LA-7675-MS

Informal Report

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# Jezebel and Godiva

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This work was supported by the US Department of Energy, Division of Reactor Research and Technology and the Department of Military Affairs.



UNITED STATES
DEPARTMENT OF ENERGY
CONTRACT W-7405-ENG. 36

LA-7675-MS
Informal Report

UC-34c
Issued: February 1979

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JEZEBEL AND GODIVA

by

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ABSTRACT

Various code options and input data are tested in the calculation of the fast reactor benchmarks, JEZEBEL and GODIVA. Their effects on the eigenvalue and $^{238}U$ to $^{235}U$ central fission rate ratio are documented in this report. Although the results can be used to improve past or future calculations, it appears that no reasonable choice of data or options can bring the calculated central fission ratio into agreement with the experimental value.

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## I. INTRODUCTION

Nuclear data, nuclear data processing codes, and reactor physics codes provide almost endless opportunities to vary the input and calculation of any particular problem. Hence there is no single final calculational result for any reactor-physics problem.

In this brief report, the results of varying only a few options are presented for the critical benchmarks[1] JEZEBEL and GODIVA. The resulting range of parametric values indicate whether or not the tested option is important for JEZEBEL or GODIVA. Some of the results can be used to correct past or future calculations of JEZEBEL and GODIVA for the various tested effects.

## II. DATA, CODES, AND RESULTS

The parameters studied while varying the tested options are the multiplication factor (K or eigenvalue) and the central $^{238}U$ to $^{235}U$ fission rate ratio (R). The computed parameters for all the tested variations are compared to experimental values in Tables I, II, III, and IV. The calculated average central

TABLE I

JEZEBEL EIGENVALUES

| | | Cross Sections from MINX or NJOY: 50-Gp, Old Chi, $P_0$ (1) | 50-Gp, Old Chi, $P_1$ (2) | 50-Gp, Old Chi, $P_2$ (3) | 50-Gp, Old Chi, $P_3$ (4) | 50-Gp, Comp Chi, $P_3$ (5) | Comp Chi 185-Gp, $P_3$ (6) | 240-Gp, Comp Chi, $P_3$ (7) | 240-Gp, Comp Chi, $P_2$ (8) | 240-Gp, Comp Chi, $P_1$ (9) | 240-Gp, Comp Chi, $P_0$ (10) | Cross Sections Through 1DX, 50-Gp, Old Chi: Only 1 Elastic Removal Term, Only 10 Downscatter Groups, FF=iterate, Sige=5 (11) | Only 10 Downscatter Groups, FF=1, Sige=0 (12) | Only 10 Downscatter Groups, FF=iterate, Sige=0 (13) | Full Inelastic, FF=iterate, Sige=5 (14) | Full Inelastic, Full Elastic, Sige=5 (15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Based on Preliminary ENDF/B-V** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 1.13783 | 1.06017 | | | | | | | | | 1.05458 | 1.05446 | 1.05458 | | |
| 2 | $S_4$ | 1.10477 | 1.01120 | 1.01748 | 1.01738 | 1.01720 | | | | | | 1.02070 | 1.02059 | 1.02070 | | |
| 3 | $S_8$ | 1.09624 | 1.00164 | 1.00786 | 1.00772 | 1.00754 | | | | | | 1.01120 | 1.01110 | 1.01121 | | |
| 4 | $S_{16}$ | 1.09381 | 0.99904 | 1.00513 | 1.00503 | 1.00484 | | | | | | 1.00850 | 1.00839 | 1.00850 | | |
| 5 | $S_{32}$ | 1.09314 | 0.99832 | 1.00438 | 1.00428 | 1.00409 | | | | | | 1.00775 | 1.00765 | 1.00775 | | |
| 6 | $S_{48}$ | 1.09301 | 0.99818 | 1.00424 | 1.00414 | 1.00395 | 1.00387 | | | | | 1.00761 | 1.00751 | 1.00761 | | |
| **Based on ENDF/B-IV** | | | | | | | | | | | | | | | | |
| 7 | $S_2$ | 1.12906 | 1.05132 | | | | | | | | | 1.04572 | 1.04560 | | | |
| 8 | $S_4$ | 1.09609 | 1.00245 | 1.00873 | 1.00864 | 1.00821 | | 1.00785 | | | | 1.01196 | 1.01184 | | | |
| 9 | $S_8$ | 1.08759 | 0.99292 | 0.99915 | 0.99901 | 0.99859 | | 0.99823 | | | | 1.00250 | 1.00239 | | | |
| 10 | $S_{16}$ | 1.08517 | 0.99033 | 0.99643 | 0.99632 | 0.99590 | | 0.99555 | | | | 0.99980 | 0.99969 | | 0.99982 | 0.99982 |
| 11 | $S_{32}$ | 1.08450 | 0.98962 | 0.99568 | 0.99558 | 0.99516 | | 0.99481 | | | | 0.99905 | 0.99895 | | | |
| 12 | $S_{48}$ | 1.08437 | 0.98948 | 0.99554 | 0.99544 | 0.99502 | | 0.99467 | 0.99476 | 0.098872 | 1.08332 | 0.99891 | 0.99880 | | | |

TABLE II

GODIVA EIGENVALUES

| | | Cross Sections from MINX or NJOY | | | | | | | | | | Cross Sections Through 1DX, 50-Gp, Old Chi | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50-Gp | | | | | | | | | | Only 1 Elastic Removal Term | | | | |
| | | | | | | | | | | | | Only 10 Downscatter Groups | | | Full Inelastic | |
| | | Old Chi | | | | Comp Chi | Comp Chi 185-Gp | 240-Gp, Comp Chi | | | | FF= iterate | FF=1 | | FF=iterate | Full Elastic |
| | | $P_0$ | $P_1$ | $P_2$ | $P_3$ | $P_3$ | $P_3$ | $P_3$ | $P_2$ | $P_1$ | $P_0$ | Sige=5 | Sige=0 | | Sige=5 | |
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| **Based on Preliminary ENDF/B-V** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 1.13005 | 1.03579 | | | | | | | | | 1.02888 | 1.02887 | 1.02900 | | |
| 2 | $S_4$ | 1.10630 | 0.99307 | 0.99897 | 0.99894 | 0.99732 | | | | | | 1.00242 | 1.00241 | 1.00253 | | |
| 3 | $S_8$ | 1.10124 | 0.98688 | 0.99241 | 0.99234 | 0.99072 | | | | | | 0.99586 | 0.99585 | 0.99598 | | |
| 4 | $S_{16}$ | 1.09980 | 0.98522 | 0.99058 | 0.99053 | 0.98891 | | | | | | 0.99399 | 0.99399 | 0.99411 | | |
| 5 | $S_{32}$ | 1.09940 | 0.98476 | 0.99007 | 0.99003 | 0.98841 | | | | | | 0.99348 | 0.99347 | 0.99360 | | |
| 6 | $S_{48}$ | 1.09933 | 0.98466 | 0.98997 | 0.98993 | 0.98831 | 0.98727 | | | | | 0.99338 | 0.99337 | 0.99350 | | |
| **Based on ENDF/B-IV** | | | | | | | | | | | | | | | | |
| 7 | $S_2$ | 1.14885 | 1.05355 | | | | | | | | | 1.04627 | 1.04637 | | | |
| 8 | $S_4$ | 1.12486 | 1.01033 | 1.01634 | 1.01631 | 1.01563 | | 1.01453 | | | | 1.01949 | 1.01960 | | | |
| 9 | $S_8$ | 1.11974 | 1.00406 | 1.00969 | 1.00963 | 1.00896 | | 1.00787 | | | | 1.01285 | 1.01296 | | | |
| 10 | $S_{16}$ | 1.11829 | 1.00238 | 1.00784 | 1.00780 | 1.00713 | | 1.00604 | | | | 1.01096 | 1.01107 | | | |
| 11 | $S_{32}$ | 1.11788 | 1.00191 | 1.00733 | 1.00729 | 1.00663 | | 1.00554 | | | | 1.01044 | 1.01055 | | | |
| 12 | $S_{48}$ | 1.11780 | 1.00182 | 1.00723 | 1.00719 | 1.00653 | | 1.00544 | 1.00548 | 1.0012 | 1.11524 | 1.01034 | 1.01045 | | | |

TABLE III

JEZEBEL $\left(\frac{F^{28}}{F^{25}}\right)_C \Big/ \left(\frac{F^{28}}{F^{25}}\right)_E$

| | | Cross Sections from MINX or NJOY: 50-Gp, Old Chi, $P_0$ (1) | 50-Gp, Old Chi, $P_1$ (2) | 50-Gp, Old Chi, $P_2$ (3) | 50-Gp, Old Chi, $P_3$ (4) | 50-Gp, Comp Chi, $P_3$ (5) | Comp Chi 185-Gp, $P_3$ (6) | 240-Gp, Comp Chi, $P_3$ (7) | 240-Gp, Comp Chi, $P_2$ (8) | 240-Gp, Comp Chi, $P_1$ (9) | 240-Gp, Comp Chi, $P_0$ (10) | Cross Sections Through 1DX, 50-Gp, Old Chi: Only 1 Elastic Removal Term, Only 10 Downscatter Groups, FF=iterate, Sige=5 (11) | Only 10 Downscatter Groups, FF=1, Sige=0 (12) | Only 10 Downscatter Groups, FF=iterate, Sige=0 (13) | Full Inelastic, FF=iterate, Sige=5 (14) | Full Inelastic, Full Elastic, Sige=5 (15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Based on Preliminary ENDF/B-V** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 0.92931 | 0.92534 | | | | | | | | | 0.91919 | 0.91926 | 0.91909 | | |
| 2 | $S_4$ | 0.93594 | 0.92435 | 0.92954 | 0.92947 | 0.94360 | | | | | | 0.92743 | 0.92750 | 0.92733 | | |
| 3 | $S_8$ | 0.93755 | 0.92269 | 0.93113 | 0.93027 | 0.94445 | | | | | | 0.92954 | 0.92961 | 0.92945 | | |
| 4 | $S_{16}$ | 0.93800 | 0.92228 | 0.93182 | 0.93052 | 0.94471 | | | | | | 0.93009 | 0.93016 | 0.93000 | | |
| 5 | $S_{32}$ | 0.93813 | 0.92221 | 0.93205 | 0.93062 | 0.94482 | | | | | | 0.93024 | 0.93032 | 0.93015 | | |
| 6 | $S_{48}$ | 0.93815 | 0.92220 | 0.93210 | 0.93065 | 0.94485 | 0.94572 | | | | | 0.93027 | 0.93035 | 0.93018 | | |
| **Based on ENDF/B-IV** | | | | | | | | | | | | | | | | |
| 7 | $S_2$ | 0.92156 | 0.91737 | | | | | | | | | 0.91077 | 0.91099 | | | |
| 8 | $S_4$ | 0.92826 | 0.91624 | 0.92154 | 0.92147 | 0.91781 | | 0.91368 | | | | 0.91911 | 0.91934 | | | |
| 9 | $S_8$ | 0.92990 | 0.91452 | 0.92313 | 0.92226 | 0.91860 | | 0.91450 | | | | 0.92125 | 0.92148 | | | |
| 10 | $S_{16}$ | 0.93035 | 0.91409 | 0.92383 | 0.92250 | 0.91884 | | 0.91474 | | | | 0.92181 | 0.92204 | | 0.92105 | 0.92104 |
| 11 | $S_{32}$ | 0.93048 | 0.91401 | 0.92406 | 0.92261 | 0.91895 | | 0.91486 | | | | 0.92196 | 0.92219 | | | |
| 12 | $S_{48}$ | 0.93050 | 0.91401 | 0.92412 | 0.92264 | 0.91898 | | 0.91488 | 0.91638 | 0.90613 | 0.92293 | 0.92199 | 0.92222 | | | |

