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(January 2002 to December 2002 inclusive)

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Editor

J. Katakura

Japanese Nuclear Data Committee

Japan Atomic Energy Research Institute
Tokai Research Establishment
Tokai-mura, Naka-gun, Ibaraki-ken, Japan

Editor's Note

This is a collection of reports which have been submitted to the Japanese Nuclear Data Committee at the committee's request. The request was addressed to the following individuals who might represent or be touch with groups doing researches related to the nuclear data of interest to the development of the nuclear energy programs.

Although the editor tried not to miss any appropriate addressed, there may have been some oversight. Meanwhile, contribution of a report rested with discretion of its author. The coverage of this document, therefore, may not be uniform over the related field or research.

In this progress report, each individual report is generally reproduced as it was received by the JNDC secretariat, and editor also let pass some simple obvious errors in the manuscripts if any.

This edition covers a period of January 1, 2002 to December 31, 2002. The information herein contained is of a nature of "Private Communication." Data contained in this report should not be quoted without the author's permission.

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PU	241	EVALUATION	2.0+7	2.5+8	JAE	EVAL-PROG	INDC(JPN)-190U	MAR	03		KONOBEYEV+.P11.FOR JENDL HIGH-E FILE
PU	242	EVALUATION	2.0+7	2.5+8	JAE	EVAL-PROG	INDC(JPN)-190U	MAR	03		KONOBEYEV+.P11.FOR JENDL HIGH-E FILE
NP	237	EVALUATION	2.0+7	2.5+8	JAE	EVAL-PROG	INDC(JPN)-190U	MAR	03		KONOBEYEV+.P11.FOR JENDL HIGH-E FILE
AM	241	EVALUATION	2.0+7	2.5+8	JAE	EVAL-PROG	INDC(JPN)-190U	MAR	03		KONOBEYEV+.P11.FOR JENDL HIGH-E FILE
AM	242	EVALUATION	2.0+7	2.5+8	JAE	EVAL-PROG	INDC(JPN)-190U	MAR	03		KONOBEYEV+.P11.GS,META.FOR JENDL/HE
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U	238	EVALUATION		1.5+8	JAE	THEO-PROG	INDC(JPN)-190U	MAR	03		SUKHOVITSKIJ+.P18.CC OPTMDL ANALYSIS

ELEMENT S A	QUANTITY	ENERGY MIN	ENERGY MAX	LAB	TYPE	DOCUMENTATION REF VOL PAGE DATE	COMMENTS
HO 166	(N,GAMMA)	2.5-2		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	KATOH+.P24.META.SIG=3.11+-0.82 KB
HO 166	RES INT ABS	5.0-1		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	KATOH+.P24.META.RI=10.0+-2.7 KB
AG 109	(N,GAMMA)	2.5-2		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	NAKAMURA+.P25.TO META.S=4.12+-0.10 B
AG 109	RES INT ABS	5.0-1		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	NAKAMURA+.P25.TO META.RI=67.9+-3.1 B
SE 80	(N,GAMMA)	2.5-2		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	NAKAMURA+.P26.TO GS,META.SIG'S GIVEN
ZR 94	(N,GAMMA)	2.5-2		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	NAKAMURA+.P26.SIG=0.0478+-0.0013 B
ZR 96	(N,GAMMA)	2.5-2		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	NAKAMURA+.P26.SIG=0.0438+-0.0050 B
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SN 124	RES INT ABS	5.0-1		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	NAKAMURA+.P26.TO GS,META.RI'S GIVEN
NP 237	(N,GAMMA)	2.5-2		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	KATOH+.P27.SIG=144.1+-5.4 B
NP 237	RES INT CAP	3.0-1		JNC	EXPT-PROG	INDC(JPN)-190U MAR 03	KATOH+.P27.RIG=806+-50 B
NP 237	(N,GAMMA)	5.0-2	1.0+4	KTO	EXPT-PROG	INDC(JPN)-190U MAR 03	KOBAYASHI+.P31.TOF,PB SLOW DOWN SPEC
RH 103	(N,GAMMA)	3.0-2	8.0+4	KTO	EXPT-PROG	INDC(JPN)-190U MAR 03	LEE+.P32.TOF,113.0+-0.93B AT .0253EV
I 129	(N,GAMMA)		+4	KTO	EXPT-PROG	INDC(JPN)-190U MAR 03	KOBAYASHI+.P33.TOF,NDG
CS 133	(N,GAMMA)		+4	KTO	EXPT-PROG	INDC(JPN)-190U MAR 03	KOBAYASHI+.P33.TOF,NDG
PR 141	(N,GAMMA)		+4	KTO	EXPT-PROG	INDC(JPN)-190U MAR 03	KOBAYASHI+.P33.TOF,NDG
MG 26	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG

ELEMENT S	A	QUANTITY	ENERGY MIN	MAX	LAB	TYPE	DOCUMENTATION REF	VOL	PAGE	DATE	COMMENTS
SI	29	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
SI	30	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
CR	53	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
CR	54	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
ZN	67	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
SR	87	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
MO	98	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
MO	100	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
RU	102	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
PD	105	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
PD	106	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
PD	108	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
TE	123	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
DY	163	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
HF	179	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
OS	189	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P47.ACTSIG (N,NP)+(N,D).NDG
ND	146	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG
ND	148	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG
SM	152	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG
GD	155	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)-190U			MAR 03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG

ELEMENT S	A	QUANTITY	ENERGY MIN	MAX	LAB	TYPE	DOCUMENTATION REF	VOL	PAGE	DATE	COMMENTS
GD	158	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG
DY	164	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG
ER	170	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG
YB	174	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG
YB	176	(N,D)	1.3+7	1.5+7	NAG	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SAKANE+.P49.ACTSIG (N,NP)+(N,D).NDG
BE	9	(N,GAMMA)		5.0+5	JPN	THEO-PROG	INDC(JPN)	-190U	MAR	03	MATSUSHIMA+.P55.VALENCE CAPTURE MDL
C	12	(N,GAMMA)		5.0+5	JPN	THEO-PROG	INDC(JPN)	-190U	MAR	03	MATSUSHIMA+.P55.VALENCE CAPTURE MDL
O	16	(N,GAMMA)		5.0+5	JPN	THEO-PROG	INDC(JPN)	-190U	MAR	03	KITAZAWA+.P55.VALENCE CAPTURE MDL
MN	55	(N,2N)	1.5+7		OSA	EXPT-PROG	INDC(JPN)	-190U	MAR	03	MITSUDA+.P65.SIG=0.6+-0.1B.DA IN FIG
C	12	DIFF ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF.25 ANGS 2.6 TO 53 DEG
SI		DIFF ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF.25 ANGS 2.6 TO 53 DEG
FE		DIFF ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF.25 ANGS 2.6 TO 53 DEG
ZR		DIFF ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF.25 ANGS 2.6 TO 53 DEG
PB		DIFF ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF.25 ANGS 2.6 TO 53 DEG
C	12	ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF
SI	12	ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF
FE	12	ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF
ZR	12	ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF
PB	12	ELASTIC	5.5+7	7.5+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.TOF
U	233	SPECT FISS N	6.0+5	4.1+6	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.NDG

ELEMENT S	A	QUANTITY	ENERGY MIN	MAX	LAB	TYPE	DOCUMENTATION REF	VOL	PAGE	DATE	COMMENTS
U	238	SPECT FISS N	6.0+5	4.1+6	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.NDG
TH	232	SPECT FISS N	6.0+5	4.1+6	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	BABA+.P74.NDG
U	233	SPECT FISS N	5.5+5	4.1+6	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	MIURA+.TOF.NDG
U	238	SPECT FISS N	5.5+5	4.1+6	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	MIURA+.TOF.NDG
TH	232	SPECT FISS N	5.5+5	4.1+6	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	MIURA+.TOF.NDG
O	16	P EMISSION	7.5+7		TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SANAMI+.P75.DA/DE AT 25, 65, 125 DEG
O	16	D EMISSION	7.5+7		TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SANAMI+.P75.DA/DE AT 25, 65, 125 DEG
O	16	T EMISSION	7.5+7		TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SANAMI+.P75.DA/DE AT 25, 65, 125 DEG
O	16	A EMISSION	7.5+7		TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SANAMI+.P75.DA/DE AT 25, 65, 125 DEG
N	14	P EMISSION	7.5+7		TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SANAMI+.P75.DA/DE AT 25, 65, 125 DEG
N	14	D EMISSION	7.5+7		TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SANAMI+.P75.DA/DE AT 25, 65, 125 DEG
N	14	T EMISSION	7.5+7		TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SANAMI+.P75.DA/DE AT 25, 65, 125 DEG
N	14	A EMISSION	7.5+7		TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	SANAMI+.P75.DA/DE AT 25, 65, 125 DEG
C	12	NONELASTIC	4.0+7	8.0+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	IBARAKI+.P76.TRANS + CLOSE GEOMETRY
SI		NONELASTIC	4.0+7	8.0+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	IBARAKI+.P76.TRANS + CLOSE GEOMETRY
FE		NONELASTIC	4.0+7	8.0+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	IBARAKI+.P76.TRANS + CLOSE GEOMETRY
ZR		NONELASTIC	4.0+7	8.0+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	IBARAKI+.P76.TRANS + CLOSE GEOMETRY
PB		NONELASTIC	4.0+7	8.0+7	TOH	EXPT-PROG	INDC(JPN)	-190U	MAR	03	IBARAKI+.P76.TRANS + CLOSE GEOMETRY
DY	161	(N,GAMMA)	1.0+4	9.0+4	TIT	EXPT-PROG	INDC(JPN)	-190U	MAR	03	KIM+.P79.TOF.REL AU197(N,G)
DY	162	(N,GAMMA)	1.0+4	9.0+4	TIT	EXPT-PROG	INDC(JPN)	-190U	MAR	03	KIM+.P79.TOF.REL AU197(N,G)

