

LA-7675-MS

Informal Report

C.3

CIC-14 REPORT COLLECTION

**REPRODUCTION
COPY**

Jezebel and Godiva

University of California



LOS ALAMOS SCIENTIFIC LABORATORY

Post Office Box 1663 Los Alamos, New Mexico 87545

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

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

LA-7675-MS
Informal Report

UC-34c
Issued: February 1979

Jezebel and Godiva

R. B. Kidman



JEZEBEL AND GODIVA

by

R. B. Kidman

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.

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 benchmarks¹ 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										Cross Sections Through 1DX, 50-Gp, Old Chi				
50-Gp										Only 1 Elastic Removal Term				
Old Chi				Comp Chi	Comp Chi	240-Gp, Comp Chi				Only 10 Downscatter Groups		Full Inelastic		
P ₀	P ₁	P ₂	P ₃	P ₃	P ₃	P ₃	P ₂	P ₁	P ₀	FF=iterate	FF=1	FF=iterate	Full Elastic	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	Sige=5	Sige=0	Sige=5	(15)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Based on Preliminary ENDF/B-V														
1 S ₂	1.13783	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				
Old Chi					Comp Chi	Comp Chi	240-Gp, Comp Chi				Full Inelastic			
P ₀	P ₁	P ₂	P ₃	P ₃	P ₃	P ₃	P ₂	P ₁	P ₀		Full			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	FF=	Elastic			
										iterate	FF=1	FF=iterate	Full	
										Size=5	Size=0	Size=5		
										(11)	(12)	(13)	(14)	(15)
<u>Based on Preliminary ENDF/B-V</u>														
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	
<u>Based on ENDF/B-IV</u>														
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

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

Cross Sections from MINX or NJOY										Cross Sections Through IDX, 50-Gp, Old Chi				
50-Gp										Only 1 Elastic Removal Term				
Old Chi				Comp Chi	Comp Chi	240-Gp, Comp Chi				Only 10 Downscatter Groups		Full Inelastic		
P ₀	P ₁	P ₂	P ₃	P ₃	185-Gp P ₃	P ₃	P ₂	P ₁	P ₀	FF=iterate	FF=1	FF=iterate	Full Elastic	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	Size=5	Size=0	Size=5	(14)	(15)
Based on Preliminary ENDF/B-V														
1	S ₂	0.92931	0.92534											
2	S ₄	0.93594	0.92435	0.92954	0.92947	0.94360				0.91919	0.91926	0.91909		
3	S ₈	0.93755	0.92269	0.93113	0.93027	0.94445				0.92743	0.92750	0.92733		
4	S ₁₆	0.93800	0.92228	0.93182	0.93052	0.94471				0.92954	0.92961	0.92945		
5	S ₃₂	0.93813	0.92221	0.93205	0.93062	0.94482				0.93009	0.93016	0.93000		
6	S ₄₈	0.93815	0.92220	0.93210	0.93065	0.94485	0.94572			0.93024	0.93032	0.93015		
										0.93027	0.93035	0.93018		
Based on ENDF/B-IV														
7	S ₂	0.92156	0.91737											
8	S ₄	0.92826	0.91624	0.92154	0.92147	0.91781				0.91077	0.91099			
9	S ₈	0.92990	0.91452	0.92313	0.92226	0.91860				0.91911	0.91934			
10	S ₁₆	0.93035	0.91409	0.92383	0.92250	0.91884				0.92125	0.92148			
11	S ₃₂	0.93048	0.91401	0.92406	0.92261	0.91895				0.92181	0.92204		0.92105	0.92104
12	S ₄₈	0.93050	0.91401	0.92412	0.92264	0.91898				0.92196	0.92219			
										0.92188	0.91638	0.90613	0.92293	

TABLE IV

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

Cross Sections from MINX or NJOY

50-Gp

Old Chi				Comp Chi	Comp Chi	240-Gp, Comp Chi			
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)

Cross Sections Through 1DX, 50-Gp, Old Chi

Only 1 Elastic Removal Term

Only 10 Downscatter Groups Full Inelastic

FF=iterate	FF=1	FF=iterate	Full Elastic
Sige=5	Sige=0	Sige=5	
(11)	(12)	(13)	(14) (15)

Based on Preliminary ENDF/B-V

1	S ₂	1.06012	1.05682							
2	S ₄	1.06689	1.05145	1.05777	1.05787	1.06923				
3	S ₈	1.06822	1.04791	1.05742	1.05685	1.06825				
4	S ₁₆	1.06859	1.04713	1.05767	1.05670	1.06811				
5	S ₃₂	1.06870	1.04701	1.05782	1.05674	1.06815				
6	S ₄₈	1.06872	1.04700	1.05786	1.05677	1.06818	1.06649			

1.04484	1.04513	1.04482	
1.05404	1.05434	1.05403	
1.05601	1.05630	1.05599	
1.05649	1.05679	1.05648	
1.05663	1.05693	1.05662	
1.05667	1.05696	1.05665	

Based on ENDF/B-IV

1	S ₂	1.05796	1.05371							
2	S ₄	1.06458	1.04782	1.05423	1.05432	1.04451	1.03513			
3	S ₈	1.06589	1.04416	1.05379	1.05321	1.04340	1.03404			
4	S ₁₆	1.06625	1.04336	1.05402	1.05304	1.04322	1.03387			
5	S ₃₂	1.06636	1.04322	1.05416	1.05308	1.04326	1.03391			
6	S ₄₈	1.06638	1.04321	1.05421	1.05310	1.04328	1.03394	1.03505	1.02398	1.04753

