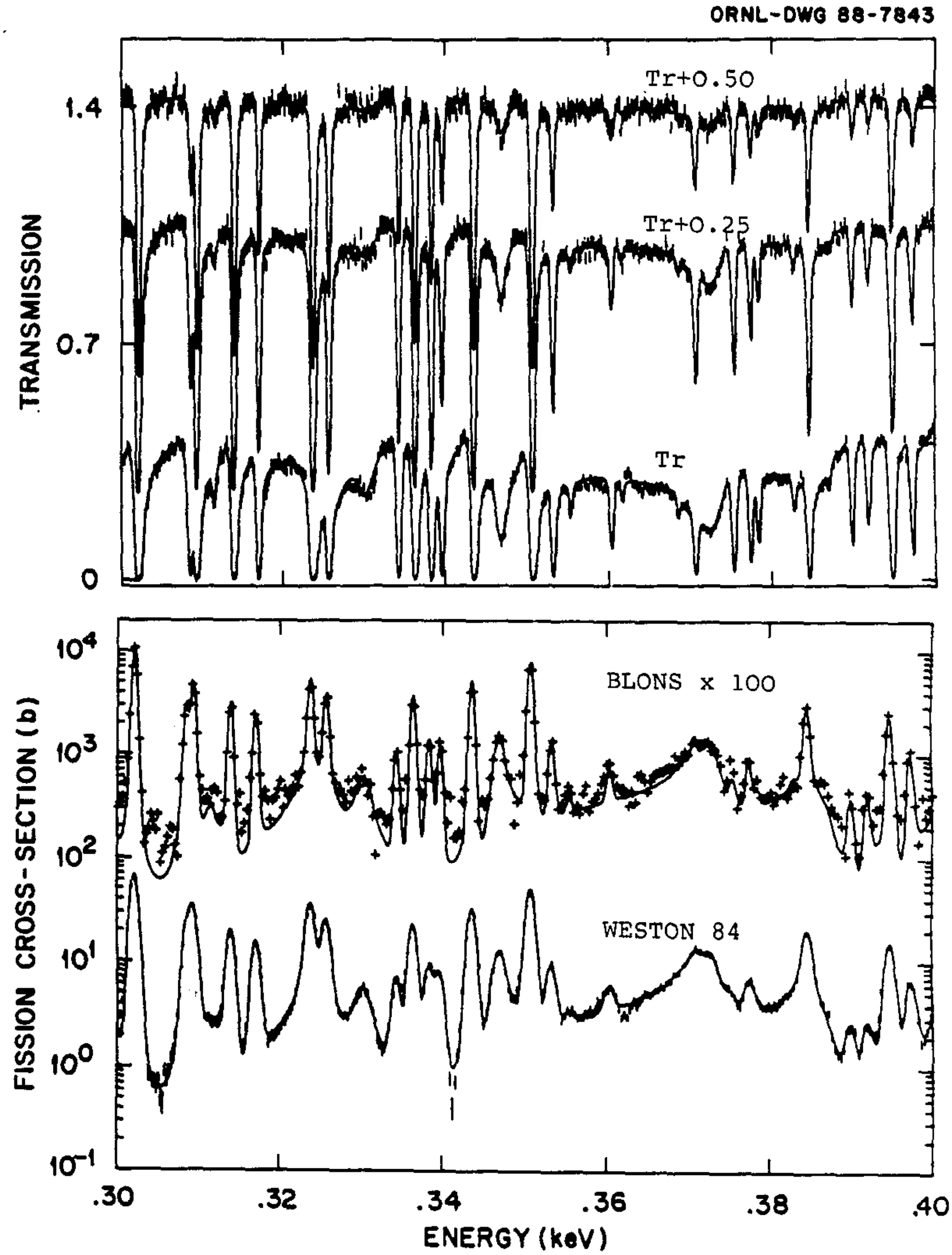

Figure 16

Experimental and calculated data in the energy range 0.30 keV to 0.40 keV.

