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COMPARISON OF FISSION AND CAPTURE CROSS
SECTIONS OF MINOR ACTINIDES

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Comparison of Fission and Capture Cross Sections of Minor Actinides

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The fission and capture cross sections of minor actinides given in JENDL-3.3 are compared with other evaluated data and experimental data. The comparison was made for 32 nuclides of Th-227, 228, 229, 230, 233, 234, Pa-231, 232, 233, U-232, 234, 236, 237, Np-236, 237, 238, Pu-236, 237, 238, 242, 244, Am-241, 242, 242m, 243, Cm-242, 243, 244, 245, 246, 247 and 248. Given in the present report are figures of these cross sections and tables of cross sections at 0.0253 eV and resonance integrals.

Keywords: Fission Cross Section, Capture Cross Section, Thermal Cross Sections, Resonance Integrals, JENDL-3.3, Minor Actinides

マイナーアクチニドの核分裂断面積と捕獲断面積の比較

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JENDL-3.3 に与えられているマイナーアクチニドの核分裂断面積と捕獲断面積を他の評価済みデータおよび実験データと比較した。データを比較した核種は、Th-227、228、229、230、233、234、Pa-231、232、233、U-232、234、236、237、Np-236、237、238、Pu-236、237、238、242、244、Am-241、242、242m、243、Cm-242、243、244、245、246、247 および 248 の合計 32 核種である。本レポートでは、これらの核種の断面積図と、0.0253 eV における断面積および共鳴積分値の表を示す。

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1. Introduction

The latest version of Japanese Nuclear Data Library, JENDL-3.3¹⁾, was released in May 2002. This version contains the evaluated neutron-induced reaction data for 337 nuclides in the neutron energy range from 10^{-5} eV to 20 MeV. Data of important nuclides were revised from JENDL-3.2 to overcome the problems found in JENDL-3.2. Various kinds of benchmark tests were performed to confirm that JENDL-3.3 could predict reactor characteristics better than JENDL-3.2.

For minor actinides (MA), many kinds of data were also revised from JENDL-3.2, especially for important MA's of Np, Pu, Am and Cm isotopes. However, we did not update the data of less important minor actinides such as some of Th, Pa, Np, Bk, Cf isotopes. In the present work, therefore, we compared in graphs the data of JENDL-3.3 with other evaluations and experimental data to know the present status of the nuclear data for MA, and to identify the problems of the evaluated data. The data of ENDF/B-VI²⁾ and JEFF-3³⁾ were selected as "other evaluated data". Experimental data were taken from the EXFOR CD-ROM⁴⁾ provided by the IAEA Nuclear Data Section in May, 2002. The experimental data were stored once in the NESTOR-2 system⁵⁾ which was a data storage and retrieval system developed at the Nuclear Data Center, JAERI, and format-changed into suitable form for a graph drawing program.

The nuclides considered in the present work are 32 nuclides of Th-227, 228, 229, 230, 233, 234, Pa-231, 232, 233, U-232, 234, 236, 237, Np-236, 237, 238, Pu-236, 237, 238, 242, 244, Am-241, 242, 242m, 243, Cm-242, 243, 244, 245, 246, 247 and 248. The present comparison was restricted to the fission and capture cross sections which were the most important for the MA's..

In Chapter 2, the graphs of the fission and capture cross sections are shown for above-mentioned nuclides. Comparisons with experimental data measured with a lead slowing down spectrometer are given in a separate chapter, Chapter 3. Chapter 4 shows tables of cross sections at 0.0253 eV and resonance integral.

2. Graphs of Fission and Capture Cross Sections

The fission and capture cross sections of MA are shown in figures. Three types of figures are provided:

- (1) Comparison of evaluated data in the energy range from thermal to 20 MeV

Three sets of evaluated data (JENDL-3.3, ENDF/B-VI and JEFF-3) are drawn in each figure. The cross section in the energy range from 0.322 eV to the upper boundary of the resolved resonance region is averaged in the suitable energy intervals.

- (2) Comparison of evaluated data with experimental data below 10 eV
- (3) Comparison of evaluated data with experimental data above 1 keV

If data of cross section ratio are available, they are also shown.

Type 1 figures are drawn for all the nuclides. However, type 2 and 3 figures are created only in the cases where experimental data exist. The experimental data averaged with reactor spectra, fission spectra, etc. are excluded. However, Maxwellian averaged cross-section data at the thermal neutron energy are included in the figures of type 2. The data measured with a lead slowing-down spectrometer are also included. These data are shown in Chapter 3 again comparing with evaluated data broadened with experimental energy resolution. The evaluated data shown in these figures are cross sections at 0K.

Symbols of experimental data are changed every subentry of the EXFOR database. Therefore there are cases where several sets of experimental data are shown for a single reference. Usually error bars of experimental data are shown. However, they are not shown when so many data points are available. In a few figures, the experimental data are connected with a solid line.

When so many experimental data sets are available, only recent data sets are shown. In such cases, a cut-off year is indicated in a legend box.

For the cross-section ratio data, ratios of evaluated data were calculated using the data in the same library. For example, the ratio data of JENDL-3.3 to ^{235}U fission was calculated by using the ^{235}U data of JENDL-3.3. Only one exception is the ratio to ^{197}Au capture cross section. Since JENDL-3.3 does not contain the data of ^{197}Au , that of ENDF/B-VI was used instead.

References of experimental data shown in the figures are listed in Tables 2.1 to 2.31. In the tables, abbreviations of references and laboratories defined in CINDA⁽⁶⁾ and EXFOR⁽⁷⁾ are used.

Table 2.1 References of ^{227}Th experimental data

Reac.* ¹⁾	First author (year)* ²⁾	T* ³⁾	Reference	Year	Lab	Ent.#* ⁴⁾
FIS	H.R.Von Gunten+('70)	J	JIN,32,3441	1970	WUR	20438
FIS	P.DelMarmol+('73)	J	JIN,35,4323	1973	MOL	20351

*1) Type of reaction. "FIS": fission, "CAP": capture, "ABS": absorption.

*2) First author and year of publication. "+" means "et al."

*3) Type of reference (C: conference proceedings, J: journal, P: progress report, R: report, S: proceedings published as a laboratory report, T: thesis, W: private communication)

*4) Entry number defined in EXFOR. Data of references with Ent.# of "-" were not stored in EXFOR. Their data were directly taken from the reference.

Table 2.2 References of ^{228}Th experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	P.E.Vorotnikov+('72)	J	YF,16,(5),916	1972	KUR	40155
FIS	G.D.James+('83)	R	AERE-R-10842	1983	HAR	21877
FIS	G.D.James+('84)	J	NP/A,419,497	1984	HAR	68026

Table 2.3 References of ^{229}Th experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	M.H.Studier+('47)	R	CF-3809	1947	ANL	12296
FIS	B.M.Gokhberg+('59)	J	DOK,128,(5),911	1959	KUR	40713
FIS	J.E.Gindler+('60)	J	JIN,15,1	1960	ANL	12259
FIS	Ju.Ja.Konakhovich+('60)	J	AE,8,47	1960	KUR	40632

Table 2.4 References of ^{230}Th experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	M.I.Kazarinova+('60)	J	AE,8,139	1960	KUR	40636
FIS	D.W.Muir+('71)	C	71KNOX,1,292	1971	LAS	10223
FIS	J.E.Lynn+('72)	J	NP/A,189,225	1972	HAR	20472

FIS	J.Blons+('80)	W	Private communication	1980	GEL	21656
FIS	J.W.Meadows('83)	R	ANL-NDM-83	1983	ANL	10843
FIS	J.W.Meadows('88)	J	ANE,15,421	1988	ANL	13134
CAP	E.K.Hyde('48)	R	ANL-4183	1948	ANL	12292
CAP	H.Pomerance('53)	R	ORNL-1620,42	1953	ORL	12303
CAP	M.J.Cabell('58)	J	CJP,36,989	1958	CRC	12297

Table 2.5 Reference of ^{233}Th experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
CAP	F.J.Johnston+('60)	J	JNE,11,95	1960	ORL	11739

Table 2.6 References of ^{231}Pa experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	J.H.Williams('44)	R	LA-150	1944	LAS	12300
FIS	B.R.Leonard+('61)	J	BAP,6,8(A8)	1961	HAN	12286
FIS	S.M.Dubrovina+('64)	J	DOK,157,(3),561	1964	KUR	40716
FIS	O.Birgul+('69)	J	RCA,11,108	1969	KEN	21731
FIS	D.W.Muir+('71)	C	71KNOX,1,292	1971	LAS	10223
FIS	K.Kobayashi+('75)	R	KURRI-TR-8,10	1975	KTO	20562
FIS	E.M.Gryntakis('76)	T	(thesis)	1976	MUN	20625
FIS	R.H.Iyer+('76)	P	BARC-872,106	1976	TRM	30518
FIS	C.Wagemans+('77)	J	NP/A,285,32	1977	ILL	20824
FIS	C.Wagemans+('78)	J	ANE,5,267	1978	ILL	21538
FIS	S.Plattard+('81)	J	PRL,46,633	1981	ORL	10929
FIS	B.I.Fursov+('85)	J	AE,59,339	1985	FEI	40837
CAP	R.R.Smith+('56)	J	PR,101,1053	1956	MTR	12273
CAP	B.M.Aleksandrov+('72)	J	AE,32,(2),178	1972	RI	40163
CAP	E.M.Gryntakis+('74)	J	JIN,36,1447	1974	MUN	20634
CAP	K.Kobayashi('74)	P	NEANDC(J)-36L,40	1974	KTO	20691

Table 2.7 References of ^{232}Pa experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	S.Abramovich+('95)	C	95OBNIN,,303	1995	EPA	41324
FIS	Y.Danon+('96)	J	NSE,124,482	1996	LAS	13602
FIS	E.F.Fomushkin+('97)	C	97TRIEST,2,1353	1997	EPA	41341
CAP	E.M.Gryntakis('76)	T	(thesis)	1976	MUN	20625

Table 2.8 References of ^{233}Pa experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
CAP	R.R.Smith+('55)	R	IDO-16226	1955	MTR	12299
CAP	T.A.Eastwood+('60)	J	CJP,38,751	1960	CRC	12256
CAP	J.Halperin+('62)	R	ORNL-3320,1	1962	ORL	12302
CAP	J.C.Connor('70)	R	WAPD-TM-837	1970	BET	10083

Table 2.9 References of ^{232}U experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	G.T.Seaborg+('46)	P	CS-3471,2	1946	ANL	12287
FIS	R.Elson+('53)	J	PR,89,320	1953	ANL	12387
FIS	G.D.James('64)	J	NP,55,517	1964	HAR	20916
FIS	G.F.Auchampaugh+('68)	J	NP/A,112,329	1968	LRL	12383
FIS	J.A.Farrell('70)	R	LA-4420,3	1970	LAS	10055
FIS	P.E.Vorotnikov+('70)	P	YFI-10,30	1970	KUR	40057
FIS	M.J.Cabell+('71)	C	71CANT,,161	1971	HAR	20477
FIS	E.M.Gryntakis('76)	T	(thesis)	1976	MUN	20625
FIS	B.I.Fursov+('86)	J	AE,61,383	1986	FEI	40919
CAP	J.Halperin+('65)	J	NSE,21,257	1965	ORL	12374
CAP	M.J.Cabell+('71)	C	71CANT,,161	1971	HAR	20477

Table 2.10 References of ^{234}U experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	R.W.Lamphere('53)	J	PR,91,655	1953	ORL	13776
FIS	R.W.Lamphere('56)	J	PR,104,1654	1956	ORL	12338
FIS	R.H.Odegaarden('60)	R	HW-64866,4	1960	HAN	12320
FIS	R.V.Babcock('61)	W	Private communication	1961	BET	12294
FIS	R.W.Lamphere('62)	J	NP,38,561	1962	ORL	12325
FIS	J.L.Perkin+('65)	J	JNE/AB,19,(6),423	1965	ALD	20584
FIS	P.H.White+('65)	C	65SALZBURG,1,219	1965	ALD	21463
FIS	P.H.White+('67)	J	JNE,21,671	1967	ALD	21195
FIS	G.D.James+('68)	J	NP/A,118,313	1968	HAR	20975
FIS	G.D.James+('77)	J	PR/C,15,2083	1977	ORL	10620
FIS	J.W.Behrens+('77)	J	NSE,63,250	1977	LRL	10653
FIS	J.W.Meadows('78)	J	NSE,65,171	1978	ANL	10654
FIS	K.Kanda+('85)	R	JAERI-M-85-035,220	1985	TOH	21963
FIS	A.A.Goverdovskij+('86)	J	AE,60,(6),416	1986	FEI	40885
FIS	A.A.Goverdovskiy+('86)	J	YF,44,287	1986	FEI	40913
FIS	K.Kanda+('86)	J	RE,93,233	1986	TOH	22014
FIS	A.A.Goverdovskiy+('87)	J	AE,63,(1),60	1987	FEI	40954
FIS	J.W.Meadows('88)	J	ANE,15,421	1988	ANL	13134
FIS	B.I.Fursov+('91)	J	AE,71,(4),320	1991	FEI	41111
CAP	H.Pomerance('51)	P	ORNL-CF-51-12,151	1951	ORL	12353
CAP	M.Lounsbury+('70)	C	70HELSINKI,1,287(2)	1970	CRC	10013
CAP	M.J.Cabell+('71)	R	AERE-R-6761	1971	HAR	20449
CAP	G.V.Muradyan+('99)	S	JINR-E3-98-212,287	1999	KUR	41354

Table 2.11 References of ^{236}U experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	J.L.Perkin+('65)	J	JNE/AB,19,(6),423	1965	ALD	20584
FIS	P.H.White+('65)	C	65SALZBURG,1,219	1965	ALD	21463
FIS	P.H.White+('67)	J	JNE,21,671	1967	ALD	21195
FIS	J.W.Cramer+('70)	R	LA-4420,74	1970	LAS	10058
FIS	H.Rosler+('72)	J	PL/B,38,501	1972	ORL	10262
FIS	J.W.Behrens+('77)	J	NSE,63,250	1977	LRL	10653
FIS	C.Nordborg+('78)	C	78HARWELL,910	1978	UPP	20844
FIS	J.W.Meadows('78)	J	NSE,65,171	1978	ANL	10654
FIS	A.A.Goverdovskij+('84)	C	84UPPSAL,,315	1984	FEI	40832
FIS	A.A.Goverdovskiy+('85)	J	AE,59,429	1985	FEI	40921
FIS	B.I.Fursov+('85)	J	AE,59,284	1985	FEI	40836
FIS	A.A.Goverdovskij+('86)	J	AE,60,(6),416	1986	FEI	40885
FIS	H.Terayama+('86)	P	NETU-47	1986	TOH	22024

FIS	J.W.Meadows('88)	J	ANE,15,421	1988	ANL	13134
FIS	D.L.Shpak+('90)	J	AE,69,(5),336	1990	FEI	41096
CAP	D.C.Stupegia+('61)	J	JNE,15,200	1961	ANL	12450
CAP	J.F.Barry+('61)	J	PPS,78,801	1961	ALD	60817
CAP	J.R.Berreth+('62)	P	WASH-1041,37	1962	MTR	12635
CAP	N.P.Baumann+('68)	J	NSE,32,265	1968	SRL	12466
CAP	R.P.Schuman+('69)	R	IN-1296	1969	MTR	11687
CAP	A.D.Carlson('70)	J	NP/A,141,577	1970	GA	10695
CAP	M.J.Cabell+('71)	R	AERE-R-6761	1971	HAR	20449
CAP	A.A.Bergman+('82)	J	AE,52,(6),406	1982	FEI	40625
CAP	L.E.Kazakov+('85)	J	YK,1985,(2),44	1985	FEI	40890
CAP	A.N.Gudkov+('86)	J	AE,61,379	1986	MIF	40886
CAP	A.N.Davletshin+('87)	C	87KIEV,2,309	1987	FEI	40988
CAP	Yu.N.Trofimov('87)a	C	87KIEV,3,331	1987	RI	41001
CAP	Yu.N.Trofimov('87)b	J	YK,,(4),10	1987	RI	40975
CAP	P.N.Vorona+('87)	C	87KIEV,2,283	1987	IJI	41012
CAP	N.N.Buleeva+('88)	J	AE,65,(6),348	1988	FEI	40969
CAP	Yu.N.Trofimov('88)	J	AE,64,(2),150	1988	RI	40958
CAP	Yu.V.Adamchuk+('88)	J	AE,65,(5),356	1988	KUR	40987
CAP	G.V.Muradyan+('99)	S	JINR-E3-98-212,287	1999	KUR	41354

Table 2.12 References of ^{237}U experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	G.A.Cowen+('55)	R	LA-1669,8	1955	LAS	12500
FIS	J.W.McNally+('74)	J	PR/C,9,717	1974	LAS	10059

Table 2.13 References of ^{236}Np experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	A.H.Jaffey+('61)	R	ANL-6600,124	1961	ANL	12251
FIS	G.V.Val'skiy+('87)	C	87KIEV,3,99	1987	KUR	40995
FIS	Y.Danon+('96)	J	NSE,124,482	1996	LAS	13602

Table 2.14 References of ^{237}Np experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	B.R.LeonardJr+('59)	J	BAP,4,31(K1)	1959	HAN	12476
FIS	S.Plattard('73)	T	(thesis)	1973	SAC	20448
FIS	C.Wagemans+('77)	J	NP/A,285,32	1977	ILL	20824
FIS	V.M.Kuprijanov+('78)	J	AE,45,(6),440	1978	FEI	40507
FIS	R.Arlt+('81)	J	KE,24,48	1981	TUD	30475
FIS	J.W.Behrens+('82)	J	NSE,80,393	1982	LRL	10647
FIS	M.Cance+('82)	C	82ANTWER,51	1982	BRC	21821
FIS	I.D.Alkhazov+('83)	C	83MOSKVA,2,201	1983	TUD	40911
FIS	J.W.Meadows('83)	J	NSE,85,271	1983	ANL	12852
FIS	A.A.Goverdovskij+('84)	J	YK,3/57,13	1984	FEI	40835
FIS	A.A.Goverdovskij+('84)	R	FEI-1552	1984	FEI	40833
FIS	I.Garlea+('84)	J	RRP,29,421	1984	PIT	30813
FIS	K.R.Zasadny+('84)	J	ANS,47,425	1984	MHG	12910
FIS	Wu Jingxia+('84)	J	CNP,6,369	1984	AEP	30717
FIS	A.A.Goverdovskij+('85)	J	AE,58,(2),137	1985	FEI	40861
FIS	K.Kanda+('85)	R	JAERI-M-85-035,220	1985	TOH	21963
FIS	R.Arlt+('85)	J	IP,21,344	1985	TUD	30558
FIS	H.Terayama+('86)	P	NETU-47	1986	TOH	22024
FIS	I.D.Alkhazov+('86)	J	YK,1986,(4),19	1986	RI	40927
FIS	I.Garlea+('86)	P	INDC(ROM)-017,22	1986	BUC	31459
FIS	V.V.Kozharin+('86)	J	AE,60,(6),419	1986	RI	40901
FIS	V.A.Kalinin+('87)	J	YK,,(4),3	1987	RI	40976
FIS	J.W.Meadows('88)	J	ANE,15,421	1988	ANL	13134
FIS	L.Desdin+('89)	J	AHP,65,(2-3),271	1989	KOS	31425
FIS	K.Merla+('91)	C	91JUELIC,,510	1991	DRE	22304
CAP	D.C.Stupegia+('67)	J	NSE,29,218	1967	ANL	12483
CAP	M.Lindner+('76)	J	NSE,59,381	1976	LRL	10221
CAP	L.W.Weston+('81)	J	NSE,79,184	1981	ORL	10887
CAP	Ju.N.Trofimov+('83)	C	83KIEV,2,142	1983	RI	40827
CAP	Yu.N.Trofimov('87)	J	YK,,(4),10	1987	RI	40975
CAP	N.N.Buleeva+('88)	J	AE,65,(6),348	1988	FEI	40969
CAP	K.Kobayashi+('93)	S	JAERI-M-94-019,171	1993	KTO	22366

Table 2.15 References of ^{238}Np experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	J.D.Spencer+('69)	J	ANS,12,284	1969	SRL	12475
FIS	S.Abramovich+('95)	C	95OBNIN,,303	1995	EPA	41324
FIS	Y.Danon+('96)	J	NSE,124,482	1996	LAS	13602
FIS	E.F.Fomushkin+('97)	C	97TRIEST,2,1353	1997	EPA	41341

Table 2.16 References of ^{236}Pu experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	J.E.Gindler+('59)	J	PR,115,1271	1959	ANL	13572
FIS	P.E.Vorotnikov+('87)	C	87KIEV,3,76	1987	KUR	40992
FIS	B.N.Belyaev+('90)	J	AE,68,(4),285	1990	KUR	41093
FIS	E.F.Gromova+('90)	J	AE,68,(3),193	1990	KUR	41064
FIS	V.F.Gerasimov+('97)	S	JINR-E3-97-213,348	1997	KUR	41369

Table 2.17 Reference of ^{237}Pu experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	J.E.Gindler+('59)	J	PR,115,1271	1959	ANL	13572

Table 2.18 References of ^{238}Pu experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	G.C.Hanna+ ('51)	J	PR,81,893	1951	CRC	12496
FIS	E.K.Hulet+ ('57)	J	PR,107,1294	1957	LRL	12497
FIS	T.A.Eastwood+ ('58)	C	58GENEVA,16,54(203)	1958	CRC	12011
FIS	V.F.Gerasimov('66)	J	YF,4,(5),985	1966	KUR	40085
FIS	W.F.Stubbins+('67)	J	PR,154,1111	1967	LRL	12489
FIS	E.F.Fomushkin+('69)	J	YF,10,(5),917	1969	KUR	40012
FIS	D.M.Drake+('70)	R	LA-4420,101	1970	LAS	10061
FIS	M.G.Silbert+('73)	J	NSE,52,176	1973	LAS	10032
FIS	H.-H.Knitter+('81)	W	Private communication	1981	GEL	21763
FIS	C.Budtz-Joergensen+('82)	C	82ANTWER,,206	1982	GEL	21828
FIS	B.M.Aleksandrov+('83)	J	YK,1/50,3	1983	RI	40673
FIS	B.Alam+('88)	J	NSE,99,268	1988	RPI	12991
FIS	V.S.Zenkevich+('90)	J	YK,,(4),6	1990	KUR	41091
FIS	B.I.Fursov+('97)	C	97TRIEST,1,488	1997	FEI	41303
CAP	J.Butler+('57)	J	CJP,35,147	1957	CRC	12481
CAP	M.G.Silbert+('73)	J	NSE,52,187	1973	LAS	10291

Table 2.19 References of ^{242}Pu experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	T.A.Eastwood+ ('58)	C	58GENEVA,16,54(203)	1958	CRC	12011
FIS	E.F.Fomushkin+('69)	J	YF,10,(5),917	1969	KUR	40012
FIS	J.W.Behrens+('78)	J	NSE,66,433	1978	LRL	10597
FIS	J.W.Meadows('78)	J	NSE,68,360	1978	ANL	10749
FIS	V.M.Kuprijanov+('79)	J	AE,46,(1),35	1979	FEI	40509
FIS	N.A.Khan+('80)	J	NIM,173,137	1980	NIL	30548
FIS	M.Cance+('82)	C	82ANTWER,51	1982	BRC	21821
FIS	I.D.Alkhazov+('83)	C	83MOSKVA,2,201	1983	TUD	40911
FIS	H.Weigmann+('84)	J	NP/A,438,(2),333	1984	GEL	21996
FIS	R.Arlt+('85)	J	IP,21,344	1985	TUD	30475
FIS	J.W.Meadows('88)	J	ANE,15,421	1988	ANL	13134
FIS	T.Iwasaki+('90)	J	NST,27,(10),885	1990	TOH	22211
FIS	P.Staples+('98)	J	NSE,129,149	1998	LAS	13801
CAP	J.Butler+('57)	J	CJP,35,147	1957	CRC	12481
CAP	R.W.Durham+('70)	J	CJP,48,716	1970	CRC	10171
CAP	R.W.Hockenbury+('75)	C	75WASH,2,584	1975	RPI	10436
CAP	P.J.Bendt+('79)	R	LA-7853	1979	LAS	10891

Table 2.20 References of ^{244}Pu experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	G.F.Auchampaugh+('71)	J	NP/A,171,31	1971	LAS	10266
FIS	B.M.Gokhberg+('76)	P	YFI-22,10	1976	KUR	40406
FIS	E.F.Fomushkin+('76)	P	YFI-22,11	1976	EPA	40407
FIS	J.W.Behrens+('78)	J	NSE,66,433	1978	LRL	10648
FIS	N.A.Khan+('80)	J	NIM,173,137	1980	NIL	30548
FIS	M.S.Moore+('83)	J	NP/A,393,(1),1	1983	GEL	21806
FIS	P.Staples+('98)	J	NSE,129,149	1998	LAS	13801
CAP	R.P.Schuman('69)	P	IN-1317,54	1969	MTR	12510

Table 2.21 References of ^{241}Am experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	V.F.Gerasimov('62)	J	IFG,8,75	1962	CCP	40801
FIS	C.D.Bowman+('65)	J	PR/B,137,326	1965	LRL	12571
FIS	M.Hyakutake('66)	W	Private communication	1966	KYU	20274
FIS	V.F.Gerasimov('66)	J	YF,4,(5),985	1966	KUR	40085
FIS	E.F.Fomushkin+('69)	J	YF,10,(5),917	1969	KUR	40012
FIS	H.Derrien+('75)	C	75WASH,2,637	1975	SAC	20415
FIS	K.D.Zhuravlev+('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	V.D.Gavrilov+('75)	J	AE,41,185	1975	NIR	40467
FIS	V.M.Kuprijanov+('78)	J	AE,45,(6),440	1978	FEI	40507
FIS	H.H.Knitter+('79)	J	AKE,33,205	1979	GEL	20764
FIS	K.Wisshak+('80)	J	NSE,76,(2),148	1980	KFK	20774
FIS	N.A.Khan+('80)	J	NIM,173,137	1980	NIL	30548
FIS	J.W.Behrens+('81)	J	NSE,77,444	1981	LRL	10652
FIS	M.Cance+('81)	R	CEA-N-2194	1981	BRC	21621
FIS	B.M.Aleksandrov+('83)	J	YK,1/50,3	1983	RI	40673
FIS	J.W.T.Dabbs+('83)	J	NSE,83,22	1983	ORL	12809
FIS	P.E.Vorotnikov+('86)	J	YF,44,(6),1403	1986	KUR	40948
FIS	K.Kobayashi+('96)	S	JAERI-97-004,47	1996	KTO	22344
FIS	V.Ya.Golovnya+('99)	S	JINR-E3-419,293	1999	KFT	41361
CAP	H.Pomerance('55)	P	ORNL-1879,50	1955	ORL	11885
CAP	R.A.Deal+('64)	P	WASH-1053,76	1964	MTR	12573
CAP	G.N.Flerov+('67)	J	NP/A,102,443	1967	BUC	30021
CAP	R.M.Harbour+('73)	J	NSE,50,364	1973	SRL	10317
CAP	V.D.Gavrilov+('75)	J	AE,41,185	1975	NIR	40467
CAP	D.B.Gayther+('77)	C	77KIEV,3,3	1977	HAR	20785
CAP	G.Vanpraet+('85)	C	85SANTA,1,493	1985	UIA	21978
CAP	N.Shinohara+('97)	J	NST,34,613	1997	JAE	-
CAP	N.L.Maidana+('01)	J	RCA,89,419	2001	IPE	31518

Table 2.22 References of ^{242}Am experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	G.C.Hanna+('51)	J	PR,81,893	1951	CRC	12496
FIS	G.H.Higgins+('54)	J	PR,94,735	1954	BRK	12584

Table 2.23 References of ^{242m}Am experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	K.Street Jr+ ('52)	J	PR,85,135	1952	BRK	12583
FIS	E.K.Hulet+ ('57)	J	PR,107,1294	1957	LRL	12497
FIS	K.Wolfsberg+ ('66)	J	JNE,20,588	1966	LAS	12563
FIS	K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	J.W.T.Dabbs+('83)	J	NSE,84,1	1983	ORL	12808
FIS	J.C.Browne+('84)	J	PR/C,29,2188	1984	LRL	10805
FIS	V.F.Gerasimov+('87)	C	87KIEV,3,84	1987	KUR	40993
FIS	B.M.Gokhberg+('91)	J	YF,53,(3),653	1991	KUR	41108
FIS	B.I.Fursov+('97)	C	97TRIEST,1,488	1997	FEI	41303
FIS	V.F.Gerasimov+('97)	S	JINR-E3-97-213,348	1997	KUR	41369
FIS	T.Kai+ ('01)	J	ANE,28,723	2001	KTO	-

Table 2.24 References of ^{243}Am experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	K.Street Jr+('52)	J	PR,85,135	1952	BRK	12583
FIS	E.K.Hulet+('57)	J	PR,107,1294	1957	LRL	12497
FIS	V.D.Gavrilov+('75)	J	AE,41,185	1975	NIR	40467
FIS	J.W.Behrens+('81)	J	NSE,77,444	1981	LRL	10652
FIS	K.Wisshak+('83)	J	NSE,85,251	1983	KFK	21863
FIS	E.F.Fomushkin+('84)	J	YK,3/57,17	1984	KUR	40856
FIS	B.I.Fursov+('85)	J	AE,59,339	1985	FEI	40837
FIS	A.A.Goverdovskiy+('86)	C	85SANTA,1,629	1986	FEI	40912
FIS	H.Terayama+('86)	P	NETU-47	1986	TOH	22024
FIS	K.Kanda+('87)	J	NST,24,423	1987	TOH	22044
FIS	H.Knitter+('88)	J	NSE,99,1	1988	GEL	22032
FIS	A.A.Goverdovskiy+('89)	J	AE,67,(1),30	1989	FEI	41058
FIS	K.Kobayashi+('99)	J	NST,36,(1),20	1999	KTO	22422
FIS	V.Ya.Golovnya+('99)	S	JINR-E3-419,293	1999	KFT	41361
CAP	K.Street Jr+('50)	J	PR,79,530	1950	BRK	12581
CAP	J.Butler+('57)	J	CJP,35,147	1957	CRC	12481
CAP	M.A.Bak+ ('67)	J	SJA,23,1059	1967	FTI	-
CAP	R.P.Schuman('67)	R	IN-1126,19	1967	MTR	12577
CAP	R.L.Folger+('68)	C	68WASH,2,1279(H11)	1968	SRL	12534
CAP	V.D.Gavrilov+('75)	J	AE,41,185	1975	NIR	40467
CAP	K.Wisshak+('83)	J	NSE,85,251	1983	KFK	21863
CAP	L.W.Weston+('85)	J	NSE,91,444	1985	ORL	12951
CAP	Y.Hatsukawa+('97)	S	JAERI-98-003,221	1997	JAE	22429

Table 2.25 References of ^{242}Cm experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	E.F.Fomushkin+('67)	J	YF,5,(5),966	1967	KUR	40779
FIS	P.E.Vorotnikov+('84)	J	YF,40,(5),1141	1984	KUR	40597
FIS	B.Alam+('88)	J	NSE,99,268	1988	RPI	12991

Table 2.26 References of ^{243}Cm experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	E.K.Hulet+('57)	J	PR,107,1294	1957	LRL	12497
FIS	C.E.Bemis+('77)	J	NSE,63,413	1977	ORL	10681
FIS	K.D.Zhuravlev+('79)	J	AE,47,(1),55	1979	NIR	40490
FIS	E.F.Fomushkin+('87)	J	AE,62,(4),278	1987	KUR	40931
FIS	E.F.Fomushkin+('90)	J	AE,69,(4),258	1990	EPA	41095
FIS	E.F.Fomushkin+('91)	C	91JUELIC,,439	1991	EPA	41180
FIS	B.I.Fursov+('97)	C	97TRIEST,1,488	1997	FEI	41343
CAP	C.E.Bemis+('77)	J	NSE,63,413	1977	ORL	10681

Table 2.27 References of ^{244}Cm experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	M.S.Moore+('71)	J	PR/C,3,1656	1971	LAS	10121
FIS	R.W.Benjamin+('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	E.F.Fomushkin+('80)	J	YF,31,(1),39	1980	KUR	40571
FIS	P.E.Vorotnikov+('81)	J	YK,1/40,44	1981	KUR	40668
FIS	H.T.Maguire Jr+('85)	J	NSE,89,293	1985	RPI	12788
FIS	E.F.Fomushkin+('91)	C	91JUELIC,,439	1991	EPA	41180
FIS	B.I.Fursov+('97)	C	97TRIEST,1,488	1997	FEI	41343
CAP	M.S.Moore+('71)	J	PR/C,3,1656	1971	LAS	10121
CAP	V.D.Gavrilov+('78)	J	AE,44,(3),246	1978	NIR	40486

Table 2.28 References of ^{245}Cm experimental data

Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	E.K.Hulet+('57)	J	PR,107,1294	1957	LRL	12497
FIS	H.Diamond+('68)	J	JIN,30,2553	1968	ANL	12531
FIS	J.C.Browne+('78)	J	NSE,65,166	1978	LRL	10730
FIS	J.Halperin+('70)	P	ORNL-4581,37	1970	ORL	10165
FIS	M.S.Moore+('71)	J	PR/C,3,1656	1971	LAS	10121
FIS	R.W.Benjamin+('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	V.D.Gavrilov+('75)	J	AE,41,185	1975	NIR	40467
FIS	E.F.Fomushkin+('87)	J	AE,63,(4),242	1987	KUR	41023
FIS	V.F.Gerasimov+('87)	C	87KIEV,3,84	1987	KUR	40993
FIS	B.M.Gokhberg+('91)	J	YF,53,(3),649	1991	KUR	41108
FIS	E.F.Fomushkin+('91)	C	91JUELIC,,439	1991	EPA	41180
FIS	M.I.Kuvshinov+('96)	C	96MITO,2,338	1996	EPA	41359
FIS	I.A.Ivanin+('97)	C	97TRIEST,1,664	1997	EPA	41360
FIS	B.I.Fursov+('97)	C	97TRIEST,1,488	1997	FEI	41303
FIS	V.F.Gerasimov+('97)	S	JINR-E3-97-213,348	1997	KUR	41369
CAP	J.Halperin+('69)	P	ORNL-4437	1969	ORL	10164
CAP	V.D.Gavrilov+('78)	J	AE,44,(3),246	1978	NIR	40486

Table 2.29 References of ^{246}Cm experimental data

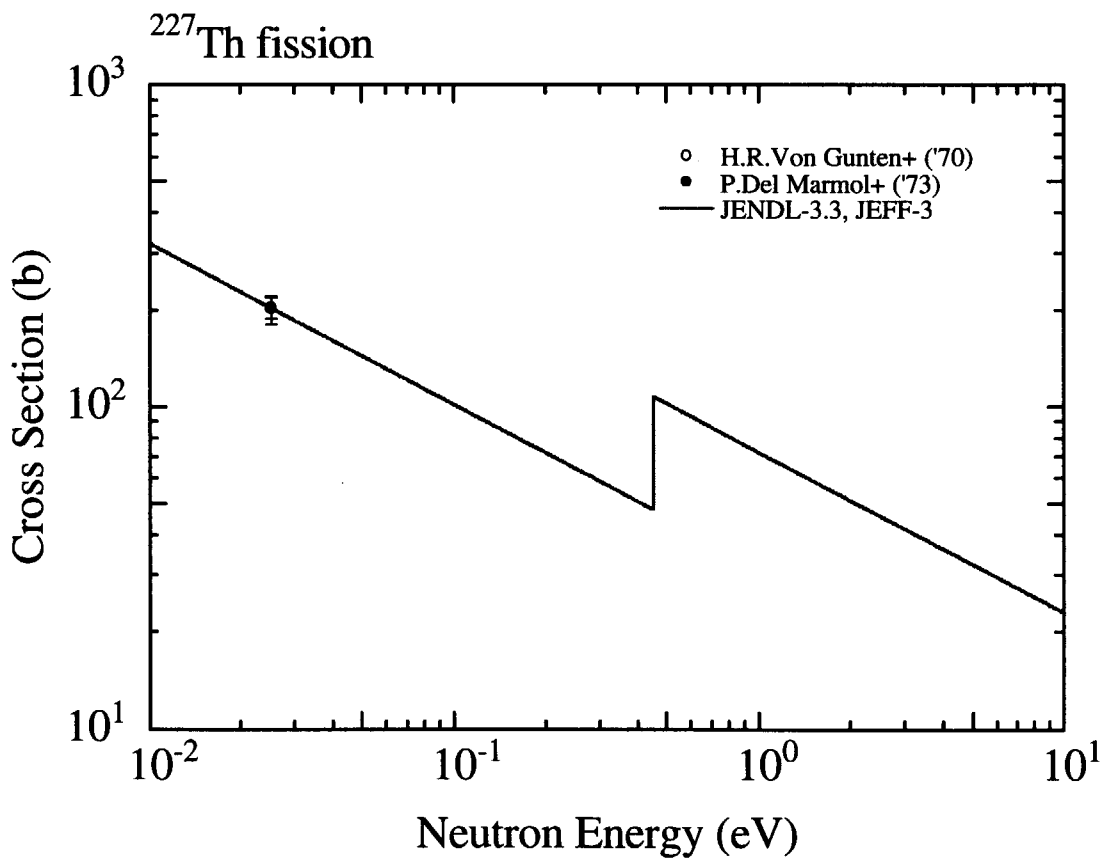
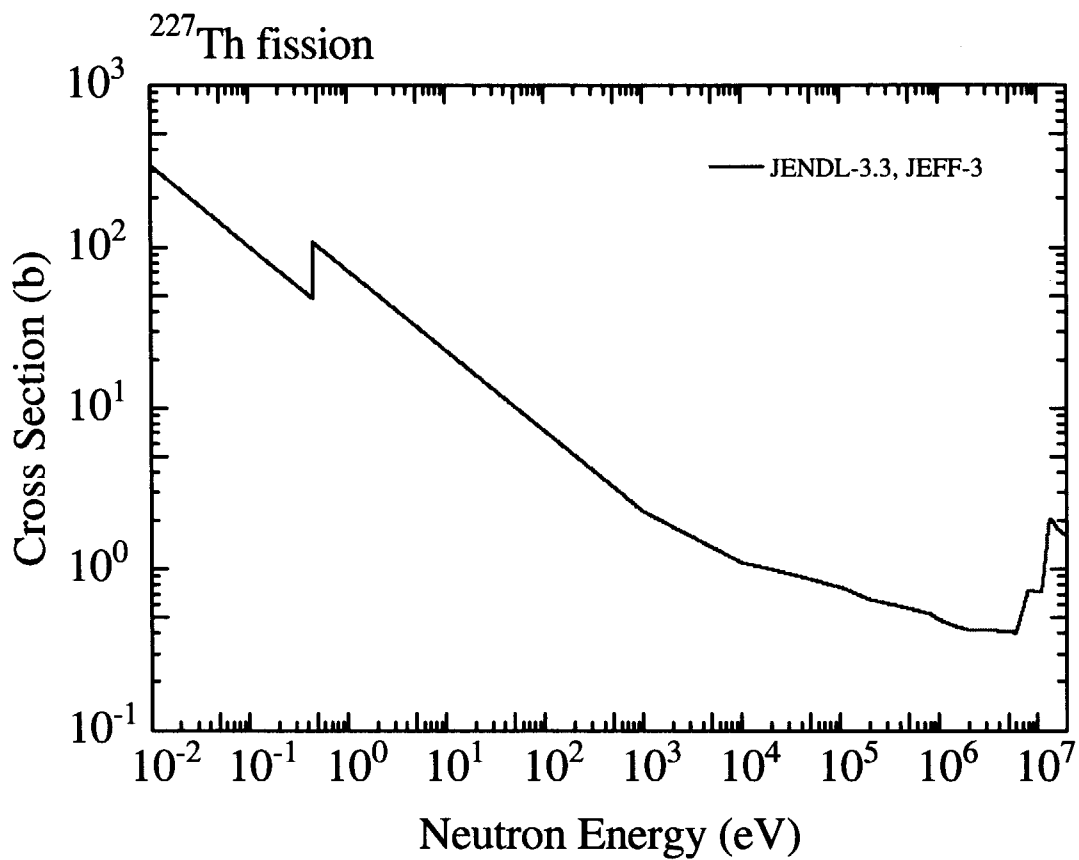
Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	M.S.Moore+('71)	J	PR/C,3,1656	1971	LAS	10121
FIS	R.W.Benjamin+('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	E.F.Fomushkin+('80)	J	YF,31,(1),39	1980	KUR	40571
FIS	H.T.Maguire Jr+('85)	J	NSE,89,293	1985	RPI	12788
FIS	E.F.Fomushkin+('91)	C	91JUELIC,,439	1991	EPA	41180
FIS	B.I.Fursov+('97)	C	97TRIEST,1,488	1997	FEI	41343
FIS	I.A.Ivanin+('97)	C	97TRIEST,1,664	1997	EPA	41360
CAP	J.Halperin+('69)	P	ORNL-4437	1969	ORL	10164
CAP	V.D.Gavrilov+('78)	J	AE,44,(3),246	1978	NIR	40486

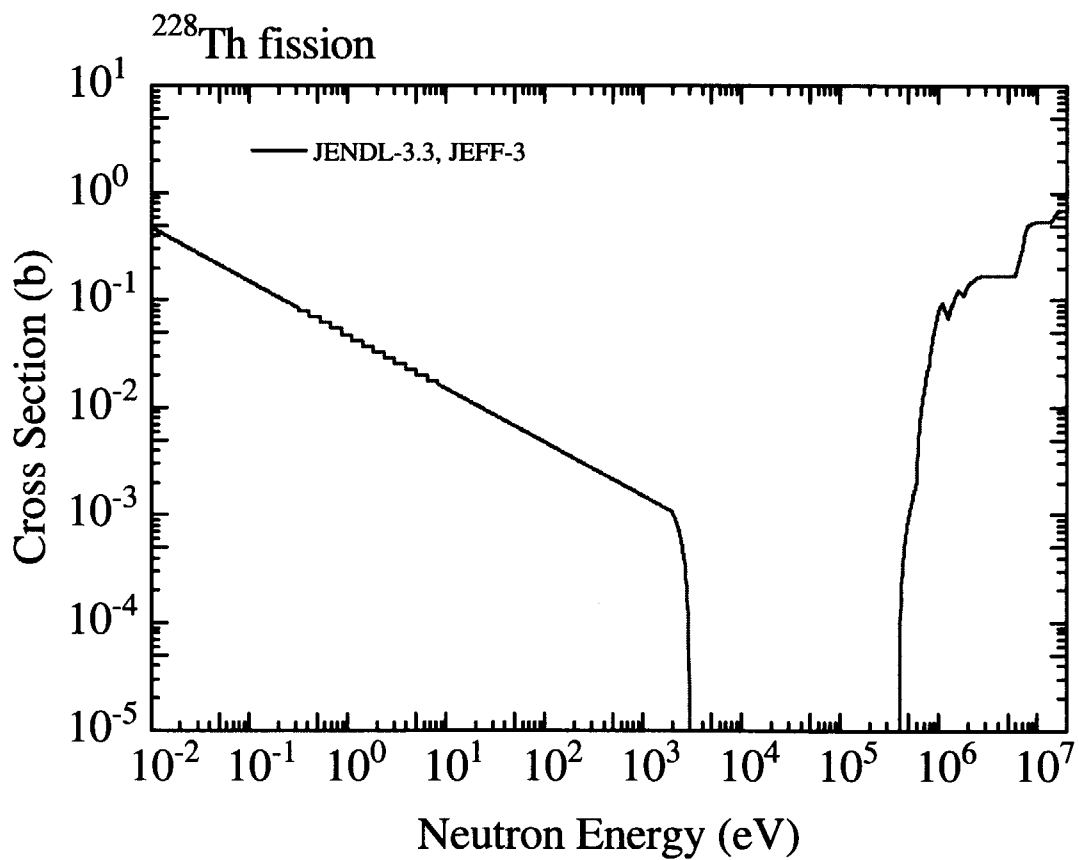
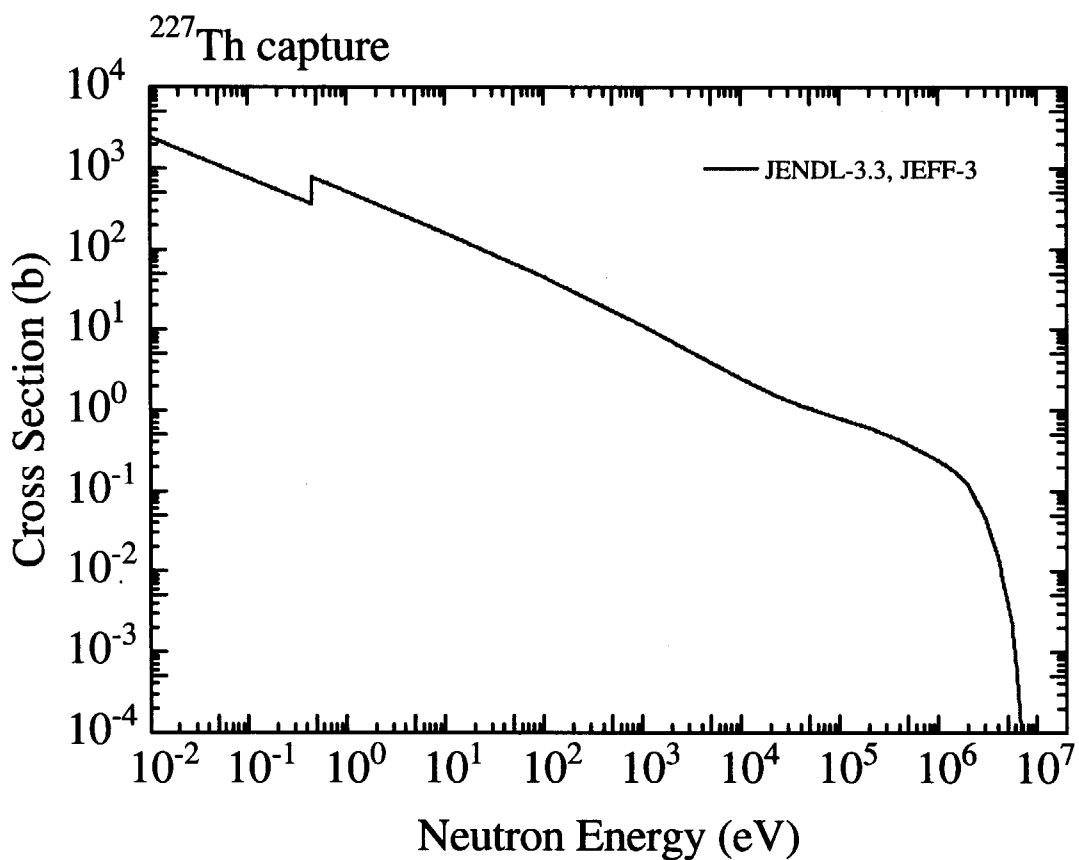
Table 2.30 References of ^{247}Cm experimental data

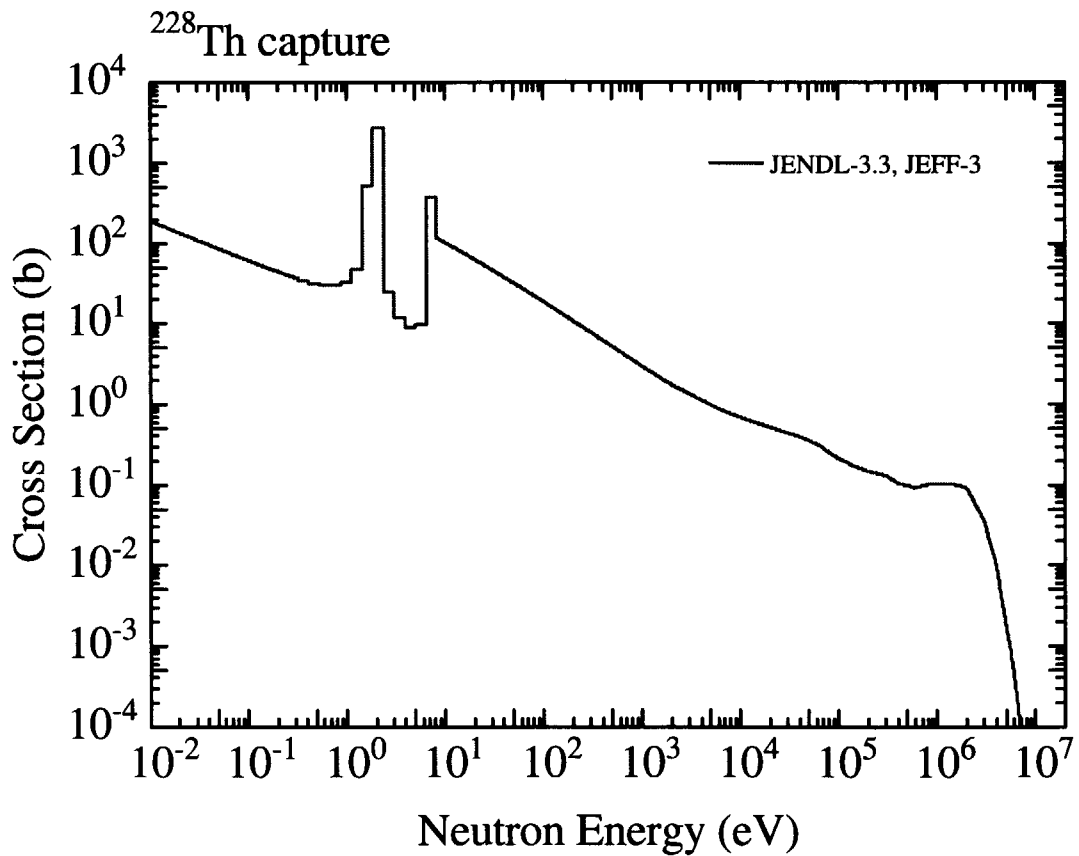
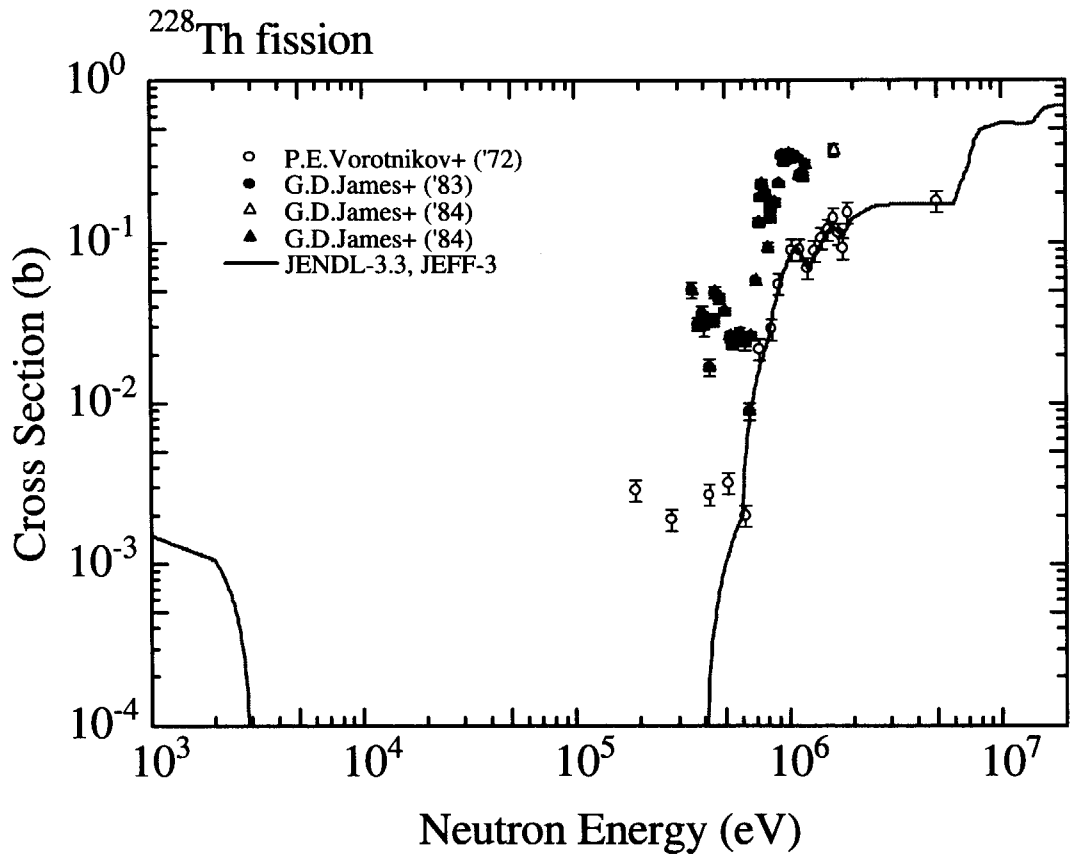
Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	H.Diamond+('68)	J	JIN,30,2553	1968	ANL	12531
FIS	J.Halperin+('70)	P	ORNL-4581,37	1970	ORL	10165
FIS	M.S.Moore+('71)	J	PR/C,3,1656	1971	LAS	10121
FIS	R.W.Benjamin+('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	E.F.Fomushkin+('87)	J	AE,62,(4),279	1987	KUR	40931
FIS	E.F.Fomushkin+('91)	C	91JUELIC,,439	1991	EPA	41180
FIS	Y.Danon+('91)	J	NSE,109,341	1991	RPI	13197
FIS	Y.Danon+('94)	C	94GATLIN,1,245	1994	LAS	13646
FIS	M.I.Kuvshinov+('96)	C	96MITO,2,338	1996	EPA	41359
FIS	B.I.Fursov+('97)	C	97TRIEST,1,488	1997	FEI	41303
FIS	I.A.Ivanin+('97)	C	97TRIEST,1,664	1997	EPA	41360
CAP	V.D.Gavrilov+('78)	J	AE,44,(3),246	1978	NIR	40486

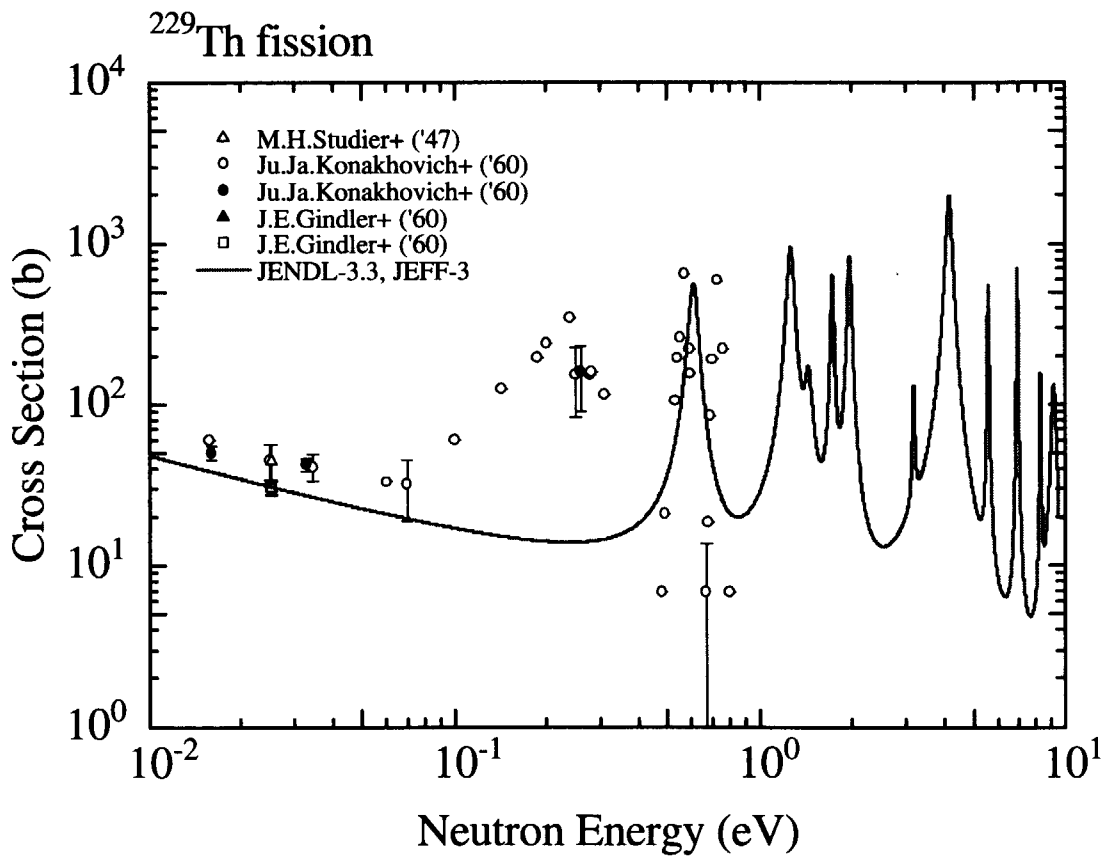
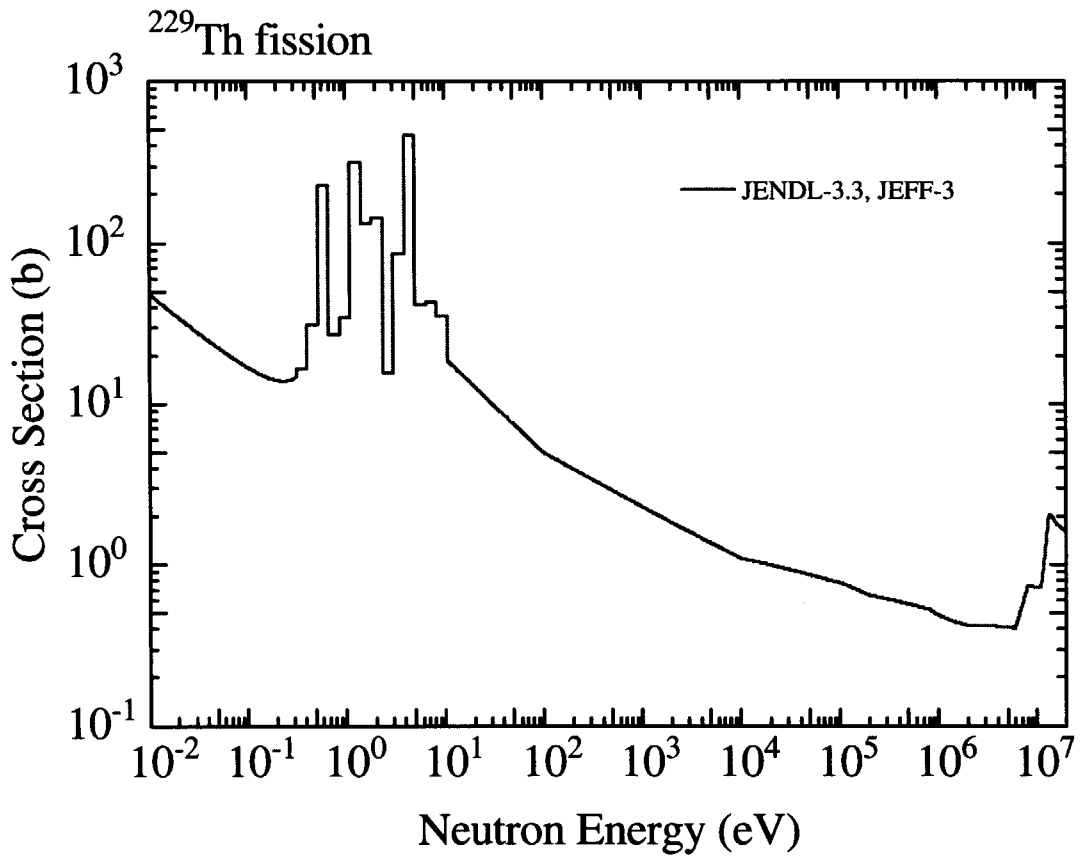
Table 2.31 References of ^{248}Cm experimental data

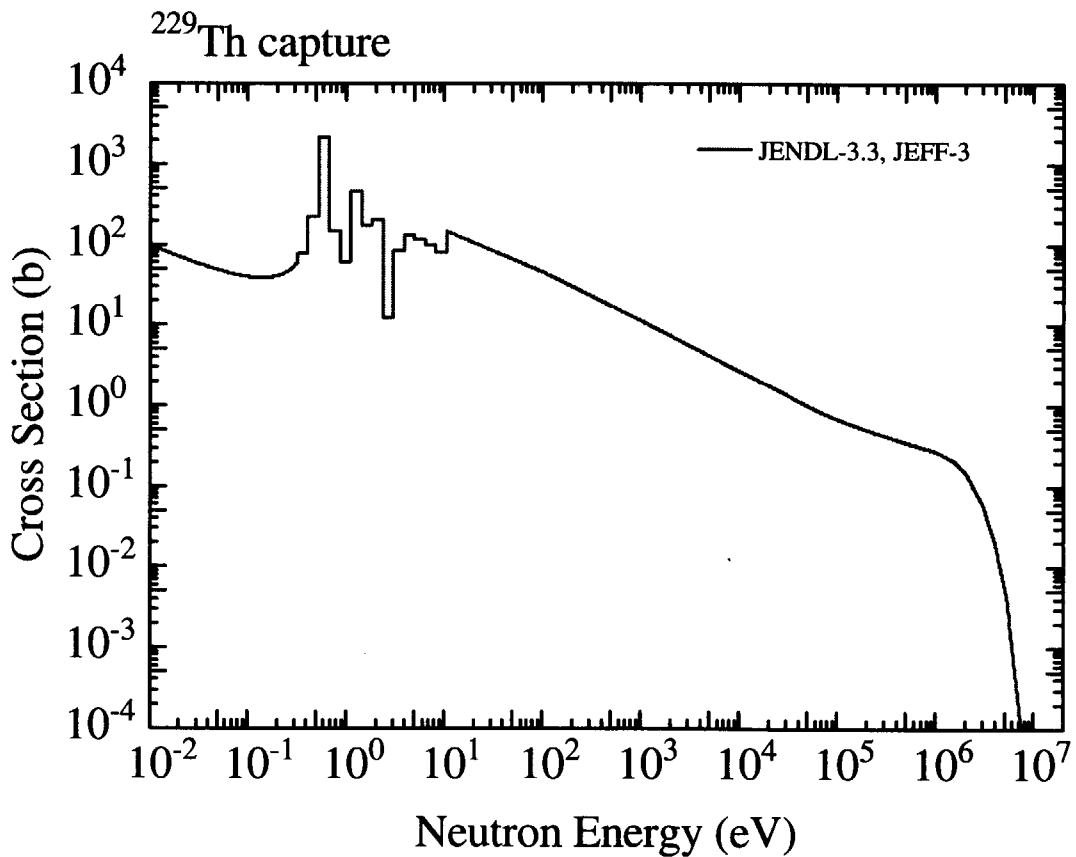
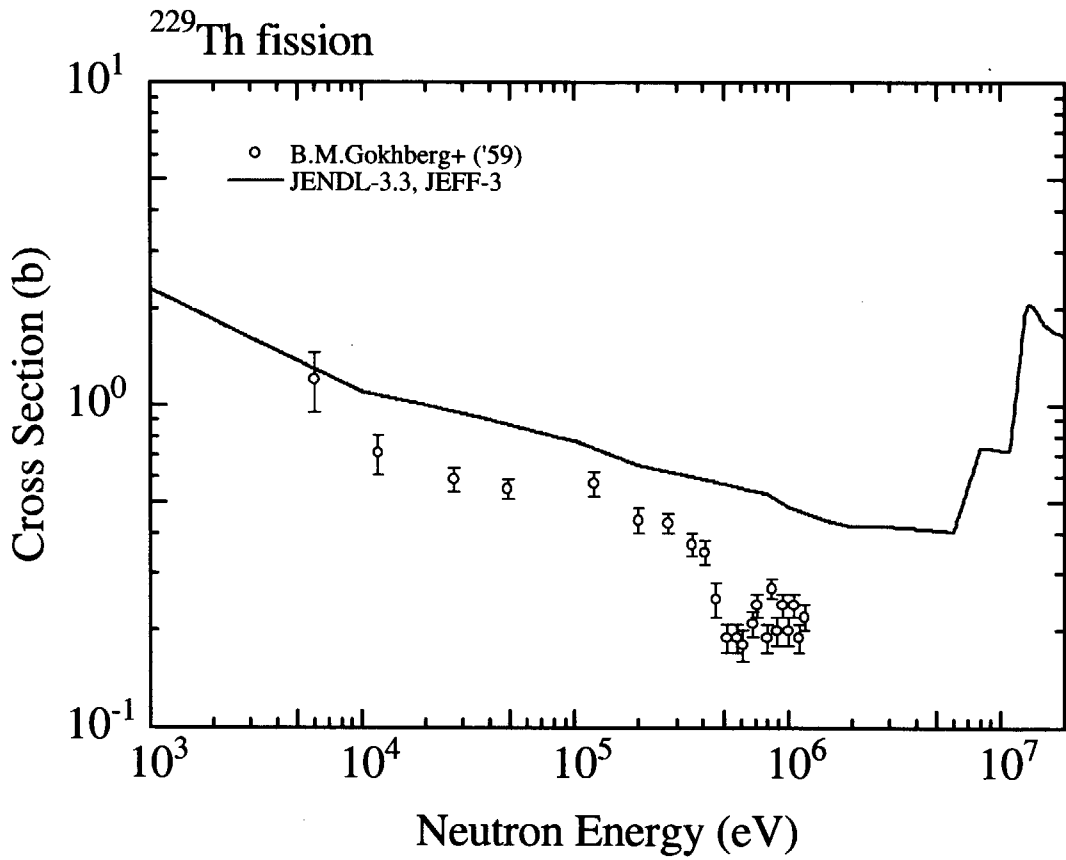
Reac.	First author (year)	T	Reference	Year	Lab	Ent. #
FIS	E.F.Fomushkin+('80)	C	80KIEV,3,25	1980	KUR	40602
FIS	M.S.Moore+('71)	J	PR/C,3,1656	1971	LAS	10121
FIS	R.W.Benjamin+('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	H.T.Maguire Jr+('85)	J	NSE,89,293	1985	RPI	12788
FIS	B.I.Fursov+('97)	C	97TRIEST,1,488	1997	FEI	41343
CAP	M.S.Moore+('71)	J	PR/C,3,1656	1971	LAS	10121
CAP	R.E.Druschel+('73)	P	ORNL-4891,23	1973	ORL	13015
CAP	V.D.Gavrilov+('78)	J	AE,44,(3),246	1978	NIR	40486

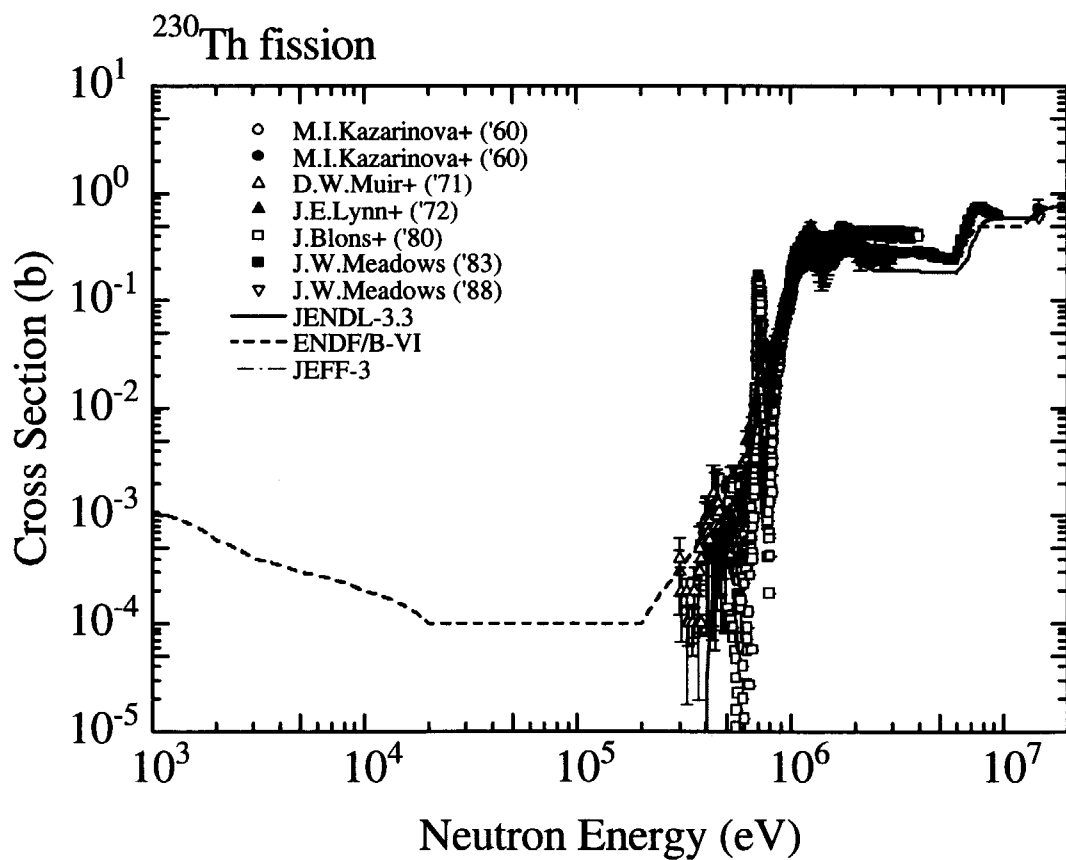
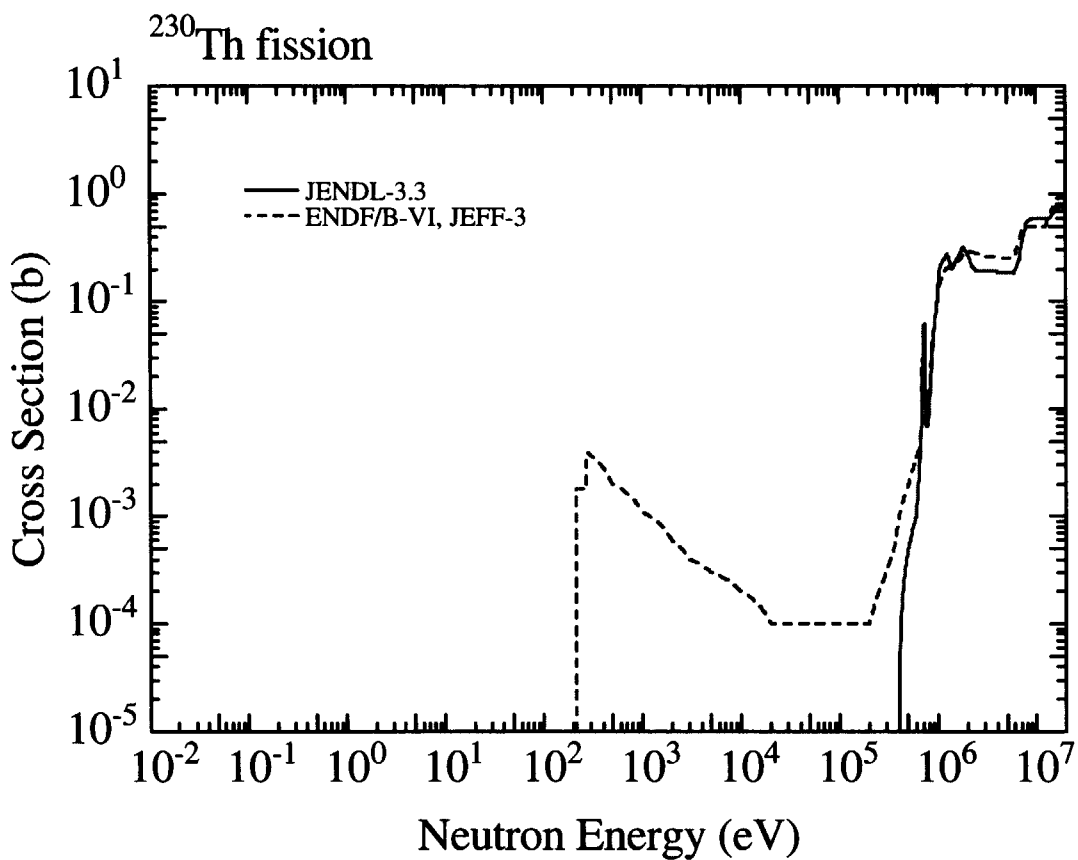


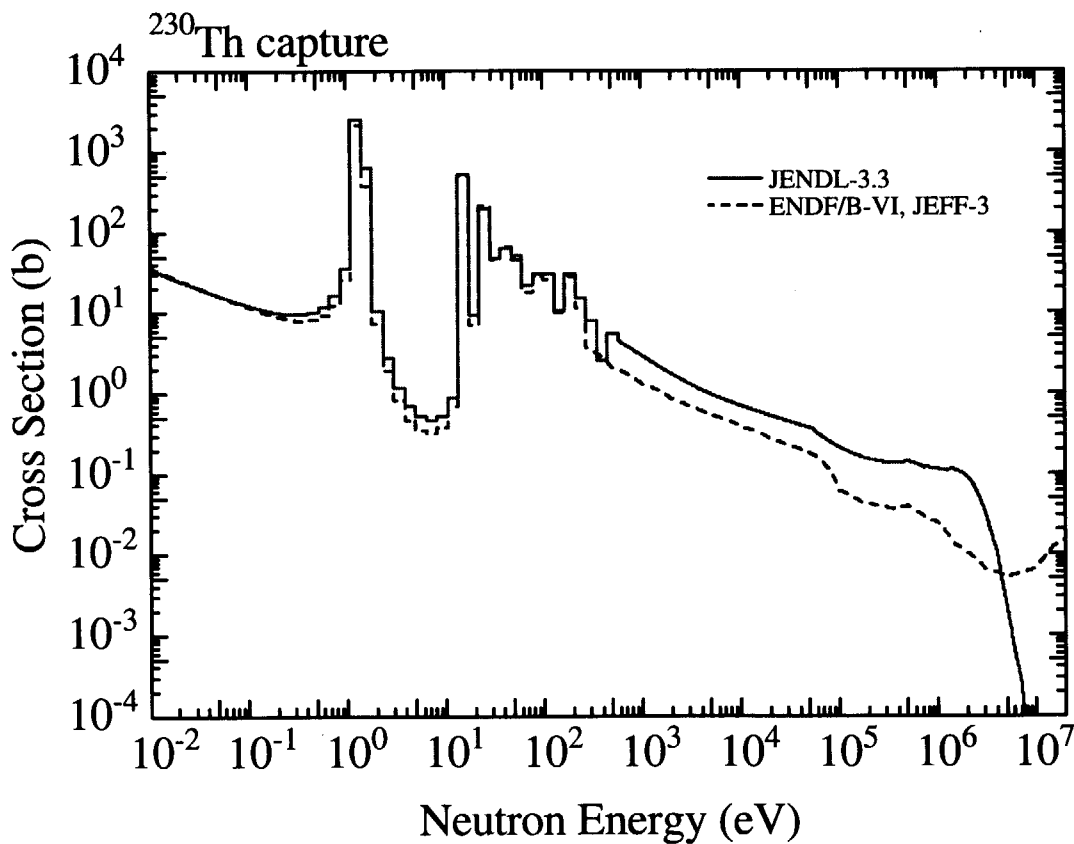
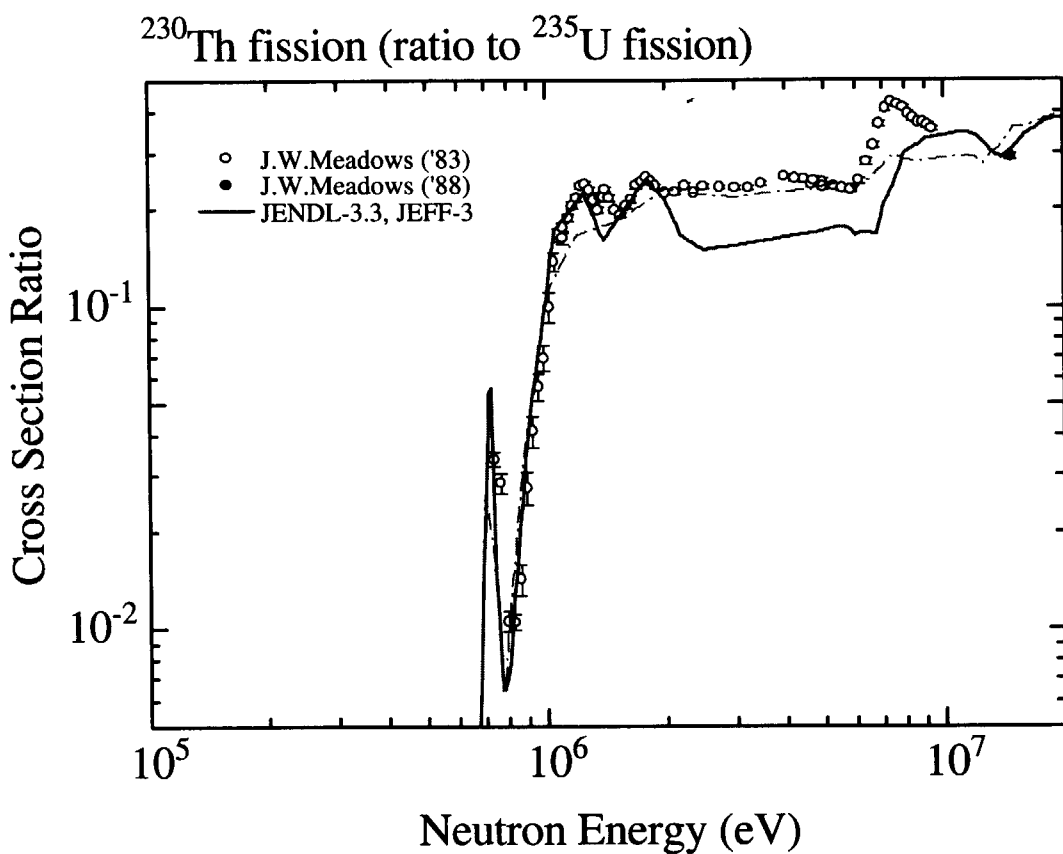