I. Aichi Shukutoku University

A. Department of Media Production and Theories

I-A-1

Reactor Kinetics Calculated in the Summation Method

Kazuhiro Oyamatsu

Department of Media Production and Theories, Aichi Shukutoku University

A paper on this subject was published in Proc. Intl. Conf. on Nucl. Data for Sci. and Technol., October 7-12, 2001, Tsukuba, Ibaraki, Japan, (J. Nucl. Sci. and Technol., Suppl. 2, pp. 1109-1111, 2002) with the following abstract.

The kinetics of a point reactor is solved directly form buildup and decay of fission-product (FP) nuclei for the first time, The purpose of this paper is to identify causes of the peculiar inhour equations calculated from delayed neutron temporal data in ENDF/B-VI, that were obtained from FP fission yields decay data. In this paper, the inhour equation is calculated in the summation method directly from FP data in ENDF/B-VI. For ^{235}U, ^{238}U and ^{239}Pu, the inhour equation in the present method shows similar behavior. To identify FP data responsible for this peculiarity, the asymptotic form of the inhour equation at infinitely long periods is examined. It is found that the most important precursors for long reactor periods are found ^{137}I, ^{88}Br and ^{87}Br. They cover more than 60 % of the reactivity. Among them, ^{137}I alone covers 30-50 %. Moreover, ^{136}Te is found a candidate precursor for the peculiarity from the time dependence of the delayed neutron emission. It is recommended that the precision of their Pn values should be improved experimentally. For ^{137}I, ^{88}Br, and ^{87}Br, the precision, dPn/Pn, should be decreased down to 2 % and for ^{136}Te to 5%.

I-A-2

Summation Calculation of Delayed Neutron Emission and its Application to Reactor Kinetics

Kazuhiro Oyamatsu

A paper on this subject was published in Proceedings of PHYSOR 2002 (Seoul, Korea, October 7-10, 2002) with the following abstract.

The kinetics of a point reactor is solved directly form buildup and decay of fission-product (FP) nuclei for the first time. The purpose of this paper is to identify possible sources of the peculiar behavior of inhour equations calculated from delayed neutron temporal data in ENDF/B-VI, that were obtained from FP fission yields decay data. Specifically, the inhour equation is calculated in the summation method directly from FP data in ENDF/B-VI. For ^{235}U, ^{238}U and ^{239}Pu, the present calculation of the inhour equation show similar behavior to those obtained from the temporal data. To identify FP data responsible for this peculiarity, the asymptotic form of the inhour equation at infinitely long periods is examined. It is found that the most important precursors for long reactor periods are found ^{137}I, ^{88}Br and ^{87}Br. They cover more than 60 % of the reactivity. Among them, ^{137}I alone covers 30-50 %. Moreover, ^{136}Te is found a possible candidate for the peculiarity from the time dependence of the delayed neutron emission. It is recommended that the precision of their Pn values should be improved experimentally. For ^{137}I, ^{88}Br, and ^{87}Br, the precision, dPn/Pn, should be decreased down to 2 % and for ^{136}Te to 5%. Except for the Pn and fission yield data of these precursors, the presently available FP data seem to provide reasonable time dependence of DN emission having almost comparable precision ($\leq$ 10%) with empirical evaluations.

II. Japan Atomic Energy Research Institute

A. Nuclear Data Center and Working Groups of Japanese Nuclear Data Committee

II-A-1

Curves and Tables of Neutron Cross Sections in JENDL-3.3

(Eds.) Tsuneo NAKAGAWA, Hiromitsu KAWASAKI* and Keiichi SHIBATA

A paper on this subject was published as JAERI-Data/Code 2002-020 (Nov. 2002) with the following abstract.

Neutron cross sections of 337 nuclides in JENDL-3.3 are presented in figures and tables. In the tables, shown are cross sections at 0.0253 eV and 14 MeV, Maxwellian average cross sections (kT=0.0253 eV), resonance integrals and fission spectrum average cross sections. The average cross sections calculated with typical reactor spectra are also tabulated. The numbers of delayed and total neutrons per fission are given in figures.