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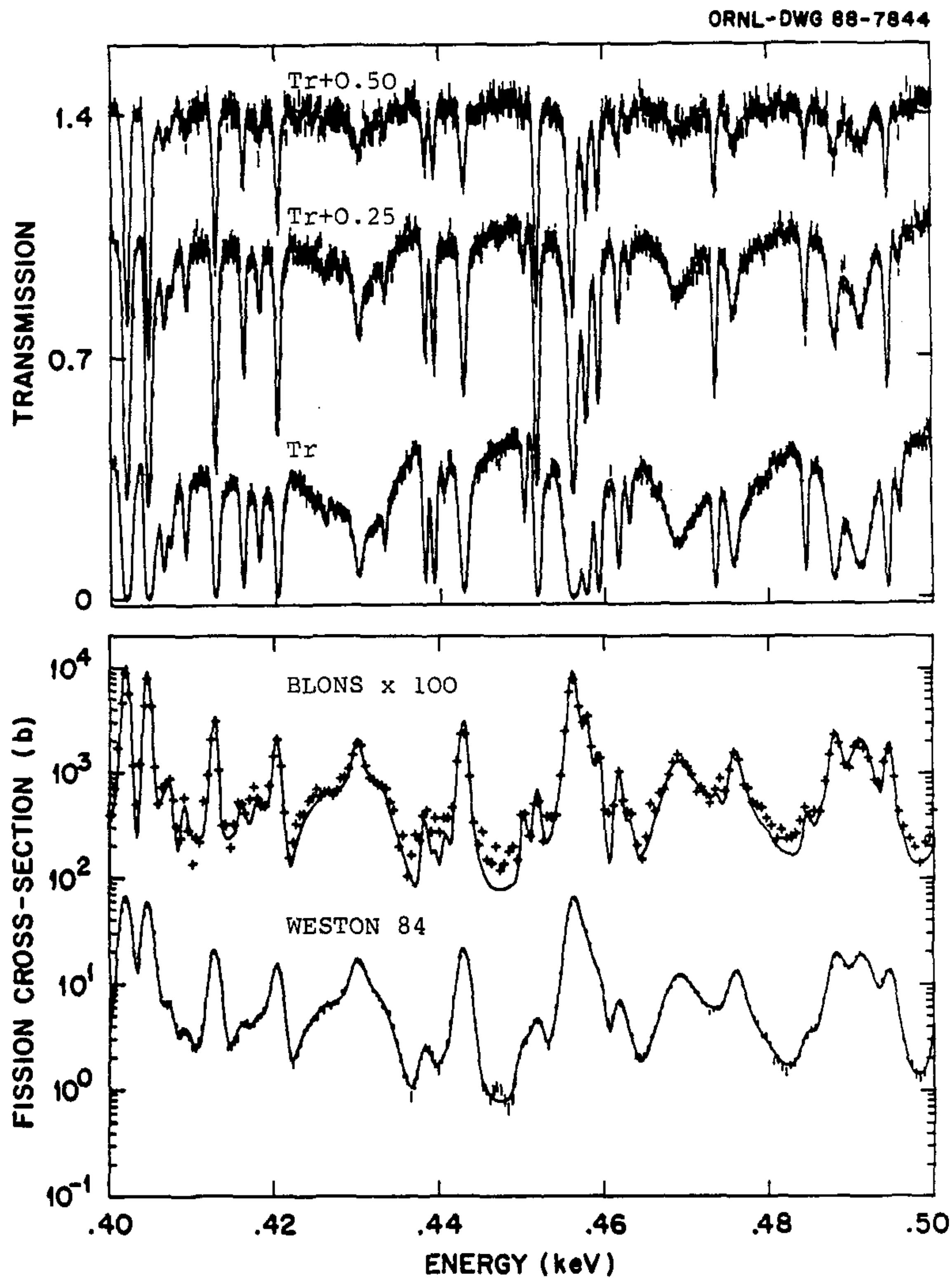
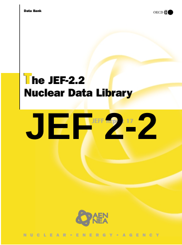


Figure 17

Experimental and calculated data in the energy range 0.40 keV to 0.50 keV.



