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# Comparison of Calculated Infinite Diluted Group Averaged Constants and Resonance Integrals in Resolved and Unresolved Regions

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# COMPARISON OF CALCULATED INFINITE DILUTED GROUP AVERAGED CONSTANTS AND RESONANCE INTEGRALS IN RESOLVED AND UNRESOLVED REGIONS

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The evaluated data sets for the three isotopes U-235 (1261), U-238 (1262) and Pu-239 (1264) in the ENDF/B-IV file were used for a comparative study of resonance calculating procedures using in the codes RESEND [1], RECENT [2] and FEDGROUP-3 [3], respectively. In our institution the codes RESEND, RECENT and FEDGROUP-3 are available for this purpose. The constants published in Refs [4] and [5] are also drawn into the comparison.

In the RESEND code two modes of calculation are possible:

Mode 1 linearization is performed only by checking the total cross-section

Mode 2 linearization is performed by checking the total, (n,γ), fission and elastic cross-sections.

FEDGROUP's treatment corresponds to Mode 2.

In a calculation using RESEND in addition to the mode, the required accuracy of linear interpolation should also be specified.

In RECENT there are three modes of calculation all of which are concerned with the distant resonance treatment. The finest treatment is represented by Mode 0, the crudest is by Mode 2 [2]. To the best of our knowledge the checking of the accuracy of linear interpolation corresponds to that of Mode 2 of RESEND. FEDGROUP's treatment of distant resonances roughly corresponds to that of Mode 0 of RECENT. In our RECENT calculations, Mode 0 is used for U-235 and Pu-239; for U-238 we had to give up Modes 0 and 1 because of the considerable computer time requirement.

The point-wise cross-section sets generated by RECENT and RESEND were integrated numerically by means of FEDGROUP-3.

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The results given in Ref.[4] were also obtained by RESEND but we have no information about the code version, mode and accuracy used in the calculation.

In the Tables 1-3 the group constants calculated for groups 10-23 of the ABBN system [6] are demonstrated. These groups cover the range 1.0 eV - 46.5 keV which overlaps the resolved and unresolved energy ranges for the nuclei U-235, U-238 and Pu-239. In ENDF/B-IV, these ranges are specified in the following way:

| | Resolved | | Unresolved | |
|---|---|---|---|---|
| | Energy | Groups | Energy | Groups |
| U-235 | 1.0 - 82.0 eV | 23-18 | 82.0 eV - 25.0 keV | 18-10 |
| U-238 | 1.0 eV - 4.0 keV | 23-13 | 4.0 keV - 45.0 keV | 13-10 |
| Pu-239 | 1.0 eV - 301.0 eV | 23-16 | 301.0 eV - 25.0 keV | 16-10 |

In Tables 1-3 the relative deviations (percentages) of constants from those calculated by RECENT are given in parantheses.

In Tables 4-6 the calculated resonance integrals taken from 0.5 eV to 50.0 keV are demonstrated. Above 50.0 keV and below 0.5 eV the calculation should be code independent because in these regions no resonance calculation is involved. For comparison, the results given in Ref. [5] were taken. (Obviously we took the results referred as being calculated from the parameters given by ENDF/B-IV.)

From the results we reached the following conclusions:

In the resolved resonance region the results from RECENT, FEDGROUP and the more accurate ones from RESEND agreed well, except some groups for U-238. But here we had to be satisfied with less accurate calculation. (The required accuracy in FEDGROUP's calculation is taken to 1%.) The less accurate RESEND calculations in some cases show a pretty large deviation. In the case of Pu-239 the values in [4] differ apprecably from those of the others.

In the unresolved resonance region there are more apprecable deviations in the constants calculated by different codes. The reason for these discrepancies may be the different number of

energy points taken in this region. In FEDGROUP a lethargy equidistant mesh is taken where the number of subintervals per group is a user specified input parameter. In our calculation this was taken to 10 intervals/group but for some cases the calculation has been performed for a 20 intervals/group, too. It should be noted that in FEDGROUP-3 the energy dependent unresolved parameters are interpolated rather than the calculated cross-sections. In RESEND and RECENT the mesh is determined by the required accuracy of the linear interpolation. (In our opinion, due to this fact, sometimes less points are generated by these codes than it would be recommended.)

In the ENDF/B prescription for the resonance region formulae the effective scattering radius â and channel radius a are distinguished [7]. The effective scattering radius is given in the file and used to calculate the phase shift. The channel radius should be calculated by the formula:

$$a=0.08+0.123*A^{1/3}$$

where A is the ratio of atomic mass to neutron mass. The channel radius is used for the calculation of penetration factors which have an important role in resonances with angular momentum higher than 0. The code MIGROS-3 [8] makes no such distinction. The effect of these two approaches is demonstrated in Tables 7-9. Some groups in the unresolved region are taken. It can be seen that in the groups of higher energy the resonance cross-sections calculated by the MIGROS-3 prescription may be as much as 6% higher than those calculated by ENDF/B. In Tables 7-9 the effect of the number of subintervals on the constants is also demonstrated (the line 10, the second is 20 intervals/group).

