***SYNTHESIS OF THE COMPARISON OF JEF2.2 (ENDF/B-VI) and LEAL-DERRIEN/95 EVALUATIONS FOR $^{235}U$***

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## 1. Introduction

In several recent studies, it has been demonstrated that the resonance region evaluation of $^{235}$U (of Leal and de Saussure) adopted in both the US (ENDF/B-VI) and Western European (JEF2.2) nuclear data files, is unsatisfactory, especially for the capture cross-section in the resolved resonance energy range. These studies have shown that, while the fission cross-section seemed to be correct over the whole energy range, an underestimation of about 10 % to 13 % has been found for the capture cross-section in the resonance energy range.

An investigation of the evaluated data file concluded that the probable explanation was an underestimation of the mean capture width (by about 10 %).

This is the reason why several studies have been undertaken in the US in order to produce a new resonance region evaluation for the $^{235}$U isotope : a recent evaluation by LEAL and DERRIEN (1995) is now available. Several studies are now in progress in Europe and the USA to quantify the benefits of this new evaluation.

This paper summarizes the studies performed at CEA Cadarache (France) devoted to the testing of the LEAL-DERRIEN evaluation by means of LWRs lattice calculations. The first section compares the sets of resonance parameters and the infinitely dilute multigroup cross-sections of the JEF2.2 and the LEAL-DERRIEN evaluations. The second section describes briefly the code and the experimental benchmarks which have been used for benchmarking the new evaluation. The third section is devoted to the results of this benchmarking.

## 2. Comparison of the JEF2.2 and LEAL-DERRIEN evaluations

In the LEAL-DERRIEN evaluation, cross-sections between 0 eV and 2250 eV are represented by about 3170 resonances, described by the REICH-MOORE Cross Section Formalism. Fourteen bound states have been added in order to determine the shape of the cross-sections in the thermal energy region. Above 2250 eV, fourteen levels have been added in order to simulate the contribution of all the resonances located at higher energies. These 28 fictitious levels give a very good representation of the potential cross-section in each considered energy range.

In this evaluation, a unique scattering radius has been used over the whole energy range. This radius was deduced from the analysis (performed using the SAMMY code) of the experimental data related to the transmission measurements of Harvey. The LEAL-DERRIEN scattering radius is lower by 4 %, which gives a reduction of the potential cross section of 8 % (1 barn in 12 barns).

TABLE I and TABLE II give the averaged resonance parameters in both evaluations. We can note major differences from about 100 eV up to 2250 eV.
As expected, the mean capture width is increased in all the resolved resonance domain, in most cases by more than 20 percent (to be compared with M. Moxon's previous analysis estimating the mean capture width in the range 0 - 110 eV to be about 38 meV).

Figures 1 to 4 give the differences between JEF2.2 and the new LEAL-DERRIEN evaluation. The infinite dilution cross-sections have been reconstructed using the NJOY-THEMIS code with a fine structure weighting spectrum. We can note that in the low thermal energy range (0 eV - 0.1 eV), the evaluations are very similar (the observed differences are about or lower than 3 %, except for the scattering cross-section). For the fission and the capture cross-section, very large differences can be noted for each resolved resonance (from 0.3 eV up to 2250 eV) : for example, the fission cross-section is decreased by about 5 % and the capture by about 10 % in the first resonance at 0.32 eV in the LEAL-DERRIEN evaluation. We can also note differences up to about + 18 % for the fission cross-section (4 eV) and by about 37 % for the capture (700 eV).

Figure 5 presents the differences between the “ fission/capture ” ratio in the two evaluations : it can be seen that values in the LEAL/DERRIEN-95 evaluation are much lower than in the JEF2.2 evaluation and consequently, the multiplication factors $k_{eff}$ calculated with the new evaluation will be smaller than those obtained with JEF2.2 : the effect due to the decrease of the fission cross-section is added to the effect due to the increase of the capture cross-section.

This first analysis indicates that, while the modification of the capture cross-section seems to go in the right direction, the strong modification of the fission cross-section could induce unexpected effects on the multiplication factor of thermal lattices.

These tests are presented in the following section.

## 3. Benchmarking calculations

### *3.1. Code and library description*

For this study, we have used the APOLLO-2 code which is the latest version of the lattice code for thermal reactors. It has been developed over the past ten years : it is completely modular and a specific user friendly language is used. It solves the Boltzmann equation in the multigroup approximation using collision probability methods.

Specific self-shielding methods have been developed which calculate the effective reaction rates (and self-shielded cross-sections) with very low discrepancies compared to results obtained using MONTE-CARLO reference methods.

APOLLO-2 was used as a reference code for the comparison of calculated neutronic parameters obtained with both JEF2.2-$^{235}$U and LEAL/DERRIEN-$^{235}$U evaluations (the data for the other nuclides remained the same).

We used the CEA93 library in 172 groups this being completely based on JEF2.2 evaluations. The multigroup cross-sections were obtained using the NJOY code with appropriate weighting spectra.

### *3.2 Brief description of the investigated experiments*

The studies performed at CEA in 1993 /1/, and showing the error in the epithermal range for the $^{235}$U capture cross-section (JEF2.2), were realized using few (about 10) experiments involving $^{235}$U : however, it was concluded at the time that more experiments should be analysed.

Consequently, during the present study, we have investigated a wider range of available experimental results involving $^{235}$U. Thus, several experimental programs have been calculated.

TABLE III gives an overview of the experiments, which involve metallic uranium fuel and $UO_2$ fuel, both $H_2O$ and $D_2O$ moderators, stainless steel, aluminium or Zircalloy cladding materials, hexagonal and square pitches. Spherical uranium nitrate experiments have also be calculated. These experiments were performed in several countries.

## 4. Results of the calculations

TABLE III summarizes the $k_{eff}$ values obtained using the APOLLO-2 code for the chosen experiments with both JEF2.2 and the LEAL/DERRIEN evaluation. A slight underestimation of the calculated $k_{eff}$ is obtained in the calculations using $^{235}U$ from JEF2.2 (Average (E-C)/C = + 105 ± 625 pcm), and this underestimation is greater when the LEAL/DERRIEN evaluation is used (Average (E-C)/C = + 411 ± 680 pcm). The differences between calculated $k_{eff}$ values obtained using JEF2.2 and the LEAL/DERRIEN evaluations are plotted versus the slowing down density at 4 eV (*SDD*) in fig. 6. It can be seen that the difference decreases with the slowing-down density (formally defined as the fraction of fission neutrons absorbed below 4 eV) : the $^{235}U$ resonance region capture rate is more sensitive for " under-moderated " experiments in which the epithermal spectrum is higher than in standard PWR lattices : for example we can observe a difference of about 730 pcm for the CRISTO experiment (q = 0.36) and differences between 0 pcm and -34 pcm for the $D_2O$ experiments (q ~ 0.7 to 0.9). This trend is completely consistent with the differences between the cross-sections in the JEF2.2 and LEAL/DERRIEN evaluations which have been described in the previous section.

However, if we refer to the experiments which were investigated in 1993 (TABLE IV), we can conclude that the new evaluation gives better results than the previous one.

Another test which has been made concerned the $^{235}U$ capture rate relative to $^{235}U$ fission rate, measured during the SHERWOOD program. The results obtained are the following ones:

| | |
|---|---|
| $^{235}U$ JEF2.2 calculation: | (E-C)/C = + 5.4 ± 3.0 % (2σ) |
| $^{235}U$ LEAL-DERRIEN calculation: | (E-C)/C = + 4.4 ± 3.0 % (2σ) |

This result shows that the new evaluation gives a better prediction than the older one (JEF2.2), but the experiment/calculation discrepancy remains.

We noticed no significant changes in the other spectral indices analysed (less than 1 percent), essentially $^{235}U$ capture rate relative to $^{235}U$ fission rate and $^{238}U$ fission rate relative to $^{235}U$ fission rate. The results are not reported here.