1.04106	1.04150		
1.05016	1.05060		
1.05210	1.05253		
1.05258	1.05301		
1.05272	1.05315		
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 sources² were used in this study, ENDF/B-IV and preliminary ENDF/B-V. The MINX³ code was used to generate 50-group and 240-group libraries from ENDF/B-IV, while the NJOY⁴ 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 for neutron production. The individual isotope chi vectors for the various fission sources and group structures are obtained from the MINX and NJOY data mentioned above. The volume averaged cross sections for neutron production were taken from the 50-group, $S_{48}P_3$ ONETRAN⁵ runs that used the old chi vectors. Thus for JEZEBEL we have composition-dependent fission source vectors for 50-group and 240-group structures, based on ENDF/B-IV (LIB-IV) and in addition 50-group and 185-group structures based on preliminary ENDF/B-V (PRE-V). Similar vectors for GODIVA were generated in a similar fashion. All of the chi vectors 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 LD_X,⁶ in which case, depending on the LD_X 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 composition 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	
														Full	
											FF=			Elastic	
											iterate			Elastic	
											Sig=5			Sig=0	
											(11)			(12)	
											(13)			(14)	
											(15)			(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		

TABLE VI

GODIVA $\bar{\sigma}$ U-238
 σ_f

Cross Sections from MINX or NJOY										Cross Sections Through 1DX, 50-Gp, Old Chi						
50-Gp										Only 1 Elastic Removal Term						
Old Chi				Comp Chi	Comp Chi	240-Gp, Comp Chi				FF-iterate	FF=1	FF-iterate	Full Inelastic			
P ₀	P ₁	P ₂	P ₃	P ₃	P ₃	P ₃	P ₂	P ₁	P ₀	FF-iterate	FF=1	FF-iterate	Full Inelastic			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	Si _{ge} =5	Si _{ge} =0	Si _{ge} =5	Si _{ge} =5			
										(11)	(12)	(13)	(14)	(15)		
<u>Based on Preliminary ENDF/B-V</u>																
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
<u>Based on ENDF/B-IV</u>																
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				
Old Chi				Comp Chi	Comp Chi	240-Gp, Comp Chi				Only 10 Downscatter Groups		Full Inelastic		
P ₀	P ₁	P ₂	P ₃	P ₃	P ₃	P ₃	P ₂	P ₁	P ₀	FF=iterate	FF=1	FF=iterate	Full Elastic	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	Sige=5	Sige=0	Sige=5	(15)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
<u>Based on Preliminary ENDF/B-V</u>														
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		
<u>Based on ENDF/B-IV</u>														
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-235

Cross Sections from MINX or NJOY										Cross Sections Through 1DX, 50-Gp, Old Chi				
50-Gp										Only 1 Elastic Removal Term				
Old Chi				Comp Chi	Comp Chi	240-Gp, Comp Chi				FF=iterate	FF=1	FF=iterate	Full Inelastic	
P ₀	P ₁	P ₂	P ₃	P ₃	P ₃	P ₃	P ₂	P ₁	P ₀	Siqe=5	Siqe=0	Siqe=5	Full Elastic	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
<u>Based on Preliminary ENDF/B-V</u>														
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	
<u>Based on ENDF/B-IV</u>														
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_1 - an i th Legendre order anisotropic scattering calculation was made. If P_1 is missing, a P_0 calculation with the transport cross section was made. ¹

S_1 - an i th 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 down-scattering 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 i th row and j th 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,

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

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,

$$E(i,5) - E(i,4) \quad \text{for } i = 1, \dots, 12 \quad .$$

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 composition-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,

$$E(i+6,5) - E(i,5) \quad \text{for } i = 1, \dots, 6 \quad ,$$

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,

$$E(6,6) - E(6,5) \quad \text{and} \quad E(12,7) - E(12,5) \quad .$$

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 ~ 0.00169 while the 240-group structure lowers K by ~ 0.00109 and lowers R by ~ 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 ~ 0.00002 and decreases R by ~ 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 ~ 0.00001 .

G. Elastic Removal Iteration

The elastic removal cross section can be 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,

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

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

H. Self-Shielding

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

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

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

I. Angular Quadrature and Legendre Order

Several series of S_1 and P_1 calculations have been made to test the approach to $S_\infty P_\infty$. In general, the approach to S_∞ or P_∞ 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_∞ and P_∞ .

The tables allow one to convert practically any $S_1 P_1$ 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_1 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 ~ 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 \rightarrow full inelastic matrix [E(10,14) - E(10,11)]
- 0.00035	42-group \rightarrow 240-group [E(12,7) - E(12,5)]
- 0.00337	transport corrected \rightarrow 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)
<u>+ 0.00870</u>	ENDF/B-IV \rightarrow V [E(6,4) - E(12,4)]
1.00137	corrected eigenvalue

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

53-GP STRUCTURE AND FIRSTIN SOURCE VECTORS (NEUTRONS/FISSION)