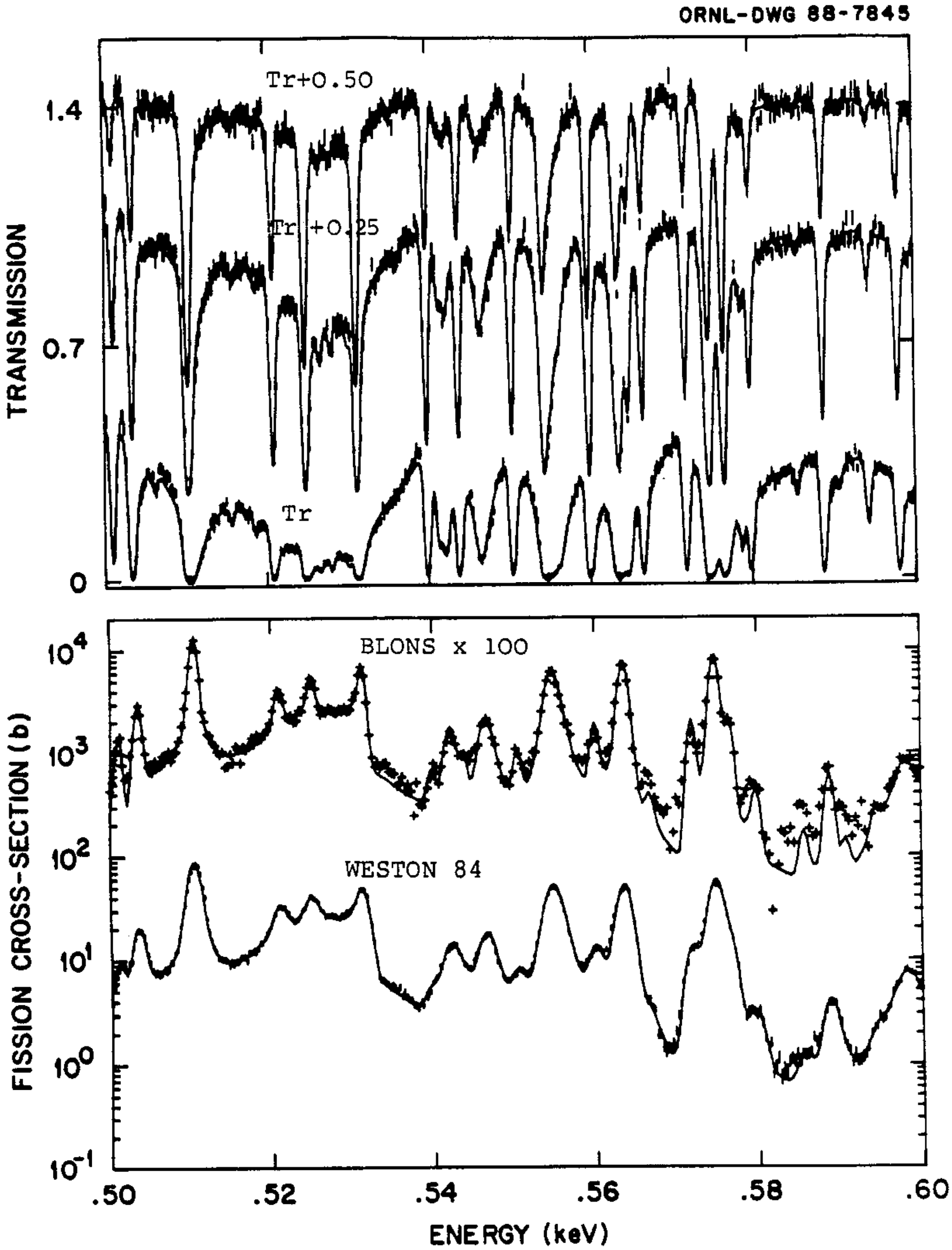
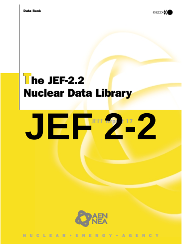


Figure 18

Experimental and calculated data in the energy range 0.50 keV to 0.60 keV.