In addition to this work, a specific study has been performed comparing the sensitivity coefficients of $k_{eff}$ to $^{235}U$ cross-sections obtained in both evaluations. The differences between the sensitivity coefficients calculated in 15 macrogroups (TRX2 experiment) are shown in figure 7. It is shown that the sensitivity coefficients are drastically modified (between + 4 % and + 16 %) in the energy range of interest (0.1 - 1 keV) : a specific investigation of these effects must be performed in order to understand what happens in these calculations (it is usually assumed that the sensitivity coefficient does not change significantly with the cross-section data set).

## 5. Conclusions

This work is devoted to the benchmarking of the new evaluation " LEAL/DERRIEN-95 " for $^{235}U$ which has been completed recently because some studies have demonstrated that the previous evaluation gave poor results for Uranium fuel in thermal reactors : the capture cross-sections seemed to be underestimated by about 10 % to 13 % in the epithermal energy range but the fission cross-section in the JEF2.2 evaluation appeared to be good.

This study began by a comparison of the multigroup (172 groups) cross-sections obtained using NJOY : the observed differences for the capture cross-section were consistent with the changes found to be required during the benchmarking of JEF2.2 but the differences for the fission cross-sections seem to be too high : consequently it could be concluded that the multiplication factors obtained using the new LEAL/DERRIEN evaluation would be smaller than those required to give agreement with experiment.

This has been demonstrated during the benchmarking which has used more critical experimental results than previously studied. The observed effects on $k_{eff}$ are consistent with the modifications of the evaluated cross-sections (increase of the capture cross-section and decrease of fission cross-section). However, it is very difficult to conclude at this stage of the study which evaluation is better.

In particular, the average (E-C)/C using our calculational scheme with the LEAL/DERRIEN evaluation goes in the wrong direction : this might be due to uncertainties in the newly investigated experiments for which the material composition is not very well-known (" old " experiments) or also because, in these experiments, the fundamental mode was not completely established. Another explanation might be that the calculational models used in this study (cylindrical geometry with white boundary conditions) must be improved using more accurate self-shielding and collision probability (exact 2D) methods. However, if we consider only the experiments analyzed in the study performed at CEA in 1993, the new evaluation reduces the experiment/calculation discrepancies.

In order to clarify these questions, a selection from among the tested experiments must be made in order to define a set of experiments with which the benchmarking exercices can be performed with a very high level of confidence.

Furthermore, additional investigations must be performed, especially using reference codes such as a MONTE-CARLO code, in order determine a reference calculational scheme involving APOLLO-2.

TABLE I.

*Mean values (in meV) of the partial widths between both evaluations*

| | JEF2.2 | | | | Leal-Derrien | | | |
|---|---|---|---|---|---|---|---|---|
| Energy group | $g\Gamma_n$ | $\Gamma_\gamma$ | $\Gamma_f$ | $\Gamma_t$ | $g\Gamma_n$ | $\Gamma_\gamma$ | $\Gamma_f$ | $\Gamma_t$ |
| 0-110 eV | 0.704 | 34.721 | 195.839 | 231.264 | 0.685 | 41.676 | 198.047 | 240.408 |
| 110-300 eV | 1.599 | 35.001 | 215.803 | 252.402 | 1.645 | 47.331 | 229.761 | 278.736 |
| 300-500 eV | 2.796 | 43.722 | 275.693 | 322.211 | 2.100 | 52.900 | 294.083 | 349.083 |
| 500-750 eV | 4.311 | 43.501 | 165.998 | 213.810 | 4.476 | 49.347 | 154.213 | 208.036 |
| 750-1000 eV | 5.392 | 42.982 | 111.177 | 159.551 | 5.524 | 49.760 | 97.815 | 153.099 |
| 1000-1250 eV | 5.711 | 44.965 | 138.020 | 188.696 | 5.442 | 49.346 | 126.508 | 181.297 |
| 1250-1500 eV | 6.222 | 38.734 | 107.195 | 152.151 | 6.216 | 45.113 | 105.729 | 157.058 |
| 1500-1750 eV | 7.937 | 38.621 | 63.639 | 110.197 | 7.425 | 40.779 | 83.135 | 131.338 |
| 1750-2000 eV | 10.149 | 38.338 | 81.482 | 129.969 | 10.168 | 46.336 | 84.090 | 140.593 |
| 2000-2250 eV | 5.312 | 33.901 | 60.112 | 99.326 | 5.784 | 50.029 | 70.022 | 125.835 |

TABLE II.

*Differences (in %) in the partial widths between Leal-Derrien and JEF-2.2*
*(LD-JEF2.2) / JEF2.2*

| Energy group | $g\Gamma_n$ | $\Gamma_\gamma$ | $\Gamma_f$ | $\Gamma_t$ |
|---|---|---|---|---|
| 0-110 eV | -2.73 | 20.03 | 1.13 | 3.95 |
| 110-300 eV | 2.91 | 35.23 | 6.47 | 10.43 |
| 300-500 eV | -24.90 | 20.99 | 6.67 | 8.34 |
| 500-750 eV | 3.81 | 13.44 | -7.10 | -2.70 |
| 750-1000 eV | 2.45 | 15.77 | -12.02 | -4.04 |
| 1000-1250 eV | -4.71 | 9.74 | -8.34 | -3.92 |
| 1250-1500 eV | -0.09 | 16.47 | -1.37 | 3.23 |
| 1500-1750 eV | -6.45 | 5.59 | 30.64 | 19.19 |
| 1750-2000 eV | 0.19 | 20.86 | 3.20 | 8.17 |
| 2000-2250 eV | 8.88 | 47.57 | 16.48 | 26.69 |

TABLE II

*Experiments Analyzed.*

| *Experiment* | *Country* | *Characteristics* | *Number of Keff* | *Number of SI* [1] |
|---|---|---|---|---|
| ZPR | USA | $UO_2$ of several % of $^{235}$U-Stainless Steel clad. several moderation ratios | 6 | 5 |
| CRISTO | France | $UO_2$ Zr clad. square Undermoderated and over moderated cores | 2 | / |
| VVER | Hungary | $UO_2$ of several % of $^{235}$U, Zr clad - Hexa. pitch - several moderation ratios and temperature | 15 | / |
| DIMPLE S01A | U.K. | $UO_2$ - 3% - Mod ratio =1. Square Al Clad. | 1 | 2 |
| EPICURE | France | $UO_2$ - 3.7% - MR = 1.2 - Zr clad ; Square | 1 | / |
| MELODIE | France | $UO_2$ - 3% - MR = 1.2 - Zr clad ; Square | 1 | 1 |
| AZUR | France | U Metal ; plates | 3 | / |
| CAMELEON | France | $UO_2$ - 3.25% - MR = 1.8 - Al clad ; Square | 1 | / |
| BNL | USA | $UO_2$ - 3% - Zr clad ; Hexa. pitch | 5 | / |
| TRX | USA | U metal - Hexa. pitch | 2 | 4 |
| KRITZ | Sweden | $UO_2$ - square - Al clad. | 1 | / |
| BAPL | USA | $UO_2$ - square | 3 | 3 |
| $H_2O$ exp. | USA | U metal - $D_2O$ | 5 | / |
| $D_2O$ exp. | USA | $UO_2$ - $D_2O$ moderator | 4 | / |
| MIT ($D_2O$) | USA | $UO_2$ - $D_2O$ moderator | 3 | / |
| ORNL | USA | Spherical Uranyl. | 2 | / |

[1] S.I.: Spectral Indices (involving U-235)

TABLE III :