GP	ENERGY (EV)	LETH WIDTH	JFZFHL			GODIVA		
			ALN CHI	11A-TV CHI	PRE-V CHI	OLD CHI	L1B-TV CHI	PRE-V CHI
1	2.20000E+07	.69	2.46500E-03	2.50077E-03	1.51500E-03	1.00200E-03	1.00917E-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	0.00531E+06	.50	1.21445E-01	1.20500E-01	1.22652E-01	1.12174E-01	1.10041E-01	1.13213E-01
4	3.67070E+06	.50	2.10301E-01	2.00095E-01	2.20001E-01	2.05200E-01	2.00094E-01	2.12310E-01
5	2.23130E+06	.50	2.22367E-01	2.22504E-01	2.29115E-01	2.24516E-01	2.24929E-01	2.20078E-01
6	1.35335E+06	.50	1.72323E-01	1.72009E-01	1.71625E-01	1.77776E-01	1.79024E-01	1.76456E-01
7	0.20050E+05	.50	1.10173E-01	1.10690E-01	1.06504E-01	1.15178E-01	1.16350E-01	1.12606E-01
8	4.97071E+05	.25	3.60360E-02	3.62177E-02	3.41969E-02	3.79300E-02	3.00000E-02	3.60230E-02
9	3.07742E+05	.25	2.65500E-02	2.66927E-02	2.50052E-02	2.00000E-02	2.00000E-02	2.71262E-02
10	3.01974E+05	.25	1.92630E-02	1.93716E-02	1.00100E-02	2.00000E-02	2.00000E-02	1.96926E-02
11	2.35170E+05	.25	1.30100E-02	1.30000E-02	1.20364E-02	1.46400E-02	1.40000E-02	1.41297E-02
12	1.03156E+05	.25	9.00000E-03	9.06717E-03	9.07162E-03	1.00160E-02	1.05629E-02	1.00000E-02
13	1.42642E+05	.25	6.91600E-03	6.95827E-03	6.30000E-03	7.35300E-03	7.45000E-03	7.12012E-03
14	1.11000E+05	.25	4.00000E-03	4.07911E-03	4.46883E-03	5.16000E-03	5.23523E-03	5.01000E-03
15	0.65170E+04	.25	3.00000E-03	3.00000E-03	3.11435E-03	3.60500E-03	3.63750E-03	3.40067E-03
16	6.73705E+04	.25	2.35500E-03	2.36960E-03	2.13637E-03	2.50000E-03	2.50612E-03	2.40000E-03
17	5.24752E+04	.25	1.63400E-03	1.64400E-03	1.40000E-03	1.74100E-03	1.76741E-03	1.60000E-03
18	4.00000E+04	.25	1.13100E-03	1.13032E-03	1.00000E-03	1.20000E-03	1.22416E-03	1.14276E-03
19	3.10270E+04	.25	7.00000E-04	7.00000E-04	7.00000E-04	8.30000E-04	8.46445E-04	7.00000E-04
20	2.47075E+04	.25	5.40000E-04	5.43224E-04	4.07927E-04	5.76000E-04	5.84492E-04	5.40119E-04
21	1.93045E+04	.25	3.72000E-04	3.74650E-04	3.35825E-04	3.97000E-04	4.00100E-04	3.71075E-04
22	1.50340E+04	.25	2.57000E-04	2.50196E-04	2.31034E-04	2.74000E-04	2.77000E-04	2.54070E-04
23	1.17000E+04	.25	1.77000E-04	1.77000E-04	1.50000E-04	1.80000E-04	1.91420E-04	1.75027E-04
24	9.11000E+03	.25	1.22000E-04	1.22422E-04	1.00000E-04	1.30000E-04	1.31700E-04	1.20104E-04
25	7.10170E+03	.25	8.40000E-05	8.42471E-05	7.90000E-05	8.90000E-05	9.00000E-05	8.25226E-05
26	5.53000E+03	.25	5.00000E-05	5.79599E-05	5.16180E-05	6.10000E-05	6.24017E-05	5.66626E-05
27	4.30743E+03	.25	4.00000E-05	3.90662E-05	3.94767E-05	4.20000E-05	4.29231E-05	3.80071E-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	2.61250E+03	.25	1.90000E-05	1.88517E-05	1.67549E-05	2.00000E-05	2.02903E-05	1.83463E-05
30	2.00000E+03	.25	1.30000E-05	1.29614E-05	1.15138E-05	1.40000E-05	1.39563E-05	1.25992E-05
31	1.50000E+03	.25	9.00000E-06	8.91075E-06	7.91212E-06	9.00000E-06	9.59000E-06	8.65293E-06
32	1.23410E+03	.25	6.00000E-06	6.12562E-06	5.43705E-06	6.00000E-06	6.59590E-06	5.94305E-06
33	9.61117E+02	.25	4.00000E-06	4.21001E-06	3.73624E-06	4.00000E-06	4.53417E-06	4.00000E-06
34	7.40518E+02	.25	3.00000E-06	2.89443E-06	2.56740E-06	3.00000E-06	3.11673E-06	2.80000E-06
35	5.82947E+02	.25	2.00000E-06	1.98952E-06	1.76434E-06	2.00000E-06	2.14233E-06	1.92218E-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	9.00000E-07
38	2.75365E+02	.50	1.00000E-06	1.29000E-06	9.66057E-07	1.00000E-06	1.17379E-06	1.05367E-06
39	1.67017E+02	.50	0.	6.14938E-07	4.56240E-07	1.00000E-06	5.54405E-07	4.97419E-07
40	1.01301E+02	.50	0.	2.43240E-07	2.15475E-07	0.	2.61935E-07	2.34050E-07
41	6.14421E+01	.50	0.	1.14905E-07	1.01760E-07	0.	1.23733E-07	1.10000E-07
42	3.72665E+01	.50	0.	5.42701E-08	4.80616E-08	0.	5.04401E-08	5.23632E-08
43	2.26033E+01	.50	0.	2.56394E-08	2.26052E-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	0.31529E+00	.50	0.	5.72000E-09	5.04721E-09	0.	6.16040E-09	5.51316E-09
46	0.00000E+00	.50	0.	2.70240E-09	2.30155E-09	0.	2.91001E-09	2.59023E-09
47	0.00000E+00	.50	0.	1.27652E-09	1.10010E-09	0.	1.37039E-09	1.21053E-09
48	1.05539E+00	.50	0.	6.02907E-10	5.14721E-10	0.	6.40313E-10	5.67140E-10
49	1.12535E+00	.50	0.	2.84832E-10	2.40227E-10	0.	3.06714E-10	2.50000E-10
50	0.02500E+01	11.13	0.	2.54978E-10	2.11920E-10	0.	2.74567E-10	2.19997E-10
	1.00000E+00							