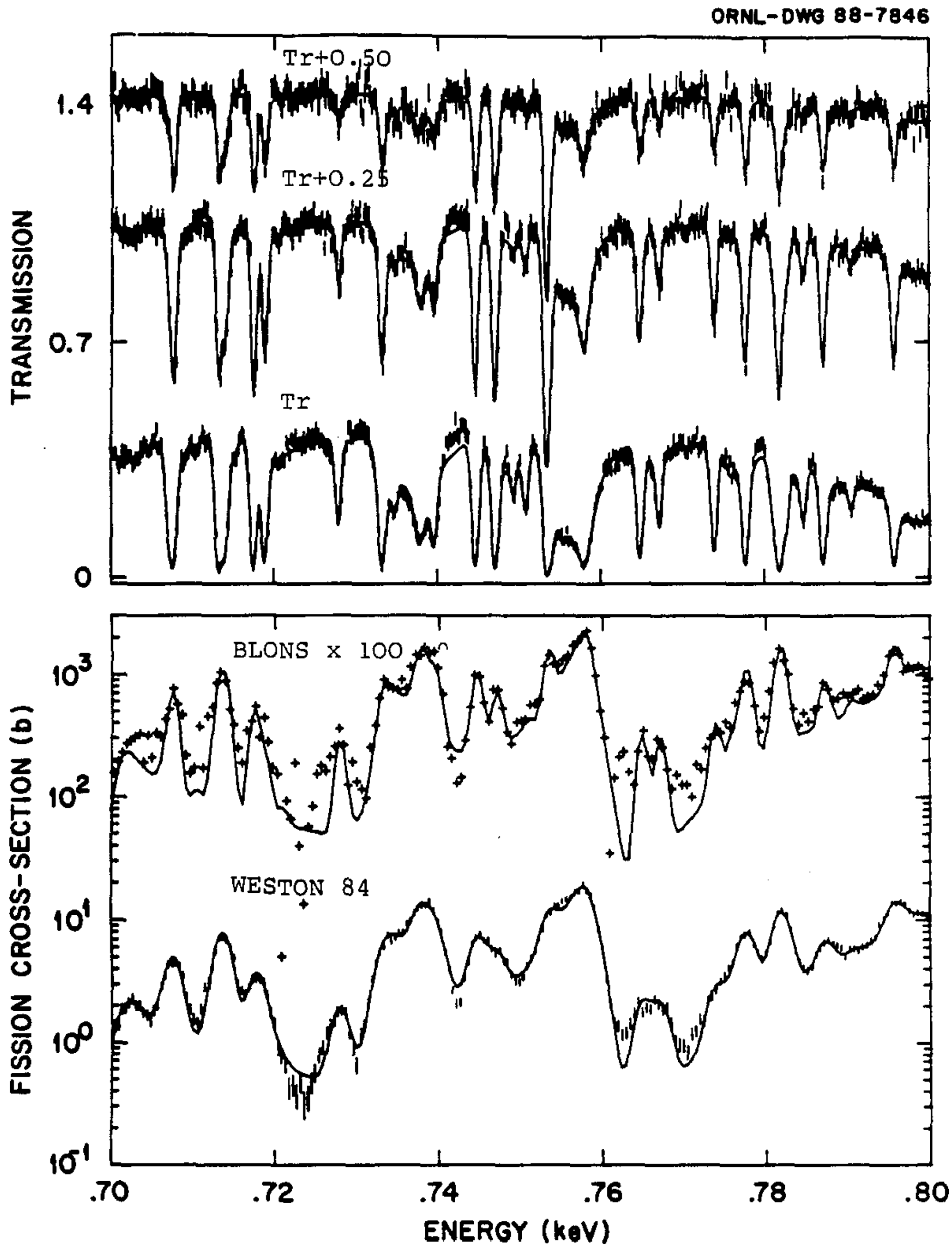
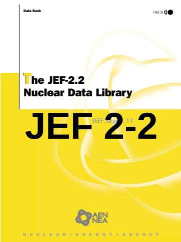


Figure 19

Experimental and calculated data in the energy range 0.70 keV to 0.80 keV.