*Discrepancies in reactivity obtained with JEF2.2 and the LEAL / DERRIEN evaluations (C-E in pcm)*

| | *U235 JEF2.2* | | *U235 Leal-Derrien* | | |
|---|---|---|---|---|---|
| *Experiment* | *SDD at 4 eV* | *(1-keff) / keff* | *SDD at 4 eV* | *(1-keff) / keff* | *LD-JEF2.2* |
| ZPRHiC-11 | 0.3578 | 136.00 | 0.3563 | 871.94 | 735.94 |
| CRISTO 3 | 0.3641 | 348.00 | 0.3627 | 1077.49 | 729.49 |
| V1103600130 | 0.4238 | 1930.77 | 0.4227 | 2520.68 | 589.90 |
| V1103600080 | 0.4301 | 1636.86 | 0.4290 | 2207.16 | 570.30 |
| ZPRHiC-9 | 0.4359 | 453.00 | 0.4349 | 985.11 | 532.11 |
| V1103600020 | 0.4385 | 491.10 | 0.4395 | 1044.70 | 553.60 |
| V1103610020 | 0.4407 | 1105.28 | 0.4395 | 1664.14 | 558.86 |
| ZPRBo-2 | 0.4504 | -136.00 | 0.4487 | 450.32 | 586.32 |
| ZPRHiC-8 | 0.4651 | 839.00 | 0.4643 | 1296.29 | 457.29 |
| ZPRBo-1 | 0.4852 | -294.00 | 0.4842 | 184.34 | 478.34 |
| V1274400020 | 0.4890 | 288.63 | 0.4881 | 716.90 | 428.27 |
| DIMPLE S01A | 0.4929 | 32.00 | 0.4920 | 481.31 | 449.31 |
| V1274406020 | 0.4970 | -399.99 | 0.4961 | 26.21 | 426.20 |
| H-MEM | 0.5021 | -235.00 | 0.5013 | 145.00 | 380.00 |
| UH1.2 | 0.5049 | -324.00 | 0.5040 | 121.15 | 445.15 |
| V1273600130 | 0.5056 | 333.71 | 0.5049 | 727.05 | 393.34 |
| ZPRHiC-6 | 0.5097 | 364.00 | 0.5087 | 837.05 | 473.05 |
| V1273600080 | 0.5102 | 207.33 | 0.5095 | 587.23 | 379.90 |
| V1273600020 | 0.5186 | -979.51 | 0.5178 | -609.96 | 369.55 |
| H-UO61 | 0.5395 | 1174.00 | 0.5389 | 1369.50 | 195.50 |
| V1273640130 | 0.5418 | 160.26 | 0.5410 | 561.23 | 400.98 |
| MELODIE-1 | 0.5450 | 1129.00 | 0.5440 | 1588.85 | 459.85 |
| V1273640080 | 0.5477 | -92.81 | 0.5469 | 291.35 | 384.16 |
| V1504400020 | 0.5491 | 339.55 | 0.5485 | 639.16 | 299.61 |
| V1274472020 | 0.5513 | -1451.52 | 0.5503 | -1017.34 | 434.18 |
| V1273640020 | 0.5514 | -185.46 | 0.5506 | 190.56 | 376.02 |
| V1273658130 | 0.5566 | 330.29 | 0.5558 | 737.19 | 406.91 |
| H-OX33 | 0.5597 | 56.00 | 0.5589 | 399.59 | 343.59 |
| V1273658080 | 0.5651 | -347.89 | 0.5642 | 39.62 | 387.50 |
| AZUR-834 | 0.5660 | 662.00 | 0.5651 | 1047.15 | 385.15 |
| V1273658020 | 0.5694 | -504.24 | 0.5685 | -126.51 | 377.73 |
| CAMELEON | 0.5720 | -939.00 | 0.5713 | -592.07 | 346.93 |
| V1503600020 | 0.5776 | -304.09 | 0.5771 | -47.38 | 256.71 |
| AZUR-1031 | 0.5786 | 604.00 | 0.5777 | 989.70 | 385.70 |
| H-OX44 | 0.5792 | 120.00 | 0.5786 | 426.81 | 306.81 |
| BNLOX-13 | 0.5811 | -575.00 | 0.5803 | -217.90 | 357.10 |
| V1273672020 | 0.5837 | -821.10 | 0.5829 | -443.33 | 377.78 |
| AZUR-1249 | 0.5925 | 540.00 | 0.5916 | 926.51 | 386.51 |
| BNLOX-16 | 0.6072 | -323.00 | 0.6065 | -18.40 | 304.60 |
| TRX-1 | 0.6219 | -145.00 | 0.6215 | 62.00 | 207.00 |
| H-UO75 | 0.6281 | 1065.00 | 0.6278 | 1244.19 | 179.19 |
| V1271600020 | 0.6287 | 942.81 | 0.6285 | 1114.59 | 171.78 |

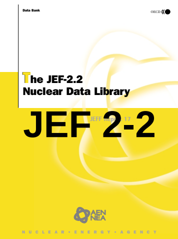



TABLE III (Continued) :

*Discrepancies in reactivity obtained with*
*JEF2.2 and the LEAL / DERRIEN evaluations (C-E in pcm)*

| | *U235 JEF2.2* | | *U235 Leal-Derrien* | | |
|---|---|---|---|---|---|
| *Experiment* | *Sl. dens. at 4 eV* | *(1-keff) / keff* | *Sl. dens. at 4 eV* | *(1-keff) / keff* | *LD-JEF2.2* |
| H-OX37 | 0.6319 | 303.00 | 0.6314 | 539.90 | 236.90 |
| BNLOX-20 | 0.6392 | -266.00 | 0.6387 | -17.10 | 248.90 |
| KRITZ-20 | 0.6477 | -120.00 | 0.6473 | 53.83 | 173.83 |
| BAPL-1 | 0.6481 | -149.00 | 0.6477 | 27.21 | 176.21 |
| V1503640020 | 0.6543 | -1226.37 | 0.6538 | -978.92 | 247.45 |
| V1271618020 | 0.6642 | 1116.02 | 0.6638 | 1304.60 | 188.58 |
| BAPL-2 | 0.6810 | -179.00 | 0.6807 | -37.59 | 141.41 |
| BNLOX-29 | 0.6848 | -520.00 | 0.6844 | -331.60 | 188.40 |
| H-UO87 | 0.6973 | 887.00 | 0.6971 | 1003.98 | 116.98 |
| TRX-2 | 0.7098 | -77.00 | 0.7089 | 42.00 | 119.00 |
| V1501600020 | 0.7175 | -85.03 | 0.7172 | 22.81 | 107.83 |
| BAPL-3 | 0.7304 | -209.00 | 0.7302 | -110.48 | 98.52 |
| BNLOX-41 | 0.7406 | -232.00 | 0.7402 | -101.30 | 130.70 |
| D-UN8 | 0.7623 | -64.00 | 0.7619 | -89.00 | -25.00 |
| D-UN0 | 0.7705 | -58.00 | 0.7702 | -12.00 | 46.00 |
| MIT-1 | 0.7715 | 69.00 | 0.7712 | 122.00 | 53.00 |
| MIT-2 | 0.7934 | 280.00 | 0.7929 | 264.00 | -16.00 |
| MIT-3 | 0.8215 | 243.00 | 0.8207 | 255.00 | 12.00 |
| ORNL-1 | 0.8302 | 329.00 | 0.8300 | 520.60 | 191.60 |
| D-UN3 | 0.8399 | -81.00 | 0.8395 | -85.00 | -4.00 |
| D-UN5 | 0.8740 | -7.00 | 0.8736 | -41.00 | -34.00 |
| CRISTO 1 | 0.8960 | -511.00 | 0.8956 | -414.18 | 96.82 |
| ORNL-10 | 0.9262 | 180.00 | 0.9261 | 300.90 | 120.90 |

| | JEF2.2 | Leal-Derrien |
|---|---|---|
| Average | 105.44 | 411.35 |
| St. deviation | 624.21 | 678.60 |