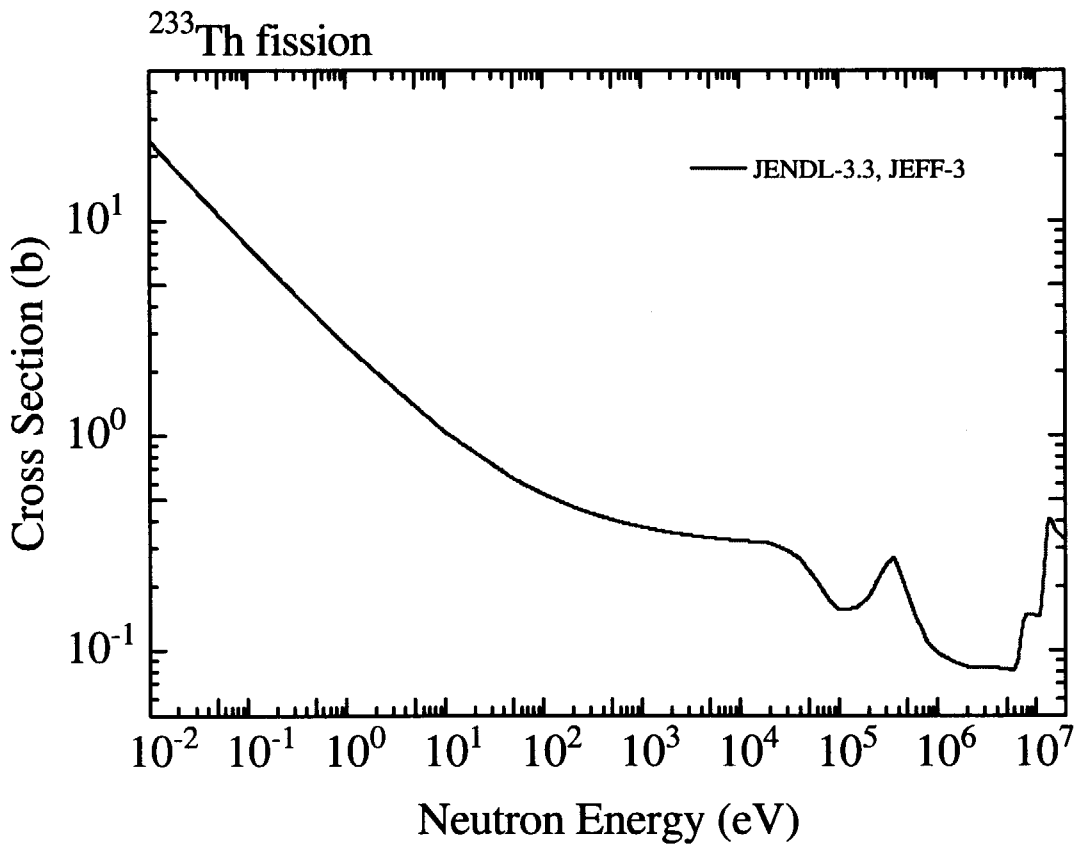
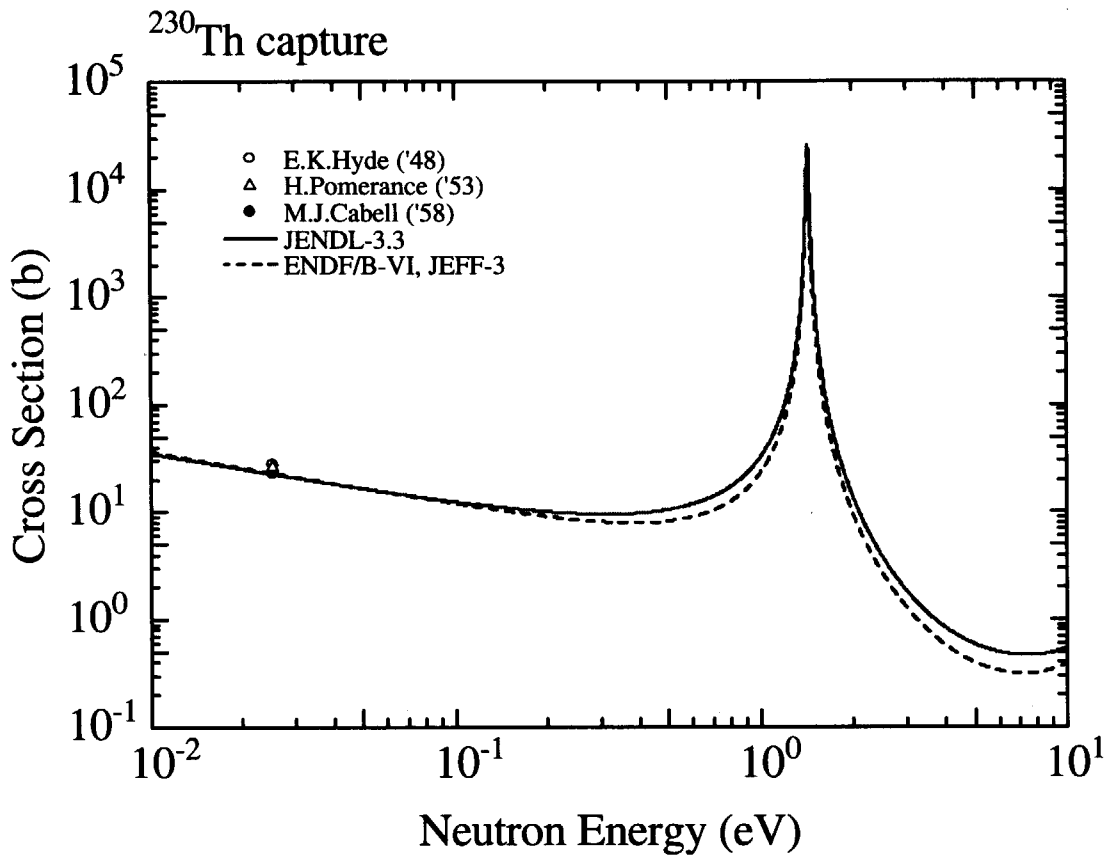


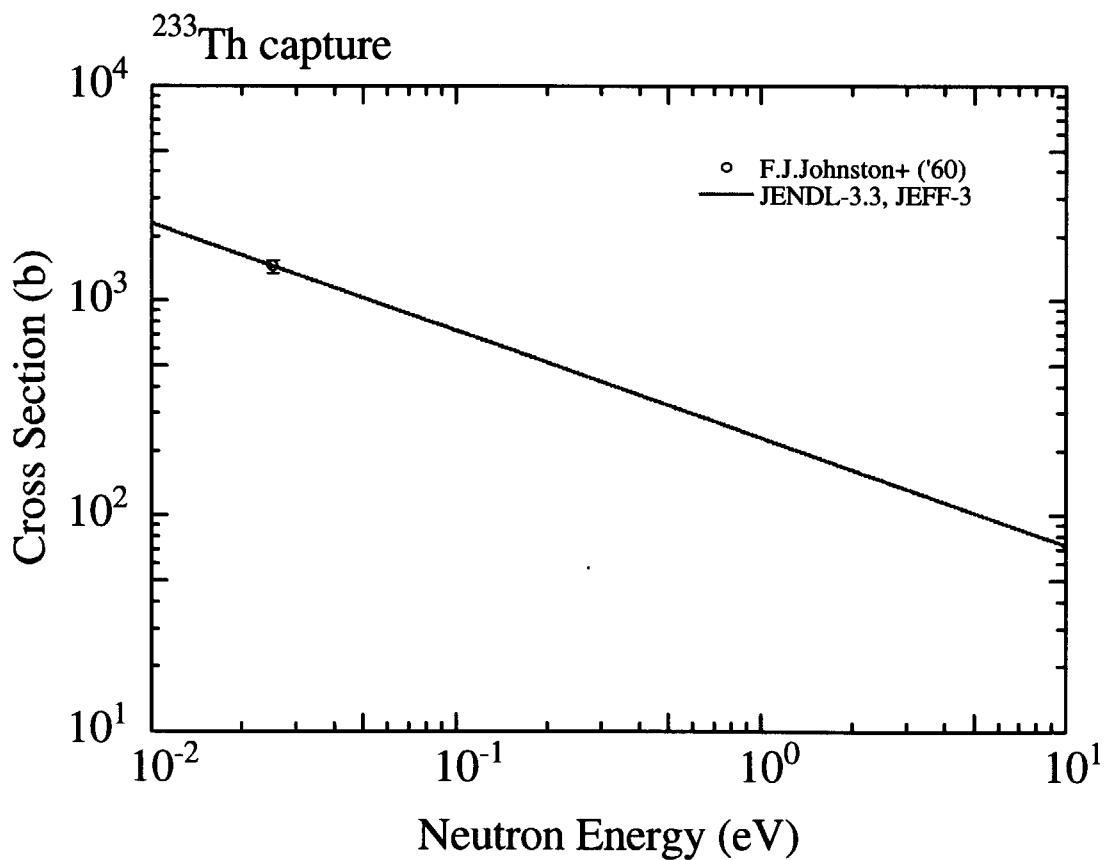
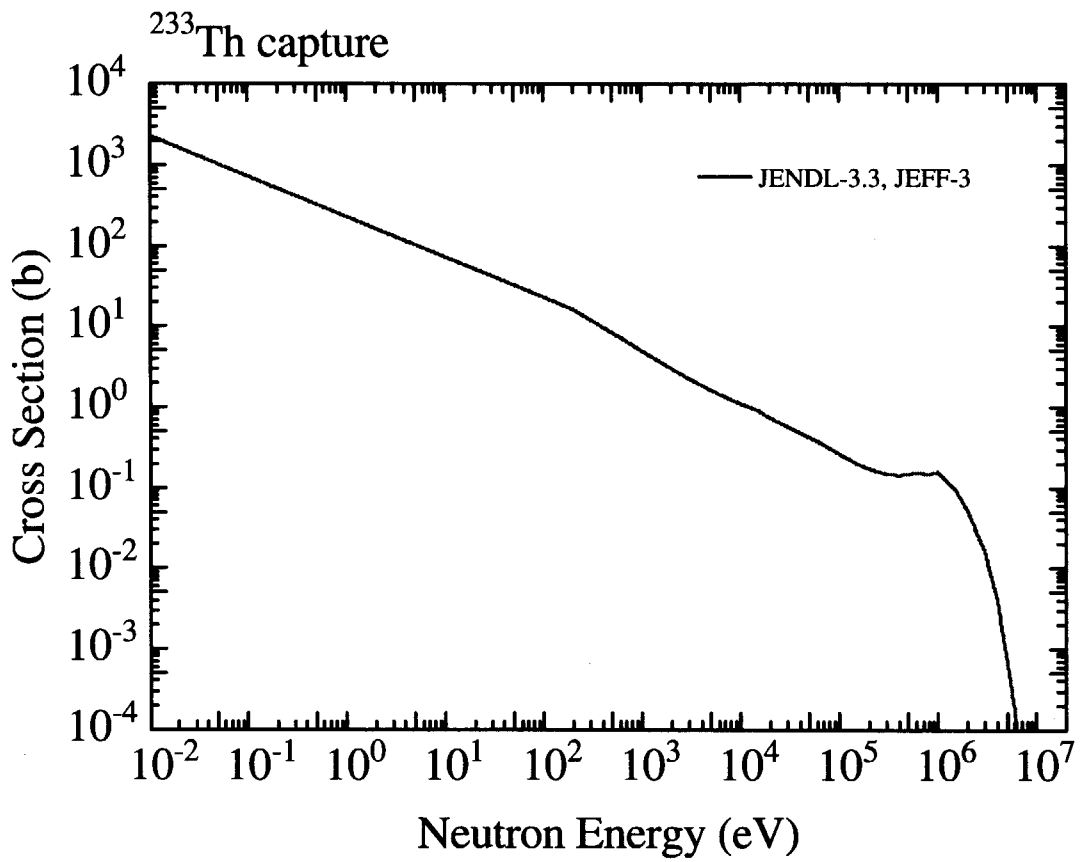


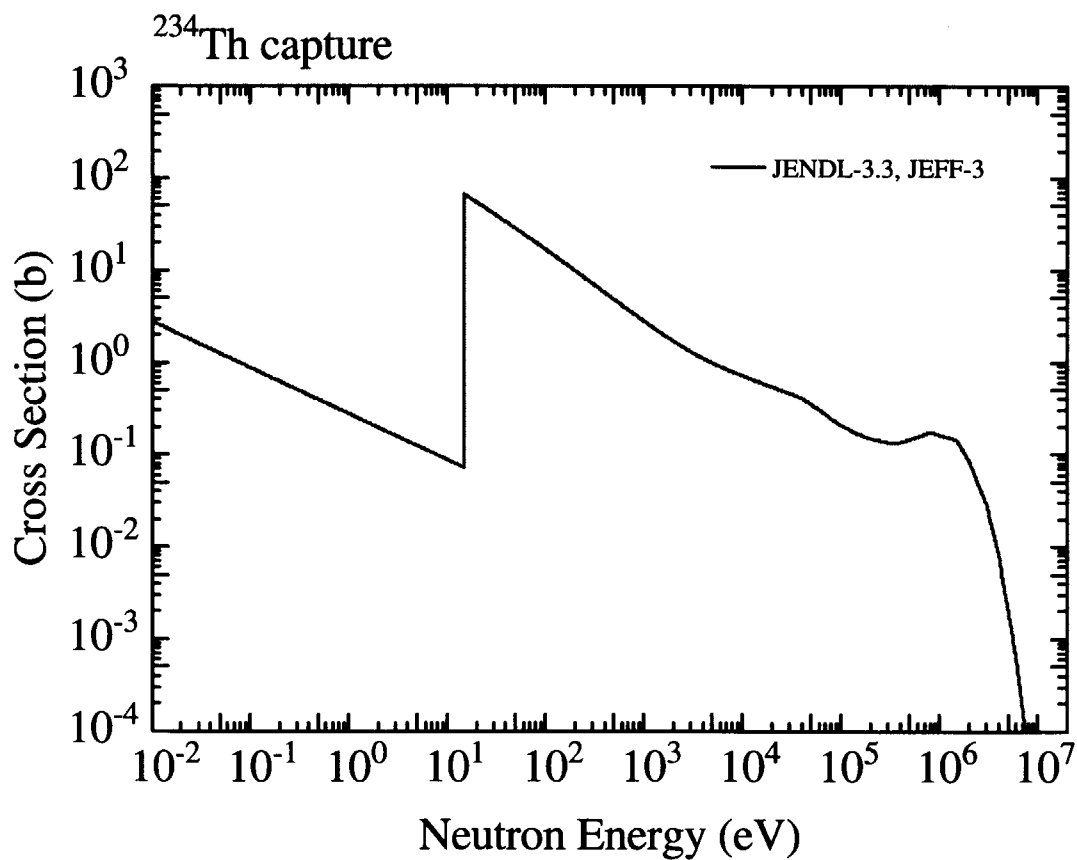
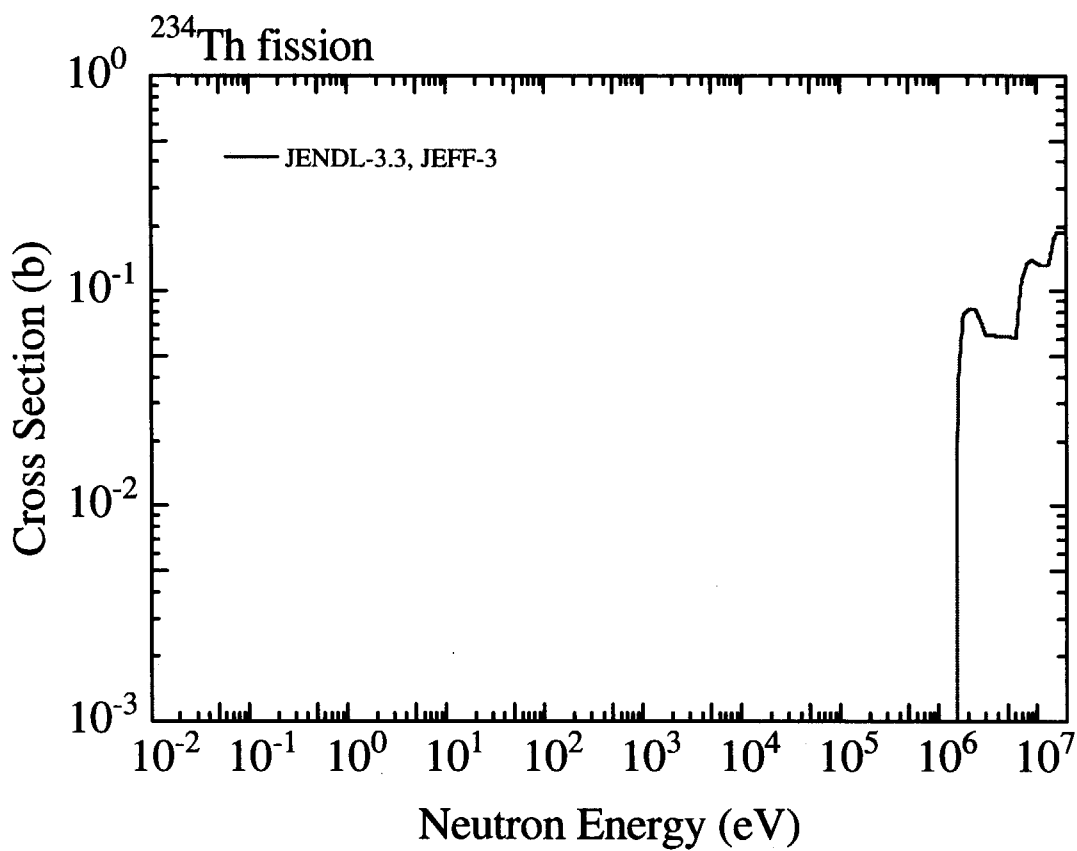


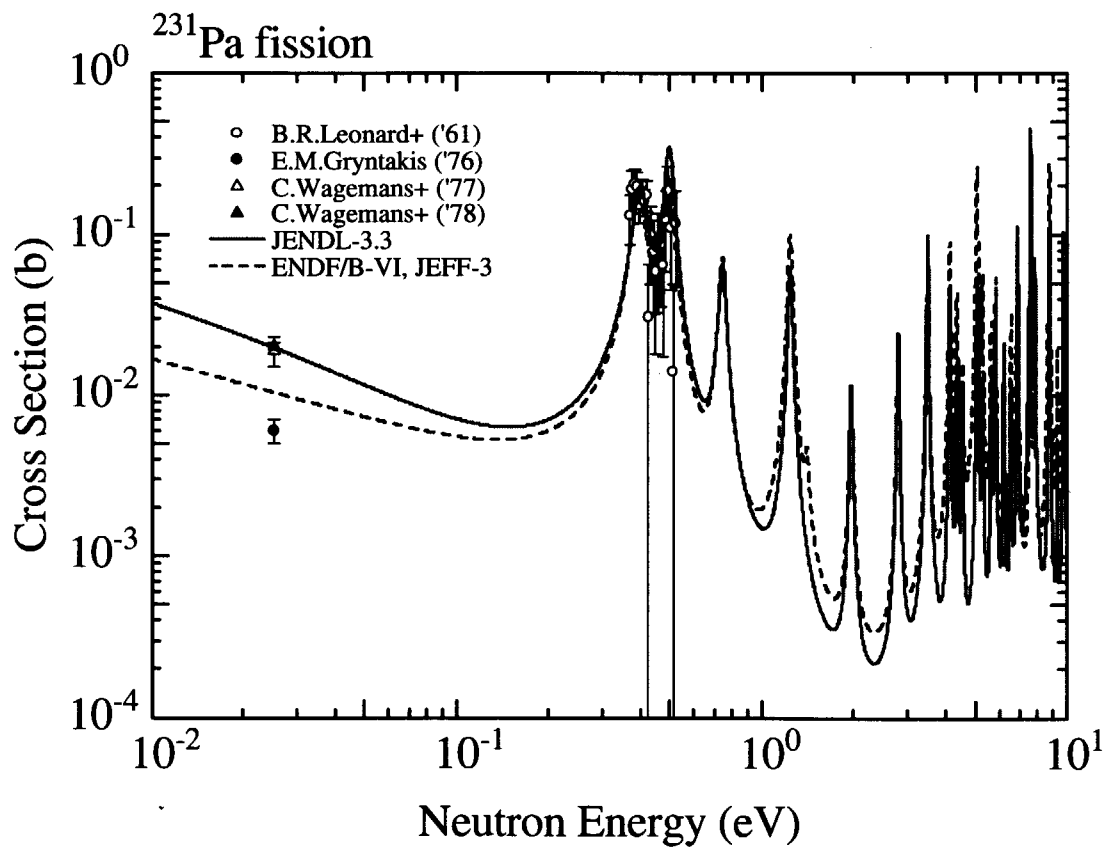
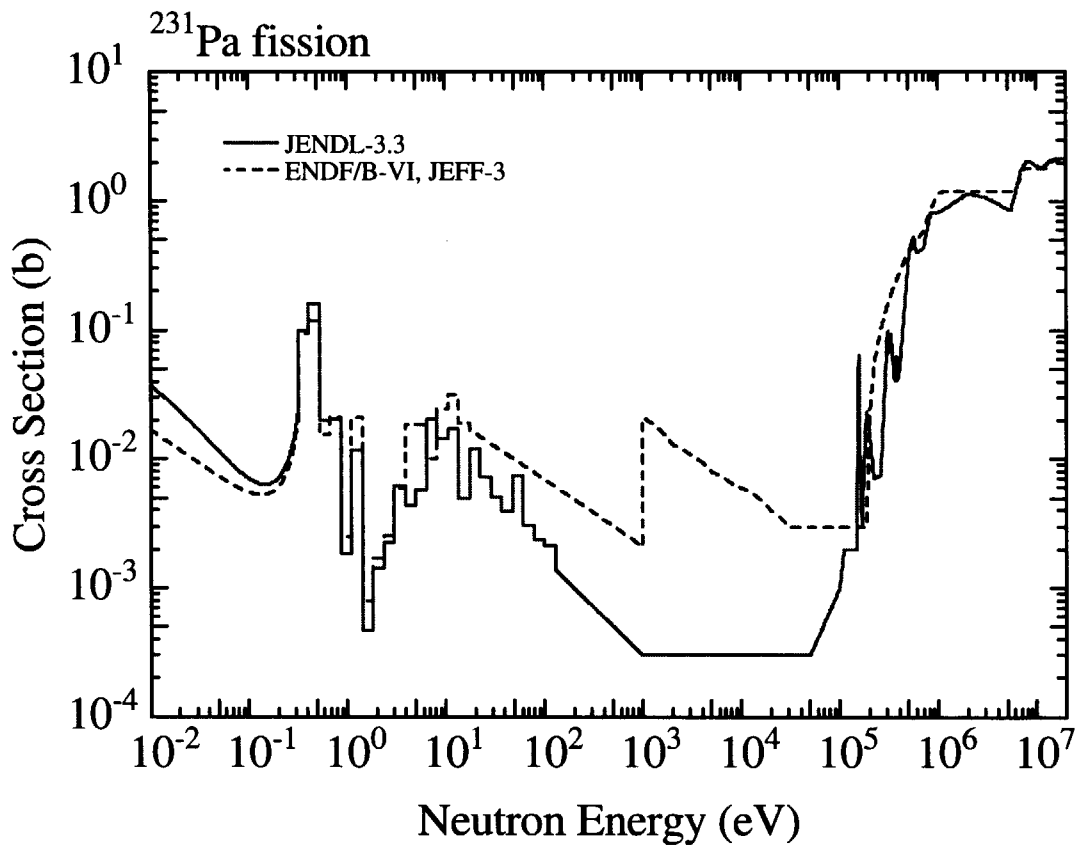


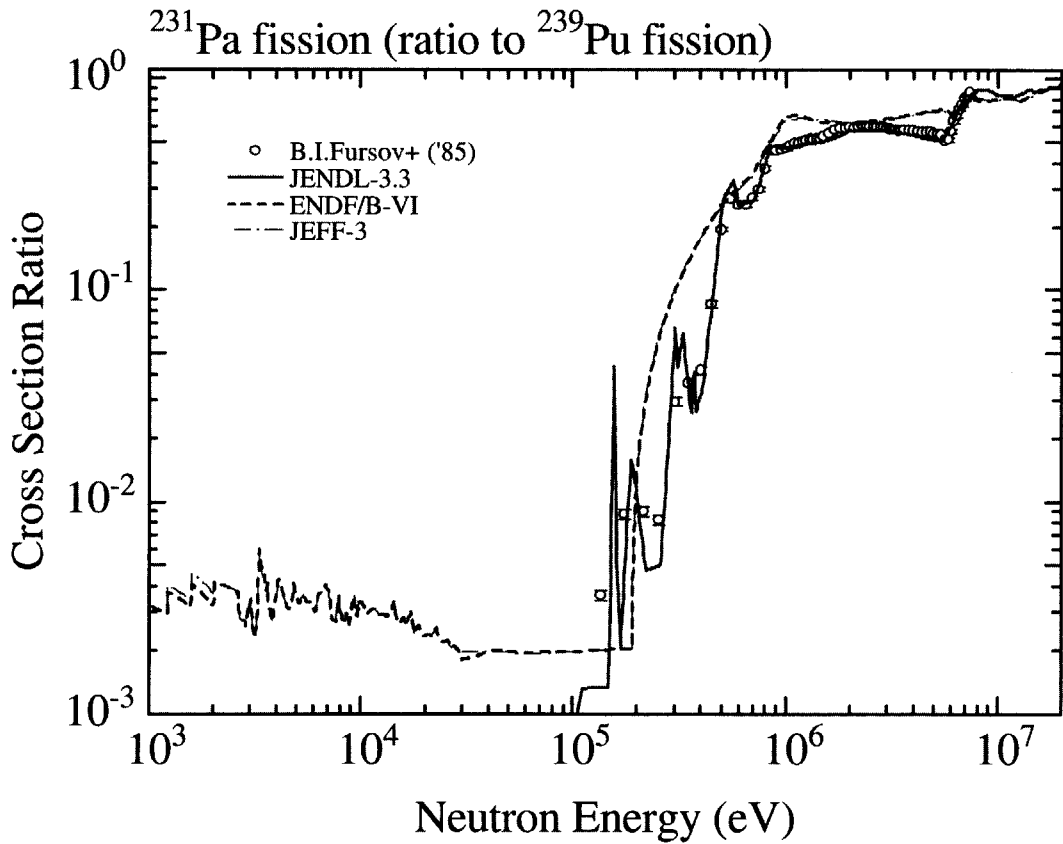
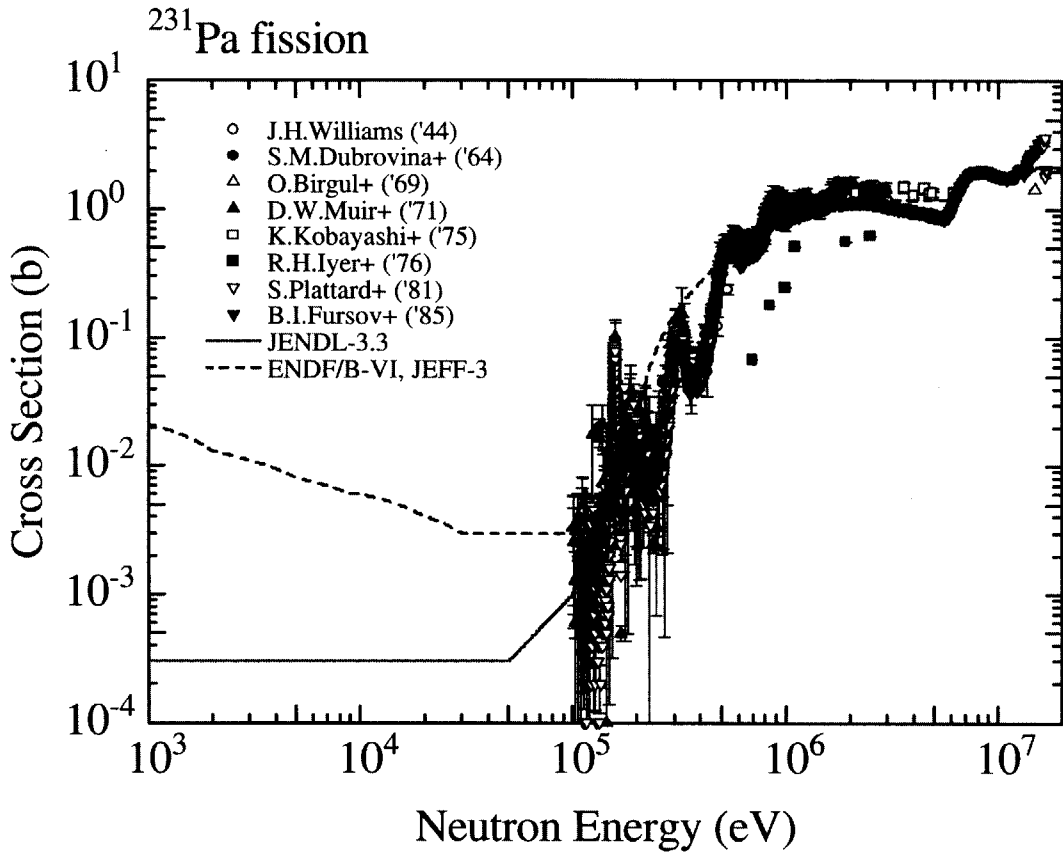


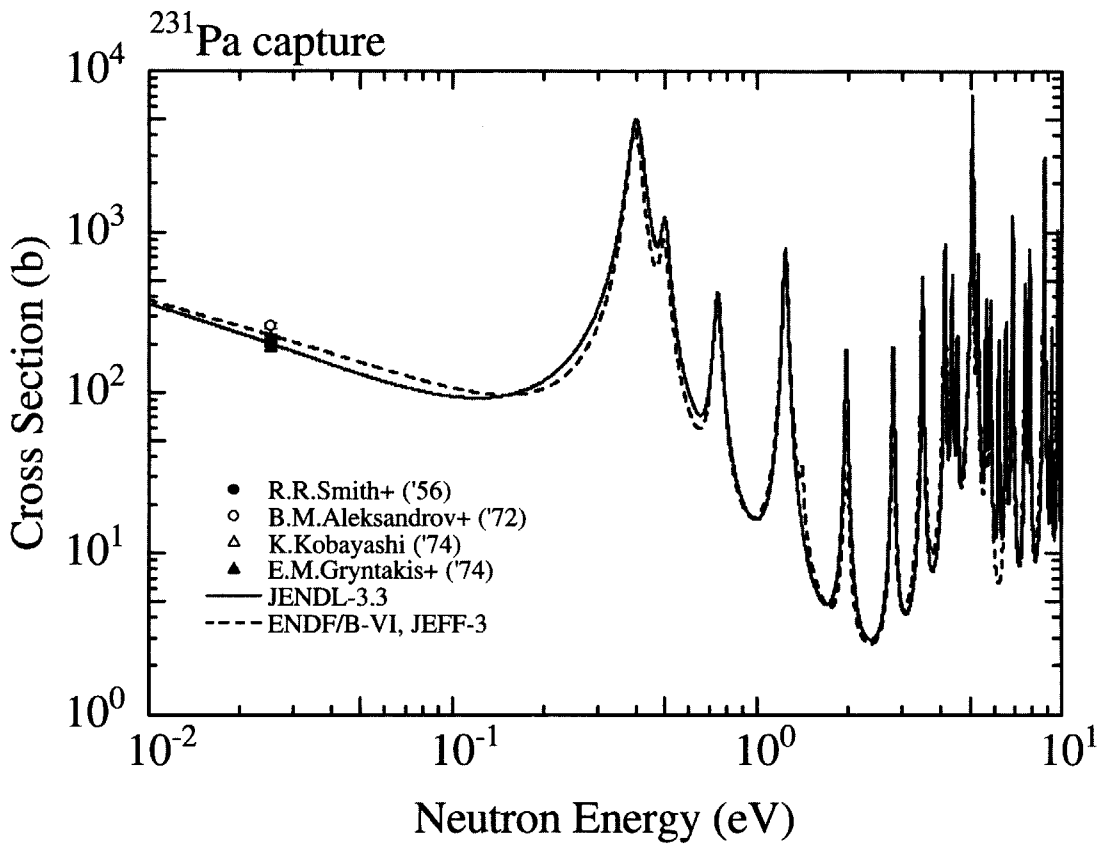
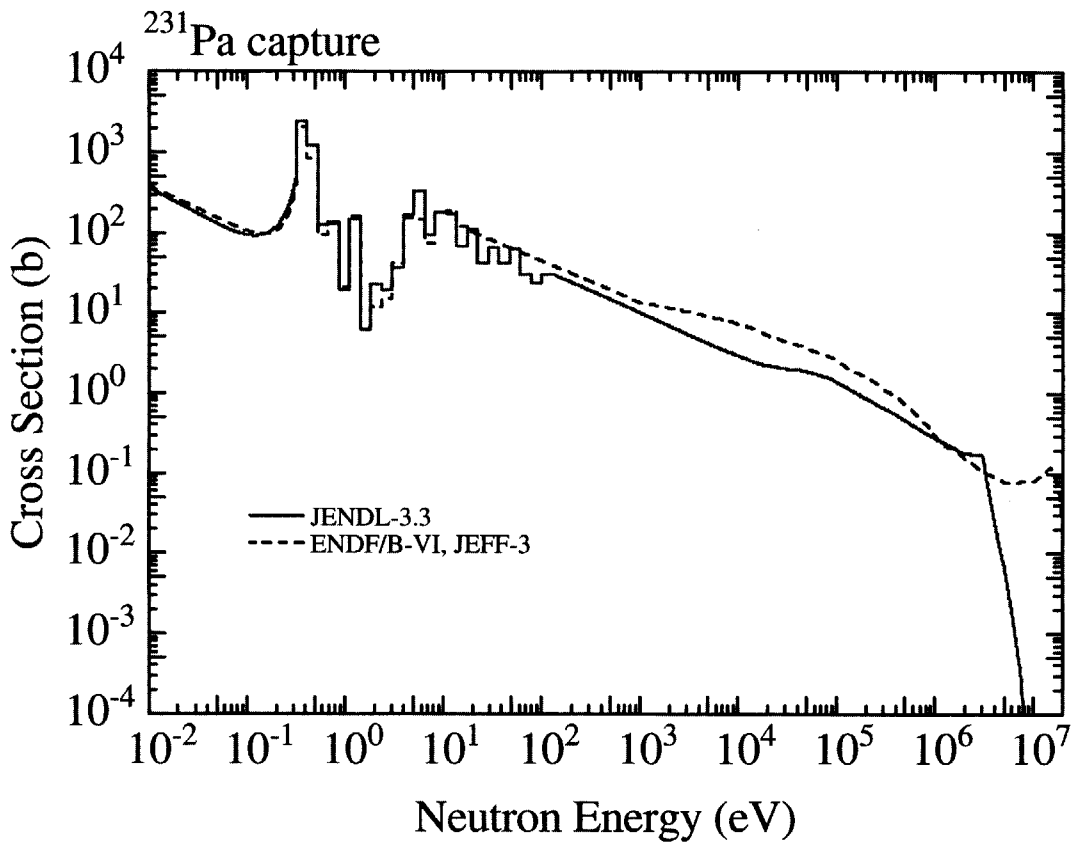


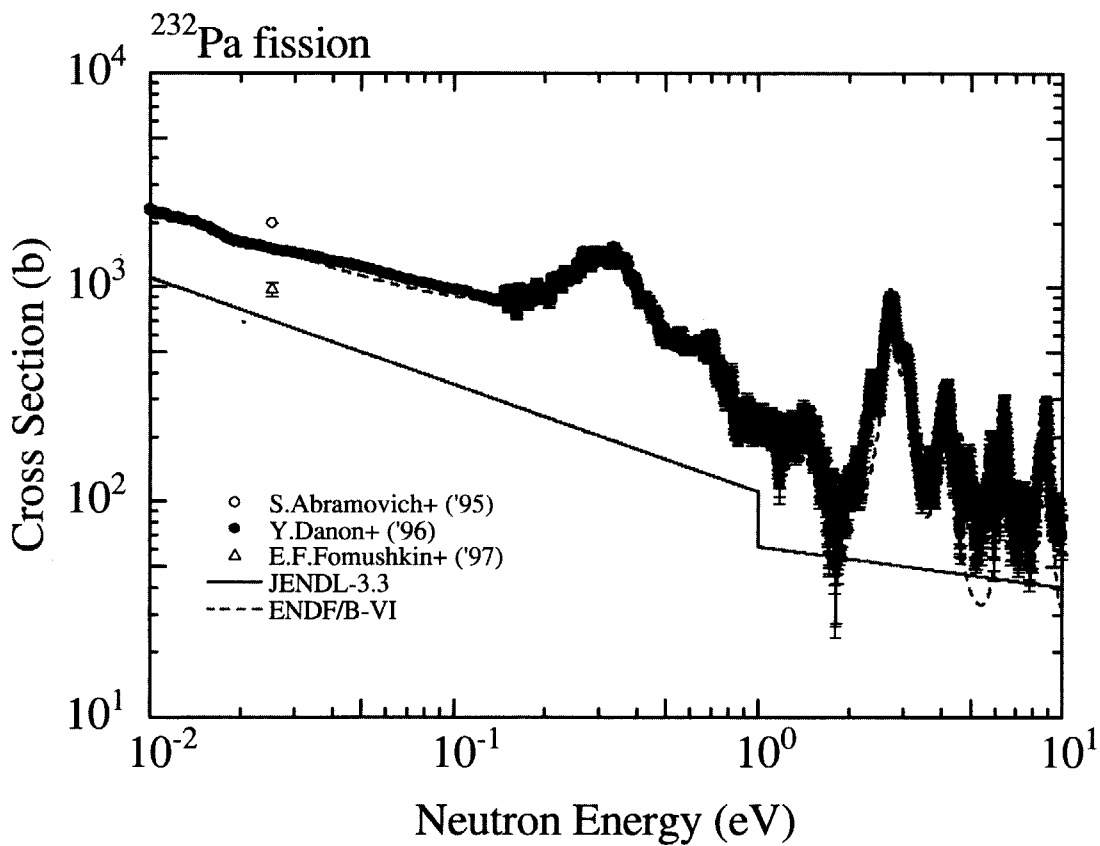
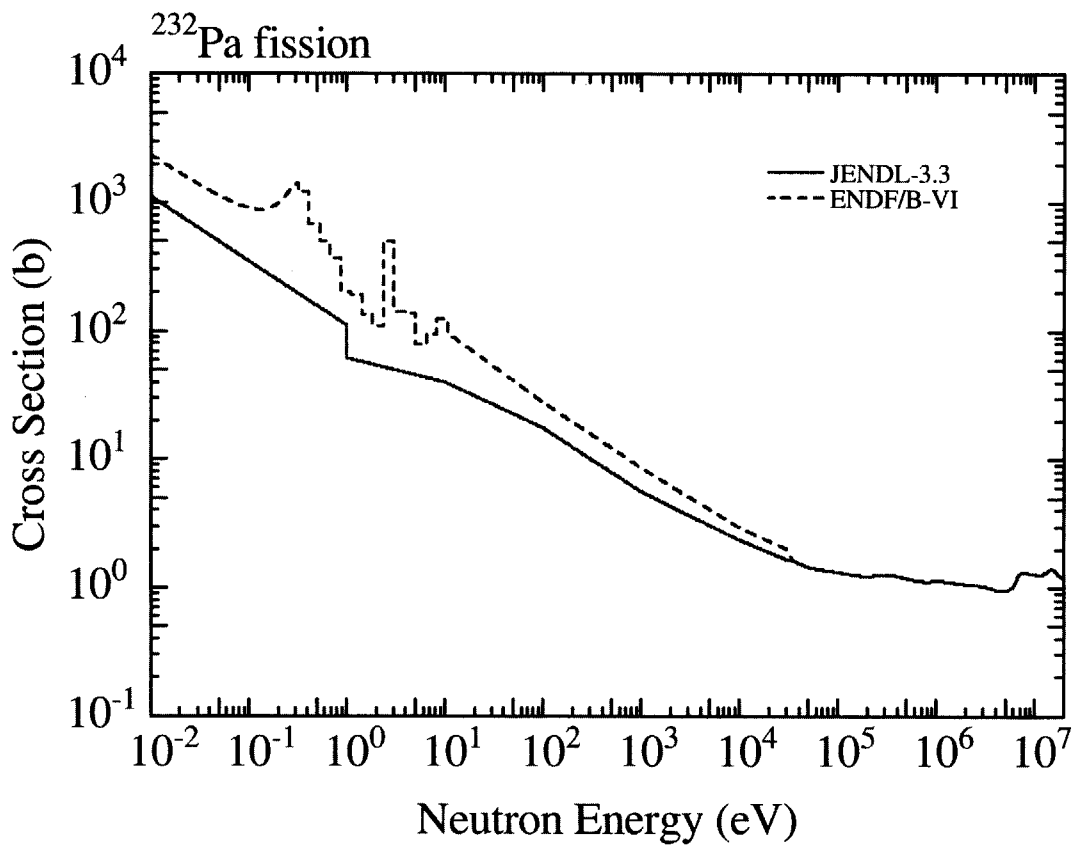


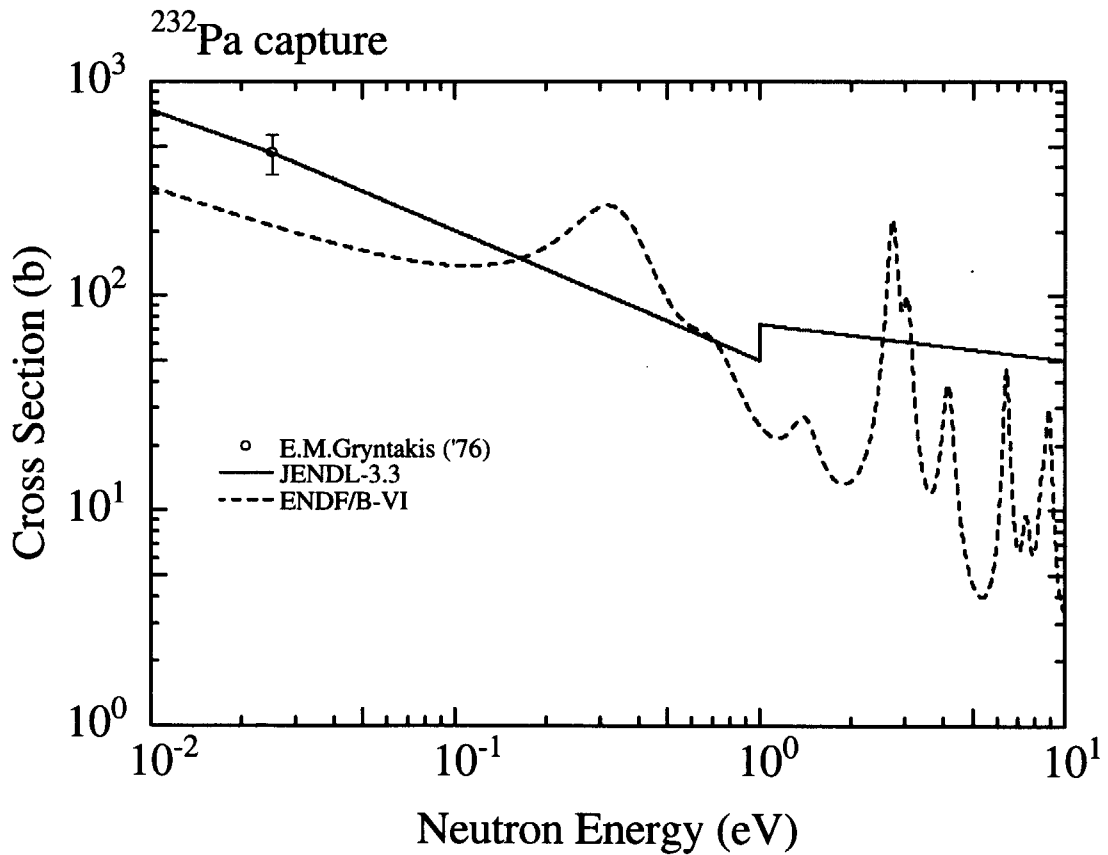
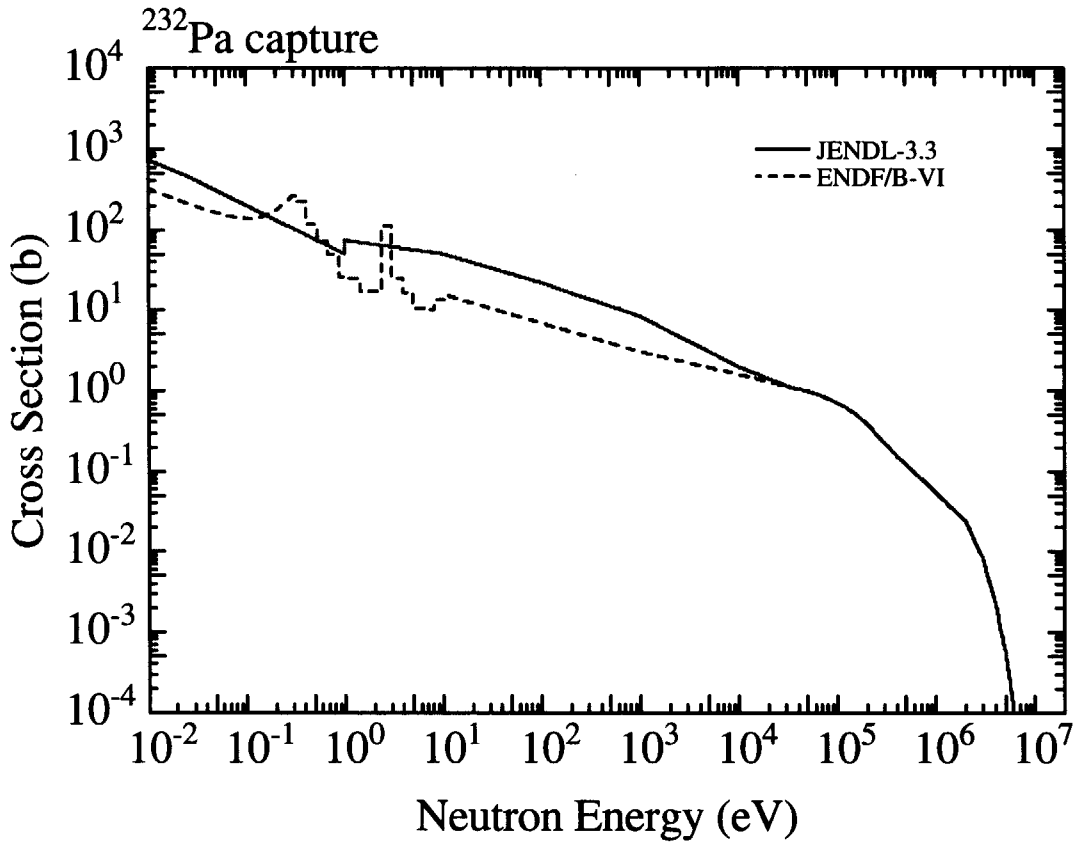


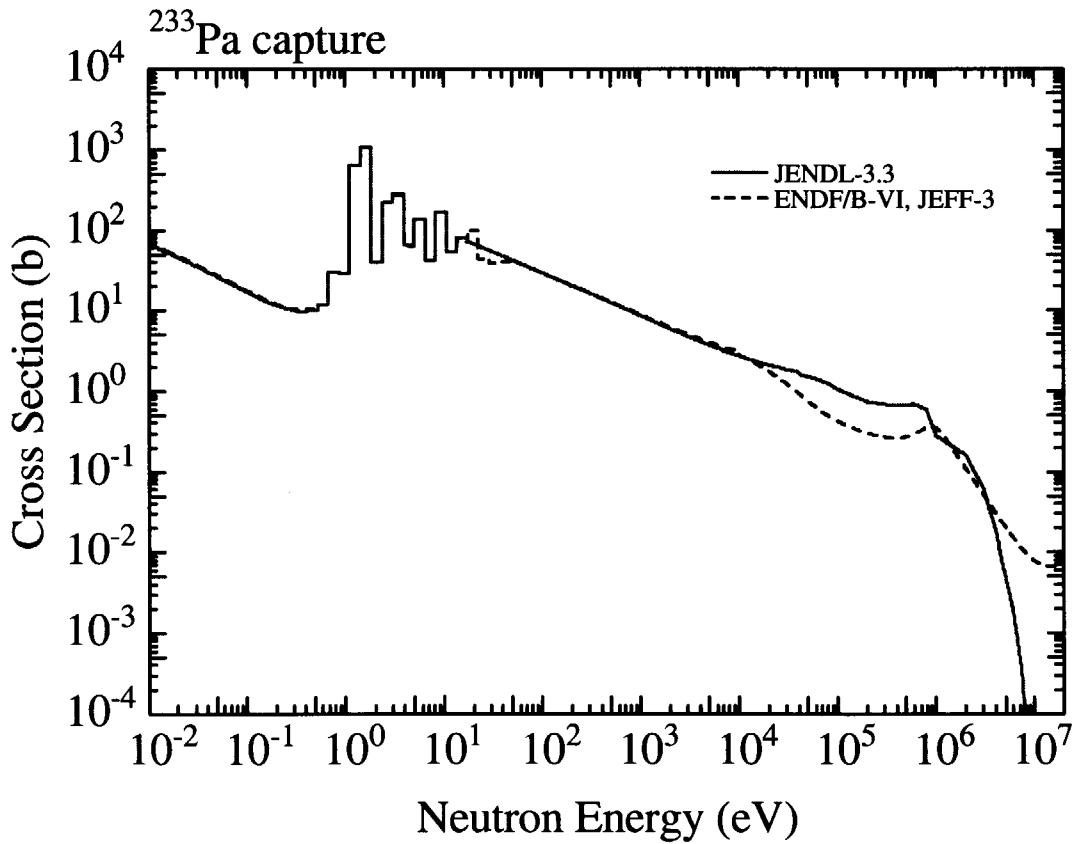
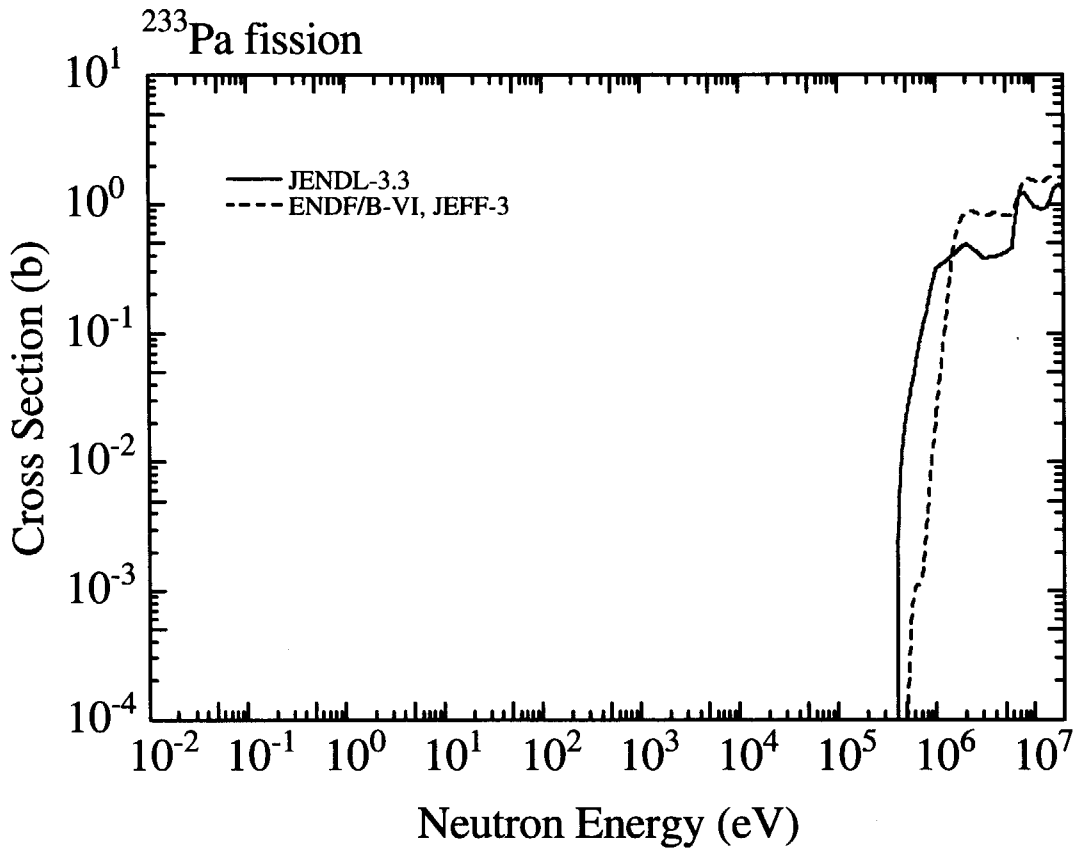


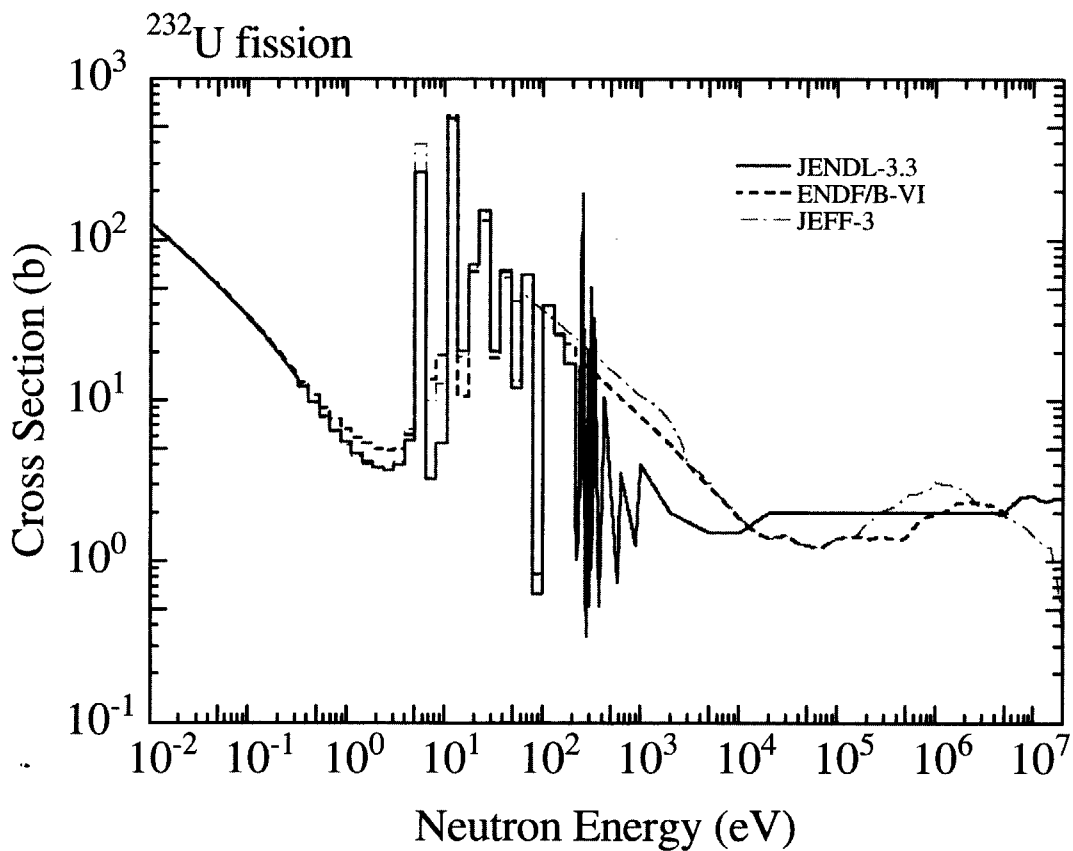
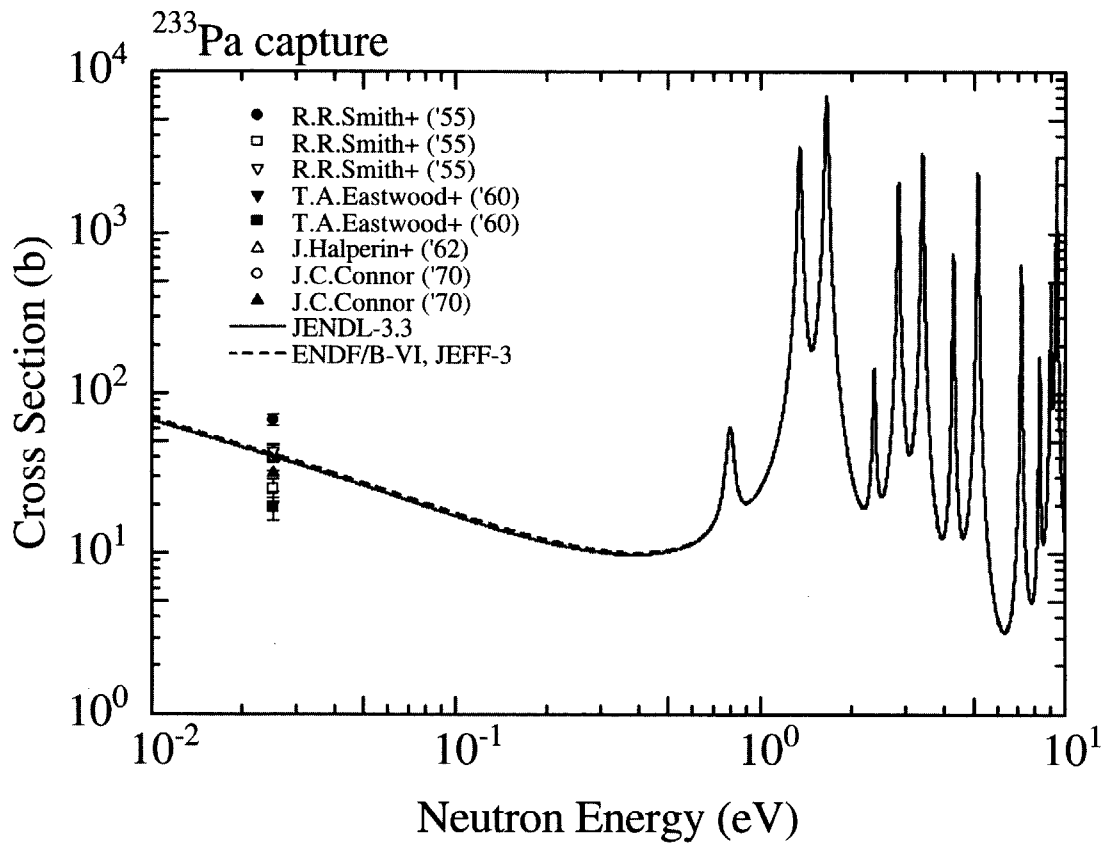


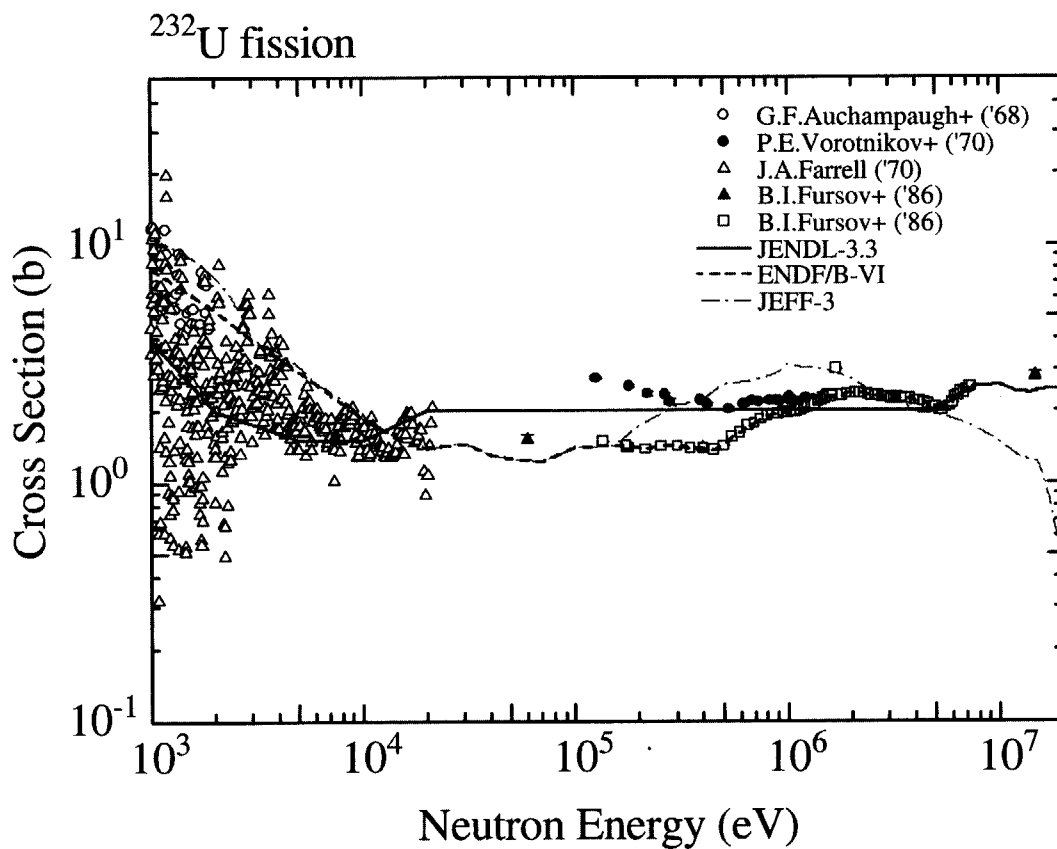
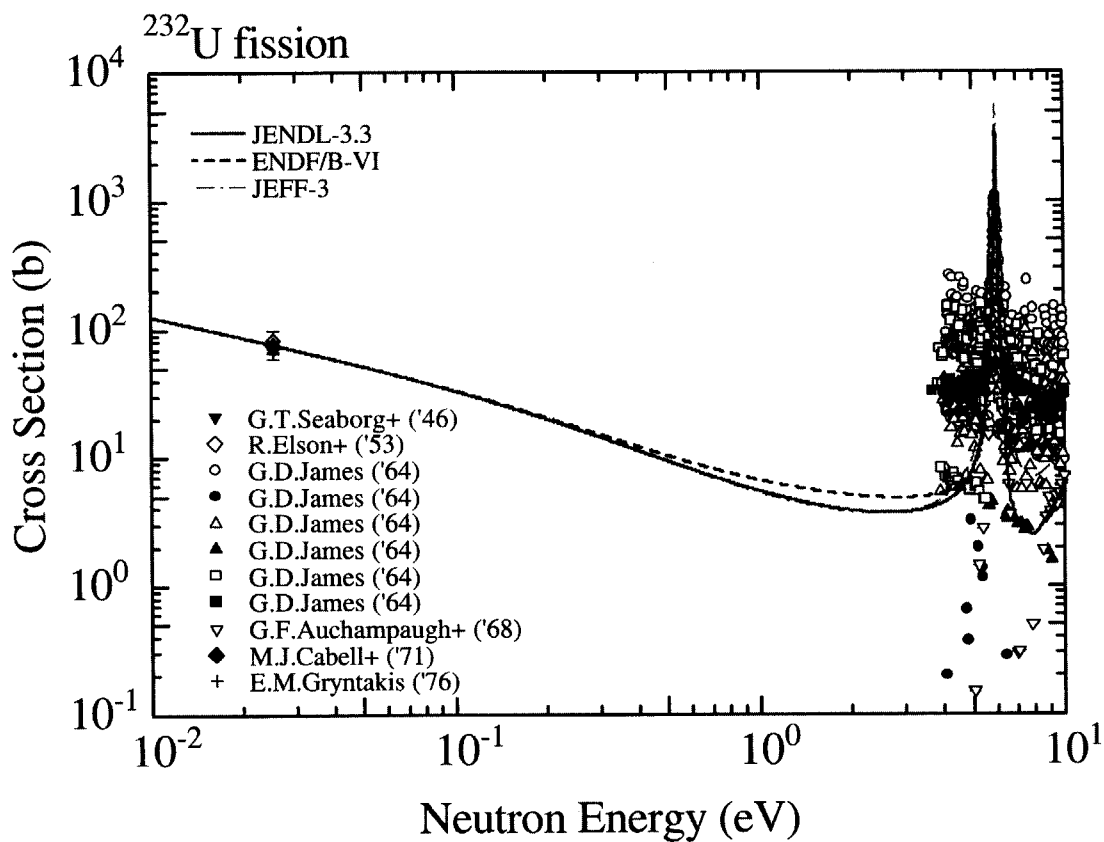


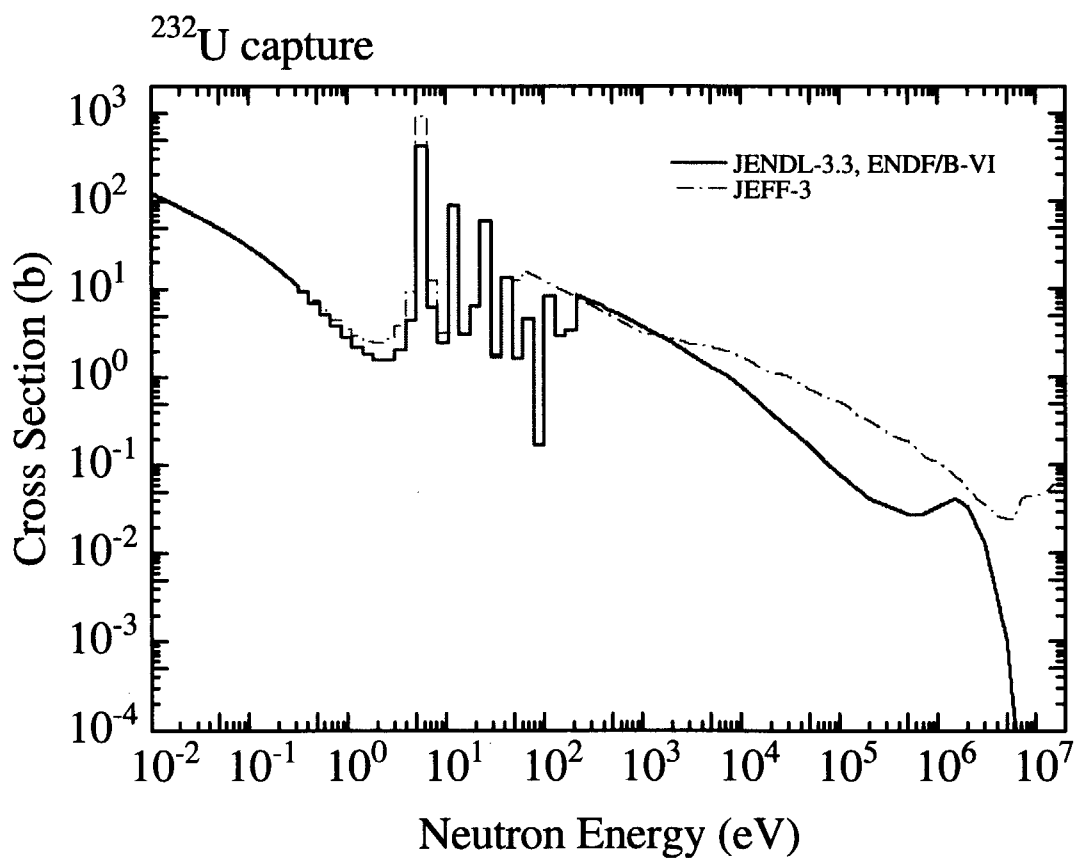
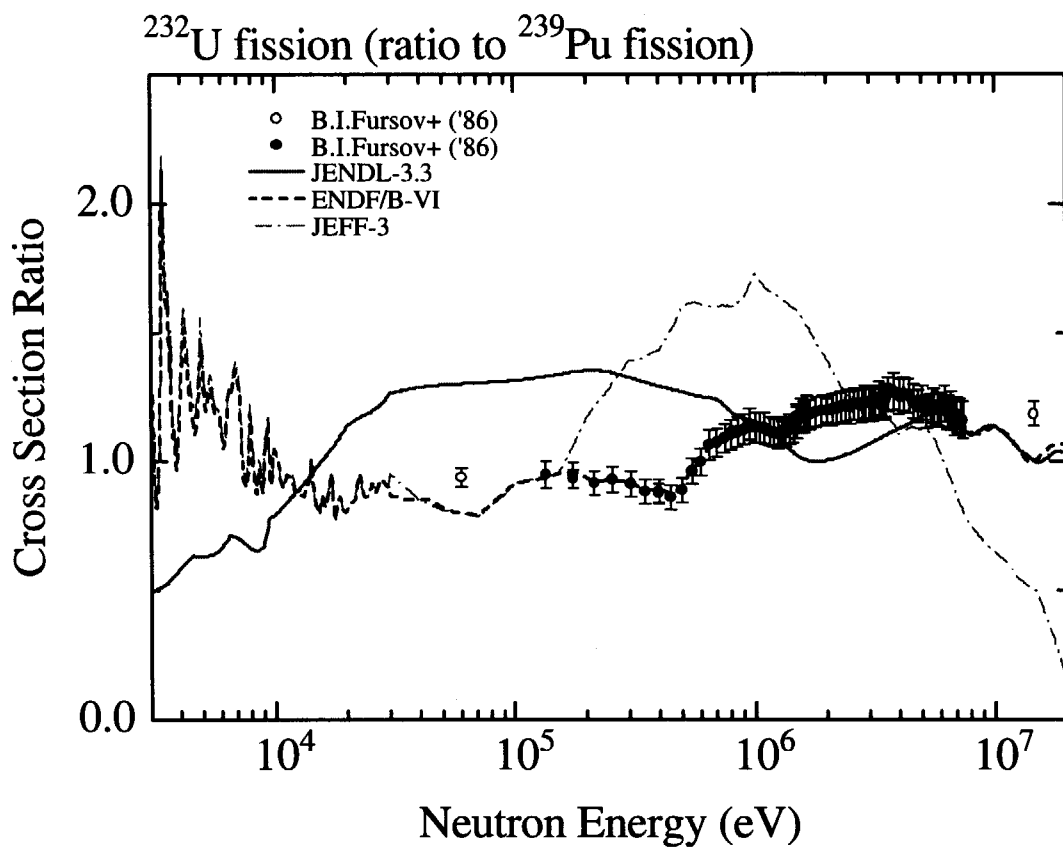


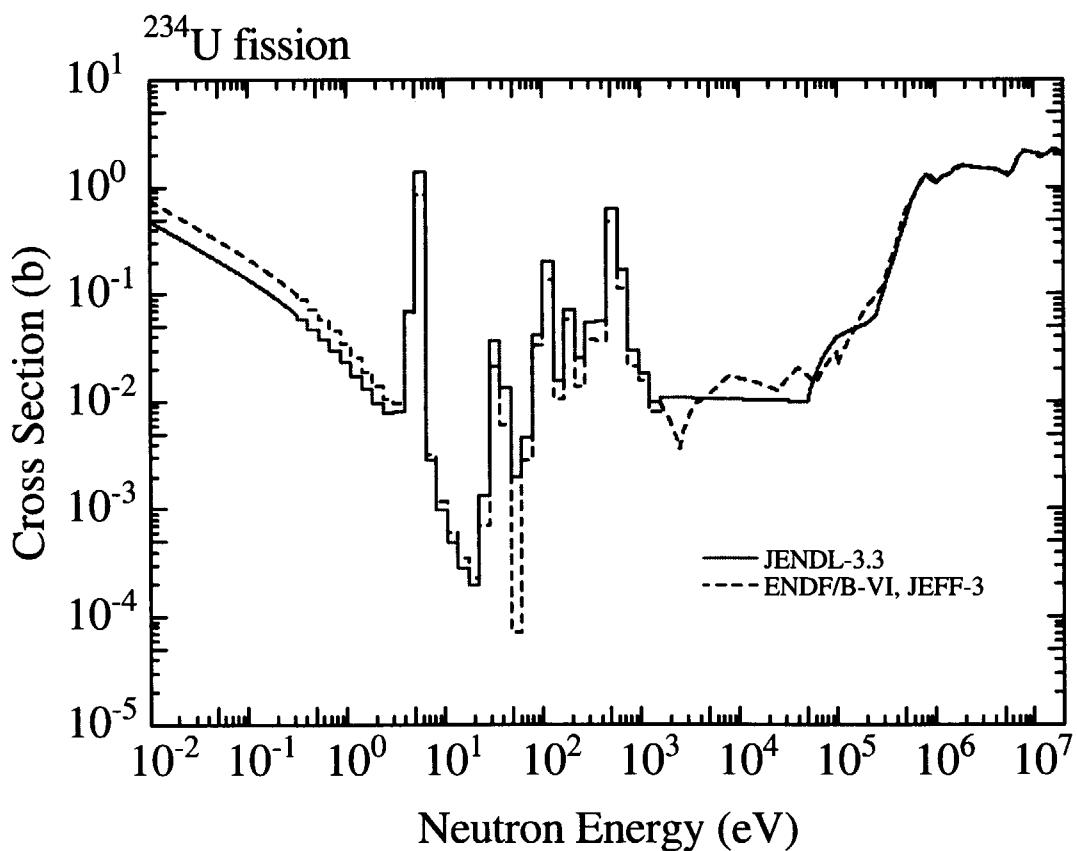
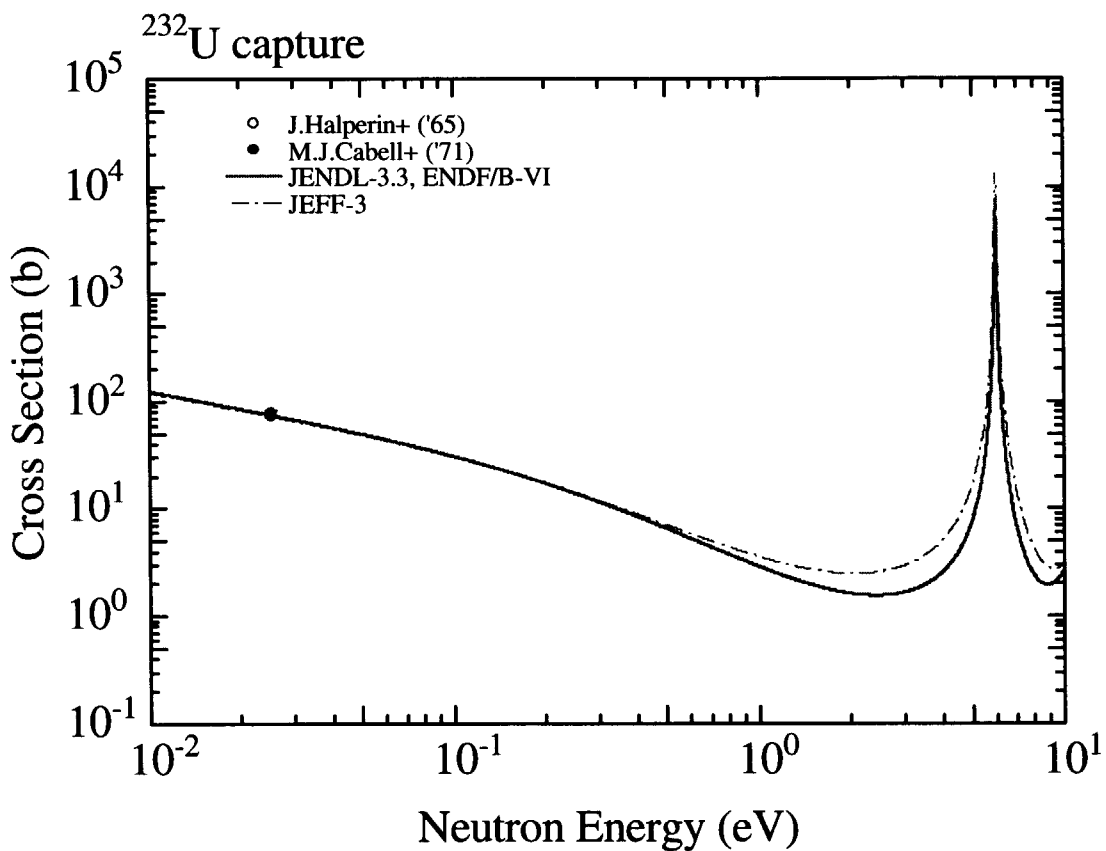


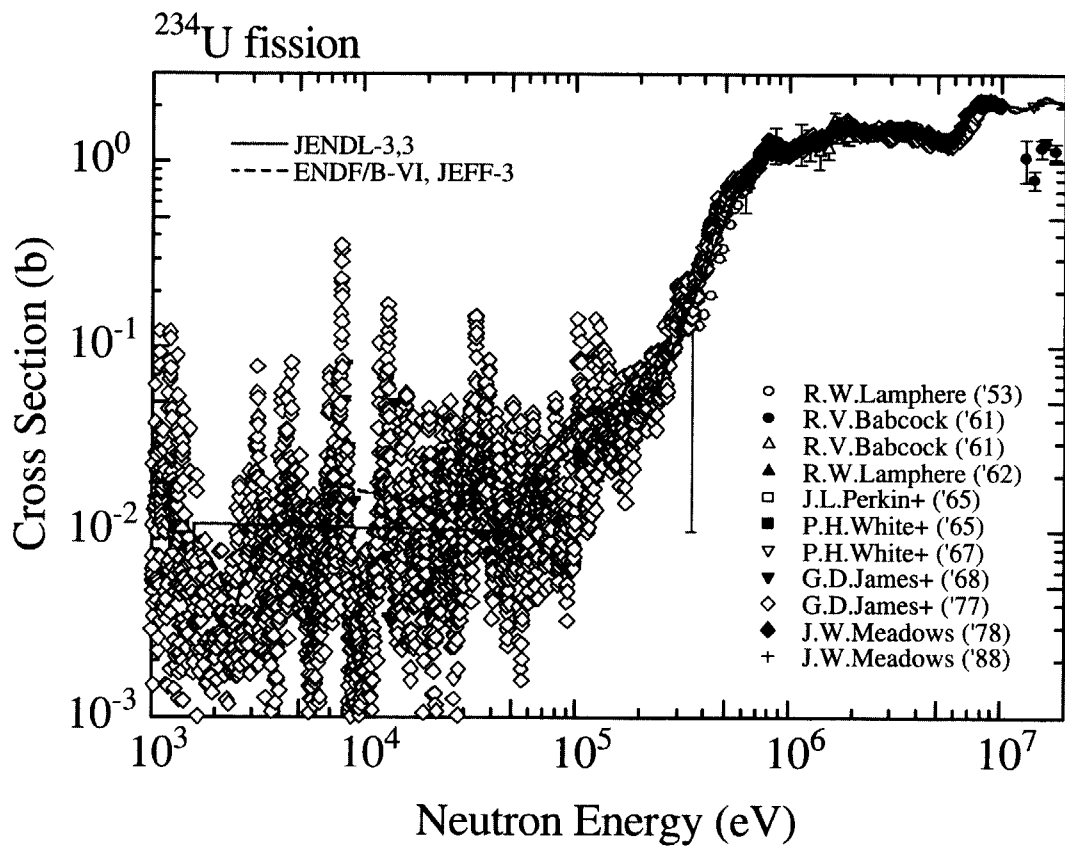
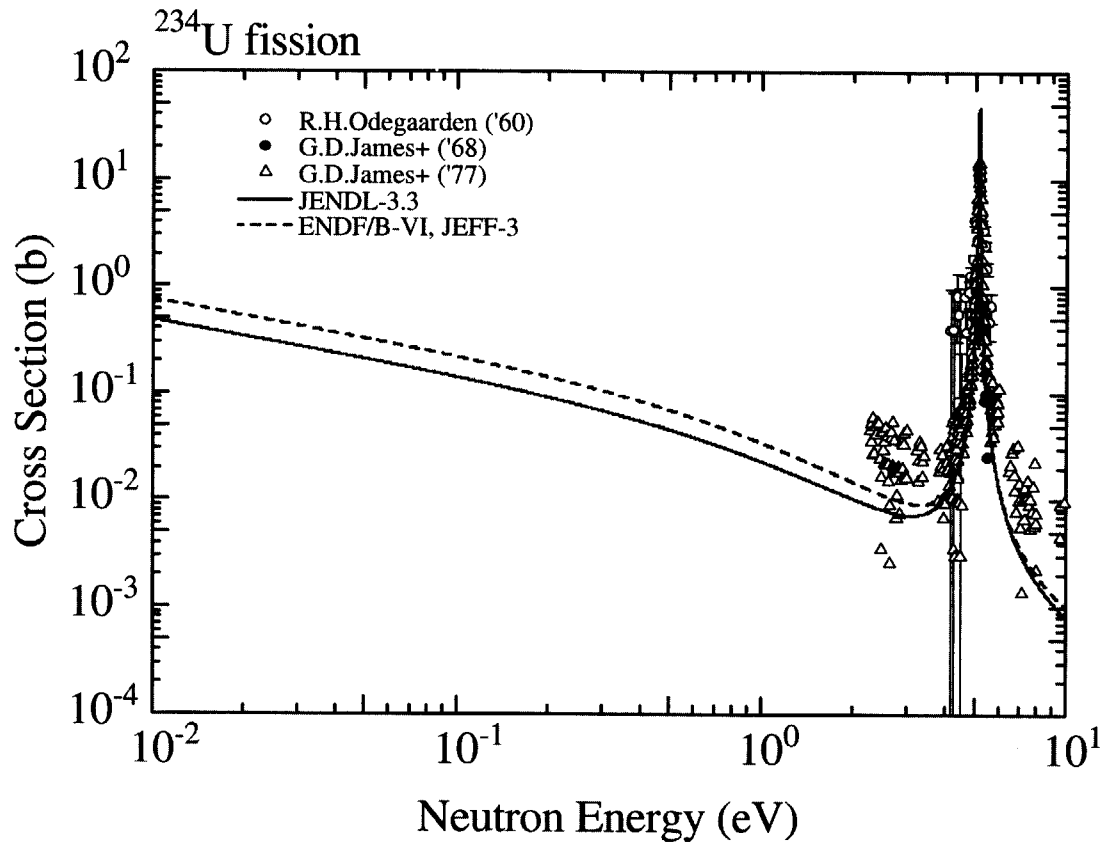