TABLE A-II

185-GP STRUCTURE AND FISSION SOURCE VECTORS

GP	ENERGY (eV)	IETH WIDTH	JE7FREL	CONIVA
			PRF-V CHI	PRF-V CHI
1	2.70000E+07	.068	8.27144E-07	6.93115F-07
2	1.86025E+07	.125	6.92462E-06	6.77852F-06
3	1.64072E+07	.051	7.72111E-06	6.45412F-06
4	1.56031E+07	.050	1.30671E-05	1.16104F-05
5	1.49103E+07	.025	1.04321E-05	8.75252F-06
6	1.45499E+07	.025	1.36385E-05	1.14435F-05
7	1.41907E+07	.025	1.76074E-05	1.40723F-05
8	1.38403E+07	.025	2.27580E-05	1.91619F-05
9	1.34986E+07	.025	2.90607E-05	2.45019F-05
10	1.31653E+07	.025	3.68317E-05	3.10006F-05
11	1.28403E+07	.125	3.72901E-04	3.16509F-04
12	1.13315E+07	.125	9.82431E-04	8.41400F-04
13	1.00000E+07	.125	2.23729E-03	1.93522F-03
14	8.24097E+06	.125	4.48193E-03	3.91750F-03
15	7.78001E+06	.125	8.02316E-03	7.09093F-03
16	6.87289E+06	.125	1.30137E-02	1.16317F-02
17	6.06531E+06	.125	1.93621E-02	1.75056F-02
18	5.5261E+06	.125	2.67127E-02	2.44311F-02
19	4.72367E+06	.125	3.45029E-02	3.19105F-02
20	4.16062E+06	.125	4.20745E-02	3.93628F-02
21	3.67879E+06	.125	4.87904E-02	4.61577F-02
22	3.24653E+06	.125	5.01825E-02	6.17907F-02
23	2.86505E+06	.125	5.79101E-02	5.59368F-02
24	2.52000E+06	.125	5.99009E-02	5.04204F-02
25	2.23130E+06	.125	6.01999E-02	5.92604E-02
26	1.96917E+06	.125	5.90110E-02	5.86036F-02
27	1.73774E+06	.125	5.66093E-02	5.66040F-02
28	1.53355E+06	.125	5.32942E-02	5.37703F-02
29	1.35335E+06	.125	4.93754E-02	5.02061F-02
30	1.19433E+06	.125	4.51317E-02	4.62707F-02
31	1.05399E+06	.125	4.07204E-02	4.20706F-02
32	9.30145E+05	.125	3.63886E-02	3.70979F-02
33	8.20850E+05	.125	3.22153E-02	3.30099F-02
34	7.24390E+05	.125	2.82624E-02	2.97813F-02
35	6.39279E+05	.125	2.46539E-02	2.61701F-02
36	5.64161E+05	.125	2.13720E-02	2.20420F-02
37	4.97071E+05	.125	1.84009E-02	1.97755F-02
38	4.39360E+05	.125	1.57869E-02	1.70466F-02
39	3.87742E+05	.125	1.35097E-02	1.46197F-02
40	3.42181E+05	.125	1.14955E-02	1.25057F-02
41	3.01974E+05	.125	9.75726E-03	1.06560F-02
42	2.66491E+05	.125	8.25550E-03	9.03602F-03
43	2.35178E+05	.125	6.96686E-03	7.65399F-03
44	2.07543E+05	.125	5.86955E-03	6.47535F-03
45	1.83156E+05	.125	4.92034E-03	5.49164F-03
46	1.61635E+05	.125	4.14320E-03	4.61600F-03
47	1.42642E+05	.125	3.47329E-03	3.86040F-03
48	1.25001E+05	.125	2.90675E-03	3.25152F-03
49	1.11000E+05	.125	2.43270E-03	2.72719F-03
50	9.80366E+04	.125	2.03617E-03	2.20271F-03
51	8.65170E+04	.125	1.69914E-03	1.90446F-03
52	7.63509E+04	.125	1.41521E-03	1.58511F-03
53	6.73795E+04	.125	1.17736E-03	1.31665F-03
54	5.94622E+04	.125	9.79010E-04	1.09323F-03
55	5.24752E+04	.125	8.13740E-04	9.07414F-04
56	4.63092E+04	.125	6.76122E-04	7.52962F-04
57	4.08677E+04	.125	5.61599E-04	6.24643F-04
58	3.60656E+04	.125	4.66344E-04	5.10003F-04
59	3.18270E+04	.125	3.87152E-04	4.29623F-04
60	2.80079E+04	.125	3.21340E-04	3.56213F-04
61	2.47875E+04	.125	2.66667E-04	2.95310F-04
62	2.18749E+04	.125	2.21260E-04	2.44793F-04