TABLE IV :

*Discrepancies in reactivity obtained with JEF2.2 and the LEAL / DERRIEN evaluations for experiments tested in 1993 at CEA (C-E in pcm)*

| | *U235 JEF2.2* | | *U235 Leal-Derrien* | | |
|---|---|---|---|---|---|
| *Experiment* | *SDD at 4 eV* | *(1-keff) / keff* | *SDD at 4 eV* | *(1-keff) / keff* | *LD-JEF2.2* |
| DIMPLE S01A | 0.4929 | 32.00 | 0.4920 | 481.31 | 449.31 |
| UH1.2 | 0.5049 | -324.00 | 0.5040 | 121.15 | 445.15 |
| V1273600130 | 0.5056 | 333.71 | 0.5049 | 727.05 | 393.34 |
| V1273600080 | 0.5102 | 207.33 | 0.5095 | 587.23 | 379.90 |
| V1273600020 | 0.5186 | -979.51 | 0.5178 | -609.96 | 369.55 |
| CAMELEON | 0.5720 | -939.00 | 0.5713 | -592.07 | 346.93 |
| V1503600020 | 0.5776 | -304.09 | 0.5771 | -47.38 | 256.71 |
| BNLOX-13 | 0.5811 | -575.00 | 0.5803 | -217.90 | 357.10 |
| TRX-1 | 0.6219 | -145.00 | 0.6215 | 62.00 | 207.00 |
| BNLOX-29 | 0.6848 | -520.00 | 0.6844 | -331.60 | 188.40 |
| TRX-2 | 0.7098 | -77.00 | 0.7089 | 42.00 | 119.00 |
| BNLOX-41 | 0.7406 | -232.00 | 0.7402 | -101.30 | 130.70 |
| ORNL-1 | 0.8302 | 329.00 | 0.8300 | 520.60 | 191.60 |

| | JEF2.2 | LEAL/DER. |
|---|---|---|
| Average | -245 | 47 |
| St. deviation | 428 | 400 |

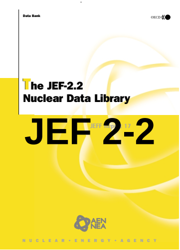



TABLE V. :

*Differences between group cross sections (infinite dilution) in percent*

| *Upper Energy Limit (eV)* | *Total Cross Section* | *Elastic Scattering* | *Fission* | *Capture* | *Eta* |
|---|---|---|---|---|---|
| 2250 | -6.16 | -21.39 | 0.47 | 50.92 | -15.34 |
| 2030 | -7.39 | -13.36 | -3.57 | 11.36 | -4.83 |
| 1510 | -6.73 | -13.1 | 2.4 | 8.3 | -1.83 |
| 1430 | -3.14 | -8.79 | -2.05 | 18.67 | -5.56 |
| 1230 | -4.85 | -9.94 | -5.19 | 12.4 | -5.57 |
| 1010 | -4.79 | -14.08 | -1.04 | 18.78 | -6.92 |
| 914 | -3.82 | -9.19 | -3.8 | 12.94 | -5.14 |
| 749 | -3.93 | -16.4 | -1.48 | 37.08 | -8.82 |
| 677 | -1.31 | -7.04 | -2.38 | 17.85 | -4.99 |
| 454 | 1.45 | -5.09 | -0.82 | 27.49 | -6.66 |
| 372 | 1.51 | -1.68 | -1.48 | 14.17 | -4.7 |
| 304 | 0.12 | -15.02 | 1.91 | 26.62 | -5.97 |
| 204 | 0.59 | -9.79 | -1.44 | 20.33 | -6.35 |
| 149 | 1.63 | -7.49 | -2.58 | 21.82 | -8.44 |
| 137 | -0.45 | -8.78 | -0.27 | 8.14 | -2.86 |
| 91.7 | -0.9 | -12.5 | 0.24 | 9.84 | -2.9 |
| 75.7 | 0.18 | -10.16 | -0.95 | 17.17 | -3.84 |
| 67.9 | -0.33 | -10.39 | 1.32 | 5.85 | -1.3 |
| 55.6 | 0.14 | -10.03 | -0.69 | 9.87 | -2.81 |
| 51.6 | 0.39 | -11.62 | 0.83 | 3.99 | -1.13 |
| 48.3 | -0.98 | -10.93 | -3.91 | 14.07 | -5.26 |
| 45.5 | -0.53 | -9.25 | -1.89 | 7.61 | -3.45 |
| 40.2 | -0.06 | -9.01 | -3.67 | 13.17 | -5.52 |
| 37.3 | 0.46 | -5.47 | -0.71 | 4.89 | -1.77 |
| 33.7 | 0.06 | -8.53 | -2.55 | 5.21 | -3.79 |
| 30.5 | -0.9 | -8.7 | -2.89 | 13.52 | -5.03 |
| 27.6 | -1.75 | -7.84 | -0.53 | 2.37 | -0.35 |
| 25 | 0.19 | -8.43 | -1.66 | 5.51 | -3.02 |
| 22.6 | 0.32 | -7.12 | 0.26 | 3.55 | -1.6 |
| 19.5 | -0.24 | -5.78 | -1.42 | 3.24 | -1.75 |
| 15.9 | -0.55 | -6.54 | -0.4 | 4.09 | -1.21 |
| 13.7 | -0.07 | -6.95 | -10.2 | 8 | -10.7 |
| 11.2 | -0.58 | -7.02 | 2.06 | 4.48 | -0.58 |
| 9.91 | -0.86 | -7.03 | 1.26 | -2.65 | 0.92 |
| 9.19 | -1.92 | -6.71 | -2.18 | -0.37 | -0.45 |
| 8.32 | -2.22 | -5.96 | 2.47 | 1.89 | 0.25 |
| 7.52 | 0.45 | -5.85 | -4.85 | 4.44 | -5.97 |
| 6.16 | -4.17 | -5.88 | -6.93 | 8.62 | -3.69 |
| 5.35 | 0.22 | -5.8 | 10.71 | -1.86 | 3.88 |
| 5.04 | -0.45 | -5.59 | 8.64 | -0.04 | 6.9 |
| 4.13 | -1.16 | -5.52 | 18.86 | -0.98 | 7.95 |
| 4 | -0.63 | -5.36 | -0.77 | 2.99 | -1.44 |