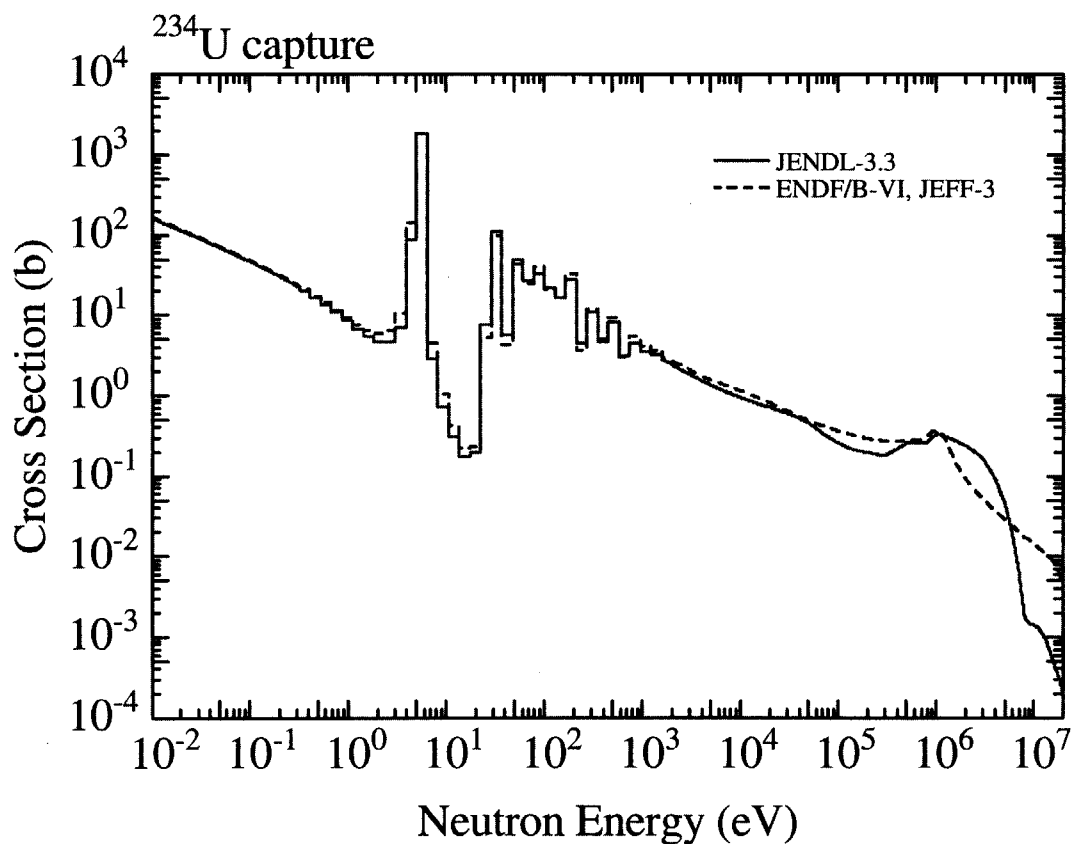
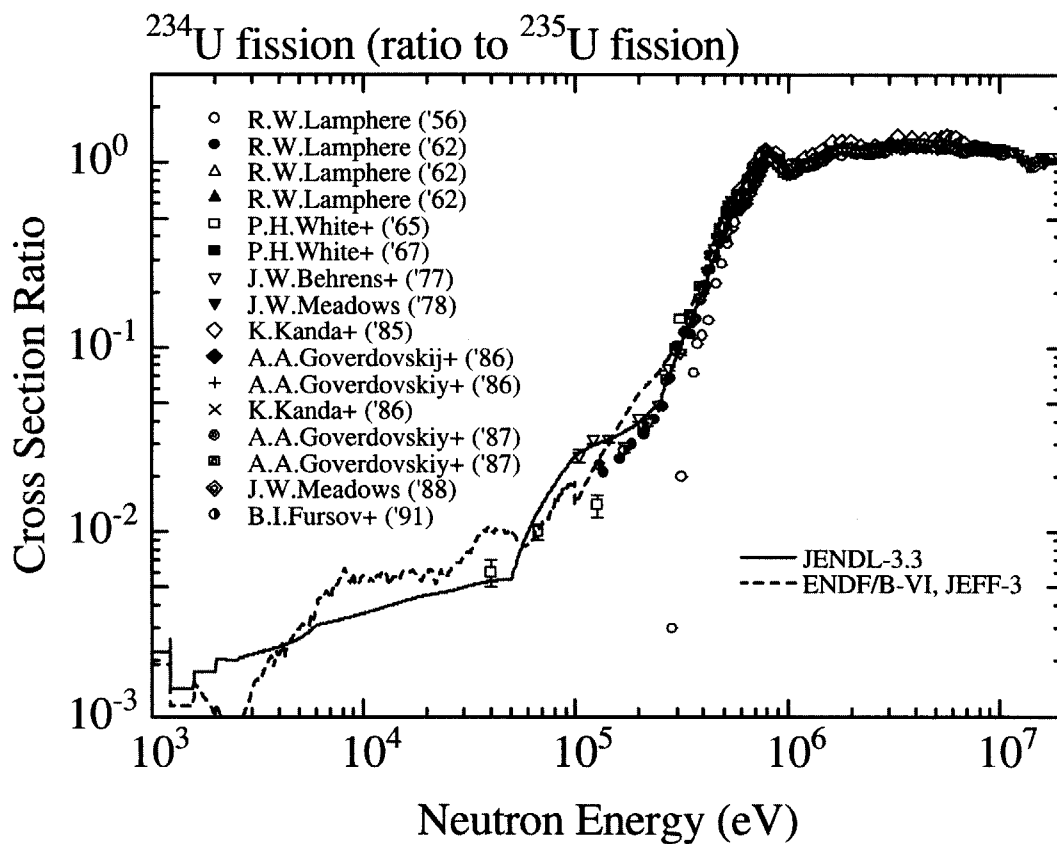


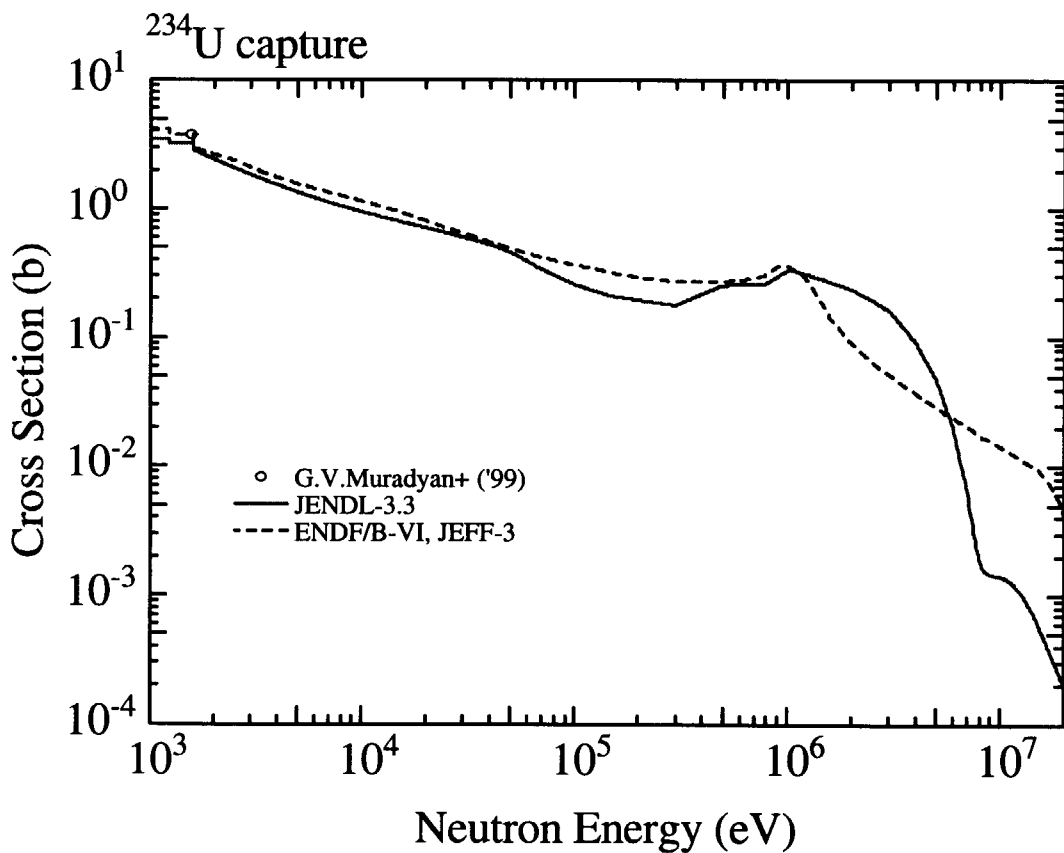
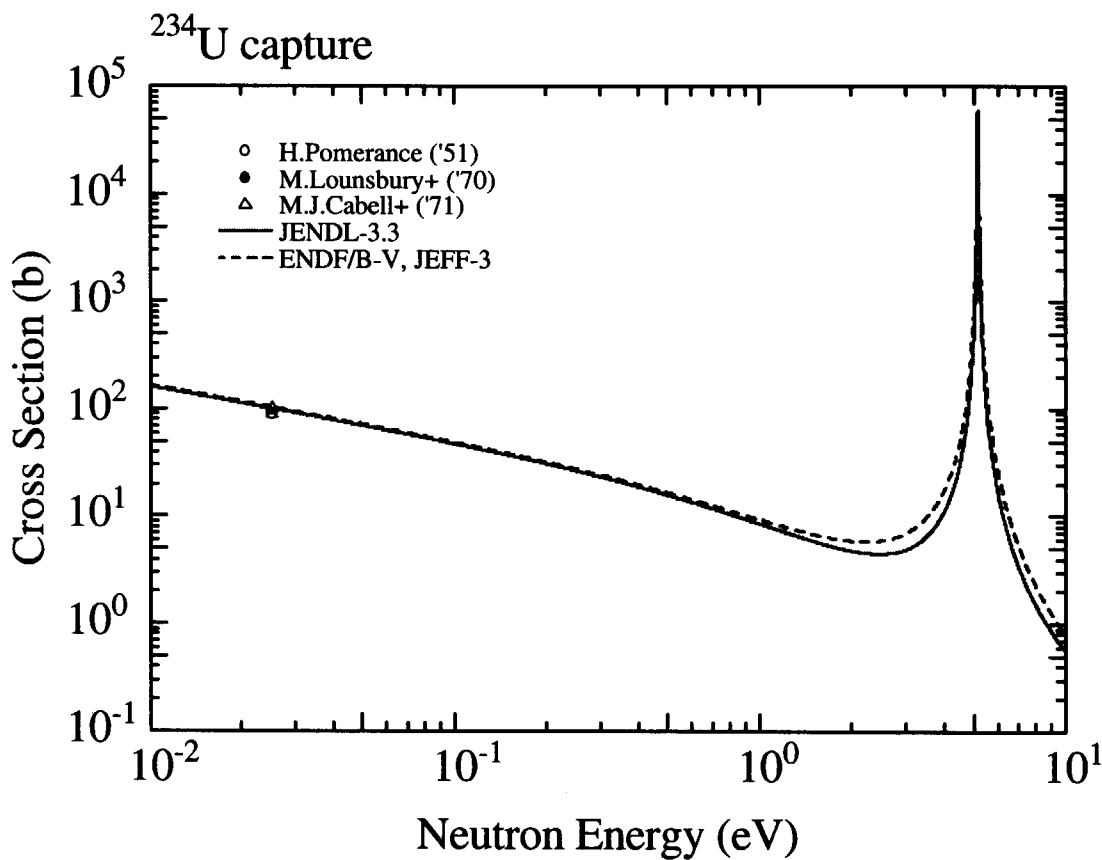


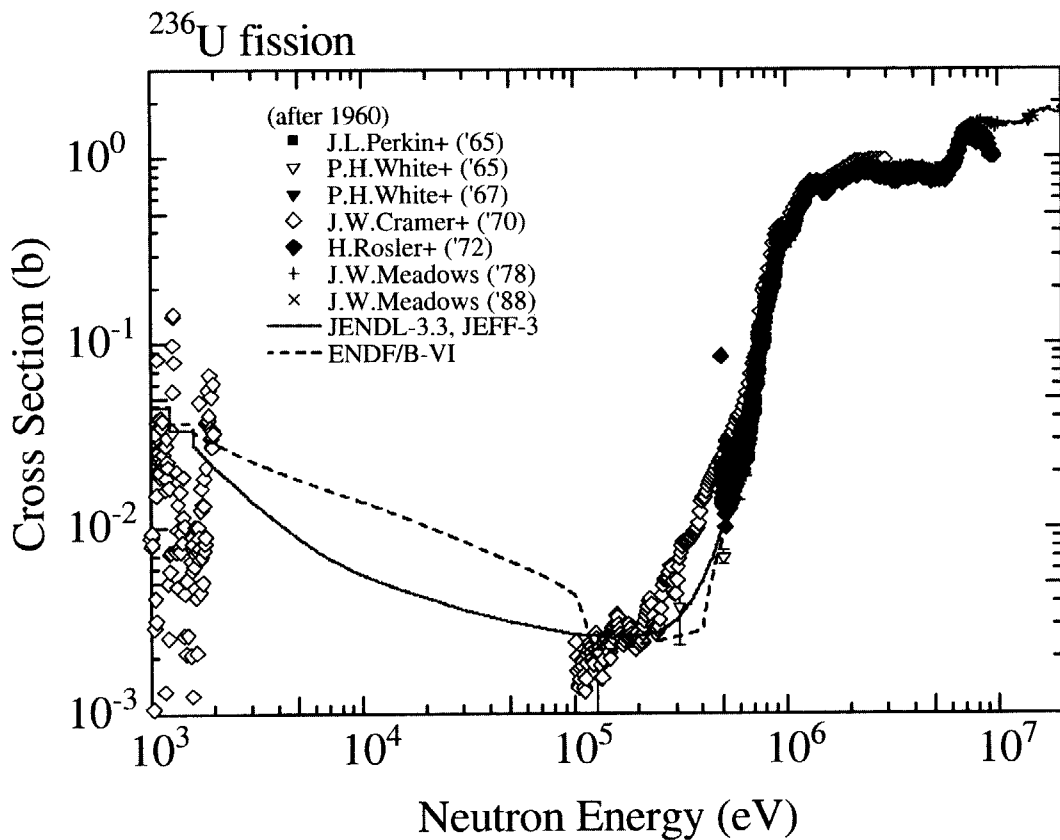
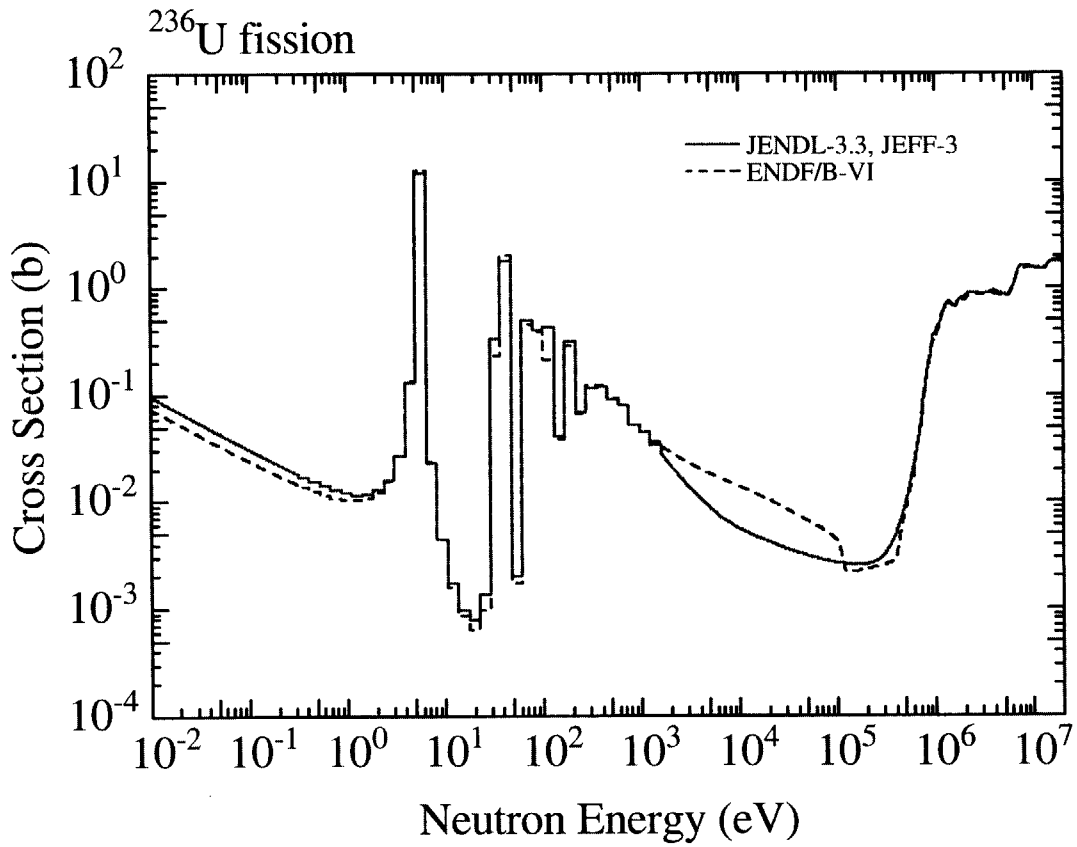


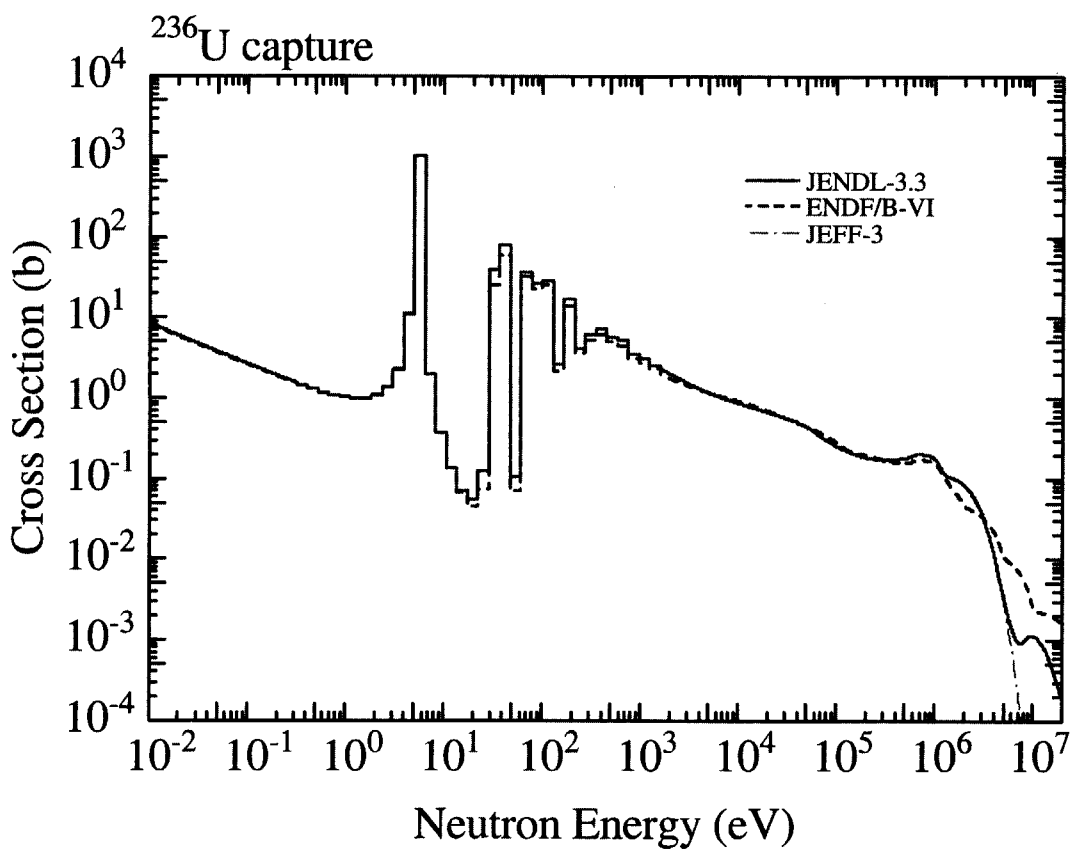
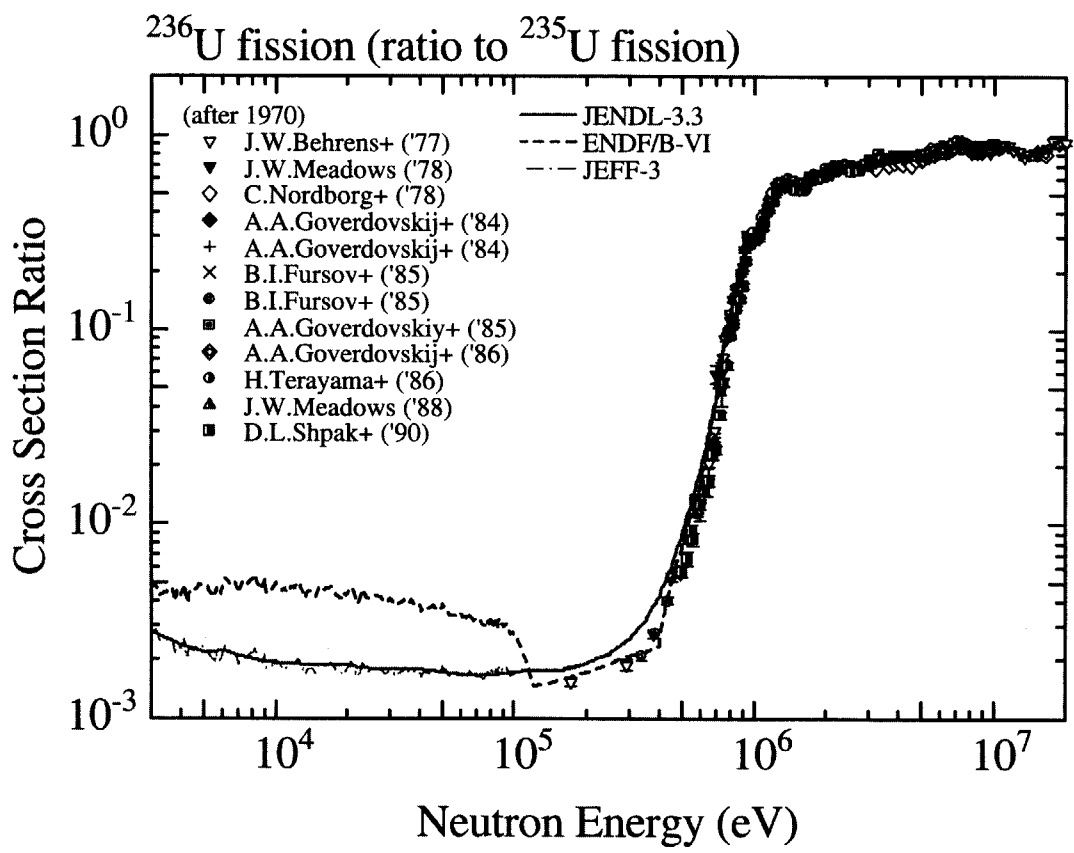


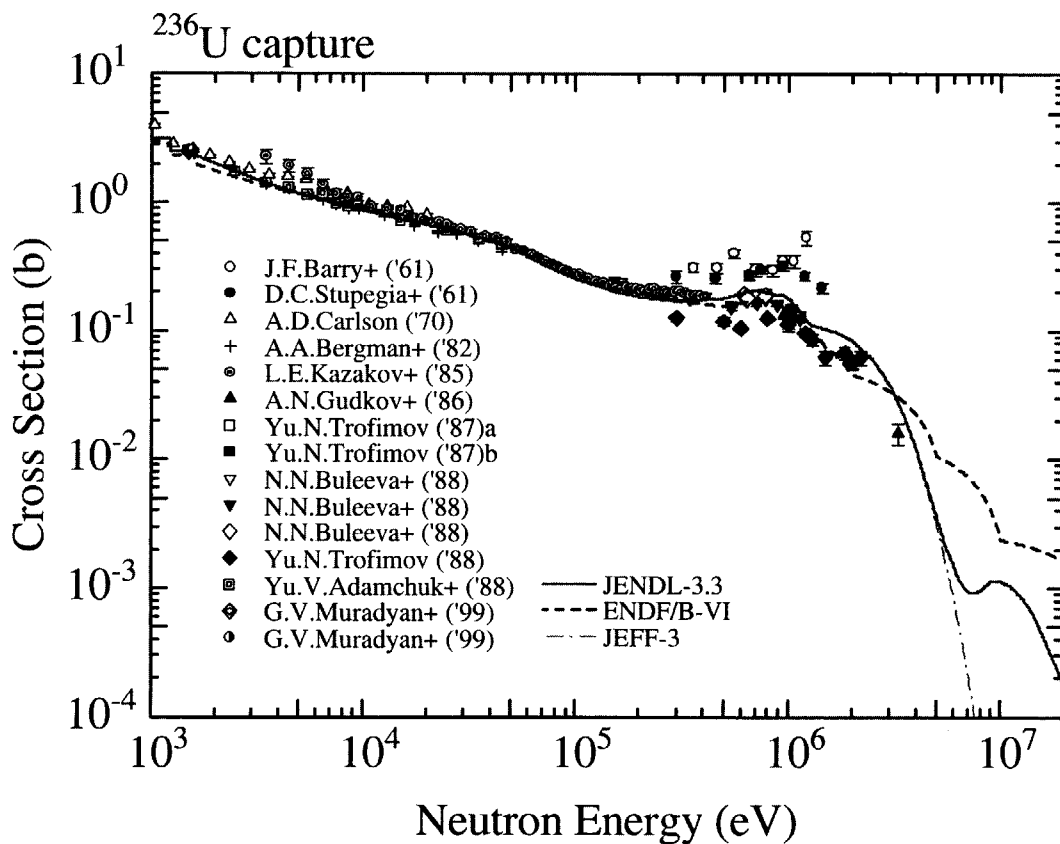
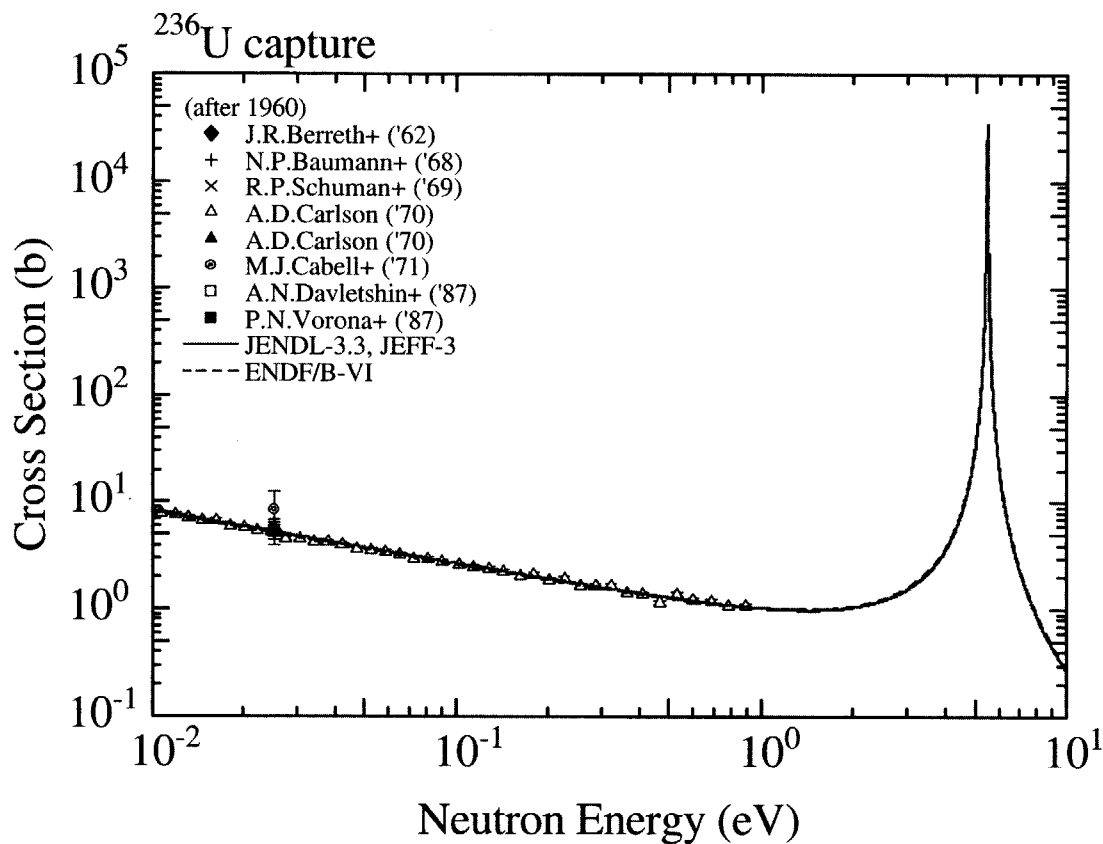


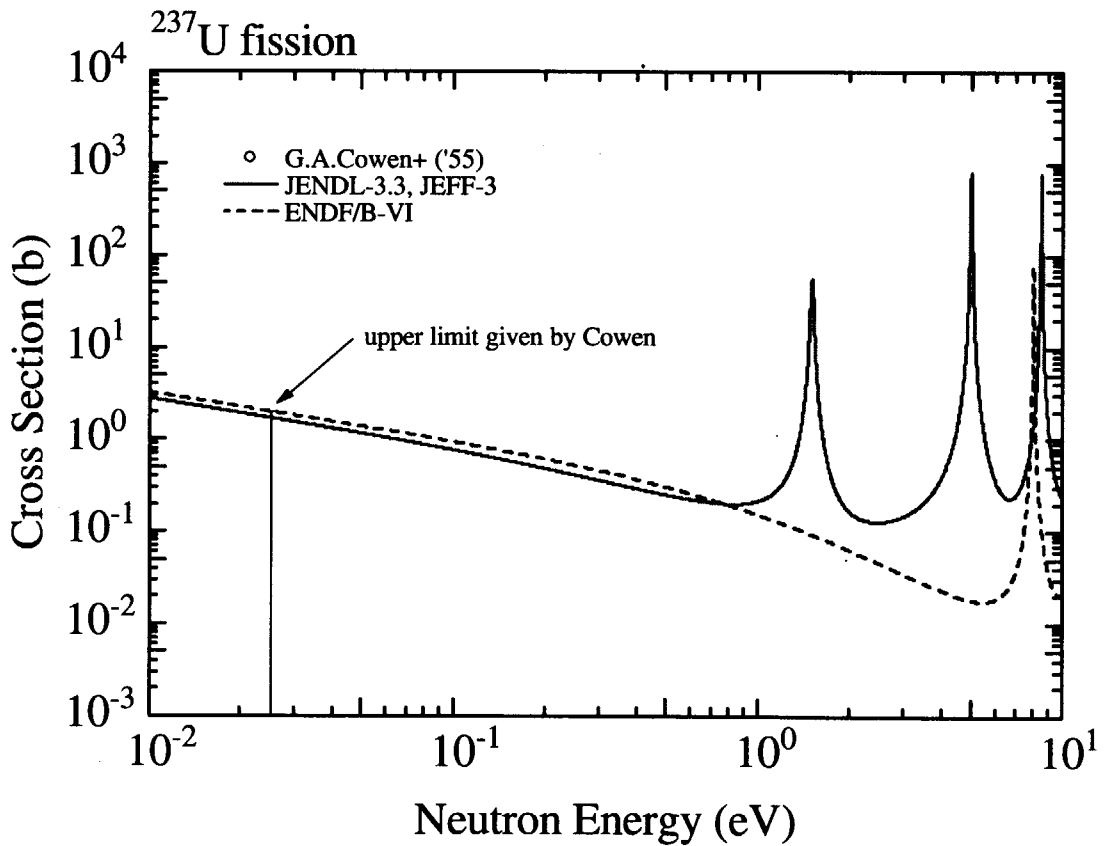
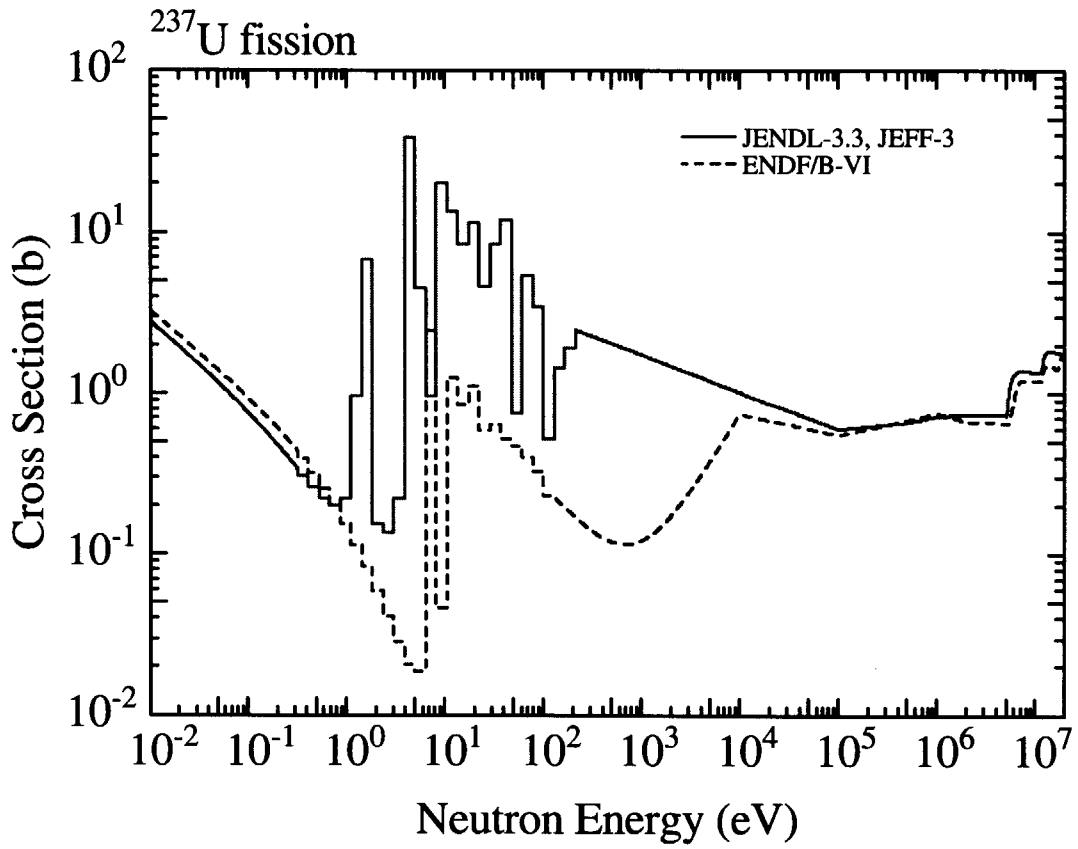


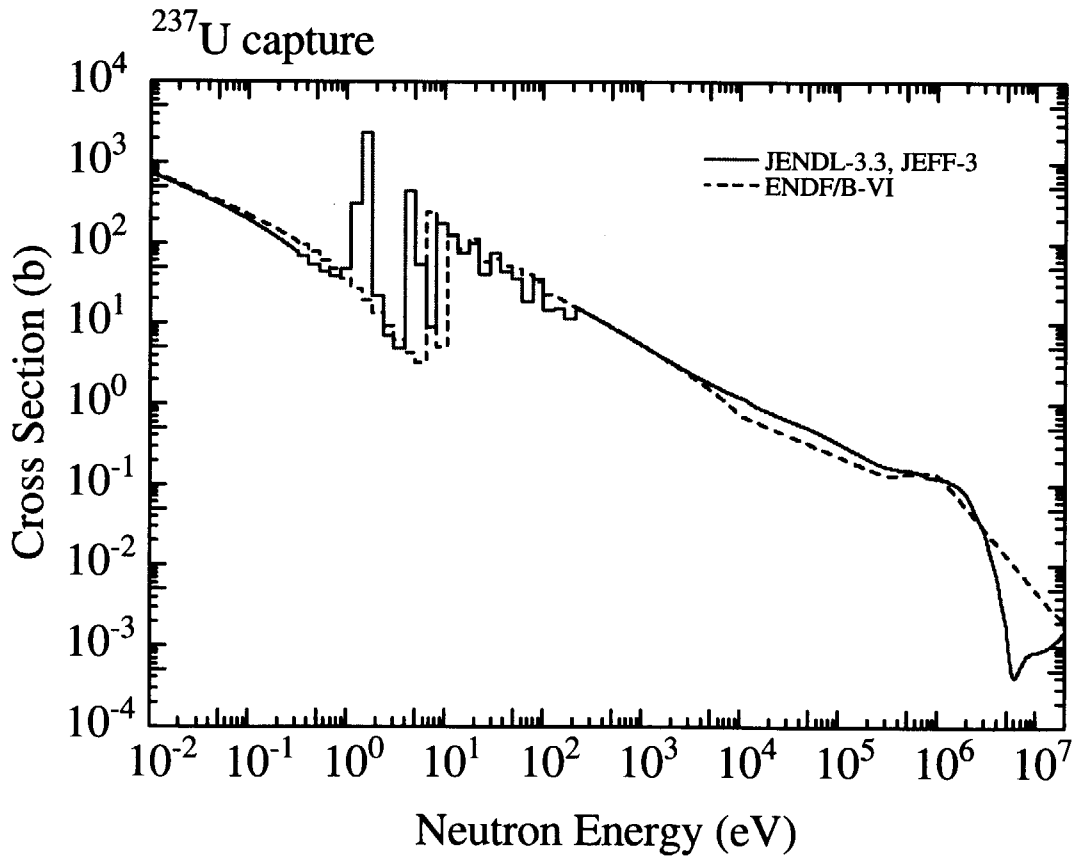
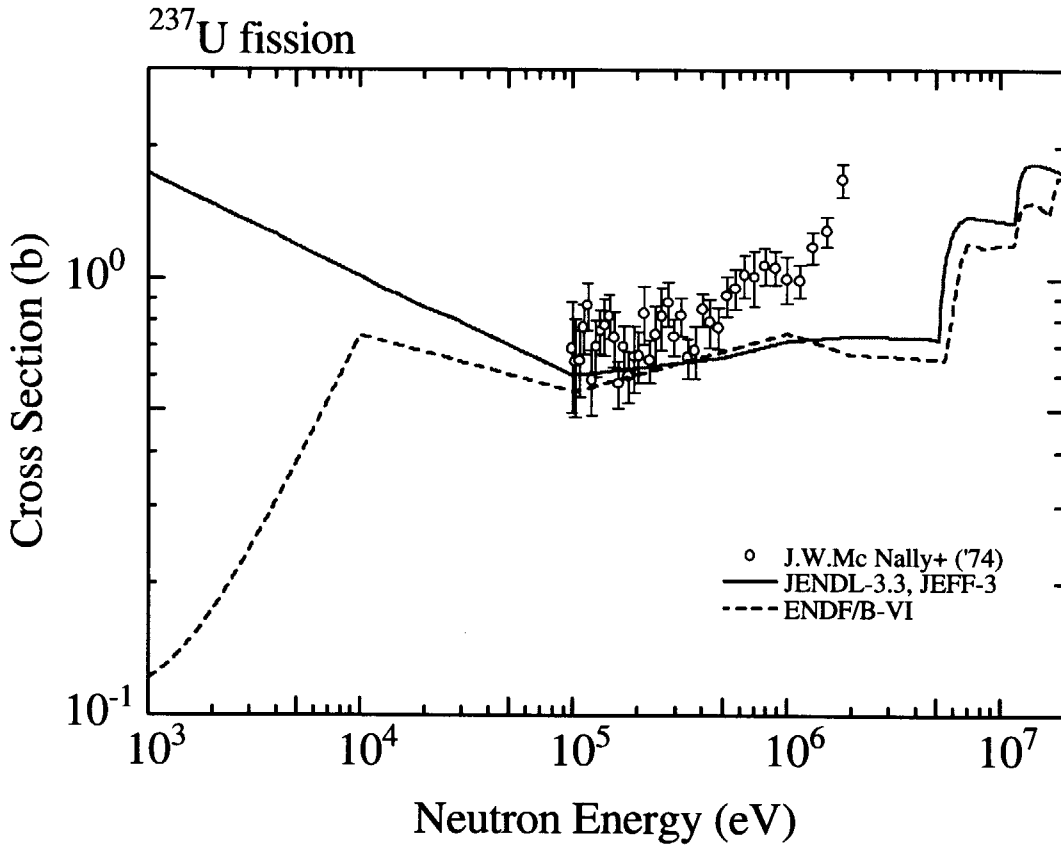


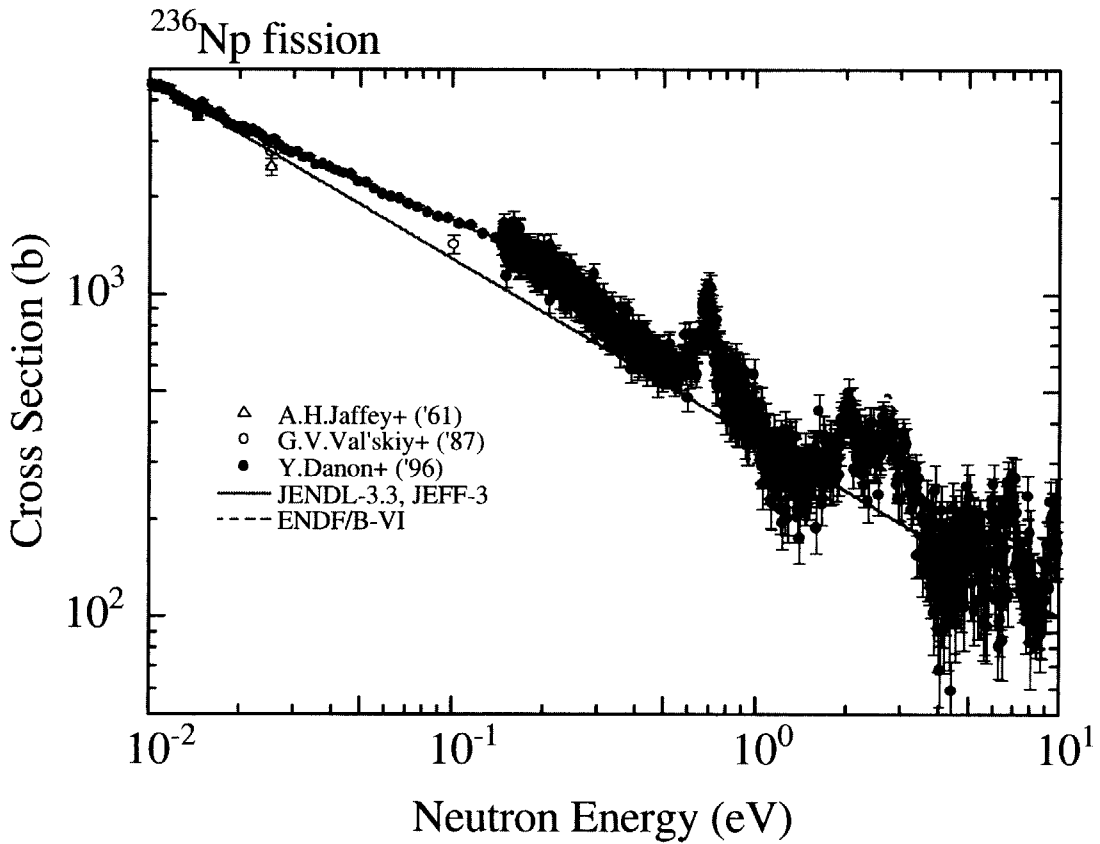
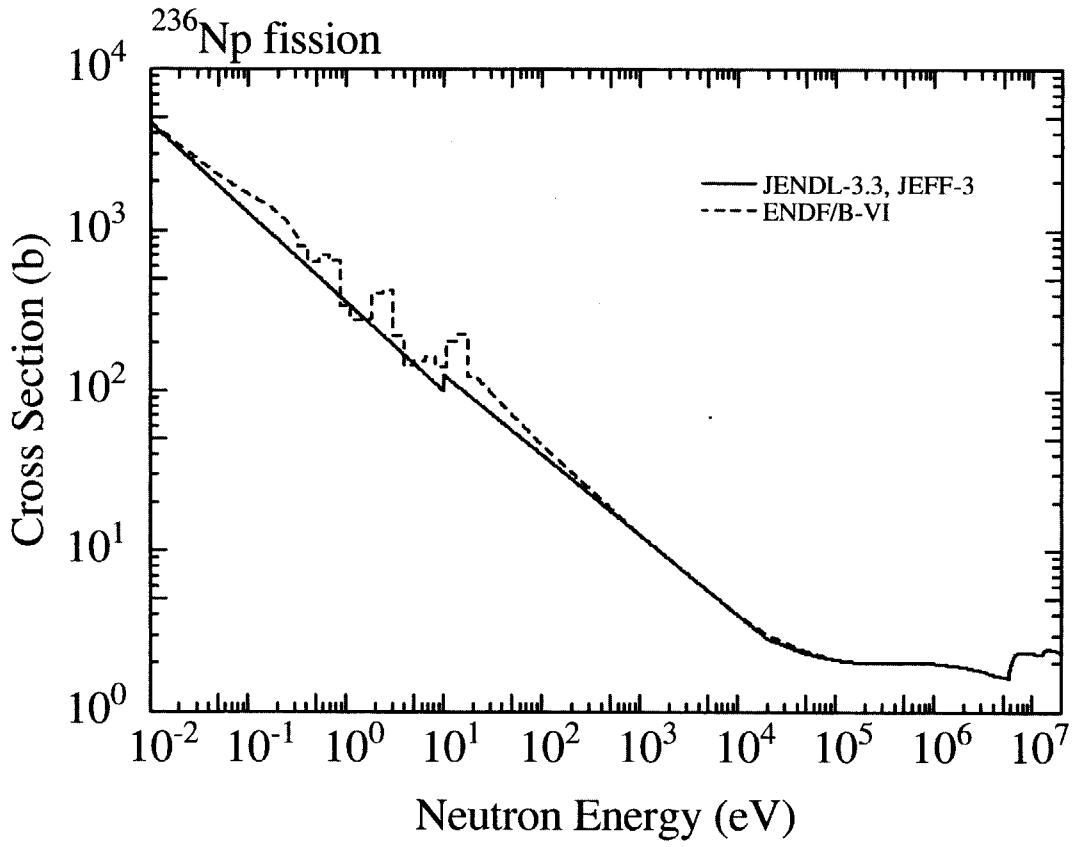


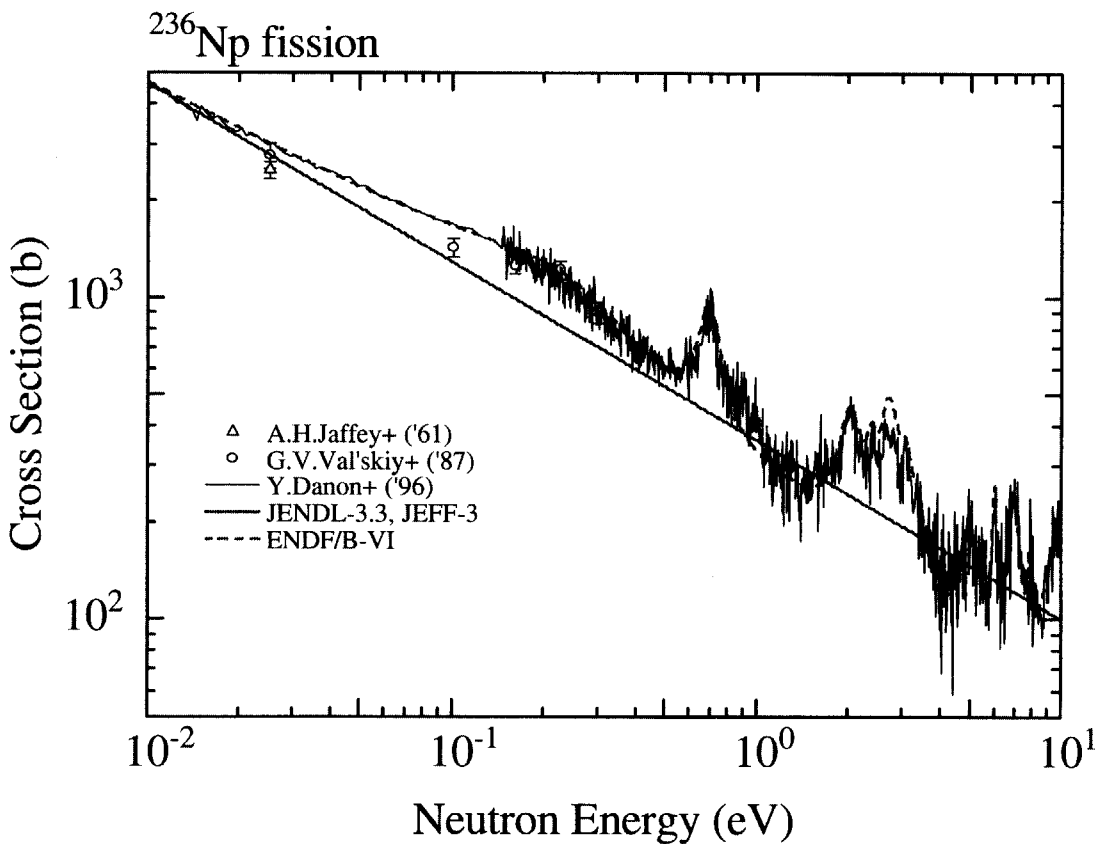
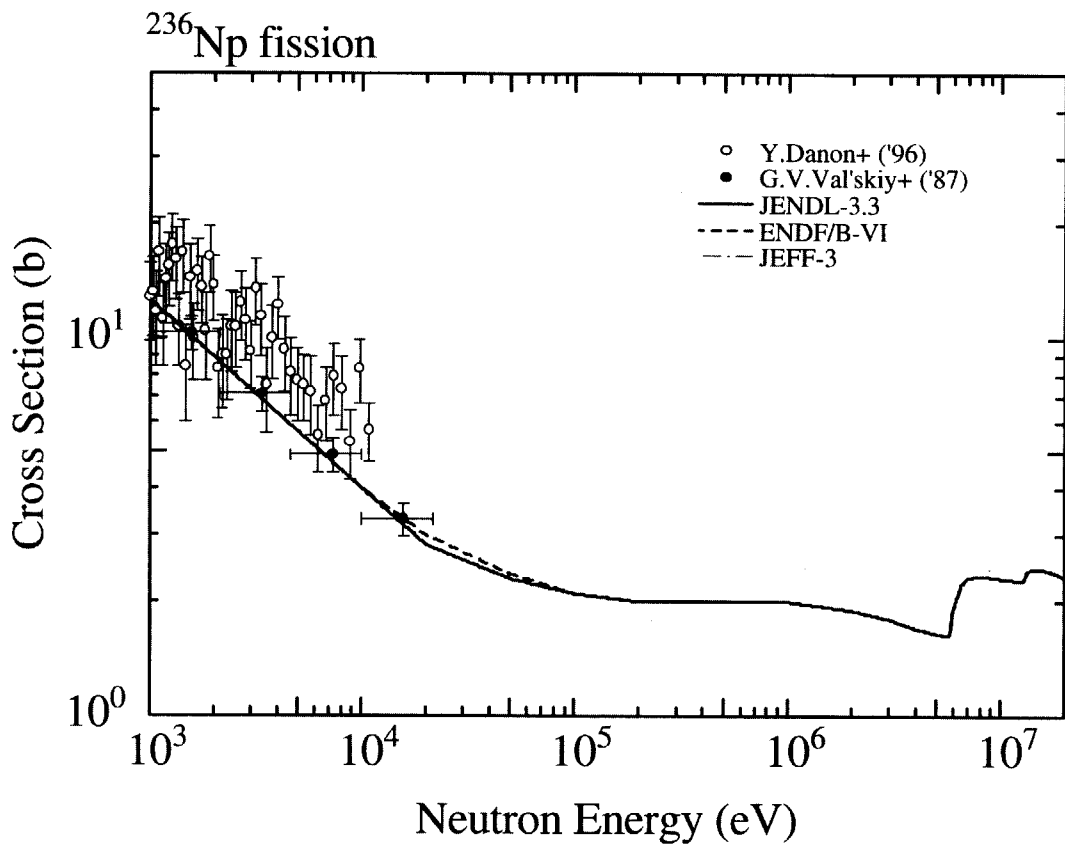


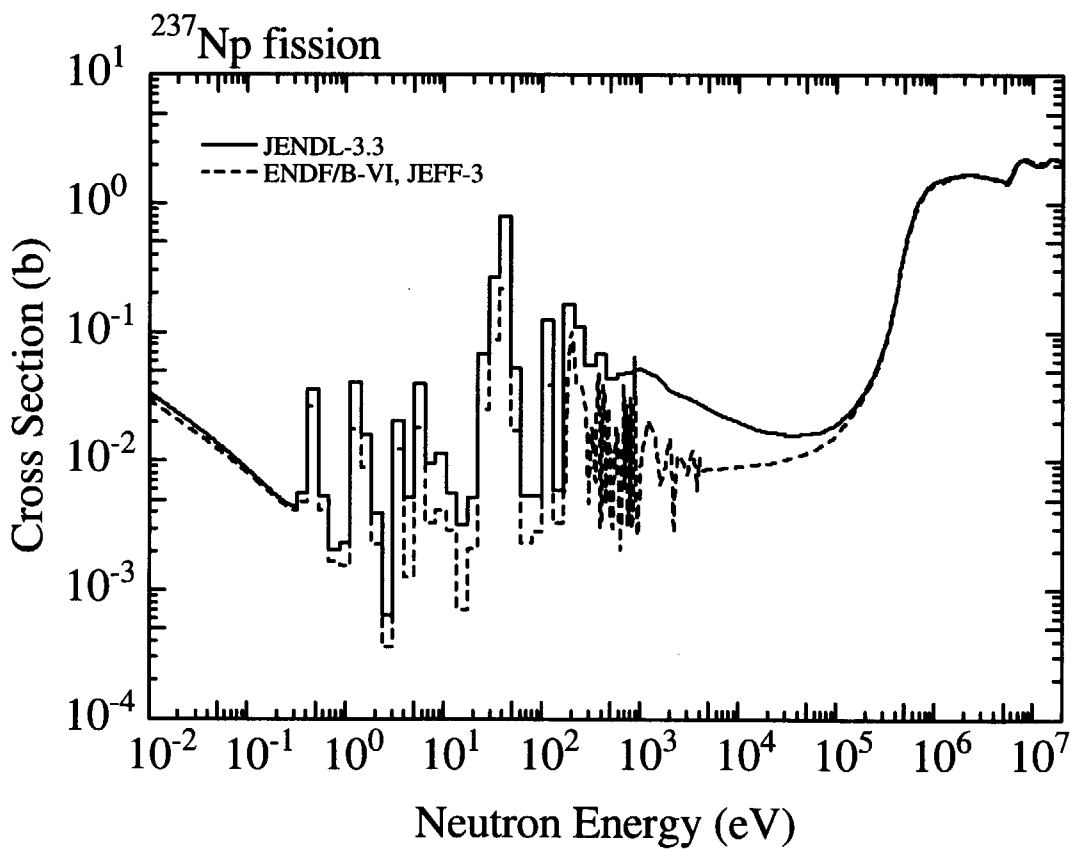
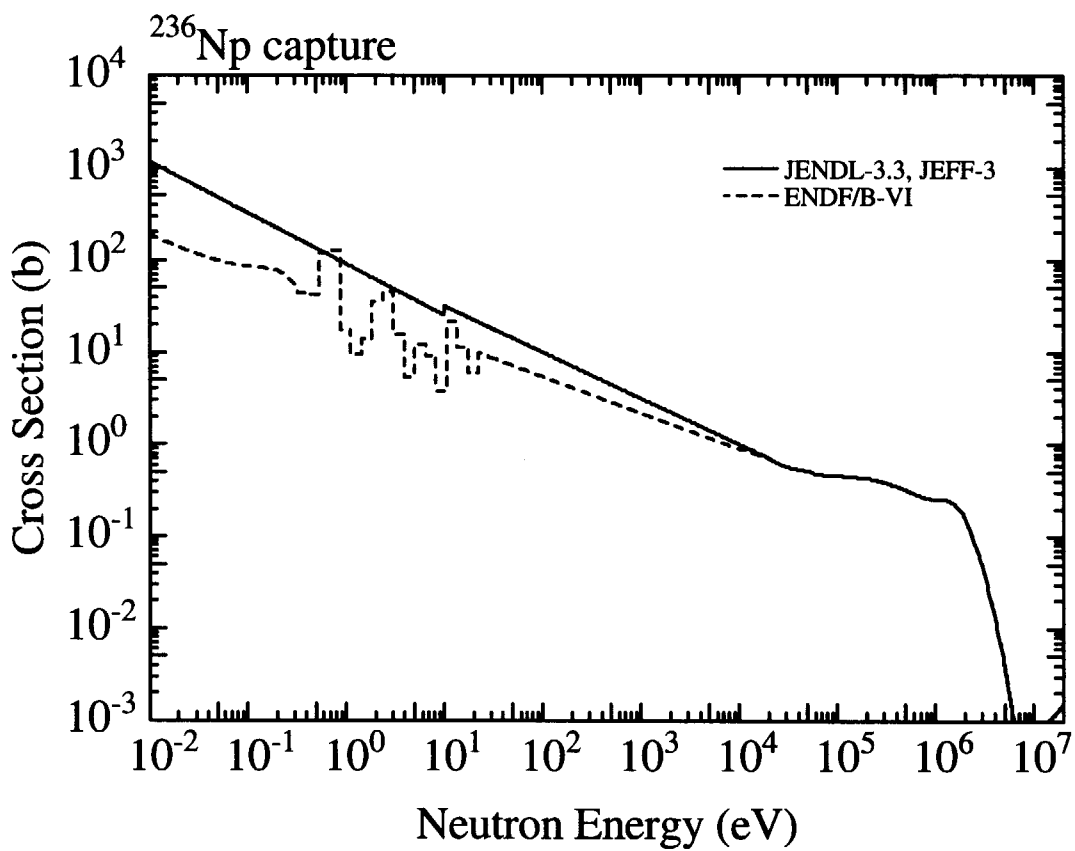


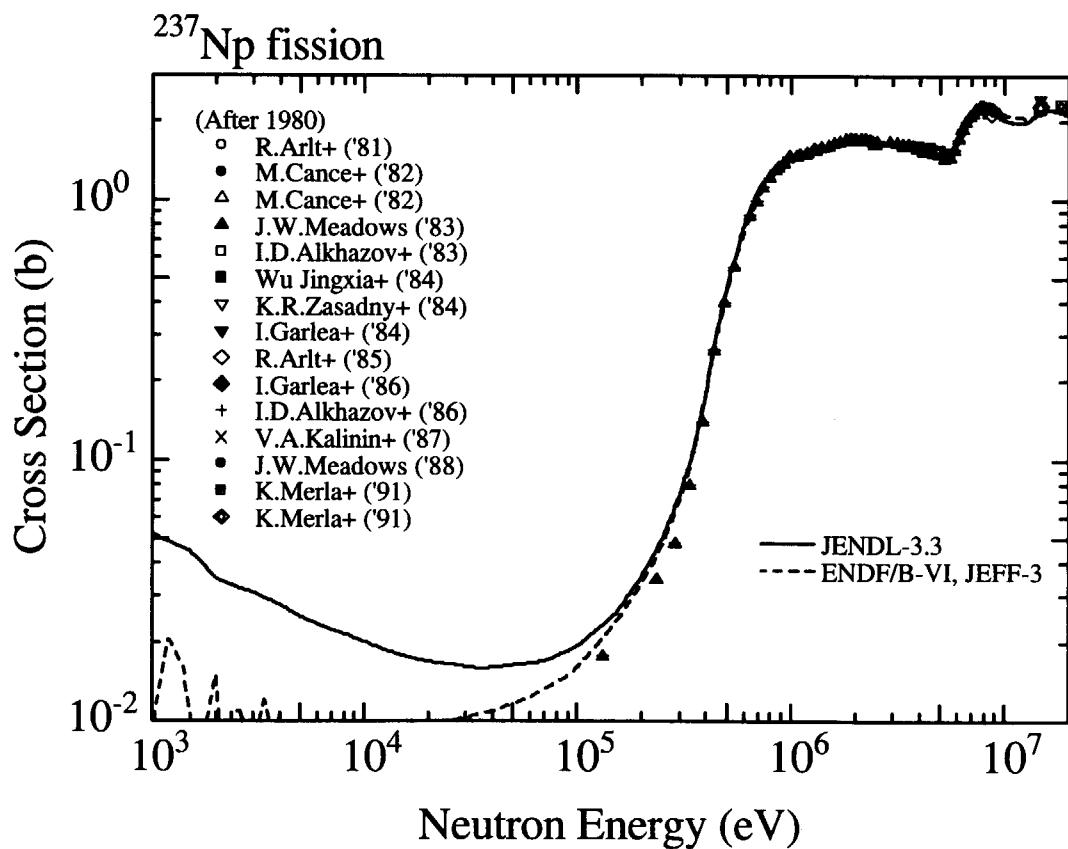
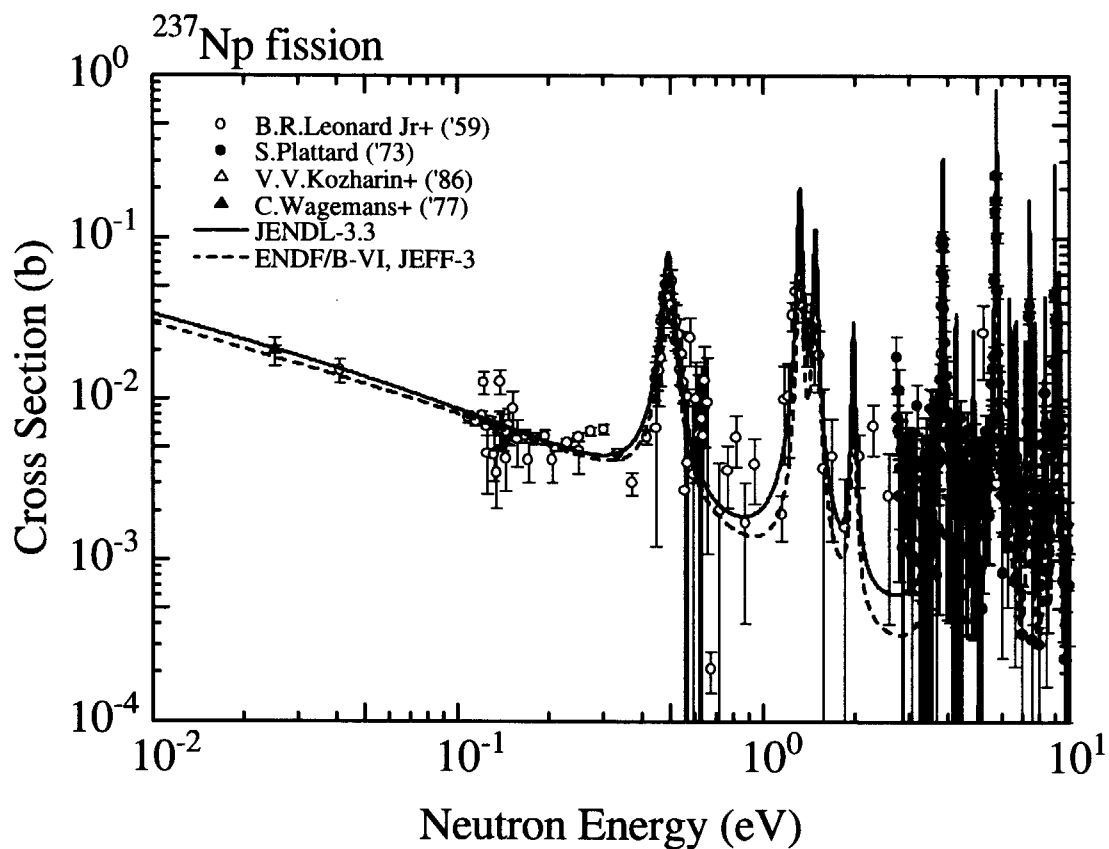


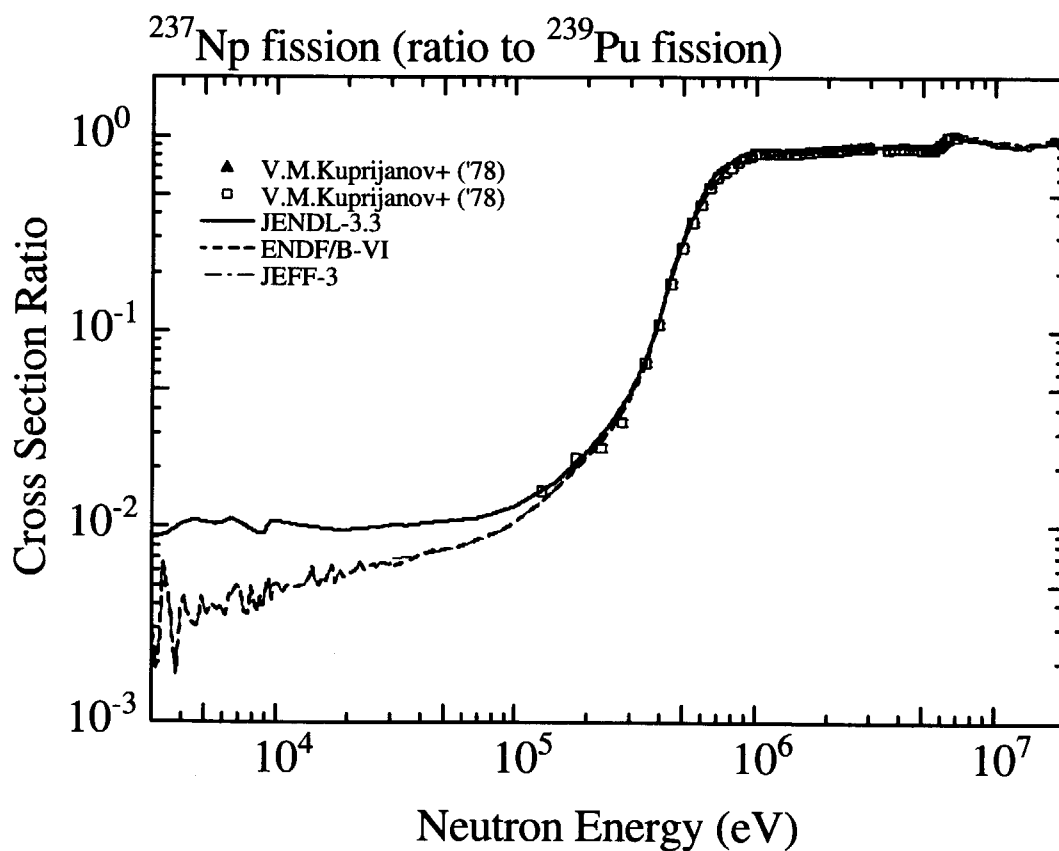
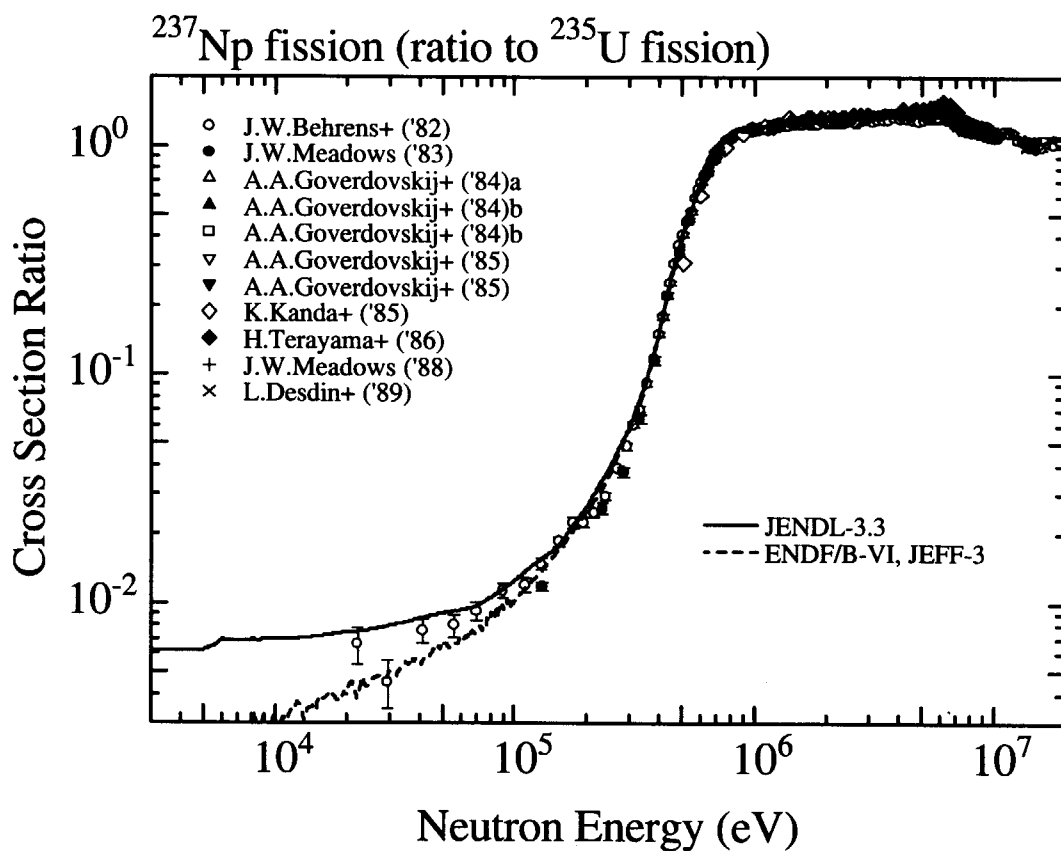


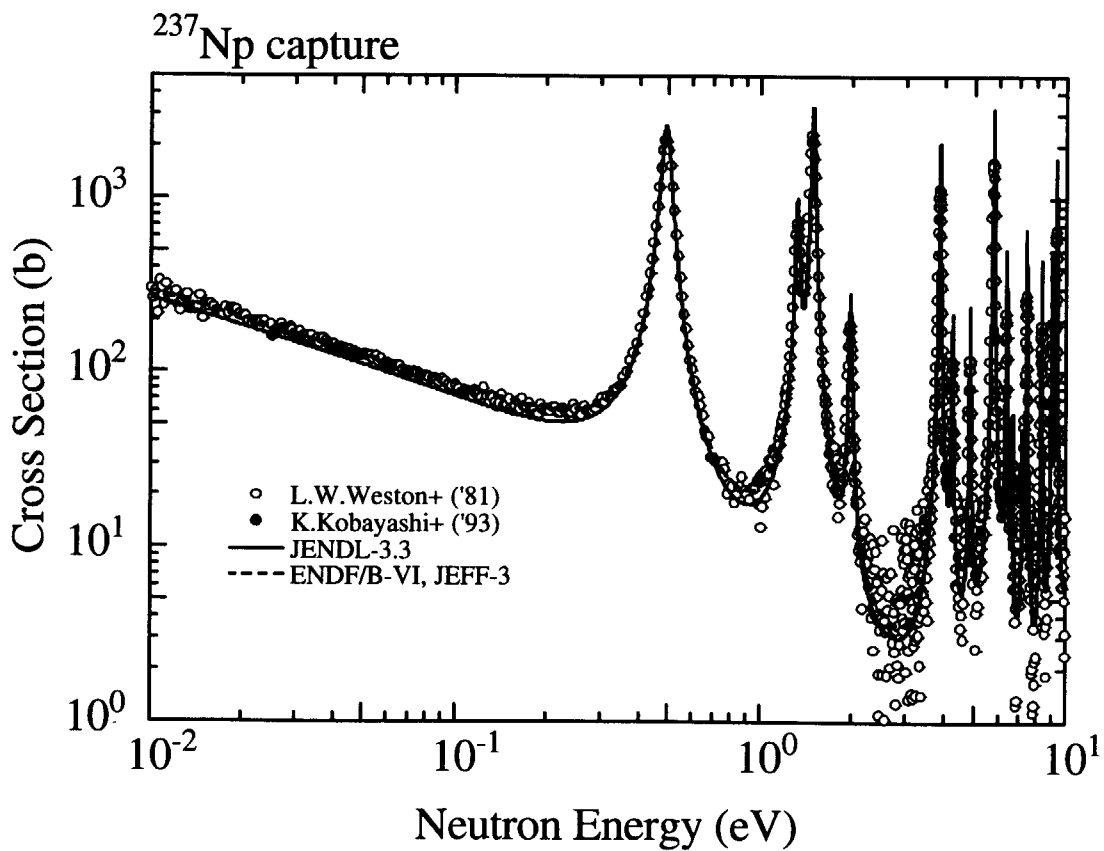
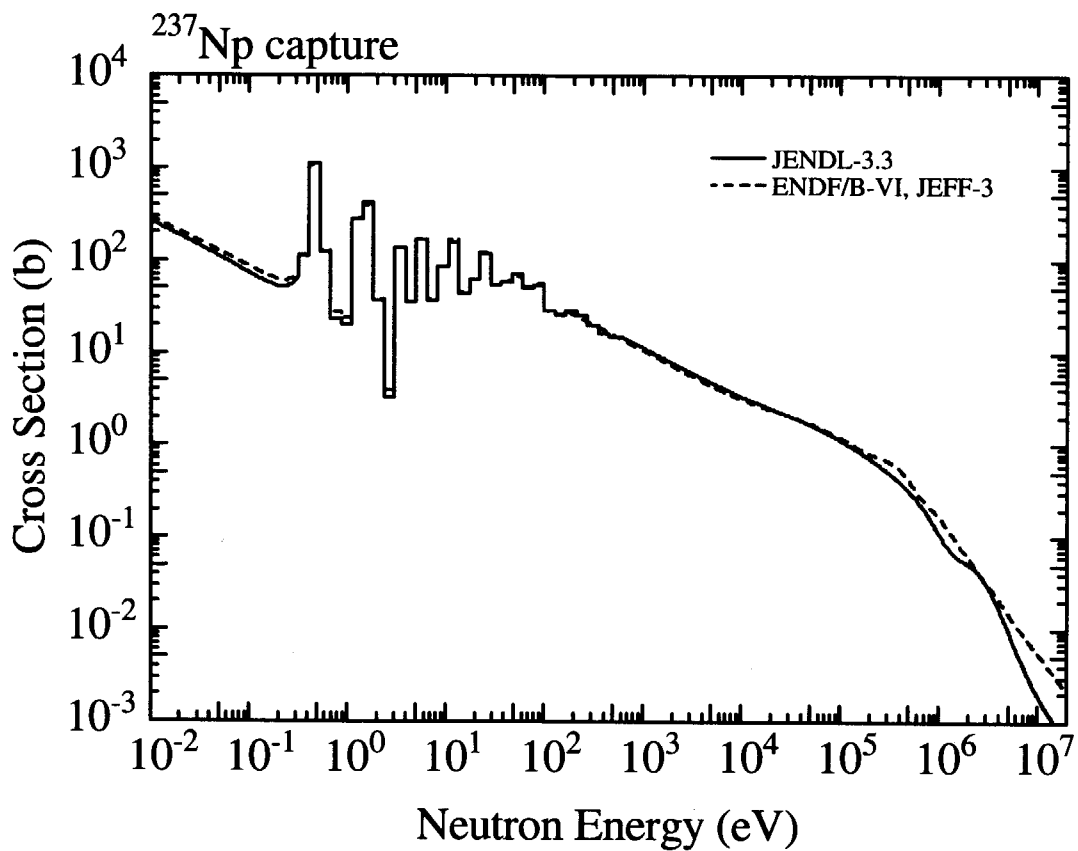