Finally it should be pointed out that the constants taken from [4] and [5] in some cases show a very high deviation from FEDGROUP/RECENT results - which are in good agreement which each other. We are not able to clarify the reason for these discrepancies because the authors do not give the exact conditions of their calculation.

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[6] I.I. Bondarenko et al., Group constants for reactor calculation, Moscow, Atomizdat, 1964

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U-235 $\sigma_{tot}$

Table 1a

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | RESEND MOD=2, 1% | GARG |
|---|---|---|---|---|---|---|
| 10 | 13.800 | 13.7934 (0.0) | 13.788 (-0.1) | 13.791 (-0.1) | 13.793 (-0.1) | 13.660 (-1.0) |
| 11 | 14.961 | 14.9397 (-0.1) | 14.962 (0.0) | 15.023 (0.4) | 14.973 (0.1) | 14.615 (-2.3) |
| 12 | 16.577 | 16.6242 (0.3) | 16.615 (0.3) | 16.326 (-1.5) | 16.600 (0.1) | 16.021 (-3.4) |
| 13 | 18.579 | 18.663 (0.5) | 18.644 (0.3) | 18.710 (0.7) | 18.605 (0.1) | 18.244 (-1.8) |
| 14 | 22.543 | 22.6033 (0.3) | 22.567 (0.1) | 22.521 (-0.1) | 22.447 (-0.4) | 22.066 (-2.1) |
| 15 | 28.686 | 28.6006 (-0.3) | 28.705 (0.1) | 28.752 (0.2) | 28.679 (0.0) | 27.186 (-5.2) |
| 16 | 36.193 | 35.5629 (-1.7) | 36.166 (-0.2) | 38.985 (7.7) | 36.455 (0.7) | 33.911 (-6.3) |
| 17 | 45.900 | 46.063 (0.4) | 45.917 (0.0) | 47.345 (3.1) | 46.357 (1.0) | 44.152 (-3.8) |
| 18 | 64.308 | 64.144 (-0.3) | 64.289 (0.0) | 64.297 (0.0) | 64.146 (-0.3) | 62.784 (-2.4) |
| 19 | 79.399 | 79.189 (-0.3) | 79.329 (-0.1) | 79.674 (0.3) | 79.330 (-0.1) | 79.435 (0.0) |
| 20 | 108.22 | 108.04 (-0.2) | 108.14 (-0.1) | 108.31 (0.1) | 108.21 (0.0) | 108.310 (0.1) |
| 21 | 96.772 | 96.384 (-0.4) | 96.721 (0.0) | 96.946 (0.2) | 96.686 (-0.1) | 96.990 (0.2) |
| 22 | 35.588 | 35.491 (-0.3) | 35.523 (-0.2) | 35.734 (0.4) | 35.526 (-0.2) | 35.880 (0.8) |
| 23 | 60.990 | 60.999 (0.0) | 61.016 (0.0) | 61.617 (1.0) | 60.901 (-0.1) | 60.873 (-0.2) |

U-235 $\sigma_{n,\gamma}$

Table 1b

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | RESEND MOD=2, 1% | GARG |
|---|---|---|---|---|---|---|
| 10 | 0.7348 | 0.73456 (0.0) | 0.7540 (2.6) | 0.7330 (-0.2) | 0.7362 (0.2) | 0.8046 (9.5) |
| 11 | 1.0087 | 1.00678 (-0.2) | 1.0630 (5.4) | 1.0208 (1.2) | 1.0155 (0.7) | 1.023 (1.4) |
| 12 | 1.3839 | 1.38038 (-0.3) | 1.4340 (3.6) | 1.3025 (-5.9) | 1.3989 (1.1) | 1.318 (-4.8) |
| 13 | 1.7333 | 1.7341 (0.1) | 1.8340 (5.8) | 1.8690 (7.8) | 1.7331 (0.0) | 1.867 (7.7) |
| 14 | 3.0410 | 3.01233 (-1.0) | 3.0430 (0.1) | 2.9238 (-3.9) | 3.0322 (-0.3) | 3.208 (5.4) |
| 15 | 4.7013 | 4.6547 (-1.0) | 4.7160 (0.3) | 4.6911 (-0.2) | 4.6696 (-0.7) | 4.642 (-1.3) |
| 16 | 7.1840 | 7.04185 (-2.0) | 7.1770 (-0.1) | 6.9553 (-3.2) | 7.3316 (2.1) | 6.610 (-8.0) |
| 17 | 12.068 | 12.0567 (-0.1) | 12.0190 (-0.4) | 11.852 (-1.8) | 12.179 (0.9) | 10.555 (-0.1) |
| 18 | 16.434 | 16.3708 (-0.4) | 16.365 (-0.4) | 15.749 (-4.2) | 15.878 (-3.4) | 15.444 (-6.0) |
| 19 | 23.932 | 23.8397 (-0.4) | 23.934 (0.0) | 24.038 (0.4) | 23.925 (0.0) | 23.998 (0.3) |
| 20 | 44.727 | 44.6633 (-0.1) | 44.717 (0.0) | 44.867 (0.3) | 44.709 (0.0) | 44.838 (0.3) |
| 21 | 37.260 | 37.1188 (-0.3) | 37.264 (0.0) | 37.340 (0.2) | 37.247 (-0.1) | 37.426 (0.4) |
| 22 | 7.001 | 6.9876 (-0.2) | 7.000 (0.0) | 7.053 (0.7) | 7.000 (0.0) | 7.130 (1.8) |
| 23 | 12.403 | 12.409 (0.0) | 12.430 (0.2) | 12.579 (1.4) | 12.385 (-0.1) | 12.398 (0.0) |