TABLE V. *(continued) :*

*Differences between group cross sections (infinite dilution) in percent*

| *Upper Energy Limit (eV)* | *Total Cross Section* | *Elastic Scattering* | *Fission* | *Capture* | *Eta* |
|---|---|---|---|---|---|
| 3.38 | -1.25 | -5.15 | 1.52 | -1.37 | 0.71 |
| 3.3 | -0.7 | -5.2 | 2.47 | -4.52 | 1.59 |
| 2.77 | 0.73 | -5.16 | 8.02 | 3.75 | 1.19 |
| 2.72 | 0.44 | -5.12 | 9.46 | 1.13 | 2.01 |
| 2.6 | -0.25 | -5.09 | 7.45 | -2.59 | 1.96 |
| 2.55 | -0.53 | -4.97 | 6.31 | -4.3 | 1.88 |
| 2.36 | -0.47 | -4.82 | 4.86 | -1.34 | 1.44 |
| 2.13 | -0.61 | -4.68 | 1.48 | 1.76 | -0.12 |
| 2.1 | -0.93 | -4.68 | -7.19 | 3.55 | -7.04 |
| 2.02 | 1.3 | -4.93 | -2.41 | 8.06 | -5.55 |
| 1.93 | -0.38 | -4.72 | 3.15 | 1.65 | 0.37 |
| 1.84 | -0.46 | -4.68 | 4.08 | -2.64 | 1.27 |
| 1.76 | -0.26 | -4.5 | 4.59 | -4.18 | 1.52 |
| 1.67 | 0.06 | -4.48 | 5.16 | -4.44 | 1.64 |
| 1.59 | 0.59 | -4.37 | 5.94 | -3.89 | 1.74 |
| 1.5 | 1.04 | -4.35 | 6.64 | -3.16 | 1.81 |
| 1.48 | 1.37 | -4.27 | 7.07 | -2.65 | 1.85 |
| 1.44 | 2.13 | -4.25 | 8.04 | -1.45 | 1.94 |
| 1.37 | 2.98 | -4.15 | 9.04 | -0.15 | 2.03 |
| 1.34 | 3.65 | -4.2 | 9.58 | 0.81 | 2.06 |
| 1.3 | 4.15 | -4.24 | 8.94 | 1.7 | 1.84 |
| 1.24 | 1.26 | -4.27 | 3.02 | 0.05 | 0.78 |
| 1.17 | -2.44 | -4.21 | -2.24 | -2.38 | 0.03 |
| 1.15 | -4.22 | -4.03 | -4.52 | -3.24 | -0.3 |
| 1.12 | -4.79 | -3.92 | -5.4 | -3.26 | -0.47 |
| 1.11 | -4.9 | -3.72 | -5.55 | -2.95 | -0.55 |
| 1.1 | -4.55 | -3.59 | -5.23 | -2.28 | -0.57 |
| 1.07 | -4.04 | -3.6 | -4.62 | -1.52 | -0.54 |
| 1.05 | -3.68 | -3.52 | -4.2 | -1.2 | -0.49 |
| 1.04 | -3.49 | -3.45 | -3.92 | -1.11 | -0.44 |
| 1.02 | -3.24 | -3.44 | -3.55 | -1.11 | -0.36 |
| 0.996 | -3.04 | -3.44 | -3.26 | -1.24 | -0.28 |
| 0.986 | -2.95 | -3.43 | -3.09 | -1.44 | -0.23 |
| 0.972 | -2.81 | -3.35 | -2.85 | -1.75 | -0.15 |
| 0.95 | -2.67 | -3.34 | -2.61 | -2.12 | -0.06 |
| 0.93 | -2.55 | -3.34 | -2.38 | -2.5 | 0.01 |
| 0.91 | -2.36 | -3.25 | -2.04 | -3.14 | 0.13 |
| 0.86 | -2.2 | -3.17 | -1.76 | -3.62 | 0.21 |
| 0.85 | -2 | -3.16 | -1.45 | -4.09 | 0.3 |
| 0.79 | -1.82 | -3.07 | -1.19 | -4.48 | 0.37 |
| 0.78 | -1.57 | -2.92 | -0.86 | -4.84 | 0.44 |
| 0.705 | -1.14 | -2.75 | -0.26 | -5.28 | 0.56 |
| 0.625 | -0.69 | -2.52 | 0.32 | -5.62 | 0.67 |
| 0.54 | -0.48 | -2.36 | 0.59 | -5.93 | 0.76 |
| 0.5 | -0.46 | -2.28 | 0.6 | -6.18 | 0.81 |

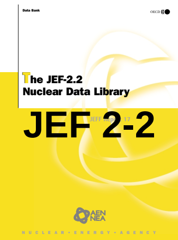



TABLE V. *(continued)* :

*Differences between group cross sections (infinite dilution) in percent*

| *Upper Energy Limit (eV)* | *Total Cross Section* | *Elastic Scattering* | *Fission* | *Capture* | *Eta* |
|---|---|---|---|---|---|
| 0.485 | -0.66 | -2.2 | 0.41 | -6.58 | 0.87 |
| 0.433 | -1.37 | -1.98 | -0.28 | -7.48 | 0.96 |
| 0.4 | -1.98 | -1.98 | -0.93 | -8.07 | 0.99 |
| 0.391 | -3.17 | -1.9 | -2.29 | -8.93 | 1 |
| 0.35 | -4.8 | -1.76 | -4.21 | -9.28 | 0.85 |
| 0.32 | -5.22 | -1.63 | -4.82 | -8.46 | 0.65 |
| 0.315 | -5.04 | -1.56 | -4.84 | -7.26 | 0.44 |
| 0.3 | -4 | -1.56 | -4.14 | -4.26 | 0.02 |
| 0.28 | -2.06 | -1.56 | -2.77 | 0.85 | -0.66 |
| 0.248 | -1.22 | -1.49 | -2.23 | 3.71 | -1.04 |
| 0.22 | -1.52 | -1.42 | -2.39 | 2.89 | -0.88 |
| 0.189 | -1.72 | -1.28 | -2.35 | 1.34 | -0.59 |
| 0.18 | -1.68 | -1.21 | -2.07 | 0.15 | -0.35 |
| 0.16 | -1.24 | 0.27 | -1.15 | -2.64 | 0.23 |
| 0.14 | -0.69 | 1.57 | -0.19 | -4.13 | 0.6 |
| 0.134 | -0.33 | 1.77 | 0.18 | -3.72 | 0.59 |
| 0.115 | 0.3 | 1.9 | 0.66 | -2.51 | 0.46 |
| 0.1 | 0.6 | 1.89 | 0.93 | -1.64 | 0.37 |
| 0.095 | 0.89 | 1.96 | 1.08 | -0.72 | 0.25 |
| 0.08 | 1.08 | 2.02 | 1.21 | -0.04 | 0.17 |
| 0.077 | 1.21 | 2.01 | 1.31 | 0.31 | 0.14 |
| 0.067 | 1.33 | 2.14 | 1.4 | 0.63 | 0.11 |
| 0.058 | 1.26 | 2.14 | 1.36 | 0.26 | 0.15 |
| 0.05 | 1.07 | 2.2 | 1.23 | -0.21 | 0.2 |
| 0.042 | 0.84 | 2.26 | 1 | -0.5 | 0.21 |
| 0.035 | 0.64 | 2.26 | 0.77 | -0.43 | 0.17 |
| 0.03 | 0.42 | 2.25 | 0.47 | -0.21 | 0.1 |
| 0.025 | 0.19 | 2.32 | 0.11 | 0.19 | -0.01 |
| 0.02 | 0.01 | 2.31 | -0.2 | 0.97 | -0.17 |
| 0.015 | 0.1 | 2.37 | -0.19 | 1.92 | -0.32 |
| 0.01 | 0.32 | 2.43 | 0 | 2.23 | -0.34 |
| 0.0069 | 0.67 | 2.42 | 0.4 | 1.88 | -0.23 |
| 0.005 | 0.88 | 2.47 | 0.86 | 0.95 | -0.01 |
| 0.003 | 1.21 | 2.48 | 1.67 | -1.08 | 0.44 |
| 0.0001 | | | | | |

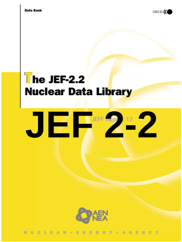



Figure 1.
*Differences between the $^{235}U$ total cross-sections in the JEF2.2 and LEAL/DERRIEN evaluations (LEAL/DERRIEN - JEF2.2)/JEF2.2 in %*