TABLE IV

GODIVA $\left(\frac{F^{28}}{F^{25}}\right)_C \Big/ \left(\frac{F^{28}}{F^{25}}\right)_E$

| | | Cross Sections from MINX or NJOY: 50-Gp, Old Chi $P_0$ (1) | 50-Gp, Old Chi $P_1$ (2) | 50-Gp, Old Chi $P_2$ (3) | 50-Gp, Old Chi $P_3$ (4) | 50-Gp, Comp Chi $P_3$ (5) | Comp Chi 185-Gp $P_3$ (6) | 240-Gp, Comp Chi $P_3$ (7) | 240-Gp, Comp Chi $P_2$ (8) | 240-Gp, Comp Chi $P_1$ (9) | 240-Gp, Comp Chi $P_0$ (10) | Cross Sections Through 1DX, 50-Gp, Old Chi: Only 1 Elastic Removal Term, Only 10 Downscatter Groups, FF=iterate, Sige=5 (11) | Only 10 Downscatter Groups, FF=1, Sige=0 (12) | Only 10 Downscatter Groups, FF=iterate, Sige=0 (13) | Full Inelastic, FF=iterate, Sige=5 (14) | Full Inelastic, Full Elastic, FF=iterate, Sige=5 (15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Based on Preliminary ENDF/B-V** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 1.06012 | 1.05682 | | | | | | | | | 1.04484 | 1.04513 | 1.04482 | | |
| 2 | $S_4$ | 1.06689 | 1.05145 | 1.05777 | 1.05787 | 1.06923 | | | | | | 1.05404 | 1.05434 | 1.05403 | | |
| 3 | $S_8$ | 1.06822 | 1.04791 | 1.05742 | 1.05685 | 1.06825 | | | | | | 1.05601 | 1.05630 | 1.05599 | | |
| 4 | $S_{16}$ | 1.06859 | 1.04713 | 1.05767 | 1.05670 | 1.06811 | | | | | | 1.05649 | 1.05679 | 1.05648 | | |
| 5 | $S_{32}$ | 1.06870 | 1.04701 | 1.05782 | 1.05674 | 1.06815 | | | | | | 1.05663 | 1.05693 | 1.05662 | | |
| 6 | $S_{48}$ | 1.06872 | 1.04700 | 1.05786 | 1.05677 | 1.06818 | 1.06649 | | | | | 1.05667 | 1.05696 | 1.05665 | | |
| **Based on ENDF/B-IV** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 1.05796 | 1.05371 | | | | | | | | | 1.04106 | 1.04150 | | | |
| 2 | $S_4$ | 1.06458 | 1.04782 | 1.05423 | 1.05432 | 1.04451 | | 1.03513 | | | | 1.05016 | 1.05060 | | | |
| 3 | $S_8$ | 1.06589 | 1.04416 | 1.05379 | 1.05321 | 1.04340 | | 1.03404 | | | | 1.05210 | 1.05253 | | | |
| 4 | $S_{16}$ | 1.06625 | 1.04336 | 1.05402 | 1.05304 | 1.04322 | | 1.03387 | | | | 1.05258 | 1.05301 | | | |
| 5 | $S_{32}$ | 1.06636 | 1.04322 | 1.05416 | 1.05308 | 1.04326 | | 1.03391 | | | | 1.05272 | 1.05315 | | | |
| 6 | $S_{48}$ | 1.06638 | 1.04321 | 1.05421 | 1.05310 | 1.04328 | | 1.03394 | 1.03505 | 1.02398 | 1.04753 | 1.05275 | 1.05318 | | | |

fission cross sections for $^{238}U$ and $^{235}U$ are also presented in Tables V, VI, VII, and VIII, which helps one understand the behavior of R.

Two basic cross-section sources[2] were used in this study, ENDF/B-IV and preliminary ENDF/B-V. The MINX[3] code was used to generate 50-group and 240-group libraries from ENDF/B-IV, while the NJOY[4] code was used to generate 50-group and 185-group libraries from preliminary ENDF/B-V data. (The preliminary ENDF/B-V data did not include $^{234}U$, so NJOY was used to process the ENDF/B-IV $^{234}U$ data into the NJOY libraries.)

Several different fission sources were tried. The old 50-group chi vectors used with JEZEBEL and GODIVA were generated from a simple fission spectrum shape with nuclear temperatures of 1.41 and 1.35 MeV, respectively. More appropriate composition-dependent fission sources were obtained by weighting constituent isotope chi vectors with the isotope's density and volume average cross section [illegible]ron production. The individual isotope chi vectors for the various [illegible]n sources and group structures are obtained from the MINX and NJOY [illegible] above. The volume averaged cross sections for neutron produc- [illegible] taken from the 50-group, $S_{48}P_3$ ONETRAN[5] runs that used the old chi [illegible] Thus for JEZEBEL we have composition-dependent fission source vectors [illegible]-group and 240-group structures, based on ENDF/B-IV (LIB-IV) and in [illegible]0 and 185-group structures based on preliminary ENDF/B-V (PRE-V). [illegible]s for GODIVA were generated in a similar fashion. All of the chi [illegible] and group structures are displayed in Appendix A.

All of the results presented in this report were generated with the ONETRAN code setup according to the JEZEBEL and GODIVA specifications of Ref. 1. ONETRAN is coded to accept cross sections in several different formats. It can accept cross sections directly from MINX or NJOY, in which case calculations can proceed at any Legendre order but only with infinitely dilute cross sections. On the other hand, ONETRAN can accept cross sections from the diffusion theory code 1DX,[6] in which case, depending on the 1DX options, calculations proceed with self-shielded and flux-iterated cross sections but only within the transport cross-section approximation $(P_{1/2})$.

Some of the specific entries or omissions in the table labels have the following meanings.

FF=iterate - an iteration between f-factors and compostion was performed to obtain effective self-shielded cross sections.

TABLE V

JEZEBEL $\bar{\sigma}_f^{U-238}$

| | | Cross Sections from MINX or NJOY | | | | | | | | | | Cross Sections Through 1DX, 50-Gp, Old Chi | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50-Gp | | | | | | | | | | Only 1 Elastic Removal Term | | | | |
| | | | | | | | | | | | | Only 10 Downscatter Groups | | | Full Inelastic | |
| | | Old Chi | | | | Comp Chi | Comp Chi 185-Gp | 240-Gp, Comp Chi | | | | FF= iterate | FF=1 | FF=iterate | | Full Elastic |
| | | | | | | | | | | | | Sige=5 | Sige=0 | | Sige=5 | |
| | | $P_0$ | $P_1$ | $P_2$ | $P_3$ | $P_3$ | $P_3$ | $P_3$ | $P_2$ | $P_1$ | $P_0$ | | | | | |
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| **Based on Preliminary ENDF/B-V** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 0.24224 | 0.24135 | | | | | | | | | 0.23960 | 0.23962 | 0.23960 | | |
| 2 | $S_4$ | 0.24394 | 0.24115 | 0.24249 | 0.24247 | 0.24561 | | | | | | 0.24171 | 0.24173 | 0.24171 | | |
| 3 | $S_8$ | 0.24436 | 0.24075 | 0.24292 | 0.24270 | 0.24585 | | | | | | 0.24226 | 0.24227 | 0.24226 | | |
| 4 | $S_{16}$ | 0.24447 | 0.24064 | 0.24311 | 0.24277 | 0.24592 | | | | | | 0.24240 | 0.24242 | 0.24240 | | |
| 5 | $S_{32}$ | 0.24450 | 0.24063 | 0.24317 | 0.24280 | 0.24595 | | | | | | 0.24244 | 0.24246 | 0.24244 | | |
| 6 | $S_{48}$ | 0.24451 | 0.24062 | 0.24318 | 0.24280 | 0.24596 | 0.24608 | | | | | 0.24245 | 0.24246 | 0.24245 | | |
| **Based on ENDF/B-IV** | | | | | | | | | | | | | | | | |
| 7 | $S_2$ | 0.24384 | 0.24288 | | | | | | | | | 0.24101 | 0.24107 | | | |
| 8 | $S_4$ | 0.24555 | 0.24263 | 0.24400 | 0.24398 | 0.24302 | | 0.24173 | | | | 0.24314 | 0.24320 | | | |
| 9 | $S_8$ | 0.24597 | 0.24221 | 0.24444 | 0.24421 | 0.24324 | | 0.24196 | | | | 0.24370 | 0.24376 | | | |
| 10 | $S_{16}$ | 0.24609 | 0.24210 | 0.24462 | 0.24428 | 0.24331 | | 0.24203 | | | | 0.24384 | 0.24390 | | 0.24385 | 0.24384 |
| 11 | $S_{32}$ | 0.24612 | 0.24209 | 0.24468 | 0.24430 | 0.24334 | | 0.24206 | | | | 0.24388 | 0.24394 | | | |
| 12 | $S_{48}$ | 0.24613 | 0.24208 | 0.24470 | 0.24431 | 0.24334 | | 0.24206 | 0.24245 | 0.23981 | 0.24391 | 0.24389 | 0.24395 | | | |

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TABLE VI

GODIVA $\bar{\sigma}_f^{U-238}$

| | | Cross Sections from MINX or NJOY | | | | | | | | | | Cross Sections Through 1DX, 50-Gp, Old Chi | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50-Gp | | | | | | | | | | Only 1 Elastic Removal Term | | | | |
| | | | | | | | | | | | | Only 10 Downscatter Groups | | | Full Inelastic | |
| | | Old Chi | | | | Comp Chi | Comp Chi 185-Gp | 240-Gp, Comp Chi | | | | FF=iterate | FF=1 | FF=iterate | | Full Elastic |
| | | $P_0$ | $P_1$ | $P_2$ | $P_3$ | $P_3$ | $P_3$ | $P_3$ | $P_2$ | $P_1$ | $P_0$ | Sige=5 | Sige=0 | | Sige=5 | |
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| **Based on Preliminary ENDF/B-V** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 0.21042 | 0.20987 | | | | | | | | | 0.20745 | 0.20749 | 0.20748 | | |
| 2 | $S_4$ | 0.21175 | 0.20887 | 0.21012 | 0.21014 | 0.21217 | | | | | | 0.20926 | 0.20930 | 0.20929 | | |
| 3 | $S_8$ | 0.21201 | 0.20819 | 0.21007 | 0.20996 | 0.21200 | | | | | | 0.20965 | 0.20969 | 0.20968 | | |
| 4 | $S_{16}$ | 0.21208 | 0.20804 | 0.21012 | 0.20993 | 0.21198 | | | | | | 0.20975 | 0.20979 | 0.20978 | | |
| 5 | $S_{32}$ | 0.21210 | 0.20802 | 0.21016 | 0.20994 | 0.21199 | | | | | | 0.20978 | 0.20982 | 0.20981 | | |
| 6 | $S_{48}$ | 0.21211 | 0.20802 | 0.21016 | 0.20994 | 0.21199 | 0.21157 | | | | | 0.20978 | 0.20982 | 0.20982 | | |
| **Based on ENDF/B-IV** | | | | | | | | | | | | | | | | |
| 7 | $S_2$ | 0.21354 | 0.21280 | | | | | | | | | 0.21019 | 0.21030 | | | |
| 8 | $S_4$ | 0.21485 | 0.21168 | 0.21295 | 0.21297 | 0.21100 | | 0.20893 | | | | 0.21199 | 0.21209 | | | |
| 9 | $S_8$ | 0.21511 | 0.21098 | 0.21289 | 0.21277 | 0.21080 | | 0.20873 | | | | 0.21237 | 0.21248 | | | |
| 10 | $S_{16}$ | 0.21518 | 0.21082 | 0.21294 | 0.21274 | 0.21077 | | 0.20870 | | | | 0.21247 | 0.21258 | | | |
| 11 | $S_{32}$ | 0.21520 | 0.21079 | 0.21297 | 0.21275 | 0.21078 | | 0.20871 | | | | 0.21250 | 0.21260 | | | |
| 12 | $S_{48}$ | 0.21521 | 0.21079 | 0.21298 | 0.21275 | 0.21078 | | 0.20872 | 0.20894 | 0.20675 | 0.21123 | 0.21250 | 0.21261 | | | |