U-235 $\sigma_n$

Table 1c

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | RESEND MOD=2, 1% | GARG |
|---|---|---|---|---|---|---|
| 10 | 10.971 | 10.9925 (0.2) | 10.992 (0.2) | 10.993 (0.2) | 10.996 (0.2) | 10.597 (-3.4) |
| 11 | 11.461 | 11.463 (0.0) | 11.497 (0.3) | 11.480 (0.2) | 11.476 (0.1) | 10.783 (-5.9) |
| 12 | 11.813 | 11.7977 (-1.6) | 11.822 (0.1) | 11.730 (-0.7) | 11.817 (0.0) | 11.008 (-6.8) |
| 13 | 11.876 | 11.877 (0.0) | 11.932 (0.5) | 11.947 (0.6) | 11.893 (0.1) | 11.199 (-5.7) |
| 14 | 12.226 | 12.1854 (-0.3) | 12.217 (-0.1) | 12.174 (-0.4) | 12.208 (-0.1) | 11.464 (-6.2) |
| 15 | 12.436 | 12.4740 (0.3) | 12.438 (0.0) | 12.431 (0.0) | 12.422 (-0.1) | 11.535 (-7.2) |
| 16 | 12.594 | 12.5128 (-0.7) | 12.571 (-0.2) | 12.647 (0.4) | 12.641 (0.4) | 11.531 (-8.2) |
| 17 | 12.643 | 12.630 (-0.1) | 12.645 (0.0) | 12.635 (-0.1) | 12.684 (0.3) | 11.519 (-8.9) |
| 18 | 12.654 | 12.6433 (-0.1) | 12.645 (-0.1) | 12.593 (-0.5) | 12.601 (-0.4) | 12.312 (-2.7) |
| 19 | 12.309 | 12.286 (0.2) | 12.297 (-0.1 | 12.319 (-0.1 | 12.303 (0.0) | 12.315 (0.0) |
| 20 | 12.264 | 12.233 (-0.2) | 12.251 (-0.1) | 12.263 (0.0) | 12.255 (-0.1) | 12.273 (0.1) |
| 21 | 11.060 | 11.016 (-0.4) | 11.050 (-0.1) | 11.048 (-0.1) | 11.044 (-0.1) | 11.050 (-0.1) |
| 22 | 11.426 | 11.391 (-0.3) | 11.409 (-0.1) | 11.413 (-0.1) | 11.404 (-0.2) | 11.410 (-0.1) |
| 23 | 12.577 | 12.558 (-0.2) | 12.550 (-0.2) | 12.564 (-0.1) | 12.561 (-0.1) | 12.545 (-0.3) |