GP	ENERGY (EV)	ITEM NO	JEFREL REF-V CUT	MODVA REF-V CUT
63	1.95049E+04	.125	1.83560E-04	2.02099F-04
64	1.72362E+04	.125	1.52265E-04	1.60164F-04
65	1.50344E+04	.125	1.26203E-04	1.39367F-04
66	1.32678E+04	.125	1.04741E-04	1.15496F-04
67	1.17088E+04	.125	8.60607E-05	9.57097F-05
68	1.03330E+04	.125	7.20279E-05	7.93113F-05
69	9.11082E+03	.125	5.97246E-05	6.57213F-05
70	8.04733E+03	.125	4.95205E-05	5.44592E-05
71	7.10174E+03	.125	4.10502E-05	4.51267F-05
72	6.26727E+03	.125	3.40047E-05	3.73934E-05
73	5.53004E+03	.125	2.82210E-05	3.09853F-05
74	4.88095E+03	.125	2.33970E-05	2.56755E-05
75	4.30743E+03	.125	1.93967E-05	2.12750F-05
76	3.80129E+03	.125	1.60800E-05	1.76301F-05
77	3.35463E+03	.125	1.33303E-05	1.46003F-05
78	2.96045E+03	.125	1.10507E-05	1.21063E-05
79	2.61259E+03	.125	9.16079E-06	1.00322F-05
80	2.30560E+03	.125	7.50007E-06	8.31366F-06
81	2.03460E+03	.125	6.29526E-06	6.80945F-06
82	1.79560E+03	.125	5.21057E-06	5.70937F-06
83	1.58461E+03	.125	4.32601E-06	4.73149E-06
84	1.39042E+03	.125	3.58611E-06	3.92116F-06
85	1.23410E+03	.125	2.97275E-06	3.24966F-06
86	1.08909E+03	.125	2.46430E-06	2.69320F-06
87	9.61117E+02	.125	2.04282E-06	2.23205F-06
88	8.48182E+02	.125	1.69342E-06	1.84909E-06
89	7.48510E+02	.125	1.40379E-06	1.53319F-06
90	6.60565E+02	.125	1.16369E-06	1.27072F-06
91	5.82947E+02	.125	9.64665E-07	1.05320F-06
92	5.14449E+02	.125	7.90670E-07	8.72920F-07
93	4.53999E+02	.125	6.62911E-07	7.23511F-07
94	4.00653E+02	.125	5.49535E-07	5.99602E-07
95	3.53575E+02	.125	4.55551E-07	4.97051E-07
96	3.12020E+02	.125	3.77641E-07	4.11900F-07
97	2.75365E+02	.125	3.13087E-07	3.41409F-07
98	2.43008E+02	.125	2.59510E-07	2.83054E-07
99	2.14450E+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	1.61203F-07
102	1.47392E+02	.125	1.22563E-07	1.33624E-07
103	1.30073E+02	.125	1.01603E-07	1.10763F-07
104	1.14789E+02	.125	8.42282E-08	9.18100E-08
105	1.01301E+02	.125	6.98245E-08	7.61069F-08
106	8.93970E+01	.125	5.78043E-08	6.30878F-08
107	7.88933E+01	.125	4.79857E-08	5.22961F-08
108	6.96231E+01	.125	3.97001E-08	4.33505E-08
109	6.14421E+01	.125	3.29776E-08	3.59301F-08
110	5.42225E+01	.125	2.73386E-08	2.97874F-08
111	4.78512E+01	.125	2.26639E-08	2.46915F-08
112	4.22285E+01	.125	1.87070E-08	2.04679E-08
113	3.72665E+01	.125	1.55749E-08	1.69669F-08
114	3.28076E+01	.125	1.29117E-08	1.40649F-08
115	2.90232E+01	.125	1.07030E-08	1.16506F-08
116	2.56129E+01	.125	8.87112E-09	9.66449F-09
117	2.26033E+01	.125	7.35260E-09	8.01139F-09
118	1.99473E+01	.125	6.00489E-09	6.64007F-09
119	1.76035E+01	.125	5.05201E-09	5.50511F-09
120	1.55350E+01	.125	4.18567E-09	4.56368F-09
121	1.37096E+01	.125	3.46602E-09	3.70314F-09
122	1.20907E+01	.125	2.87218E-09	3.13620F-09
123	1.06770E+01	.125	2.38057E-09	2.59977F-09
124	9.42246E+00	.125	1.97335E-09	2.15521F-09
125	8.31520E+00	.125	1.63580E-09	1.70641F-09
126	7.33022E+00	.125	1.35500E-09	1.40036F-09
127	6.47595E+00	.125	1.12309E-09	1.22713F-09
128	5.71501E+00	.125	9.31437E-10	1.01730F-09
129	5.04340E+00	.125	7.72032E-10	8.42532F-10