II-A-2

Re-evaluation of Neutron Nuclear Data for ^{242m}Am, ^{243}Am, ^{99}Tc and ^{140}Ce

Tsuneo NAKAGAWA, Osamu IWAMOTO and Akira HASEGAWA

A paper on this subject was published as JAERI-Research 2002-035 (Dec. 2002) with the following abstract.

The evaluated nuclear data given in JENDL-3.2 were compared with other evaluated data sets and available experimental data, for important minor actinides of ^{242m}Am and ^{243}Am, and fission product nuclides of ^{99}Tc and ^{140}Ce. Since problems were found as a result of the comparison, the data of JENDL-3.2 were improved for these nuclides. It was found that the evaluated data of Maslov et al. were superior to the others. They were adopted for ^{242m}Am and ^{243}Am after further improvements. For ^{99}Tc and ^{140}Ce, resonance parameters and optical model parameters were improved. The cross sections of these two nuclides in the smooth part were re-calculated. The present results were given in the neutron energy range from 10^{-5} eV to 20 MeV in the ENDF-6 format, and adopted to JENDL-3.3.

II-A-3

Comparison of Fission and Capture Cross Sections of Minor Actinides

Tsuneo NAKAGAWA and Osamu IWAMOTO

A paper on this subject was published as JAERI-Data/Code 2002-025 (Jan. 2003) with the following abstract.

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.

II-A-4

Evaluation of Neutron Nuclear Data for Sodium-23

Keiichi SHIBATA

A paper on this subject was published in *J. Nucl. Sci. Technol.*, **39**, 1065 (2002) with the following abstract:

Neutron nuclear data of ^{23}Na have been evaluated in the neutron energy region up to 20 MeV. Evaluated are the elastic and inelastic scattering, capture, (n,2n), (n,p), (n,α), (n,np), (n,nα) reaction and γ-ray production cross sections, and the angular and energy distributions of neutrons and γ-rays. The evaluation is mainly based on nuclear model calculations. The pre-equilibrium and direct-reaction processes were taken into account in addition to the compound process. The evaluated data have been compiled into the latest version of JENDL, JENDL-3.3.

II-A-5

Japanese Evaluated Nuclear Data Library Version 3 Revision 3: JENDL-3.3

Keiichi SHIBATA[1], Toshihiko KAWANO[2], Tsuneo NAKAGAWA[1], Osamu IWAMOTO[1], Jun-ichi KATAKURA[1], Tokio FUKAHORI[1], Satoshi CHIBA[1], Akira HASEGAWA[1], Toru MURATA[3], Hiroyuki MATSUNOBU[4], Takaaki OHSAWA[5], Yutaka NAKAJIMA[6], Tadashi YOSHIDA[7], Atsushi ZUKERAN[8], Masayoshi KAWAI[9], Mamoru BABA[10], Makoto ISHIKAWA[11] ,Tetsuo ASAMI[4], Takashi WATANABE[12], Yukinobu WATANABE[2], Masayuki IGASHIRA[13], Nobuhiro YAMAMURO[13], Hideo KITAZAWA[14], Naoki YAMANO[15], and Hideki TAKANO[1]

A paper on this subject was published in *J. Nucl. Sci. Technol.*, **39**, 1125 (2002) with the following abstract:

Evaluation for JENDL-3.3 has been performed by considering the accumulated feedback information and various benchmark tests of the previous library JENDL-3.2. The major problems of the JENDL-3.2 data were solved by the new library: overestimation of criticality values for thermal fission reactors was improved by the modifications of fission cross sections and fission neutron spectra for ^{235}U; incorrect energy distributions of secondary neutrons from important heavy nuclides were replaced with statistical model calculations; the inconsistency between elemental and isotopic evaluations was removed for medium-heavy nuclides. Moreover, covariance data were provided for 20 nuclides. The reliability of JENDL-3.3 was investigated by the benchmark analyses on reactor and shielding performances. The results of the analyses indicate that JENDL-3.3 predicts various reactor and shielding characteristics better than JENDL-3.2.

[1]JAERI, [2]Kyushu University, [3]AITEL Co., [4]Data Engineering, Inc., [5]Kinki University, [6]RIST, [7]Musashi Institute of Technology, [8]Hitachi, Ltd., [9]KEK, [10]Tohoku University, [11]JNC, [12]Enetec Co., Ltd., [13]Tokyo Institute of Technology, [14]National Defense Academy, [15]Sumitomo Atomic Energy Industries, Ltd.