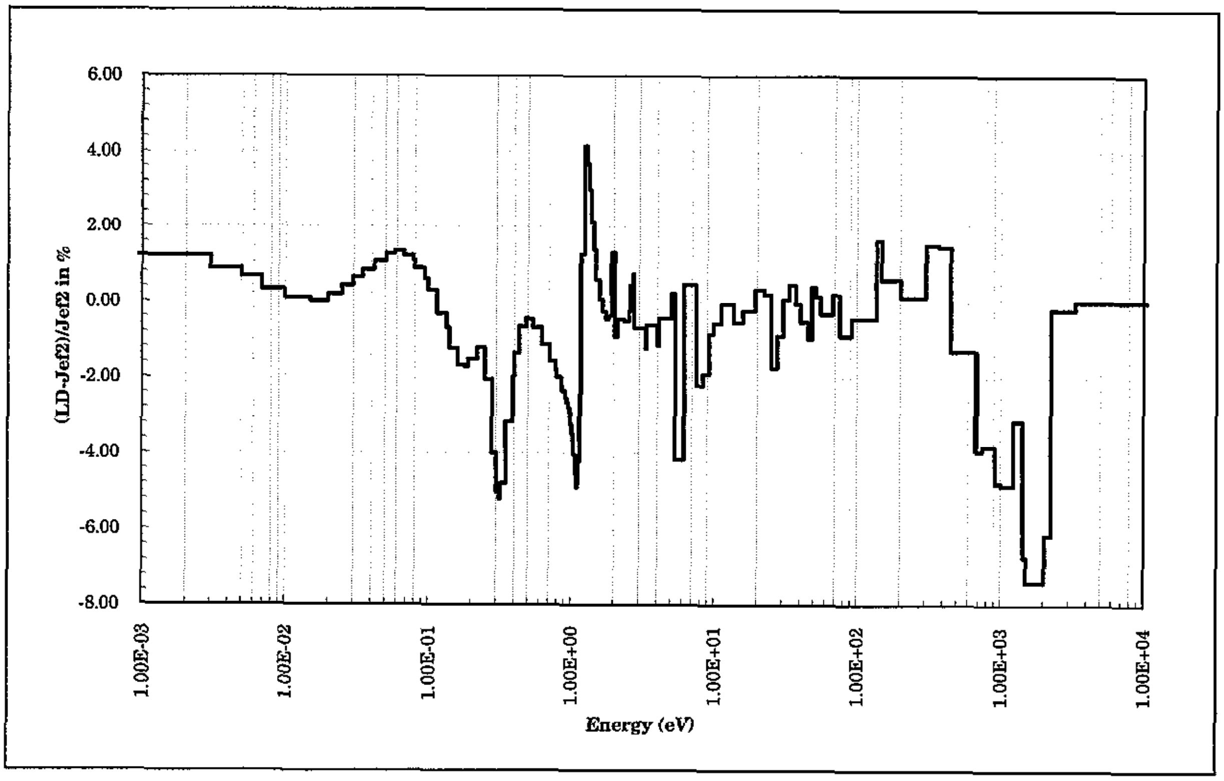
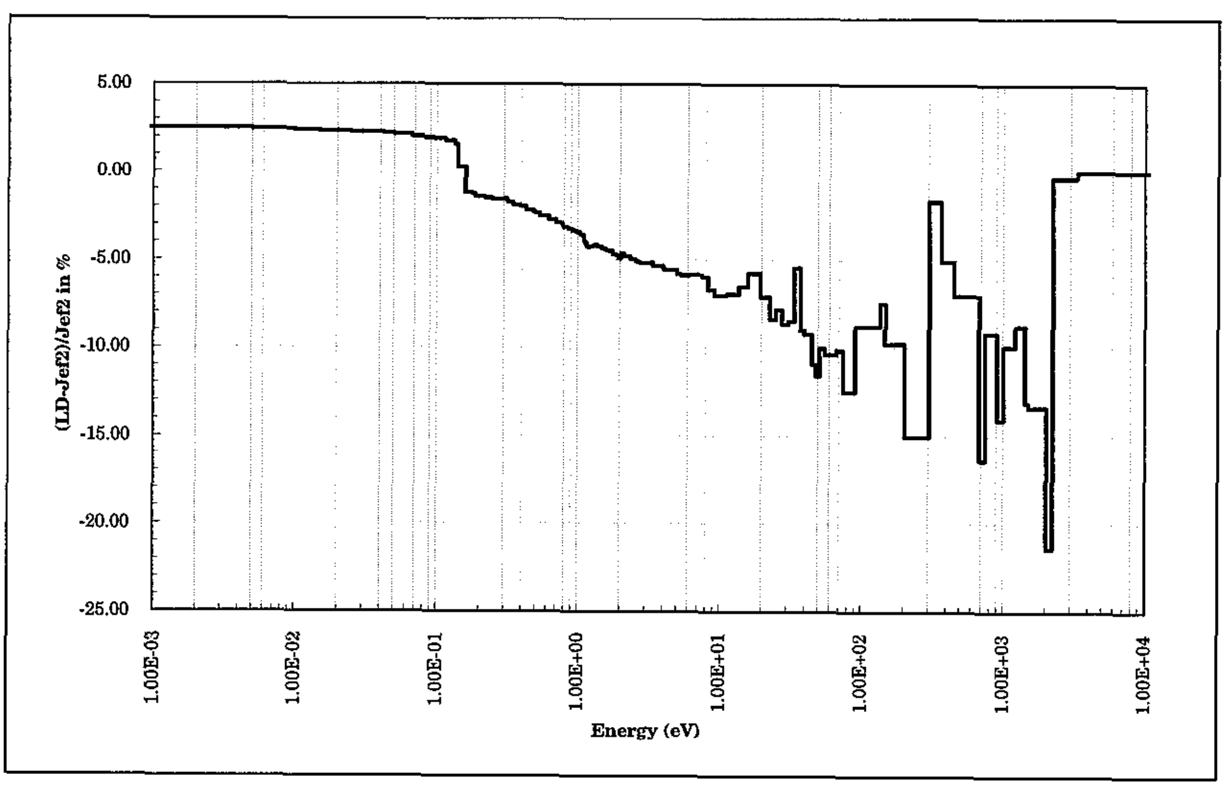



Figure 2.
*Differences between the $^{235}U$ elastic scattering cross-sections in the JEF2.2 and LEAL/DERRIEN evaluations (LEAL/DERRIEN - JEF2.2)/JEF2.2 in %*



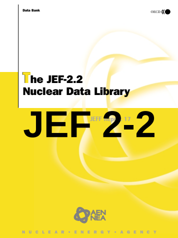



Figure 3.
*Differences between the $^{235}U$ fission cross-sections in the JEF2.2 and LEAL/DERRIEN evaluations.*
*(LEAL/DERRIEN - JEF2.2)/JEF2.2 in %*