## TABLE VII

JEZEBEL $\bar{\sigma}_f^{U-235}$

| | | Cross Sections from MINX or NJOY | | | | | | | | | | Cross Sections Through 1DX, 50-Gp, Old Chi | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50-Gp | | | | | | | | | | Only 1 Elastic Removal Term | | | | |
| | | | | | | | Comp Chi 185-Gp | | | | | Only 10 Downscatter Groups | | | Full Inelastic | |
| | | Old Chi | | | | Comp Chi | | 240-Gp, Comp Chi | | | | FF=iterate | FF=1 | | FF=iterate | Full Elastic |
| | | | | | | | | | | | | Sige=5 | Sige=0 | | Sige=5 | |
| | | $P_0$ (1) | $P_1$ (2) | $P_2$ (3) | $P_3$ (4) | $P_3$ (5) | $P_3$ (6) | $P_3$ (7) | $P_2$ (8) | $P_1$ (9) | $P_0$ (10) | (11) | (12) | (13) | (14) | (15) |
| **Based on Preliminary ENDF/B-V** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 1.23541 | 1.23614 | | | | | | | | | 1.23538 | 1.23537 | 1.23551 | | |
| 2 | $S_4$ | 1.23524 | 1.23643 | 1.23636 | 1.23635 | 1.23362 | | | | | | 1.23519 | 1.23518 | 1.23531 | | |
| 3 | $S_8$ | 1.23522 | 1.23657 | 1.23646 | 1.23645. | 1.23371 | | | | | | 1.23516 | 1.23515 | 1.23529 | | |
| 4 | $S_{16}$ | 1.23521 | 1.23660 | 1.23648 | 1.23647 | 1.23373 | | | | | | 1.23516 | 1.23515 | 1.23528 | | |
| 5 | $S_{32}$ | 1.23521 | 1.23661 | 1.23648 | 1.23647 | 1.23373 | | | | | | 1.23516 | 1.23515 | 1.23528 | | |
| 6 | $S_{48}$ | 1.23521 | 1.23661 | 1.23648 | 1.23647 | 1.23373 | 1.23318 | | | | | 1.23516 | 1.23515 | 1.23528 | | |
| **Based on ENDF/B-IV** | | | | | | | | | | | | | | | | |
| 7 | $S_2$ | 1.25398 | 1.25476 | | | | | | | | | 1.25413 | 1.25413 | | | |
| 8 | $S_4$ | 1.25367 | 1.25505 | 1.25487 | 1.25487 | 1.25487 | | 1.25385 | | | | 1.25376 | 1.25376 | | | |
| 9 | $S_8$ | 1.25361 | 1.25521 | 1.25493 | 1.25494 | 1.25495 | | 1.25393 | | | | 1.25369 | 1.25369 | | | |
| 10 | $S_{16}$ | 1.25360 | 1.25525 | 1.25494 | 1.25496 | 1.25497 | | 1.25395 | | | | 1.25368 | 1.25367 | | 1.25473 | 1.25472 |
| 11 | $S_{32}$ | 1.25360 | 1.25526 | 1.25494 | 1.25496 | 1.25497 | | 1.25395 | | | | 1.25367 | 1.25367 | | | |
| 12 | $S_{48}$ | 1.25359 | 1.25526 | 1.25494 | 1.25496 | 1.25497 | | 1.25395 | 1.25393 | 1.25426 | 1.25252 | 1.25367 | 1.25367 | | | |

TABLE VIII

GODIVA $\bar{\sigma}_f^{U\text{-}235}$

| | | Cross Sections from MINX or NJOY | | | | | | | | | | Cross Sections Through 1DX, 50-Gp, Old Chi | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50-Gp | | | | | | | | | | Only 1 Elastic Removal Term | | | | |
| | | | | | | | | | | | | Only 10 Downscatter Groups | | | Full Inelastic | |
| | | Old Chi | | | | Comp Chi | Comp Chi 185-Gp | 240-Gp, Comp Chi | | | | FF=iterate | FF=1 | | FF=iterate | Full Elastic |
| | | | | | | | | | | | | Sige=5 | Sige=0 | | Sige=5 | |
| | | $P_0$ | $P_1$ | $P_2$ | $P_3$ | $P_3$ | $P_3$ | $P_3$ | $P_2$ | $P_1$ | $P_0$ | | | | | |
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| **Based on Preliminary ENDF/B-V** | | | | | | | | | | | | | | | | |
| 1 | $S_2$ | 1.23281 | 1.23348 | | | | | | | | | 1.23322 | 1.23311 | 1.23343 | | |
| 2 | $S_4$ | 1.23273 | 1.23385 | 1.23380 | 1.23380 | 1.23253 | | | | | | 1.23312 | 1.23300 | 1.23333 | | |
| 3 | $S_8$ | 1.23274 | 1.23399 | 1.23394 | 1.23392 | 1.23266 | | | | | | 1.23313 | 1.23301 | 1.23333 | | |
| 4 | $S_{16}$ | 1.23274 | 1.23403 | 1.23397 | 1.23395 | 1.23269 | | | | | | 1.23313 | 1.23301 | 1.23333 | | |
| 5 | $S_{32}$ | 1.23273 | 1.23403 | 1.23397 | 1.23396 | 1.23269 | | | | | | 1.23313 | 1.23301 | 1.23333 | | |
| 6 | $S_{48}$ | 1.23273 | 1.23403 | 1.23397 | 1.23396 | 1.23269 | 1.23215 | | | | | 1.23313 | 1.23301 | 1.23333 | | |
| **Based on ENDF/B-IV** | | | | | | | | | | | | | | | | |
| 7 | $S_2$ | 1.25369 | 1.25437 | | | | | | | | | 1.25403 | 1.25415 | | | |
| 8 | $S_4$ | 1.25351 | 1.25480 | 1.25466 | 1.25465 | 1.25472 | | 1.25366 | | | | 1.25379 | 1.25392 | | | |
| 9 | $S_8$ | 1.25349 | 1.25499 | 1.25479 | 1.25479 | 1.25486 | | 1.25381 | | | | 1.25377 | 1.25389 | | | |
| 10 | $S_{16}$ | 1.25349 | 1.25503 | 1.25482 | 1.25482 | 1.25489 | | 1.25384 | | | | 1.25376 | 1.25388 | | | |
| 11 | $S_{32}$ | 1.25349 | 1.25504 | 1.25482 | 1.25482 | 1.25489 | | 1.25384 | | | | 1.25376 | 1.25388 | | | |
| 12 | $S_{48}$ | 1.25349 | 1.25504 | 1.25482 | 1.25482 | 1.25489 | | 1.25384 | 1.25383 | 1.25406 | 1.25246 | 1.25376 | 1.25388 | | | |

FF=1 - f-factors were set to 1.0 to induce the use of infinitely dilute cross sections via 1DX.

Sige=5 - five iterations between the elastic removal cross section and flux were performed.

Sige=0 - the input elastic removal cross sections were used.

$P_i$ - an ith Legendre order anisotropic scattering calculation was made. If $P_i$ is missing, a $P_0$ calculation with the transport cross section was made.

$S_i$ - an ith angular quadrature order calculation was performed.

Comp. Chi - a composition-dependent fission source appropriate to the data source and group structure was used. If there is no reference to chi, then the appropriate old chi was used.

N-group - the N-group structure was used. If there is no reference to the group structure, the the 50-group structure was used.

Full inelastic (elastic) - a 50 x 50 matrix was used to describe inelastic (elastic) downscatter. All of the ONETRAN runs utilizing the MINX or NJOY cross sections directly used full inelastic and elastic downscattering matrices.

All of the rows and columns in each table are numbered to facilitate comparisons. For example, in Table I, if we let E(i,j) represent the eigenvalue in the ith row and jth column, then E(6,11) would be 1.00761.

## III. PARTICULAR EFFECTS

### A. ENDF/B-IV Cross Sections vs Preliminary ENDF/B-V Cross Sections

The effect of different cross-section sets can be obtained by comparing results from calculations that differ only in their cross-section input. For example, if one forms the following differences in Tables I through IV,

$$E(i+6,j) - E(i,j) \quad \text{for } i = 1, \ldots, 6 \text{ and } j = 1, \ldots, 5, 11, 12 \quad ,$$

it becomes obvious that for JEZEBEL, the preliminary ENDF/B-V cross sections increase K by ∿0.00870 and increase R by ∿0.00801. For GODIVA, the preliminary ENDF/B-V cross sections decrease K by ∿0.01726 and increase R by ∿0.00367. Furthermore, these differences are not very sensitive to the angular quadrature, Legendre order, self-shielding treatment, or elastic removal treatment.

## B. Fission Source

The effects of using various fission sources are determined by taking the following differences in Tables I through IV,

E(i,5) - E(i,4)    for i = 1, ..., 12 .

With respect to using the old chi (see Appendix A), the effect of using a composition-dependent chi depends on which cross section source is used to generate the composition-dependent chi. If PRE-V is used, a composition-dependent chi for JEZEBEL will decrease K by ∿0.00019 and increase R by ∿0.01420, while a composition-dependent chi for GODIVA will decrease K by ∿0.00162 and increase R by ∿0.01141. If LIB-IV is used, a composition-dependent chi for JEZEBEL will decrease K by ∿0.00042 and increase R by ∿0.00366, while a compostion-dependent chi for GODIVA will decrease K by ∿0.00066 and decrease R by ∿0.00982.

The fission source affects R much more than K, probably because of the threshold nature of the $^{238}$U fission cross section. The R and K effects are larger for GODIVA than for JEZEBEL because $^{238}$U is a constituent of GODIVA's composition.

The above differences do not change significantly with angular quadratures of four and larger.

## C. Cross Sections and Fission Source

It may be more meaningful to compare the results of using cross sections and composition chi as determined from PRE-V with similar results from LIB-IV. The differences,

E(i+6,5) - E(i,5)    for i = 1, ..., 6 ,

give us that comparison. Totally PRE-V for JEZEBEL yields an increase in K of ∿0.00893 and an increase in R of ∿0.02587. Totally PRE-V for GODIVA yields a decrease in K of ∿0.01822 and an increase in R of ∿0.02490.

## D. Group Structure

With respect to the 50-group results, the effects of the 185-group and 240-group structures are determined from the following differences,

E(6,6) - E(6,5)    and    E(12,7) - E(12,5) .

For JEZEBEL, the 185-group structure lowers K by ∿0.00008 and lowers R by ∿0.00087 while the 240-group structure lowers K by ∿0.00035 and lowers R by ∿0.00410. For GODIVA, the 185-group structure lowers K by ∿0.00104 and lowers

R by $\sim$0.00169 while the 240-group structure lowers K by $\sim$0.00109 and lowers R by $\sim$0.00934.

## E. Number of Downscattering Terms

The computer code 1DX is often used to generate effective resonance-shielded cross sections. It is common practice to limit the data input by limiting the number of inelastic downscattering terms to less than the number of groups. The effect of such a data reduction was tested on JEZEBEL by comparing results from a run that included all downscatter groups with a run that limited the number of downscatter groups to 10,

$$E(10,14) - E(10,11) \quad .$$

Limiting the number of inelastic-downscatter terms to 10 decreases K by $\sim$0.00002 and decreases R by $\sim$0.00076.