II-A-6

JENDL High Energy File

T. Fukahori, Y. Watanabe, N. Yoshizawa, F. Maekawa, S. Meigo,
C. Konno, N. Yamano, A.Yu. Konobeyev and S. Chiba

A paper on this subject was published in Proc. of International Conference on Nuclear Data for Science and Technology (ND2001), Oct. 7-12, 2001, Tsukuba International Congress Center, Tsukuba, Japan (J. Nucl. Sci. Technol., **Suppl. 2**, 25 (2002)) with the following abstract.

Nuclear Data Center at Japan Atomic Energy Research Institute is developing the JENDL High Energy File in cooperating with Japanese Nuclear Data Committee. The JENDL High Energy File includes neutron and proton nuclear data 20 MeV to 3 GeV. In this report, reported are evaluation methods and results of the evaluation and benchmark tests for the JENDL High Energy File.

II-A-7

Neutron and Proton Nuclear Data Evaluation for U-235 and U-238 at Energies up to 250 MeV

A.Yu. Konobeyev, T. Fukahori and O. Iwamoto

A paper on this subject was published in JAERI-Research 2002-028 (2002) with the following abstract.

Basic features of nuclear data evaluation for uranium isotopes ^{235}U and ^{238}U at intermediate energies are described. The coupled channel optical model was used to obtain total cross section, reaction cross section, angular distributions and transmission coefficients. The direct, pre-compound and evaporation models were used to describe neutron and charged particles emission from excited nuclei. The neutron data evaluated were combined with JENDL-3.3 data below 20 MeV to obtain a full data set in the whole energy range between 10^{-5} eV and 250 MeV. Evaluation of the proton data has been done at energies from 1 to 250 MeV

II-A-8

Nuclear Data Evaluation for Pu-238, Pu-239, Pu-240, Pu-241 and Pu-242 Irradiated by Neutrons and Protons at the Energies up to 250 MeV

A.Yu. Konobeyev, T. Fukahori and O. Iwamoto

A paper on this subject was published in JAERI-Research 2002-029 (2002) with the following abstract.

The evaluation of nuclear data for plutonium isotopes with atomic mass number from 238 to 242 has been performed. Neutron data were obtained at the energies from 20 to 250 MeV and combined with JENDL-3.3 data at 20 MeV. Evaluation of the proton data has been done from 1 to 250 MeV. The coupled channel optical model was used to obtain angular distributions for elastic and inelastic scattering and transmission coefficients. Pre-equilibrium exciton model and Hauser-Feshbach statistical model were used to describe neutron and charged particles emission from the excited nuclei. These evaluation is the first work for producing the full set of evaluated file up to 250 MeV for plutonium isotopes.

II-A-9

Nuclear Data Evaluation for Np-237, Am-241, Am-242g and Am-242m Irradiated by Neutrons and Protons at the Energies up to 250 MeV

A.Yu. Konobeyev, T. Fukahori and O. Iwamoto

A paper on this subject was published in JAERI-Research 2002-032 (2002) with the following abstract.

Evaluation of nuclear data has been performed for ^{237}Np, ^{241}Am, ^{242g}Am, ^{242m}Am. Neutron data were obtained at energies from 20 to 250 MeV and combined with JENDL-3.3 data at 20 MeV. Evaluation of the proton data has been done from 1 to 250 MeV. The coupled channel optical model was used to obtain angular distributions for elastic and inelastic scattering and transmission coefficients. Pre-equilibrium exciton model and Hauser-Feshbach statistical model were used to describe neutron and charged particles emission from excited nuclei. These evaluation is the first work for producing full sets of evaluated file up to 250 MeV for ^{237}Np and Americium isotopes.

II-A-10

Photon and decay Data Libraries for ORIGEN2 Code Based on JENDL FP Decay Data File 2000

J. Katakura and H. Yanagisawa

A paper on this subject was published in JAERI-Data/Code 2002-021 (2002) with the following abstract.

Photon and decay data libraries for the ORIGEN2 code have been updated by using JENDL FP Decay Data File 2000 (JENDL/FPD-00). As for the decay data, half-lives, branching ratios and recoverable energy values have been replaced with those of the JENDL/FPD-00 file. The data of the photon library has been also replaced with those of the JENDL/FPD-00 file in which photon data of the nuclides without measured data are calculated with a theoretical method. Using the updated photon library, the calculation of photon spectrum at a short time after fission event is able to be made.