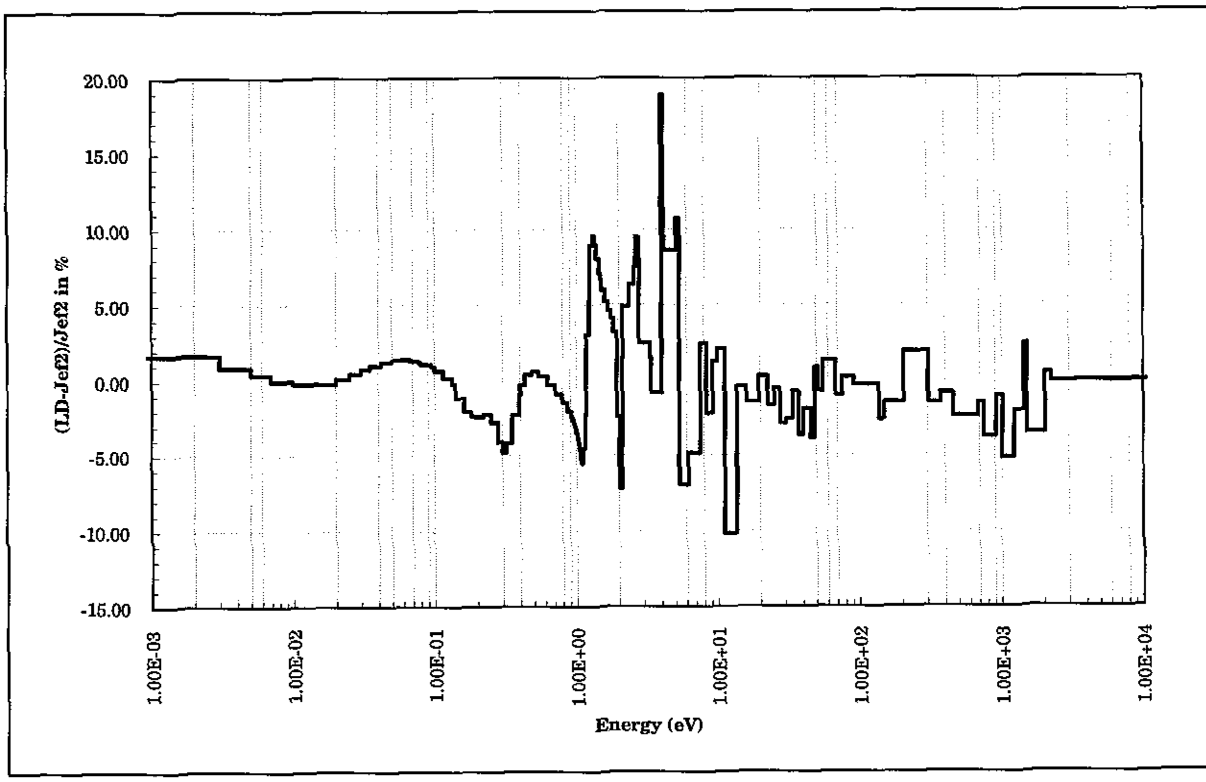
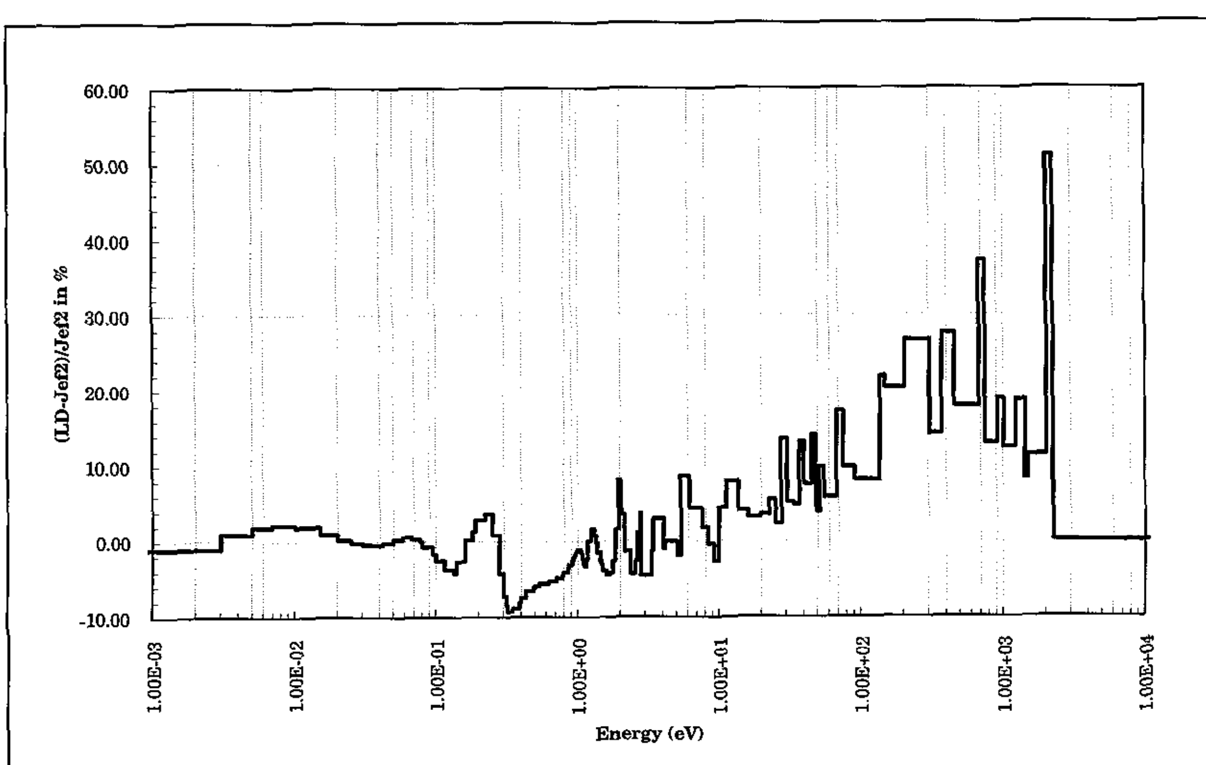



Figure 4.
*Differences between the $^{235}U$ capture cross-sections in the JEF2.2 and LEAL/DERRIEN evaluations.*
*(LEAL/DERRIEN - JEF2.2)/JEF2.2 in %*



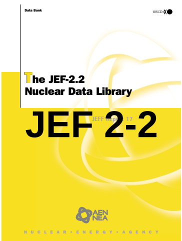
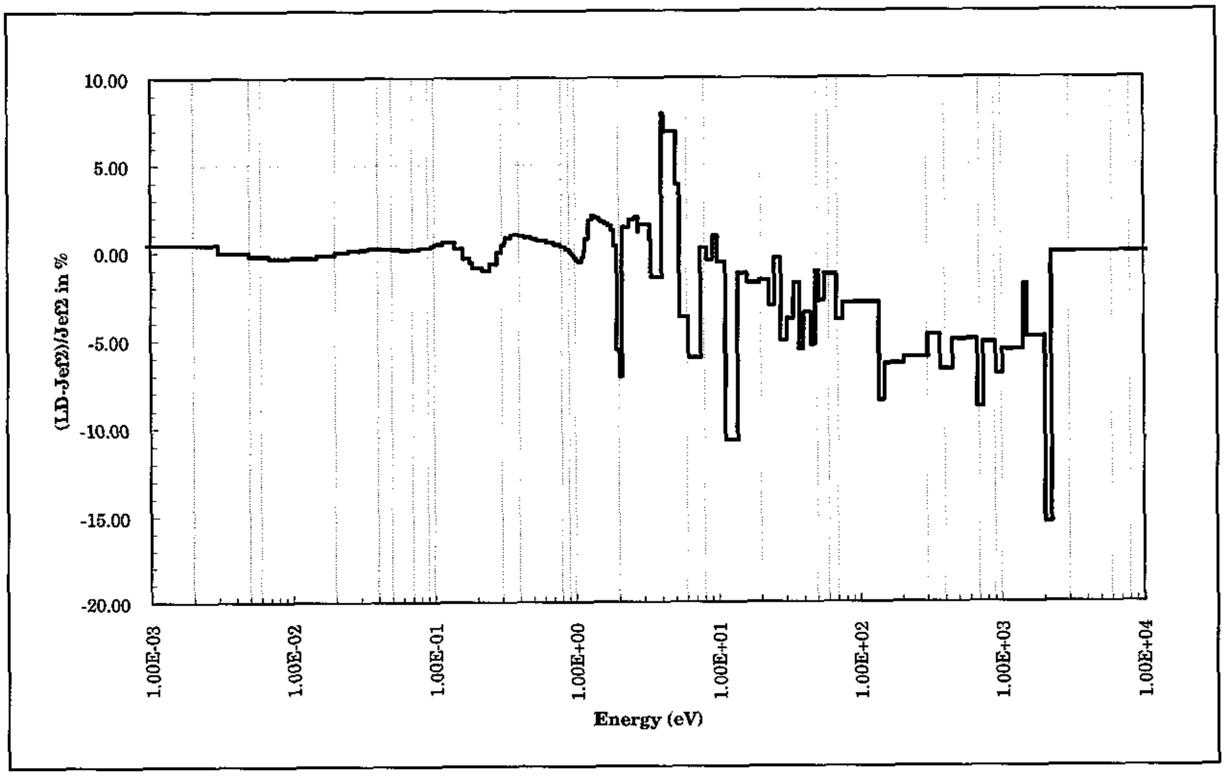