U-235 $\sigma_f$

Table 1d

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD= 1, 1% | RESEND MOD=2, 5% | RESEND MOD=2, 1% | GARG |
|---|---|---|---|---|---|---|
| 10 | 2.051 | 2.04542 (-0.3) | 2.042 (-0.4) | 2.044 (-0.3) | 2.041 (-0.3) | 2.237 (9.1) |
| 11 | 2.479 | 2.47328 (-0.2) | 2.402 (-3.1) | 2.520 (1.7) | 2.479 (0.0) | 2.806 (13.2) |
| 12 | 3.387 | 3.44607 (2.0) | 3.359 (-0.8) | 3.293 (-2.8) | 3.384 (-0.1) | 3.695 (9.1) |
| 13 | 4.954 | 4.9711 (0.4) | 4.878 (-1.5) | 4.894 (-1.2) | 4.979 (0.5) | 5.178 (4.5) |
| 14 | 7.301 | 7.40564 (1.3) | 7.307 (0.1) | 7.423 (1.7) | 7.206 (-1.3) | 7.394 (1.3) |
| 15 | 11.551 | 11.561 (0.1) | 11.551 (0.0) | 11.630 (0.7) | 11.588 (-0.3) | 11.009 (-4.7) |
| 16 | 16.397 | 16.0083 (-2.5) | 16.418 (0.1) | 19.383 (18.2) | 16.482 (0.5) | 15.770 (-3.8) |
| 17 | 21.189 | 21.0852 (-0.5) | 21.253 (0.3) | 22.858 (7.9) | 21.674 (2.3) | 22.078 (4.2) |
| 18 | 35.216 | 35.150 (-0.2) | 35.279 (0.2) | 35.955 (2.1) | 35.666 (1.3) | 35.028 (-0.5) |
| 19 | 43.140 | 43.063 (-0.2) | 43.098 (-0.1) | 43.317 (0.4) | 43.102 (-0.1) | 43.122 (0.0) |
| 20 | 51.203 | 51.141 (-0.1) | 51.172 (-0.1) | 51.176 (0.0) | 51.154 (-0.1) | 51.199 (0.0) |
| 21 | 48.424 | 48.218 (-0.4) | 48.407 (0.0) | 48.552 (0.3) | 48.394 (-0.1) | 48.514 (0.2) |
| 22 | 17.143 | 17.112 (-0.1) | 17.114 (-0.2) | 17.267 (0.7) | 17.121 (-0.1) | 17.340 (1.1) |
| 23 | 36.019 | 36.032 (0.0) | 36.036 (0.0) | 36.475 (1.3) | 35.955 (-0.2) | 35.930 (-0.2) |

U-238 $\sigma_{tot}$

Table 2a

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | | GARG |
|---|---|---|---|---|---|---|
| 10 | 13.447 | 13.3862 (-0.5) | 13.410 (-0.3) | 13.468 (0.2) | | 13.6324 (1.4) |
| 11 | 14.526 | 14.5775 (0.4) | 14.507 (-0.1) | 14.569 (0.3) | | 14.7099 (1.3) |
| 12 | 16.072 | 16.1157 (0.3) | 16.050 (-0.1) | 16.527 (2.8) | | 16.336 (1.6) |
| 13 | 19.991 | 19.8014 (-1.0) | 19.916 (-0.4) | 19.921 (-0.4) | | 19.644 (-1.7) |
| 14 | 21.237 | 20.621 (-2.9) | 20.693 (-2.6) | 20.764 (-2.2) | | 19.002 (-1.1) |
| 15 | 22.927 | 22.3907 (-2.3) | 22.459 (-2.0) | 22.573 (-1.5) | | 22.618 (-1.3) |
| 16 | 22.315 | 21.4078 (-4.1) | 21.477 (-3.8) | 21.485 (-3.7) | | 21.004 (-5.9) |
| 17 | 89.657 | 90.0396 (0.4) | 89.633 (-0.3) | 90.546 (1.0) | | 88.399 (-1.4) |
| 18 | 41.108 | 41.4663 (0.9) | 41.516 (1.0) | 41.732 (1.5) | | 41.050 (-0.1) |
| 19 | 134.300 | 133.484 (-0.9) | 133.77 (-0.4) | 135.32 (0.3) | | 133.225 (-0.8) |
| 20 | 114.960 | 114.786 (-0.2) | 114.96 (0.0) | 114.59 (-0.3) | | 113.471 (-1.3) |
| 21 | 190.33 | 189.844 (-0.3) | 190.06 (-0.1) | 189.08 (-0.7) | | 189.057 (-0.7) |
| 22 | 9.4155 | 8.90639 (-5.4) | 8.9349 (-5.1) | 8.9116 (-5.4) | | 8.9953 (-4.5) |
| 23 | 9.409 | 9.26914 (-1.5) | 9.2505 (-1.7) | 9.230 (-1.9) | | 9.2398 (-1.8) |