B. Center for Proton Accelerator Facilities

II-B-1

Research Activities on Neutronics under ASTE Collaboration at AGS/BNL

Hiroshi NAKASHIMA[1], Hiroshi TAKADA[1], Yoshimi KASUGAI[1], Shin-ichiro MEIGO[1], Fujio MAEKAWA[1], Tetsuya KAI[1], Chikara KONNO[1], Yujiro IKEDA[1], Yukio OYAMA[1], Noboru WATANABE[1], Masatoshi ARAI[2], Masayoshi KAWAI[2], Masaharu NUMAJIRI[2], Takashi INO[2], Setsuo SATO[2], Kazutoshi TAKAHASHI[2], Yoshiaki KIYANAGI[3], Ralf NEEF[4], Detlef FILGES[4], Harald CONRAD[4], Horst STECHEMESSER[4], Harald SPITZER[5], Guenter BAUER[5], Eric JERDE[6], David GLASGOW[6], John HAINES[6], Tony GABRIEL[6], Paul MONTANEZ[7], Alan CARROLL[7], Hans LUDEWIG[7] and Jerome HASTINGS[7]

A paper on this subject was published in J. Nucl. Sci. Technol. (Suppl.2), 1155-1160 (2002). The content is as follows.

A series of experiments on a mercury spallation target using high-peak-power GeV proton-beam from the Alternating Gradient Synchrotron (AGS) of Brookhaven National Laboratory (BNL) has been performed under an international collaboration among the laboratories in Japan, U.S. and Europe, namely the ASTE (AGS Spallation Target Experiment) collaboration. This paper reviews the current status of the experiments on neutronic performance of the mercury target.

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C. Fusion Neutron Laboratory

II-C-1

14 MeV Neutron Skyshine Experiments at JAERI/FNS

Takeo NISHITANI, Kentaro OCHIAI, Shigeo YOSHIDA[1], Ryohei TANAKA [2], Masashi WAKISAKA[3], Makoto NAKAO, Satoshi SATO, Michinori YAMAUCHI, Jun-ichi HORI, Akito TAKAHASHI[2], Jun-ichi KANEKO[3] and Teruko SAWAMURA[3]

A paper on this subject was submitted to Fusion Eng. Design, with the following abstract.

The D-T neutron skyshine experiments have been carried out at the Fusion Neutronics Source (FNS) of JAERI with the neutron yield of ~1.7×10^{11} n/s. The concrete thickness of the roof and the wall of a FNS target room are 1.15 and 2 m, respectively. The FNS skyshine port with a size of 0.9×0.9 m^2 was open during the experimental period. The radiation dose rate outside the target room was measured as far as about 550 m away from the D-T target point with a spherical rem-counter. Secondary gamma-rays were measured with high purity Ge detectors and NaI scintillation counters. The highest neutron dose was about 9×10^{-22} Sv/(source neutron) at a distance of 30 m from the D-T target point and the dose rate was attenuated to 4×10^{-24} Sv/(source neutron) at a distance of 550 m. The measured neutron dose distribution was analyzed with Monte Carlo code MCNP-4B and a simple line source model. The MCNP calculation overestimates the neutron dose in the distance range larger than 230 m. The line source model agrees well with the experimental results within the distance of 350 m.

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II-C-2

Measurement of Tritium Production Rate for Enriched Lithium-6 /Beryllium Assembly with D-T Neutron Source

Kentaro OCHIAI, Axel KLIX, Vury. M. VERZILOV, Jun-ichi HORI, Satoshi SATO, Michinori YAMAUCHI, Masayuki WADA and Takeo NISHITANI

A paper on this subject was submitted to Fusion Eng. Design, with the following abstract.

The Lithium-6 and beryllium assembly experiments have been carried out using the JAERI-FNS 80 degree D-T neutron source to inspect the tritium production rate (TPR). The scale of the assembly was about 500 x 500 mm^2 wide with a total thickness of 350 mm Three 12-mm thick ceramics layers consisting of 40% enriched $^6Li_2TiO_3$ were set up between 100- and 50-mm thick layers of beryllium in the assembly. The point of D-T neutron source and the assembly were enclosed in a cylindrical stainless steel reflector and a 100-mm thick beryllium reflector was set up, across from the assembly. Enriched Li_2CO_3 and Li_2TiO_3 pellets, with sizes of ϕ13 and ϕ12 mm respectively and thickness between 0.5-2 mm, were used as the tritium detectors in each $^6Li_2TiO_3$ ceramics layers to measure the produced tritium. Nb, In and Au foils were also set up at important positions in the assembly to verify the neutron field. After D-T neutron irradiation, the tritium in the pellets was measured with liquid scintillation counting methods. Measured tritium distributions obtained from the Li_2TiO_3 and Li_2CO_3 pellets in the Li_2TiO_3 layers was reflected in the thermalized neutron field in the assembly and the local TPR of the surface area is significantly higher than the bulk and especially, the surface TPR is three five times more than bulk TPR in the third $^6Li_2TiO_3$ layer. Also from the comparison the measured value and calculated one with Monte Calro code MCNP-4B and JENDL-3.2 data, the C/E values of average TPR was between 1.2 and 1.4.