Figure 5.
*Differences between the $^{235}$U Eta value in the JEF2.2 and LEAL / DERRIEN evaluations. (LEAL / DERRIEN - JEF2.2) / JEF2.2 in %*



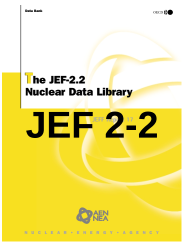



Figure 6

*Differences between JEF2.2 and LEAL / DERRIEN calculated values of reactivities*

$\Delta\rho = \rho_{LD} - \rho_{JEF2}$ *in pcm.*

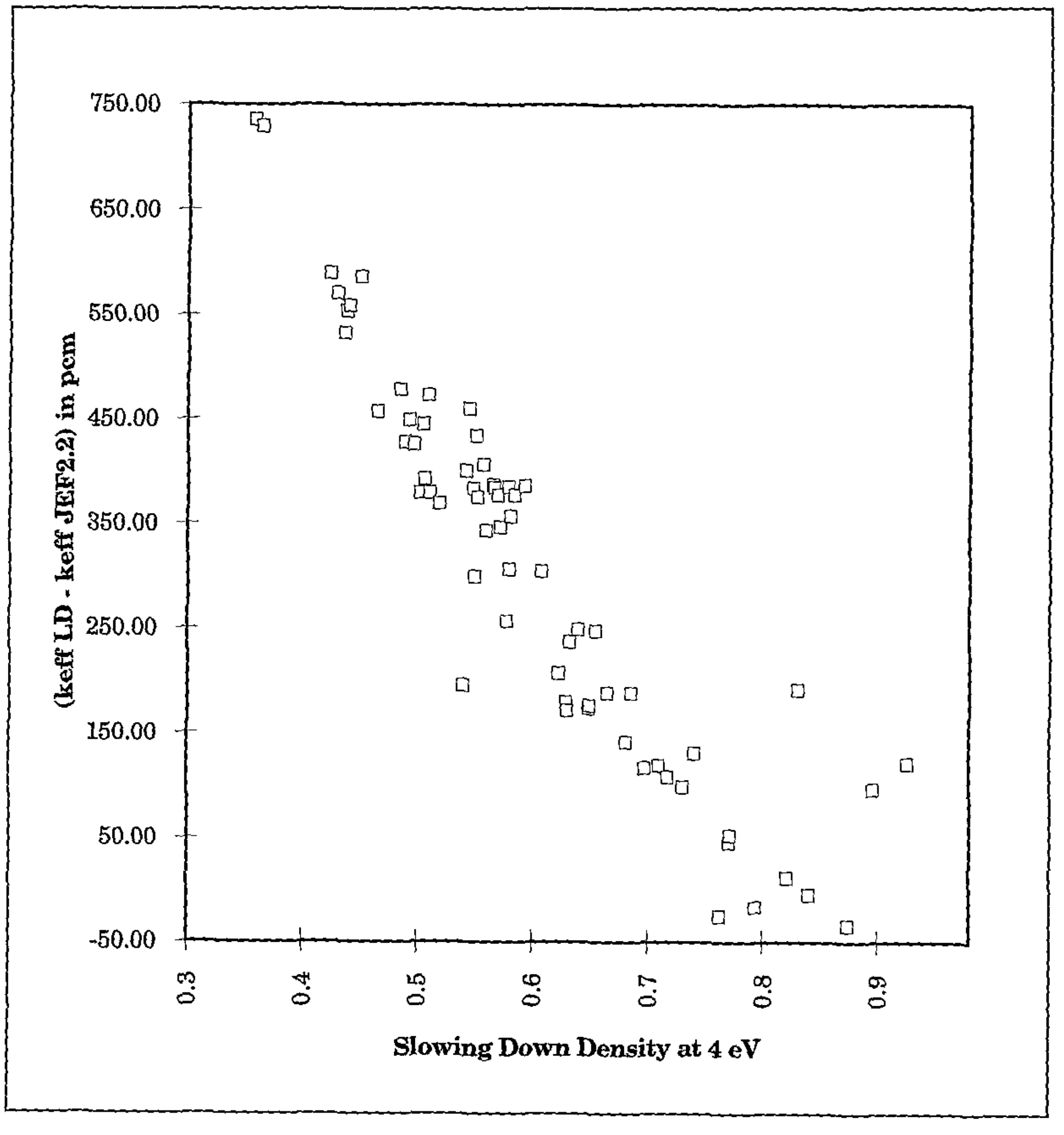





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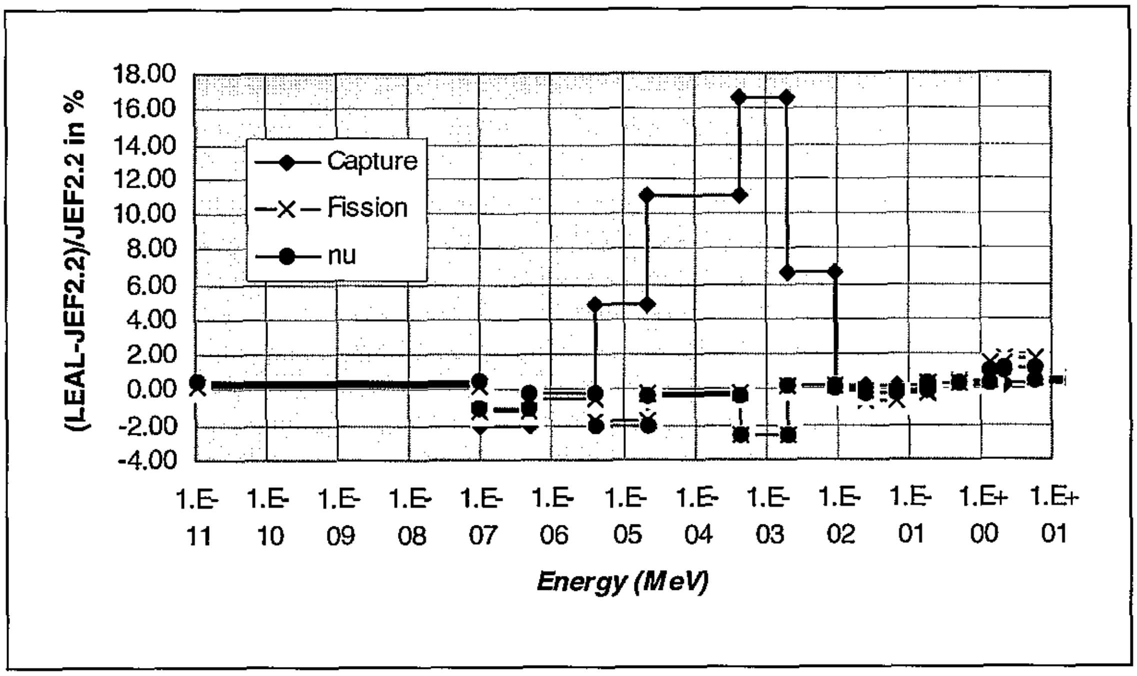
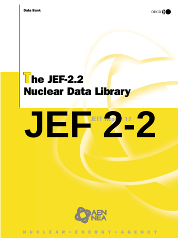
Figure 7.
*Differences in sensitivity profile for TRX2 experiment between LEAL / DERRIEN and JEF2.2 evaluations*






## References

/1/ : S. Cathalau, A. Benslimane, A. Maghnouj & P. Fougeras:
"*Qualification of the JEF2.2 Cross Sections in the Epithermal and Thermal Range using a Statistical Approach*", Nuclear Science & Engineering **121**, 326 (1995)