U-238 $\sigma_{n,\gamma}$

Table 2b

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | | GARG |
|---|---|---|---|---|---|---|
| 10 | 0.4238 | 0.431545 (-0.3) | 0.4344 (0.4) | 0.4422 (2.2) | | 0.4761 (10.0) |
| 11 | 0.6093 | 0.607600 (-0.3) | 0.6134 (0.7) | 0.6232 (2.3) | | 0.7359 (20.8) |
| 12 | 0.8439 | 0.841607 (0.0) | 0.8467 (0.3) | 0.9193 (8.9) | | 1.0410 (23.4) |
| 13 | 1.2513 | 1.25482 (0.3) | 1.3086 (4.6) | 1.2562 (0.4) | | 1.30 (3.9) |
| 14 | 1.8079 | 1.8140 (0.3) | 1.8415 (1.9) | 1.8365 (1.6) | | 1.85 (2.3) |
| 15 | 3.3575 | 3.33174 (-0.8) | 3.3626 (0.2) | 3.3586 (0.0) | | 3.534 (5.3) |
| 16 | 4.6205 | 4.57977 (-0.9) | 4.6287 (0.2) | 4.6125 (-0.2) | | 4.490 (-2.8) |
| 17 | 20.898 | 20.8937 (0.0) | 20.778 (-0.6) | 20.940 (0.2) | | 20.803 (-0.5) |
| 18 | 16.729 | 16.7062 (-0.1) | 16.733 (0.0) | 16.796 (0.4) | | 16.737 (0.0) |
| 19 | 56.635 | 56.5503 (-0.1) | 56.639 (0.0) | 57.226 (1.0) | | 56.947 (0.6) |
| 20 | 81.400 | 81.2893 (-0.1) | 81.388 (0.0) | 81.074 (-0.4) | | 81.449 (0.1) |
| 21 | 171.48 | 171.234 (-0.1) | 171.44 (0.0) | 170.42 (-0.6) | | 171.794 (0.2) |
| 22 | 0.6665 | 0.66362 (-0.6) | 0.7514 (12.7) | 0.67889 (1.9) | | 0.6653 (-0.2) |
| 23 | 0.4934 | 0.49607 (-0.5) | 0.5625 (14.0) | 0.51167 (3.7) | | 0.4938 (0.1) |

Table 2c

U-238 $\sigma_n$

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | | GARG |
|---|---|---|---|---|---|---|
| 10 | 13.028 | 13.0981 (0.5) | 12.975 (-0.5) | 13.026 (-0.2) | | 13.156 (1.0) |
| 11 | 13.923 | 13.9350 (0.1) | 13.893 (-0.2) | 13.946 (0.2) | | 13.974 (0.4) |
| 12 | 15.253 | 15.2256 (-0.2) | 15.203 (-0.3) | 15.608 (2.3) | | 15.295 (0.3) |
| 13 | 18.737 | 18.5526 (-1.0) | 18.607 (-0.7) | 18.665 (-0.4) | | 18.344 (-2.1) |
| 14 | 19.424 | 18.802 (-3.2) | 18.851 (-2.9) | 18.927 (-2.6) | | 17.152 (-11.7) |
| 15 | 19.569 | 19.0511 (-2.6) | 19.096 (-2.4) | 19.214 (-1.8) | | 19.084 (-2.5) |
| 16 | 17.685 | 16.853 (-4.7) | 16.848 (-4.7) | 16.873 (-4.6) | | 16.514 (-6.6) |
| 17 | 68.768 | 69.1459 (0.6) | 68.854 (1.3) | 69.607 (1.2) | | 67.596 (-1.7) |
| 18 | 24.357 | 24.7560 (1.6) | 24.783 (1.7) | 24.936 (2.4) | | 24.313 (-1.8) |
| 19 | 77.609 | 76.9386 (-0.9) | 77.127 (-0.6) | 78.097 (0.6) | | 76.278 (-1.7) |
| 20 | 33.530 | 32.9510 (-1.7) | 33.509 (-0.1) | 33.519 (0.0) | | 32.022 (-4.5) |
| 21 | 18.807 | 18.4276 (-2.0) | 18.628 (-1.0) | 18.667 (-0.7) | | 17.263 (-8.2) |
| 22 | 8.6639 | 8.2428 (-4.9) | 8.1835 (-5.5) | 8.2327 (-5.0) | | 8.330 (-3.9) |
| 23 | 8.8450 | 8.77316 (-0.8) | 8.6879 (-1.8) | 8.7214 (-1.4) | | 8.867 (-2.5) |