II-C-3

Radioactivity production around the surface of a cooling water pipe in a D-T fusion reactor by sequential charged particle reactions

Jun-ichi HORI, Fujio MAEKAWA, Masayuki WADA[1], Kentaro OCHIAI, Michinori YAMAUCHI, Yuichi MORIMOTO, Yasuaki TERADA, Axel KLIX, Takeo NISHITANI

A paper on this subject was submitted to Fusion Eng. Design, with the following abstract.

Around the surface of a cooling pipe in a D-T fusion reactor, it is expected that the radioactivity production via what is known as "Sequential Charged Particle Reaction (SCPR)" would be enhanced by recoiled proton from hydrogen in cooling water. In order to simulate the circumstances, several sheets of foil with a thickness of 50-250 μm were laminated on a polyethylene board for six fusion materials (Fe, Cu, V, Ti, W, Pb). The laminated samples were irradiated with intense D-T neutrons at the Fusion Neutronics Source Facility (FNS) in JAERI. After irradiation, the decay gamma rays emitted from the sequential reaction products (^{56}Co, ^{65}Zn, ^{51}Cr, ^{48}V, ^{184}Re, ^{206}Bi) were measured and the effective cross-sections for producing those were obtained at several positions. The present results indicated that the sequential reaction rate increases prominently as the location becomes closer to hydrogen compounds.

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D. Advanced Science Research Center

II-D-1

JENDL Fusion File 99

S. Chiba, T. Fukahori, K. Shibata, B. Yu, K. Kosako and N. Yamamuro

A paper on this subject was published as J. Nucl. Sci. Technol. **39**, 187(2002) with the following abstract:

The double-differential cross sections (DDXs) of secondary neutrons have been evaluated for 79 isotopes and 13 natural elements ranging from H to Bi to improve the accuracy of predictions for the neutronics calculations in the D-T thermonuclear fusion applications. The data given in JENDL-3.1, which was the newest version of JENDL general purpose file when this project was initiated, was combined with new calculations based on the optical model, DWBA, pre-equilibrium and multi-step statistical models, and the DDX data were generated based on various kinds of systematics for medium-mass nuclei. Different methods were employed for light nuclei to which the above method could not be applied. In addition, the DDXs for emission of charged particles (p, d, t, ^{3}He and α-particle) were given for ^{2}H, ^{9}Be and elements heavier or equal to F. The present results give an overall good description of the measured DDX data of both the neutron and charged particles emission channels. The data were compiled in ENDF-6 format, and released in 1999 as a special purpose file of JENDL family, namely, JENDL Fusion File 99.

II-D-2

Lifetime of Heavy Composite Systems Formed by Fusion between Heavy Nuclei

T. Maruyama, A. Bonasera, M. Papa and S. Chiba

A paper on this subject was published as J. Nuclear and Radiochemical Sciences, **3**, 77(2002) with the following abstract:

We investigate the formation and the decay of heavy systems which are above the fission barrier. By using a microscopic simulation of constrained molecular dynamics (CoMD) on Au + Au collision, we observe composite system stay for very long time before decaying by fission.

II-D-3

Formation and decay of super heavy systems

T. Maruyama, A. Bonasera, M. Papa and S. Chiba

A paper on this subject was published as Eur. Phys. J. A 14, 191-197 (2002) with the following abstract:

We investigate the formation and the decay of heavy systems which are above the fission barrier. By using a microscopic simulation of constrained molecular dynamics (CoMD) on Au + Au collision, we observe that composite system stay for a very long time before decaying by fission.

II-D-4

Nuclear Level Structure, B(E2) γ-transitions and Nucleon Interaction Data for ^{56}Fe by a Unified Soft-rotator Model and Coupled-Channels Framework

E.S.Sukhovitskiĭ, S. Chiba, J.-Y. Lee, Y.-O. Lee, J. Chang, T. Maruyama and O. Iwamoto

A paper on this subject was published as J. Nucl. Sci. Technol. **39**, 816(2002) with the following abstract:

The soft-rotator model (SRM) and a coupled-channels method based on the coupling scheme based on the wave functions of the SRM were applied for a consistent analysis of the nuclear level structure, B(E2) and the nucleon interaction data of ^{56}Fe. The model could describe the experimental collective levels of ^{56}Fe up to the excitation energy of 5.5 MeV successfully. Relativistic kinematics and global optical potential form, consistent with nuclear matter theory and Dirac phenomenology, were used in coupled-channels optical model approach to overcome problems left in our previous work. The available nucleon interaction experimental data up to 160 MeV and B(E2) γ - transitions were described satisfactorily.