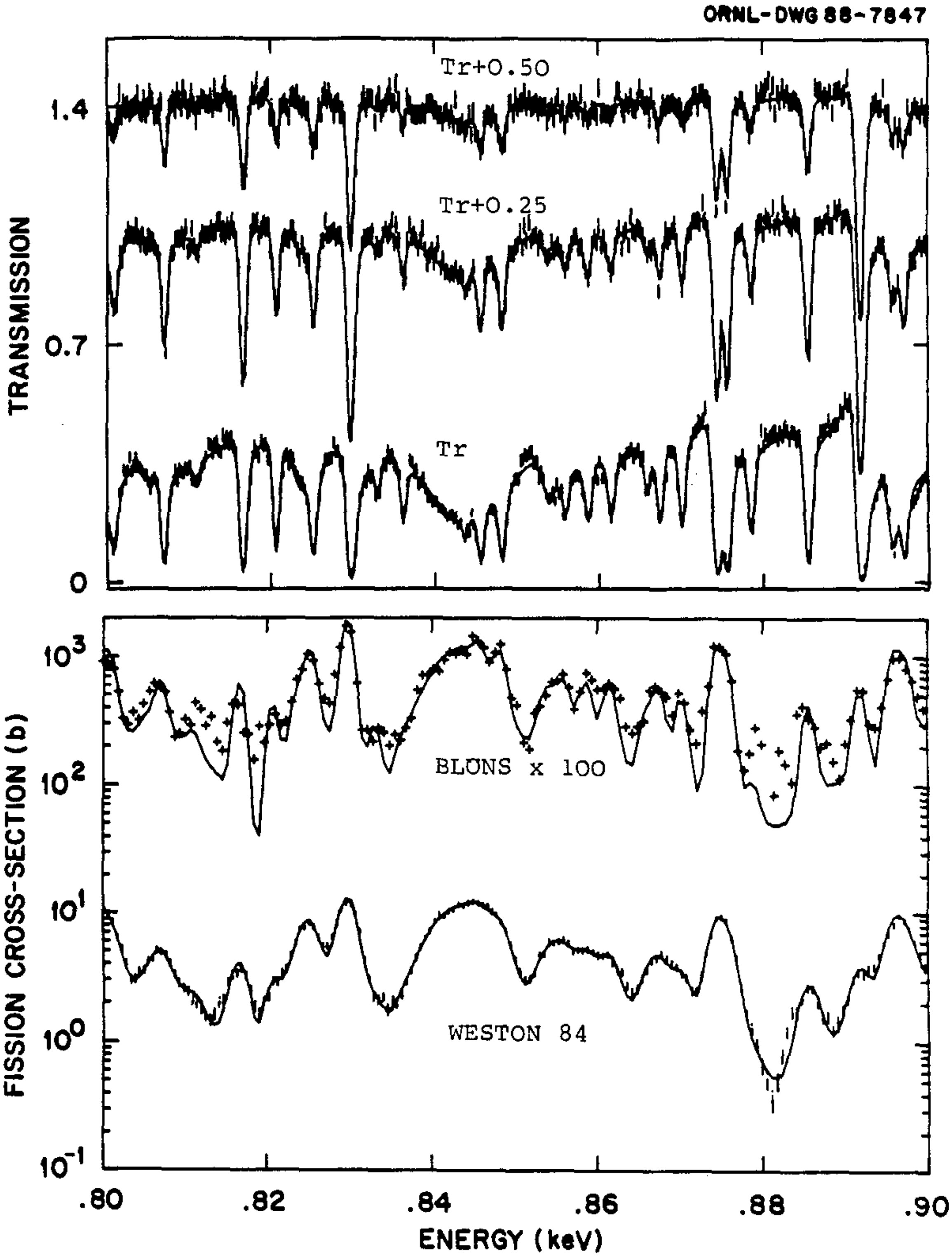


Figure 20

Experimental and calculated data in the energy range 0.80 keV to 0.90 keV.