Pu-239 $\sigma_{tot}$

Table 3a

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | RESEND MOD=2, 1% | GARG |
|---|---|---|---|---|---|---|
| 10 | 13.141 | 13.111 (-0.2) | 13.078 (-0.5) | 13.085 (-0.5) | 13.075 (-0.5) | 13.505 (2.8) |
| 11 | 14.030 | 14.0929 (0.4) | 14.038 (0.1) | 14.200 (1.2) | 13.990 (-0.3) | 14.311 (2.0) |
| 12 | 15.594 | 15.697 (0.7) | 15.631 (0.2) | 15.751 (1.0) | 15.578 (-0.1) | 15.217 (-2.4) |
| 13 | 18.988 | 18.978 (-0.1) | 18.892 (-0.5) | 18.871 (-0.6) | 19.130 (0.7) | 21.331 (12.3) |
| 14 | 21.254 | 21.3132 (0.3) | 21.186 (-0.3) | 21.542 (1.4) | 21.314 (0.3) | 32.419 (52.5) |
| 15 | 29.973 | 29.9134 (-0.2) | 30.000 (0.1) | 28.929 (-3.5) | 30.313 (1.1) | 38.278 (27.7) |
| 16 | 40.966 | 40.7896 (-0.4) | 40.920 (-0.1) | 47.251 (15.3) | 41.240 (0.7) | 49.280 (20.3) |
| 17 | 51.241 | 51.208 (-0.1) | 51.217 (0.0) | 51.171 (-0.1) | 51.165 (-0.1) | 56.783 (10.8) |
| 18 | 110.83 | 110.569 (-0.2) | 110.64 (-0.2) | 110.710 (-0.1) | 110.67 (-0.1) | 126.349 (14.0) |
| 19 | 67.504 | 66.958 (-0.8) | 67.484 (0.0) | 67.447 (0.0) | 67.418 (-0.1) | 78.919 (16.9) |
| 20 | 182.27 | 181.20 (-0.6) | 181.94 (-0.2) | 182.02 (-0.1) | 182.01 (-0.1) | 208.541 (14.4) |
| 21 | 69.680 | 69.584 (-0.1) | 69.591 (-0.1) | 69.665 (0.0) | 69.480 (-0.3) | 82.825 (18.9) |
| 22 | 21.444 | 21.470 (0.1) | 21.396 (-0.3) | 21.434 (0.0) | 21.363 (-0.4) | 22.169 (3.4) |
| 23 | 42.018 | 42.159 (0.3) | 41.871 (-0.3) | 42.094 (0.2) | 41.835 (-0.4) | 44.550 (6.0) |

Pu-239 $\sigma_{n,\gamma}$

Table 3b

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | RESEND MOD=2, 1% | GARG |
|---|---|---|---|---|---|---|
| 10 | 0.5082 | 0.5105 (0.5) | 0.5099 (0.3) | 0.5104 (0.4) | 0.5084 (0.0) | 0.5674 (11.6) |
| 11 | 0.8900 | 0.895195 (0.6) | 0.9029 (1.4) | 0.9151 (2.8) | 0.8929 (0.3) | 0.9810 (10.2) |
| 12 | 1.5267 | 1.5702 (2.8) | 1.546 (1.3) | 1.561 (2.2) | 1.5245 (-0.1) | 1.766 (15.7) |
| 13 | 2.7155 | 2.74874 (1.2) | 2.638 (-2.9) | 2.639 (-2.8) | 2.7559 (1.5) | 4.004 (47.4) |
| 14 | 3.7898 | 3.80816 (0.5) | 3.796 (0.2) | 3.667 (-3.2) | 3.8223 (0.9) | 9.506 (150.8) |
| 15 | 6.7379 | 6.74419 (0.1) | 6.748 (0.1) | 7.456 (10.7) | 7.0153 (4.1) | 12.430 (84.4) |
| 16 | 12.811 | 12.7652 (-0.4) | 12.816 (0.0) | 16.195 (26.4) | 12.928 (0.9) | 16.558 (29.2) |
| 17 | 17.130 | 17.085 (-0.3) | 17.132 (0.0) | 17.105 (-0.2) | 17.104 (-0.2) | 18.188 (6.2) |
| 18 | 37.209 | 37.021 (-0.5) | 37.206 (0.0) | 37.165 (-0.1) | 37.172 (-0.1) | 41.733 (12.2) |
| 19 | 34.111 | 33.861 (-0.7) | 34.126 (0.0) | 34.051 (-0.2) | 34.084 (-0.1) | 38.828 (13.8) |
| 20 | 66.848 | 66.272 (-0.9) | 66.741 (-0.2) | 66.841 (0.0) | 66.757 (-0.1) | 78.518 (17.5) |
| 21 | 26.395 | 26.346 (-0.2) | 26.384 (0.0) | 26.413 (0.1) | 26.333 (-0.2) | 34.088 (29.1) |
| 22 | 1.147 | 1.1398 (-0.6) | 1.154 (0.6) | 1.1647 (1.5) | 1.145 (-0.2) | 1.093 (-4.7) |
| 23 | 7.725 | 7.7371 (0.2) | 7.715 (-0.1) | 7.7859 (0.8) | 7.7033 (-0.3) | 8.122 (5.1) |