## F. Elastic Scattering Matrix

Normally in 1DX, elastic scattering is treated with only one elastic removal term. The effect of providing a full elastic scattering matrix was tested on JEZEBEL,

$$E(10,15) - E(10,14) \quad .$$

Providing a full elastic scattering matrix does not affect K and decreases R by only $\sim$0.00001.

## G. Elastic Removal Iteration

The elastic removal cross section can by highly sensitive to the intragroup flux shape. An option in 1DX allows one to use an iterative procedure between flux shape and elastic removal cross section, otherwise the input elastic removal cross section is used. This option was tested,

$$E(i,13) - E(i,11) \quad \text{for } i = 1, \ldots, 6 \quad ,$$

and for JEZEBEL, iterating does not affect K and increases R by only $\sim$0.00009. For GODIVA, iterating decreases K by $\sim$0.00012 and increases R by $\sim$0.00002.

## H. Self-Shielding

The effect of using self-shielded cross sections vs using infinitely dilute cross sections is measured by the differences,

$$E(i,13) - E(i,12) \quad \text{for } i = 1, \ldots, 6 \quad .$$

Self-shielding for JEZEBEL increases K by $\sim$0.00010 and decreases R by $\sim$0.00017 while for GODIVA it increases K by $\sim$0.00013 and decreases R by $\sim$0.00031. Quadrature order has little effect on these differences.

## I. Angular Quadrature and Legendre Order

Several series of $S_i$ and $P_i$ calculations have been made to test the approach to $S_\infty P_\infty$. In general, the approach to $S_\infty$ or $P_\infty$ is relatively unaffected by group structure, fission source, cross-section library, angular quadrature, or Legendre order. The tables show that $S_{48}$ and $P_3$ calculations are well into the relatively unchanging part of the asymptotic approach to $S_\infty$ and $P_\infty$.

The tables allow one to convert practically any $S_i P_i$ calculation to an $S_{48}P_3$ result, which is also very close to an $S_\infty P_\infty$ result. However, the monotonic and smooth behavior of the $S_i$ results allows one to use plots or numerical extrapolations to reasonably estimate the $S_{48} - S_\infty$ difference. We have estimated this eigenvalue difference for JEZEBEL and GODIVA to be $\sim$0.00009.

## J. Example

Suppose one had made, for JEZEBEL, a transport-corrected shelf-shielded $S_{16}$ 26-group transport theory calculation based on a 42-group library with 10 inelastic downscatter terms, generated from ENDF/B-IV. If the uncorrected eigenvalue was 0.99734, it might be brought up to date in the following fashion.

| | |
|---|---|
| 0.99734 | uncorrected eigenvalue |
| + 0.00002 | 10 downscatter → full inelastic matrix [E(10,14) - E(10,11)] |
| - 0.00035 | 42-group → 240-group [E(12,7) - E(12,5)] |
| - 0.00337 | transport corrected → $P_3$ [E(10,4) - E(10,12)] |
| - 0.00088 | $S_{16} \rightarrow S_{48}$ [E(12,7) - E(10,7)] |
| - 0.00009 | $S_{48} \rightarrow S_\infty$ (see Sec. I above) |
| + 0.00870 | ENDF/B-IV → V [E(6,4) - E(12,4)] |
| 1.00137 | corrected eigenvalue |

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## APPENDIX A

## GROUP STRUCTURES AND FISSION SOURCES

The following tables show the group structure and fission sources for 50-group, 185-group and 240-group structures.

TABLE A-I

50-GP STRUCTURE AND FISSION SOURCE VECTORS (NEUTRONS/FISSION)

| | | | JEZEBEL | | | GODIVA | | |
|---|---|---|---|---|---|---|---|---|
| GP | ENERGY (EV) | LETH WIDTH | OLD CHI | LIB-IV CHI | PRE-V CHI | OLD CHI | LIB-IV CHI | PRE-V CHI |
| 1 | 2.00000E+07 | .69 | 2.66500E-03 | 2.58877E-03 | 1.51508E-03 | 1.98200E-03 | 1.84917E-03 | 1.29195E-03 |
| 2 | 1.00000E+07 | .50 | 3.23930E-02 | 3.10974E-02 | 2.77561E-02 | 2.75000E-02 | 2.64546E-02 | 2.45720E-02 |
| 3 | 6.06531E+06 | .50 | 1.21445E-01 | 1.20540E-01 | 1.22652E-01 | 1.12174E-01 | 1.10041E-01 | 1.13213E-01 |
| 4 | 3.67879E+06 | .50 | 2.10381E-01 | 2.09895E-01 | 2.20801E-01 | 2.05204E-01 | 2.03894E-01 | 2.12310E-01 |
| 5 | 2.23130E+06 | .50 | 2.22367E-01 | 2.22594E-01 | 2.29115E-01 | 2.24516E-01 | 2.24929E-01 | 2.28328E-01 |
| 6 | 1.35335E+06 | .50 | 1.72323E-01 | 1.72859E-01 | 1.71625E-01 | 1.77776E-01 | 1.79024E-01 | 1.76456E-01 |
| 7 | 8.20850E+05 | .50 | 1.10173E-01 | 1.10658E-01 | 1.06504E-01 | 1.15178E-01 | 1.16358E-01 | 1.12606E-01 |
| 8 | 4.97871E+05 | .25 | 3.60350E-02 | 3.62177E-02 | 3.41969E-02 | 3.79300E-02 | 3.85816E-02 | 3.68230E-02 |
| 9 | 3.87742E+05 | .25 | 2.65500E-02 | 2.66927E-02 | 2.50052E-02 | 2.80330E-02 | 2.85878E-02 | 2.71262E-02 |
| 10 | 3.01974E+05 | .25 | 1.92630E-02 | 1.93716E-02 | 1.80128E-02 | 2.03800E-02 | 2.06585E-02 | 1.96926E-02 |
| 11 | 2.35178E+05 | .25 | 1.38100E-02 | 1.39004E-02 | 1.28364E-02 | 1.46440E-02 | 1.48449E-02 | 1.41297E-02 |
| 12 | 1.83156E+05 | .25 | 9.80900E-03 | 9.86717E-03 | 9.07162E-03 | 1.04160E-02 | 1.05629E-02 | 1.01085E-02 |
| 13 | 1.42642E+05 | .25 | 6.91600E-03 | 6.95827E-03 | 6.38044E-03 | 7.35300E-03 | 7.45858E-03 | 7.12012E-03 |
| 14 | 1.11090E+05 | .25 | 4.84900E-03 | 4.87911E-03 | 4.46883E-03 | 5.16000E-03 | 5.23523E-03 | 5.01003E-03 |
| 15 | 8.65170E+04 | .25 | 3.38500E-03 | 3.40609E-03 | 3.11435E-03 | 3.60500E-03 | 3.65758E-03 | 3.48967E-03 |
| 16 | 6.73795E+04 | .25 | 2.35500E-03 | 2.36960E-03 | 2.15637E-03 | 2.50900E-03 | 2.54612E-03 | 2.40995E-03 |
| 17 | 5.24752E+04 | .25 | 1.63400E-03 | 1.64408E-03 | 1.48986E-03 | 1.74100E-03 | 1.76741E-03 | 1.66043E-03 |
| 18 | 4.08677E+04 | .25 | 1.13100E-03 | 1.13832E-03 | 1.02794E-03 | 1.20600E-03 | 1.22416E-03 | 1.14276E-03 |
| 19 | 3.18278E+04 | .25 | 7.82000E-04 | 7.86861E-04 | 7.08492E-04 | 8.34000E-04 | 8.46445E-04 | 7.85861E-04 |
| 20 | 2.47875E+04 | .25 | 5.40000E-04 | 5.43224E-04 | 4.87927E-04 | 5.76000E-04 | 5.84492E-04 | 5.40119E-04 |
| 21 | 1.93045E+04 | .25 | 3.72000E-04 | 3.74654E-04 | 3.35825E-04 | 3.97000E-04 | 4.03108E-04 | 3.71075E-04 |
| 22 | 1.50344E+04 | .25 | 2.57000E-04 | 2.58196E-04 | 2.31034E-04 | 2.74000E-04 | 2.77897E-04 | 2.54870E-04 |
| 23 | 1.17088E+04 | .25 | 1.77000E-04 | 1.77830E-04 | 1.58889E-04 | 1.89000E-04 | 1.91420E-04 | 1.75027E-04 |
| 24 | 9.11882E+03 | .25 | 1.22000E-04 | 1.22422E-04 | 1.09245E-04 | 1.30000E-04 | 1.31780E-04 | 1.20184E-04 |
| 25 | 7.10174E+03 | .25 | 8.40000E-05 | 8.42471E-05 | 7.50988E-05 | 8.90000E-05 | 9.06989E-05 | 8.25226E-05 |
| 26 | 5.53084E+03 | .25 | 5.80000E-05 | 5.79599E-05 | 5.16180E-05 | 6.10000E-05 | 6.24017E-05 | 5.66626E-05 |
| 27 | 4.30743E+03 | .25 | 4.00000E-05 | 3.98662E-05 | 3.54767E-05 | 4.20000E-05 | 4.29231E-05 | 3.89071E-05 |
| 28 | 3.35463E+03 | .25 | 2.70000E-05 | 2.74162E-05 | 2.43810E-05 | 2.90000E-05 | 2.95193E-05 | 2.67164E-05 |
| 29 | 2.61259E+03 | .25 | 1.90000E-05 | 1.88517E-05 | 1.67549E-05 | 2.00000E-05 | 2.02983E-05 | 1.83463E-05 |
| 30 | 2.03468E+03 | .25 | 1.30000E-05 | 1.29614E-05 | 1.15138E-05 | 1.40000E-05 | 1.39563E-05 | 1.25992E-05 |
| 31 | 1.58461E+03 | .25 | 9.00000E-06 | 8.91075E-06 | 7.91212E-06 | 9.00000E-06 | 9.59485E-06 | 8.65293E-06 |
| 32 | 1.23410E+03 | .25 | 6.00000E-06 | 6.12562E-06 | 5.43705E-06 | 6.00000E-06 | 6.59598E-06 | 5.94305E-06 |
| 33 | 9.61117E+02 | .25 | 4.00000E-06 | 4.21081E-06 | 3.73624E-06 | 4.00000E-06 | 4.53417E-06 | 4.08207E-06 |
| 34 | 7.48518E+02 | .25 | 3.00000E-06 | 2.89443E-06 | 2.56748E-06 | 3.00000E-06 | 3.11673E-06 | 2.80399E-06 |
| 35 | 5.82947E+02 | .25 | 2.00000E-06 | 1.98952E-06 | 1.76434E-06 | 2.00000E-06 | 2.14233E-06 | 1.92618E-06 |
| 36 | 4.53999E+02 | .25 | 1.00000E-06 | 1.36749E-06 | 1.21245E-06 | 1.00000E-06 | 1.47253E-06 | 1.32323E-06 |
| 37 | 3.53575E+02 | .25 | 1.00000E-06 | 9.39921E-07 | 8.33193E-07 | 1.00000E-06 | 1.01212E-06 | 9.09069E-07 |
| 38 | 2.75365E+02 | .50 | 1.00000E-06 | 1.09006E-06 | 9.66057E-07 | 1.00000E-06 | 1.17379E-06 | 1.05367E-06 |
| 39 | 1.67017E+02 | .50 | 0. | 5.14938E-07 | 4.56240E-07 | 1.00000E-06 | 5.54405E-07 | 4.97419E-07 |
| 40 | 1.01301E+02 | .50 | 0. | 2.43248E-07 | 2.15475E-07 | 0. | 2.61935E-07 | 2.34850E-07 |
| 41 | 6.14421E+01 | .50 | 0. | 1.14905E-07 | 1.01768E-07 | 0. | 1.23733E-07 | 1.10891E-07 |
| 42 | 3.72665E+01 | .50 | 0. | 5.42781E-08 | 4.80616E-08 | 0. | 5.84481E-08 | 5.23632E-08 |
| 43 | 2.26033E+01 | .50 | 0. | 2.56394E-08 | 2.26852E-08 | 0. | 2.76092E-08 | 2.47263E-08 |
| 44 | 1.37096E+01 | .50 | 0. | 1.21112E-08 | 1.06921E-08 | 0. | 1.30417E-08 | 1.16773E-08 |
| 45 | 8.31529E+00 | .50 | 0. | 5.72096E-09 | 5.04721E-09 | 0. | 6.16048E-09 | 5.51316E-09 |
| 46 | 5.04348E+00 | .50 | 0. | 2.70240E-09 | 2.38155E-09 | 0. | 2.91001E-09 | 2.59023E-09 |
| 47 | 3.05902E+00 | .50 | 0. | 1.27652E-09 | 1.10918E-09 | 0. | 1.37459E-09 | 1.21053E-09 |
| 48 | 1.85539E+00 | .50 | 0. | 6.02987E-10 | 5.14721E-10 | 0. | 6.49313E-10 | 5.67140E-10 |
| 49 | 1.12535E+00 | .50 | 0. | 2.84832E-10 | 2.40227E-10 | 0. | 3.06714E-10 | 2.58867E-10 |
| 50 | 6.82560E-01 | 11.13 | 0. | 2.54978E-10 | 2.11928E-10 | 0. | 2.74567E-10 | 2.19997E-10 |
| | 1.00000E-05 | | | | | | | |