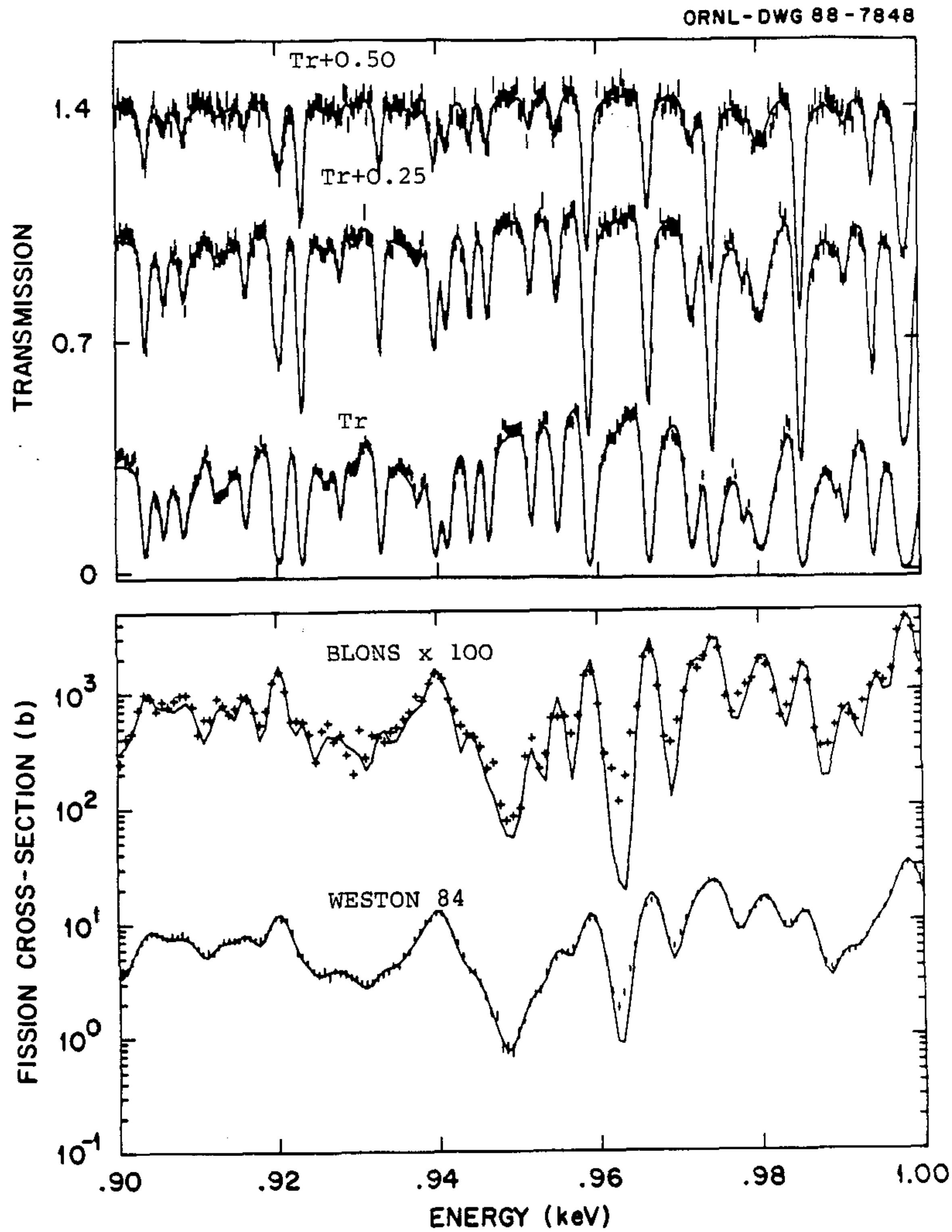


Figure 21

Experimental and calculated data in the energy range 0.90 keV to 1.00 keV.