Pu-239 $\sigma_n$

Table 3c

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | RESEND MOD=2, 1% | GARG |
|---|---|---|---|---|---|---|
| 10 | 10.713 | 10.726 (0.1) | 10.717 (0.0) | 10.721 (0.1) | 10.717 (0.0) | 10.869 (1.5) |
| 11 | 11.223 | 11.180 (-0.4) | 11.194 (-0.3) | 11.291 (0.6) | 11.172 (-0.5) | 11.104 (-1.1) |
| 12 | 11.915 | 11.943 (0.2) | 11.970 (0.5) | 12.021 (0.9) | 11.918 (0.0) | 12.223 (2.6) |
| 13 | 13.183 | 13.1328 (-0.4) | 13.096 (-0.7) | 13.036 (-1.1) | 13.282 (0.8) | 13.329 (1.1) |
| 14 | 12.943 | 12.9258 (-0.1) | 12.917 (-0.2) | 12.949 (0.5) | 13.007 (0.5) | 14.890 (15.0) |
| 15 | 14.829 | 14.7271 (-0.7) | 14.830 (0.0) | 14.181 (-4.3) | 14.951 (0.8) | 15.699 (5.9) |
| 16 | 15.970 | 15.9196 (-0.3) | 15.957 (-0.1) | 17.958 (12.4) | 16.025 (0.3) | 19.118 (19.7) |
| 17 | 15.284 | 15.238 (-0.3) | 15.275 (-0.1) | 15.307 (0.2) | 15.273 (-0.1) | 18.369 (20.2) |
| 18 | 16.991 | 17.038 (0.3) | 16.916 (-0.4) | 17.023 (0.2) | 16.967 (-0.1) | 25.008 (47.2) |
| 19 | 10.952 | 10.927 (-0.2) | 10.951 (0.0) | 10.962 (0.1) | 10.949 (0.0) | 15.026 (37.2) |
| 20 | 10.771 | 10.850 (0.7) | 10.777 (0.1) | 10.769 (0.0) | 10.764 (-0.1) | 14.393 (33.6) |
| 21 | 8.3988 | 8.495 (1.1) | 8.4128 (0.2) | 8.4087 (0.1) | 8.414 (0.2) | 9.507 (13.2) |
| 22 | 9.194 | 9.252 (0.6) | 9.166 (-0.3) | 9.167 (-0.3) | 9.166 (-0.3) | 10.011 (8.9) |
| 23 | 10.017 | 10.114 (1.0) | 9.966 (-0.5) | 9.9710 (-0.5) | 9.965 (-0.5) | 10.919 (9.0) |

Pu-239 $\sigma_f$

Table 3d

| Gr.N° | RECENT | FEDGROUP-3 | RESEND MOD=1, 1% | RESEND MOD=2, 5% | RESEND MOD=2, 1% | GARG |
|---|---|---|---|---|---|---|
| 10 | 1.629 | 1.648 (1.17) | 1.625 (-0.2) | 1.628 (-0.1) | 1.624 (-0.3) | 1.750 (7.4) |
| 11 | 1.759 | 1.7509 (-0.5) | 1.783 (1.4) | 1.836 (4.4) | 1.767 (0.5) | 1.932 (9.8) |
| 12 | 2.121 | 2.168 (2.2) | 2.101 (-0.9) | 2.154 (1.6) | 2.121 (0.0) | 2.180 (2.8) |
| 13 | 3.079 | 3.0964 (0.6) | 3.158 (2.6) | 3.202 (4.0) | 3.092 (0.4) | 3.998 (29.8) |
| 14 | 4.535 | 4.57927 (1.0) | 4.473 (-1.4) | 4.926 (8.6) | 4.485 (-1.1) | 8.023 (76.9) |
| 15 | 8.410 | 8.44223 (0.4) | 8.422 (0.1) | 7.293 (-13.3) | 8.347 (-0.7) | 10.149 (20.7) |
| 16 | 12.158 | 12.0873 (-0.6) | 12.148 (-0.1) | 13.098 (7.7) | 12.286 (1.1) | 13.604 (11.9) |
| 17 | 18.810 | 18.767 (-0.2) | 18.810 (0.0) | 18.758 (-0.3) | 18.788 (-0.1) | 20.226 (7.5) |
| 18 | 56.615 | 56.427 (-0.3) | 56.521 (-0.2) | 56.525 (-0.2) | 56.527 (-0.2) | 59.608 (5.3) |
| 19 | 22.410 | 22.079 (-1.5) | 22.408 (-0.1) | 22.434 (0.1) | 22.386 (-0.1) | 25.065 (11.8) |
| 20 | 104.66 | 104.54 (-0.1) | 104.42 (-0.2) | 104.41 (-0.2) | 104.49 (-0.2) | 115.63 (10.5) |
| 21 | 34.818 | 34.744 (-0.2) | 34.794 (-0.1) | 34.843 (0.1) | 34.734 (-0.2) | 39.230 (12.7) |
| 22 | 11.102 | 11.078 (-0.2) | 11.076 (-0.2) | 11.103 (0.0) | 11.051 (-0.5) | 11.065 (0.3) |
| 23 | 24.244 | 24.308 (0.3) | 24.190 (-0.2) | 24.337 (0.5) | 24.166 (-0.3) | 25.509 (5.2) |

Table 4

Resonance Integrals for U-235

| | FEDGROUP-3 | Ref. [5] |
|---|---|---|
| $RI_\gamma$ | 137.65 | 127.8 |
| $RI_f$ | 274.21 | 261.4 |