## TABLE A-II

185-GP STRUCTURE AND FISSION SOURCE VECTORS

| GP | ENERGY (EV) | LETH WIDTH | JEZEBEL PRE-V CHI | GODIVA PRE-V CHI |
|---|---|---|---|---|
| 1 | 2.00000E+07 | .068 | 8.27144E-07 | 6.93115E-07 |
| 2 | 1.86825E+07 | .125 | 6.92462E-06 | 5.77852E-06 |
| 3 | 1.64872E+07 | .054 | 7.72111E-06 | 6.45412E-06 |
| 4 | 1.56831E+07 | .050 | 1.38671E-05 | 1.16144E-05 |
| 5 | 1.49183E+07 | .025 | 1.84321E-05 | 8.75252E-06 |
| 6 | 1.45499E+07 | .025 | 1.36385E-05 | 1.14535E-05 |
| 7 | 1.41907E+07 | .025 | 1.76874E-05 | 1.48723E-05 |
| 8 | 1.38403E+07 | .025 | 2.27588E-05 | 1.91619E-05 |
| 9 | 1.34986E+07 | .025 | 2.90607E-05 | 2.45019E-05 |
| 10 | 1.31653E+07 | .025 | 3.68312E-05 | 3.10986E-05 |
| 11 | 1.28403E+07 | .125 | 3.72941E-04 | 3.16589E-04 |
| 12 | 1.13315E+07 | .125 | 9.82431E-04 | 8.41490E-04 |
| 13 | 1.00000E+07 | .125 | 2.23729E-03 | 1.93522E-03 |
| 14 | 8.82497E+06 | .125 | 4.48193E-03 | 3.91750E-03 |
| 15 | 7.78801E+06 | .125 | 8.02316E-03 | 7.09093E-03 |
| 16 | 6.87289E+06 | .125 | 1.30137E-02 | 1.16317E-02 |
| 17 | 6.06531E+06 | .125 | 1.93621E-02 | 1.75056E-02 |
| 18 | 5.35261E+06 | .125 | 2.67127E-02 | 2.44311E-02 |
| 19 | 4.72367E+06 | .125 | 3.45029E-02 | 3.19185E-02 |
| 20 | 4.16862E+06 | .125 | 4.20745E-02 | 3.93628E-02 |
| 21 | 3.67879E+06 | .125 | 4.87904E-02 | 4.61577E-02 |
| 22 | 3.24653E+06 | .125 | 5.41825E-02 | 5.17967E-02 |
| 23 | 2.86505E+06 | .125 | 5.79181E-02 | 5.59368E-02 |
| 24 | 2.52840E+06 | .125 | 5.99009E-02 | 5.84204E-02 |
| 25 | 2.23130E+06 | .125 | 6.01909E-02 | 5.92604E-02 |
| 26 | 1.96912E+06 | .125 | 5.90118E-02 | 5.86036E-02 |
| 27 | 1.73774E+06 | .125 | 5.66093E-02 | 5.66840E-02 |
| 28 | 1.53355E+06 | .125 | 5.32942E-02 | 5.37783E-02 |
| 29 | 1.35335E+06 | .125 | 4.93754E-02 | 5.02061E-02 |
| 30 | 1.19433E+06 | .125 | 4.51317E-02 | 4.62707E-02 |
| 31 | 1.05399E+06 | .125 | 4.07204E-02 | 4.20786E-02 |
| 32 | 9.30145E+05 | .125 | 3.63886E-02 | 3.78979E-02 |
| 33 | 8.20850E+05 | .125 | 3.22153E-02 | 3.38099E-02 |
| 34 | 7.24398E+05 | .125 | 2.82624E-02 | 2.97813E-02 |
| 35 | 6.39279E+05 | .125 | 2.46539E-02 | 2.61701E-02 |
| 36 | 5.64161E+05 | .125 | 2.13720E-02 | 2.28420E-02 |
| 37 | 4.97871E+05 | .125 | 1.84009E-02 | 1.97755E-02 |
| 38 | 4.39369E+05 | .125 | 1.57869E-02 | 1.70466E-02 |
| 39 | 3.87742E+05 | .125 | 1.35097E-02 | 1.46197E-02 |
| 40 | 3.42181E+05 | .125 | 1.14955E-02 | 1.25057E-02 |
| 41 | 3.01974E+05 | .125 | 9.75726E-03 | 1.06560E-02 |
| 42 | 2.66491E+05 | .125 | 8.25558E-03 | 9.03602E-03 |
| 43 | 2.35178E+05 | .125 | 6.96686E-03 | 7.65399E-03 |
| 44 | 2.07543E+05 | .125 | 5.86955E-03 | 6.47535E-03 |
| 45 | 1.83156E+05 | .125 | 4.92834E-03 | 5.49164E-03 |
| 46 | 1.61635E+05 | .125 | 4.14528E-03 | 4.61660E-03 |
| 47 | 1.42642E+05 | .125 | 3.47329E-03 | 3.86840E-03 |
| 48 | 1.25881E+05 | .125 | 2.90675E-03 | 3.25152E-03 |
| 49 | 1.11090E+05 | .125 | 2.43270E-03 | 2.72719E-03 |
| 50 | 9.80366E+04 | .125 | 2.03612E-03 | 2.28271E-03 |
| 51 | 8.65170E+04 | .125 | 1.69914E-03 | 1.90446E-03 |
| 52 | 7.63509E+04 | .125 | 1.41521E-03 | 1.58511E-03 |
| 53 | 6.73795E+04 | .125 | 1.17736E-03 | 1.31665E-03 |
| 54 | 5.94622E+04 | .125 | 9.79010E-04 | 1.09323E-03 |
| 55 | 5.24752E+04 | .125 | 8.13740E-04 | 9.07414E-04 |
| 56 | 4.63092E+04 | .125 | 6.76122E-04 | 7.52962E-04 |
| 57 | 4.08677E+04 | .125 | 5.61599E-04 | 6.24643E-04 |
| 58 | 3.60656E+04 | .125 | 4.66344E-04 | 5.18083E-04 |
| 59 | 3.18278E+04 | .125 | 3.87152E-04 | 4.29623E-04 |
| 60 | 2.80879E+04 | .125 | 3.21340E-04 | 3.56213E-04 |
| 61 | 2.47875E+04 | .125 | 2.66667E-04 | 2.95310E-04 |
| 62 | 2.18749E+04 | .125 | 2.21260E-04 | 2.44793E-04 |

| GP | ENERGY (EV) | LETH WIDTH | JEZEBEL PRE-V CHI | GODIVA PRE-V CHI |
|---|---|---|---|---|
| 63 | 1.93045E+04 | .125 | 1.83560E-04 | 2.02899E-04 |
| 64 | 1.70362E+04 | .125 | 1.52265E-04 | 1.68164E-04 |
| 65 | 1.50344E+04 | .125 | 1.26203E-04 | 1.39367E-04 |
| 66 | 1.32678E+04 | .125 | 1.04741E-04 | 1.15496E-04 |
| 67 | 1.17088E+04 | .125 | 8.68607E-05 | 9.57097E-05 |
| 68 | 1.03330E+04 | .125 | 7.20279E-05 | 7.93113E-05 |
| 69 | 9.11882E+03 | .125 | 5.97246E-05 | 6.57213E-05 |
| 70 | 8.04733E+03 | .125 | 4.95205E-05 | 5.44592E-05 |
| 71 | 7.10174E+03 | .125 | 4.10582E-05 | 4.51267E-05 |
| 72 | 6.26727E+03 | .125 | 3.40407E-05 | 3.73934E-05 |
| 73 | 5.53084E+03 | .125 | 2.82218E-05 | 3.09853E-05 |
| 74 | 4.88095E+03 | .125 | 2.33978E-05 | 2.56755E-05 |
| 75 | 4.30743E+03 | .125 | 1.93967E-05 | 2.12758E-05 |
| 76 | 3.80129E+03 | .125 | 1.60800E-05 | 1.76301E-05 |
| 77 | 3.35463E+03 | .125 | 1.33303E-05 | 1.46093E-05 |
| 78 | 2.96045E+03 | .125 | 1.10507E-05 | 1.21063E-05 |
| 79 | 2.61259E+03 | .125 | 9.16079E-06 | 1.00322E-05 |
| 80 | 2.30560E+03 | .125 | 7.59407E-06 | 8.31396E-06 |
| 81 | 2.03468E+03 | .125 | 6.29526E-06 | 6.88945E-06 |
| 82 | 1.79560E+03 | .125 | 5.21857E-06 | 5.70937E-06 |
| 83 | 1.58461E+03 | .125 | 4.32601E-06 | 4.73149E-06 |
| 84 | 1.39842E+03 | .125 | 3.58611E-06 | 3.92116E-06 |
| 85 | 1.23410E+03 | .125 | 2.97275E-06 | 3.24966E-06 |
| 86 | 1.08909E+03 | .125 | 2.46430E-06 | 2.69320E-06 |
| 87 | 9.61117E+02 | .125 | 2.04282E-06 | 2.23205E-06 |
| 88 | 8.48182E+02 | .125 | 1.69342E-06 | 1.84989E-06 |
| 89 | 7.48518E+02 | .125 | 1.40379E-06 | 1.53319E-06 |
| 90 | 6.60565E+02 | .125 | 1.16369E-06 | 1.27072E-06 |
| 91 | 5.82947E+02 | .125 | 9.64665E-07 | 1.05320E-06 |
| 92 | 5.14449E+02 | .125 | 7.99678E-07 | 8.72920E-07 |
| 93 | 4.53999E+02 | .125 | 6.62911E-07 | 7.23511E-07 |
| 94 | 4.00653E+02 | .125 | 5.49535E-07 | 5.99682E-07 |
| 95 | 3.53575E+02 | .125 | 4.55551E-07 | 4.97051E-07 |
| 96 | 3.12029E+02 | .125 | 3.77641E-07 | 4.11990E-07 |
| 97 | 2.75365E+02 | .125 | 3.13057E-07 | 3.41489E-07 |
| 98 | 2.43008E+02 | .125 | 2.59518E-07 | 2.83054E-07 |
| 99 | 2.14454E+02 | .125 | 2.15137E-07 | 2.34621E-07 |
| 100 | 1.89255E+02 | .125 | 1.78345E-07 | 1.94477E-07 |
| 101 | 1.67017E+02 | .125 | 1.47846E-07 | 1.61203E-07 |
| 102 | 1.47392E+02 | .125 | 1.22563E-07 | 1.33624E-07 |
| 103 | 1.30073E+02 | .125 | 1.01603E-07 | 1.10763E-07 |
| 104 | 1.14789E+02 | .125 | 8.42282E-08 | 9.18140E-08 |
| 105 | 1.01301E+02 | .125 | 6.98245E-08 | 7.61069E-08 |
| 106 | 8.93978E+01 | .125 | 5.78803E-08 | 6.30878E-08 |
| 107 | 7.88933E+01 | .125 | 4.79857E-08 | 5.22961E-08 |
| 108 | 6.96231E+01 | .125 | 3.97801E-08 | 4.33505E-08 |
| 109 | 6.14421E+01 | .125 | 3.29776E-08 | 3.59341E-08 |
| 110 | 5.42225E+01 | .125 | 2.73386E-08 | 2.97874E-08 |
| 111 | 4.78512E+01 | .125 | 2.26639E-08 | 2.46915E-08 |
| 112 | 4.22285E+01 | .125 | 1.87878E-08 | 2.04679E-08 |
| 113 | 3.72665E+01 | .125 | 1.55749E-08 | 1.69669E-08 |
| 114 | 3.28876E+01 | .125 | 1.29117E-08 | 1.40649E-08 |
| 115 | 2.90232E+01 | .125 | 1.07038E-08 | 1.16586E-08 |
| 116 | 2.56129E+01 | .125 | 8.87112E-09 | 9.66449E-09 |
| 117 | 2.26033E+01 | .125 | 7.35260E-09 | 8.01159E-09 |
| 118 | 1.99473E+01 | .125 | 6.09489E-09 | 6.64087E-09 |
| 119 | 1.76035E+01 | .125 | 5.05201E-09 | 5.50511E-09 |
| 120 | 1.55350E+01 | .125 | 4.18567E-09 | 4.56368E-09 |
| 121 | 1.37096E+01 | .125 | 3.46602E-09 | 3.78314E-09 |
| 122 | 1.20987E+01 | .125 | 2.87218E-09 | 3.13620E-09 |
| 123 | 1.06770E+01 | .125 | 2.38057E-09 | 2.59977E-09 |
| 124 | 9.42246E+00 | .125 | 1.97335E-09 | 2.15521E-09 |
| 125 | 8.31529E+00 | .125 | 1.63580E-09 | 1.78641E-09 |
| 126 | 7.33822E+00 | .125 | 1.35598E-09 | 1.48036E-09 |
| 127 | 6.47595E+00 | .125 | 1.12309E-09 | 1.22713E-09 |
| 128 | 5.71501E+00 | .125 | 9.31437E-10 | 1.01730E-09 |
| 129 | 5.04348E+00 | .125 | 7.72032E-10 | 8.42532E-10 |