14130285

ORNL-DWG 86-11932

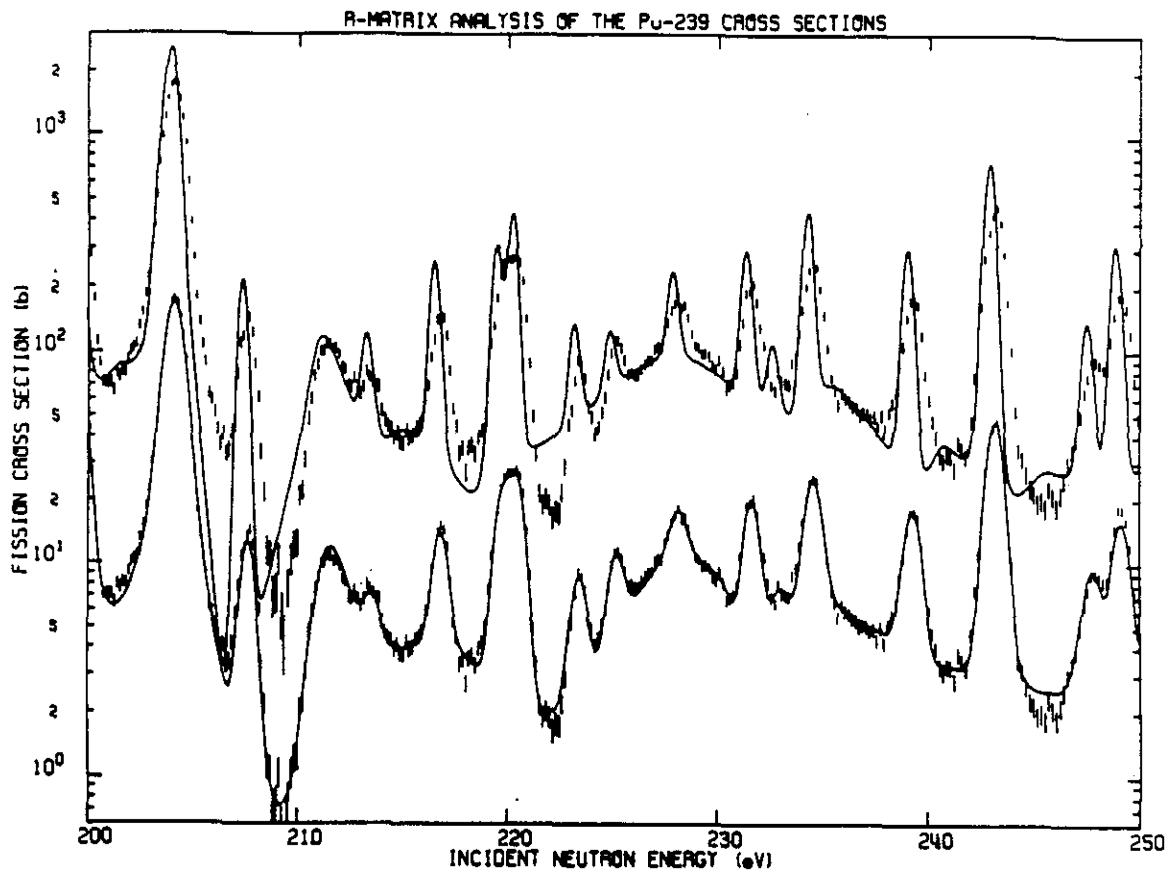


Figure 22

Comparison of the fission cross-section computed with the resonance parameters of Table I (lower solid line) and with ENDF/B-V (upper solid line), with the data from WESTON 84, in the energy range 200 eV to 250 eV. The ENDF/B-V calculation and corresponding set of data were displaced up by one decade for clarity.