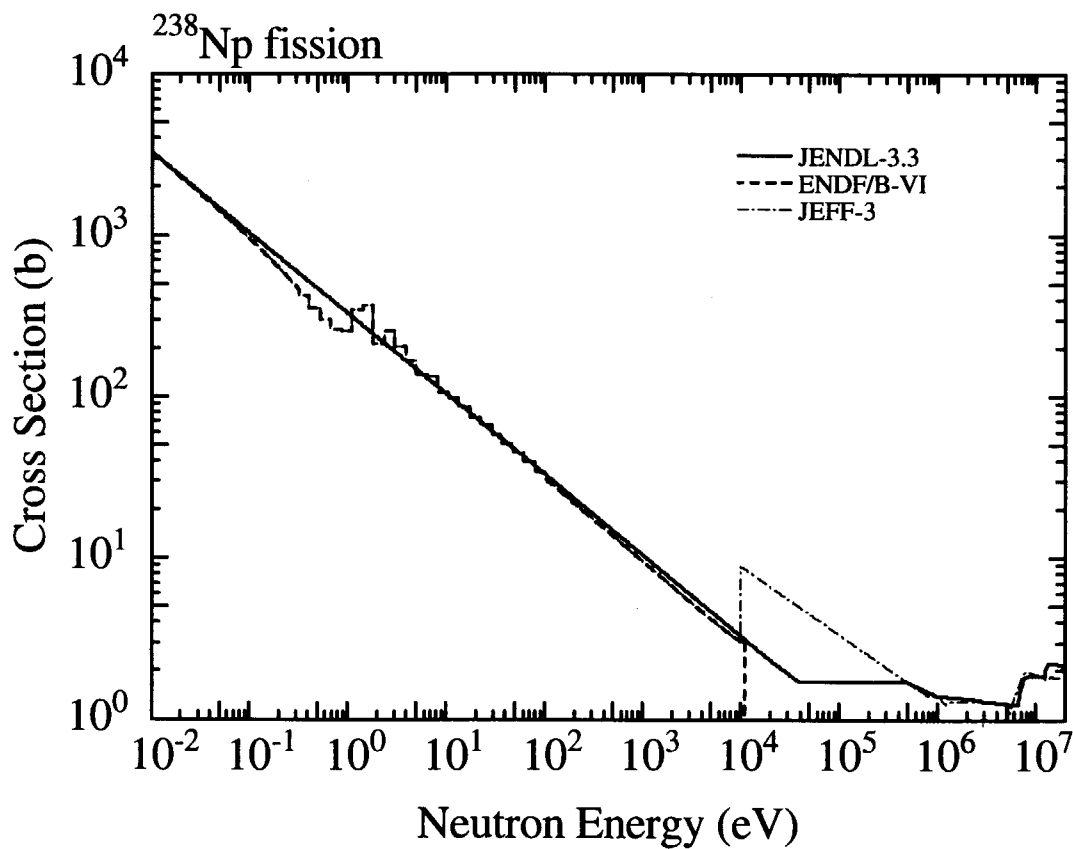
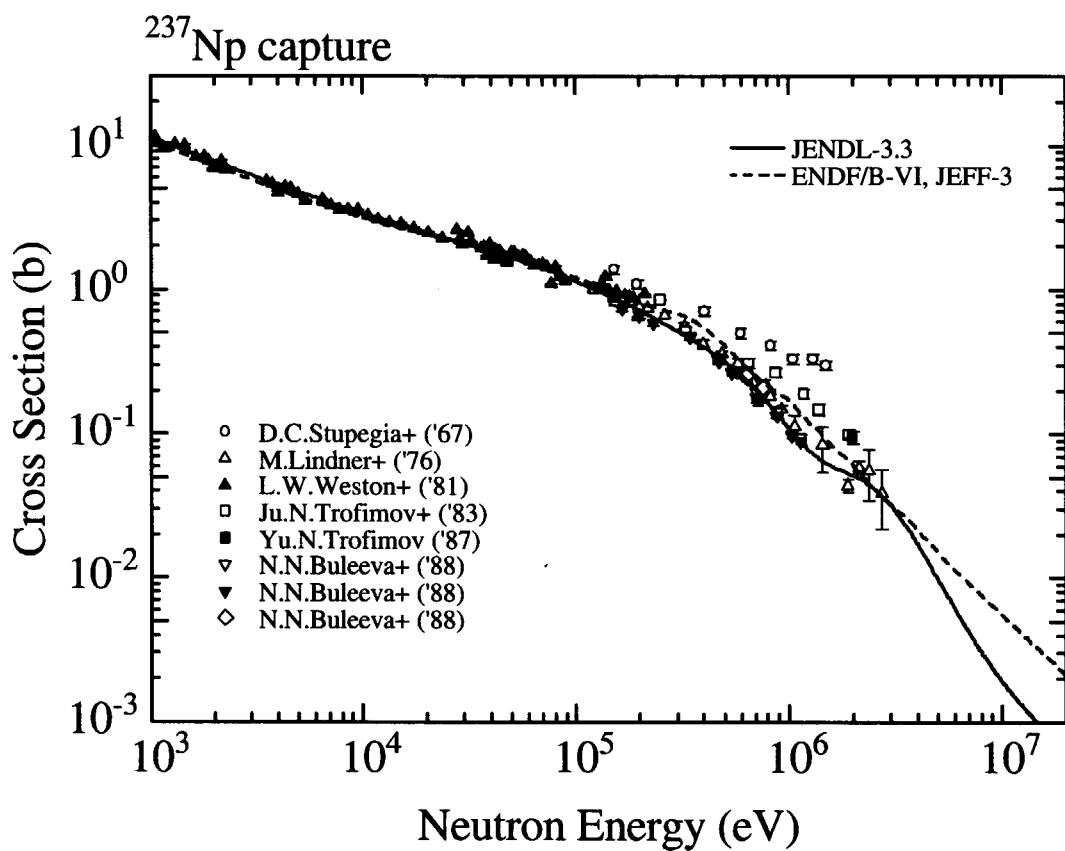


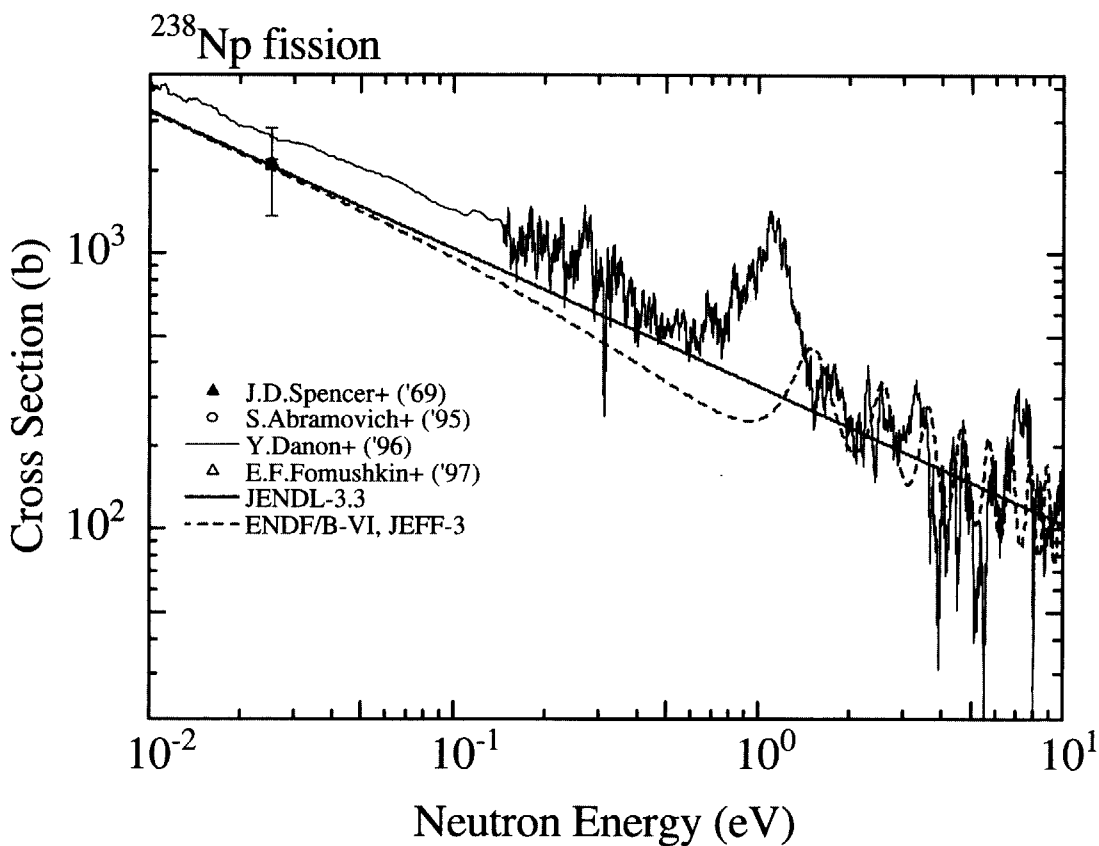
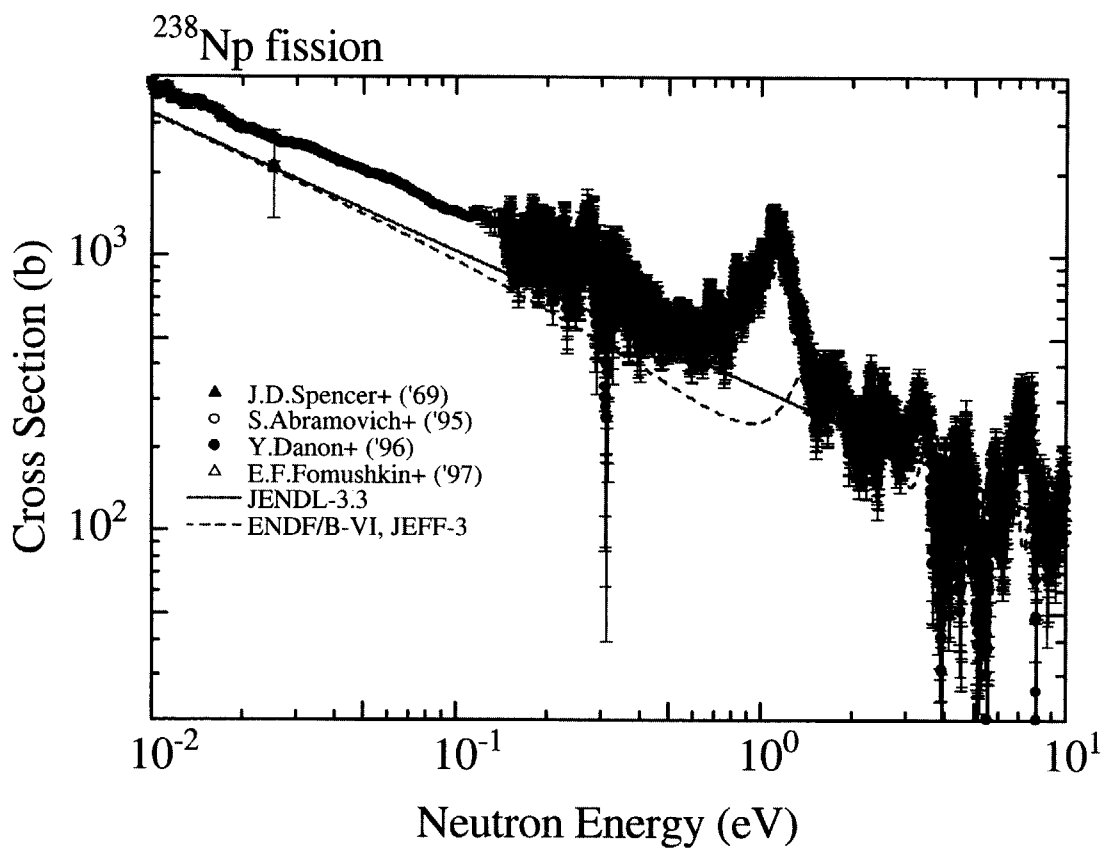


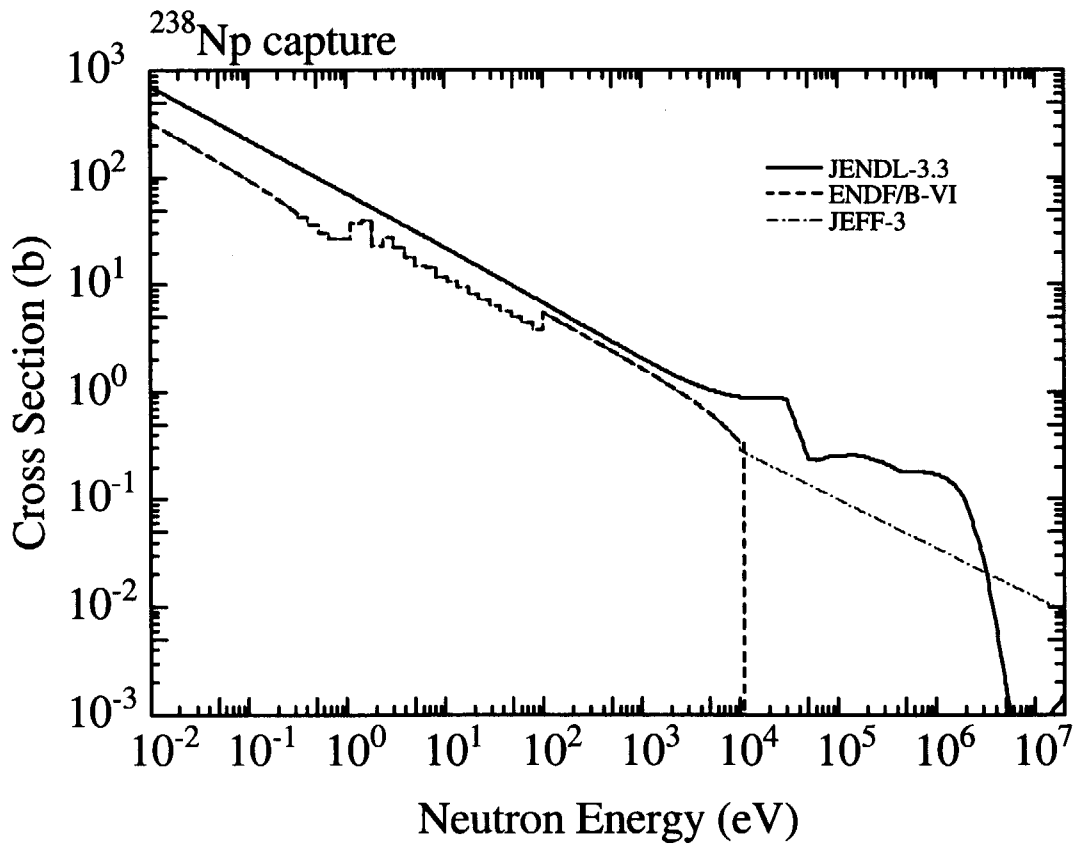
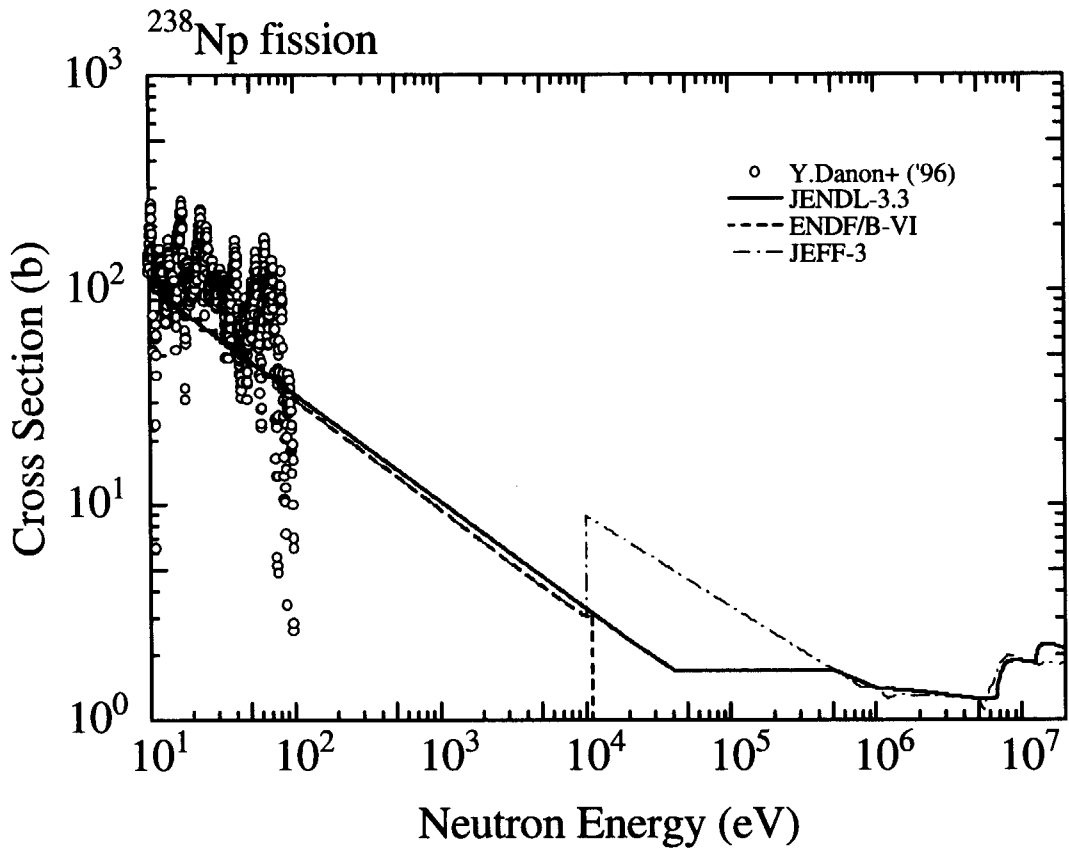


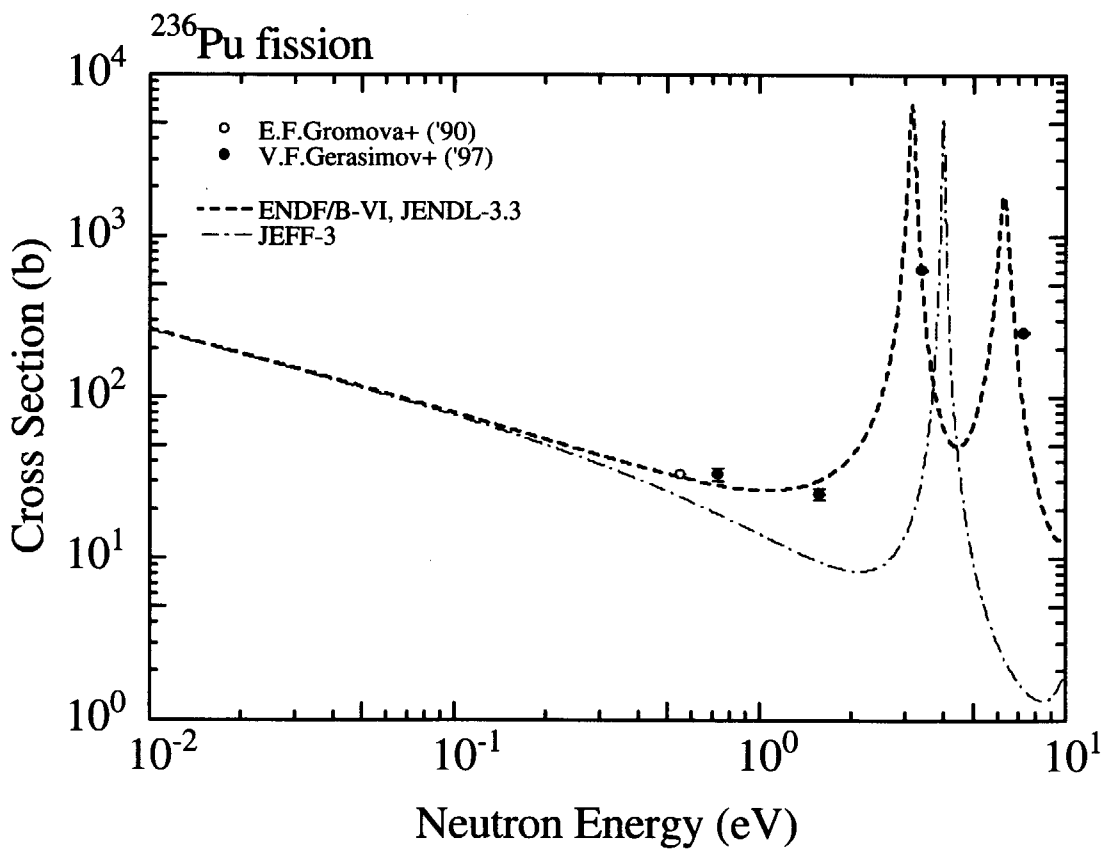
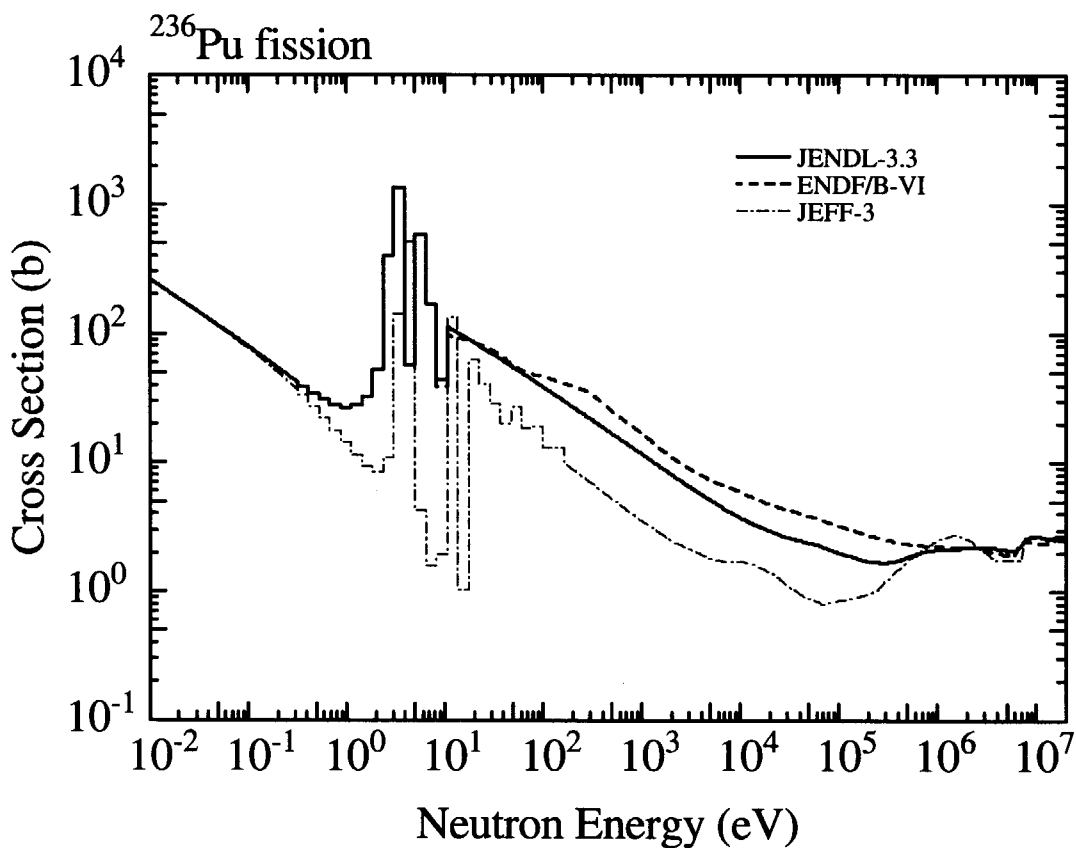


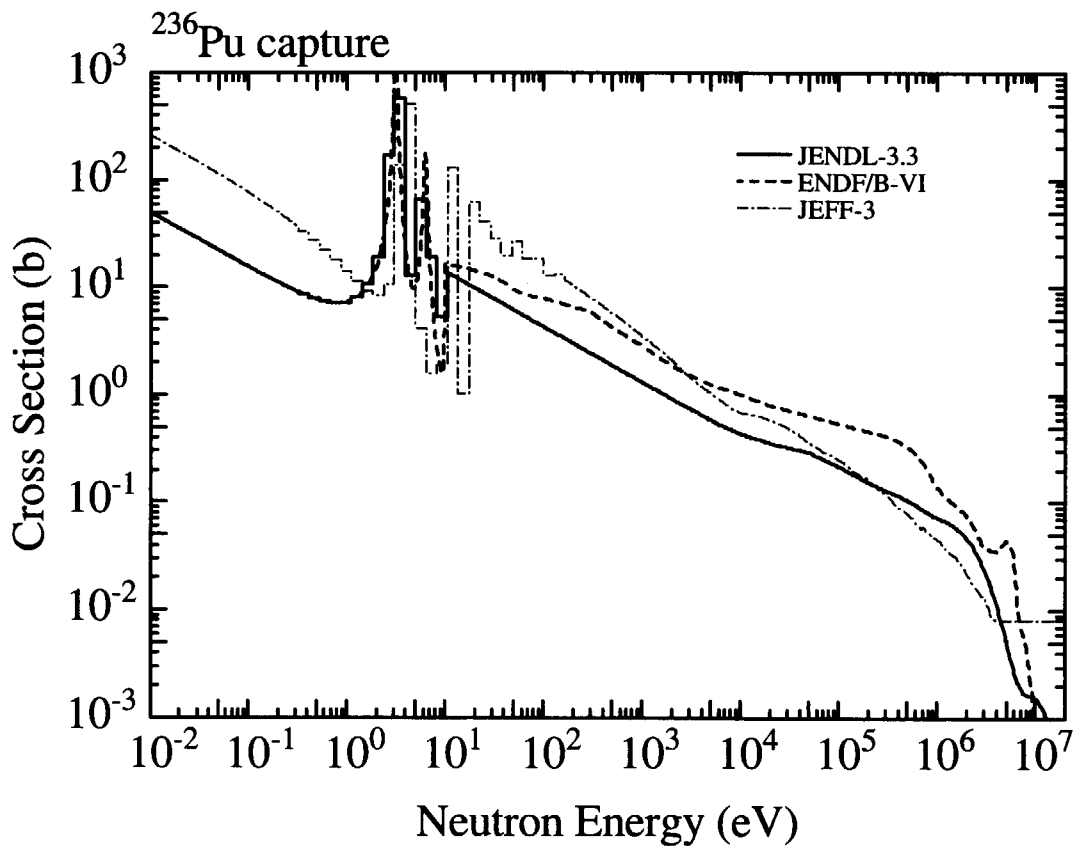
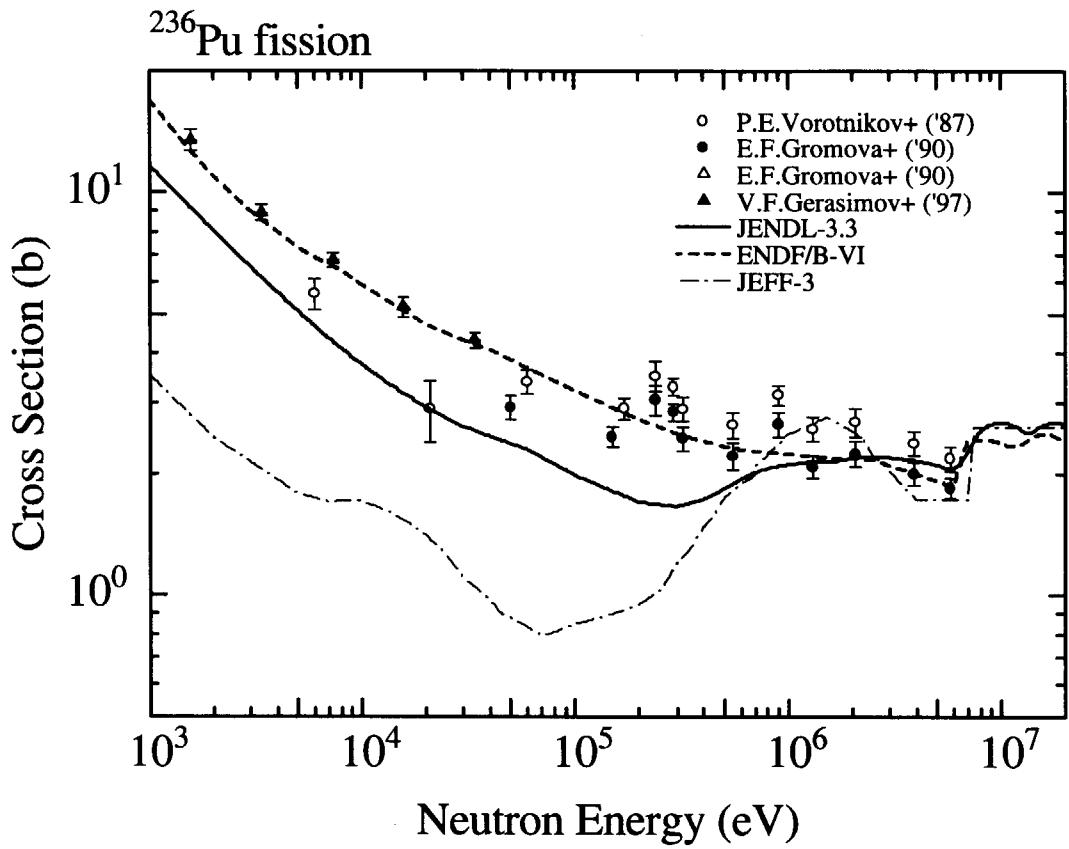


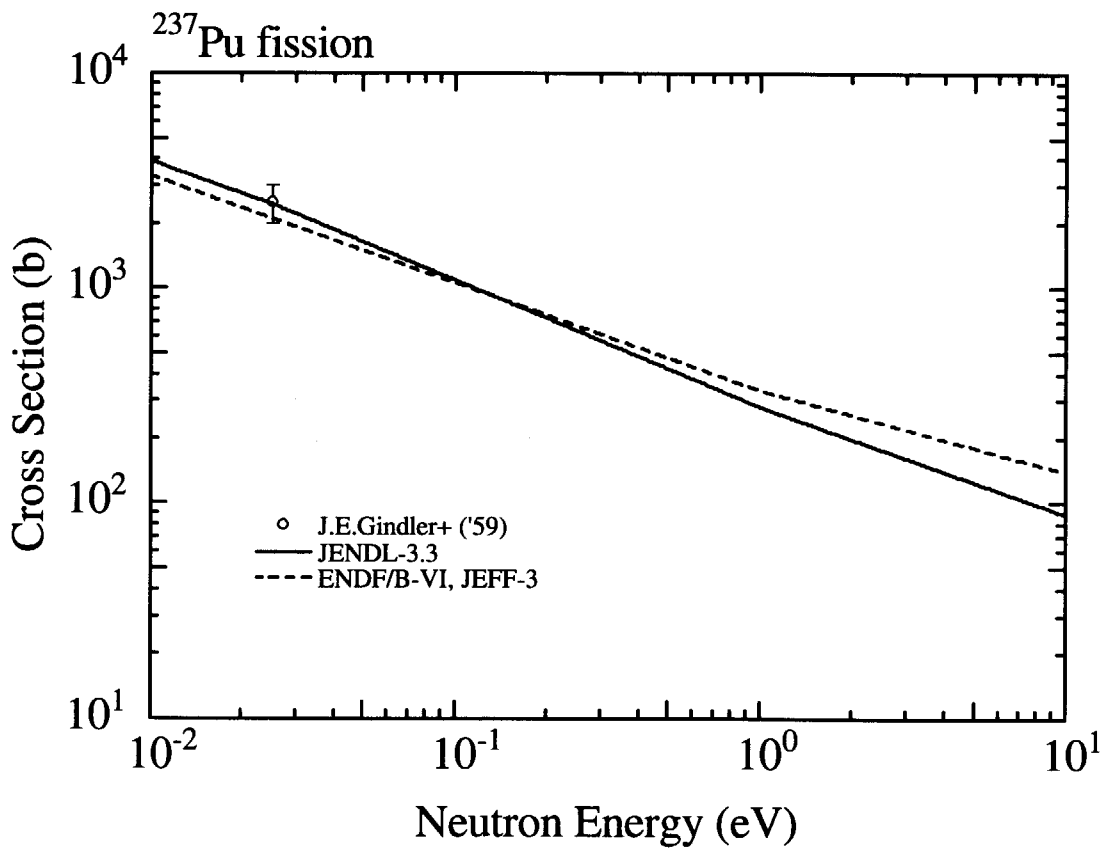
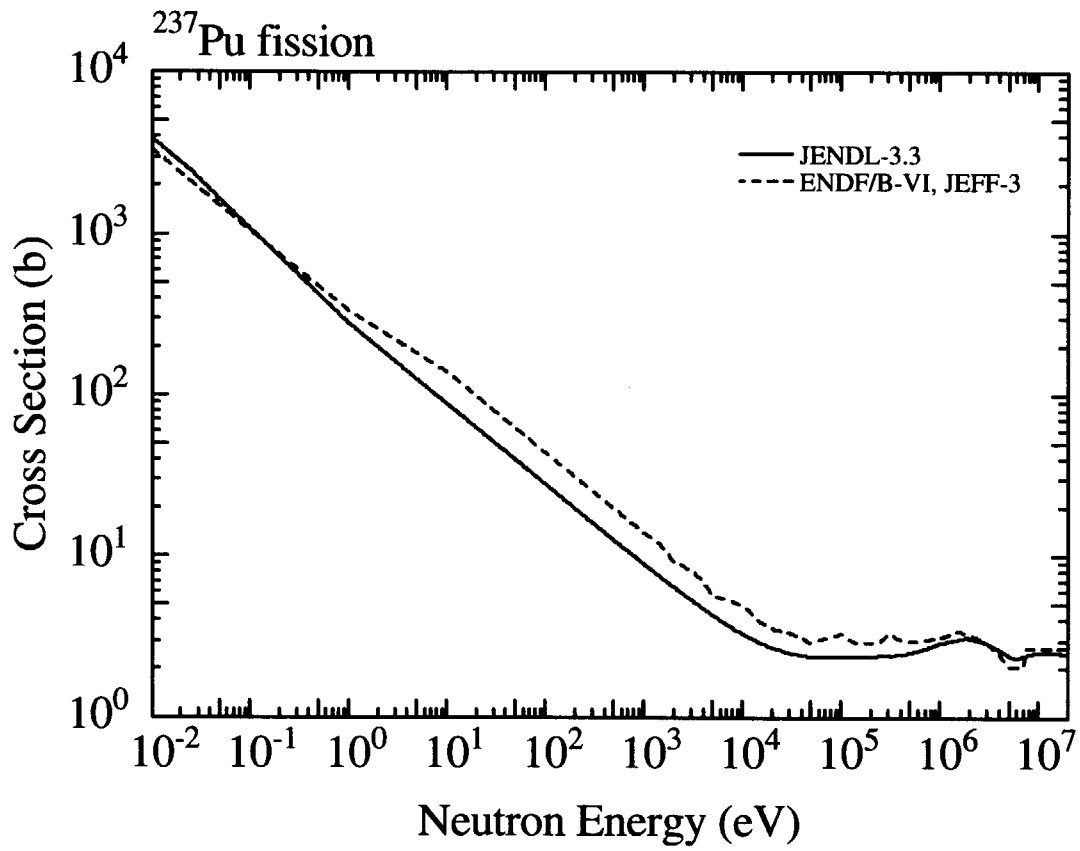


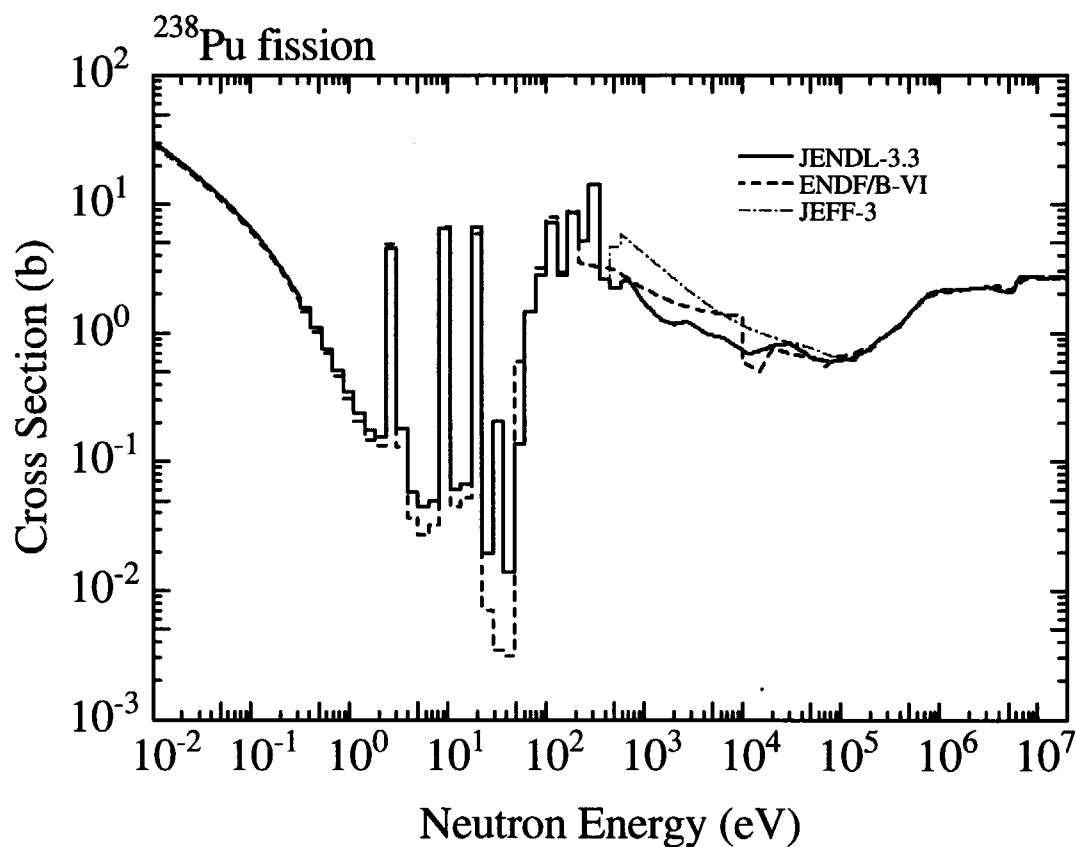
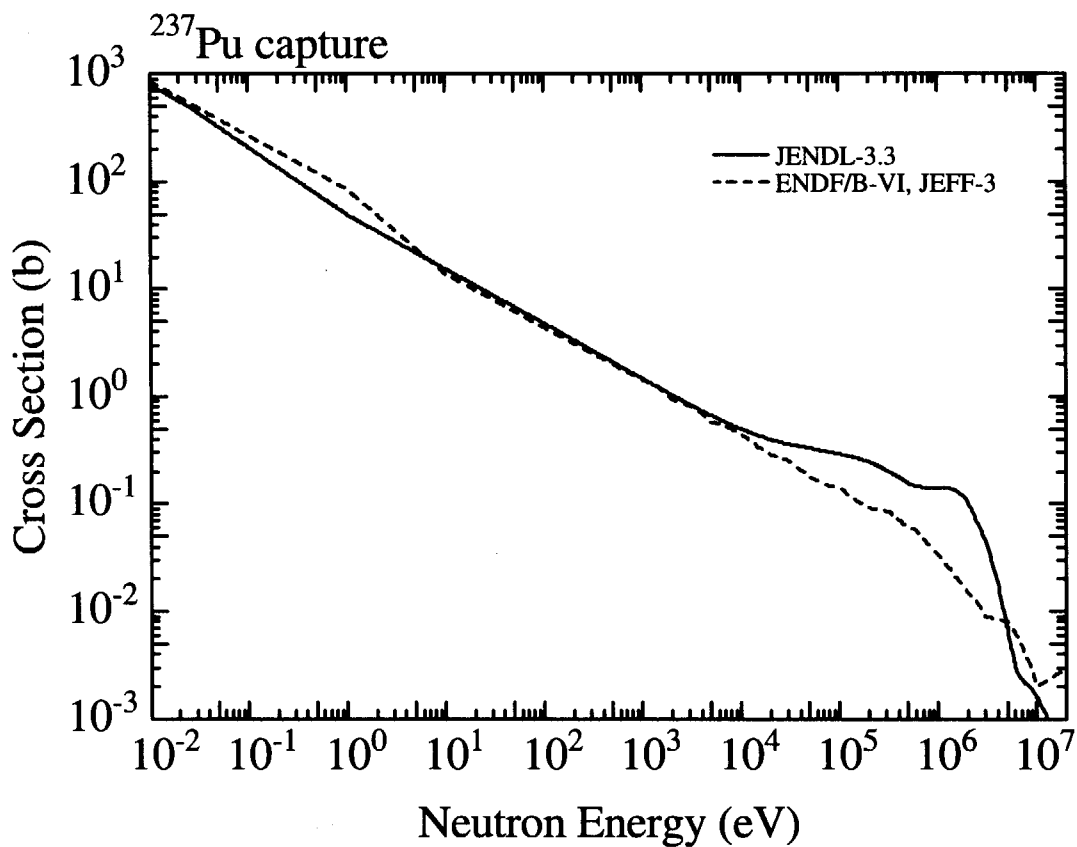


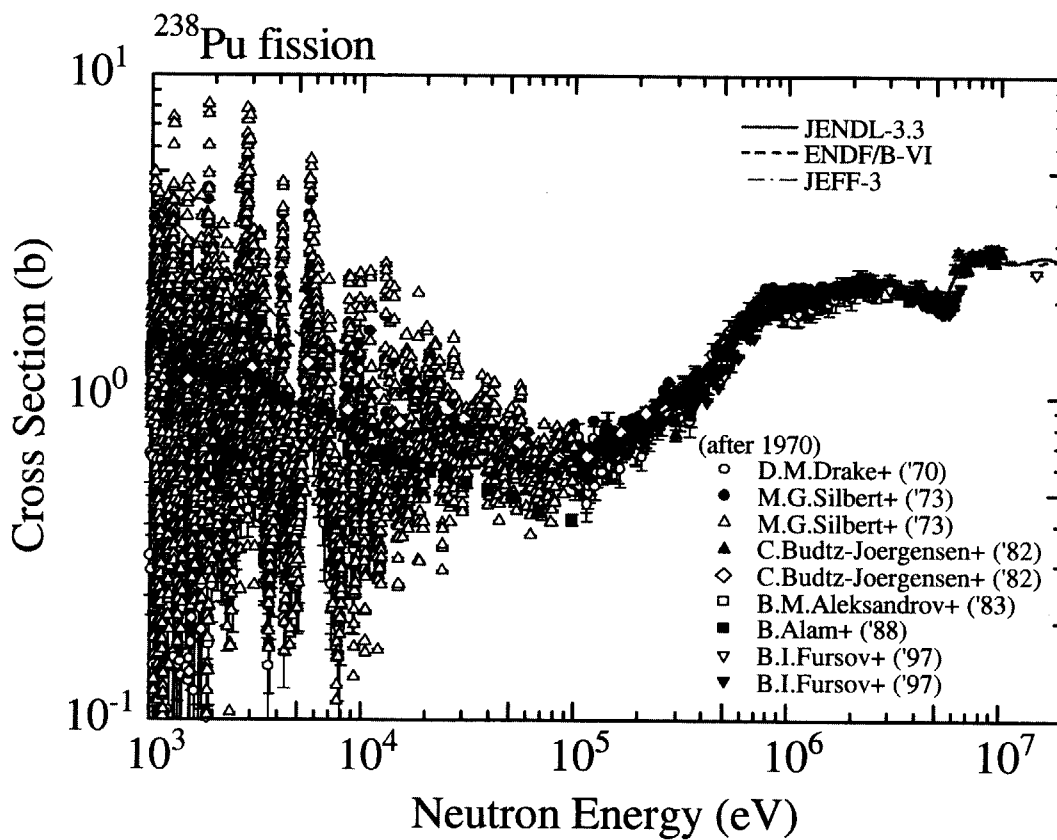
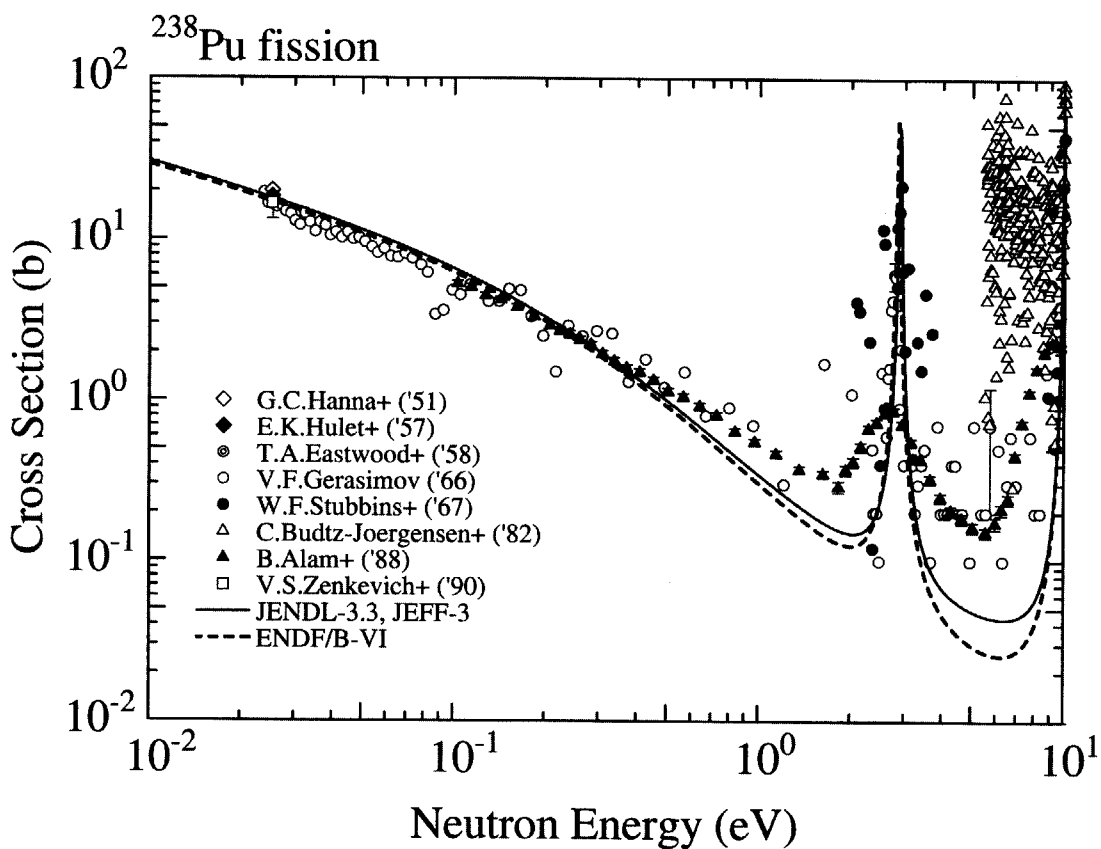


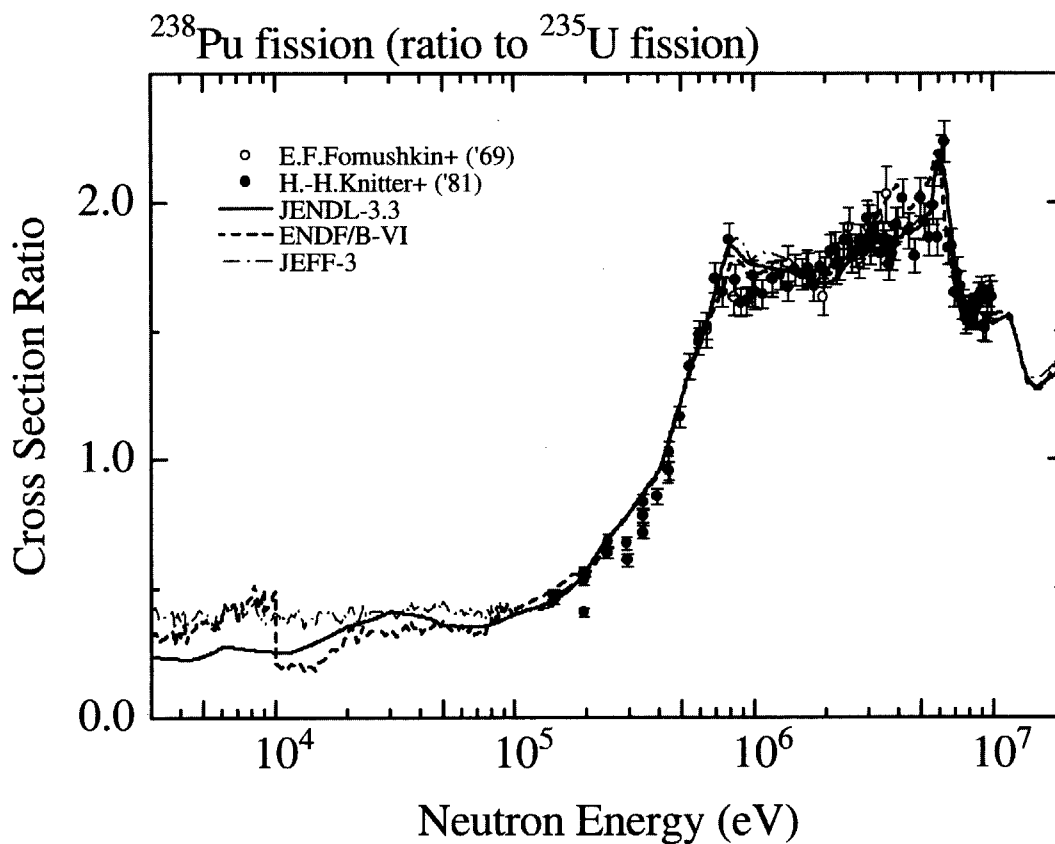
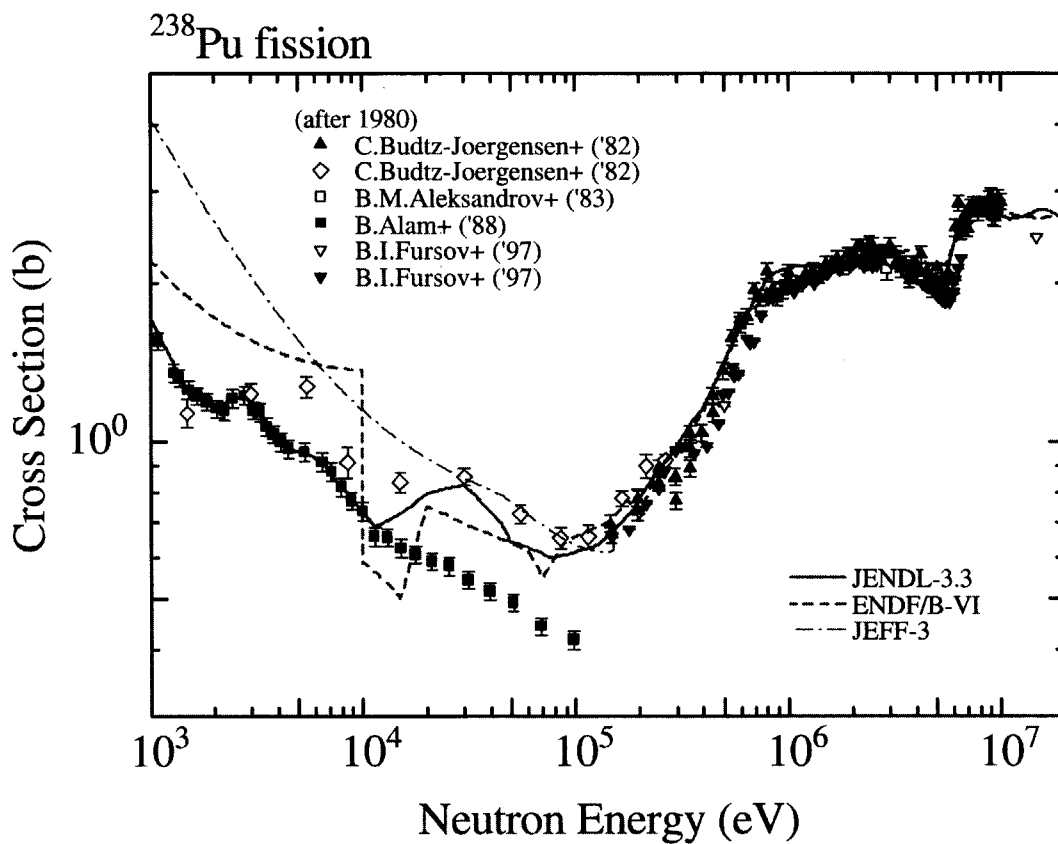


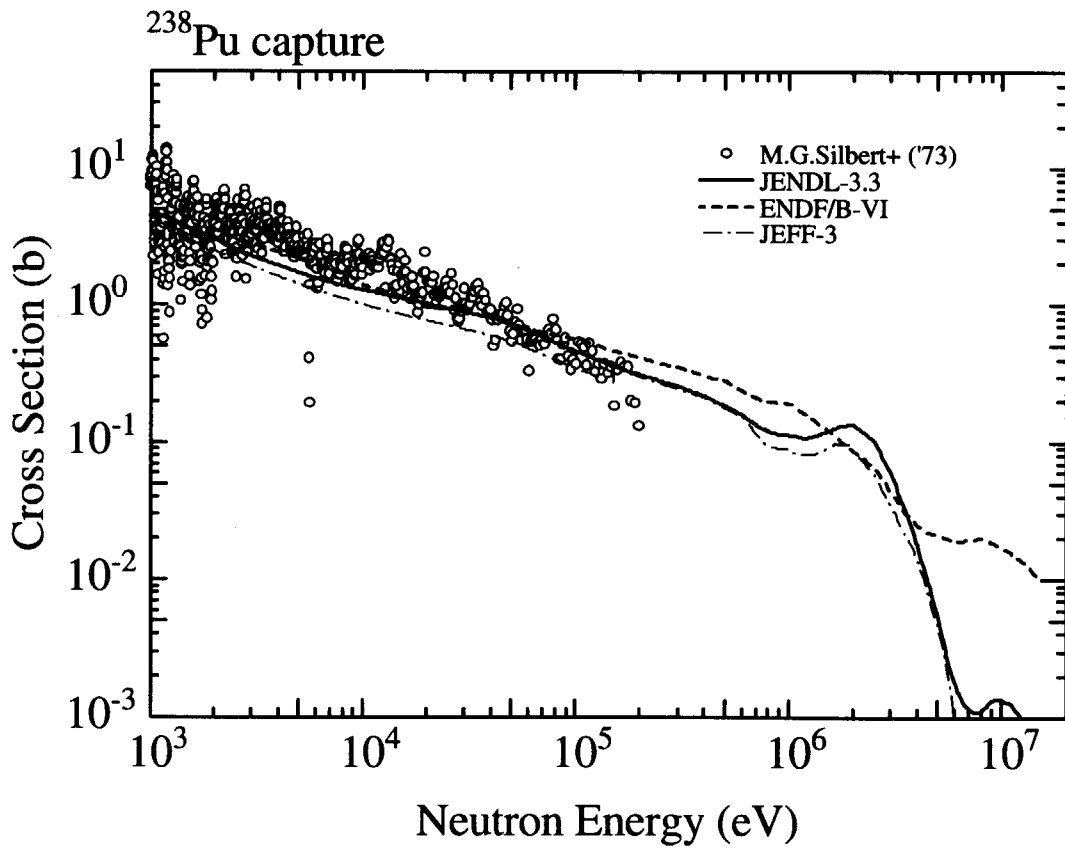
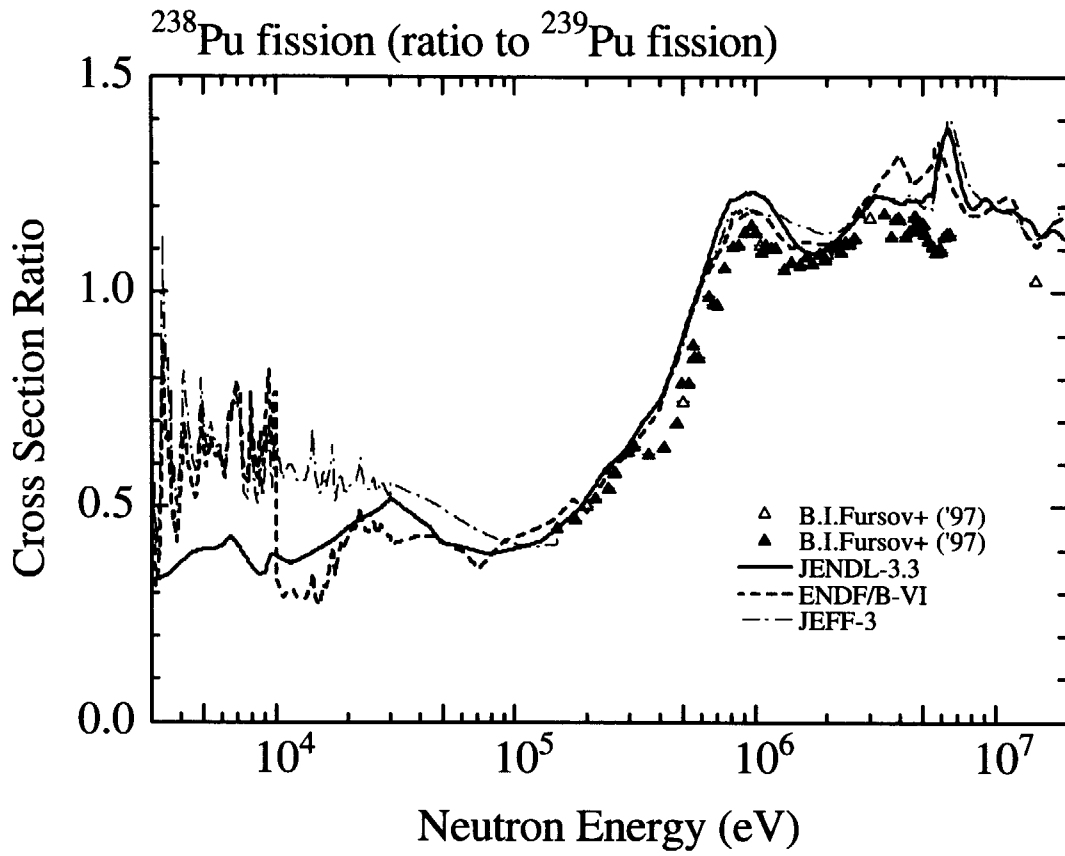


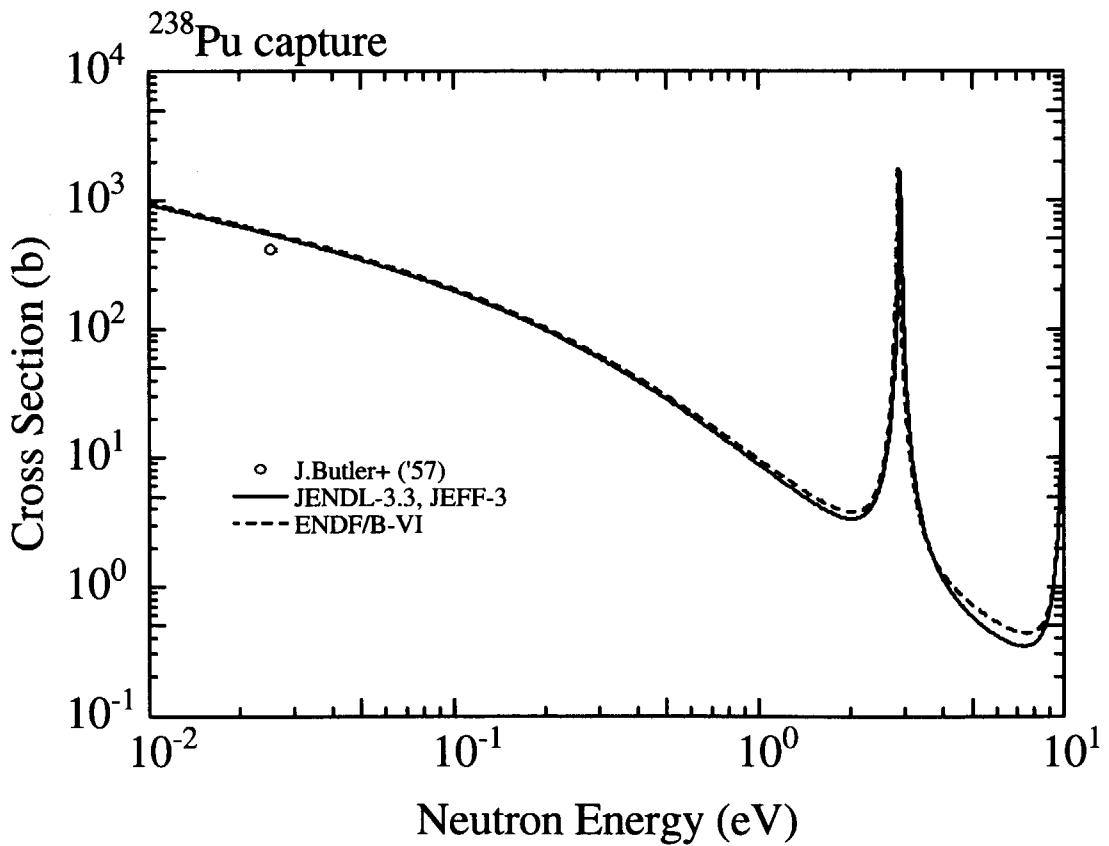
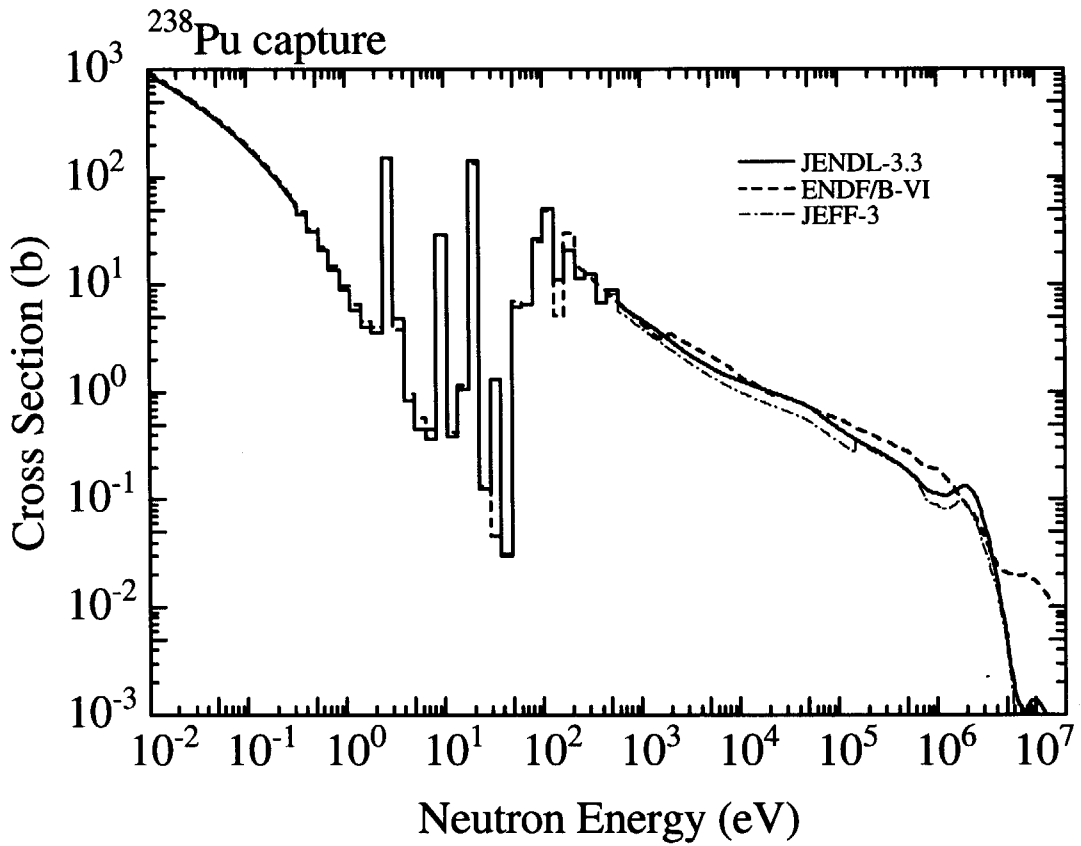


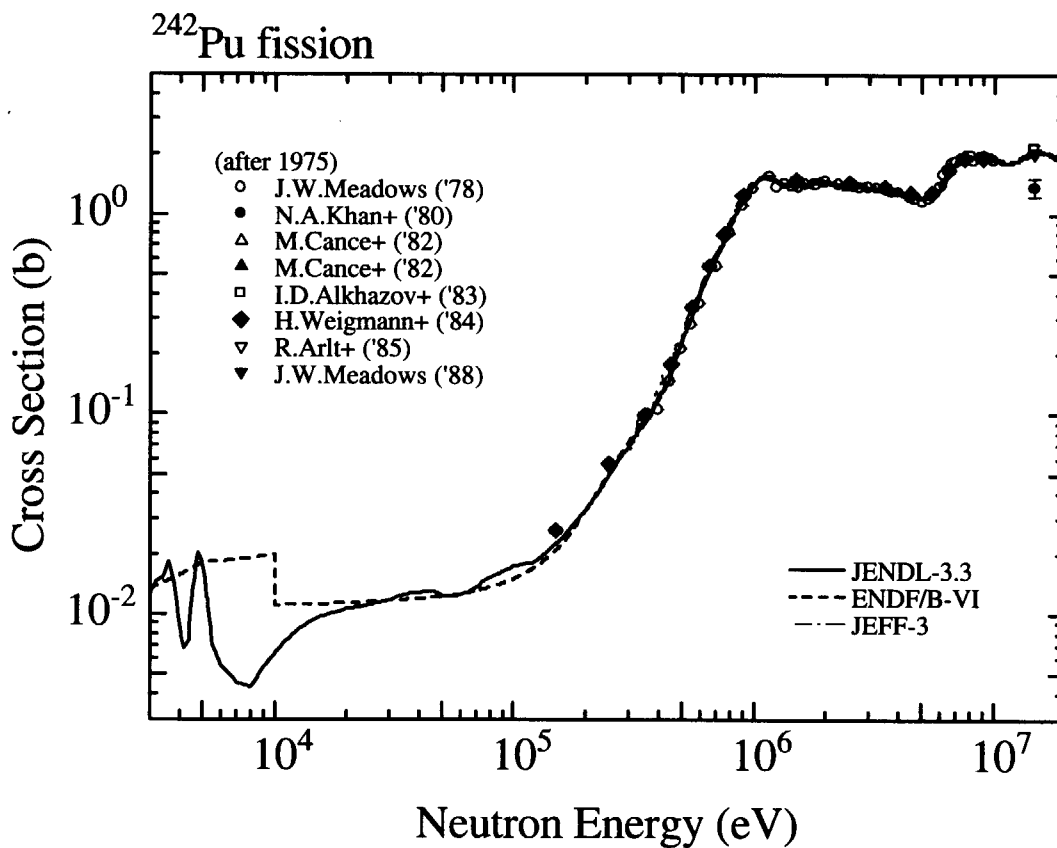
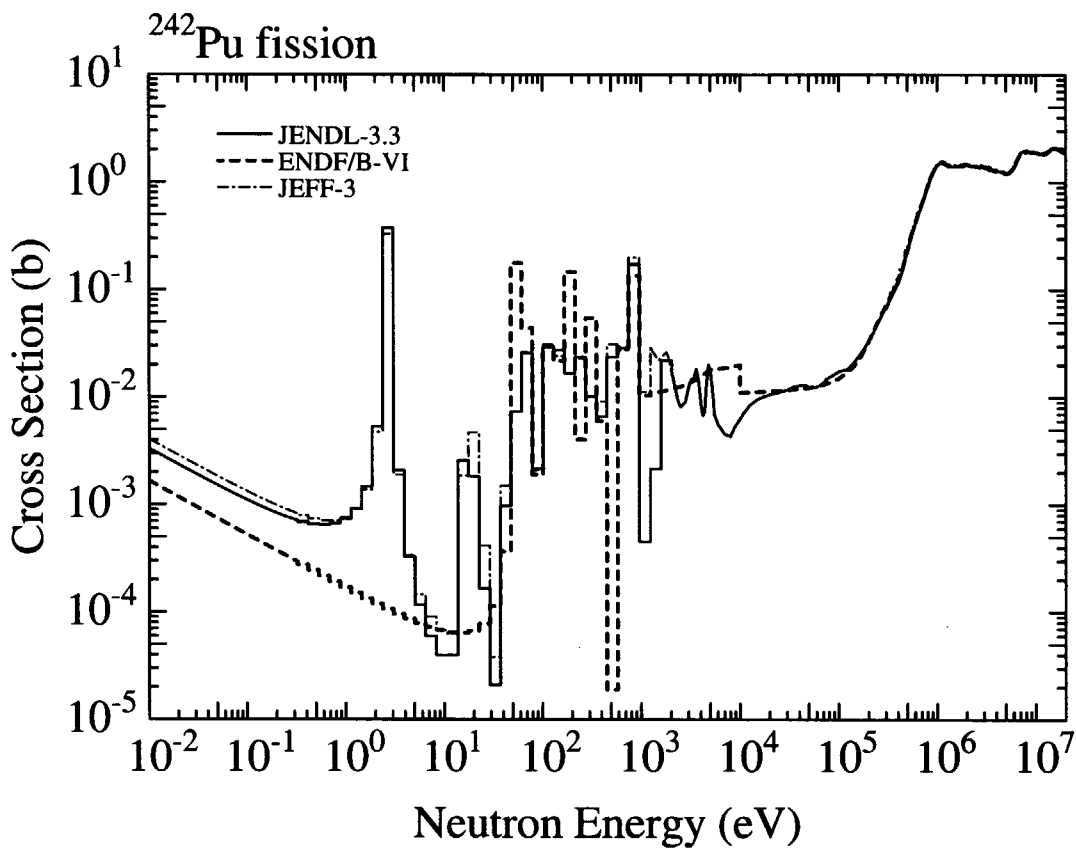


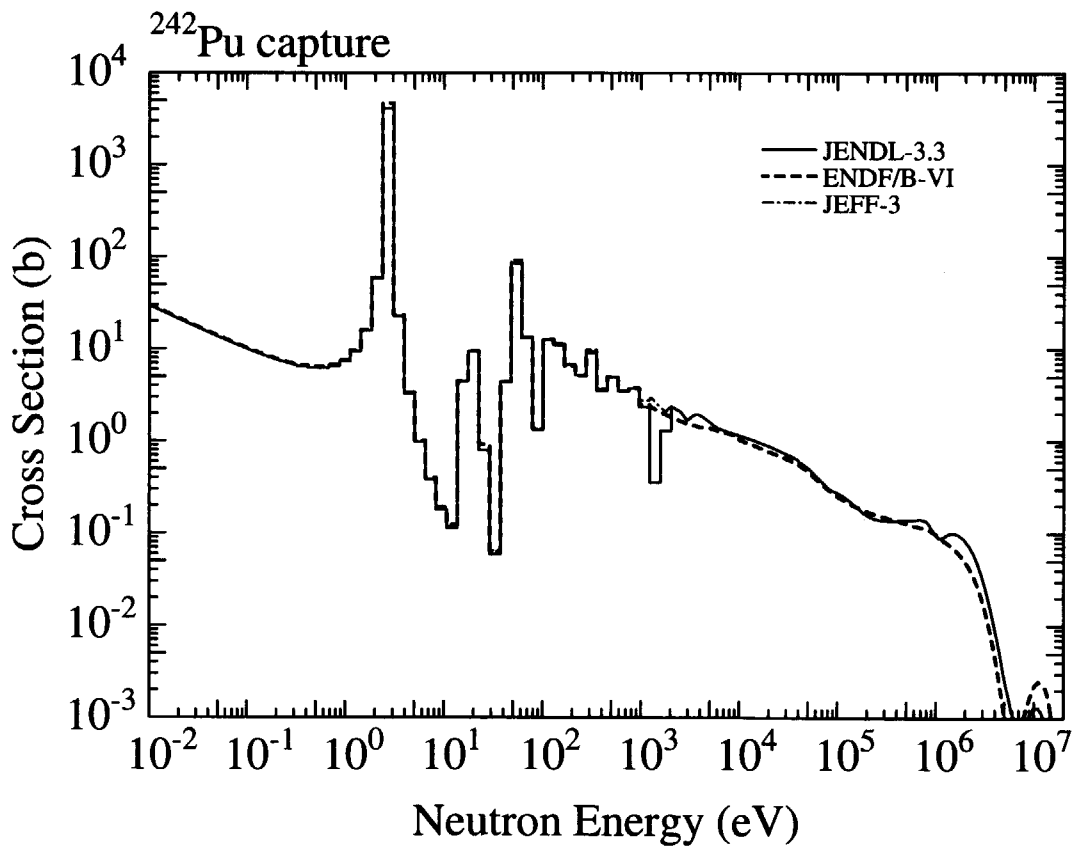
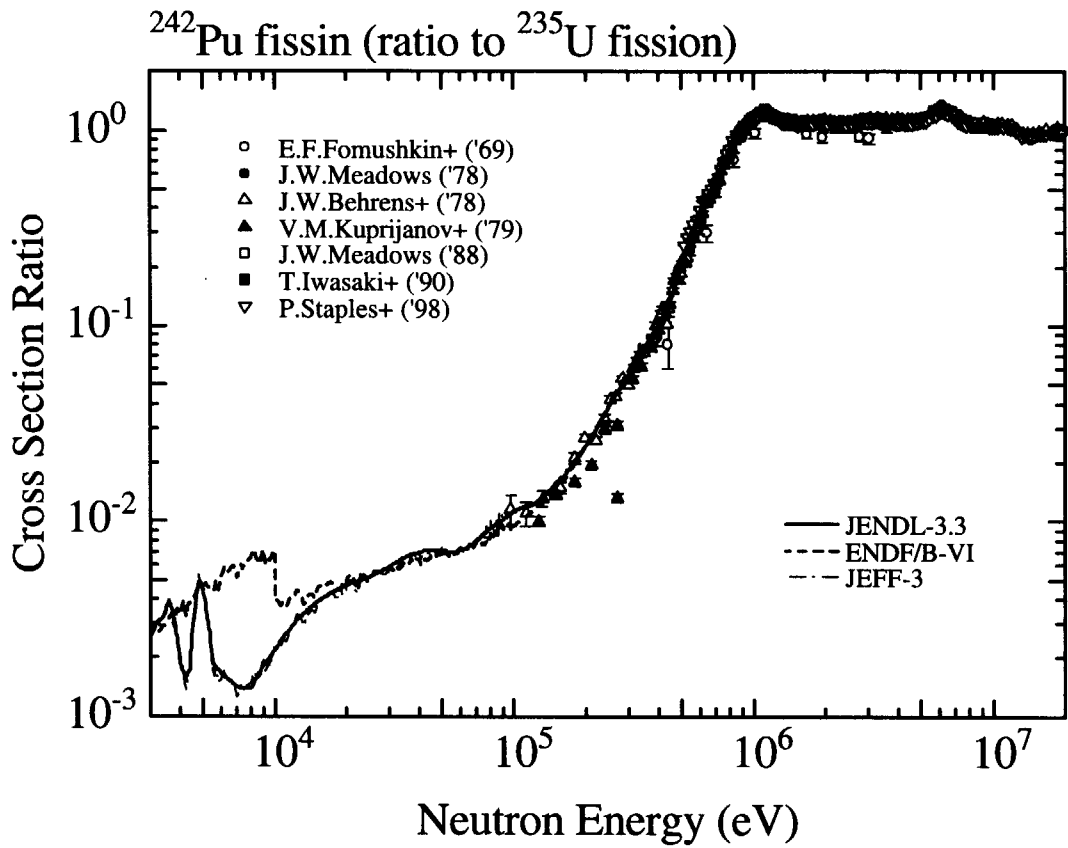


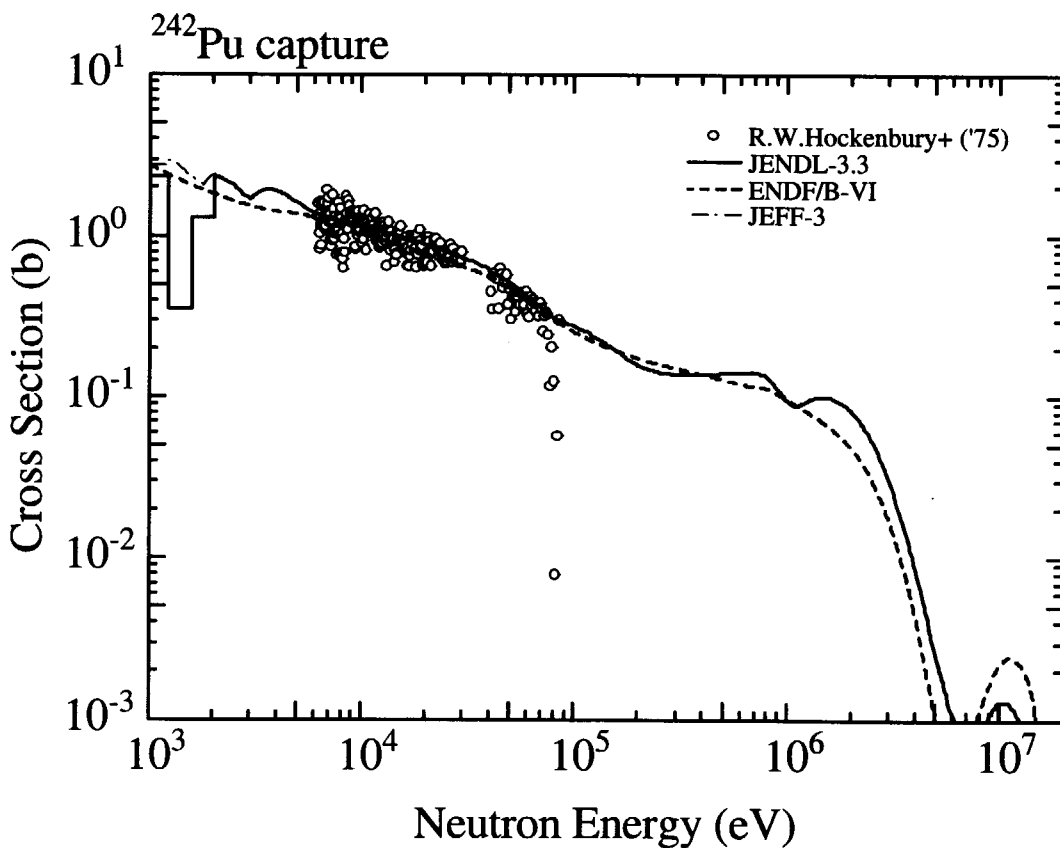
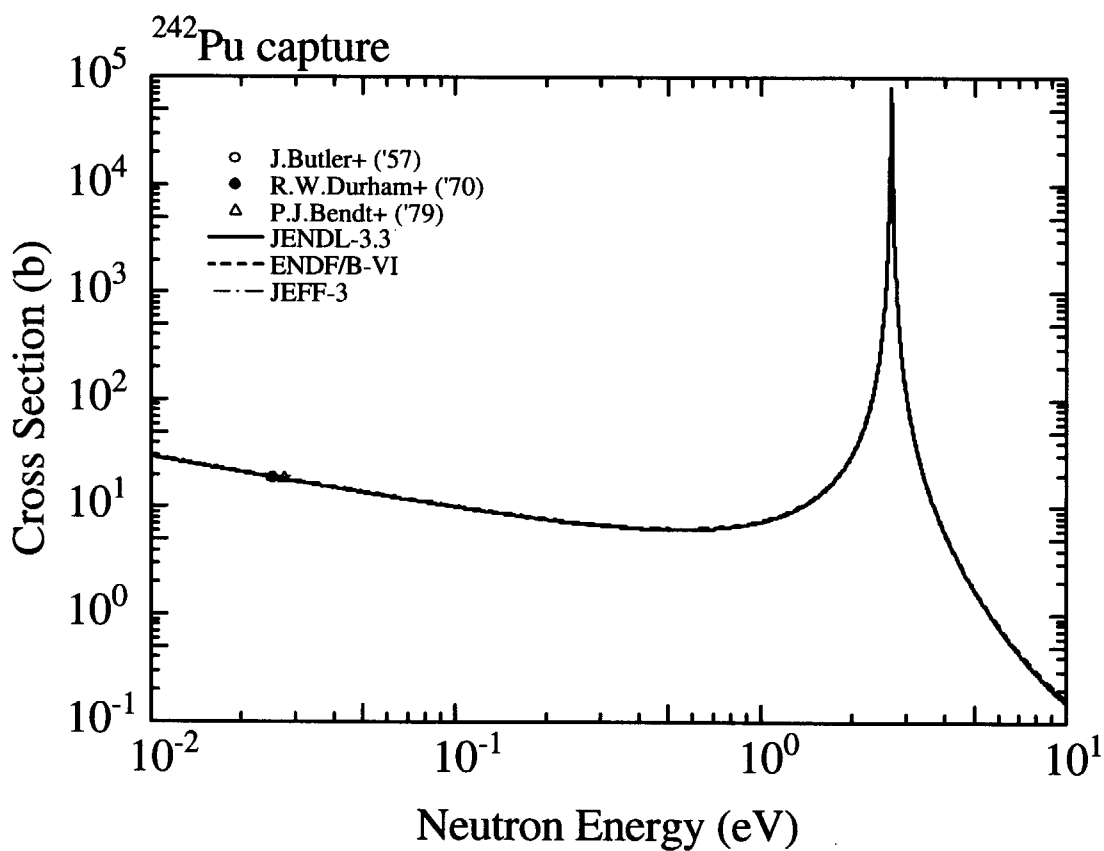