| GP | ENERGY (EV) | LETH WIDTH | JEZEBEL PRE-V CHI | GODIVA PRE-V CHI |
|---|---|---|---|---|
| 130 | 4.45085E+00 | .125 | 6.40066E-10 | 6.95004E-10 |
| 131 | 3.92786E+00 | .125 | 5.30143E-10 | 5.74595E-10 |
| 132 | 3.46633E+00 | .125 | 4.39307E-10 | 4.76247E-10 |
| 133 | 3.05902E+00 | .125 | 3.64010E-10 | 3.94690E-10 |
| 134 | 2.69958E+00 | .125 | 3.01565E-10 | 3.26113E-10 |
| 135 | 2.38237E+00 | .028 | 5.88049E-11 | 6.41909E-11 |
| 136 | 2.31603E+00 | .028 | 5.67057E-11 | 6.18713E-11 |
| 137 | 2.25113E+00 | .036 | 6.79967E-11 | 7.42709E-11 |
| 138 | 2.17213E+00 | .037 | 6.59701E-11 | 7.20199E-11 |
| 139 | 2.09408E+00 | .037 | 6.32006E-11 | 6.89529E-11 |
| 140 | 2.01791E+00 | .042 | 6.60715E-11 | 7.30996E-11 |
| 141 | 1.93562E+00 | .042 | 6.39320E-11 | 6.97279E-11 |
| 142 | 1.85539E+00 | .072 | 1.00359E-10 | 1.09898E-10 |
| 143 | 1.72608E+00 | .079 | 9.79917E-11 | 1.07276E-10 |
| 144 | 1.59493E+00 | .090 | 9.84956E-11 | 1.07830E-10 |
| 145 | 1.45742E+00 | .009 | 8.32805E-12 | 8.41368E-12 |
| 146 | 1.44498E+00 | .100 | 9.32706E-11 | 1.02067E-10 |
| 147 | 1.30785E+00 | .114 | 9.11734E-11 | 9.98230E-11 |
| 148 | 1.16638E+00 | .036 | 2.51025E-11 | 2.70606E-11 |
| 149 | 1.12535E+00 | .024 | 1.59401E-11 | 1.67696E-11 |
| 150 | 1.09868E+00 | .024 | 1.56406E-11 | 1.64242E-11 |
| 151 | 1.07217E+00 | .009 | 5.50805E-12 | 5.35607E-12 |
| 152 | 1.06231E+00 | .009 | 5.55468E-12 | 5.27555E-12 |
| 153 | 1.05250E+00 | .009 | 5.40219E-12 | 5.22605E-12 |
| 154 | 1.04273E+00 | .028 | 1.67231E-11 | 1.77503E-11 |
| 155 | 1.01370E+00 | .030 | 1.67348E-11 | 1.77791E-11 |
| 156 | 9.84222E-01 | .035 | 1.07616E-11 | 1.99630E-11 |
| 157 | 9.50653E-01 | .001 | 4.09205E-11 | 4.44525E-11 |
| 158 | 8.76425E-01 | .114 | 4.96375E-11 | 5.40474E-11 |
| 159 | 7.82079E-01 | .136 | 4.92130E-11 | 5.35602E-11 |
| 160 | 6.82560E-01 | .008 | 2.66332E-11 | 2.87460E-11 |
| 161 | 6.25060E-01 | .162 | 4.10057E-11 | 4.45839E-11 |
| 162 | 5.31579E-01 | .055 | 1.14262E-11 | 1.17838E-11 |
| 163 | 5.03235E-01 | .188 | 3.36414E-11 | 3.65345E-11 |
| 164 | 4.17016E-01 | .007 | 1.01655E-12 | 3.63007E-13 |
| 165 | 4.13994E-01 | .146 | 1.90945E-11 | 2.12498E-11 |
| 166 | 3.57665E-01 | .109 | 1.21177E-11 | 1.25164E-11 |
| 167 | 3.20628E-01 | .063 | 5.99757E-12 | 5.75631E-12 |
| 168 | 3.01120E-01 | .035 | 3.00540E-12 | 2.64096E-12 |
| 169 | 2.90737E-01 | .072 | 5.90623E-12 | 5.63857E-12 |
| 170 | 2.73510E-01 | .075 | 5.47669E-12 | 5.18316E-12 |
| 171 | 2.51028E-01 | .098 | 6.31876E-12 | 6.20001E-12 |
| 172 | 2.27690E-01 | .211 | 1.09940E-11 | 1.12952E-11 |
| 173 | 1.84429E-01 | .236 | 8.74808E-12 | 8.81710E-12 |
| 174 | 1.45721E-01 | .267 | 6.78730E-12 | 6.69577E-12 |
| 175 | 1.11568E-01 | .308 | 5.05761E-12 | 4.70085E-12 |
| 176 | 8.19683E-02 | .365 | 3.57280E-12 | 3.17904E-12 |
| 177 | 5.69224E-02 | .206 | 1.65752E-12 | 1.06475E-12 |
| 178 | 4.27551E-02 | .334 | 1.21913E-12 | 5.76974E-13 |
| 179 | 3.06116E-02 | .401 | 8.15464E-13 | 3.02418E-13 |
| 180 | 2.04921E-02 | .503 | 4.05997E-13 | 6.29176E-14 |
| 181 | 1.23964E-02 | .673 | 1.44379E-13 | 7.26768E-15 |
| 182 | 6.32472E-03 | 1.022 | 4.57837E-14 | 1.41364E-16 |
| 183 | 2.27690E-03 | 1.097 | 3.94812E-15 | 2.97377E-19 |
| 184 | 7.60219E-04 | 1.100 | 2.14524E-15 | 3.31705E-20 |
| 185 | 2.52908E-04 | 3.231 | 2.32782E-15 | 4.12547E-21 |
|  | 1.00000E-05 |  |  |  |