GP	ENERGY (EV)	1 EYM WIDTH	JEZFREL PRF-V CHI	GODIVA PRE-V CHI
130	4.45008E+00	.125	6.40066E-10	6.95004E-10
131	3.92786E+00	.125	5.30143E-10	5.74595E-10
132	3.46633E+00	.125	4.30307E-10	4.76207E-10
133	3.05902E+00	.125	3.44019E-10	3.94690E-10
134	2.69950E+00	.125	3.01565E-10	3.26113E-10
135	2.38237E+00	.020	5.08049E-11	6.41909E-11
136	2.31603E+00	.020	5.67057E-11	6.18713E-11
137	2.25113E+00	.036	6.79067E-11	7.42709E-11
138	2.17213E+00	.037	6.59701E-11	7.20199E-11
139	2.09400E+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	1.44490E+00	.100	9.32706E-11	1.02067E-10
147	1.30705E+00	.114	9.11734E-11	9.98230E-11
148	1.16638E+00	.036	2.51025E-11	2.70606E-11
149	1.12535E+00	.024	1.59001E-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	5.95468E-12	5.27555E-12
153	1.05250E+00	.009	5.49219E-12	5.22605E-12
154	1.04273E+00	.020	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	4.06375E-11	5.40074E-11
159	7.82079E-01	.136	4.02130E-11	5.35002E-11
160	6.82560E-01	.000	2.06332E-11	2.07460E-11
161	6.25060E-01	.162	4.10057E-11	4.45839E-11
162	5.31579E-01	.055	1.14262E-11	1.17030E-11
163	5.03235E-01	.100	3.36414E-11	3.65345E-11
164	4.17016E-01	.007	1.01055E-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	3.04540E-12	2.64096E-12
169	2.90737E-01	.072	5.90623E-12	5.63857E-12
170	2.70510E-01	.075	5.47669E-12	5.18316E-12
171	2.51020E-01	.090	6.31876E-12	6.20001E-12
172	2.27690E-01	.211	1.09940E-11	1.12952E-11
173	1.84420E-01	.236	8.74000E-12	8.81710E-12
174	1.45721E-01	.267	6.70730E-12	6.69577E-12
175	1.11568E-01	.300	5.05761E-12	4.70005E-12
176	8.19603E-02	.309	3.57280E-12	3.17904E-12
177	5.69224E-02	.206	1.65752E-12	1.86475E-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	.022	4.57037E-14	1.41364E-16
183	2.27690E-03	.097	3.94012E-15	2.07377E-19
184	7.60219E-04	.100	2.14584E-15	3.31705E-20
185	2.52908E-04	.231	2.32702E-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	GOMIVA LIB-IV CHI
1	1.99705E+07	.017	7.40202E-07	3.97918E-07
2	1.96403E+07	.025	1.45747E-06	7.86343E-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	2.09063E-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	7.96936E-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	2.64861E-05
16	1.38403E+07	.025	5.08185E-05	3.35373E-05
17	1.34986E+07	.025	6.22367E-05	4.15602E-05
18	1.31653E+07	.025	7.57717E-05	5.12032E-05
19	1.28403E+07	.025	9.17103E-05	6.26902E-05
20	1.25232E+07	.025	1.10399E-04	7.63018E-05
21	1.22140E+07	.025	1.32155E-04	9.23308E-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	2.57500E-04	1.87436E-04
26	1.07788E+07	.025	3.00500E-04	2.20802E-04
27	1.05127E+07	.025	3.49004E-04	2.58801E-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	4.05330E-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	1.36600E-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	2.59392E-04	7.10802E-04
46	6.54760E+06	.008	2.83363E-04	7.32637E-04
47	6.39230E+06	.008	3.09600E-04	7.52900E-04
48	6.23770E+06	.025	2.80002E-03	2.39078E-03
49	6.07628E+06	.025	3.02202E-03	2.59439E-03
50	5.91805E+06	.025	3.25150E-03	2.80708E-03
51	5.76531E+06	.025	3.48902E-03	3.02850E-03
52	5.61555E+06	.025	3.73304E-03	3.25825E-03
53	5.46950E+06	.050	4.22873E-03	7.23674E-03
54	5.32812E+06	.050	4.28134E-03	8.24321E-03
55	5.1946E+06	.050	1.03694E-02	9.29626E-03
56	4.96585E+06	.025	5.60046E-03	5.05452E-03
57	4.84325E+06	.025	5.88014E-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	1.37106E-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	JEZEREL LIB-IV CHI	GONIVA LIB-IV CHI
63	3.86741E+08	.050	1.60201E-02	1.59094F-02
64	3.67879E+06	.050	1.78947E-02	1.69312F-02
65	3.49938E+06	.050	1.80851E-02	1.79069E-02
66	3.32871E+06	.025	9.72128E-03	9.298A3E-03
67	3.24653E+06	.025	9.92071E-03	9.51736F-03
68	3.16637E+06	.025	1.01000E-02	9.72643E-03
69	3.08819E+06	.025	1.02882E-02	9.92548F-03
70	3.01194E+06	.050	2.10669E-02	2.04068E-02
71	2.86505E+06	.050	2.16444E-02	2.10745F-02
72	2.72532E+06	.050	2.21273E-02	2.16506F-02
73	2.59240E+06	.050	2.25142E-02	2.21322F-02
74	2.46597E+06	.017	7.58924E-03	7.40202F-03
75	2.42513E+06	.017	7.57241E-03	7.47099F-03
76	2.38521E+06	.008	3.84158E-03	3.79731F-03
77	2.36525E+06	.008	3.80171E-03	3.76057F-03
78	2.34570E+06	.017	7.66811E-03	7.59017F-03
79	2.32686E+06	.017	7.63740E-03	7.57319E-03
80	2.26880E+06	.017	7.69026E-03	7.64393E-03
81	2.23130E+06	.050	2.31040E-02	2.30019F-02
82	2.12248E+06	.050	2.31179E-02	2.31039F-02
83	2.01897E+06	.025	1.15394E-02	1.15022F-02
84	1.96912E+06	.025	1.15093E-02	1.15545F-02
85	1.92050E+06	.025	1.14714E-02	1.15364F-02
86	1.87308E+06	.025	1.14240E-02	1.15001F-02
87	1.82684E+06	.050	2.26603E-02	2.20921F-02
88	1.73774E+06	.050	2.23743E-02	2.26650E-02
89	1.69299E+06	.025	1.10567E-02	1.12256F-02
90	1.61218E+06	.025	1.09599E-02	1.11436E-02
91	1.57237E+06	.025	1.08563E-02	1.10539F-02
92	1.53355E+06	.025	1.07462E-02	1.09569F-02
93	1.49569E+06	.050	2.11384E-02	2.15960F-02
94	1.42274E+06	.050	2.06306E-02	2.11313F-02
95	1.35335E+06	.050	2.00853E-02	2.06230F-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	9.67621F-03
99	1.16484E+06	.050	1.82831E-02	1.88974F-02
100	1.12803E+06	.050	1.76450E-02	1.82743E-02
101	1.05399E+06	.050	1.69964E-02	1.76360E-02
102	1.02259E+06	.025	8.25290E-03	8.57525F-03
103	9.77834E+05	.017	5.42162E-03	5.63744E-03
104	9.61640E+05	.008	2.66727E-03	2.77470F-03
105	9.53692E+05	.050	1.56049E-02	1.63327F-02
106	9.07180E+05	.050	1.50295E-02	1.56759F-02
107	8.62936E+05	.050	1.43789E-02	1.50206F-02
108	8.20850E+05	.050	1.37358E-02	1.43701F-02
109	7.80017E+05	.050	1.31020E-02	1.37272F-02
110	7.42736E+05	.050	1.24820E-02	1.30943F-02
111	7.06517E+05	.050	1.18753E-02	1.24737F-02
112	6.72055E+05	.050	1.12842E-02	1.18672E-02
113	6.39279E+05	.050	1.07101E-02	1.12764F-02
114	6.08101E+05	.050	1.01533E-02	1.07025F-02
115	5.78443E+05	.050	9.61620E-03	1.01465F-02
116	5.50232E+05	.025	4.61259E-03	4.87057F-03
117	5.36647E+05	.025	4.48548E-03	4.73865E-03
118	5.23397E+05	.025	4.36085E-03	4.60916F-03
119	5.10474E+05	.025	4.23071E-03	4.48212F-03
120	4.97871E+05	.050	8.12097E-03	8.39305F-03
121	4.73589E+05	.050	7.66239E-03	8.11474E-03
122	4.58492E+05	.050	7.22376E-03	7.65643F-03
123	4.28521E+05	.050	6.80400E-03	7.21806F-03
124	4.07622E+05	.050	6.40557E-03	6.79948F-03
125	3.87742E+05	.050	6.02539E-03	6.40040F-03
126	3.68837E+05	.050	5.66307E-03	6.02048F-03
127	3.52044E+05	.050	5.32001E-03	5.65931F-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	JEZEMEL LIB-IV CHI	GODIVA LIB-IV CHI
130	3.09618E+09	.025	2.30611E-03	2.45605E-03
131	3.01974E+09	.025	2.23321E-03	2.37905E-03
132	2.94518E+09	.025	2.16237E-03	2.30415E-03
133	2.87246E+09	.025	2.09342E-03	2.23131E-03
134	2.80154E+09	.025	2.02646E-03	2.16048E-03
135	2.73237E+09	.050	3.85958E-03	4.11634E-03
136	2.59911E+09	.050	3.61402E-03	3.85625E-03
137	2.47235E+09	.050	3.38255E-03	3.61088E-03
138	2.35178E+09	.050	3.16454E-03	3.37959E-03
139	2.23708E+09	.050	2.95938E-03	3.16176E-03
140	2.12797E+09	.050	2.76644E-03	2.95676E-03
141	2.02410E+09	.050	2.58513E-03	2.76348E-03
142	1.92547E+09	.050	2.41405E-03	2.58282E-03
143	1.83156E+09	.050	2.25503E-03	2.41268E-03
144	1.74224E+09	.025	1.07070E-03	1.14583E-03
145	1.69922E+09	.025	1.03442E-03	1.10717E-03
146	1.65727E+09	.025	9.99288E-04	1.06973E-03
147	1.61635E+09	.025	9.65284E-04	1.03348E-03
148	1.57644E+09	.050	1.83289E-03	1.96279E-03
149	1.49956E+09	.050	1.78956E-03	1.83122E-03
150	1.42642E+09	.050	1.58411E-03	1.70799E-03
151	1.35686E+09	.050	1.48618E-03	1.59265E-03
152	1.29086E+09	.050	1.38507E-03	1.48473E-03
153	1.22773E+09	.050	1.29062E-03	1.38379E-03
154	1.16786E+09	.050	1.20236E-03	1.28943E-03
155	1.11090E+09	.125	2.65780E-03	2.85097E-03
156	9.88368E+08	.125	2.22211E-03	2.38888E-03
157	8.65178E+08	.125	1.85648E-03	1.99375E-03
158	7.63589E+08	.125	1.54961E-03	1.66454E-03
159	6.73795E+08	.075	8.03474E-04	8.63181E-04
160	6.25189E+08	.050	4.88951E-04	5.25368E-04
161	5.94622E+08	.050	4.54583E-04	4.88486E-04
162	5.65622E+08	.075	6.22581E-04	6.6907E-04
163	5.24752E+08	.125	8.07196E-04	9.6447E-04
164	4.63892E+08	.125	7.46885E-04	8.03804E-04
165	4.08677E+08	.125	6.81454E-04	6.68272E-04
166	3.60656E+08	.025	1.11137E-04	1.19522E-04
167	3.51752E+08	.025	1.07113E-04	1.15199E-04
168	3.43867E+08	.075	2.98615E-04	3.21175E-04
169	3.18278E+08	.125	4.29716E-04	4.62232E-04
170	2.88879E+08	.075	2.22166E-04	2.39002E-04
171	2.68584E+08	.050	1.34976E-04	1.45213E-04
172	2.47875E+08	.025	6.38282E-05	6.86715E-05
173	2.41755E+08	.025	6.15855E-05	6.61748E-05
174	2.35786E+08	.075	1.71404E-04	1.84422E-04
175	2.18749E+08	.025	5.38248E-05	5.78534E-05
176	2.13348E+08	.100	1.93461E-04	2.08172E-04
177	1.93845E+08	.125	2.84686E-04	2.28279E-04
178	1.78362E+08	.125	1.69958E-04	1.82918E-04
179	1.58344E+08	.125	1.41889E-04	1.51852E-04
180	1.32678E+08	.125	1.17186E-04	1.26846E-04
181	1.17888E+08	.125	9.71856E-05	1.04611E-04
182	1.03338E+08	.125	8.86441E-05	8.68895E-05
183	9.11882E+07	.125	6.69188E-05	7.28293E-05
184	8.84733E+07	.125	5.55189E-05	5.97595E-05
185	7.18174E+07	.125	4.68493E-05	4.95754E-05
186	6.26727E+07	.125	3.81976E-05	4.11236E-05
187	5.53884E+07	.100	2.58111E-05	2.77899E-05
188	5.80451E+07	.100	2.22237E-05	2.39271E-05
189	4.52827E+07	.050	9.92583E-06	1.06859E-05
190	4.38743E+07	.050	9.88938E-06	9.91535E-06
191	4.89735E+07	.100	1.64739E-05	1.77371E-05
192	3.78744E+07	.100	1.41838E-05	1.82787E-05
193	3.35463E+07	.100	1.22183E-05	1.31469E-05
194	3.83539E+07	.050	6.31889E-06	6.88365E-06
195	2.86349E+07	.042	4.19289E-06	4.51458E-06
196	2.74654E+07	.050	4.69486E-06	5.85422E-06