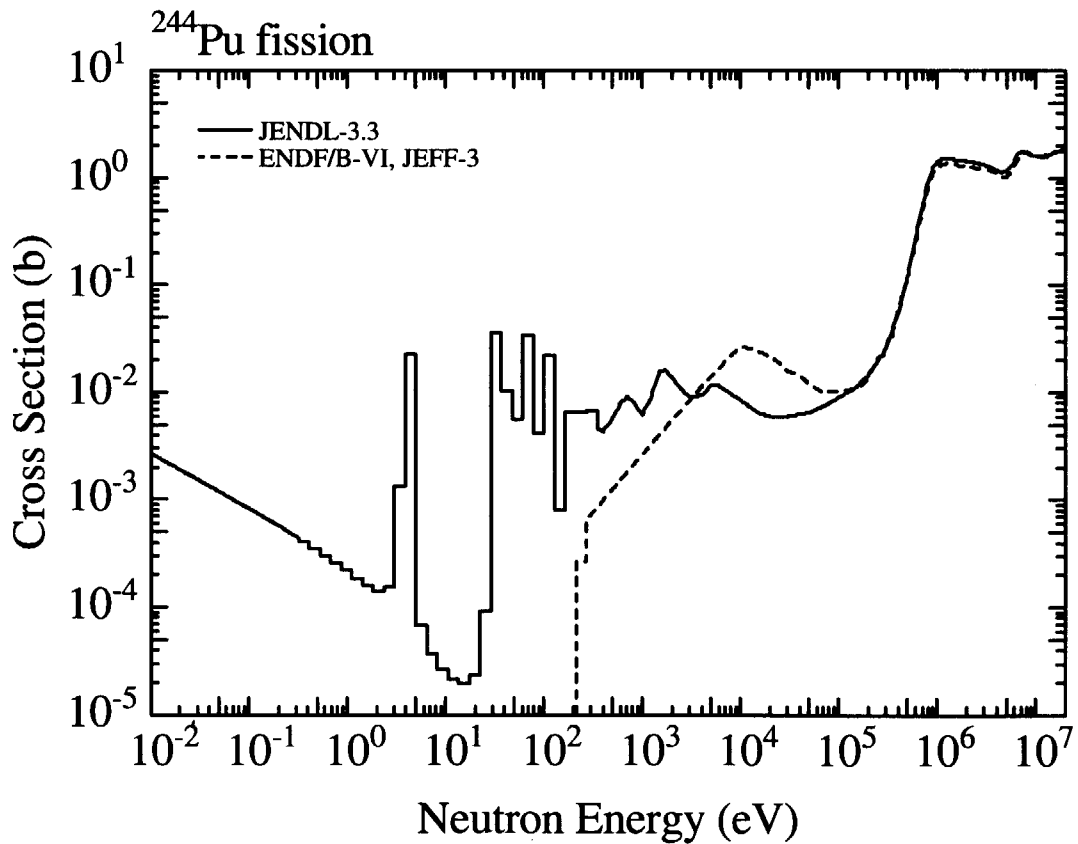
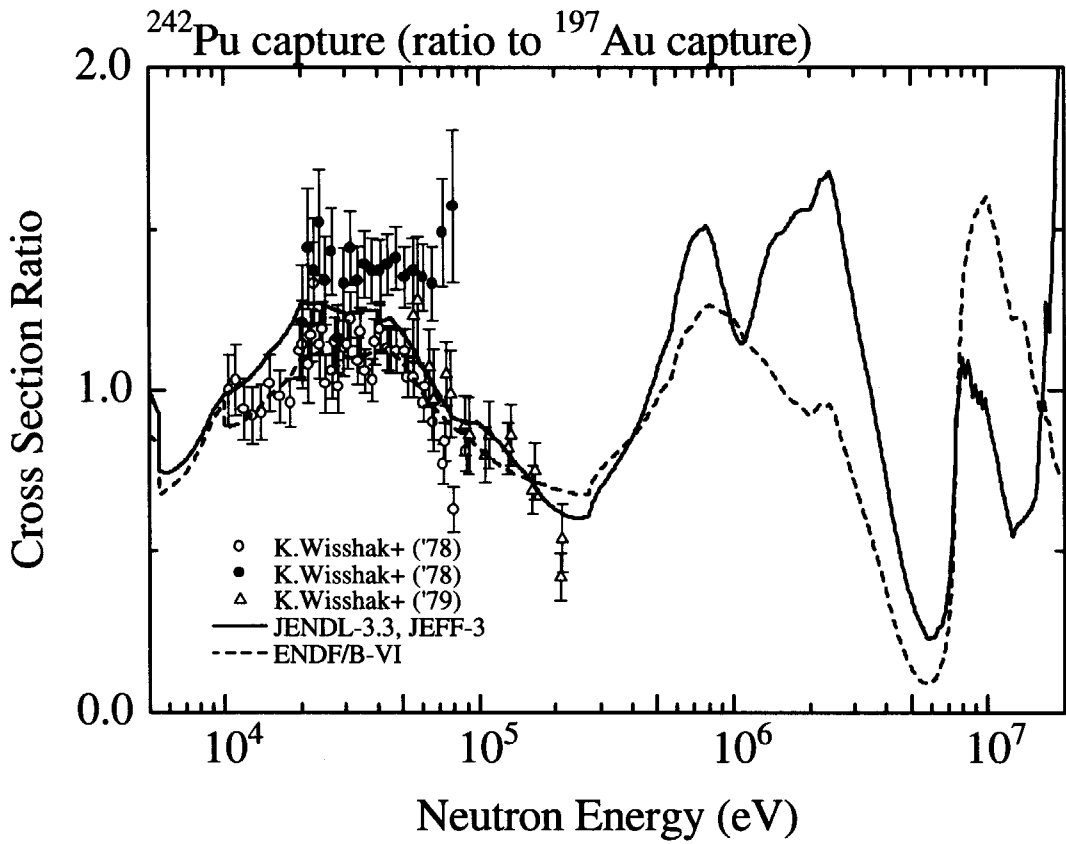


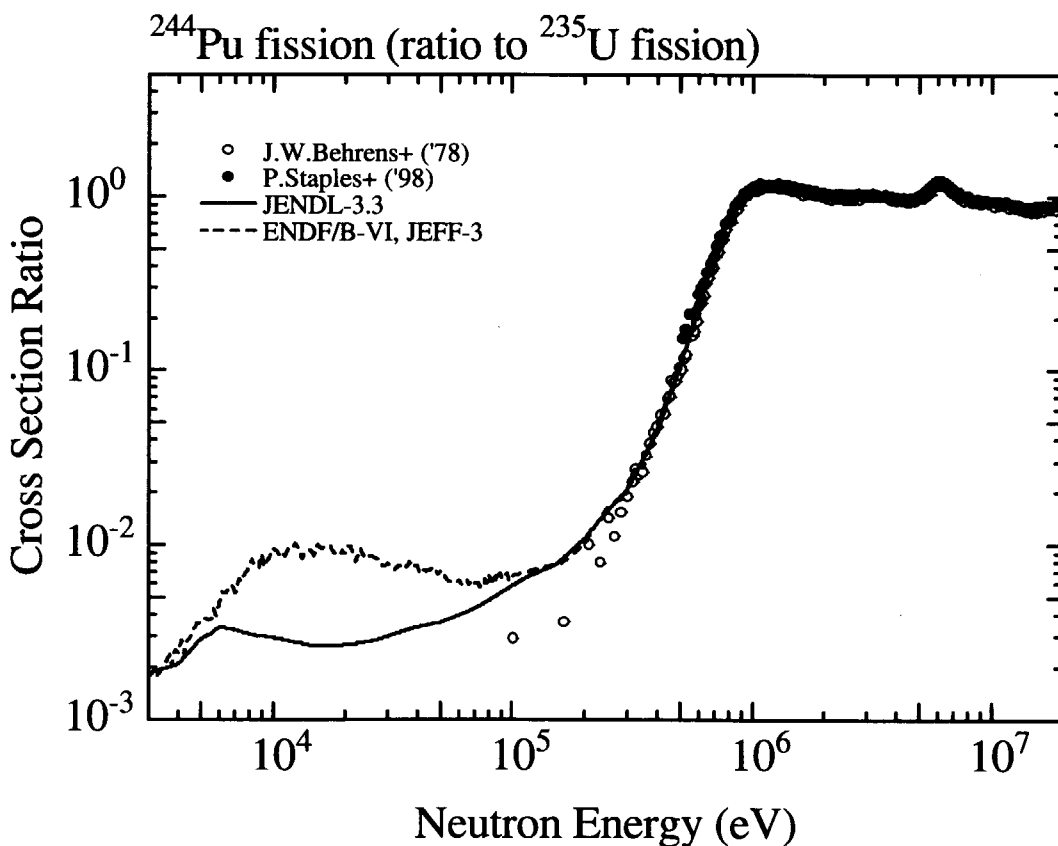
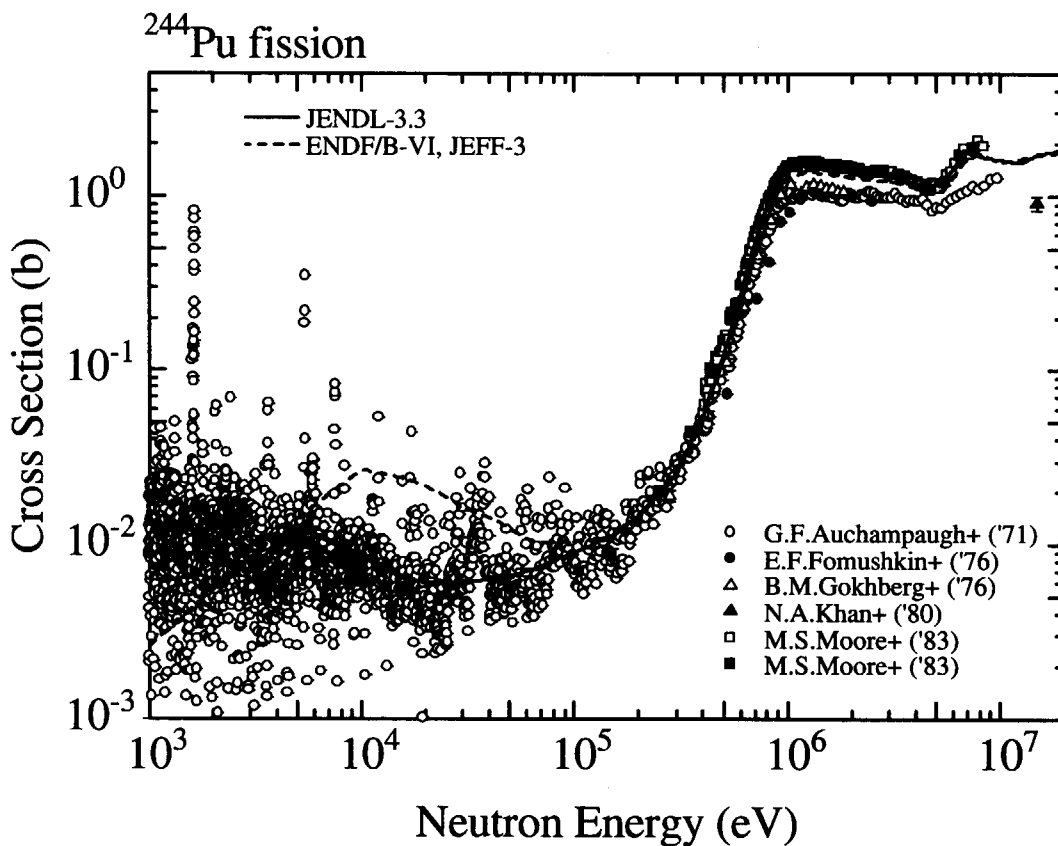


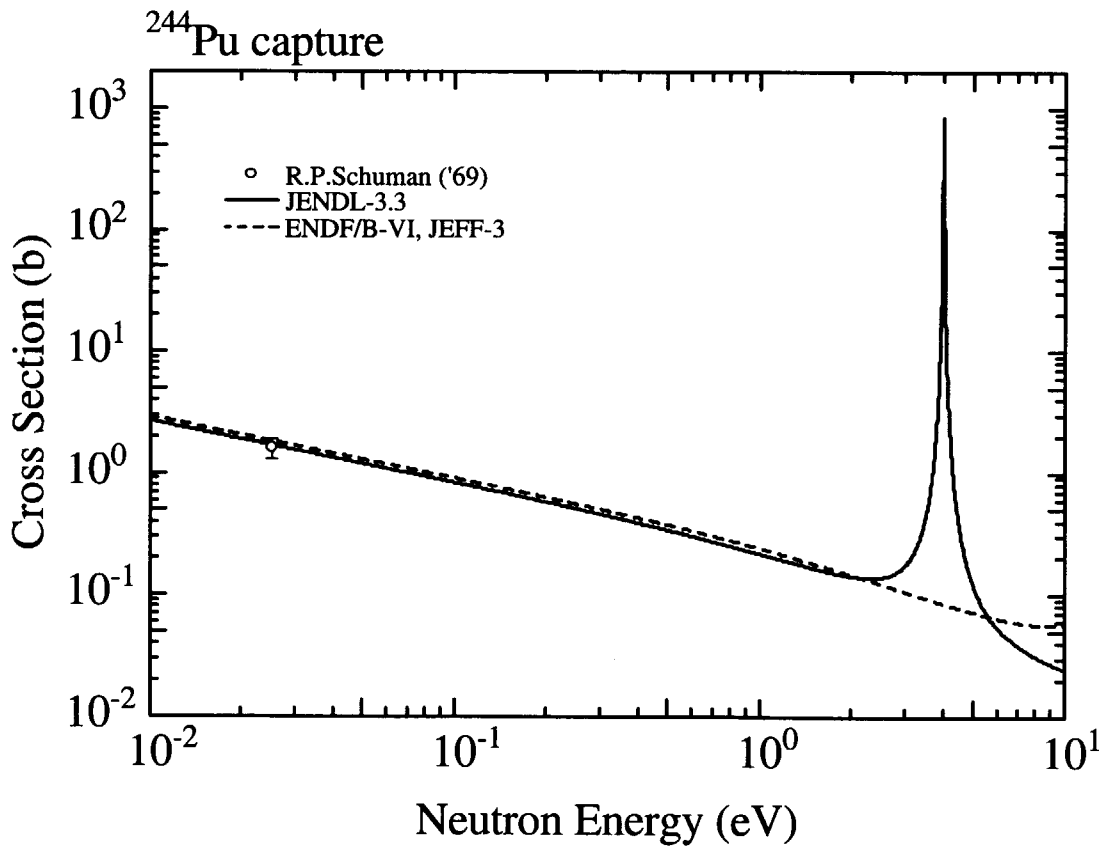
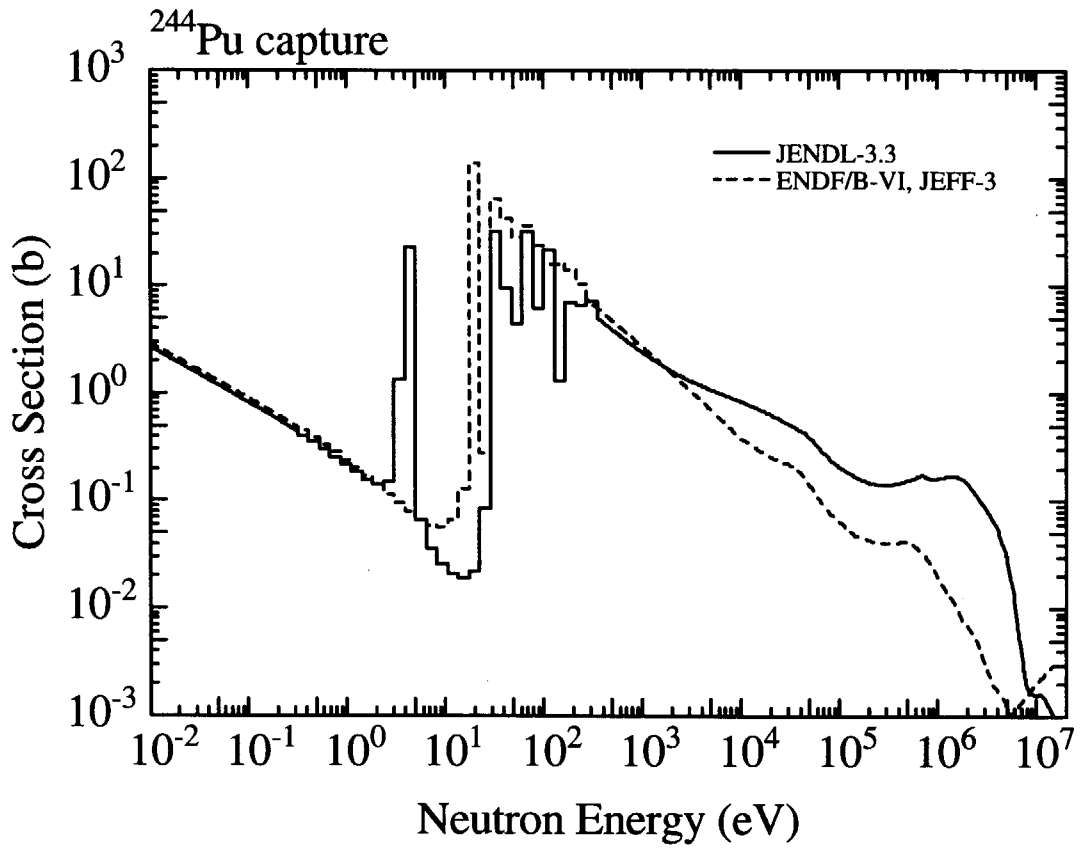


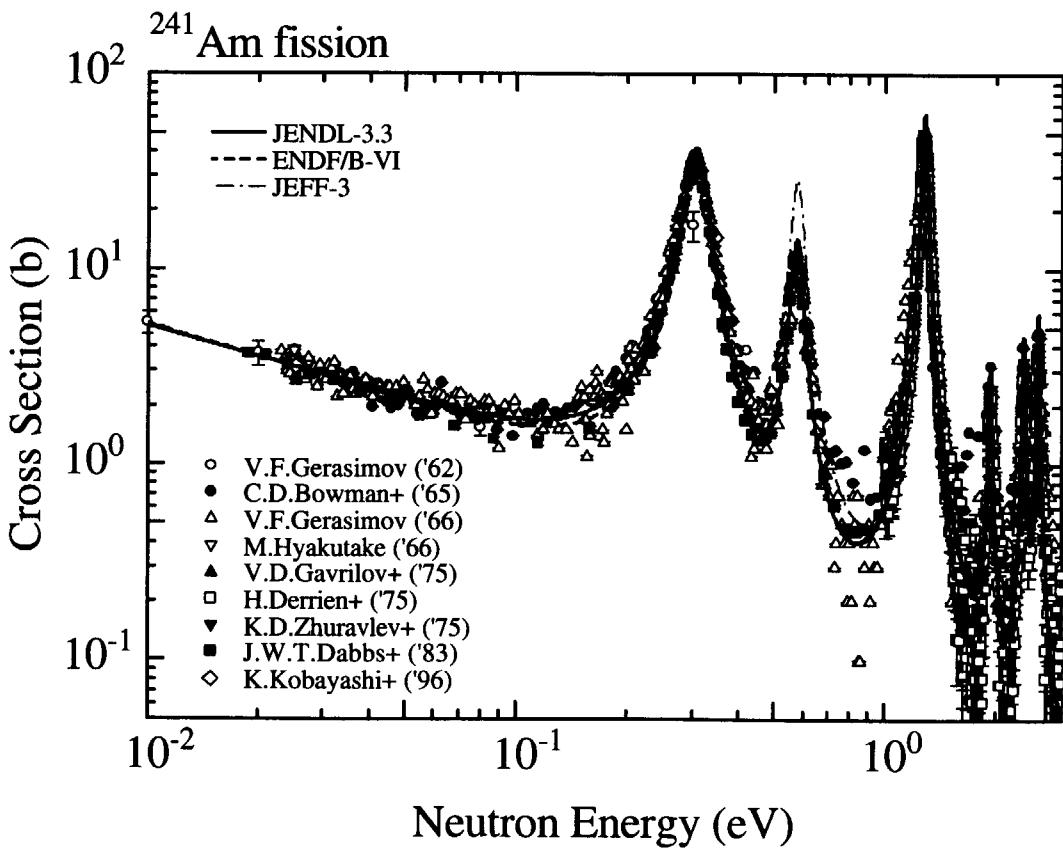
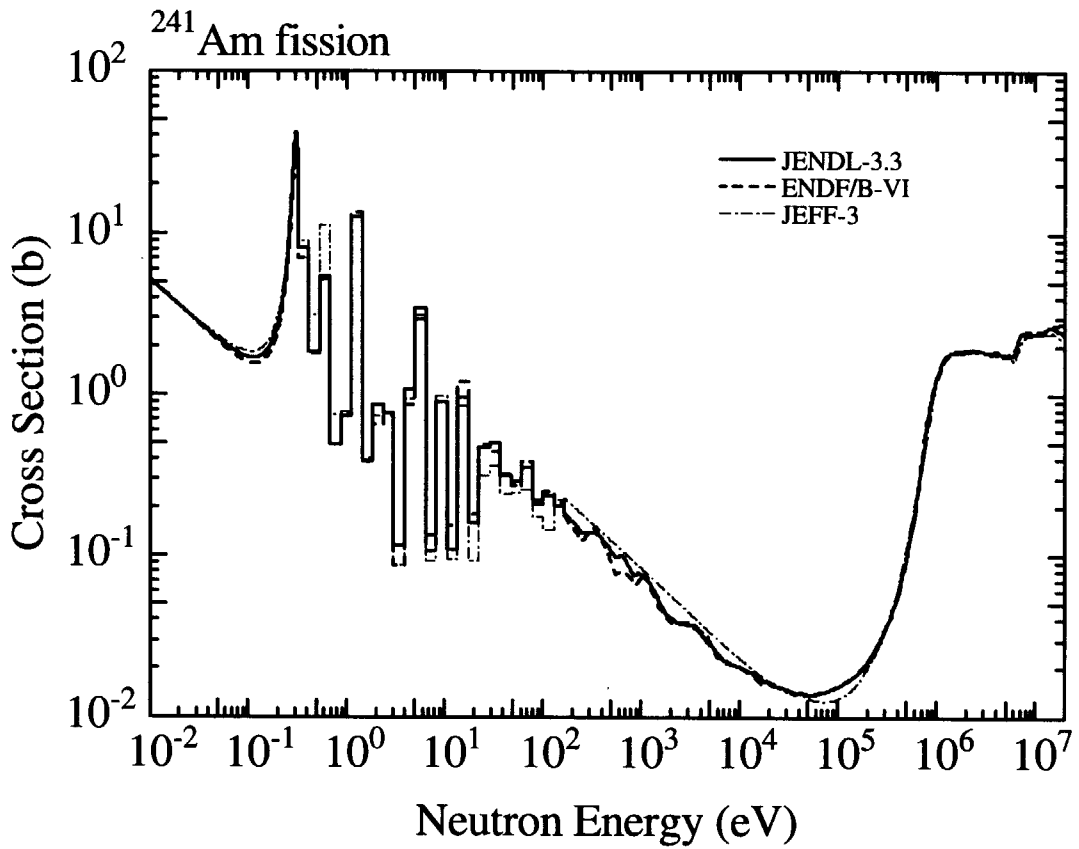


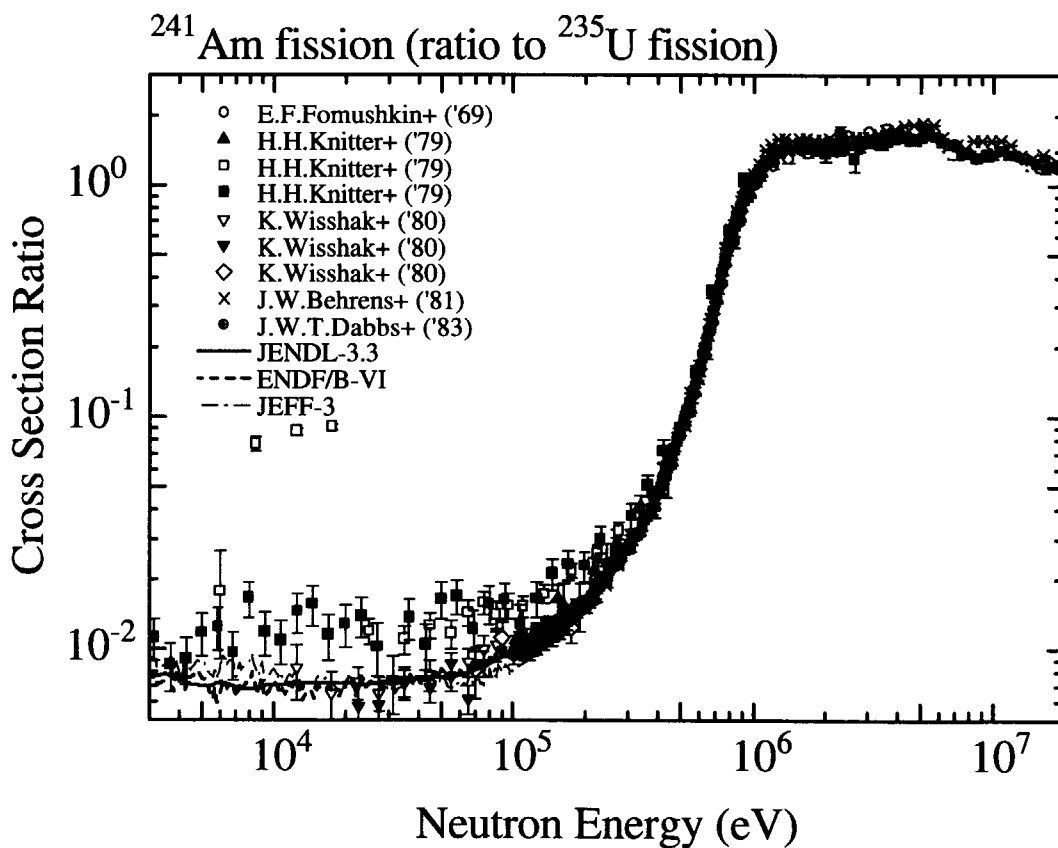
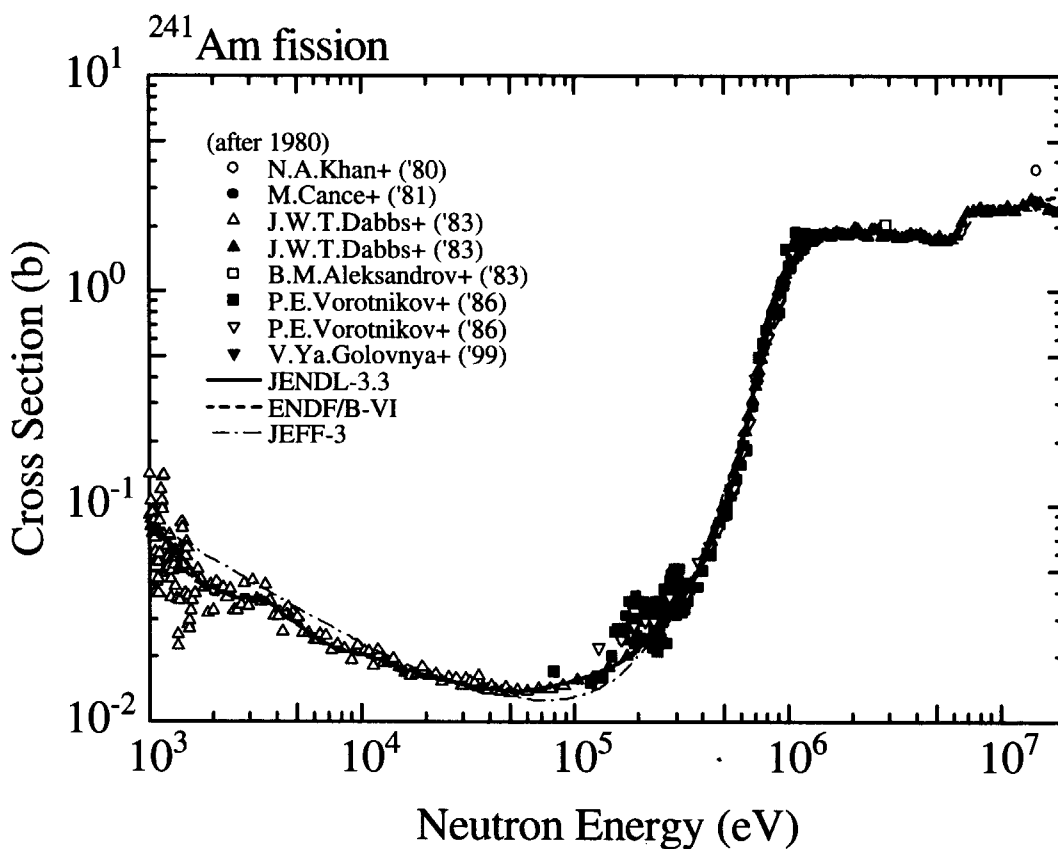


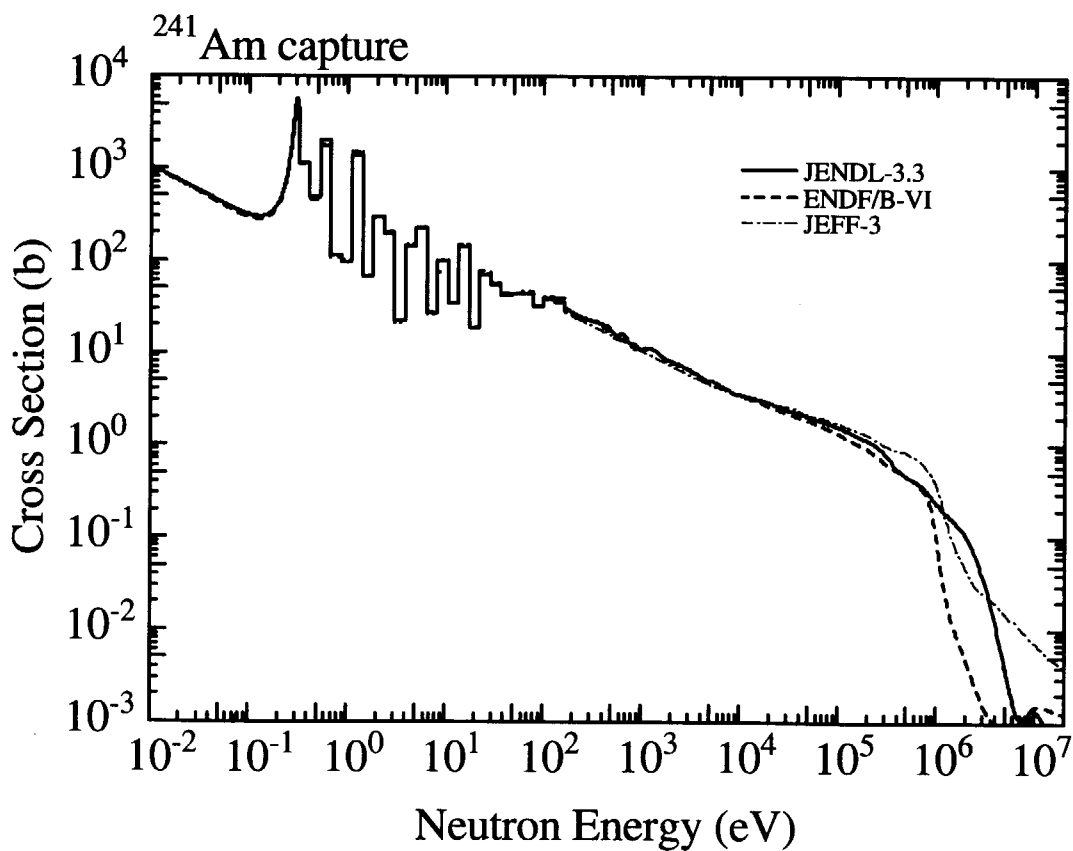
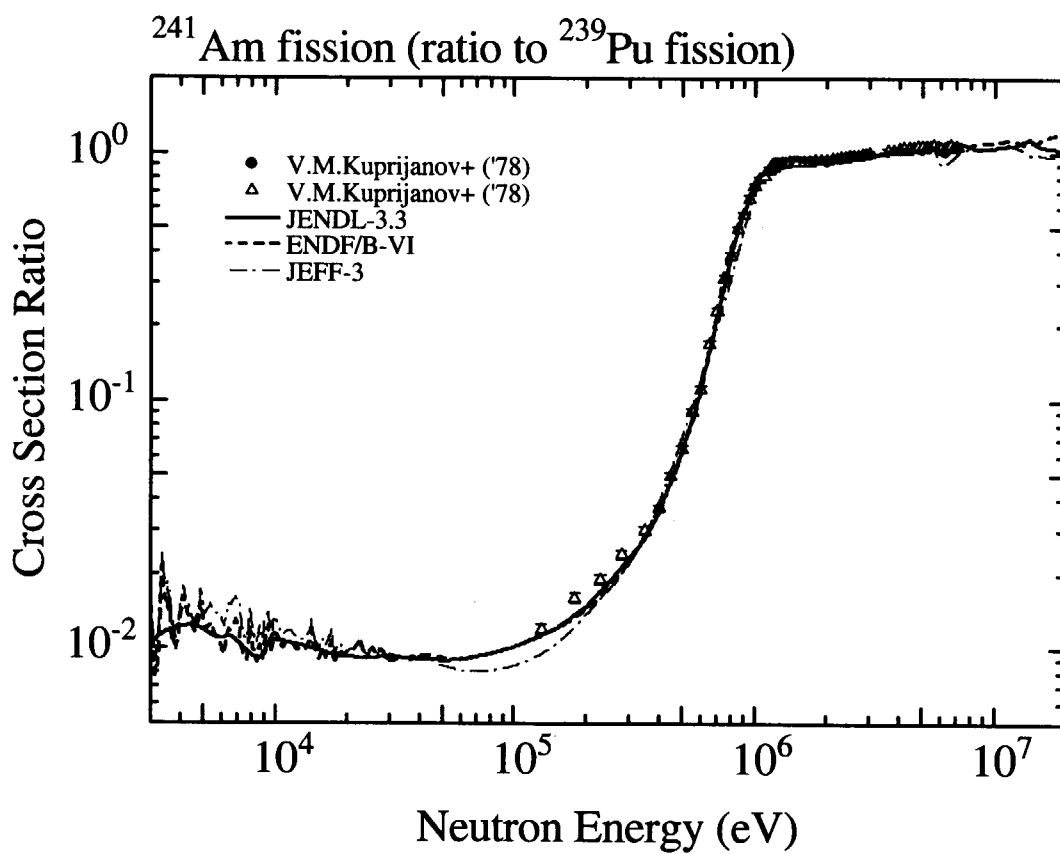


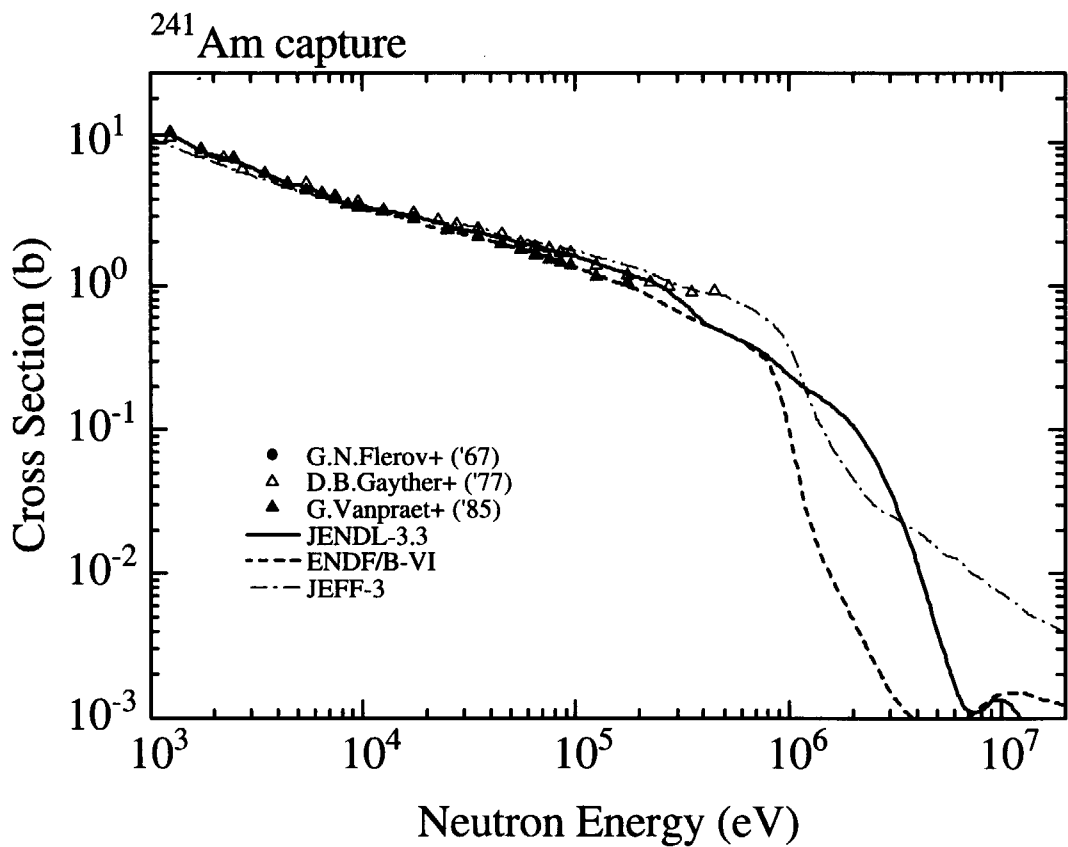
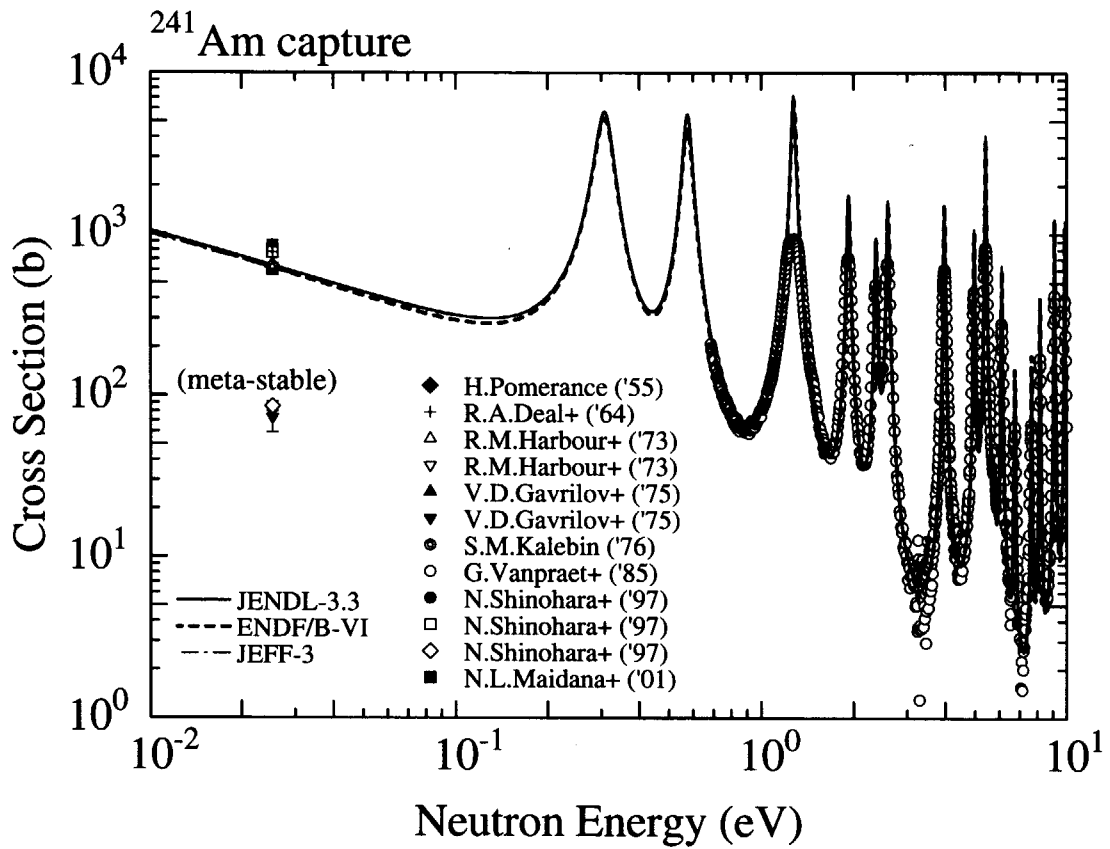


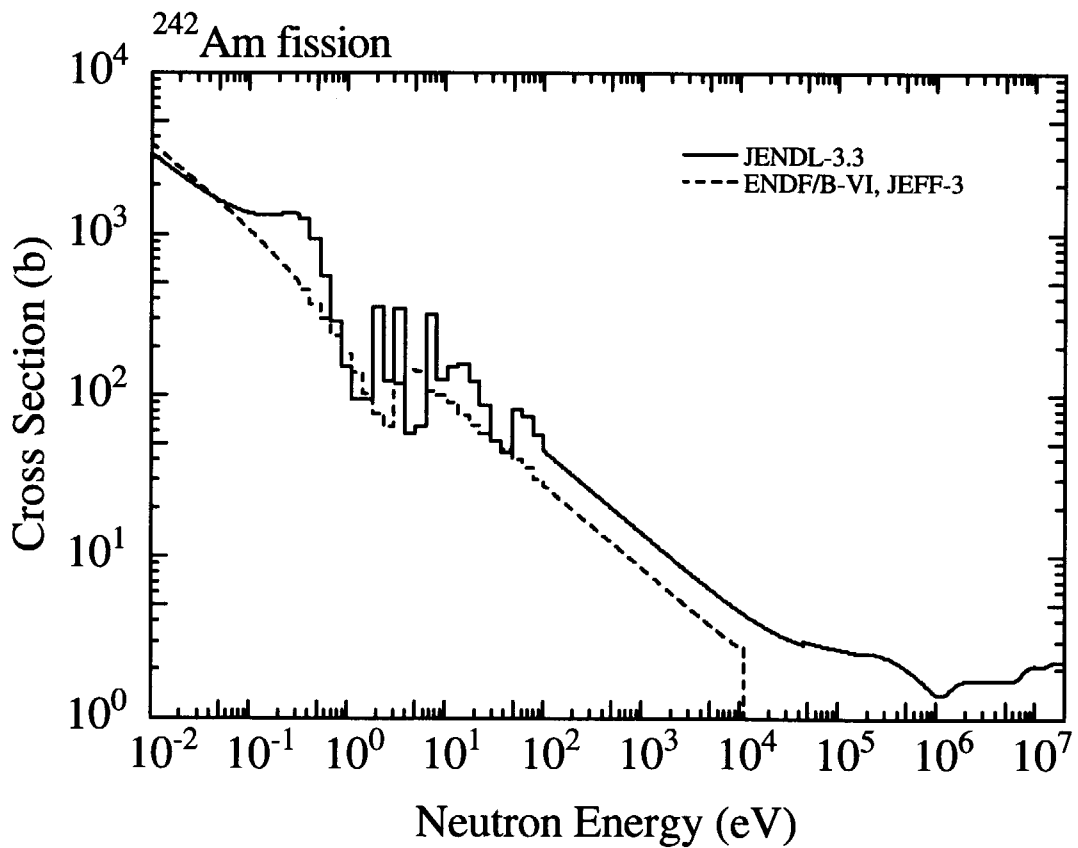
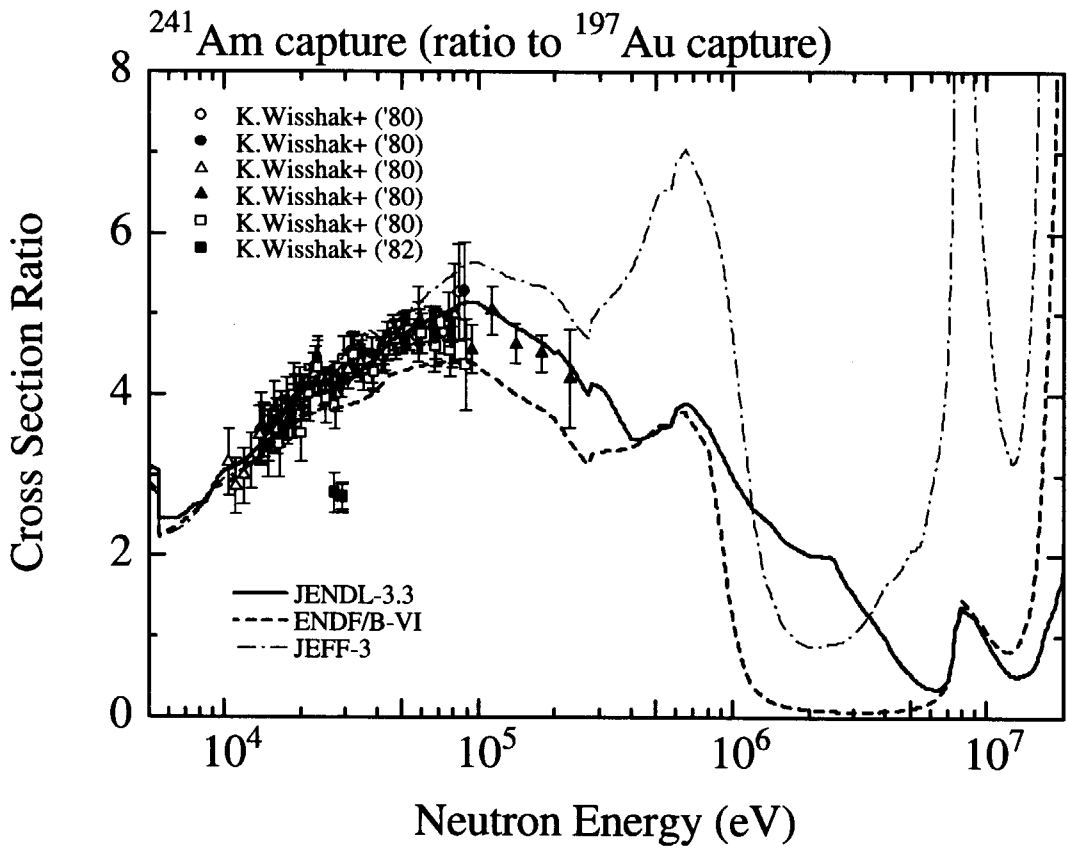


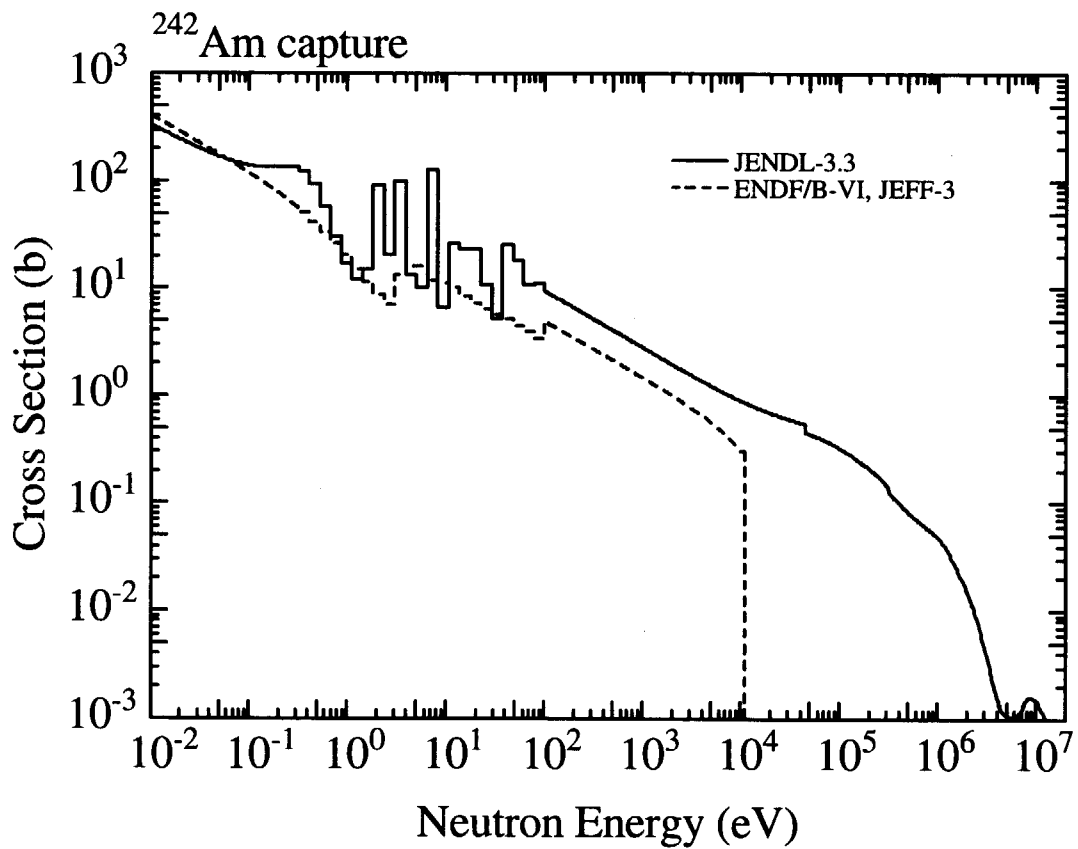
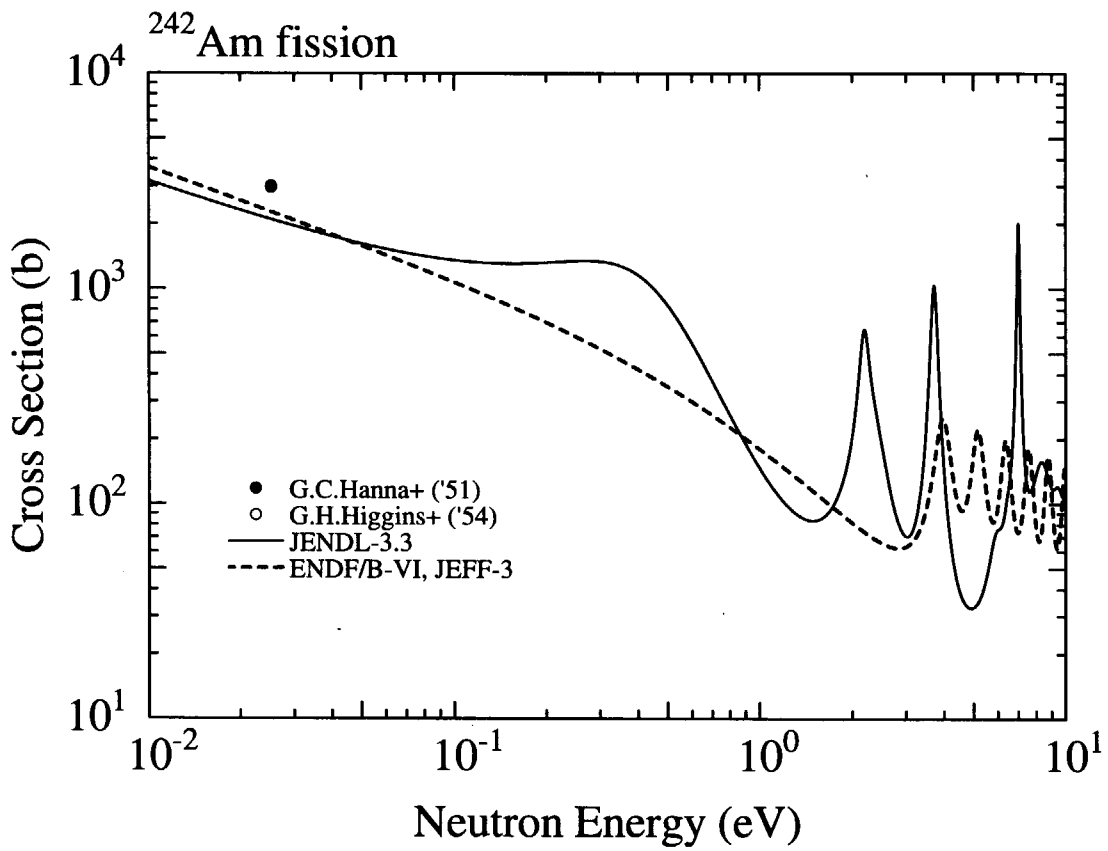


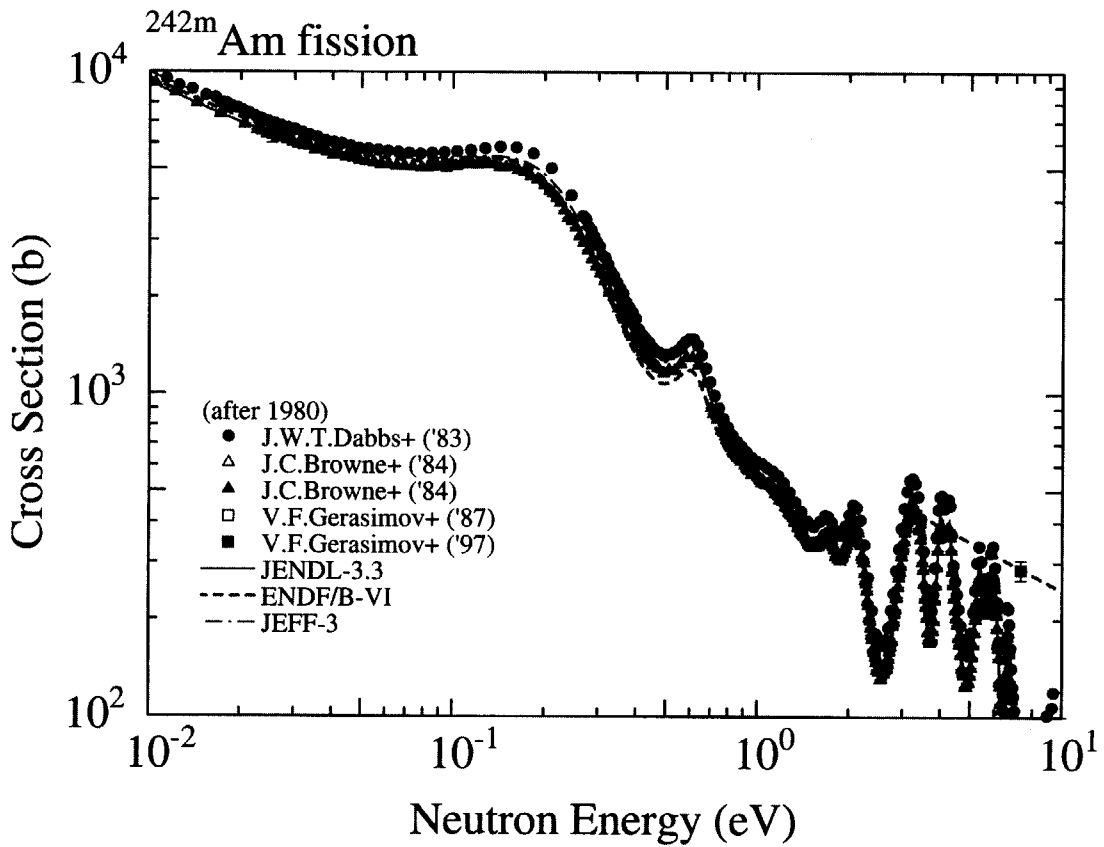
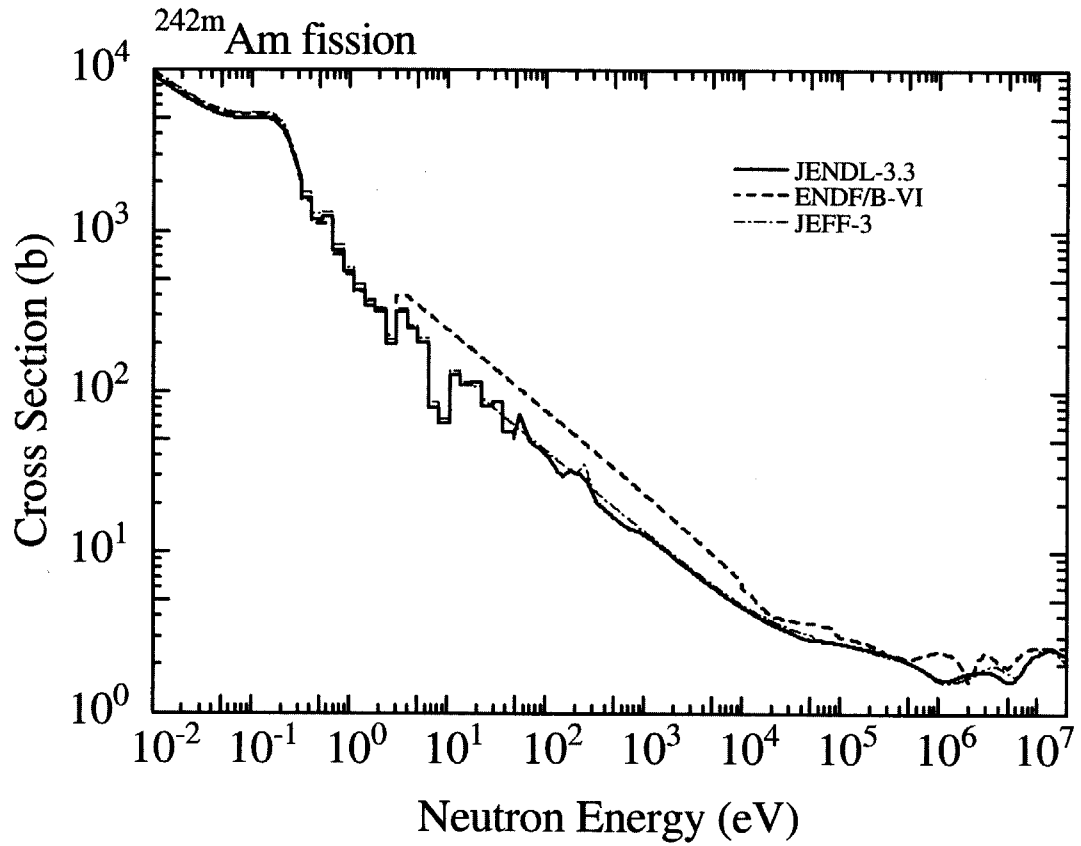


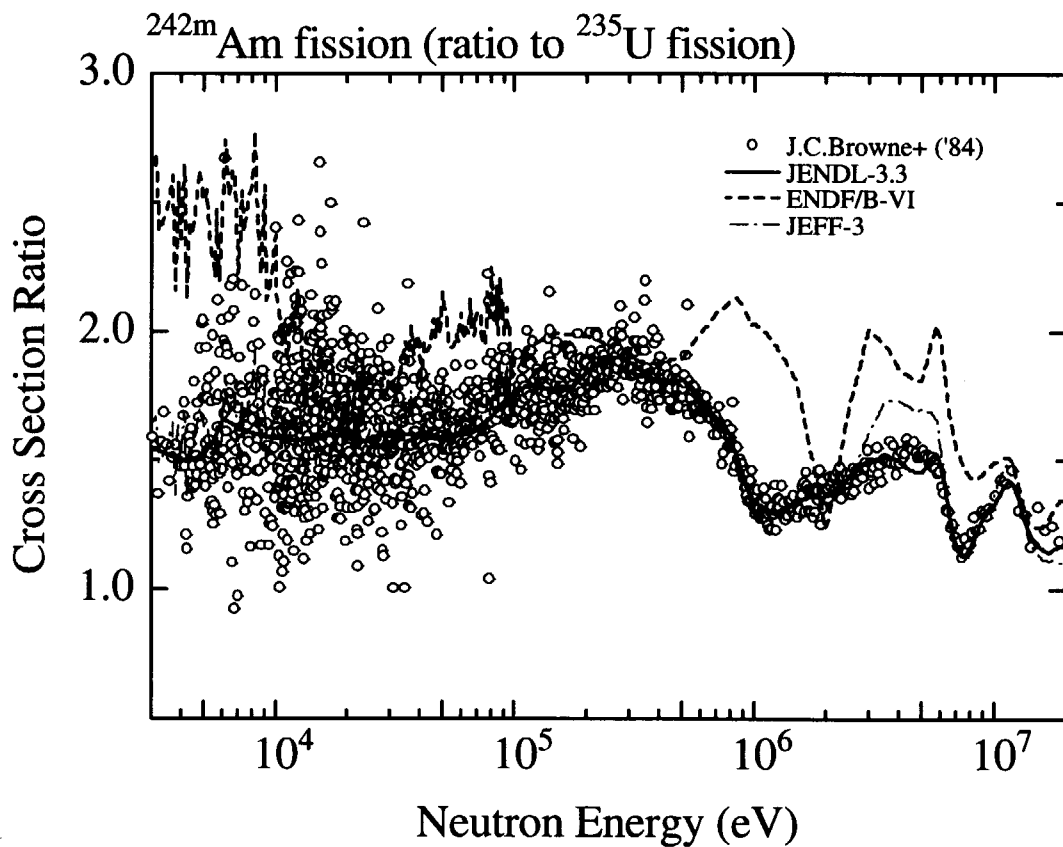
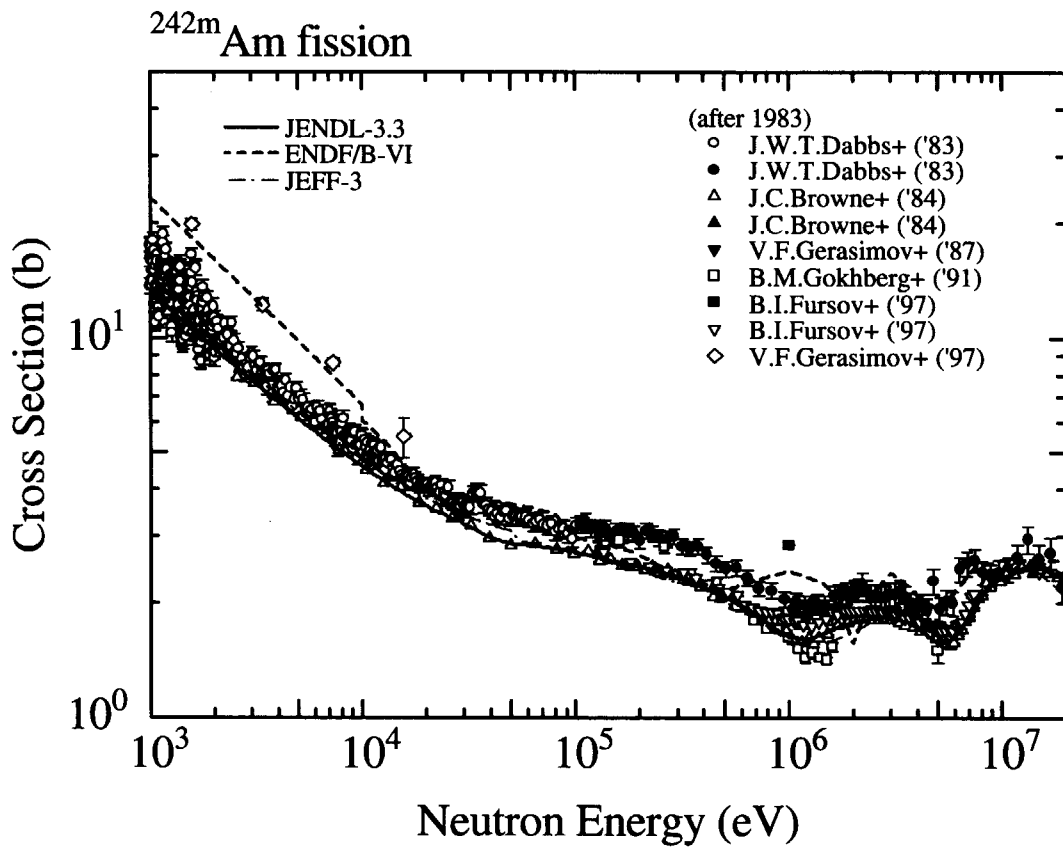


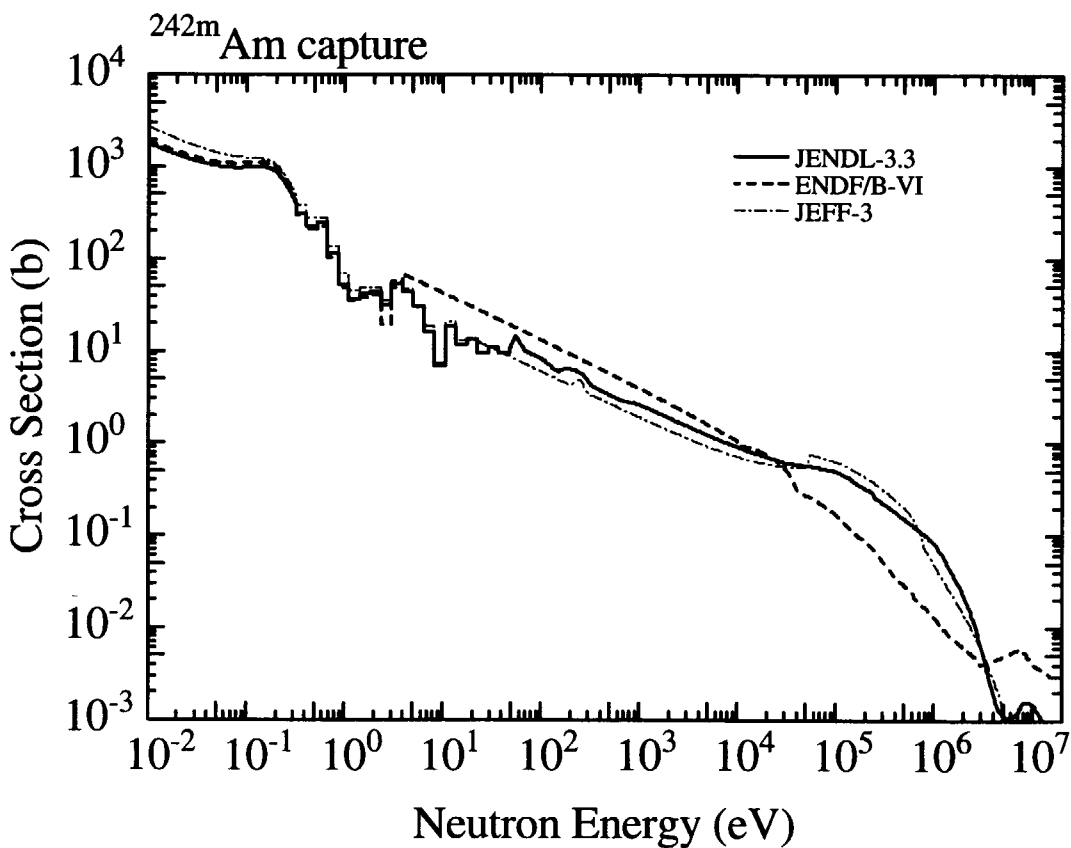
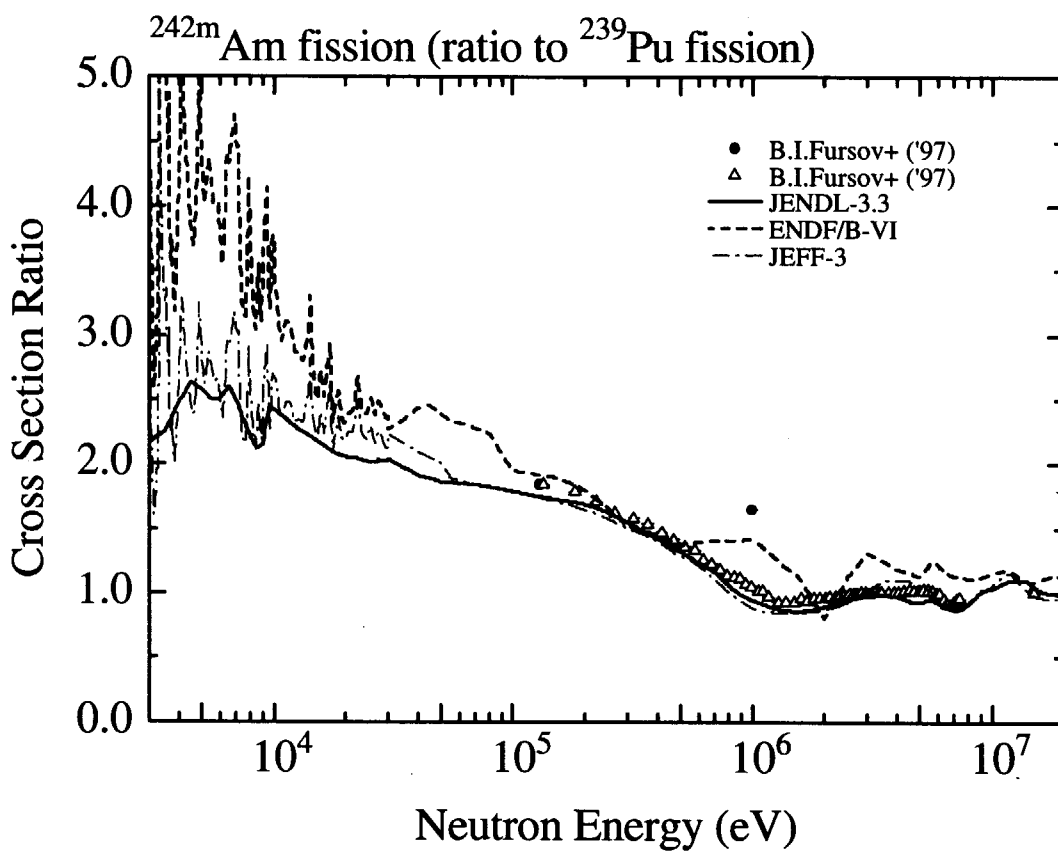


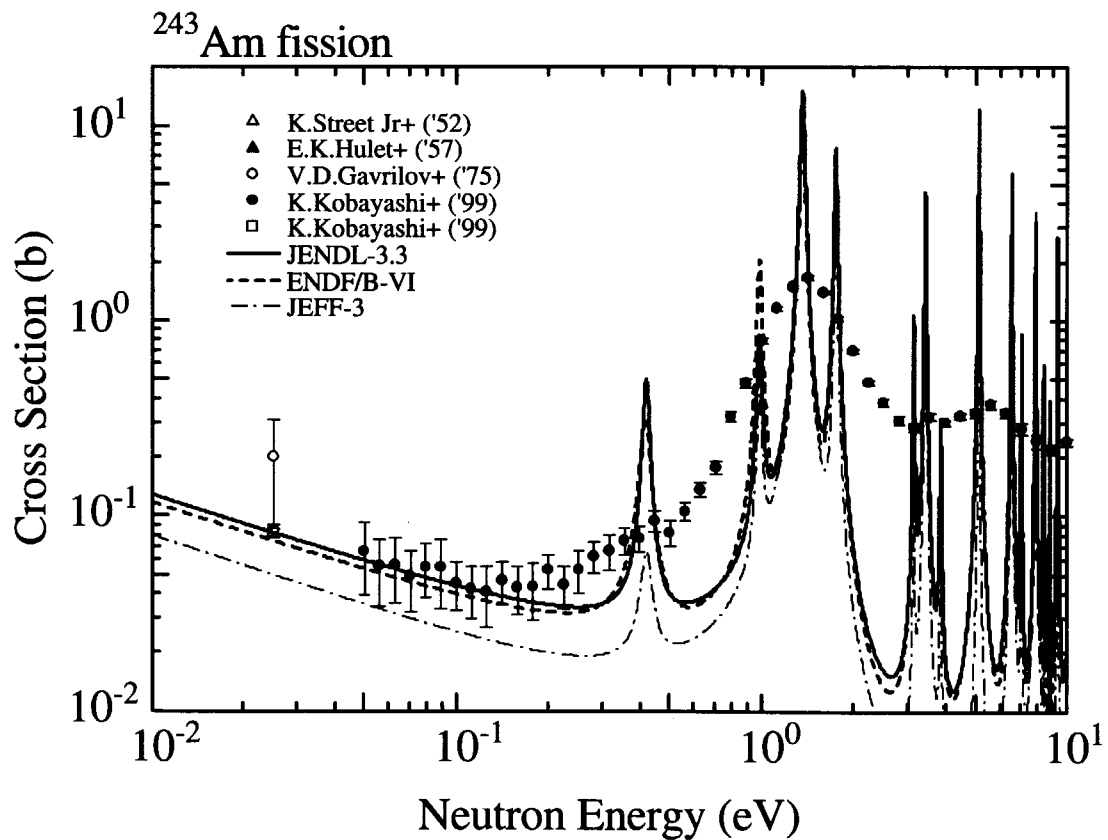
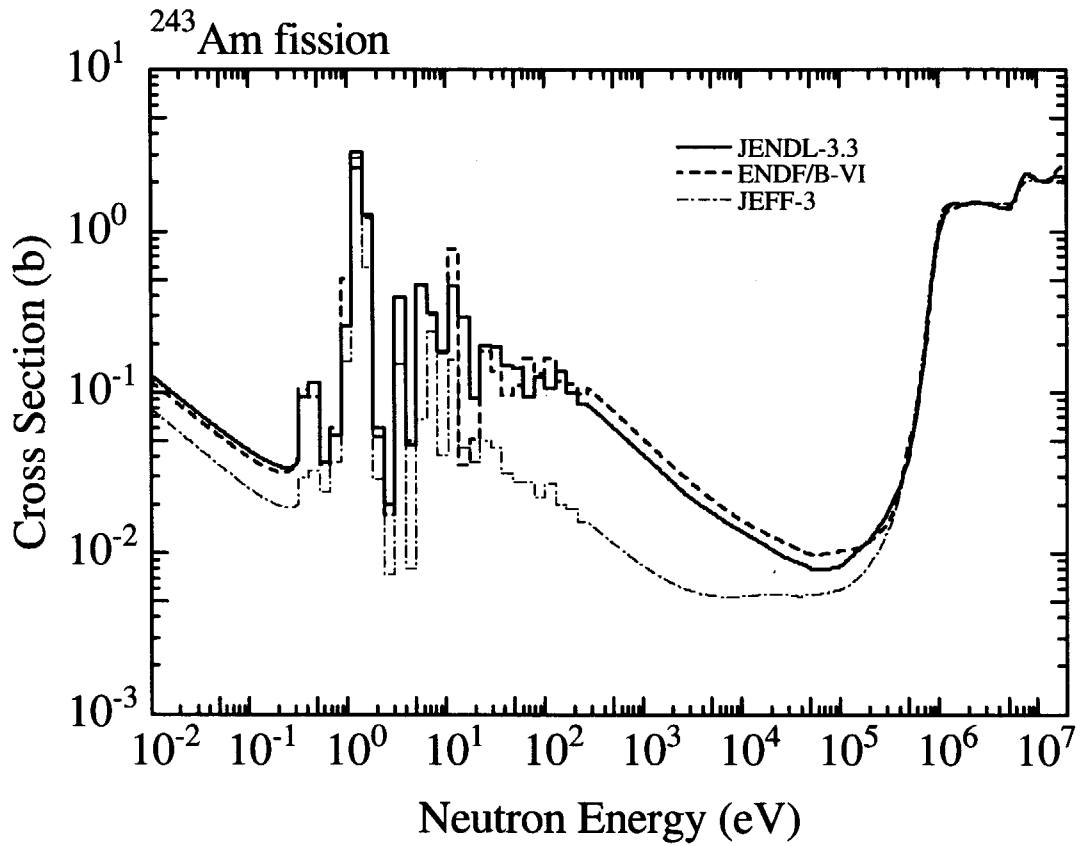