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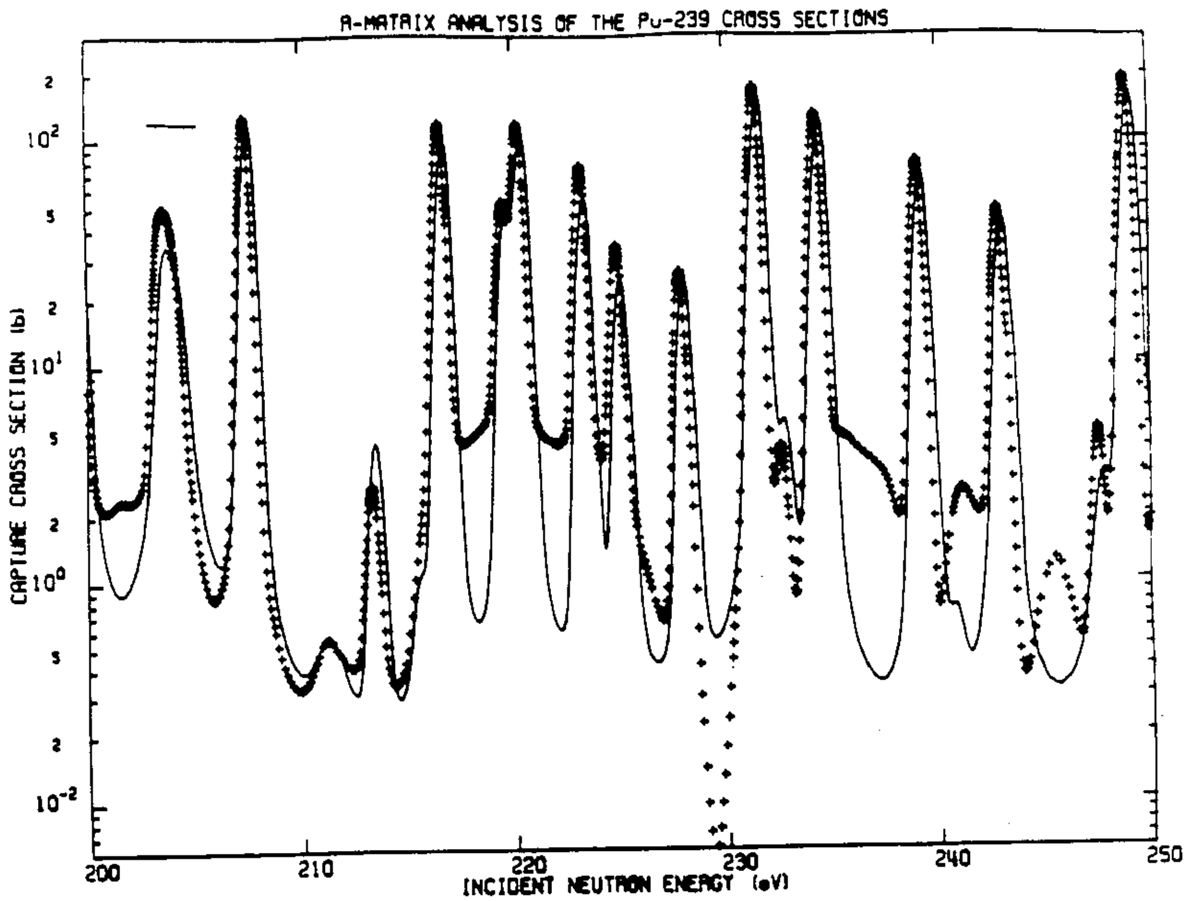

Figure 23

Comparison of the capture cross-section computed with the resonance parameters of Table I (solid line), with ENDF/B-V (crosses) over the neutron energy range 200 eV to 250 eV.

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