Table 5

Resonance Integrals for U-238

| | FEDGROUP-3 | Ref. [5] |
|---|---|---|
| $RI_\gamma$ | 276.94 | 268.0 |
| $RI_f$ | 0.0 | 0.0 |

Table 6

Resonance Integrals for PU-239

| | FEDGROUP-3 | Ref. [5] |
|---|---|---|
| $RI_\gamma$ | 182.18 | 192.4 |
| $RI_f$ | 292.24 | 288.0 |

Table 7

U-235. Some groups calculated by different approximation

| Gr.N° | $\sigma_{tot}$ | | $\delta_{n,\gamma}$ | | $\delta_n$ | | $\delta_f$ | |
|---|---|---|---|---|---|---|---|---|
| | $a \neq \hat{a}$ | $a = \hat{a}$ | $a \neq \hat{a}$ | $a = \hat{a}$ | $a \neq \hat{a}$ | $a = \hat{a}$ | $a \neq \hat{a}$ | $a = \hat{a}$ |
| 11 | 14.9586 | 15.1633 | 1.01623 | 1.07704 | 11.4645 | 11.4094 | 2.47519 | 2.61411 |
| | 14.9397 | 15.2110 | 1.00678 | 1.08590 | 11.4568 | 11.4795 | 2.47328 | 2.64284 |
| 13 | 18.5517 | 18.7447 | 1.73579 | 1.77782 | 11.8760 | 11.8797 | 4.93997 | 5.08714 |
| | 18.5828 | 18.7207 | 1.73410 | 1.77989 | 11.8776 | 11.8790 | 4.97115 | 5.06181 |
| 15 | 28.6779 | 28.7751 | 4.85285 | 4.89163 | 12.4364 | 12.4423 | 11.3887 | 11.4412 |
| | 28.6006 | 28.6659 | 4.65470 | 4.67674 | 12.3846 | 12.3847 | 11.5614 | 11.6046 |
| 17 | 45.7805 | 45.8098 | 12.0893 | 12.0995 | 12.6106 | 12.6105 | 21.0806 | 21.0999 |
| | 45.7489 | 45.7794 | 12.0567 | 12.0670 | 12.6072 | 12.6072 | 21.0852 | 21.1053 |

Table 8

U-238. Some groups calculated by different approximation

| Gr.N° | $\sigma_{tot}$ | | $\sigma_{n,\gamma}$ | | $\sigma_n$ | |
|---|---|---|---|---|---|---|
| | $a \neq \hat{a}$ | $a = \hat{a}$ | $a \neq \hat{a}$ | $a = \hat{a}$ | $a \neq \hat{a}$ | $a = \hat{a}$ |
| 10 | 13.3862 | 13.5479 | 0.431545 | 0.449506 | 12.9543 | 13.0981 |
| 11 | 14.448 | 14.5775 | 0.6076 | 0.642364 | 13.8371 | 13.9350 |
| 12 | 16.0205 | 16.1157 | 0.841607 | 0.890148 | 15.1789 | 15.2256 |

Table 9

Pu-239. Some groups calculated by different approximation

| Gr.N° | $\sigma_{tot}$ | | $\sigma_{n,\gamma}$ | | $\sigma_n$ | | $\sigma_f$ | |
|---|---|---|---|---|---|---|---|---|
| | $a \neq \hat{a}$ | $a = \hat{a}$ | $a \neq \hat{a}$ | $a = \hat{a}$ | $a \neq \hat{a}$ | $a = \hat{a}$ | $a \neq \hat{a}$ | $a = \hat{a}$ |
| 11 | 13.9525 | 14.0929 | 0.879357 | 0.895195 | 11.1642 | 11.1778 | 1.75127 | 1.86203 |
| | 13.9519 | 14.0921 | 0.879073 | 0.894913 | 11.1640 | 11.1776 | 1.75094 | 1.86172 |
| 13 | 18.9926 | 19.0635 | 2.72565 | 2.73700 | 13.1850 | 13.1863 | 3.08195 | 3.14023 |
| | 18.9153 | 18.978 | 2.73229 | 2.74874 | 13.1355 | 13.1328 | 3.04755 | 3.09644 |
| 14 | 21.4305 | 21.4794 | 3.82081 | 3.82906 | 12.9559 | 12.9554 | 4.65463 | 4.69498 |
| | 21.2737 | 21.3132 | 3.79838 | 3.80816 | 12.9308 | 12.9258 | 4.54656 | 4.57927 |
| 15 | 30.6624 | 30.6959 | 6.87690 | 6.88266 | 14.9961 | 14.9961 | 8.78945 | 8.81716 |
| | 29.9171 | 29.9134 | 6.74669 | 6.74419 | 14.7418 | 14.7271 | 8.42868 | 8.44223 |