TABLE A-III

240-GP STRUCTURE AND FISSION SOURCE VECTORS

| GP | ENERGY (EV) | LETH WIDTH | JEZEBEL LIB-IV CHI | GODIVA LIB-IV CHI |
|---|---|---|---|---|
| 1 | 1.99705E+07 | .017 | 7.48282E-07 | 3.97918E-07 |
| 2 | 1.96403E+07 | .025 | 1.45747E-06 | 7.86393E-07 |
| 3 | 1.91554E+07 | .025 | 1.97384E-06 | 1.08290E-06 |
| 4 | 1.86825E+07 | .025 | 2.65078E-06 | 1.47823E-06 |
| 5 | 1.82212E+07 | .025 | 3.53080E-06 | 2.00063E-06 |
| 6 | 1.77713E+07 | .025 | 4.66553E-06 | 2.68510E-06 |
| 7 | 1.73325E+07 | .025 | 6.11704E-06 | 3.57443E-06 |
| 8 | 1.69046E+07 | .025 | 7.95936E-06 | 4.72058E-06 |
| 9 | 1.64872E+07 | .025 | 1.02800E-05 | 6.18600E-06 |
| 10 | 1.60801E+07 | .025 | 1.31815E-05 | 8.04512E-06 |
| 11 | 1.56831E+07 | .025 | 1.67831E-05 | 1.03899E-05 |
| 12 | 1.52959E+07 | .025 | 2.12221E-05 | 1.33114E-05 |
| 13 | 1.49183E+07 | .025 | 2.66556E-05 | 1.69414E-05 |
| 14 | 1.45499E+07 | .025 | 3.32618E-05 | 2.14137E-05 |
| 15 | 1.41907E+07 | .025 | 4.12409E-05 | 2.68861E-05 |
| 16 | 1.38403E+07 | .025 | 5.08165E-05 | 3.35373E-05 |
| 17 | 1.34986E+07 | .025 | 6.22362E-05 | 4.15682E-05 |
| 18 | 1.31653E+07 | .025 | 7.57717E-05 | 5.12032E-05 |
| 19 | 1.28403E+07 | .025 | 9.17193E-05 | 6.26902E-05 |
| 20 | 1.25232E+07 | .025 | 1.10399E-04 | 7.63018E-05 |
| 21 | 1.22140E+07 | .025 | 1.32155E-04 | 9.23348E-05 |
| 22 | 1.19125E+07 | .025 | 1.57351E-04 | 1.11110E-04 |
| 23 | 1.16183E+07 | .025 | 1.86374E-04 | 1.32971E-04 |
| 24 | 1.13315E+07 | .025 | 2.19627E-04 | 1.58285E-04 |
| 25 | 1.10517E+07 | .025 | 2.57528E-04 | 1.87436E-04 |
| 26 | 1.07788E+07 | .025 | 3.00508E-04 | 2.20828E-04 |
| 27 | 1.05127E+07 | .025 | 3.49004E-04 | 2.58881E-04 |
| 28 | 1.02532E+07 | .025 | 4.03460E-04 | 3.02023E-04 |
| 29 | 1.00000E+07 | .025 | 4.64318E-04 | 3.50695E-04 |
| 30 | 9.75310E+06 | .025 | 5.32012E-04 | 4.05338E-04 |
| 31 | 9.51229E+06 | .025 | 6.06971E-04 | 4.66393E-04 |
| 32 | 9.27744E+06 | .025 | 6.89604E-04 | 5.34297E-04 |
| 33 | 9.04837E+06 | .025 | 7.80300E-04 | 6.09475E-04 |
| 34 | 8.82497E+06 | .025 | 8.79422E-04 | 6.92337E-04 |
| 35 | 8.60708E+06 | .025 | 9.87301E-04 | 7.83271E-04 |
| 36 | 8.39457E+06 | .025 | 1.10423E-03 | 8.82639E-04 |
| 37 | 8.18731E+06 | .025 | 1.23046E-03 | 9.90770E-04 |
| 38 | 7.98516E+06 | .025 | 1.36620E-03 | 1.10796E-03 |
| 39 | 7.78801E+06 | .025 | 1.51160E-03 | 1.23445E-03 |
| 40 | 7.59572E+06 | .025 | 1.66677E-03 | 1.37045E-03 |
| 41 | 7.40818E+06 | .025 | 1.83174E-03 | 1.51612E-03 |
| 42 | 7.22527E+06 | .025 | 2.00649E-03 | 1.67155E-03 |
| 43 | 7.04688E+06 | .025 | 2.19095E-03 | 1.83678E-03 |
| 44 | 6.87289E+06 | .025 | 2.38490E-03 | 2.01179E-03 |
| 45 | 6.70320E+06 | .008 | 8.39392E-04 | 7.10882E-04 |
| 46 | 6.64760E+06 | .008 | 8.63363E-04 | 7.32637E-04 |
| 47 | 6.59238E+06 | .008 | 8.85600E-04 | 7.52990E-04 |
| 48 | 6.53770E+06 | .025 | 2.80082E-03 | 2.39078E-03 |
| 49 | 6.37628E+06 | .025 | 3.02202E-03 | 2.59439E-03 |
| 50 | 6.21885E+06 | .025 | 3.25158E-03 | 2.80708E-03 |
| 51 | 6.06531E+06 | .025 | 3.48902E-03 | 3.02850E-03 |
| 52 | 5.91555E+06 | .025 | 3.73384E-03 | 3.25825E-03 |
| 53 | 5.76950E+06 | .050 | 8.22873E-03 | 7.23674E-03 |
| 54 | 5.48812E+06 | .050 | 9.28134E-03 | 8.24321E-03 |
| 55 | 5.22046E+06 | .050 | 1.03694E-02 | 9.29626E-03 |
| 56 | 4.96585E+06 | .025 | 5.60046E-03 | 5.05452E-03 |
| 57 | 4.84325E+06 | .025 | 5.80014E-03 | 5.33007E-03 |
| 58 | 4.72367E+06 | .025 | 6.16065E-03 | 5.60810E-03 |
| 59 | 4.60704E+06 | .025 | 6.44116E-03 | 5.88777E-03 |
| 60 | 4.49329E+06 | .050 | 1.37196E-02 | 1.26170E-02 |
| 61 | 4.27415E+06 | .050 | 1.48206E-02 | 1.37345E-02 |
| 62 | 4.06570E+06 | .050 | 1.58916E-02 | 1.48350E-02 |

| GP | ENERGY (EV) | LETH WIDTH | JEZEBEL LIB-IV CHI | GODIVA LIB-IV CHI |
|---|---|---|---|---|
| 63 | 3.86741E+06 | .050 | 1.60201E-02 | 1.59054E-02 |
| 64 | 3.67879E+06 | .050 | 1.70947E-02 | 1.69312E-02 |
| 65 | 3.49938E+06 | .050 | 1.80051E-02 | 1.79069E-02 |
| 66 | 3.32871E+06 | .025 | 9.72128E-03 | 9.29803E-03 |
| 67 | 3.24653E+06 | .025 | 9.92071E-03 | 9.51736E-03 |
| 68 | 3.16637E+06 | .025 | 1.01090E-02 | 9.72643E-03 |
| 69 | 3.08819E+06 | .025 | 1.02882E-02 | 9.92558E-03 |
| 70 | 3.01194E+06 | .050 | 2.10669E-02 | 2.04068E-02 |
| 71 | 2.86505E+06 | .050 | 2.16444E-02 | 2.10745E-02 |
| 72 | 2.72532E+06 | .050 | 2.21273E-02 | 2.16506E-02 |
| 73 | 2.59240E+06 | .050 | 2.25142E-02 | 2.21322E-02 |
| 74 | 2.46597E+06 | .017 | 7.58924E-03 | 7.48202E-03 |
| 75 | 2.42513E+06 | .017 | 7.57241E-03 | 7.47709E-03 |
| 76 | 2.38521E+06 | .008 | 3.84158E-03 | 3.79731E-03 |
| 77 | 2.36525E+06 | .008 | 3.80171E-03 | 3.76057E-03 |
| 78 | 2.34570E+06 | .017 | 7.66511E-03 | 7.59017E-03 |
| 79 | 2.30686E+06 | .017 | 7.63740E-03 | 7.57319E-03 |
| 80 | 2.26880E+06 | .017 | 7.69826E-03 | 7.64393E-03 |
| 81 | 2.23130E+06 | .050 | 2.31040E-02 | 2.30019E-02 |
| 82 | 2.12248E+06 | .050 | 2.31179E-02 | 2.31039E-02 |
| 83 | 2.01897E+06 | .025 | 1.15374E-02 | 1.15622E-02 |
| 84 | 1.96912E+06 | .025 | 1.15093E-02 | 1.15545E-02 |
| 85 | 1.92050E+06 | .025 | 1.14714E-02 | 1.15364E-02 |
| 86 | 1.87308E+06 | .025 | 1.14240E-02 | 1.15081E-02 |
| 87 | 1.82684E+06 | .050 | 2.26693E-02 | 2.28921E-02 |
| 88 | 1.73774E+06 | .050 | 2.23743E-02 | 2.26650E-02 |
| 89 | 1.65299E+06 | .025 | 1.10567E-02 | 1.12256E-02 |
| 90 | 1.61218E+06 | .025 | 1.09599E-02 | 1.11436E-02 |
| 91 | 1.57237E+06 | .025 | 1.08563E-02 | 1.10539E-02 |
| 92 | 1.53355E+06 | .025 | 1.07462E-02 | 1.09569E-02 |
| 93 | 1.49569E+06 | .050 | 2.11384E-02 | 2.15960E-02 |
| 94 | 1.42274E+06 | .050 | 2.06306E-02 | 2.11313E-02 |
| 95 | 1.35335E+06 | .050 | 2.00853E-02 | 2.06230E-02 |
| 96 | 1.28735E+06 | .050 | 1.95085E-02 | 2.00773E-02 |
| 97 | 1.22456E+06 | .025 | 9.52969E-03 | 9.82397E-03 |
| 98 | 1.19433E+06 | .025 | 9.37626E-03 | 9.67621E-03 |
| 99 | 1.16484E+06 | .050 | 1.82831E-02 | 1.88974E-02 |
| 100 | 1.10803E+06 | .050 | 1.76450E-02 | 1.82743E-02 |
| 101 | 1.05399E+06 | .050 | 1.69964E-02 | 1.76360E-02 |
| 102 | 1.00259E+06 | .025 | 8.25290E-03 | 8.57525E-03 |
| 103 | 9.77834E+05 | .017 | 5.42162E-03 | 5.63744E-03 |
| 104 | 9.61640E+05 | .008 | 2.66727E-03 | 2.77470E-03 |
| 105 | 9.53692E+05 | .050 | 1.56849E-02 | 1.63327E-02 |
| 106 | 9.07180E+05 | .050 | 1.50295E-02 | 1.56759E-02 |
| 107 | 8.62936E+05 | .050 | 1.43789E-02 | 1.50206E-02 |
| 108 | 8.20850E+05 | .050 | 1.37358E-02 | 1.43701E-02 |
| 109 | 7.80817E+05 | .050 | 1.31028E-02 | 1.37272E-02 |
| 110 | 7.42736E+05 | .050 | 1.24820E-02 | 1.30943E-02 |
| 111 | 7.06512E+05 | .050 | 1.18753E-02 | 1.24737E-02 |
| 112 | 6.72055E+05 | .050 | 1.12842E-02 | 1.18672E-02 |
| 113 | 6.39279E+05 | .050 | 1.07101E-02 | 1.12764E-02 |
| 114 | 6.08101E+05 | .050 | 1.01538E-02 | 1.07025E-02 |
| 115 | 5.78443E+05 | .050 | 9.61628E-03 | 1.01465E-02 |
| 116 | 5.50232E+05 | .025 | 4.61259E-03 | 4.87057E-03 |
| 117 | 5.36647E+05 | .025 | 4.48548E-03 | 4.73865E-03 |
| 118 | 5.23397E+05 | .025 | 4.36085E-03 | 4.60916E-03 |
| 119 | 5.10474E+05 | .025 | 4.23871E-03 | 4.48212E-03 |
| 120 | 4.97871E+05 | .050 | 8.12097E-03 | 8.59305E-03 |
| 121 | 4.73589E+05 | .050 | 7.66239E-03 | 8.11474E-03 |
| 122 | 4.50492E+05 | .050 | 7.22376E-03 | 7.65643E-03 |
| 123 | 4.28521E+05 | .050 | 6.80408E-03 | 7.21806E-03 |
| 124 | 4.07622E+05 | .050 | 6.40557E-03 | 6.79948E-03 |
| 125 | 3.87742E+05 | .050 | 6.02539E-03 | 6.40040E-03 |
| 126 | 3.68837E+05 | .050 | 5.66307E-03 | 6.02048E-03 |
| 127 | 3.50844E+05 | .050 | 5.32081E-03 | 5.65931E-03 |
| 128 | 3.33733E+05 | .050 | 4.99540E-03 | 5.31639E-03 |
| 129 | 3.17456E+05 | .025 | 2.38106E-03 | 2.53517E-03 |