GP	ENERGY (EV)	LETH WIDTH	JEZEREL LIB-IV CHI	GORIVA LIB-IV CHI
197	2.61259E+03	.050	4.35529E-06	4.60948E-06
198	2.40517E+03	.100	7.79023E-06	8.30804E-06
199	2.24067E+03	.100	6.30019E-06	7.22007E-06
200	2.03468E+03	.100	5.77291E-06	6.21601E-06
201	1.84106E+03	.100	4.96944E-06	5.35091E-06
202	1.66506E+03	.050	2.21008E-06	2.30933E-06
203	1.50461E+03	.050	2.05076E-06	2.21602E-06
204	1.50733E+03	.100	3.60229E-06	3.96499E-06
205	1.36309E+03	.100	3.16968E-06	3.41305E-06
206	1.23410E+03	.250	6.12562E-06	6.59599E-06
207	9.61117E+02	.250	4.21000E-06	4.33418E-06
208	7.40518E+02	.250	2.80443E-06	3.11673E-06
209	5.02947E+02	.250	1.90962E-06	2.14233E-06
210	4.53999E+02	.250	1.36749E-06	1.47253E-06
211	3.53579E+02	.250	9.39919E-07	1.01212E-06
212	2.73365E+02	.250	6.46020E-07	6.95657E-07
213	2.14454E+02	.250	4.44026E-07	4.70137E-07
214	1.67017E+02	.250	3.05103E-07	3.20629E-07
215	1.30073E+02	.250	2.09764E-07	2.25009E-07
216	1.01301E+02	.250	1.44164E-07	1.55240E-07
217	7.08933E+01	.250	9.90040E-08	1.06696E-07
218	6.14421E+01	.250	6.01001E-08	7.33322E-08
219	4.70512E+01	.250	4.60049E-08	5.04009E-08
220	3.72665E+01	.250	3.21007E-08	3.46402E-08
221	2.93232E+01	.250	2.21003E-08	2.30000E-08
222	2.26033E+01	.250	1.51956E-08	1.63630E-08
223	1.76035E+01	.250	1.04430E-08	1.12462E-08
224	1.37006E+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	5.04340E+00	.250	1.60162E-09	1.72467E-09
229	3.92786E+00	.250	1.10070E-09	1.10535E-09
230	3.05902E+00	.250	7.56552E-10	8.14670E-10
231	2.30237E+00	.250	5.19971E-10	5.59920E-10
232	1.85539E+00	.250	3.57370E-10	3.84827E-10
233	1.44000E+00	.250	2.45617E-10	2.64400E-10
234	1.12535E+00	.250	1.60010E-10	1.81700E-10
235	8.76425E-01	.050	2.60005E-11	2.80602E-11
236	8.33601E-01	.200	0.92120E-11	9.60670E-11
237	6.82560E-01	.000	3.15326E-11	3.39533E-11
238	6.25062E-01	.162	4.02075E-11	5.19113E-11
239	5.31579E-01	.250	5.40045E-11	5.90152E-11
240	4.13994E-01	10.631	1.20443E-10	1.29697E-10
	1.00000E-00			