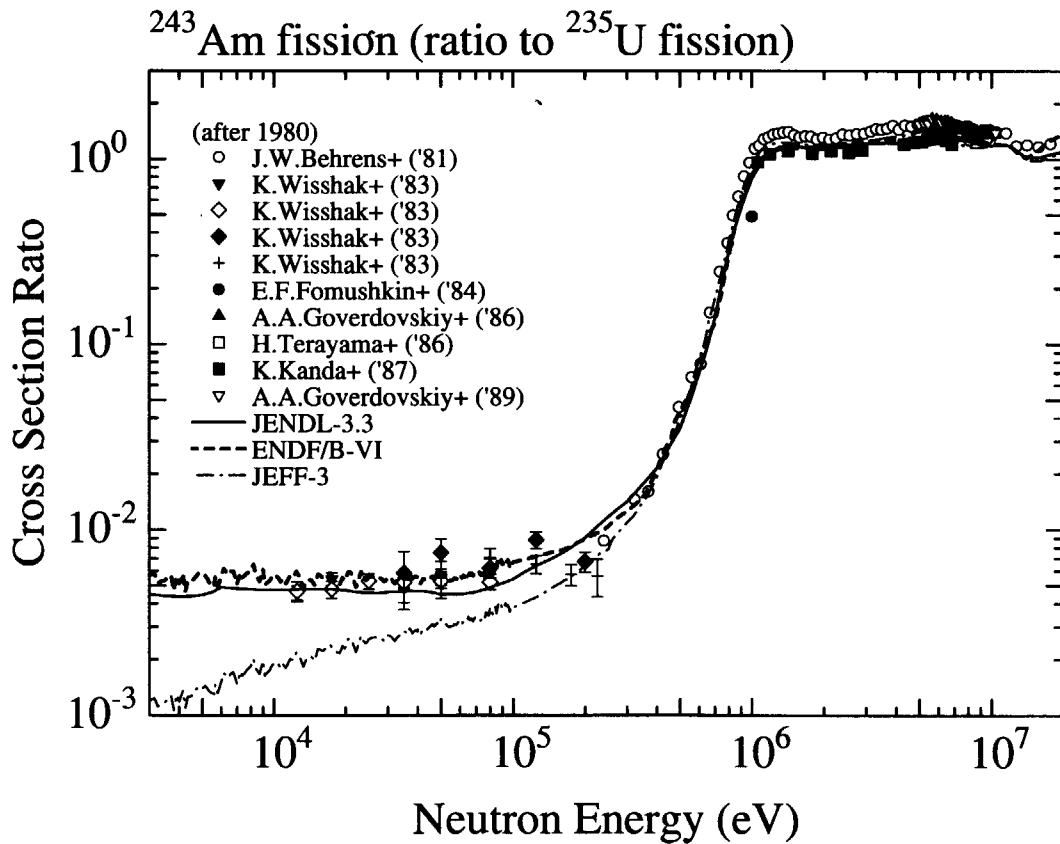
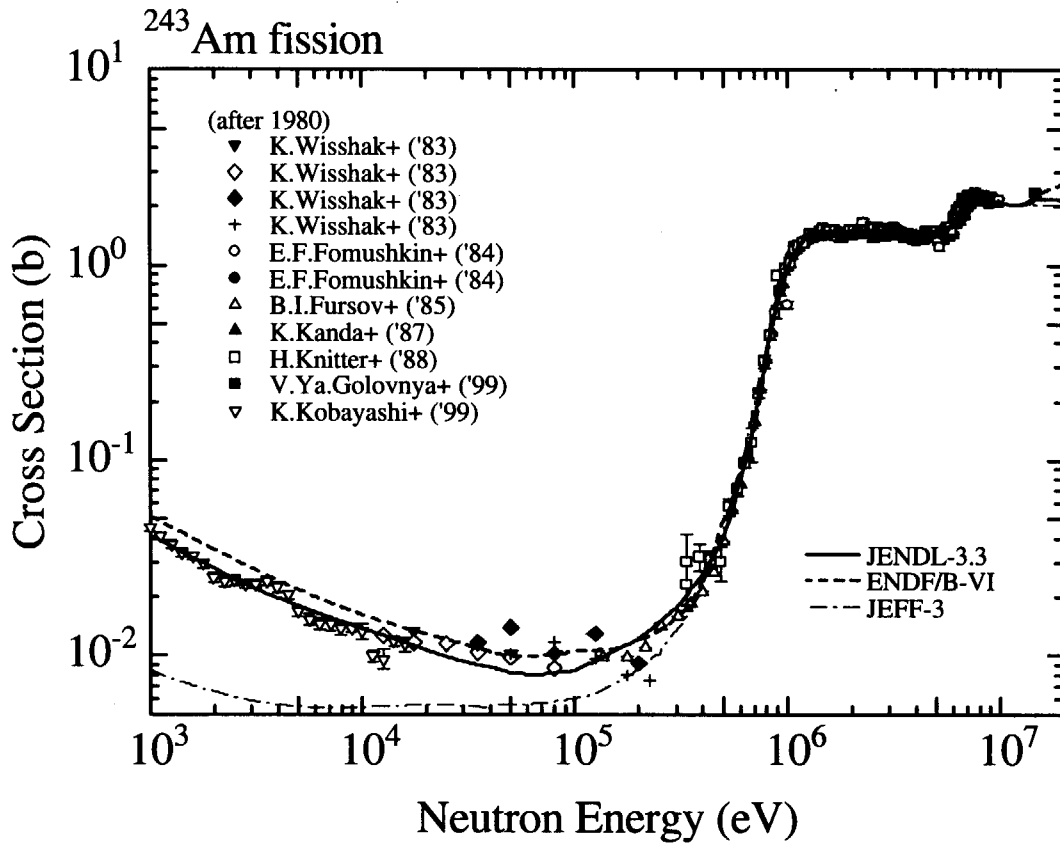


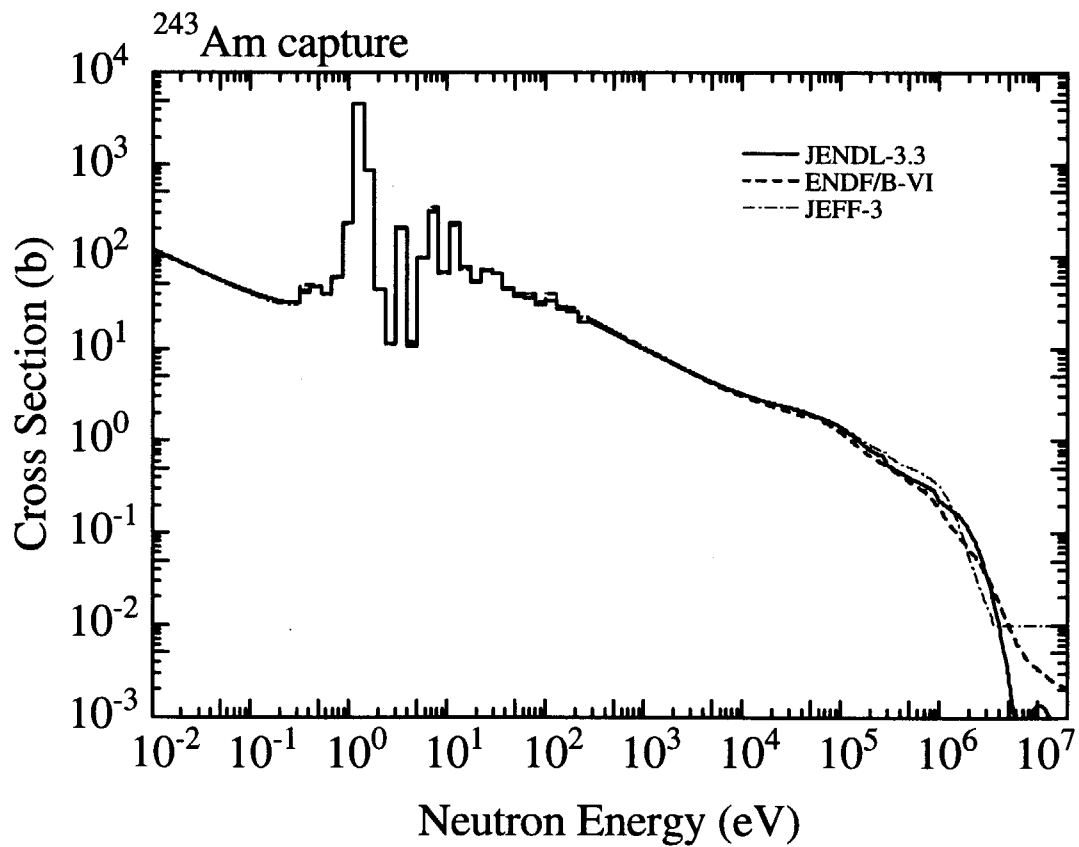
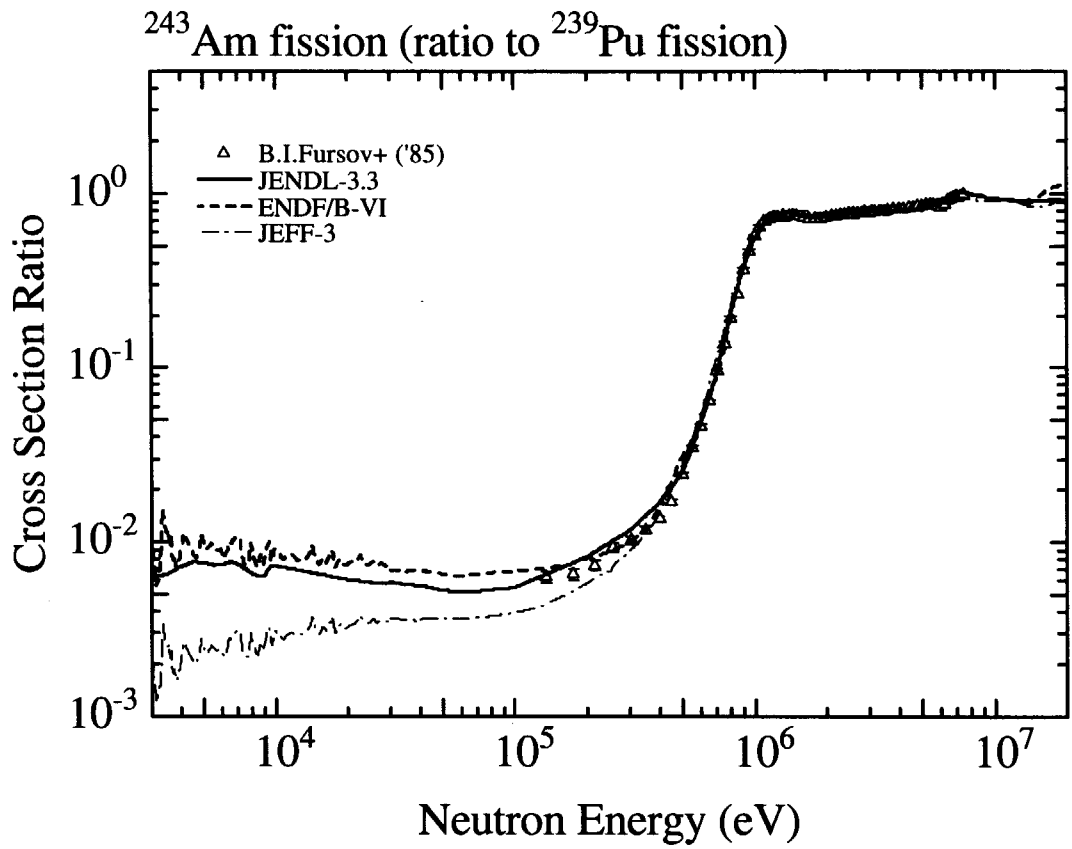


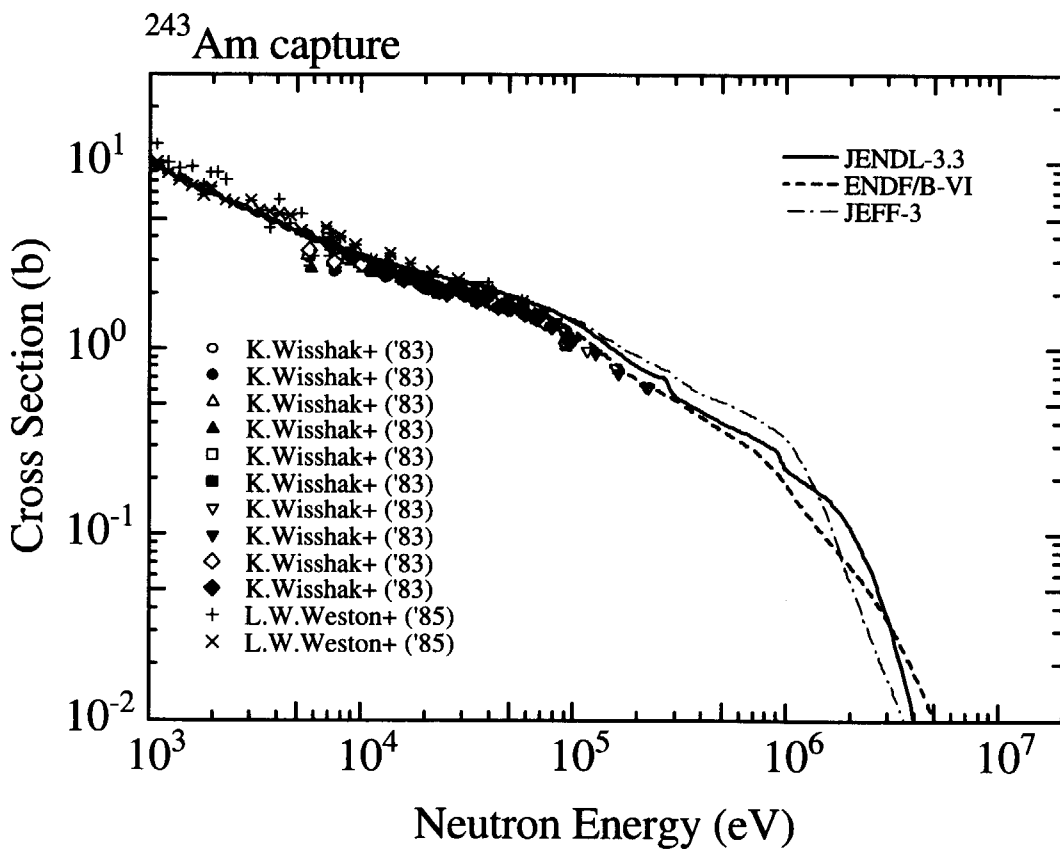
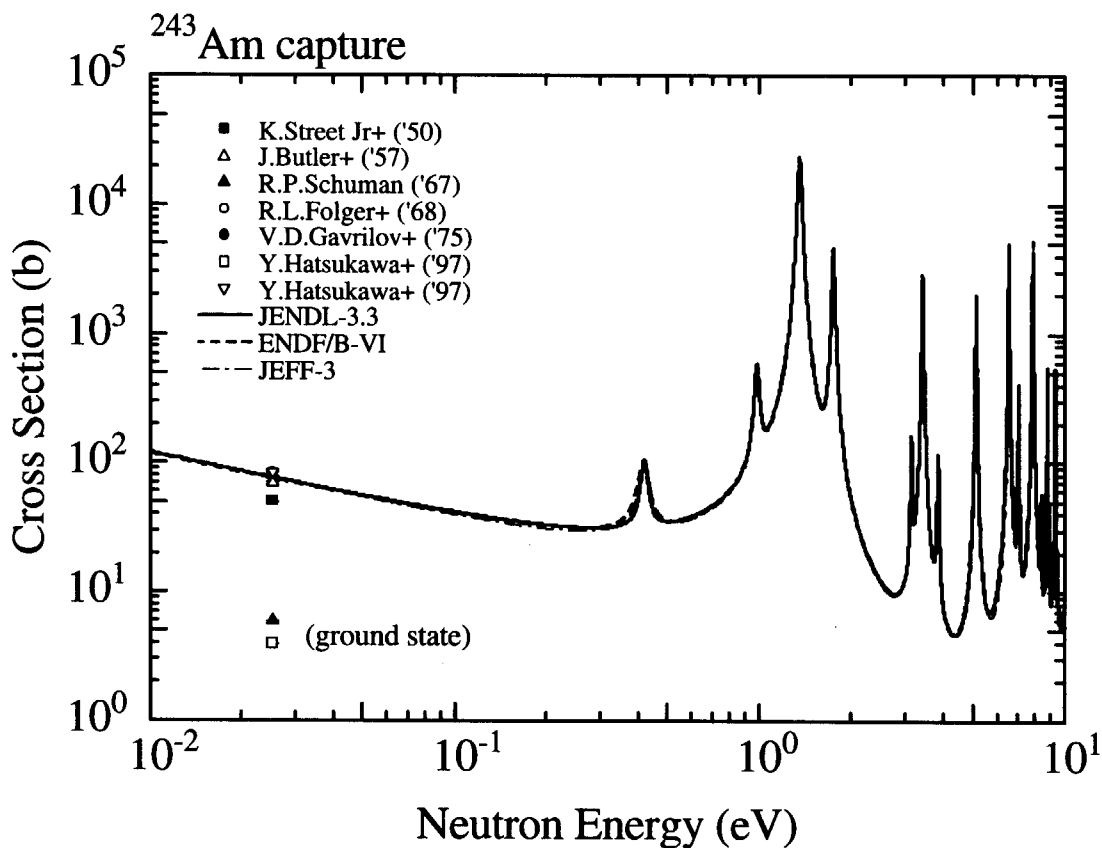


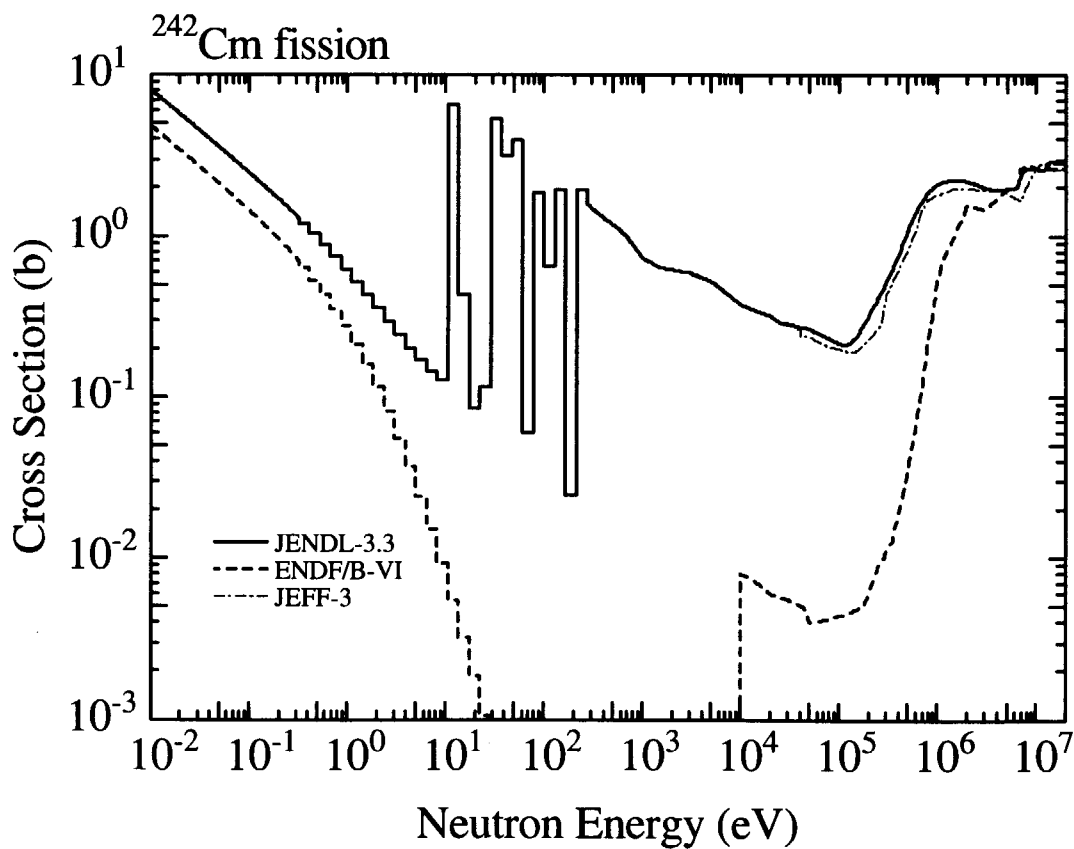
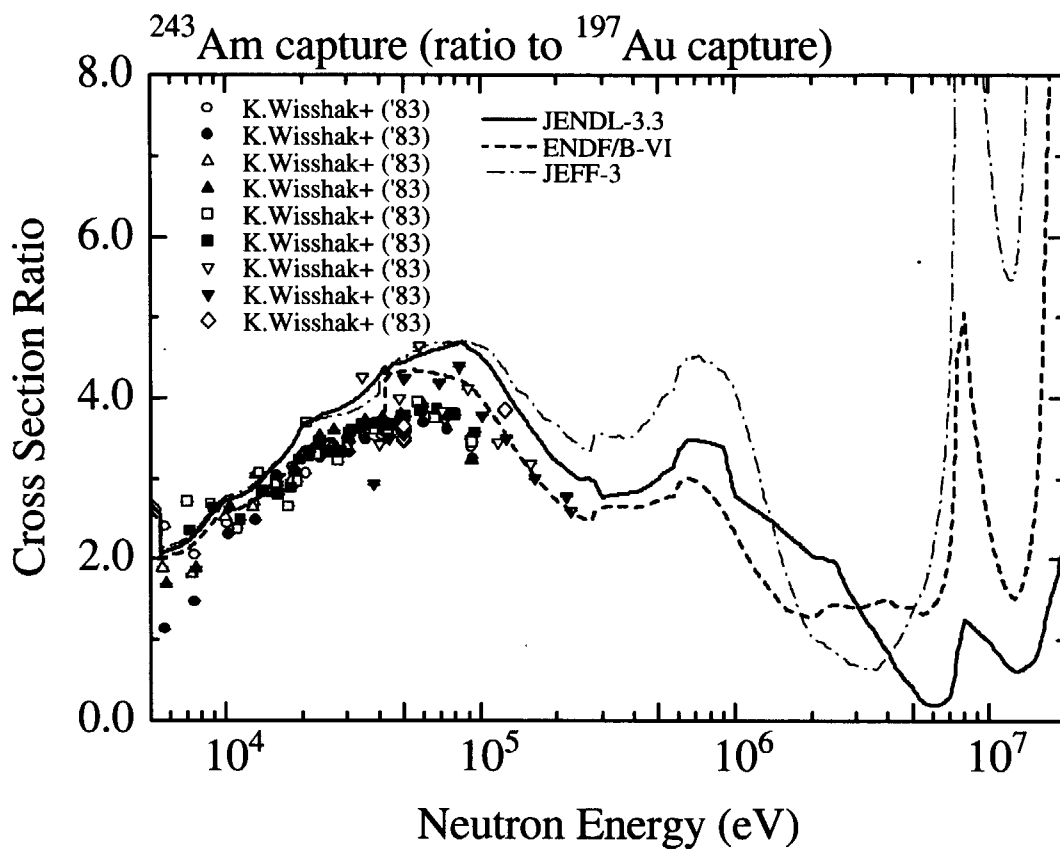


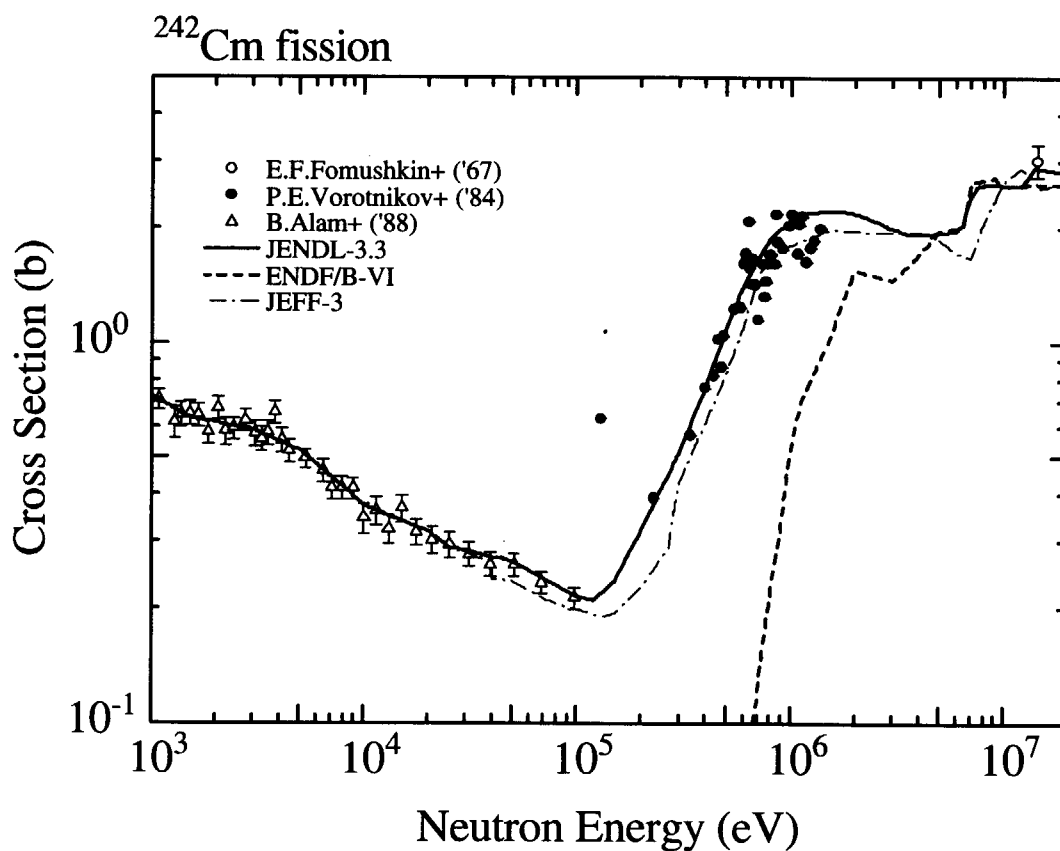
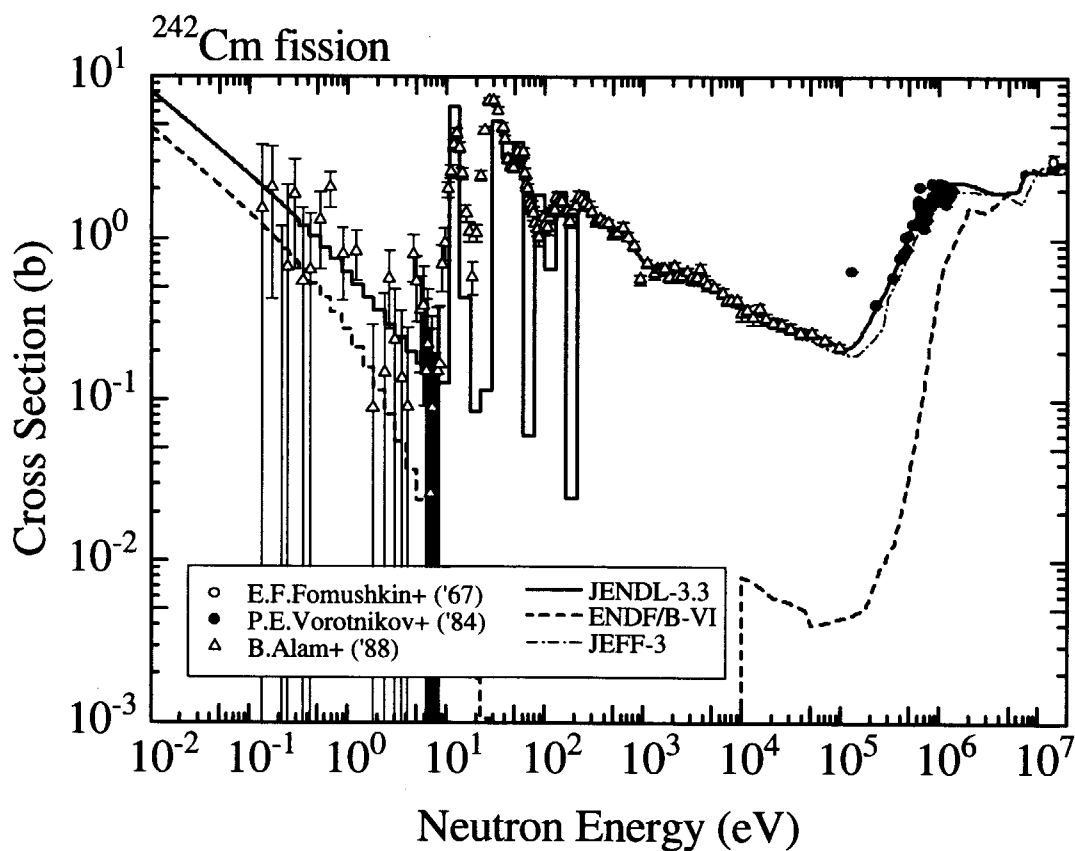


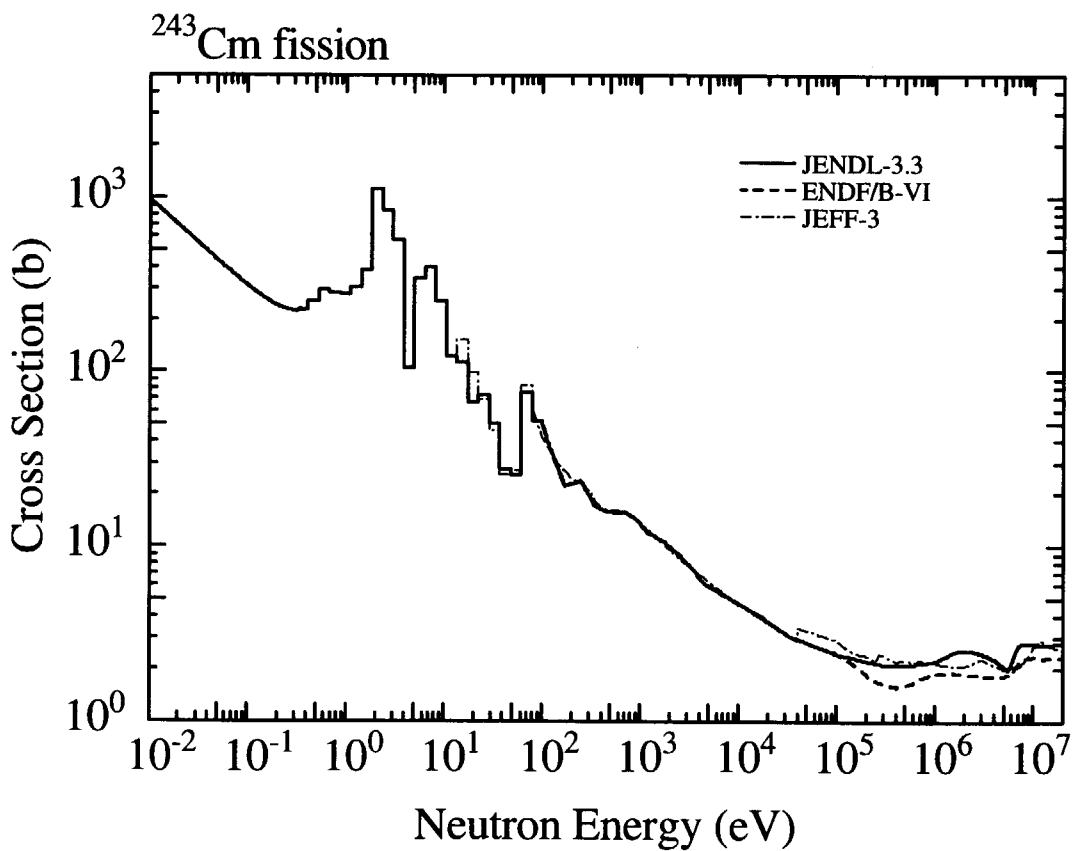
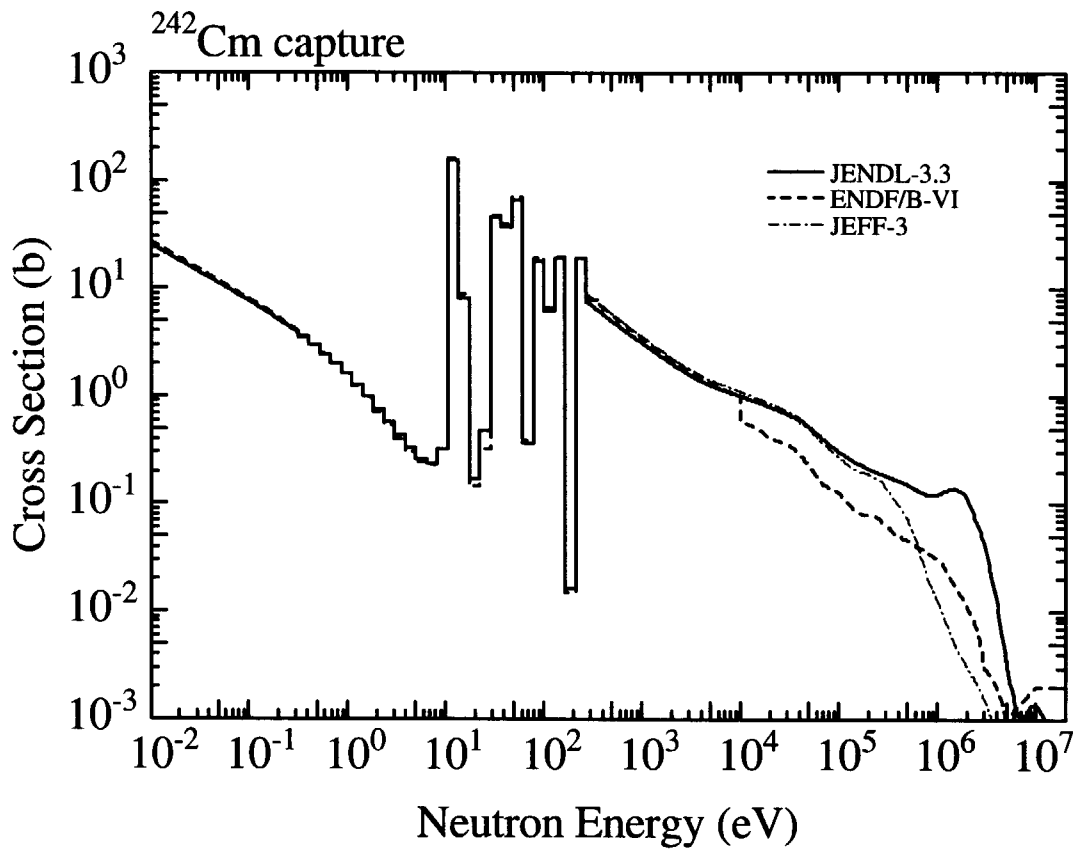


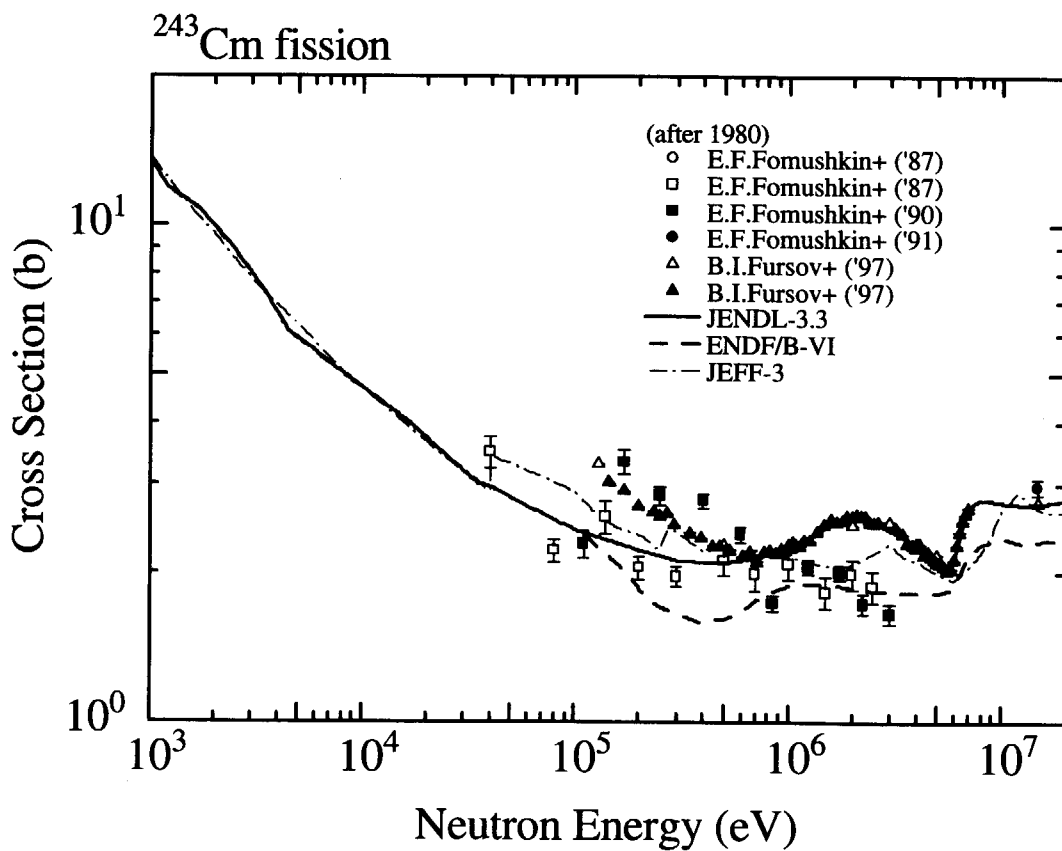
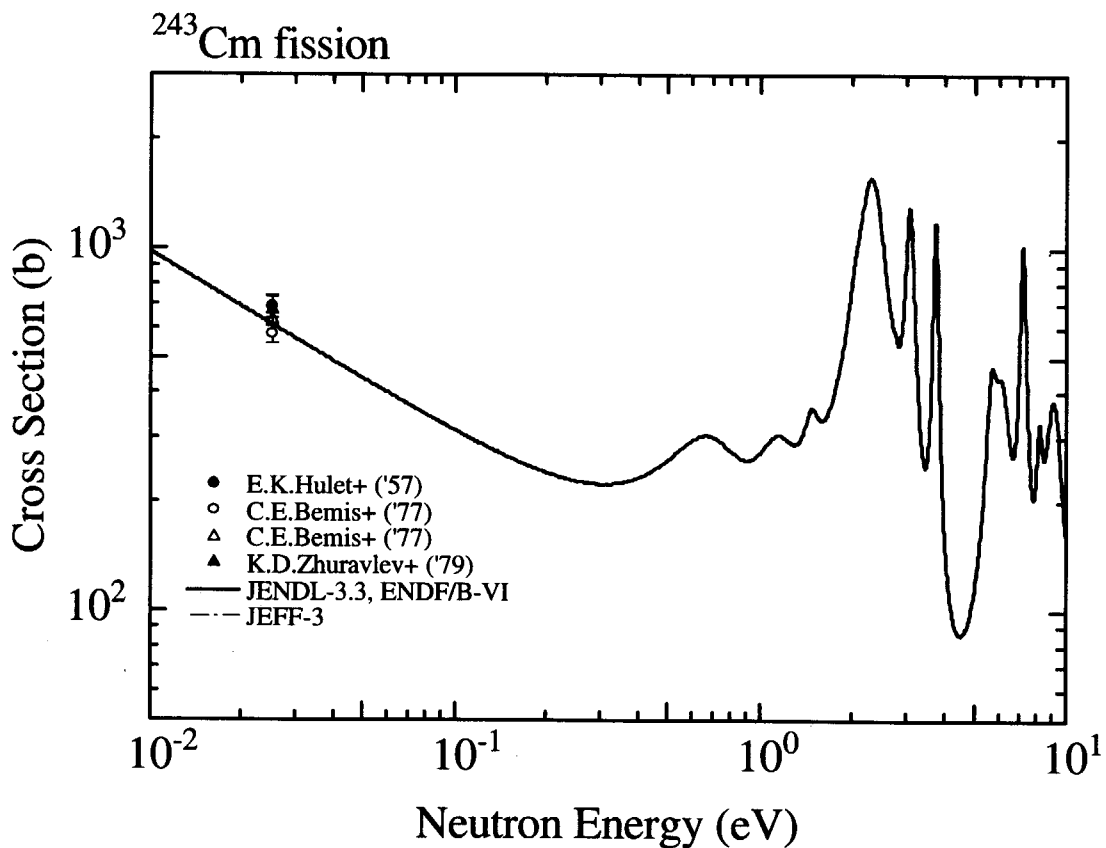


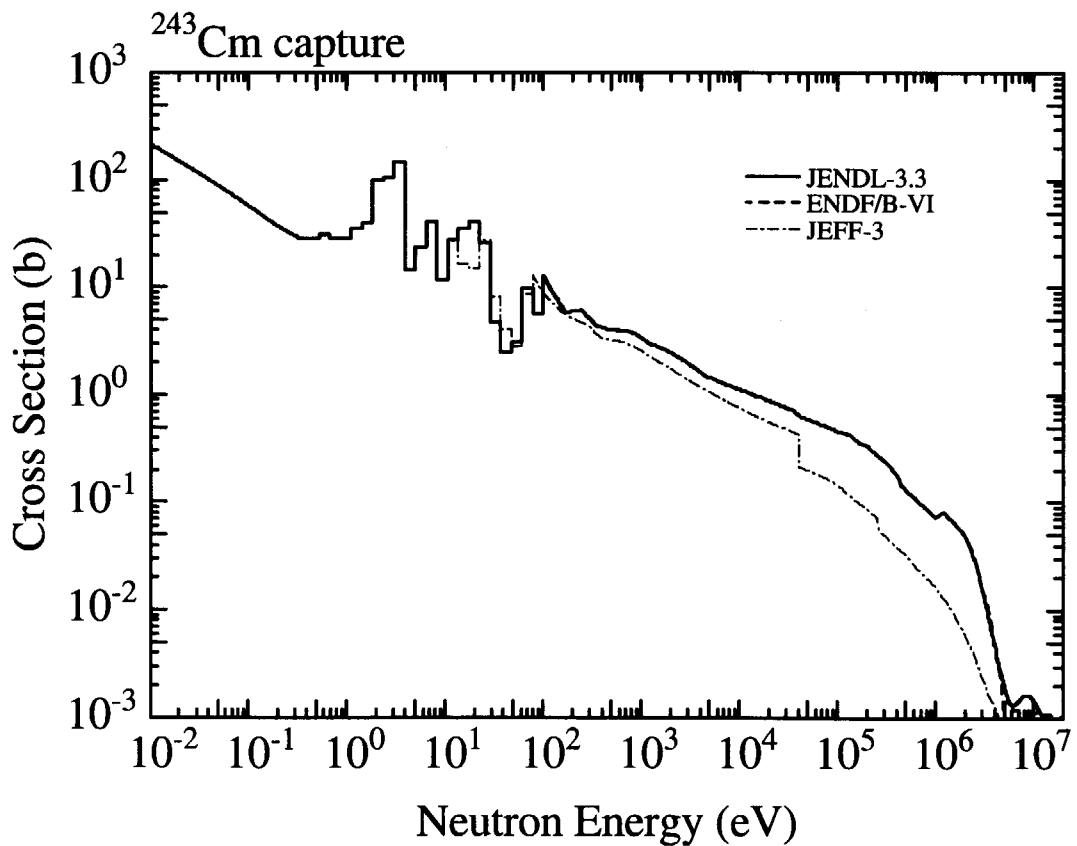
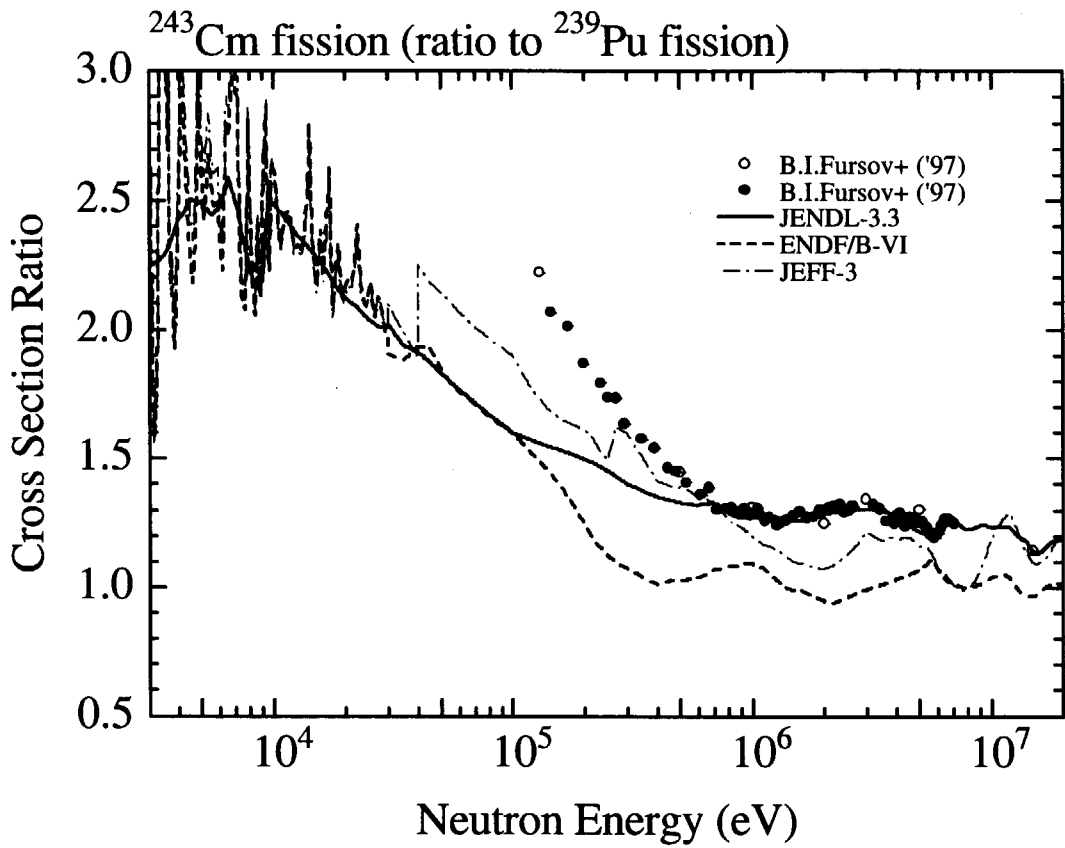


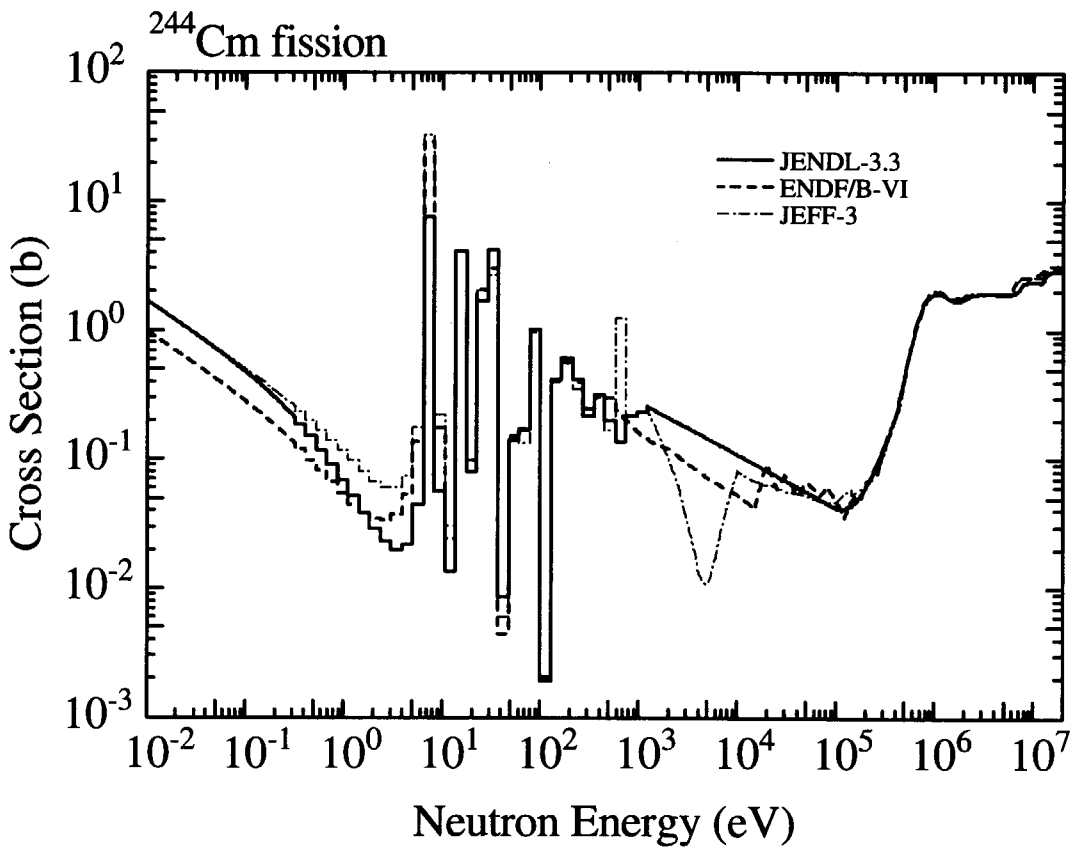
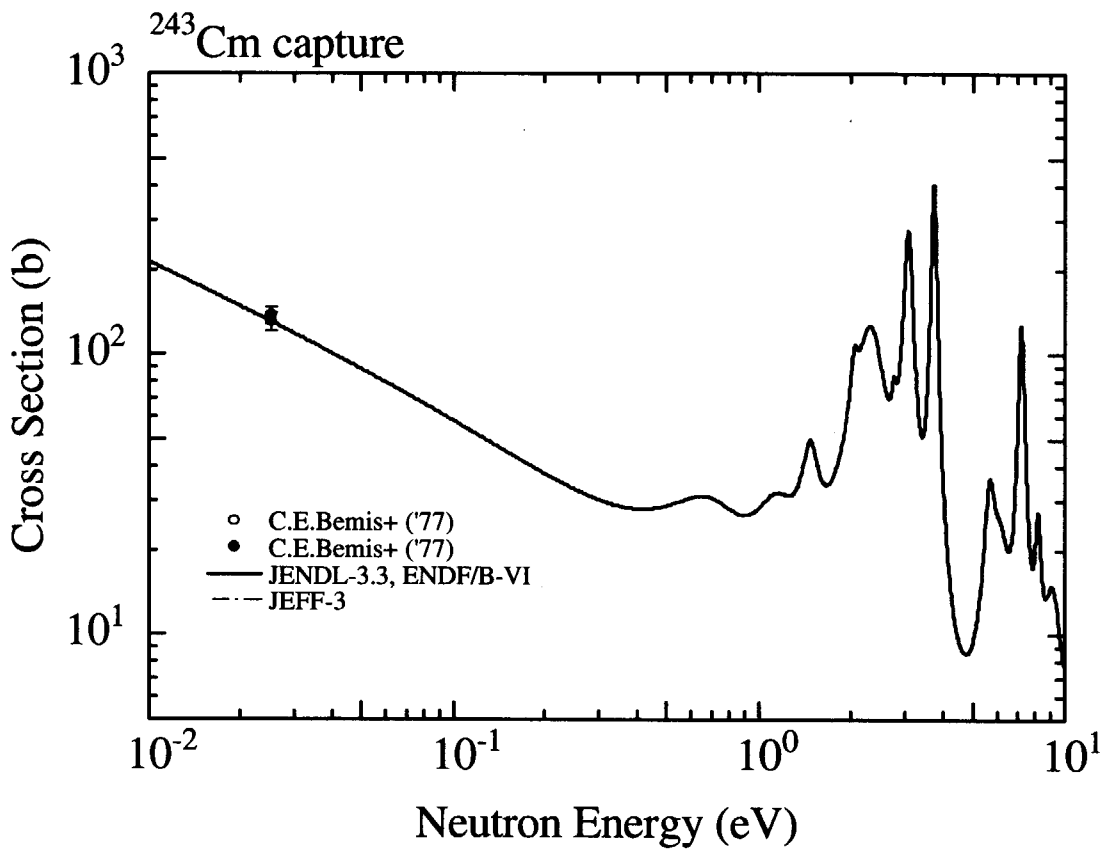


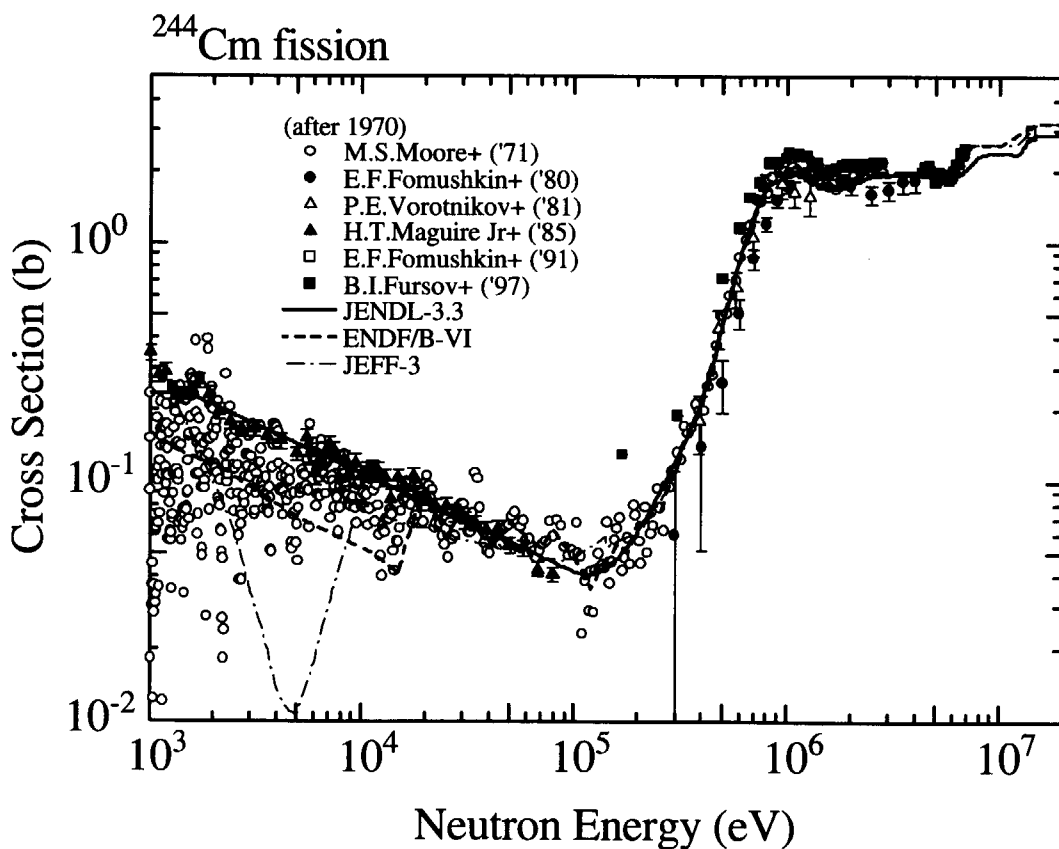
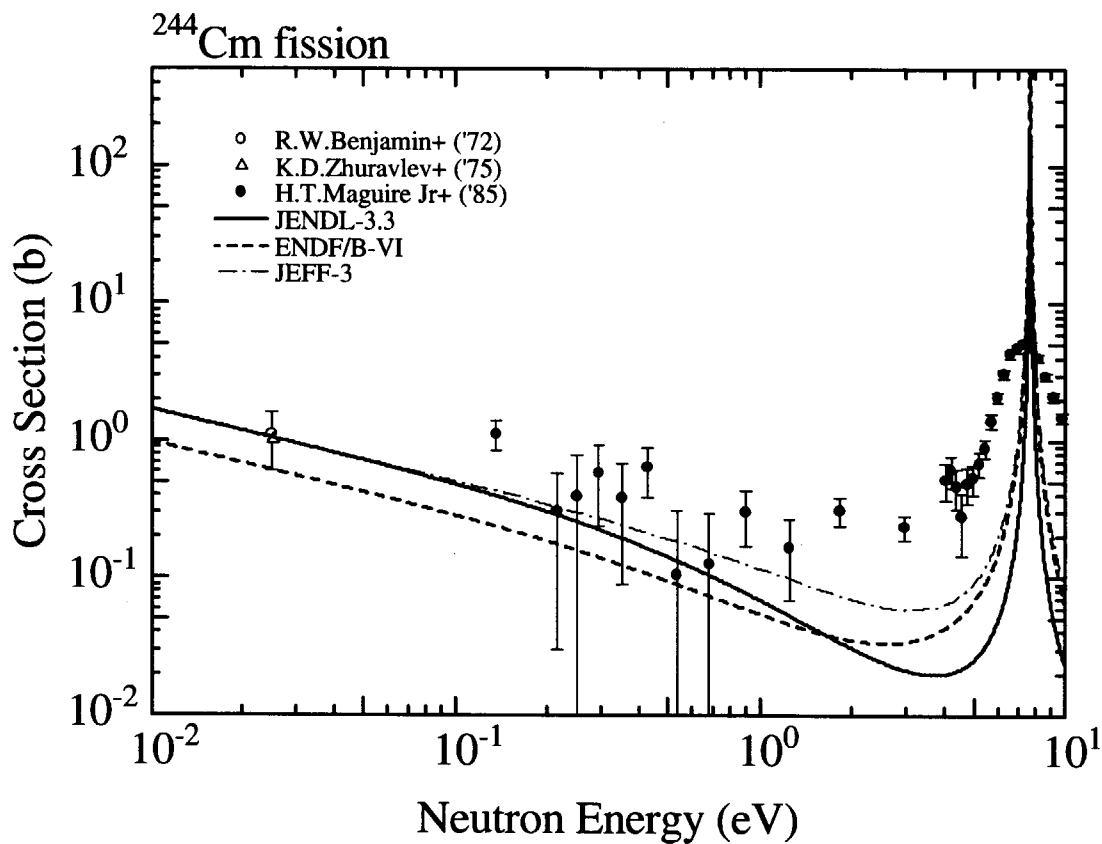


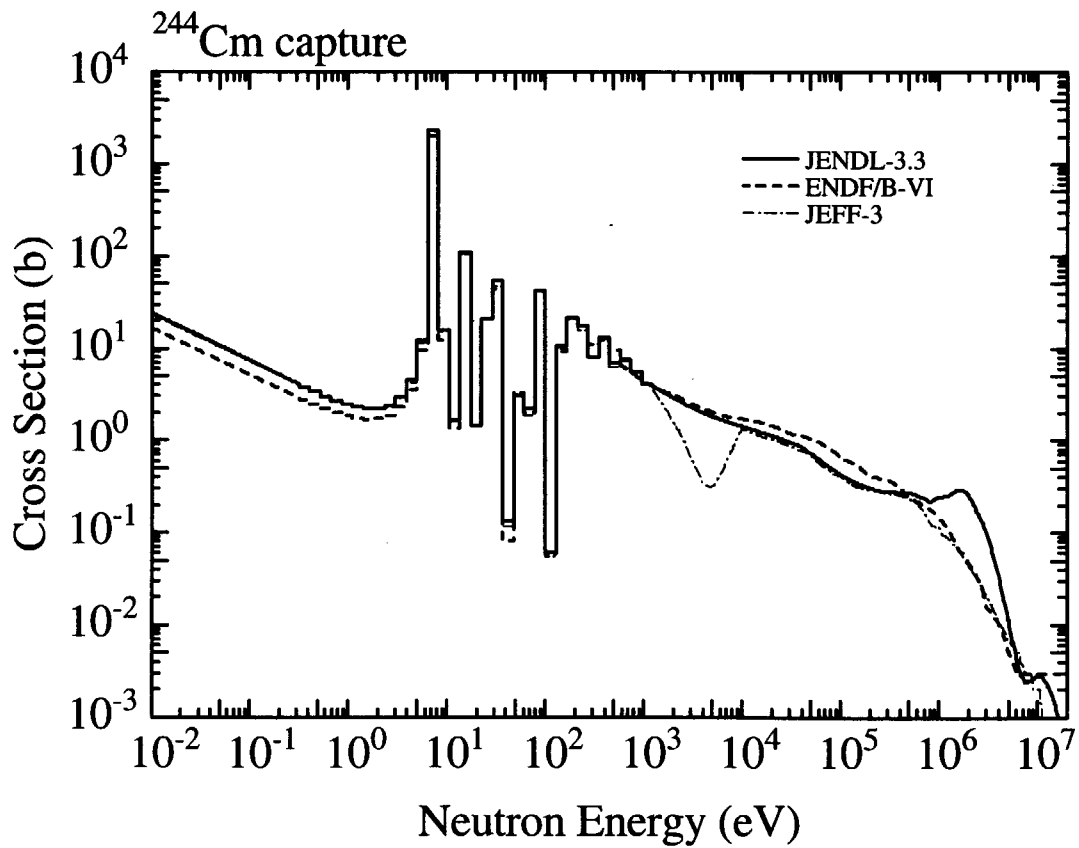
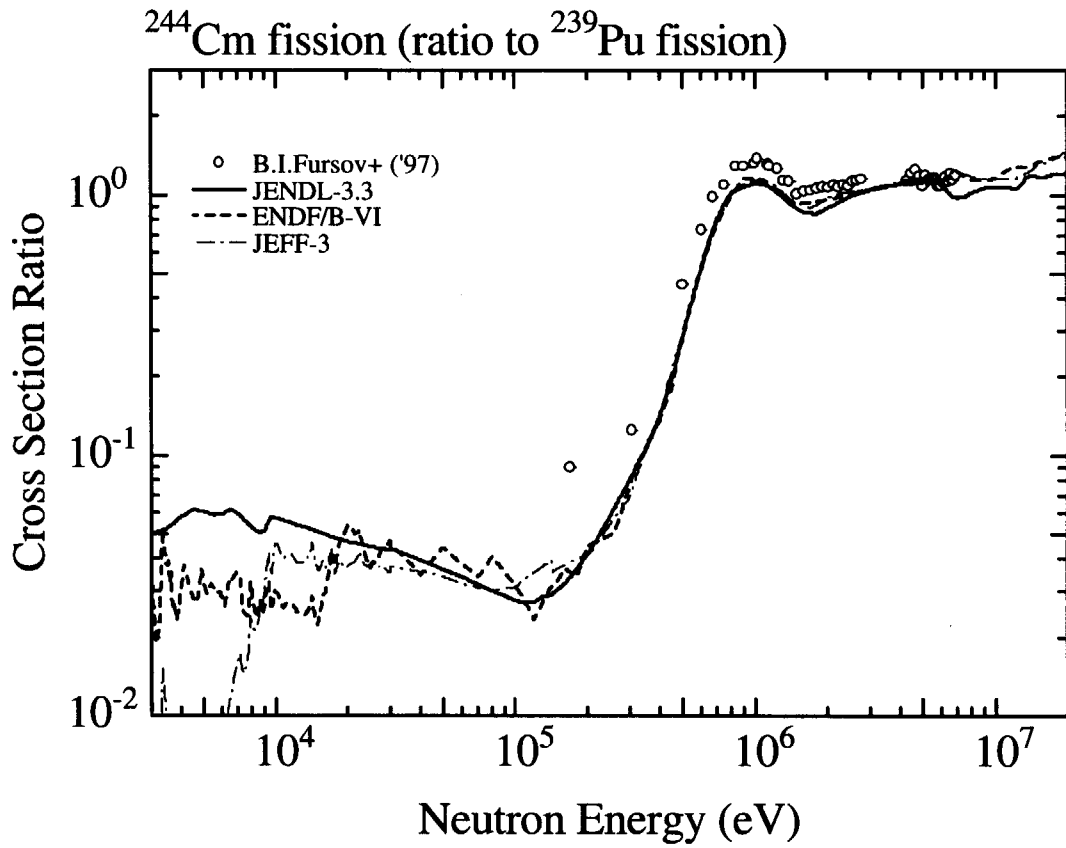


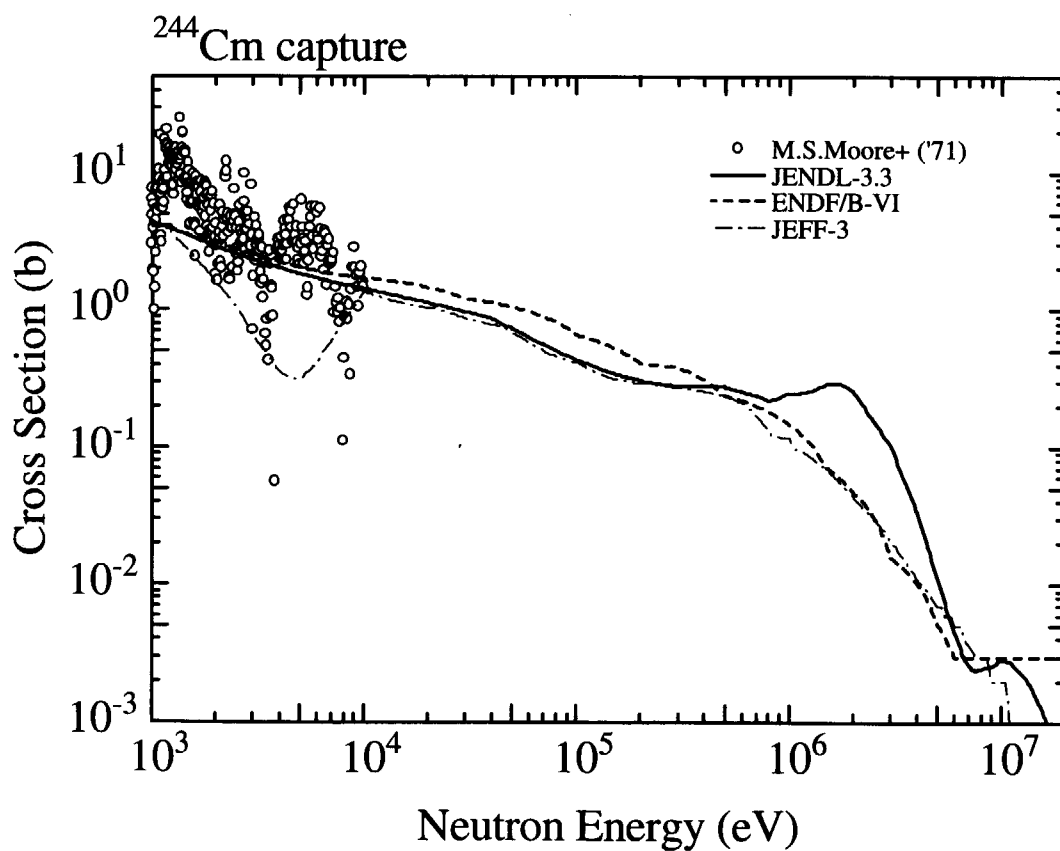
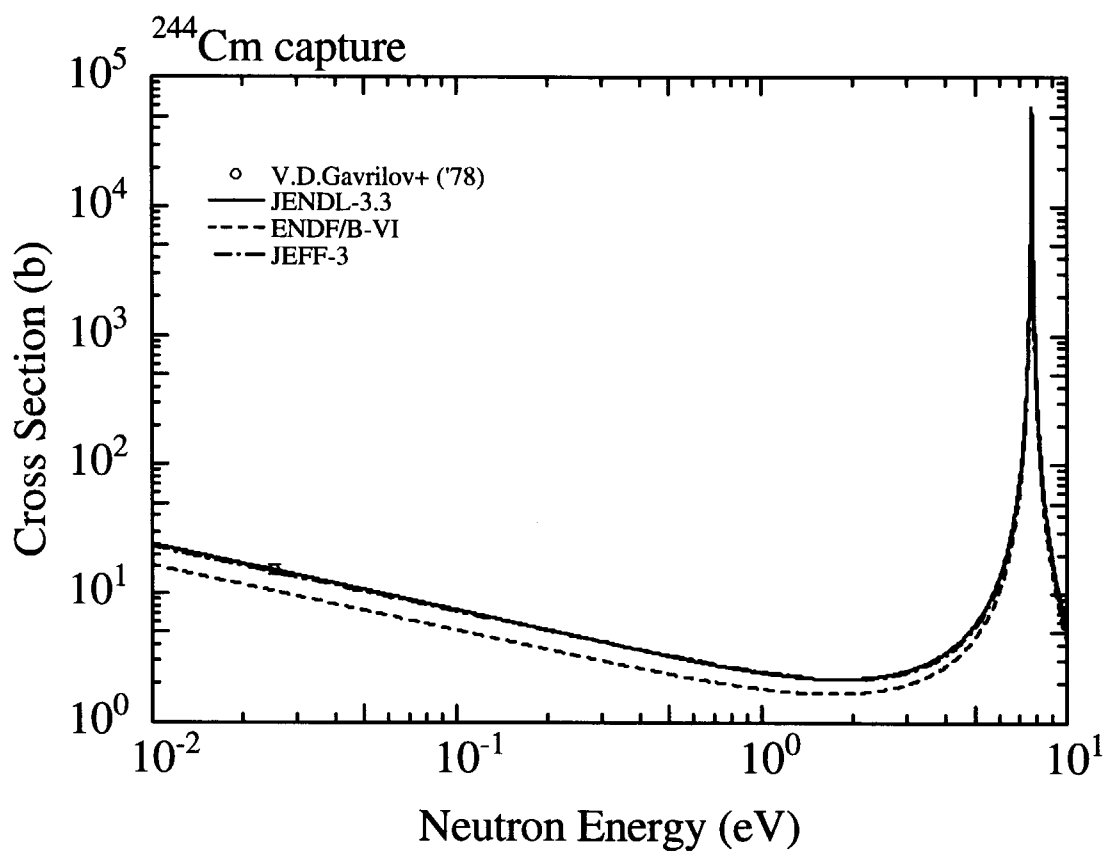


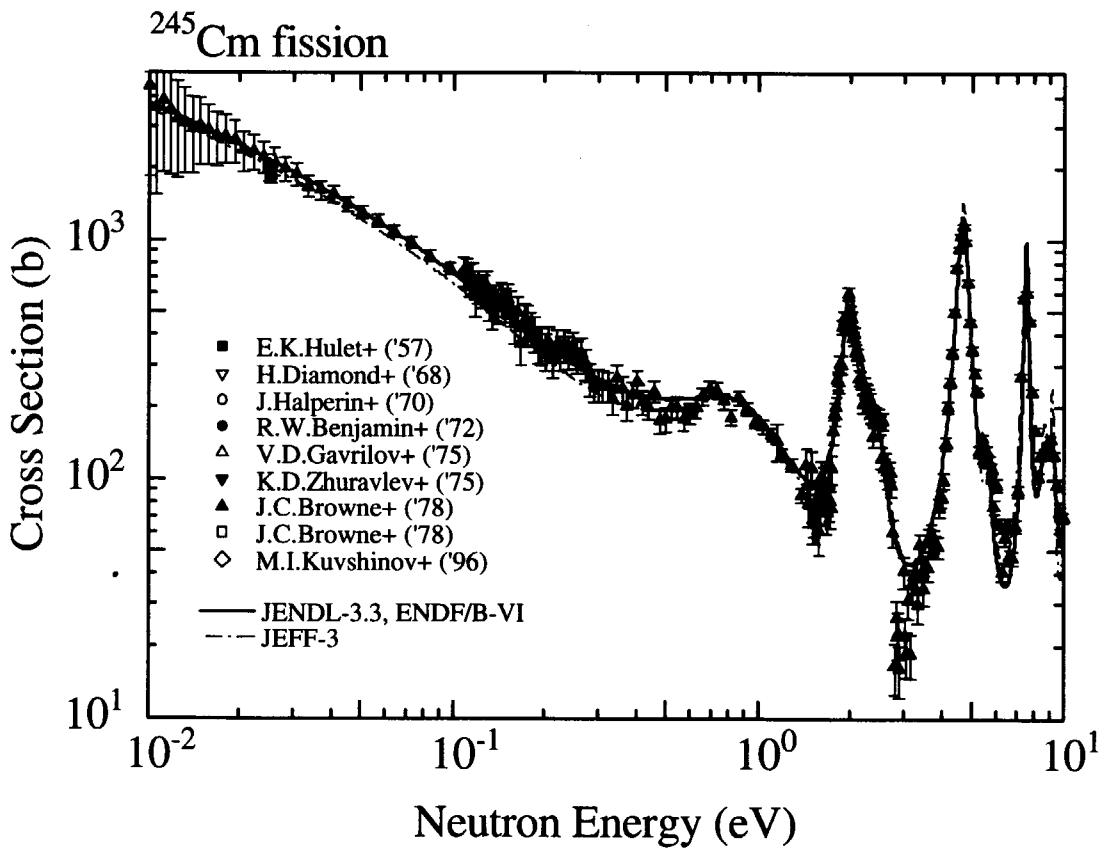
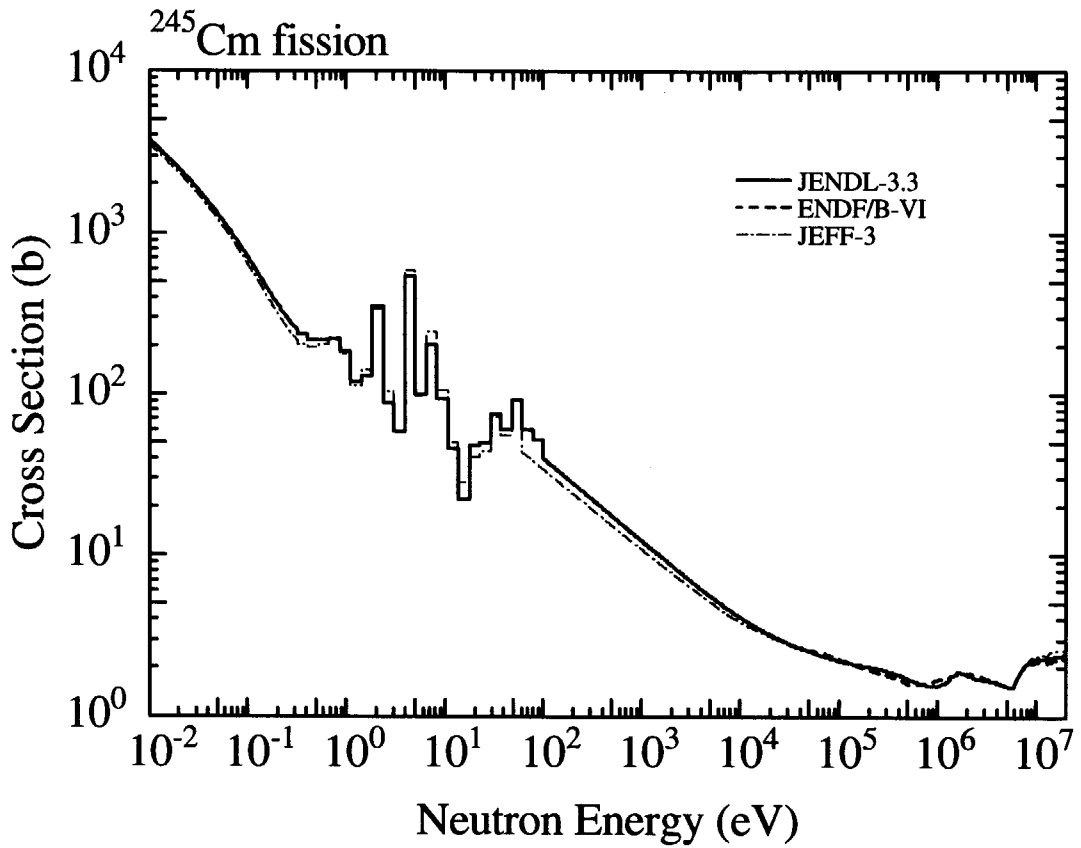


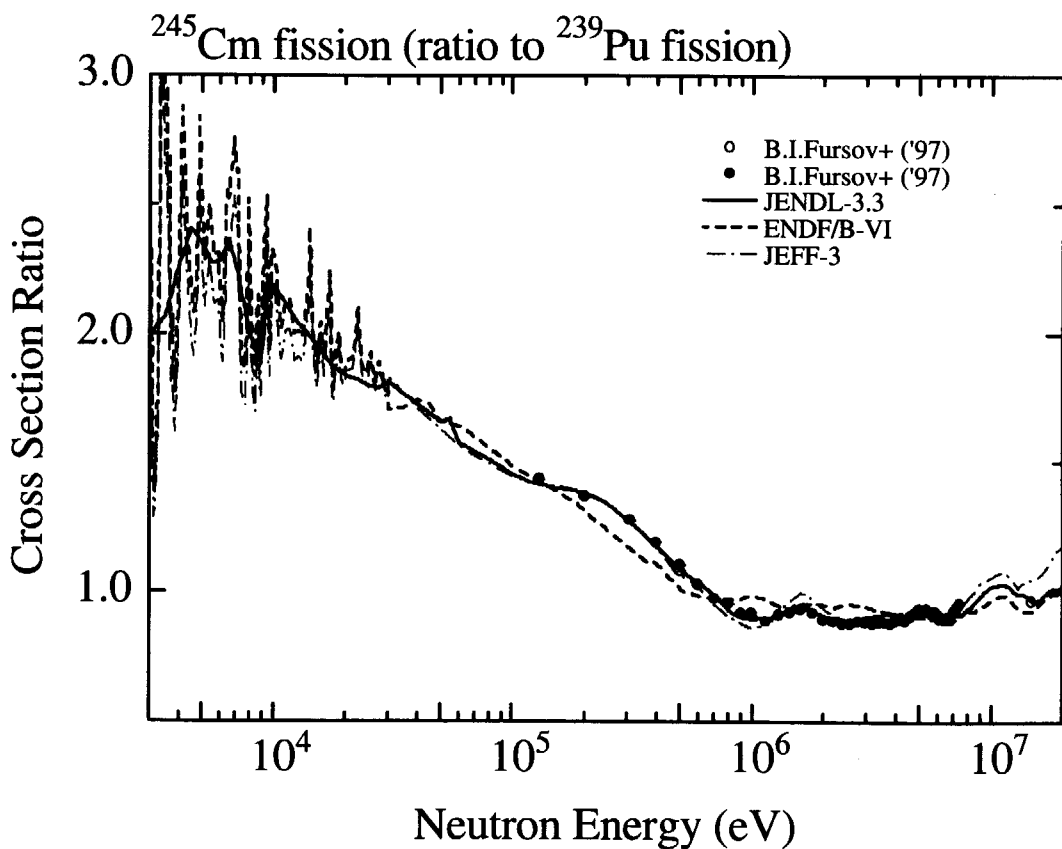
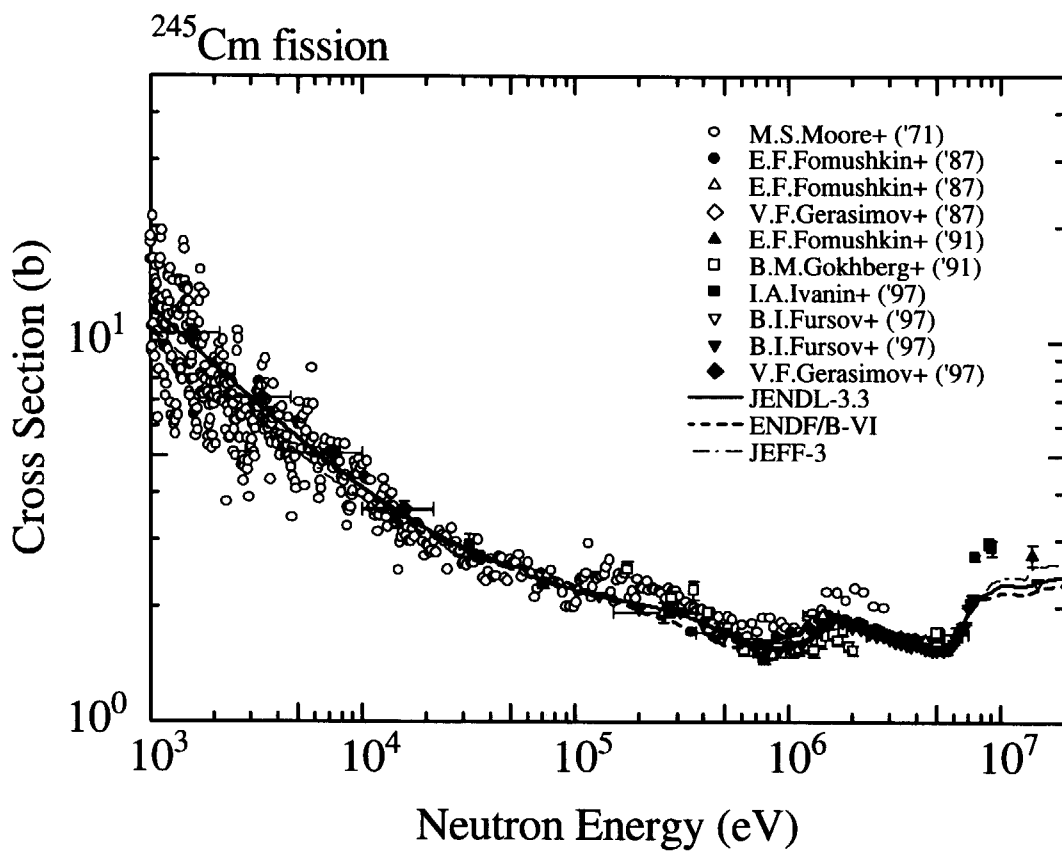