| GP | ENERGY (EV) | LETH WIDTH | JEZEBEL LIB-IV CHI | GODIVA LIB-IV CHI |
|---|---|---|---|---|
| 130 | 3.09618E+05 | .025 | 2.30611E-03 | 2.45605E-03 |
| 131 | 3.01974E+05 | .025 | 2.23321E-03 | 2.37905E-03 |
| 132 | 2.94518E+05 | .025 | 2.16232E-03 | 2.30415E-03 |
| 133 | 2.87246E+05 | .025 | 2.09342E-03 | 2.23131E-03 |
| 134 | 2.80154E+05 | .025 | 2.02646E-03 | 2.16040E-03 |
| 135 | 2.73237E+05 | .050 | 3.85958E-03 | 4.11634E-03 |
| 136 | 2.59911E+05 | .050 | 3.61402E-03 | 3.85625E-03 |
| 137 | 2.47235E+05 | .050 | 3.38255E-03 | 3.61088E-03 |
| 138 | 2.35178E+05 | .050 | 3.16454E-03 | 3.37959E-03 |
| 139 | 2.23708E+05 | .050 | 2.95938E-03 | 3.16176E-03 |
| 140 | 2.12797E+05 | .050 | 2.76644E-03 | 2.95676E-03 |
| 141 | 2.02419E+05 | .050 | 2.58513E-03 | 2.76348E-03 |
| 142 | 1.92547E+05 | .050 | 2.41485E-03 | 2.58282E-03 |
| 143 | 1.83156E+05 | .050 | 2.25503E-03 | 2.41268E-03 |
| 144 | 1.74224E+05 | .025 | 1.07070E-03 | 1.14583E-03 |
| 145 | 1.69922E+05 | .025 | 1.03442E-03 | 1.10717E-03 |
| 146 | 1.65727E+05 | .025 | 9.99288E-04 | 1.06973E-03 |
| 147 | 1.61635E+05 | .025 | 9.65284E-04 | 1.03348E-03 |
| 148 | 1.57644E+05 | .050 | 1.83289E-03 | 1.96279E-03 |
| 149 | 1.49956E+05 | .050 | 1.70956E-03 | 1.83122E-03 |
| 150 | 1.42642E+05 | .050 | 1.59411E-03 | 1.70799E-03 |
| 151 | 1.35686E+05 | .050 | 1.48610E-03 | 1.59265E-03 |
| 152 | 1.29068E+05 | .050 | 1.38507E-03 | 1.48473E-03 |
| 153 | 1.22773E+05 | .050 | 1.29062E-03 | 1.38379E-03 |
| 154 | 1.16786E+05 | .050 | 1.20236E-03 | 1.28943E-03 |
| 155 | 1.11090E+05 | .125 | 2.65700E-03 | 2.85057E-03 |
| 156 | 9.80366E+04 | .125 | 2.22211E-03 | 2.38488E-03 |
| 157 | 8.65170E+04 | .125 | 1.85648E-03 | 1.99325E-03 |
| 158 | 7.63509E+04 | .125 | 1.54961E-03 | 1.66434E-03 |
| 159 | 6.73795E+04 | .075 | 8.03474E-04 | 8.63181E-04 |
| 160 | 6.25109E+04 | .050 | 4.88951E-04 | 5.25360E-04 |
| 161 | 5.94622E+04 | .050 | 4.54583E-04 | 4.88486E-04 |
| 162 | 5.65622E+04 | .075 | 6.22581E-04 | 6.69097E-04 |
| 163 | 5.24752E+04 | .125 | 8.97196E-04 | 9.64407E-04 |
| 164 | 4.63092E+04 | .125 | 7.46885E-04 | 8.03004E-04 |
| 165 | 4.08677E+04 | .125 | 6.21454E-04 | 6.68272E-04 |
| 166 | 3.60656E+04 | .025 | 1.11137E-04 | 1.19522E-04 |
| 167 | 3.51752E+04 | .025 | 1.07113E-04 | 1.15199E-04 |
| 168 | 3.43067E+04 | .075 | 2.98615E-04 | 3.21175E-04 |
| 169 | 3.18278E+04 | .125 | 4.29716E-04 | 4.62232E-04 |
| 170 | 2.80879E+04 | .075 | 2.22166E-04 | 2.39002E-04 |
| 171 | 2.60584E+04 | .050 | 1.34976E-04 | 1.45213E-04 |
| 172 | 2.47875E+04 | .025 | 6.38282E-05 | 6.86715E-05 |
| 173 | 2.41755E+04 | .025 | 6.15855E-05 | 6.61740E-05 |
| 174 | 2.35786E+04 | .075 | 1.71404E-04 | 1.84422E-04 |
| 175 | 2.18749E+04 | .025 | 5.30240E-05 | 5.70534E-05 |
| 176 | 2.13348E+04 | .100 | 1.93461E-04 | 2.08172E-04 |
| 177 | 1.93045E+04 | .125 | 2.04606E-04 | 2.20279E-04 |
| 178 | 1.70362E+04 | .125 | 1.69958E-04 | 1.82910E-04 |
| 179 | 1.50344E+04 | .125 | 1.41889E-04 | 1.51852E-04 |
| 180 | 1.32678E+04 | .125 | 1.17106E-04 | 1.26046E-04 |
| 181 | 1.17088E+04 | .125 | 9.71856E-05 | 1.04611E-04 |
| 182 | 1.03330E+04 | .125 | 8.06441E-05 | 8.68095E-05 |
| 183 | 9.11882E+03 | .125 | 6.69108E-05 | 7.20293E-05 |
| 184 | 8.04733E+03 | .125 | 5.55109E-05 | 5.97595E-05 |
| 185 | 7.10174E+03 | .125 | 4.60493E-05 | 4.95734E-05 |
| 186 | 6.26727E+03 | .125 | 3.81976E-05 | 4.11236E-05 |
| 187 | 5.53084E+03 | .100 | 2.58111E-05 | 2.77889E-05 |
| 188 | 5.00451E+03 | .100 | 2.22237E-05 | 2.39271E-05 |
| 189 | 4.52827E+03 | .050 | 9.92503E-06 | 1.06859E-05 |
| 190 | 4.30743E+03 | .050 | 9.20930E-06 | 9.91535E-06 |
| 191 | 4.09735E+03 | .100 | 1.64739E-05 | 1.77371E-05 |
| 192 | 3.70744E+03 | .100 | 1.41830E-05 | 1.52707E-05 |
| 193 | 3.35463E+03 | .100 | 1.22103E-05 | 1.31469E-05 |
| 194 | 3.03539E+03 | .058 | 6.31889E-06 | 6.80365E-06 |
| 195 | 2.86349E+03 | .042 | 4.19289E-06 | 4.51498E-06 |
| 196 | 2.74654E+03 | .050 | 4.69406E-06 | 5.05422E-06 |

| GP | ENERGY (EV) | LETH WIDTH | JEZEBEL LIB-IV CHI | GODIVA LIB-IV CHI |
|---|---|---|---|---|
| 197 | 2.61259E+03 | .050 | 4.35529E-06 | 4.68948E-06 |
| 198 | 2.48517E+03 | .100 | 7.79023E-06 | 8.38804E-06 |
| 199 | 2.24867E+03 | .100 | 6.70619E-06 | 7.22087E-06 |
| 200 | 2.03468E+03 | .100 | 5.77291E-06 | 6.21601E-06 |
| 201 | 1.84106E+03 | .100 | 4.96944E-06 | 5.35091E-06 |
| 202 | 1.66586E+03 | .050 | 2.21808E-06 | 2.38933E-06 |
| 203 | 1.58461E+03 | .050 | 2.05876E-06 | 2.21682E-06 |
| 204 | 1.50733E+03 | .100 | 3.68229E-06 | 3.96499E-06 |
| 205 | 1.36389E+03 | .100 | 3.16968E-06 | 3.41305E-06 |
| 206 | 1.23410E+03 | .250 | 6.12562E-06 | 6.59599E-06 |
| 207 | 9.61117E+02 | .250 | 4.21080E-06 | 4.53418E-06 |
| 208 | 7.48518E+02 | .250 | 2.80443E-06 | 3.11673E-06 |
| 209 | 5.82947E+02 | .250 | 1.98952E-06 | 2.14233E-06 |
| 210 | 4.53999E+02 | .250 | 1.36749E-06 | 1.47253E-06 |
| 211 | 3.53575E+02 | .250 | 9.39919E-07 | 1.01212E-06 |
| 212 | 2.75365E+02 | .250 | 6.46028E-07 | 6.95657E-07 |
| 213 | 2.14454E+02 | .250 | 4.44026E-07 | 4.78137E-07 |
| 214 | 1.67017E+02 | .250 | 3.05183E-07 | 3.28629E-07 |
| 215 | 1.30073E+02 | .250 | 2.09764E-07 | 2.25869E-07 |
| 216 | 1.01301E+02 | .250 | 1.44164E-07 | 1.55240E-07 |
| 217 | 7.88933E+01 | .250 | 9.90840E-08 | 1.06696E-07 |
| 218 | 6.14421E+01 | .250 | 6.81001E-08 | 7.33322E-08 |
| 219 | 4.78512E+01 | .250 | 4.68049E-08 | 5.04009E-08 |
| 220 | 3.72665E+01 | .250 | 3.21687E-08 | 3.46402E-08 |
| 221 | 2.90232E+01 | .250 | 2.21093E-08 | 2.38080E-08 |
| 222 | 2.26033E+01 | .250 | 1.51956E-08 | 1.63630E-08 |
| 223 | 1.76035E+01 | .250 | 1.04430E-08 | 1.12462E-08 |
| 224 | 1.37096E+01 | .250 | 7.17792E-09 | 7.72940E-09 |
| 225 | 1.06770E+01 | .250 | 4.93332E-09 | 5.31234E-09 |
| 226 | 8.31529E+00 | .250 | 3.39062E-09 | 3.65112E-09 |
| 227 | 6.47595E+00 | .250 | 2.33034E-09 | 2.50938E-09 |
| 228 | 5.04348E+00 | .250 | 1.60162E-09 | 1.72467E-09 |
| 229 | 3.92786E+00 | .250 | 1.10078E-09 | 1.18535E-09 |
| 230 | 3.05902E+00 | .250 | 7.56552E-10 | 8.14678E-10 |
| 231 | 2.38237E+00 | .250 | 5.19971E-10 | 5.59920E-10 |
| 232 | 1.85539E+00 | .250 | 3.57370E-10 | 3.84827E-10 |
| 233 | 1.44498E+00 | .250 | 2.45617E-10 | 2.64488E-10 |
| 234 | 1.12535E+00 | .250 | 1.68810E-10 | 1.81780E-10 |
| 235 | 8.76425E-01 | .050 | 2.68085E-11 | 2.88682E-11 |
| 236 | 8.35681E-01 | .200 | 8.92120E-11 | 9.60670E-11 |
| 237 | 6.82560E-01 | .088 | 3.15326E-11 | 3.39553E-11 |
| 238 | 6.25062E-01 | .162 | 4.82075E-11 | 5.19113E-11 |
| 239 | 5.31579E-01 | .250 | 5.48045E-11 | 5.90152E-11 |
| 240 | 4.13994E-01 | 10.631 | 1.20443E-10 | 1.29697E-10 |
| | 1.00000E-05 | | | |

TABLE A-IV

RELATIVE NEUTRON PRODUCTION RATES

| Isotope | JEZEBEL LIB-IV Old Chi | JEZEBEL LIB-IV LIB-IV Chi | JEZEBEL PRE-V Old Chi | GODIVA LIB-IV Old Chi | GODIVA LIB-IV LIB-IV Chi | GODIVA Pre-V Old Chi |
|---|---|---|---|---|---|---|
| $^{234}U$ | | | | 17.050 | 16.989 | 17.096 |
| $^{235}U$ | | | | 21.971 | 21.957 | 21.586 |
| $^{238}U$ | | | | 4.078 | 4.036 | 4.055 |
| $^{239}Pu$ | 25.949 | 25.938 | 26.193 | | | |
| $^{240}Pu$ | 17.757 | 17.733 | 17.647 | | | |
| $^{241}Pu$ | 24.971 | 24.967 | 23.646 | | | |
| Used to Produce | LIB-IV Chi (Table A-1) | LIB-IV Chi (Table A-3) | PRE-V Chi (Tables A-1,A-2) | LIB-IV Chi (Table A-1) | LIB-IV Chi (Table A-3) | PRE-V Chi (Tables A-1,A-2) |

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| 026-050 | 4.50 | 151-175 | 8.00 | 276-300 | 11.00 | 401-425 | 13.25 | 526-550 | 15.50 |
| 051-075 | 5.25 | 176-200 | 9.00 | 301-325 | 11.75 | 426-450 | 14.00 | 551-575 | 16.25 |
| 076-100 | 6.00 | 201-225 | 9.25 | 326-350 | 12.00 | 451-475 | 14.50 | 576-600 | 16.50 |
| 101-125 | 6.50 | 226-250 | 9.50 | 351-375 | 12.50 | 476-500 | 15.00 | 601-up | |

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