TABLE A-IV

RELATIVE NEUTRON PRODUCTION RATES

Isotope	JEZEBEL			GODIVA		
	LIB-IV Old Chi	LIB-IV LIB-IV Chi	PRE-V Old Chi	LIB-IV Old Chi	LIB-IV LIB-IV Chi	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)

REFERENCES

1. H. Alter, R. B. Kidman, R. LaBauve, R. Protsik, and B. A. Zolotar, "ENDF-202 Cross Section Evaluation Working Group Benchmark Specifications," Brookhaven National Laboratory report BNL-19302 (1974).
2. D. Garber, Ed., "Data Formats and Procedures for the ENDF Neutron Cross Section Library," Brookhaven National Laboratory report BNL-50274 (1976).
3. C. R. Weisbin, P. D. Soran, R. E. MacFarlane, D. R. Harris, R. J. LaBauve, J. S. Hendricks, J. E. White, and R. B. Kidman, "MINX, A Multigroup Interpretation of Nuclear X-Sections from ENDF/B," Los Alamos Scientific Laboratory report LA-6486-MS (1976).
4. R. E. MacFarlane and R. M. Boicourt, "NJOY: A Neutron and Photon Cross-Section Processing System," Trans. Am. Nucl. Soc. 22, 720 (1975).
5. T. R. Hill, "ONETRAN: A Discrete Ordinates Finite Element Code for the Solution of the One-Dimensional Multigroup Transport Equation," Los Alamos Scientific Laboratory report LA-5990-MS (June 1975).
6. R. W. Hardie and W. W. Little, "1DX, A One-Dimensional Diffusion Code for Generating Effective Nuclear Cross Sections, Battelle Northwest Laboratory report BNWL=954 (March 1969).

Printed in the United States of America. Available from
National Technical Information Service
US Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Microfiche \$3.00

001-025	4.00	126-150	7.25	251-275	10.75	376-400	13.00	501-525	15.25
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	

Note: Add \$2.50 for each additional 100-page increment from 601 pages up.