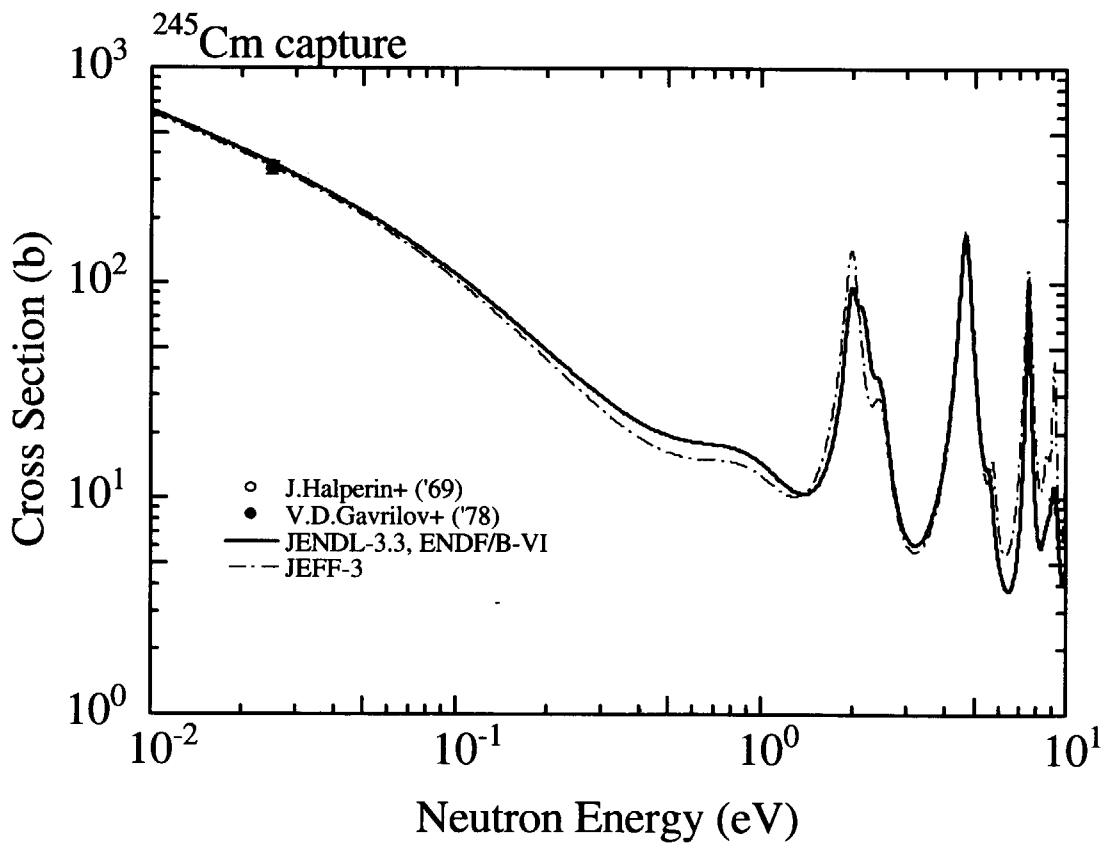
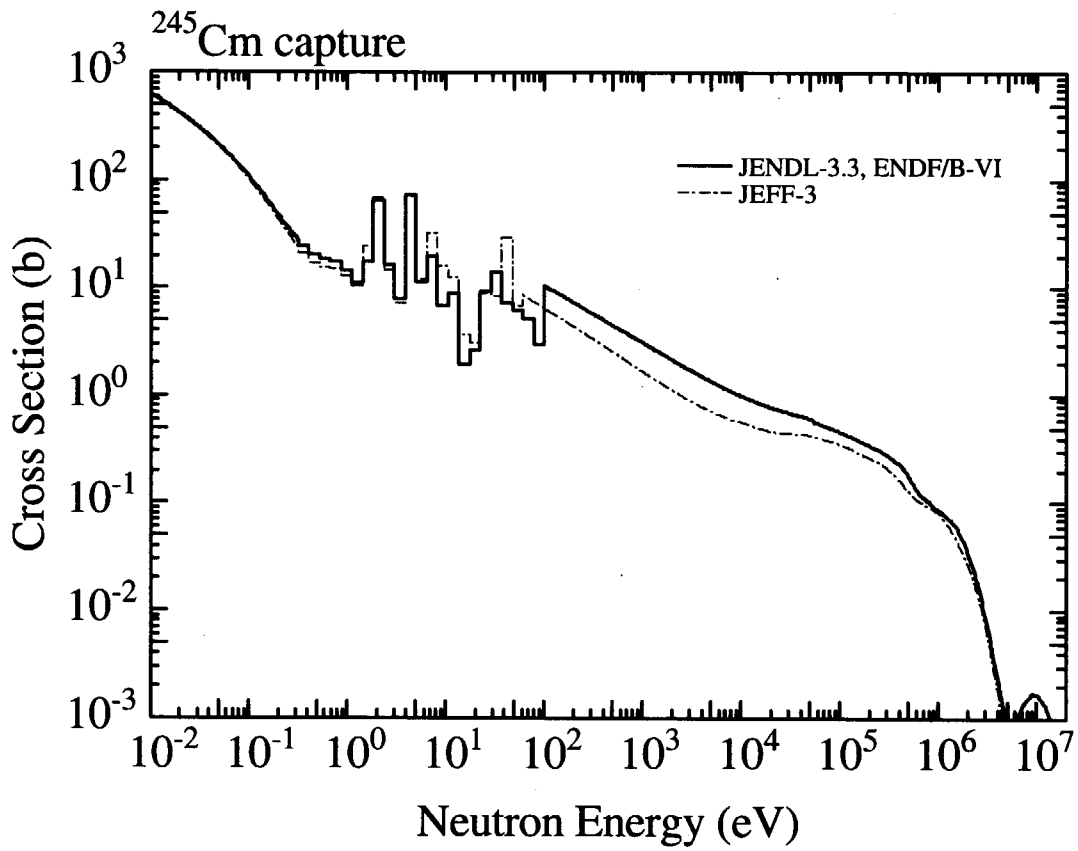


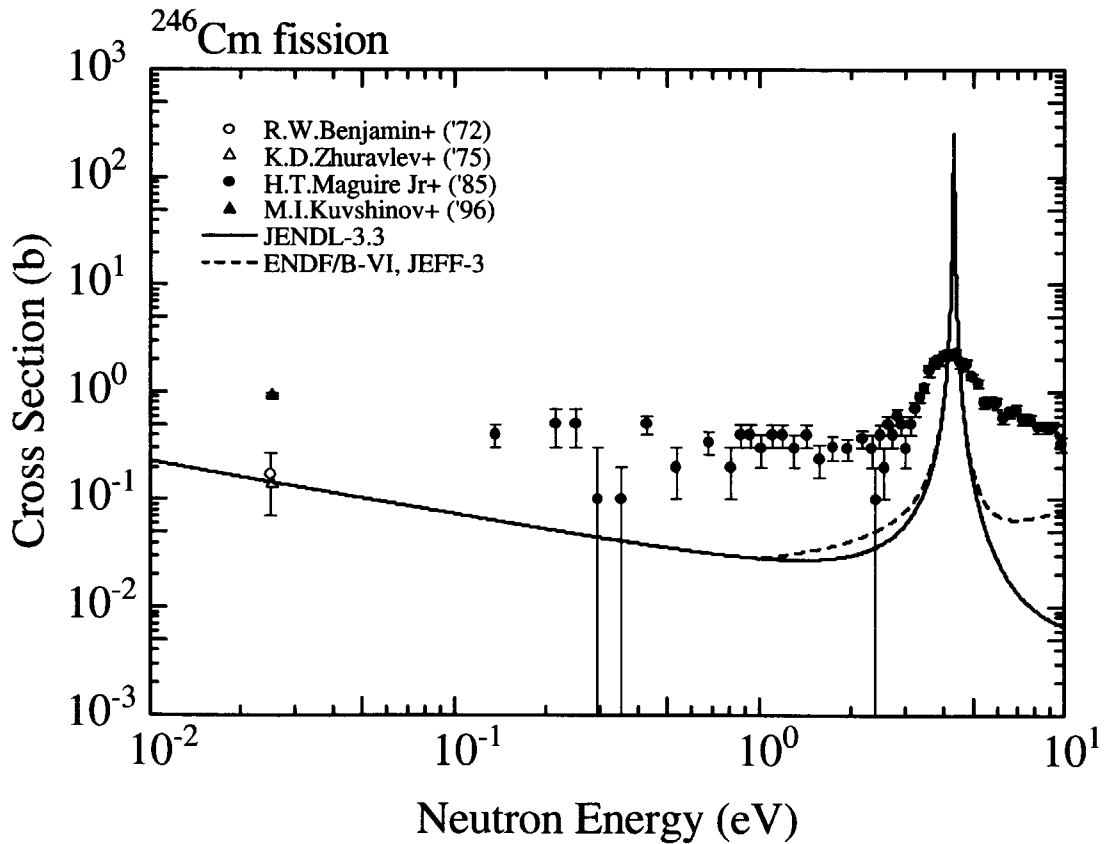
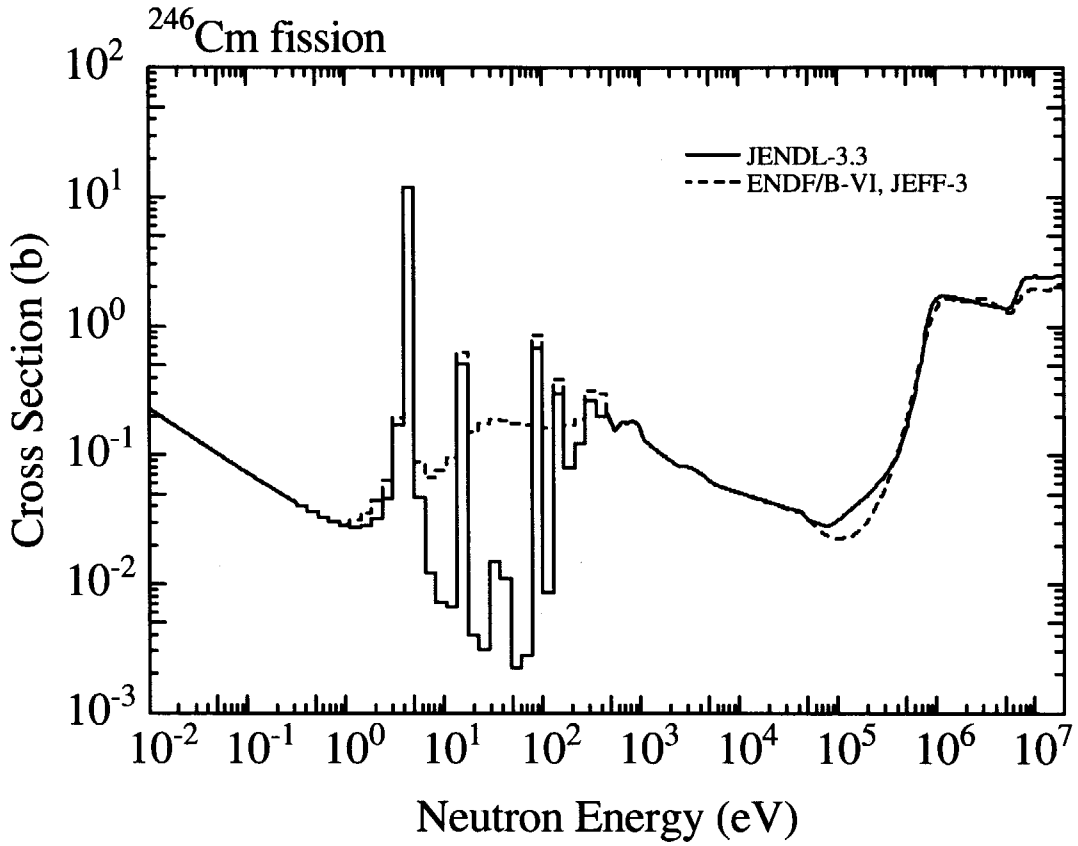


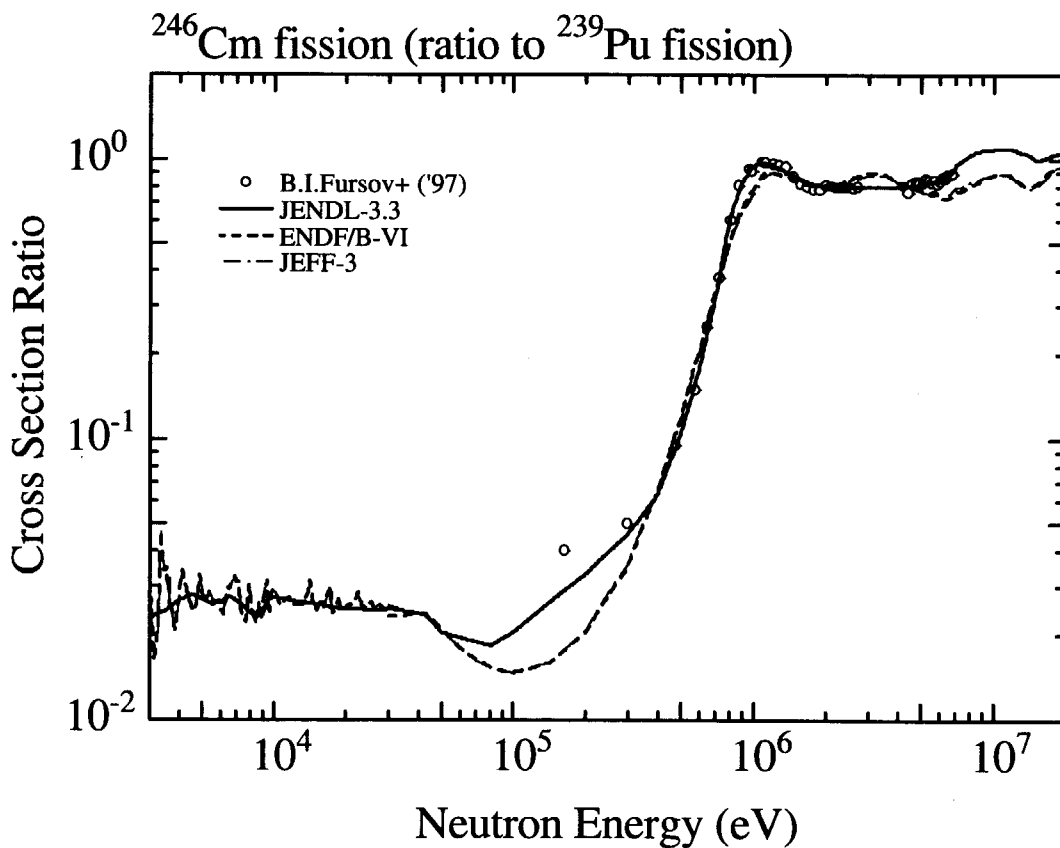
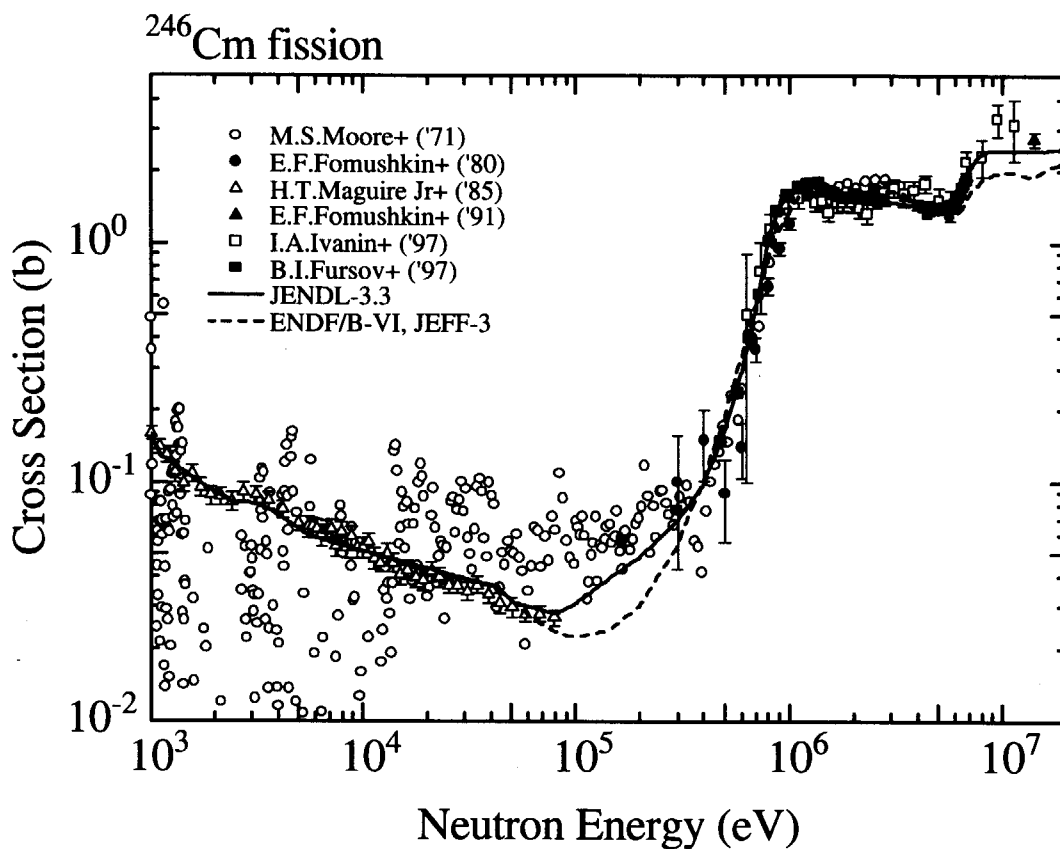


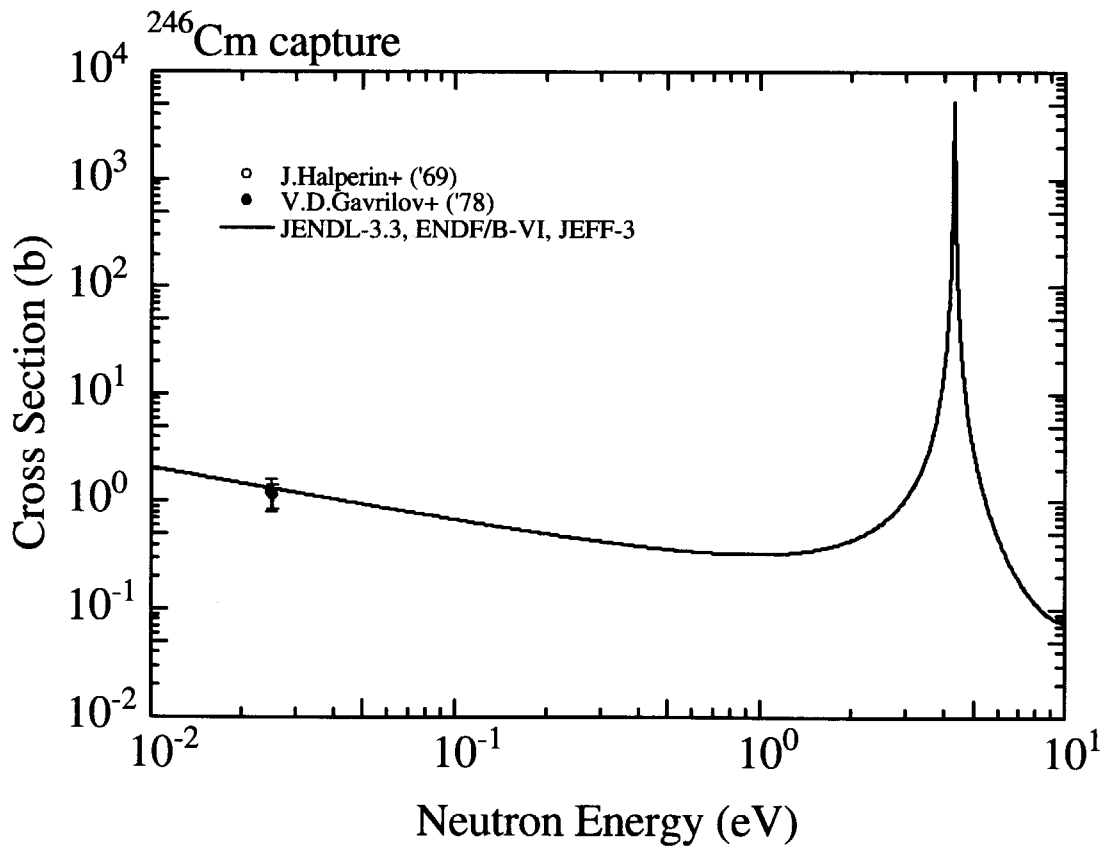
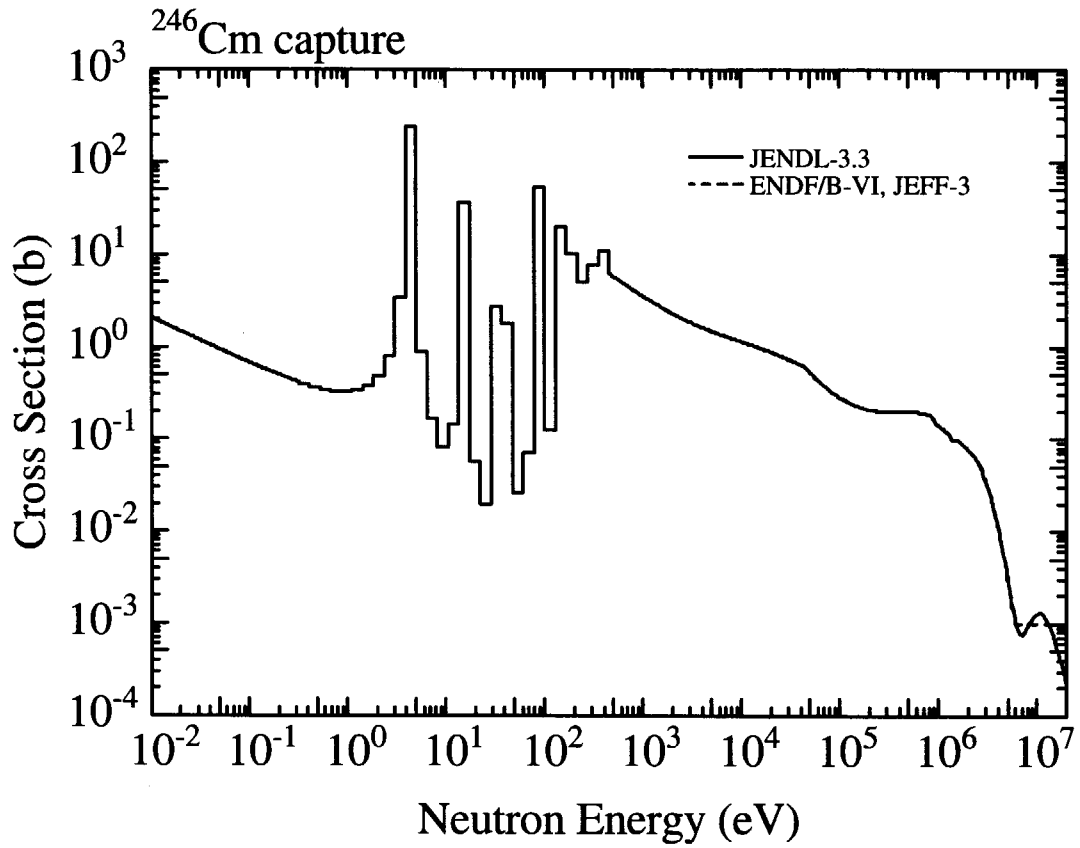


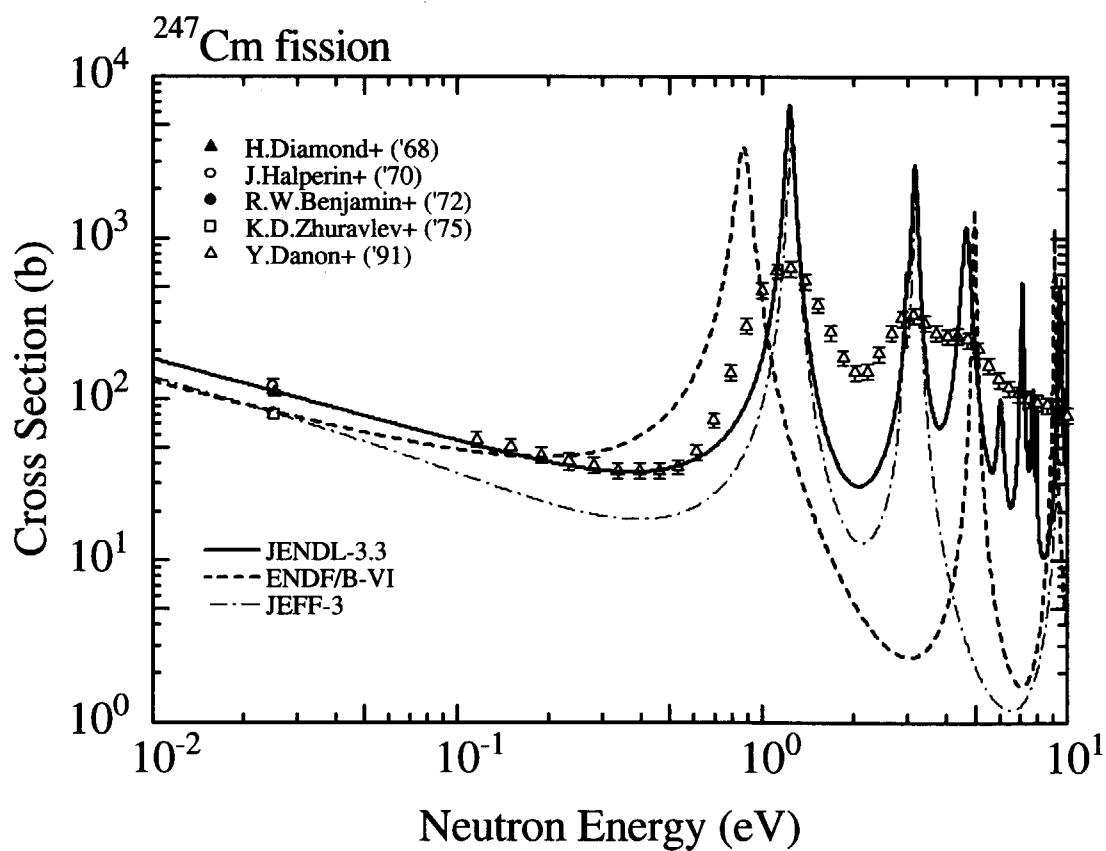
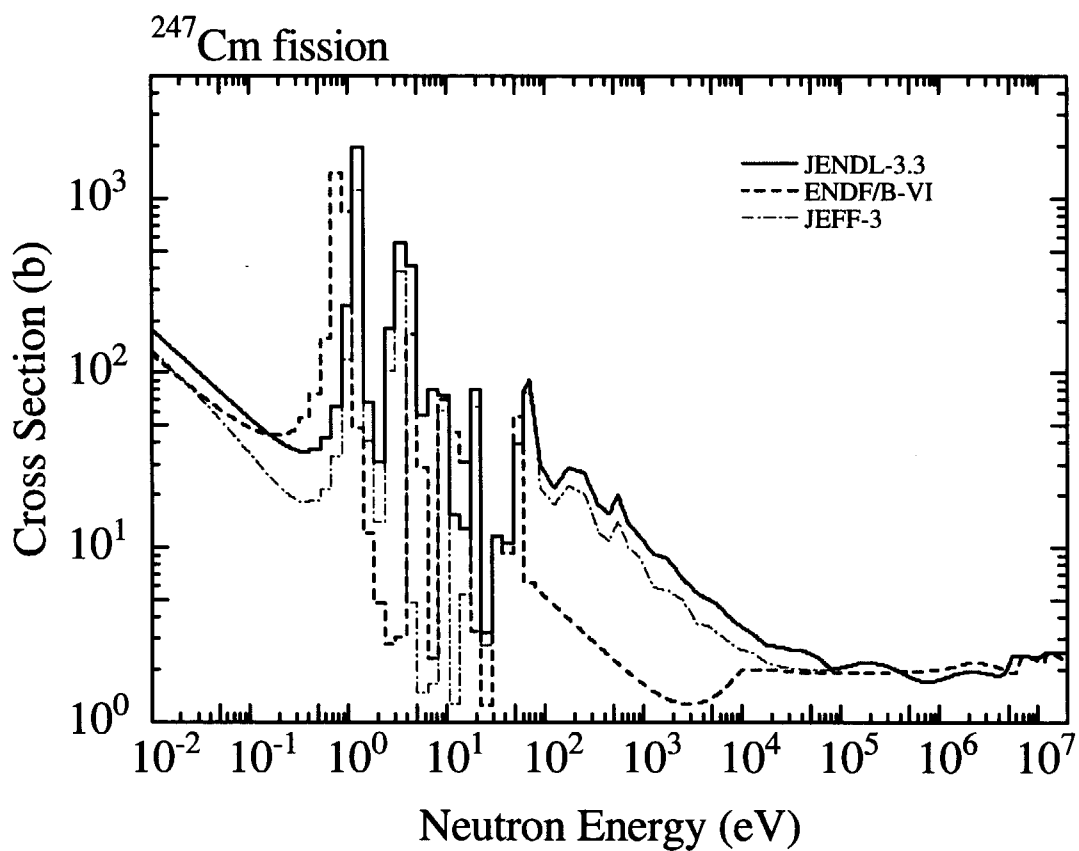


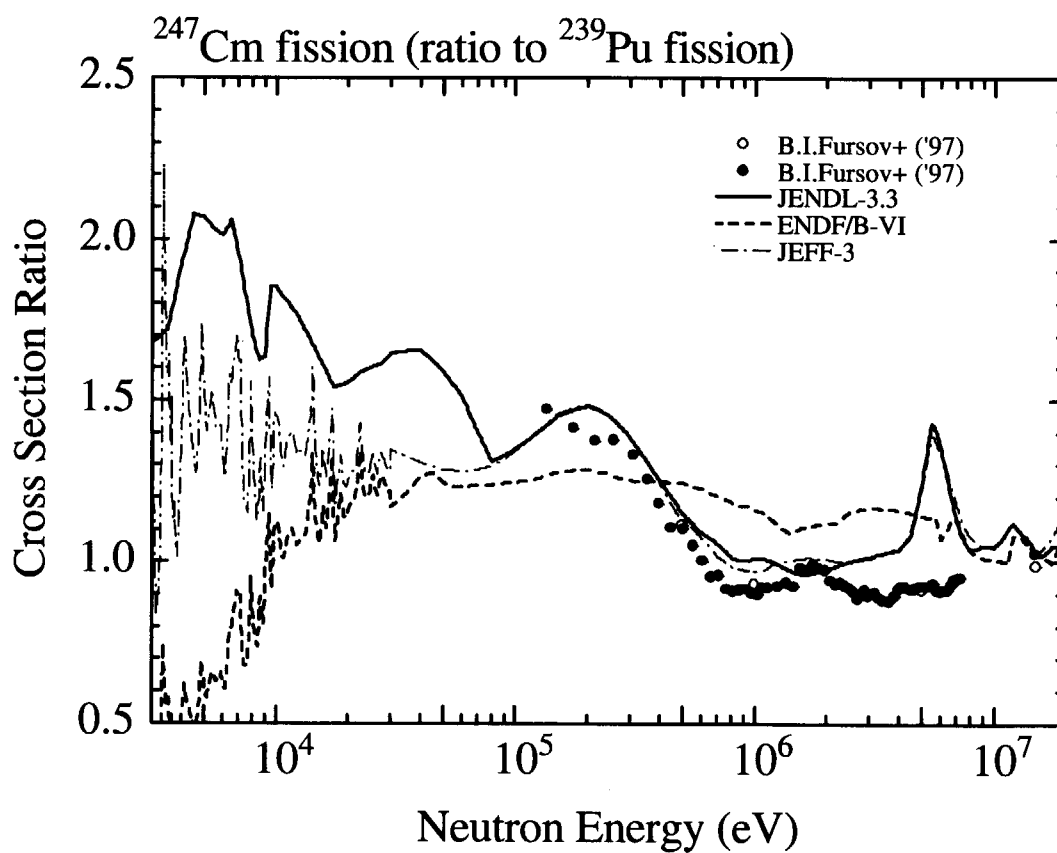
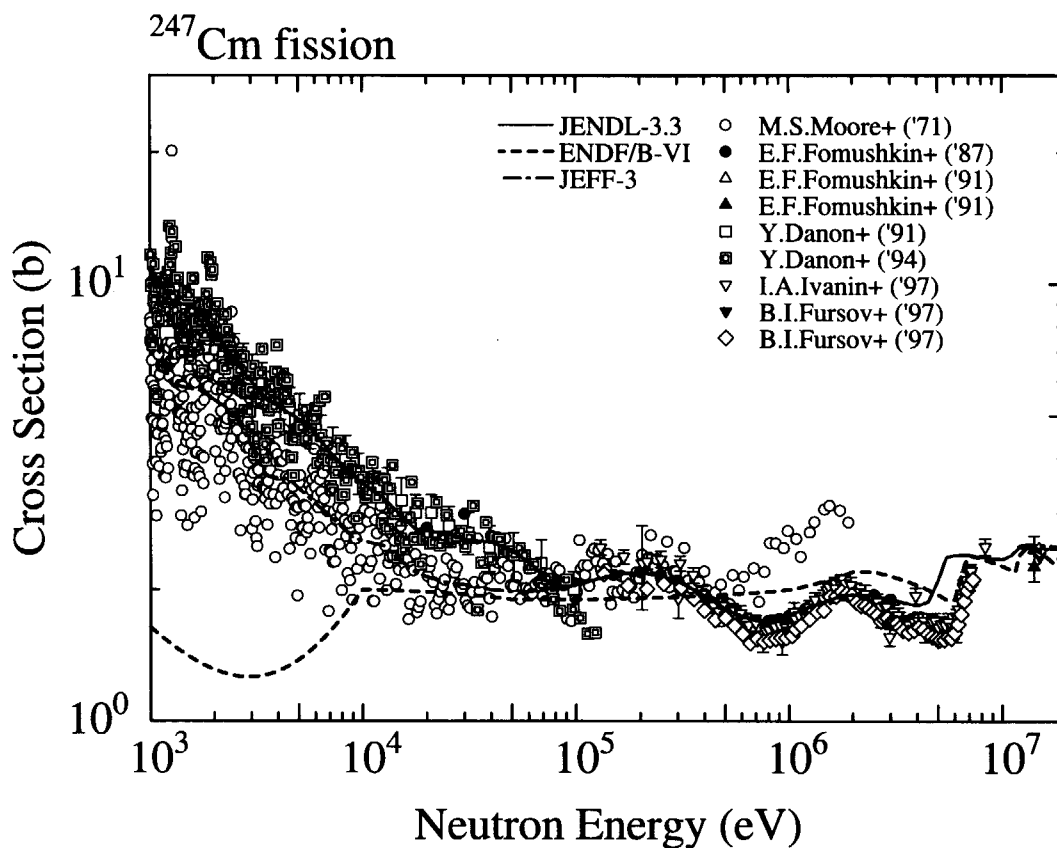


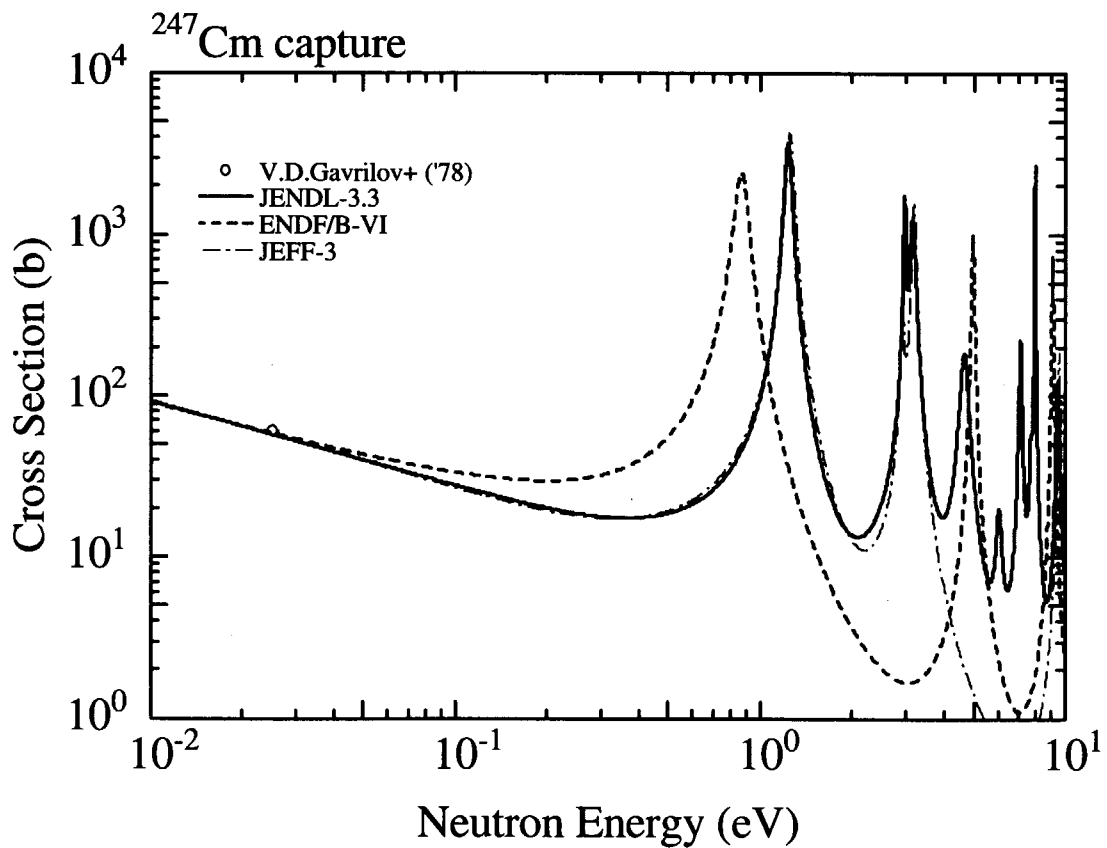
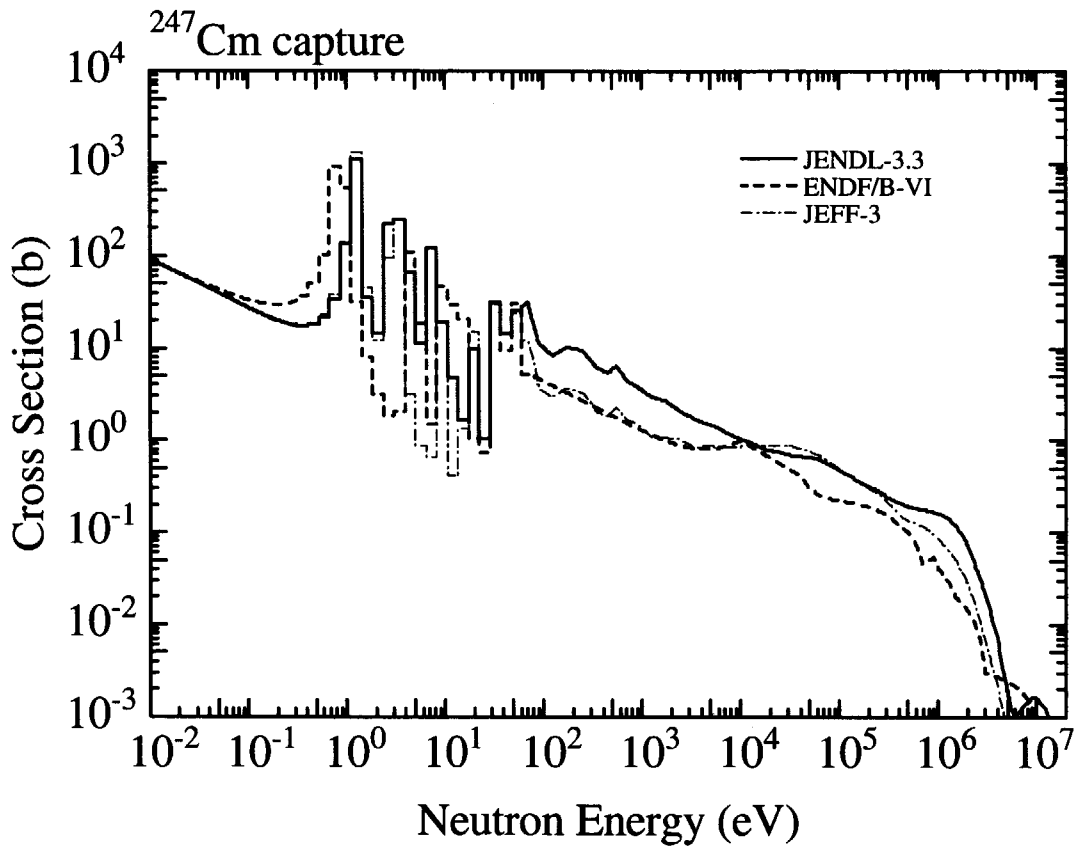


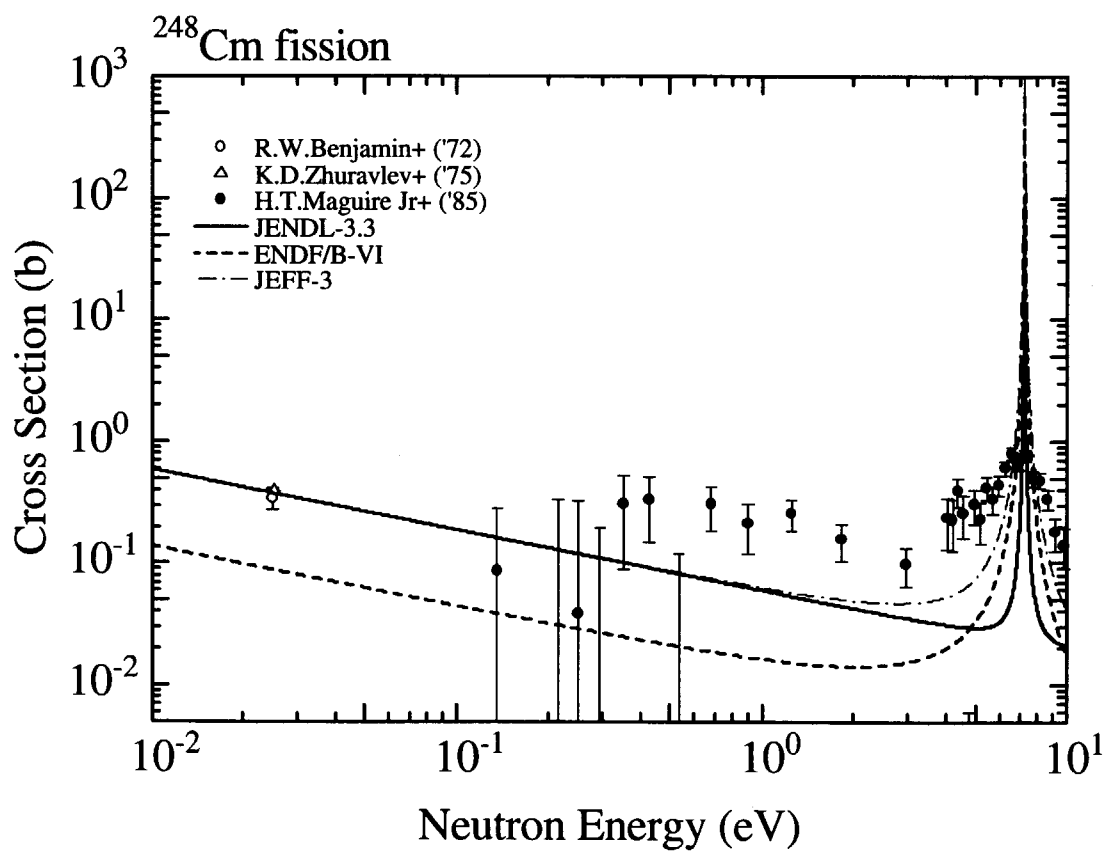
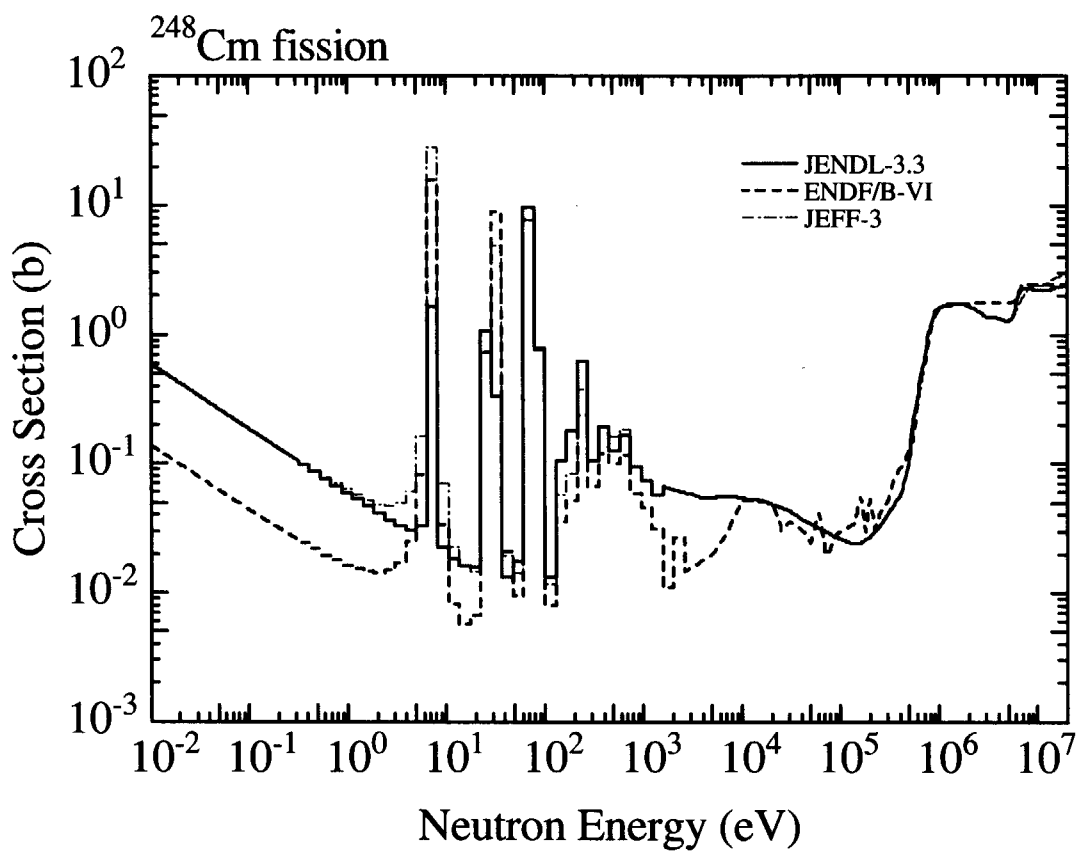


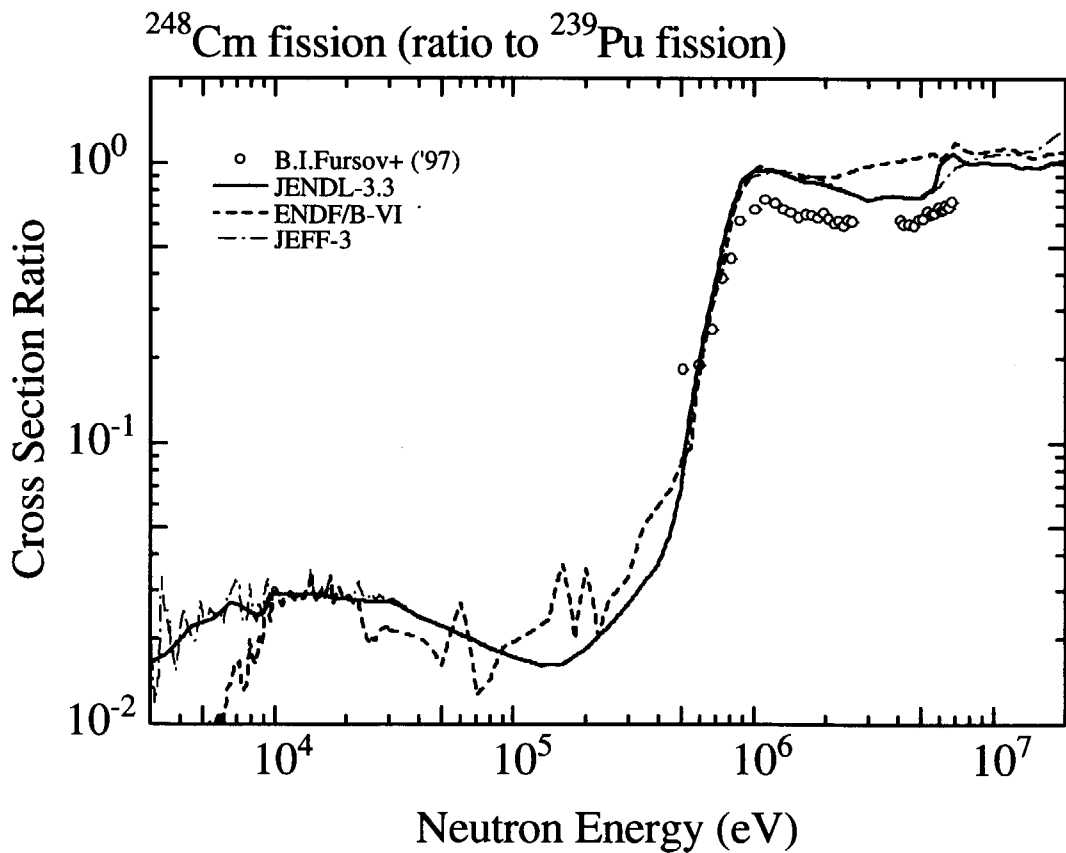
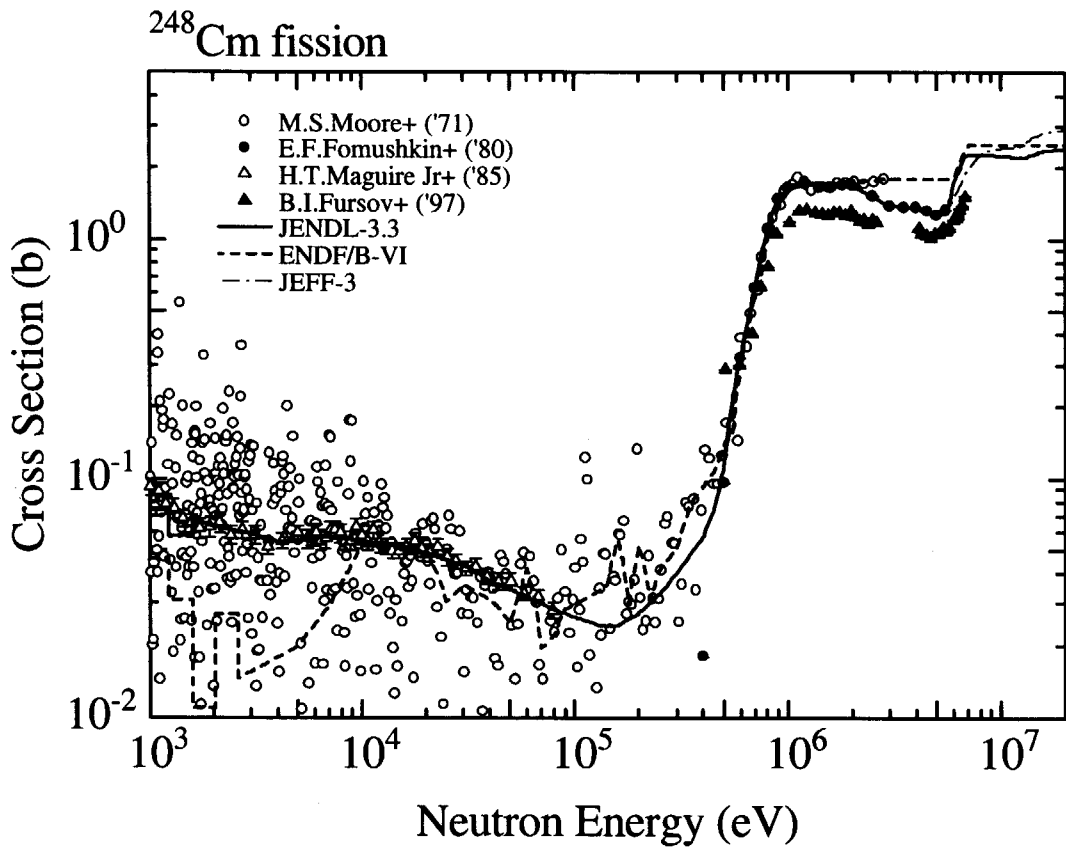


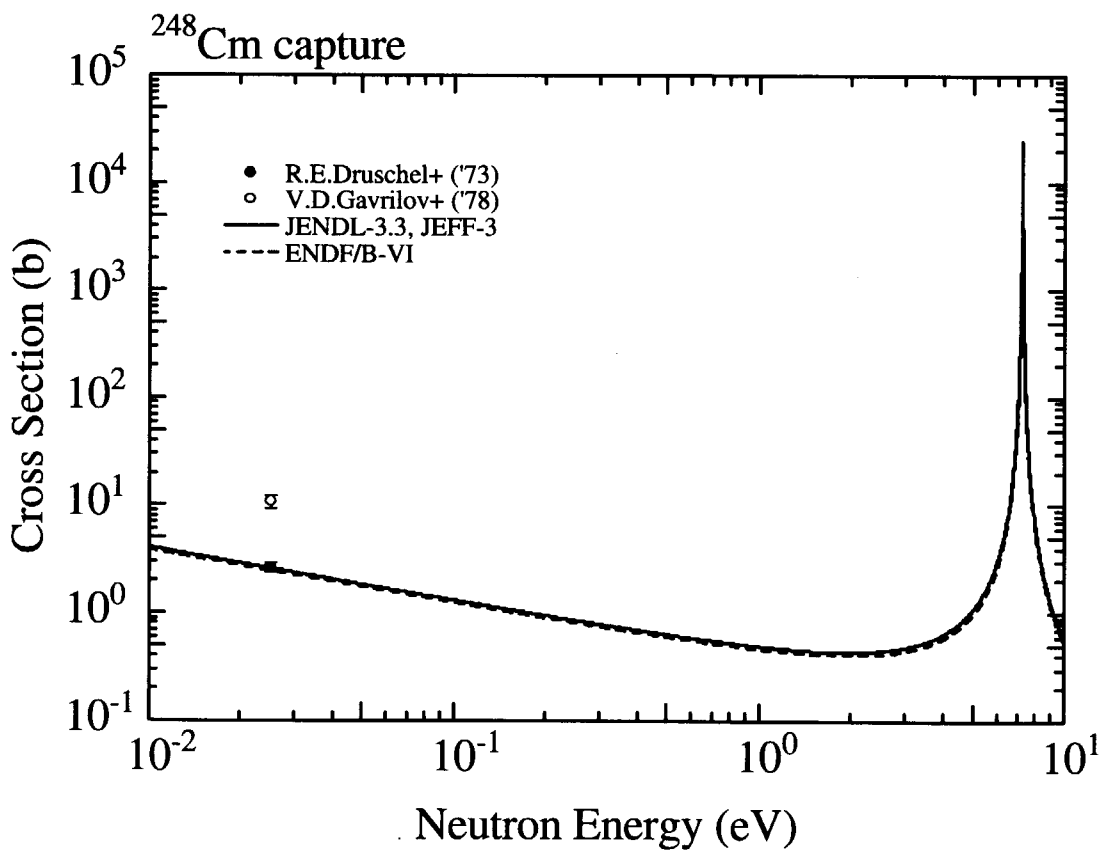
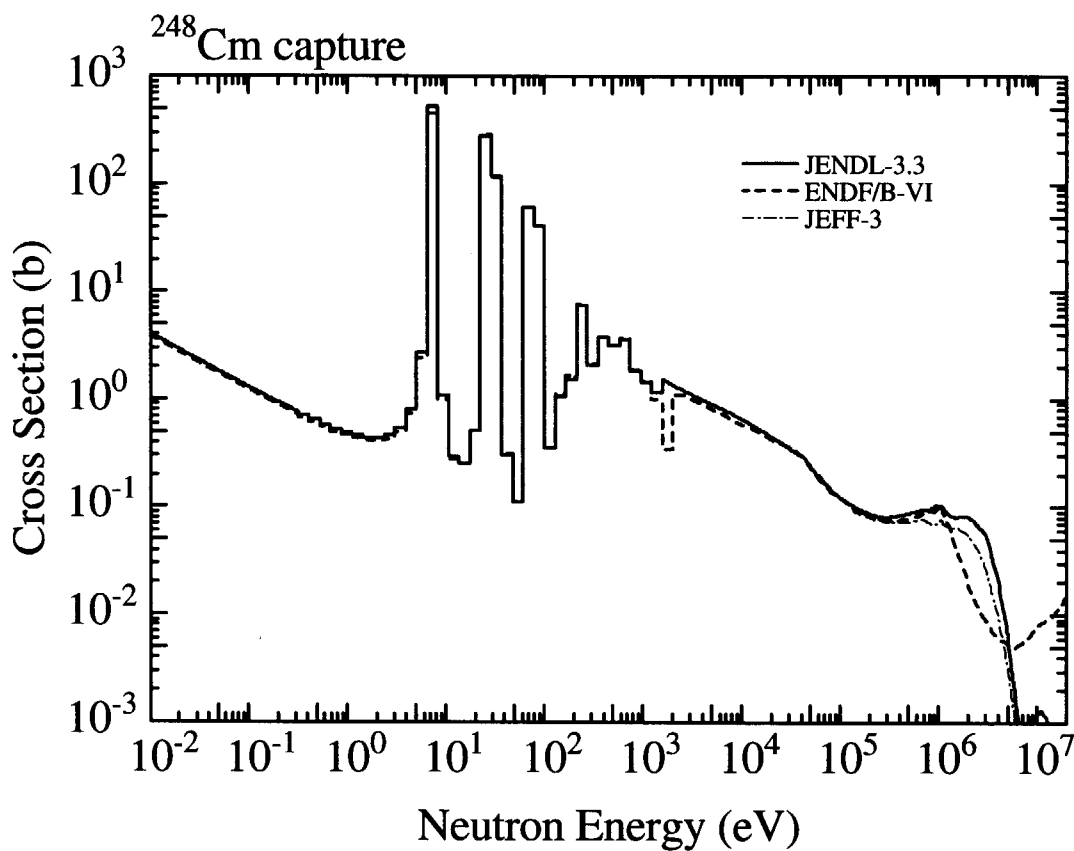












3. Graphs of Cross Sections Measured with Lead Slowing Down Spectrometers

The evaluated data are compared with experimental data obtained with lead slowing down spectrometers. The following experimental data are shown in figures:

Alam et al. ⁸⁾	²³⁸ Pu fission, ²⁴² Cm fission
Danon et al. ⁹⁾	²⁴⁷ Cm fission
Kai et al. ¹⁰⁾	^{242m} Am fission
Kobayashi et al. ¹¹⁾	²⁴³ Am fission
Kobayashi et al. ¹²⁾	²²⁹ Th fission, ²³¹ Pa fission
Kobayashi et al. ¹³⁾	²³⁷ Np capture
Maguire et al. ¹⁴⁾	²⁴⁴ Cm fission, ²⁴⁶ Cm fission, ²⁴⁸ Cm fission
Yamamoto et al. ¹⁵⁾	²⁴¹ Am fission
Yamanaka et al. ¹⁶⁾	²³⁷ Np fission

The evaluated data are broadened with experimental energy resolution. Resolution functions used in the present work are as follows:

1) For the measurements by Kobayashi et al.^{11,12,13)}, Kai et al.¹⁰⁾, Yamanaka et al.¹⁶⁾, Yamamoto et al.¹⁵⁾ at the Kyoto University:

$$\Delta E_{\text{FWHM}} = \frac{0.162899}{\sqrt{E}} + 0.352787 + 7.599 \times 10^{-5} E$$

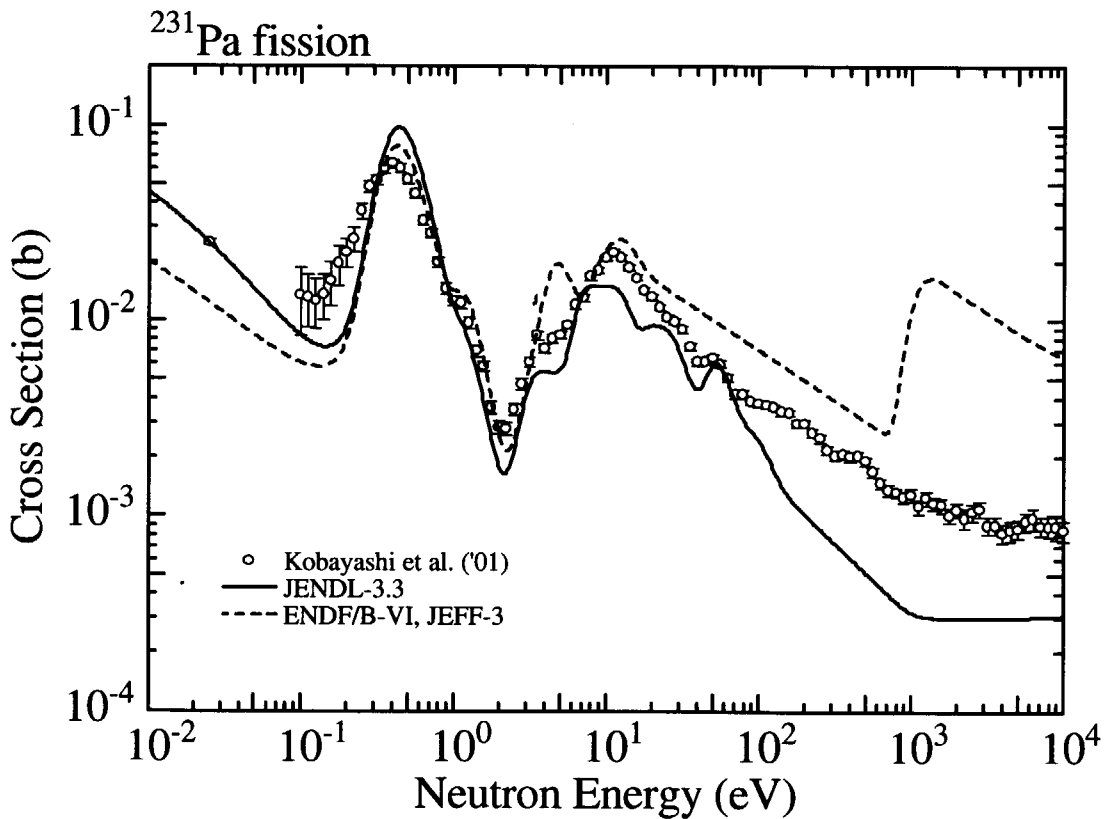
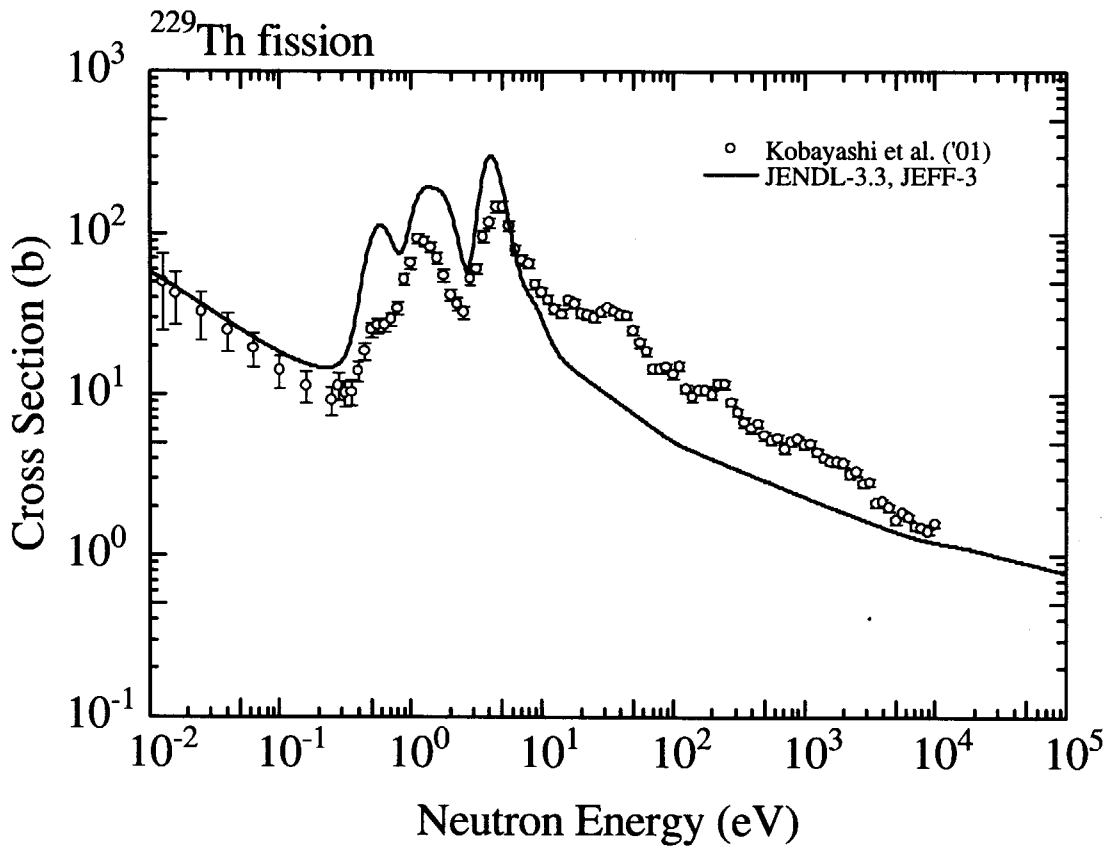
2) For the measurements by Danon et al.⁹⁾ at the Rensselaer Polytechnic Institute:

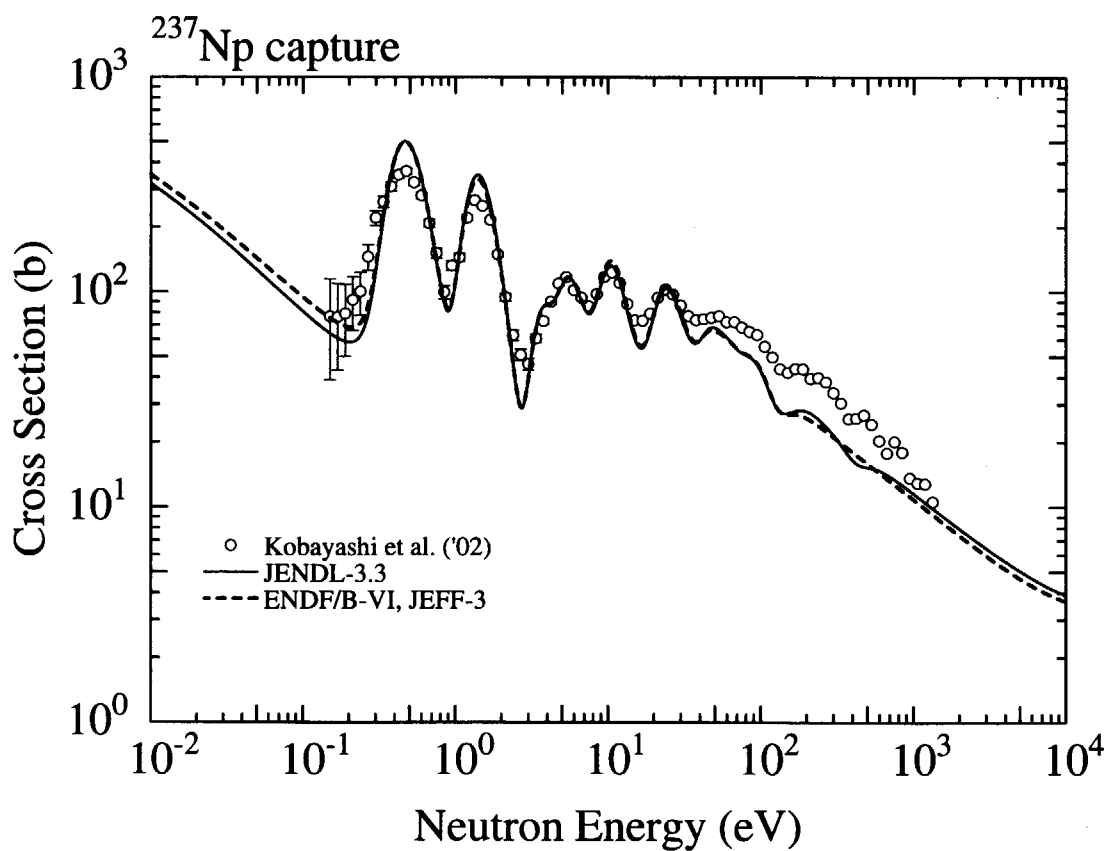
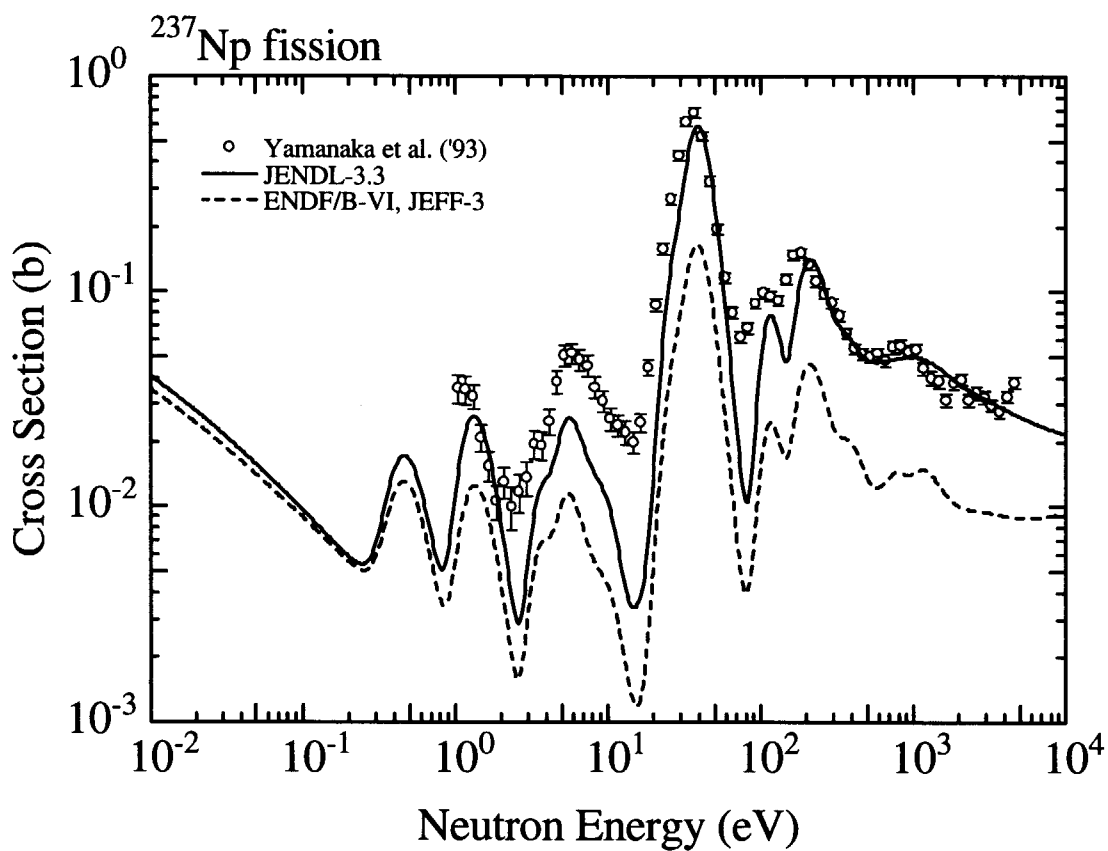
$$\Delta E_{\text{FWHM}} = E \times \left(0.0835 + \frac{0.128}{E} + 3.05 \times 10^{-5} E \right)^{1/2}$$

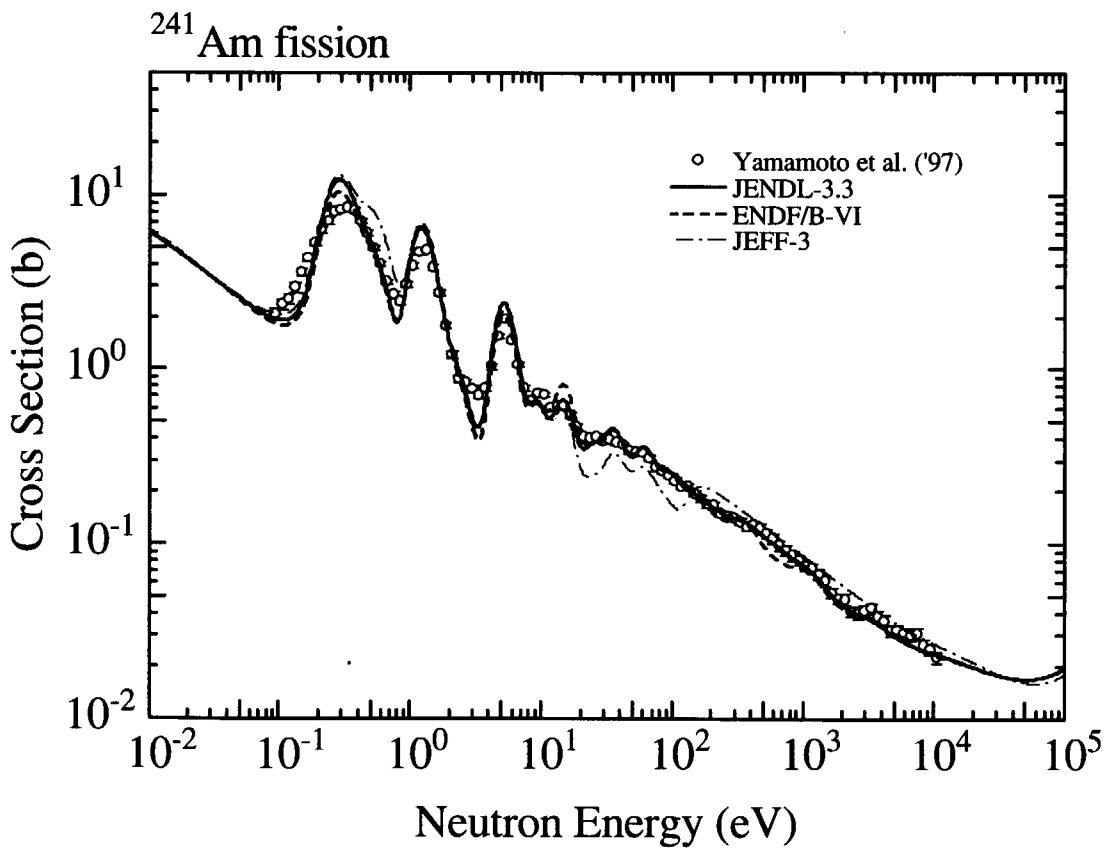
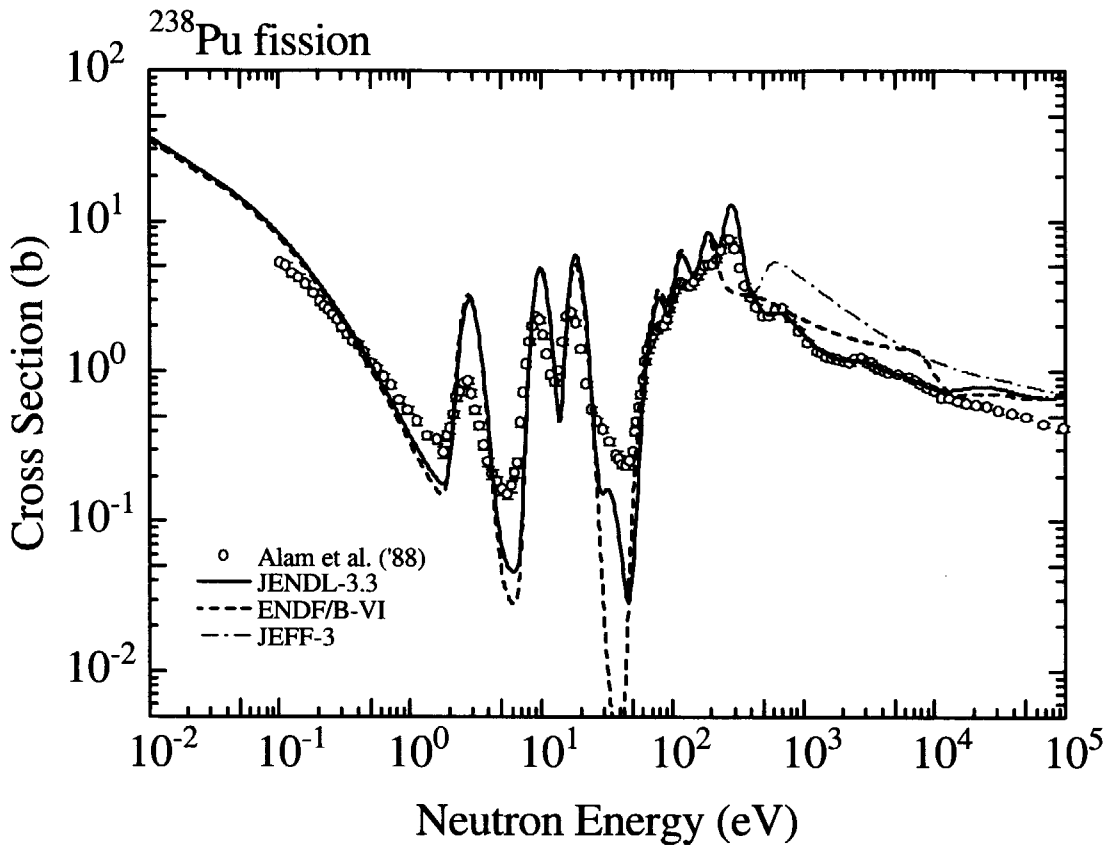
3) For the measurements by Maguire et al.¹⁴⁾, Alam et al.⁸⁾ at the Rensselaer Polytechnic Institute:

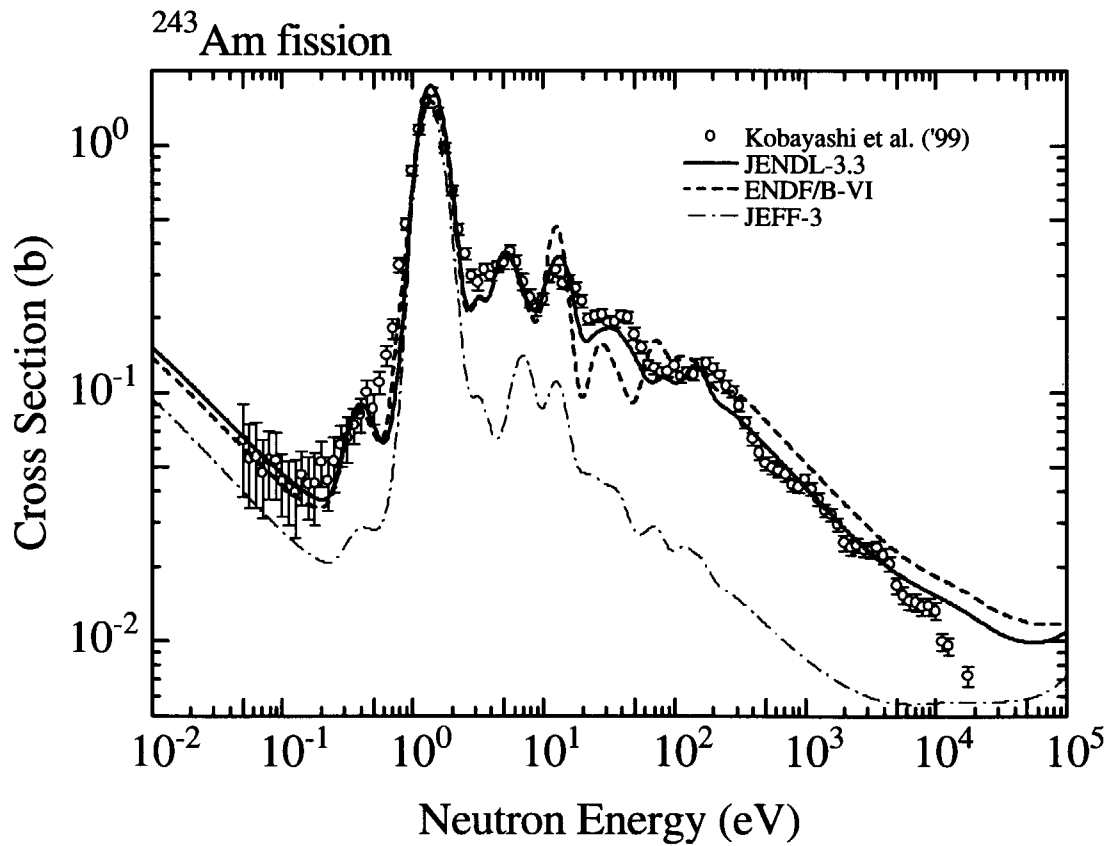
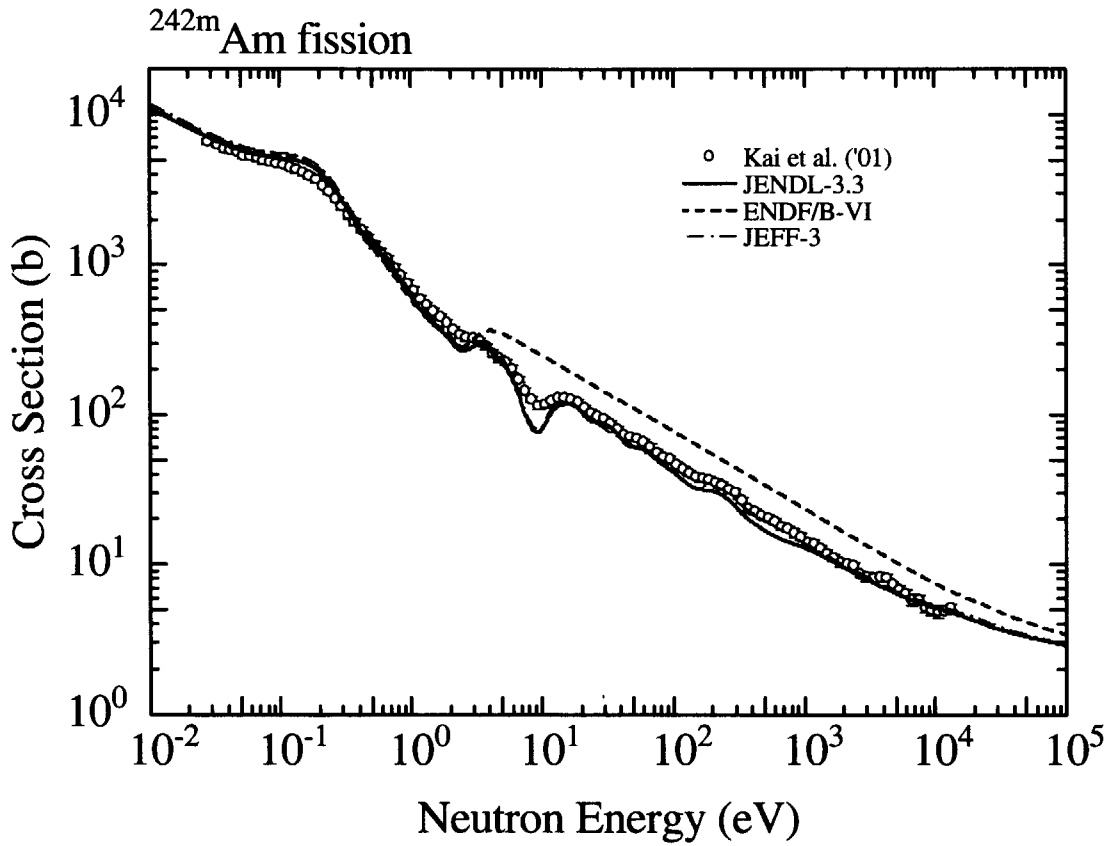
$$\Delta E_{\text{FWHM}} = E \times \left(0.0746 + \frac{0.130}{E} + 2.52 \times 10^{-5} E \right)^{1/2}$$

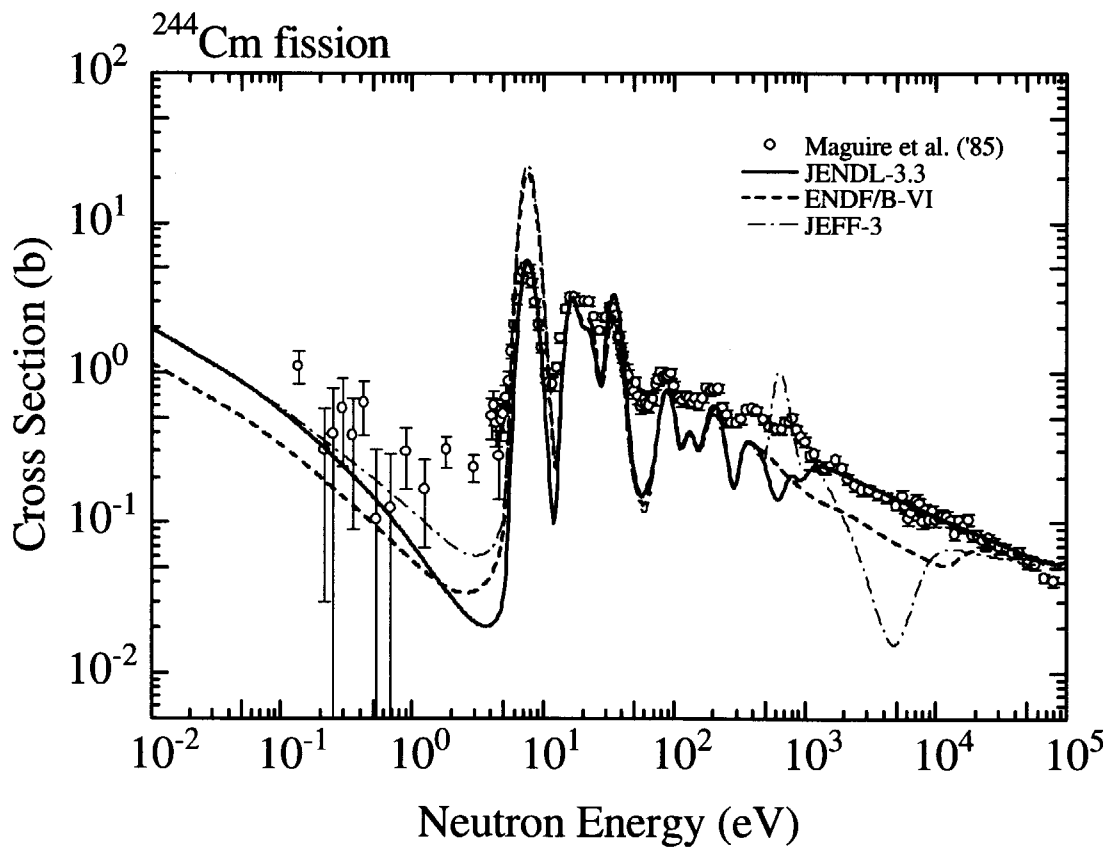
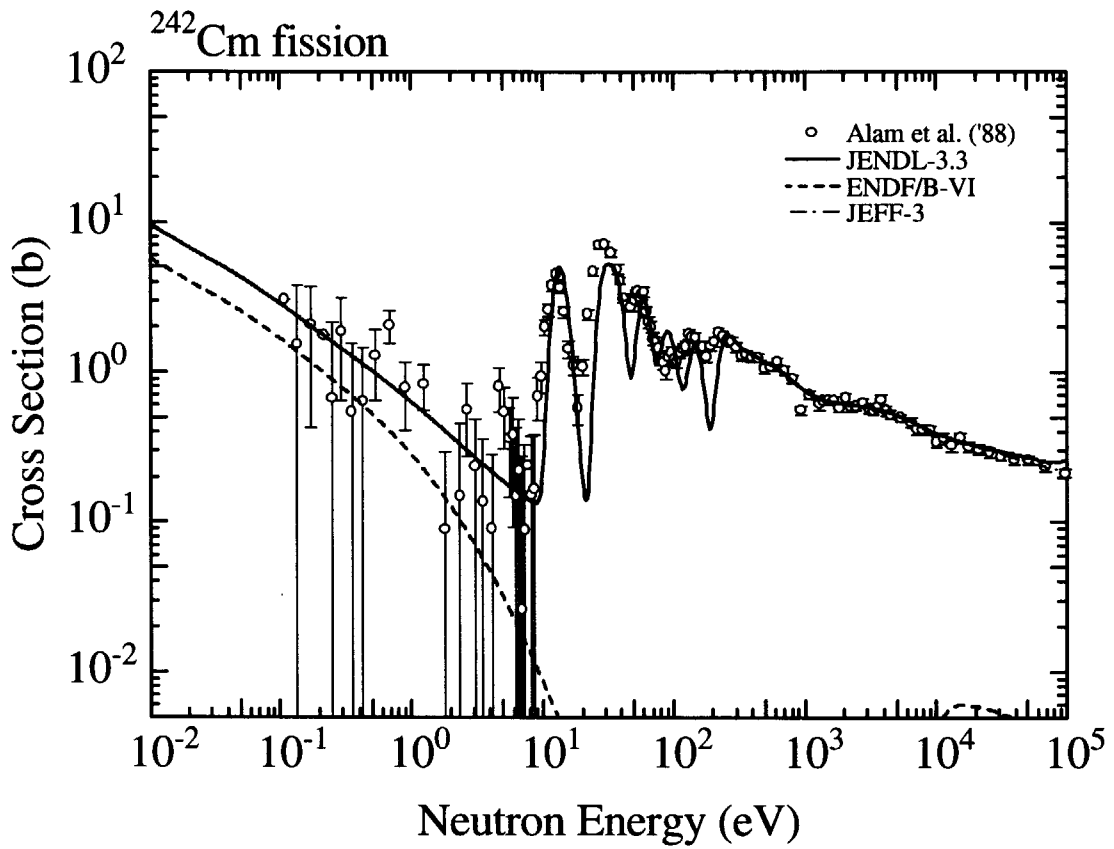
The unit of energy E in the above functions is eV. The shape of resolution function is assumed to be Gaussian type. The above functions give very large values near to the lower and upper boundaries (0.1 eV and 10 keV). When the Gaussian width ($=\Delta E_{\text{FWHM}} \times 0.42466$) is larger than the neutron energy, it is assumed to be the same as the neutron energy.

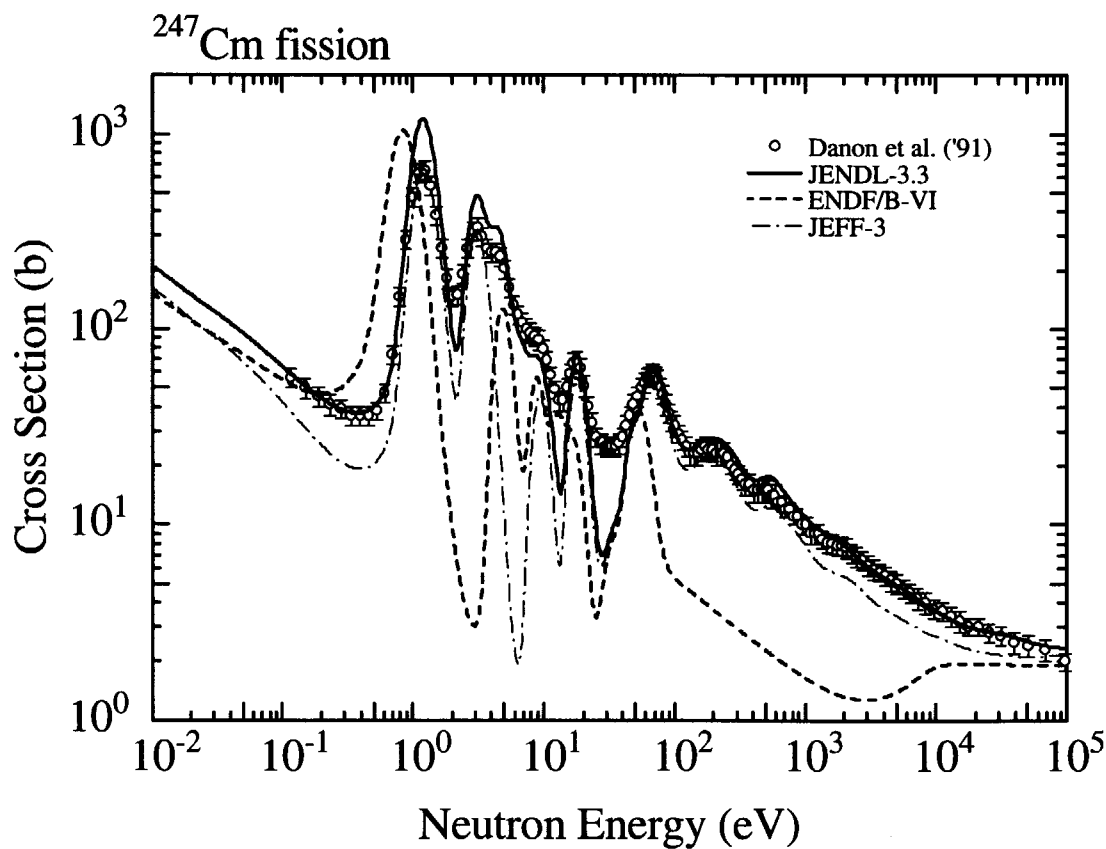
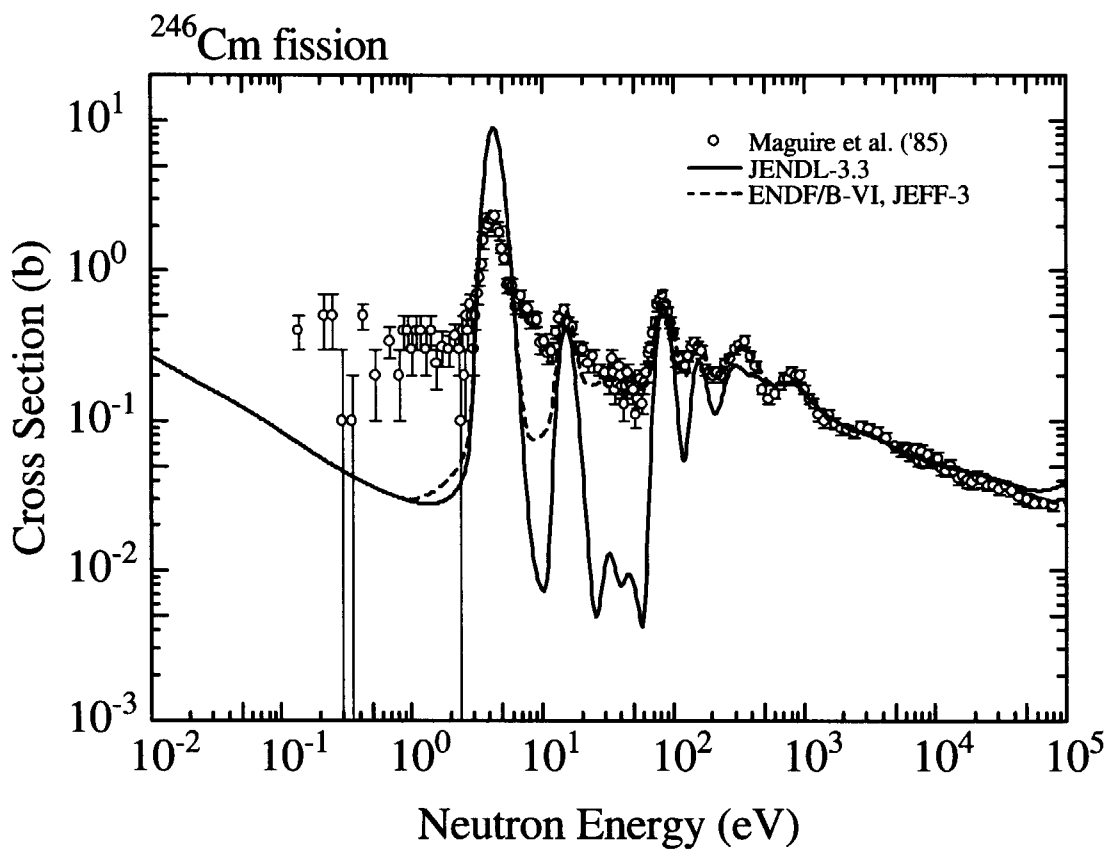


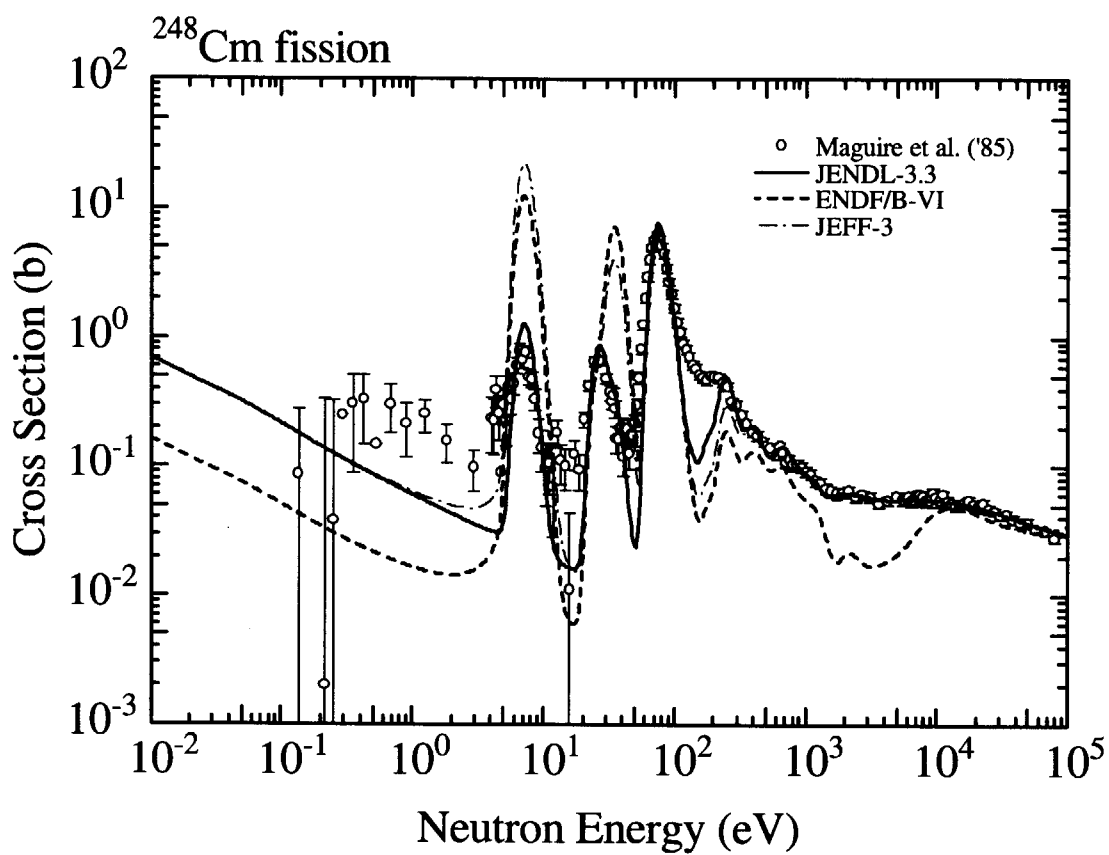












4. Thermal Cross Sections and Resonance Integrals

The fission and capture cross sections at the neutron energy of 0.0253 eV are listed in Table 4.1. The point-wise cross sections of evaluated data were calculated with the LINEAR and RECENT codes of PREPRO2000¹⁷⁾ allowing an interpolation error of 0.1 %. The evaluated data are compared with recommendation by Mughabghab¹⁸⁾, and with experimental data stored in the EXFOR database. In the table, Maxwellian spectrum average data which have an EXFOR flag of "MXW" are included, but average data in a reactor spectrum with a flag of "SPA" are excluded. Ratio data to other reaction cross sections are also excluded from the table. References of the experimental data are found in Tables 2.1 to 2.31 given in Chapter 2.

The resonance integrals of fission and capture cross sections are given in Table 4.2. Those of evaluated data were calculated in the energy range from 0.5 eV to 20 MeV by using the above-mentioned point-wise cross-section data. For the experimental data, the energy range is shown in the table if available. References of the experimental data are listed in Table 4.3. When a single reference gives a couple of data because of various experimental conditions, they are listed with the same reference name.

Table 4.1 Thermal cross sections

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag ^{*1)}	
²²⁷ Th	FIS	JENDL-3.3	202			
	FIS	JEFF-3	202			
	FIS	Mughabghab ('84)	202	13		
	FIS	H.R.Von Gunten+ ('70)	200	20		
	FIS	P.Del Marmol+ ('73)	203	16		
	CAP	JENDL-3.3	1535			
	CAP	JEFF-3	1535			
	²²⁸ Th	FIS	JENDL-3.3	0.3		
		FIS	JEFF-3	0.3		
		FIS	Mughabghab ('84)	< 0.3		
CAP		JENDL-3.3	119.86			
CAP		JEFF-3	119.86			
CAP		Mughabghab ('84)	123			
²²⁹ Th		FIS	JENDL-3.3	30.807		
	FIS	JEFF-3	30.807			
	FIS	Mughabghab ('84)	30.8	1.5		
	FIS	M.H.Studier+ ('47)	45	11	MX	
	FIS	J.E.Gindler+ ('60)	30.4	3.0	MX	
	FIS	J.E.Gindler+ ('60)	30.6	3.0	MX	
	CAP	JENDL-3.3	63.337			
	CAP	JEFF-3	63.337			
	CAP	Mughabghab ('84)	61	6		
	ABS	Mughabghab ('84)	92	6		
	²³⁰ Th	FIS	JENDL-3.3	0		
		FIS	ENDF/B-VI	0		
		FIS	JEFF-3	0		
FIS		Mughabghab ('84)	< 0.0012			
CAP		JENDL-3.3	22.548			
CAP		ENDF/B-VI	23.078			
CAP		JEFF-3	23.078			
CAP		Mughabghab ('84)	23.0	0.3		
CAP		E.K.Hyde ('48)	28			
CAP		H.Pomerance ('53)	26	2	MX	
CAP		M.J.Cabell ('58)	22.7	0.6		

*1) MX: Maxwellian averaged cross section
MS+GS: sum of cross sections to ground and meta-stable states

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*	
²³³ Th	FIS	JENDL-3.3	15			
	FIS	JEFF-3	15			
	FIS	Mughabghab ('84)	15	2		
	CAP	JENDL-3.3	1450			
	CAP	JEFF-3	1450			
	CAP	Mughabghab ('84)	1500	100		
	CAP	F.J.Johnston+ ('60)	1450	100	MX	
	²³⁴ Th	FIS	JENDL-3.3	0		
FIS		JEFF-3	0			
FIS		Mughabghab ('84)	< 0.01			
CAP		JENDL-3.3	1.75			
CAP		JEFF-3	1.75			
CAP		Mughabghab ('84)	1.8	0.5		
²³¹ Pa		FIS	JENDL-3.3	0.019662		
		FIS	ENDF/B-VI	0.010385		
	FIS	JEFF-3	0.010385			
	FIS	Mughabghab ('84)	0.020	0.001		
	FIS	E.M.Gryntakis ('76)	0.006	0.001	MX	
	FIS	C.Wagemans+ ('77)	0.019	0.004	MX	
	FIS	C.Wagemans+ ('78)	0.020	0.001	MX	
	CAP	JENDL-3.3	200.71			
	CAP	ENDF/B-VI	226.92			
	CAP	JEFF-3	226.92			
	CAP	Mughabghab ('84)	200.6	2.3		
	CAP	R.R.Smith+ ('56)	200	15	MX	
	CAP	B.M.Aleksandrov+ ('72)	260	13		
	CAP	E.M.Gryntakis+ ('74)	201	22	MX	
	CAP	E.M.Gryntakis+ ('74)	218	14	MX	
	CAP	K.Kobayashi ('74)	201	6	MX	
²³² Pa	FIS	JENDL-3.3	700			
	FIS	ENDF/B-VI	1516.5			
	FIS	Mughabghab ('84)	700	100		
	FIS	S.Abramovich+ ('95)	2000			
	FIS	E.F.Fomushkin+ ('97)	977	75	MX	
	CAP	JENDL-3.3	464			
	CAP	ENDF/B-VI	211.94			
	CAP	Mughabghab ('84)	464	95		
	CAP	E.M.Gryntakis ('76)	464	95	MX	

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*	
²³³ Pa	FIS	JENDL-3.3	0			
	FIS	ENDF/B-VI	0			
	FIS	JEFF-3	0			
	FIS	Mughabghab ('84)	< 0.1			
	CAP	JENDL-3.3	40.029			
	CAP	ENDF/B-VI	41.459			
	CAP	JEFF-3	41.459			
	CAP	Mughabghab ('84)	39.5	1.2		
	CAP	R.R.Smith+ ('55)	68	6	MX	
	CAP	J.Halperin+ ('62)	42	5	MX	
	CAP	J.C.Connor ('70)	31.4	1.0	MX	
	CAP	J.C.Connor ('70)	39.5	1.2		
	²³² U	FIS	JENDL-3.3	76.659		
		FIS	ENDF/B-VI	76.765		
FIS		JEFF-3	77.093			
FIS		Mughabghab ('84)	76.8	4.8		
FIS		G.T.Seaborg+ ('46)	70	10	MX	
FIS		R.Elson+ ('53)	83	15	MX	
FIS		M.J.Cabell+ ('71)	75.2	4.7	MX	
FIS		E.M.Gryntakis ('76)	74	8	MX	
CAP		JENDL-3.3	74.881			
CAP		ENDF/B-VI	75.208			
CAP		JEFF-3	72.582			
CAP		Mughabghab ('84)	74.9	1.6		
CAP		J.Halperin+ ('65)	78	4	MX	
CAP		M.J.Cabell+ ('71)	73.1	1.5	MX	
ABS		Mughabghab ('84)	151.7	4.6		
²³⁴ U		FIS	JENDL-3.3	0.29854		
		FIS	ENDF/B-VI	0.4641		
		FIS	Mughabghab ('84)	< 0.65		
	CAP	JENDL-3.3	99.75			
	CAP	ENDF/B-VI	103.03			
	CAP	Mughabghab ('84)	99.8	1.3		
	CAP	H.Pomerance ('51)	88.0	6.2	MX	
	CAP	M.Lounsbury+ ('70)	95.6	2.1	MX	
	CAP	M.J.Cabell+ ('71)	100.5	1.3	MX	
	²³⁶ U	FIS	JENDL-3.3	0.061286		
		FIS	ENDF/B-VI	0.04709		

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*
²³⁶ U	FIS	JEFF-3	0.061286		
	FIS	Mughabghab ('84)	0.07		
	CAP	JENDL-3.3	5.2951		
	CAP	ENDF/B-VI	5.1319		
	CAP	JEFF-3	5.2951		
	CAP	Mughabghab ('84)	5.11	0.21	
	CAP	H.Pomerance ('51)	5.8	1.7	MX
	CAP	P.Hubert+ ('55)	24	7	
	CAP	B.V.Efimov+ ('56)	24.599	6	
	CAP	J.Halperin+ ('58)	6	1	MX
	CAP	M.J.Cabell+ ('58)	5.5	0.3	MX
	CAP	J.R.Berreth+ ('62)	5.4		MX
	CAP	N.P.Baumann+ ('68)	6	0.5	MX
	CAP	R.P.Schuman+ ('69)	5.4	1.5	MX
	CAP	A.D.Carlson ('70)	5.10	0.25	
	CAP	M.J.Cabell+ ('71)	8.47	4	MX
	CAP	A.N.Davletshin+ ('87)	5.09	0.1	
	CAP	P.N.Vorona+ ('87)	5.41	0.6	
²³⁷ U	FIS	JENDL-3.3	1.7023		
	FIS	ENDF/B-VI	2.0003		
	FIS	JEFF-3	1.7023		
	FIS	Mughabghab ('84)	< 0.35		
	FIS	G.A.Cowen+ ('55)	< 2		MX
	CAP	JENDL-3.3	452.35		
	CAP	ENDF/B-VI	475.98		
	CAP	JEFF-3	452.35		
	CAP	Mughabghab ('84)	443	167	
	²³⁶ Np	FIS	JENDL-3.3	2770	
FIS		ENDF/B-VI	3009.9		
FIS		JEFF-3	2770		
FIS		Mughabghab ('84)	2500	150	
FIS		A.H.Jaffey+ ('61)	2500	150	MX
FIS		G.V.Val'skiy+ ('87)	2770	260	
CAP		JENDL-3.3	701		
CAP		ENDF/B-VI	125.74		
CAP		JEFF-3	701		
²³⁷ Np		FIS	JENDL-3.3	0.020368	
	FIS	ENDF/B-VI	0.018		
	FIS	JEFF-3	0.018		

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*
²³⁷ Np	FIS	Mughabghab ('84)	0.0215	0.0024	
	FIS	C.Wagemans+ ('77)	0.020	0.004	MX
	FIS	V.V.Kozharin+ ('86)	0.020	0.001	
	CAP	JENDL-3.3	161.71		
	CAP	ENDF/B-VI	181.02		
	CAP	JEFF-3	181.02		
	CAP	Mughabghab ('84)	175.9	2.9	
	CAP	K.Kobayashi+ ('93)	158	3	
²³⁸ Np	FIS	JENDL-3.3	2070		
	FIS	ENDF/B-VI	2026.8		
	FIS	JEFF-3	2026.8		
	FIS	Mughabghab ('84)	2088	30	
	FIS	J.D.Spencer+ ('69)	2070	30	MX
	FIS	S.Abramovich+ ('95)	2110	740	
	FIS	E.F.Fomushkin+ ('97)	2110	75	
	CAP	JENDL-3.3	450.1		
	CAP	ENDF/B-VI	202.83		
	CAP	JEFF-3	202.82		
²³⁶ Pu	FIS	JENDL-3.3	164.8		
	FIS	ENDF/B-VI	164.8		
	FIS	JEFF-3	162.52		
	FIS	Mughabghab ('84)	170	35	
	FIS	J.E.Gindler+ ('59)	170	35	MX
	FIS	B.N.Belyaev+ ('90)	135	16	MX
	CAP	JENDL-3.3	31.222		
	CAP	ENDF/B-VI	31.222		
	CAP	JEFF-3	162.52		
²³⁷ Pu	FIS	JENDL-3.3	2455		
	FIS	ENDF/B-VI	2100		
	FIS	JEFF-3	2100		
	FIS	Mughabghab ('84)	2455	295	
	FIS	J.E.Gindler+ ('59)	2500	500	MX
	CAP	JENDL-3.3	500		
	CAP	ENDF/B-VI	540		
	CAP	JEFF-3	540		
²³⁸ Pu	FIS	JENDL-3.3	17.89		
	FIS	ENDF/B-VI	17.012		

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*	
²³⁸ Pu	FIS	JEFF-3	17.89			
	FIS	Mughabghab ('84)	17.9	0.4		
	FIS	G.C.Hanna+ ('51)	20		MX	
	FIS	E.K.Hulet+ ('57)	18.4	0.9	MX	
	FIS	T.A.Eastwood+ ('58)	17.1	0.4		
	FIS	V.S.Zenkevich+ ('90)	16.7	0.8	MX	
	CAP	JENDL-3.3	540.3			
	CAP	ENDF/B-VI	561.08			
	CAP	JEFF-3	540.3			
	CAP	Mughabghab ('84)	540	7		
	CAP	J.Butler+ ('57)	410	14	MX	
	²⁴² Pu	FIS	JENDL-3.3	0.0020994		
		FIS	ENDF/B-VI	0.0010423		
		FIS	JEFF-3	0.0025566		
FIS		Mughabghab ('84)	< 0.2			
FIS		T.A.Eastwood+ ('58)	0	0.2		
CAP		JENDL-3.3	18.758			
CAP		ENDF/B-VI	19.158			
CAP		JEFF-3	18.789			
CAP		Mughabghab ('84)	18.5	0.5		
CAP		J.Butler+ ('57)	18.6	0.8		
CAP		R.W.Durham+ ('70)	18.7	0.7	MX	
²⁴⁴ Pu		FIS	JENDL-3.3	0.0016851		
		FIS	ENDF/B-VI	0		
		FIS	JEFF-3	0		
	CAP	JENDL-3.3	1.6801			
	CAP	ENDF/B-VI	1.8297			
	CAP	JEFF-3	1.8297			
	CAP	Mughabghab ('84)	1.7	0.1		
	CAP	R.P.Schuman ('69)	1.6	0.3	MX	
	²⁴¹ Am	FIS	JENDL-3.3	3.1423		
		FIS	ENDF/B-VI	3.1384		
		FIS	JEFF-3	3.1806		
		FIS	Mughabghab ('84)	3.20	0.09	
		FIS	B.B.Cunningham+ ('51)	3.0	0.2	MX
		FIS	G.C.Hanna+ ('51)	3		MX
FIS		E.K.Hulet+ ('57)	3.13	0.15	MX	
FIS		M.Hyakutake ('66)	3.8	0.2	MX	
FIS		K.D.Zhuravlev+ ('75)	3.20	0.15	MX	

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*	
²⁴¹ Am	FIS	V.D.Gavrilov+ ('75)	2.80	0.25		
	FIS	J.W.T.Dabbs+ ('83)	3.06	0.19		
	FIS	K.Kobayashi+ ('96)	3.150	0.097	MX	
	CAP	JENDL-3.3	639.45			
	CAP	ENDF/B-VI	618.74			
	CAP	JEFF-3	616.44			
	CAP	Mughabghab ('84)	587	12		
	CAP	H.Pomerance ('55)	625	35	MX	
	CAP	R.M.Harbour+ ('73)	832	20	MS+GS	
	CAP	V.D.Gavrilov+ ('75)	853	52	MS+GS	
	CAP	S.M.Kalebin ('76)	624	20		
	CAP	N.Shinohara+ ('97)	854	58		
	²⁴² Am	FIS	JENDL-3.3	2093.2		
FIS		ENDF/B-VI	2268.8			
FIS		JEFF-3	2268.8			
FIS		Mughabghab ('84)	2100	200		
FIS		G.C.Hanna+ ('51)	3000		MX	
FIS		G.H.Higgins+ ('54)	2950		MX	
CAP		JENDL-3.3	218.83			
CAP		ENDF/B-VI	252.07			
CAP		JEFF-3	252.07			
^{242m} Am		FIS	JENDL-3.3	6390.2		
		FIS	ENDF/B-VI	6619.6		
		FIS	JEFF-3	6874.4		
		FIS	Mughabghab ('84)	6950	280	
	FIS	K.Street Jr+ ('52)	6000		MX	
	FIS	E.K.Hulet+ ('57)	6390	500	MX	
	FIS	K.Wolfsberg+ ('66)	7200	300	MX	
	FIS	K.D.Zhuravlev+ ('75)	6080		MX	
	FIS	J.W.T.Dabbs+ ('83)	6950	250		
	FIS	J.C.Browne+ ('84)	6328	320		
	FIS	T.Kai+ ('01)	5820	250		
	CAP	JENDL-3.3	1229.2			
	CAP	ENDF/B-VI	1342.4			
	CAP	JEFF-3	1806.2			
	CAP	Mughabghab ('84)	2000	600		
	²⁴³ Am	FIS	JENDL-3.3	0.0813		
FIS		ENDF/B-VI	0.073895			
FIS		JEFF-3	0.049559			

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*	
²⁴³ Am	FIS	Mughabghab ('84)	0.1983	0.0043		
	FIS	K.Street Jr+ ('52)	< 40		MX	
	FIS	E.K.Hulet+ ('57)	< 0.072		MX	
	FIS	V.D.Gavrilov+ ('75)	0.2	0.11		
	FIS	K.Kobayashi+ ('99)	0.0813	0.004	MX	
	CAP	JENDL-3.3	76.704			
	CAP	ENDF/B-VI	75.076			
	CAP	JEFF-3	75.942			
	CAP	Mughabghab ('84)	75.1	1.8		
	CAP	J.Butler+ ('57)	68.5	2	MX	
	CAP	M.A.Bak+ ('67)	73	6		
	CAP	R.L.Folger+ ('68)	78			
	CAP	V.D.Gavrilov+ ('75)	83	6		
	²⁴² Cm	FIS	JENDL-3.3	5.0635		
FIS		ENDF/B-VI	3.0198			
FIS		JEFF-3	5.0635			
FIS		Mughabghab ('84)	5			
FIS		G.C.Hanna+ ('51)	< 5		MX	
CAP		JENDL-3.3	15.897			
CAP		ENDF/B-VI	16.87			
CAP		JEFF-3	15.897			
CAP		Mughabghab ('84)	16	5		
²⁴³ Cm		FIS	JENDL-3.3	613.31		
		FIS	ENDF/B-VI	613.31		
	FIS	JEFF-3	617.42			
	FIS	Mughabghab ('84)	617	20		
	FIS	E.K.Hulet+ ('57)	690	50	MX	
	FIS	C.E.Bemis+ ('77)	579	31		
	FIS	C.E.Bemis+ ('77)	633.3	26.9	MX	
	FIS	K.D.Zhuravlev+ ('79)	672	60	MX	
	CAP	JENDL-3.3	130.52			
	CAP	ENDF/B-VI	130.52			
	CAP	JEFF-3	130.16			
	CAP	Mughabghab ('84)	130	10		
	CAP	C.E.Bemis+ ('77)	130.7	9.6		
	CAP	C.E.Bemis+ ('77)	137.4	9.6	MX	
ABS	Mughabghab ('84)	747	23			
²⁴⁴ Cm	FIS	JENDL-3.3	1.0374			

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*	
²⁴⁴ Cm	FIS	ENDF/B-VI	0.60361			
	FIS	JEFF-3	1.0304			
	FIS	Mughabghab ('84)	1.04	0.2		
	FIS	R.W.Benjamin+ ('72)	1.1	0.5		
	FIS	K.D.Zhuravlev+ ('75)	1		MX	
	CAP	JENDL-3.3	15.102			
	CAP	ENDF/B-VI	10.365			
	CAP	JEFF-3	14.41			
	CAP	Mughabghab ('84)	15.2	1.2		
	CAP	V.D.Gavrilov+ ('78)	15.2	1.2		
	²⁴⁵ Cm	FIS	JENDL-3.3	2142.4		
		FIS	ENDF/B-VI	2142.4		
		FIS	JEFF-3	2000.6		
FIS		Mughabghab ('84)	2145	58		
FIS		E.K.Hulet+ ('57)	1880	150	MX	
FIS		H.Diamond+ ('68)	2040	80	MX	
FIS		J.Halperin+ ('70)	1920	180		
FIS		R.W.Benjamin+ ('72)	2018	37		
FIS		K.D.Zhuravlev+ ('75)	2070		MX	
FIS		V.D.Gavrilov+ ('75)	1900	100		
FIS		J.C.Browne+ ('78)	2143	58		
CAP		JENDL-3.3	359.14			
CAP		ENDF/B-VI	359.14			
CAP		JEFF-3	346.35			
CAP		Mughabghab ('84)	369	17		
CAP		J.Halperin+ ('69)	340	20		
CAP		V.D.Gavrilov+ ('78)	350	18		
ABS		Mughabghab ('84)	2514	60		
²⁴⁶ Cm		FIS	JENDL-3.3	0.14418		
	FIS	ENDF/B-VI	0.14418			
	FIS	JEFF-3	0.14418			
	FIS	Mughabghab ('84)	0.14	0.05		
	FIS	R.W.Benjamin+ ('72)	0.17	0.1		
	FIS	K.D.Zhuravlev+ ('75)	0.14		MX	
	CAP	JENDL-3.3	1.311			
	CAP	ENDF/B-VI	1.311			
	CAP	JEFF-3	1.311			
	CAP	Mughabghab ('84)	1.22	0.16		
	CAP	J.Halperin+ ('69)	1.2	0.4		

Table 4.1 (continued)

Nuclide	Reac.	Library or reference	data (b)	error (b)	Flag*
²⁴⁶ Cm	CAP	V.D.Gavrilov+ ('78)	1.14	0.3	
²⁴⁷ Cm	FIS	JENDL-3.3	111.26		
	FIS	ENDF/B-VI	83.432		
	FIS	JEFF-3	81.789		
	FIS	Mughabghab ('84)	81.9	4.4	
	FIS	H.Diamond+ ('68)	108	5	MX
	FIS	K.D.Zhuravlev+ ('75)	80		MX
	FIS	J.Halperin+ ('70)	120	12	
	FIS	R.W.Benjamin+ ('72)	82	5	
	CAP	JENDL-3.3	56.915		
	CAP	ENDF/B-VI	58.169		
	CAP	JEFF-3	57.203		
	CAP	Mughabghab ('84)	57	10	
	CAP	V.D.Gavrilov+ ('78)	60		
	²⁴⁸ Cm	FIS	JENDL-3.3	0.37175	
FIS		ENDF/B-VI	0.08734		
FIS		JEFF-3	0.37		
FIS		Mughabghab ('84)	0.37	0.05	
FIS		R.W.Benjamin+ ('72)	0.34	0.07	
FIS		K.D.Zhuravlev+ ('75)	0.39		MX
CAP		JENDL-3.3	2.5702		
CAP		ENDF/B-VI	2.4441		
CAP		JEFF-3	2.5702		
CAP		Mughabghab ('84)	2.63	0.26	
CAP		R.E.Druschel+ ('73)	2.63	0.26	MX
CAP		V.D.Gavrilov+ ('78)	10.7	1.5	

Table 4.2 Resonance integrals

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)	
²²⁷ Th	FIS	JENDL-3.3	210			
	FIS	JEFF-3	210			
	CAP	JENDL-3.3	1420			
	CAP	JEFF-3	1420			
²²⁸ Th	FIS	JENDL-3.3	1.02			
	FIS	JEFF-3	1.02			
	CAP	JENDL-3.3	1170			
	CAP	JEFF-3	1170			
	CAP	Mughabghab ('84)	1014			
	²²⁹ Th	FIS	JENDL-3.3	444		
FIS		JEFF-3	444			
FIS		Mughabghab ('84)	466	75		
CAP		JENDL-3.3	1240			
CAP		JEFF-3	1240			
CAP		Mughabghab ('84)	1000	175		
²³⁰ Th		FIS	JENDL-3.3	1.08		
		FIS	ENDF/B-VI	1.13		
	FIS	JEFF-3	1.13			
	CAP	JENDL-3.3	1040			
	CAP	ENDF/B-VI	851			
	CAP	JEFF-3	851			
	CAP	Mughabghab ('84)	1007	35		
	CAP	M.J.Cabell ('58)	996	40	0.5 eV	
	CAP	S.M.Kalebin+ ('68)	1035	85	1.431eV - 563 eV	
	CAP	L.N.Jurova+ ('84)	990	40		
²³³ Th	FIS	JENDL-3.3	11.1			
	FIS	JEFF-3	11.1			
	CAP	JENDL-3.3	643			
	CAP	JEFF-3	643			
	CAP	Mughabghab ('84)	400	100		
	CAP	F.J.Johnston+ ('60)	400	100	0.5 eV	
	²³⁴ Th	FIS	JENDL-3.3	0.26		
		FIS	JEFF-3	0.26		

Table 4.2 (continued)

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)
²³⁴ Th	CAP	JENDL-3.3	93.7		
	CAP	JEFF-3	93.7		
²³¹ Pa	FIS	JENDL-3.3	4.61		
	FIS	ENDF/B-VI	5.11		
	FIS	JEFF-3	5.11		
	FIS	E.M.Gryntakis ('76)	0.049	0.013	0.55 eV
	CAP	JENDL-3.3	594		
	CAP	ENDF/B-VI	596		
	CAP	JEFF-3	596		
	CAP	Mughabghab ('84)	525	60	
	CAP	B.M.Aleksandrov+ ('72)	1180	120	0.4 eV
	CAP	L.N.Jurova+ ('84)	1044	44	
	CAP	L.N.Jurova+ ('84)	1413	60	
²³² Pa	FIS	JENDL-3.3	313		
	FIS	ENDF/B-VI	869		
	FIS	E.F.Fomushkin+ ('97)	915	320	
	CAP	JENDL-3.3	309		
	CAP	ENDF/B-VI	147		
	CAP	Mughabghab ('84)	300	70	
	²³³ Pa	FIS	JENDL-3.3	2.11	
FIS		ENDF/B-VI	2.95		
FIS		JEFF-3	2.95		
FIS		Mughabghab ('84)	3		
CAP		JENDL-3.3	863		
CAP		ENDF/B-VI	856		
CAP		JEFF-3	855		
CAP		Mughabghab ('84)	860	35	
CAP		R.R.Smith+ ('55)	670		0.5 eV
CAP		J.Halperin+ ('62)	920	90	0.55 eV
CAP		J.C.Connor+ ('67)	842	45	0.5 eV
CAP		J.C.Connor ('70)	857	35	0.5 eV
CAP		L.N.Jurova+ ('84)	436	67	
²³² U		FIS	JENDL-3.3	364	
	FIS	ENDF/B-VI	384		
	FIS	JEFF-3	426		
	FIS	Mughabghab ('84)	350	30	
	FIS	E.M.Gryntakis ('76)	378	116	0.55 eV

Table 4.2 (continued)

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)
²³² U	CAP	JENDL-3.3	173		
	CAP	ENDF/B-VI	181		
	CAP	JEFF-3	317		
	CAP	Mughabghab ('84)	280	15	
	CAP	J.Halperin+ ('65)	280	15	0.5 eV
²³⁴ U	FIS	JENDL-3.3	6.75		
	FIS	ENDF/B-VI	6.54		
	FIS	Mughabghab ('84)	6.5		
	CAP	JENDL-3.3	631		
	CAP	ENDF/B-VI	660		
	CAP	Mughabghab ('84)	660	70	
	²³⁶ U	FIS	JENDL-3.3	7.76	
FIS		ENDF/B-VI	7.83		
FIS		JEFF-3	7.76		
FIS		Mughabghab ('84)	7.8	1.6	
CAP		JENDL-3.3	346		
CAP		ENDF/B-VI	342		
CAP		JEFF-3	346		
CAP		Mughabghab ('84)	360	15	
CAP		J.Halperin+ ('58)	450	30	0.5 eV
CAP		M.J.Cabell+ ('58)	257	22	0.5 eV
CAP		N.P.Baumann+ ('68)	417	25	0.5 eV
CAP		R.P.Schuman+ ('69)	381	20	0.5 eV
CAP		J.R.Berreth+ ('62)	381		0.5 eV
CAP	L.N.Jurova+ ('84)	340	15		
²³⁷ U	FIS	JENDL-3.3	48.6		
	FIS	ENDF/B-VI	9.21		
	FIS	JEFF-3	48.6		
	CAP	JENDL-3.3	1080		
	CAP	ENDF/B-VI	310		
	CAP	JEFF-3	1080		
	CAP	Mughabghab ('84)	1200	200	
²³⁶ Np	FIS	JENDL-3.3	1030		
	FIS	ENDF/B-VI	1360		
	FIS	JEFF-3	1030		
	FIS	G.V.Val'skiy+ ('87)	1040	60	
	CAP	JENDL-3.3	259		

Table 4.2 (continued)

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)	
²³⁶ Np	CAP	ENDF/B-VI	141			
	CAP	JEFF-3	259			
²³⁷ Np	FIS	JENDL-3.3	6.9			
	FIS	ENDF/B-VI	6.43			
	FIS	JEFF-3	6.43			
	FIS	Mughabghab ('84)	6.9	1.0		
	FIS	V.V.Kozharin+ ('86)	4.70	0.23	0.5 eV	
	CAP	JENDL-3.3	657			
	CAP	ENDF/B-VI	654			
	CAP	JEFF-3	654			
	CAP	Mughabghab ('84)	640	50		
	CAP	L.N.Jurova+ ('84)	730	30		
	CAP	L.N.Jurova+ ('84)	860	40		
	CAP	K.Kobayashi+ ('93)	652	24	0.5 eV	
	CAP	Yu.E.Titareenko+ ('99)	518	47	0.489 eV	
	CAP	Yu.E.Titareenko+ ('99)	549	50	0.489 eV	
	CAP	Yu.E.Titareenko+ ('99)	576	84	0.489 eV	
ABS	J.J.Scoville+ ('68)	900	30	0.5 eV		
²³⁸ Np	FIS	JENDL-3.3	940			
	FIS	ENDF/B-VI	897			
	FIS	JEFF-3	919			
	FIS	Mughabghab ('84)	883	70		
	FIS	J.D.Spencer+ ('69)	880	70	0.5 eV	
	FIS	S.Abramovich+ ('95)	905	48	0.45 eV	
	CAP	JENDL-3.3	201			
	CAP	ENDF/B-VI	100			
	CAP	JEFF-3	101			
	ABS	Mughabghab ('84)	1500	500		
	²³⁶ Pu	FIS	JENDL-3.3	960		
		FIS	ENDF/B-VI	993		
FIS		JEFF-3	325			
FIS		P.E.Vorotnikov+ ('87)	1020	60	0.18 eV	
FIS		E.F.Gromova+ ('90)	970	60	0.45 eV	
FIS		E.F.Gromova+ ('90)	990	30	0.45 eV - 5.78 MeV	
CAP		JENDL-3.3	267			
CAP		ENDF/B-VI	286			
CAP		JEFF-3	313			

Table 4.2 (continued)

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)	
^{237}Pu	FIS	JENDL-3.3	816			
	FIS	ENDF/B-VI	1080			
	FIS	JEFF-3	1080			
	CAP	JENDL-3.3	142			
	CAP	ENDF/B-VI	190			
	CAP	JEFF-3	190			
^{238}Pu	FIS	JENDL-3.3	32.5			
	FIS	ENDF/B-VI	30.7			
	FIS	JEFF-3	37.3			
	FIS	Mughabghab ('84)	33	5		
	FIS	V.S.Zenkevich+ ('90)	26.3	1.5	0.5 eV	
	CAP	JENDL-3.3	152			
	CAP	ENDF/B-VI	152			
	CAP	JEFF-3	150			
	CAP	Mughabghab ('84)	162	15		
	CAP	J.Butler+ ('57)	3310	400	0.5 eV	
	^{242}Pu	FIS	JENDL-3.3	5.57		
		FIS	ENDF/B-VI	5.57		
FIS		JEFF-3	5.74			
FIS		Mughabghab ('84)	5	2		
CAP		JENDL-3.3	1130			
CAP		ENDF/B-VI	1270			
CAP		JEFF-3	1130			
CAP		Mughabghab ('84)	1115	40		
CAP		J.Butler+ ('57)	1275	30	0.5 eV	
ABS		R.L.Folger+ ('68)	1180		0.92 eV	
^{244}Pu		FIS	JENDL-3.3	5.07		
		FIS	ENDF/B-VI	4.73		
	FIS	JEFF-3	4.73			
	CAP	JENDL-3.3	50			
	CAP	ENDF/B-VI	105			
	CAP	JEFF-3	105			
	CAP	Mughabghab ('84)	40.6	2.9		
	CAP	R.P.Schuman ('69)	35	7	0.5 eV	
	^{241}Am	FIS	JENDL-3.3	14.8		
		FIS	ENDF/B-VI	14.9		

Table 4.2 (continued)

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)
²⁴¹ Am	FIS	JEFF-3	16.1		
	FIS	Mughabghab ('84)	14.4	1.0	
	FIS	M.A.Bak+ ('70)	21	2	
	FIS	K.D.Zhuravlev+ ('75)	27.7		
	FIS	V.D.Gavrilov+ ('75)	22.5	1.7	0.5 eV
	CAP	JENDL-3.3	1460		
	CAP	ENDF/B-VI	1390		
	CAP	JEFF-3	1450		
	CAP	Mughabghab ('84)	1425	100	
	CAP	N.Shinohara+ ('97)	1808	147	
²⁴² Am	FIS	JENDL-3.3	996		
	FIS	ENDF/B-VI	621		
	FIS	JEFF-3	621		
	FIS	M.A.Bak+ ('67)	2100	200	
	CAP	JENDL-3.3	187		
	CAP	ENDF/B-VI	72		
	CAP	JEFF-3	72		
	CAP	M.A.Bak+ ('67)	73	6	
^{242m} Am	FIS	JENDL-3.3	1540		
	FIS	ENDF/B-VI	1880		
	FIS	JEFF-3	1640		
	FIS	Mughabghab ('84)	1800	65	
	FIS	C.D.Bowman+ ('68)	1570	110	0.5 eV
	FIS	K.D.Zhuravlev+ ('75)	2260	200	
	FIS	J.W.T.Dabbs+ ('83)	1800	65	0.5 eV - 20 MeV
	FIS	J.C.Browne+ ('84)	1553	78	0.5 eV - 20 MeV
	CAP	JENDL-3.3	239		
	CAP	ENDF/B-VI	286		
CAP	JEFF-3	262			
²⁴³ Am	FIS	JENDL-3.3	7.54		
	FIS	ENDF/B-VI	7.55		
	FIS	JEFF-3	6.52		
	FIS	Mughabghab ('84)	9	1	
	FIS	K.D.Zhuravlev+ ('75)	9	1	
	FIS	V.D.Gavrilov+ ('75)	17.1	1.3	0.5 eV
	FIS	H.Knitter+ ('88)	3.05	0.15	0.5 eV - 30 keV
	FIS	H.Knitter+ ('88)	3.8	0.2	800 keV - 10 MeV
	FIS	H.Knitter+ ('88)	5.4	0.3	800 keV - 20 MeV

Table 4.2 (continued)

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)	
²⁴³ Am	CAP	JENDL-3.3	1790			
	CAP	ENDF/B-VI	1820			
	CAP	JEFF-3	1810			
	CAP	Mughabghab ('84)	1820	70		
	CAP	J.Butler+ ('57)	2130	110	0.5 eV	
	CAP	M.A.Bak+ ('67)	2300	200	0.4 eV	
	CAP	R.P.Schuman ('67)	2160		0.5 eV	
	CAP	R.L.Folger+ ('68)	2250		0.83 eV	
	CAP	O.D.Simpson+ ('74)	1825	80	0.532 eV	
	CAP	O.D.Simpson+ ('74)	1819	80	0.625 eV	
	CAP	V.D.Gavrilov+ ('75)	2200	150	0.5 eV	
	²⁴² Cm	FIS	JENDL-3.3	19.9		
FIS		ENDF/B-VI	6.25			
FIS		JEFF-3	19.0			
CAP		JENDL-3.3	107			
CAP		ENDF/B-VI	111			
CAP		JEFF-3	108			
CAP		Mughabghab ('84)	110	20		
²⁴³ Cm		FIS	JENDL-3.3	1540		
		FIS	ENDF/B-VI	1540		
		FIS	JEFF-3	1570		
	FIS	Mughabghab ('84)	1570	100		
	FIS	C.E.Bemis+ ('77)	1575	136	0.54 eV	
	FIS	K.D.Zhuravlev+ ('79)	1480	150	0.68 eV	
	CAP	JENDL-3.3	212			
	CAP	ENDF/B-VI	212			
	CAP	JEFF-3	198			
	CAP	Mughabghab ('84)	215	20		
	CAP	C.E.Bemis+ ('77)	214.4	20.3	0.54 eV	
	ABS	J.R.Berreth+ ('72)	2345	470	0.4 eV	
	²⁴⁴ Cm	FIS	JENDL-3.3	13.4		
FIS		ENDF/B-VI	18.7			
FIS		JEFF-3	19.8			
FIS		Mughabghab ('84)	12.5	2.5		
FIS		R.W.Benjamin+ ('72)	18	1	0.625 eV	
FIS		K.D.Zhuravlev+ ('75)	13.4	1.5		
CAP		JENDL-3.3	660			
CAP		ENDF/B-VI	594			

Table 4.2 (continued)

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)	
²⁴⁴ Cm	CAP	JEFF-3	634			
	CAP	Mughabghab ('84)	650	30		
	CAP	V.D.Gavrilov+ ('78)	626	53		
	ABS	R.L.Folger+ ('68)	700		0.83 eV	
	ABS	J.R.Berreth+ ('72)	605	40	0.4 eV	
	²⁴⁵ Cm	FIS	JENDL-3.3	804		
FIS		ENDF/B-VI	803			
FIS		JEFF-3	799			
FIS		Mughabghab ('84)	840	40		
FIS		J.Halperin+ ('70)	1140	100	0.54 eV	
FIS		R.W.Benjamin+ ('72)	772	40	0.625 eV	
FIS		K.D.Zhuravlev+ ('75)	805	80		
FIS		V.D.Gavrilov+ ('75)	850	60	0.5 eV	
CAP		JENDL-3.3	106			
CAP		ENDF/B-VI	106			
CAP		JEFF-3	110			
CAP		Mughabghab ('84)	101	8		
CAP		J.Halperin+ ('69)	101	8	0.54 eV	
CAP		V.D.Gavrilov+ ('78)	108	81		
ABS		R.L.Folger+ ('68)	260		0.83 eV	
ABS		J.R.Berreth+ ('72)	897	180	0.4 eV	
ABS		V.D.Gavrilov+ ('78)	900	70		
²⁴⁶ Cm		FIS	JENDL-3.3	10.4		
		FIS	ENDF/B-VI	10.3		
		FIS	JEFF-3	10.3		
	FIS	Mughabghab ('84)	10.2	0.4		
	FIS	R.W.Benjamin+ ('72)	10.0	0.4	0.625 eV	
	FIS	K.D.Zhuravlev+ ('75)	13.3	1.5		
	CAP	JENDL-3.3	115			
	CAP	ENDF/B-VI	115			
	CAP	JEFF-3	115			
	CAP	Mughabghab ('84)	121	7		
	CAP	J.Halperin+ ('69)	121	7	0.54 eV	
	CAP	V.D.Gavrilov+ ('78)	118	15		
	ABS	R.L.Folger+ ('68)	260		0.83 eV	
	²⁴⁷ Cm	FIS	JENDL-3.3	1120		
		FIS	ENDF/B-VI	751		

Table 4.2 (continued)

Nuclide	Reac.	Library or reference	data (b)	error(b)	cut-off energy (eV)	
²⁴⁷ Cm	FIS	JEFF-3	611			
	FIS	Mughabghab ('84)	760	50		
	FIS	J.Halperin+ ('70)	1060	110	0.54 eV	
	FIS	R.W.Benjamin+ ('72)	778	50	0.625 eV	
	FIS	K.D.Zhuravlev+ ('75)	730	70		
	FIS	Y.Danon+ ('94)	1091	80	0.5 eV	
	CAP	JENDL-3.3	573			
	CAP	ENDF/B-VI	492			
	CAP	JEFF-3	535			
	CAP	Mughabghab ('84)	530	30		
	CAP	V.D.Gavrilov+ ('78)	490			
	²⁴⁸ Cm	FIS	JENDL-3.3	10.0		
		FIS	ENDF/B-VI	15.4		
		FIS	JEFF-3	17.5		
FIS		Mughabghab ('84)	15			
FIS		R.W.Benjamin+ ('72)	13.2	0.8	0.625 eV	
FIS		K.D.Zhuravlev+ ('75)	13.1	1.5		
CAP		JENDL-3.3	267			
CAP		ENDF/B-VI	248			
CAP		JEFF-3	260			
CAP		Mughabghab ('84)	270	15		
CAP		A.Chetham-Strode+ ('65)	350	40	0.5 eV	
CAP		R.E.Druschel+ ('73)	267	27	0.5 eV	
CAP		V.D.Gavrilov+ ('78)	250	24		

Table 4.3 References of experimental data for resonance integrals

<u>Nuclide</u>	Reac.	First author (year)	Type	Reference	Year	Lab	Ent.#
<u>²³⁰Th</u>							
CAP		M.J.Cabell ('58)	J	CJP,36,989	1958	CRC	12297
CAP		S.M.Kalebin+ ('68)	J	AE,24,(3),243	1968	ITE	40093
CAP		L.N.Jurova+ ('84)	J	YK,1/55,3	1984	MIF	40579
<u>²³³Th</u>							
CAP		F.J.Johnston+ ('60)	J	JNE,11,95	1960	ORL	11739
<u>²³¹Pa</u>							
FIS		E.M.Gryntakis ('76)	T	(thesis)	1976	MUN	20625
CAP		B.M.Aleksandrov+ ('72)	J	AE,32,(2),178	1972	RI	40163
CAP		L.N.Jurova+ ('84)	J	YK,1/55,3	1984	MIF	40579
<u>²³²Pa</u>							
FIS		E.F.Fomushkin+ ('97)	C	97TRIEST,2,1353	1997	EPA	41341
<u>²³³Pa</u>							
CAP		R.R.Smith+ ('55)	R	IDO-16226	1955	MTR	12299
CAP		J.Halperin+ ('62)	R	ORNL-3320,1	1962	ORL	12302
CAP		J.C.Connor+ ('67)	J	NSE,29,408	1967	BET	12427
CAP		J.C.Connor ('70)	R	WAPD-TM-837	1970	BET	10083
<u>²³²U</u>							
FIS		E.M.Gryntakis ('76)	T	(thesis)	1976	MUN	20625
CAP		J.Halperin+ ('65)	J	NSE,21,257	1965	ORL	12374
<u>²³⁶U</u>							
CAP		J.Halperin+ ('58)	C	58GENEVA,16,64(1072)	1958	ORL	12447
CAP		M.J.Cabell+ ('58)	J	JNE,7,81	1958	CRC	12449
CAP		J.R.Berreth+ ('62)	P	WASH-1041,37	1962	MTR	12635
CAP		N.P.Baumann+ ('68)	J	NSE,32,265	1968	SRL	12466
CAP		R.P.Schuman+ ('69)	R	IN-1296	1969	MTR	11687
CAP		L.N.Jurova+ ('84)	J	YK,1/55,3	1984	MIF	40579
<u>²³⁶Np</u>							
FIS		G.V.Val'skiy+ ('87)	C	87KIEV,3,99	1987	KUR	40995
<u>²³⁷Np</u>							
FIS		V.V.Kozharin+ ('86)	J	AE,60,(6),419	1986	RI	40901
CAP		L.N.Jurova+ ('84)	J	YK,1/55,3	1984	MIF	40579
CAP		K.Kobayashi+ ('93)	S	JAERI-M-94-019,171	1993	KTO	22366
CAP		Yu.E.Titarenko+ ('99)	J	NSE,131,96	1999	ITE	41344
ABS		J.J.Scoville+ ('68)	R	IN-1195	1968	MTR	11820

Table 4.3 (continued)

<u>Nuclide</u>	Reac.	First author (year)	Type	Reference	Year	Lab	Ent.#
<u>²³⁸Np</u>							
FIS		J.D.Spencer+ ('69)	J	ANS,12,284	1969	SRL	12475
FIS		S.Abramovich+ ('95)	C	95OBNIN,,303	1995	EPA	41324
<u>²³⁶Pu</u>							
FIS		P.E.Vorotnikov+ ('87)	C	87KIEV,3,76	1987	KUR	40992
FIS		E.F.Gromova+ ('90)	J	AE,68,(3),193	1990	KUR	41064
<u>²³⁸Pu</u>							
FIS		V.S.Zenkevich+ ('90)	J	YK,,(4),6	1990	KUR	41091
CAP		J.Butler+ ('57)	J	CJP,35,147	1957	CRC	12481
<u>²⁴²Pu</u>							
CAP		J.Butler+ ('57)	J	CJP,35,147	1957	CRC	12481
ABS		R.L.Folger+ ('68)	C	68WASH,2,1279(H11)	1968	SRL	12534
<u>²⁴⁴Pu</u>							
CAP		R.P.Schuman ('69)	P	IN-1317,54	1969	MTR	12510
<u>²⁴¹Am</u>							
FIS		K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
FIS		M.A.Bak+ ('70)	J	AE,28,(4),359	1970	FTI	40349
FIS		V.D.Gavrilov+ ('75)	J	AE,41,185	1975	NIR	40467
CAP		N.Shinohara+ ('97)	R	NST,34,613	1997	JAE	-
<u>²⁴²Am</u>							
FIS		M.A.Bak+ ('67)	J	AE,23,(4),316	1967	RI	40062
CAP		M.A.Bak+ ('67)	J	AE,23,(4),316	1967	RI	40062
<u>^{242m}Am</u>							
FIS		C.D.Bowman+ ('68)	J	PR,166,1219	1968	LRL	12572
FIS		K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
FIS		J.W.T.Dabbs+ ('83)	J	NSE,84,1	1983	ORL	-
FIS		J.C.Browne+ ('84)	J	PR,C29,2188	1984	LRL	-
<u>²⁴³Am</u>							
FIS		K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
FIS		V.D.Gavrilov+ ('75)	J	AE,41,185	1975	NIR	40467
FIS		H.Knitter+ ('88)	J	NSE,99,1	1988	GEL	22032
CAP		J.Butler+ ('57)	J	CJP,35,147	1957	CRC	12481
CAP		M.A.Bak+ ('67)	J	AE,23,(4),316	1967	RI	40062
CAP		R.P.Schuman ('67)	R	IN-1126,19	1967	MTR	12577
CAP		R.L.Folger+ ('68)	C	68WASH,2,1279(H11)	1968	SRL	12534
CAP		O.D.Simpson+ ('74)	J	NSE,55,273	1974	ORL	10204

Table 4.3 (continued)

<u>Nuclide</u>		Type	Reference	Year	Lab	Ent.#
Reac.	First author (year)					
<u>²⁴³Am</u>						
CAP	V.D.Gavrilov+ ('75)	J	AE,41,185	1975	NIR	40467
<u>²⁴³Cm</u>						
FIS	C.E.Bemis+ ('77)	J	NSE,63,413	1977	ORL	10681
FIS	K.D.Zhuravlev+ ('79)	J	AE,47,(1),55	1979	NIR	40490
CAP	C.E.Bemis+ ('77)	J	NSE,63,413	1977	ORL	10681
ABS	J.R.Berreth+ ('72)	J	NSE,49,145	1972	MTR	10271
<u>²⁴⁴Cm</u>						
FIS	R.W.Benjamin+ ('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
CAP	V.D.Gavrilov+ ('78)	J	AE,44,(3),246	1978	NIR	40486
ABS	R.L.Folger+ ('68)	C	68WASH,2,1279(H11)	1968	SRL	12534
ABS	J.R.Berreth+ ('72)	J	NSE,49,145	1972	MTR	10271
<u>²⁴⁵Cm</u>						
FIS	J.Halperin+ ('70)	P	ORNL-4581,37	1970	ORL	10165
FIS	R.W.Benjamin+ ('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	V.D.Gavrilov+ ('75)	J	AE,41,185	1975	NIR	40467
CAP	J.Halperin+ ('69)	P	ORNL-4437	1969	ORL	10164
CAP	V.D.Gavrilov+ ('78)	J	AE,44,(3),246	1978	NIR	40486
ABS	R.L.Folger+ ('68)	C	68WASH,2,1279(H11)	1968	SRL	12534
ABS	J.R.Berreth+ ('72)	J	NSE,49,145	1972	MTR	10271
ABS	V.D.Gavrilov+ ('78)	J	AE,44,(3),246	1978	NIR	40486
<u>²⁴⁶Cm</u>						
FIS	R.W.Benjamin+ ('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
ABS	R.L.Folger+ ('68)	C	68WASH,2,1279(H11)	1968	SRL	12534
CAP	J.Halperin+ ('69)	P	ORNL-4437	1969	ORL	10164
CAP	V.D.Gavrilov+ ('78)	J	AE,44,(3),246	1978	NIR	40486
<u>²⁴⁷Cm</u>						
FIS	J.Halperin+ ('70)	P	ORNL-4581,37	1970	ORL	10165
FIS	R.W.Benjamin+ ('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
FIS	Y.Danon+ ('94)	C	94GATLIN,1,245	1994	LAS	13646
CAP	V.D.Gavrilov+ ('78)	J	AE,44,(3),246	1978	NIR	40486

Table 4.3 (continued)

Nuclide						
Reac.	First author (year)	Type	Reference	Year	Lab	Ent.#
²⁴⁸ Cm						
FIS	R.W.Benjamin+ ('72)	J	NSE,47,203	1972	SRL	10128
FIS	K.D.Zhuravlev+ ('75)	J	AE,39,(4),285	1975	NIR	40436
CAP	A.Chetham-Strode+ ('65)	P	ORNL-3832,1	1965	ORL	13014
CAP	R.E.Druschel+ ('73)	P	ORNL-4891,23	1973	ORL	13015
CAP	V.D.Gavrilov+ ('78)	J	AE,44,(3),246	1978	NIR	40486

5. Conclusions

The fission and capture cross sections of MA's given in JENDL-3.3, ENDF/B-VI and JEFF-3 were compared with each other and with experimental data. It was seen from the cross-section graphs that the data of JENDL-3.3 were not in good agreement with experimental data of the fission cross section of ^{228}Th , ^{229}Th , ^{230}Th , ^{232}U , ^{247}Cm in the smooth region, and those of ^{232}Pa , ^{236}Np , ^{238}Np fission cross section and ^{232}Pa capture cross section in the thermal and resonance region. From the comparison with the data of lead slowing-down spectrometers, discrepancies were found for the ^{229}Th fission, ^{231}Pa fission, ^{237}Np capture cross sections and fission cross section of Cm isotopes in the resonance region.

It should also be noted that the discrepancies among experimental data are quite large and available experimental data are old for several nuclides. In particular the capture cross section above the resonance region was not reported in the last one decade. Therefore, we can conclude that the re-evaluation of nuclear data is needed for the minor actinides mentioned above, and new measurements, especially for the capture cross section, should be performed to improve the nuclear data of MA's.

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国際単位系 (SI) と換算表

表1 SI基本単位および補助単位

量	名称	記号
長さ	メートル	m
質量	キログラム	kg
時間	秒	s
電流	アンペア	A
熱力学温度	ケルビン	K
物質質量	モル	mol
光度	カンデラ	cd
平面角	ラジアン	rad
立体角	ステラジアン	sr

表3 固有の名称をもつSI組立単位

量	名称	記号	他のSI単位による表現
周波数	ヘルツ	Hz	s ⁻¹
力	ニュートン	N	m·kg/s ²
圧力, 応力	パスカル	Pa	N/m ²
エネルギー, 仕事, 熱量	ジュール	J	N·m
工率, 放射束	ワット	W	J/s
電気量, 電荷	クーロン	C	A·s
電位, 電圧, 起電力	ボルト	V	W/A
静電容量	ファラド	F	C/V
電気抵抗	オーム	Ω	V/A
コンダクタンス	ジーメン	S	A/V
磁束	ウェーバ	Wb	V·s
磁束密度	テスラ	T	Wb/m ²
インダクタンス	ヘンリー	H	Wb/A
セルシウス温度	セルシウス度	°C	
光束	ルーメン	lm	cd·sr
照射線量	グレイ	Gy	J/kg
吸収線量	シーベルト	Sv	J/kg

表2 SIと併用される単位

名称	記号
分, 時, 日	min, h, d
度, 分, 秒	°, ', "
リットル	l, L
トン	t
電子ボルト	eV
原子質量単位	u

1 eV = 1.60218 × 10⁻¹⁹ J

1 u = 1.66054 × 10⁻²⁷ kg

表4 SIと共に暫定的に維持される単位

名称	記号
オングストローム	Å
バ	b
バール	bar
ガリ	Gal
キュリー	Ci
レントゲン	R
ラド	rad
レム	rem

1 Å = 0.1 nm = 10⁻¹⁰ m

1 b = 100 fm² = 10⁻²⁸ m²

1 bar = 0.1 MPa = 10⁵ Pa

1 Gal = 1 cm/s² = 10⁻² m/s²

1 Ci = 3.7 × 10¹⁰ Bq

1 R = 2.58 × 10⁻⁴ C/kg

1 rad = 1 cGy = 10⁻² Gy

1 rem = 1 cSv = 10⁻² Sv

表5 SI接頭語

倍数	接頭語	記号
10 ¹⁸	エクサ	E
10 ¹⁵	ペタ	P
10 ¹²	テラ	T
10 ⁹	ギガ	G
10 ⁶	メガ	M
10 ³	キロ	k
10 ²	ヘクト	h
10 ¹	デカ	da
10 ⁻¹	デシ	d
10 ⁻²	センチ	c
10 ⁻³	ミリ	m
10 ⁻⁶	マイクロ	μ
10 ⁻⁹	ナノ	n
10 ⁻¹²	ピコ	p
10 ⁻¹⁵	フェムト	f
10 ⁻¹⁸	アト	a

(注)

- 表1-5は「国際単位系」第5版, 国際度量衡局 1985年刊行による。ただし, 1 eV および 1 uの値は CODATA の1986年推奨値によった。
- 表4には海里, ノット, アール, ヘクトールも含まれているが日常の単位なのでここでは省略した。
- barは, JISでは流体の圧力を表わす場合に限り表2のカテゴリーに分類されている。
- EC閣僚理事会指令では bar, barn および「血圧の単位」 mmHgを表2のカテゴリーに入れている。

換算表

力	N (=10 ⁵ dyn)	kgf	lbf
	1	0.101972	0.224809
	9.80665	1	2.20462
	4.44822	0.453592	1

粘 度 1 Pa·s(N·s/m²) = 10 P(ポアズ)(g/(cm·s))

動粘度 1 m²/s = 10⁴ St(ストークス)(cm²/s)

圧	MPa (=10 bar)	kgf/cm ²	atm	mmHg(Torr)	lbf/in ² (psi)
	1	10.1972	9.86923	7.50062 × 10 ³	145.038
力	0.0980665	1	0.967841	735.559	14.2233
	0.101325	1.03323	1	760	14.6959
	1.33322 × 10 ⁻⁴	1.35951 × 10 ⁻³	1.31579 × 10 ⁻³	1	1.93368 × 10 ⁻²
	6.89476 × 10 ⁻³	7.03070 × 10 ⁻²	6.80460 × 10 ⁻²	51.7149	1

エネルギー・仕事・熱量	J (=10 ⁷ erg)	kgf·m	kW·h	cal(計量法)	Btu	ft·lbf	eV
	1	0.101972	2.77778 × 10 ⁻⁷	0.238889	9.47813 × 10 ⁻⁴	0.737562	6.24150 × 10 ¹⁸
	9.80665	1	2.72407 × 10 ⁻⁶	2.34270	9.29487 × 10 ⁻³	7.23301	6.12082 × 10 ¹⁹
	3.6 × 10 ⁶	3.67098 × 10 ⁵	1	8.59999 × 10 ⁵	3412.13	2.65522 × 10 ⁶	2.24694 × 10 ²⁵
	4.18605	0.426858	1.16279 × 10 ⁻⁶	1	3.96759 × 10 ⁻³	3.08747	2.61272 × 10 ¹⁹
	1055.06	107.586	2.93072 × 10 ⁻⁴	252.042	1	778.172	6.58515 × 10 ²¹
	1.35582	0.138255	3.76616 × 10 ⁻⁷	0.323890	1.28506 × 10 ⁻³	1	8.46233 × 10 ¹⁸
	1.60218 × 10 ⁻¹⁹	1.63377 × 10 ⁻²⁰	4.45050 × 10 ⁻²⁶	3.82743 × 10 ⁻²⁰	1.51857 × 10 ⁻²²	1.18171 × 10 ⁻¹⁹	1

- 1 cal = 4.18605 J(計量法)
 = 4.184 J(熱化学)
 = 4.1855 J(15 °C)
 = 4.1868 J(国際蒸気表)
 仕事率 1 PS(仏馬力)
 = 75 kgf·m/s
 = 735.499 W

放射能	Bq	Ci
	1	2.70270 × 10 ⁻¹¹
	3.7 × 10 ¹⁰	1

吸収線量	Gy	rad
	1	100
	0.01	1

照射線量	C/kg	R
	1	3876
	2.58 × 10 ⁻⁴	1

線量当量	Sv	rem
	1	100
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電位, 電圧, 起電力	ボルト	V	W/A
静電容量	ファラド	F	C/V
電気抵抗	オーム	Ω	V/A
コンダクタンス	ジーメンズ	S	A/V
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インダクタンス	ヘンリー	H	Wb/A
セルシウス温度	セルシウス度	°C	
光照度	ルーメン	lm	cd·sr
放射線量	ルクス	lx	lm/m ²
放射線量	ベクレル	Bq	s ⁻¹
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	1055.06	107.586	2.93072 × 10 ⁻⁴	252.042	1	778.172	6.58515 × 10 ²¹	= 75 kgf·m/s
	1.35582	0.138255	3.76616 × 10 ⁻⁷	0.323890	1.28506 × 10 ⁻³	1	8.46233 × 10 ¹⁸	= 735.499 W
	1.60218 × 10 ⁻¹⁹	1.63377 × 10 ⁻²⁰	4.45050 × 10 ⁻²⁶	3.82743 × 10 ⁻²⁰	1.51857 × 10 ⁻²²	1.18171 × 10 ⁻¹⁹	1	

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