II-D-5

Soft-Rotator Model and Coupled-Channels Approach for Consistent Description of the Nuclear Collective Levels and Their Excitation by Nucleons

E.S. Sukhovitskiĭ and S. Chiba

A paper on this subject was published as J. Nucl. Sci. Technol. Suppl. 2, 697(2002) with the following abstract:

Coupled-channels optical model approach built on the wave functions of the soft-rotator nuclear Hamiltonian is applied for the self-consistent analyses of the low-lying collective nuclear level structure and nucleon interaction with even-even nuclei in a wide A- mass region. It succeeds to describe available experimental data and $B(E\lambda)$ γ - transitions with reasonable accuracy. Along with the account of the global optical potential form and relativistic kinematics, present method was proved to be a powerful tool for studies of nucleon-induced reaction data.

II-D-6

Analyses of Nucleon Interaction with ^{238}U up to 150 MeV Incident Energies Using Coupled-Channels Approach with a Saturated Coupling Scheme Based on Soft-Rotator Nuclear Model Hamiltonian

E.S. Sukhovitskiĭ and S. Chiba

A paper on this subject was published as J. Nucl. Sci. Technol. Suppl. 2, 144(2002) with the following abstract:

Coupled-channels optical model with a saturated coupling built on the wave functions of the soft-rotator nuclear Hamiltonian is applied for the self-consistent analyses of ^{238}U collective nuclear level structure and nucleon interaction with this nuclei. Experimental ^{238}U low-lying level structure, $B(E\lambda)$ γ - transitions and available nucleon (both neutron and proton) interaction data up to 150 MeV incident energies are described simultaneously within less than two experimental errors. Results are recommended to be used for nucleon-induced high energy data evaluation.

II-D-7

Instanton and Monopole in Color Magnetic Field

M. Fukushima, H. Suganuma and S. Chiba

A paper on this subject was published as Prog. Theor. Phys. **107**, 1147(2002) with the following abstract:

We study properties of instanton and monopole in an external chromomagnetic field. Generally, the 't Hooft ansatz is no longer a solution of the Yang-Mills field equation in the presence of external fields. Therefore, we investigate a stabilized instanton solution with minimal total Yang-Mills action in a nontrivial topological sector. With this aim, we consider numerical minimization of the action with respect to the global color orientation, the anisotropic scale transformation and the local gauge-like transformation starting from a simple superposed gauge field of the 't Hooft ansatz and the external color field. Here, the external color field is, for simplicity, chosen to be a constant Abelian magnetic field along a certain direction. Then, the 4-dimensional rotational symmetry $O(4)$ of the instanton solution is reduced to two 2-dimensional rotational symmetries $O(2) \times O(2)$ due to the effect of a homogeneous external field. In the space R^3 at fixed t, we find a quadrupole deformation of this instanton solution. In the presence of a magnetic field $\vec{H}$, a prolate deformation occurs along the direction of $\vec{H}$. Contrastingly, in the presence of an electric field $\vec{E}$ an oblate deformation occurs along the direction of $\vec{E}$. We further discuss the local correlation between the instanton and the monopole in the external field in the maximally Abelian gauge. The external field affects the appearance of the monopole trajectory around the instanton. In fact, a monopole and anti-monopole pair appears around the instanton center, and this monopole loop seems to partially screen the external field.

III. Japan Nuclear Cycle Development Institute

A. Waste Management and Fuel Cycle Research Center

III-A-1

Resonance Self-Shielding Corrections for Activation Cross Section Measurements

O. Shcherbakov and H. Harada

A paper on this subject was published in J. Nucl. Sci. Technol. Vol. **39**, 548-553 (2002) with the following abstract.

The Pade approximations of the Doppler broadening function $\psi(\theta,x)$ have been used for the calculations of resonance self-shielding factors used in activation measurements. It is shown that this method of the calculations is effective from the point of view of fastness and accuracy.

III-A-2

Measurement of Thermal Neutron Capture Cross Section and Resonance Integral of the $^{166m}Ho(n, \gamma)^{167}Ho$ Reaction using a Two-Step Irradiation Technique

T. Katoh, S. Nakamura, K. Furutaka, H. Harada,
T. Baba, T. Fujii[1], and H. Yamana[1]

A paper on this subject was published in J. Nucl. Sci. Technol. Vol. **39**, 705-715 (2002) with the following abstract.

The thermal neutron capture cross section(σ_0) and the resonance integral(I_0) of ^{166m}Ho have been measured as data for the transmutation of nuclear waste. Samples of ^{166m}Ho were made by the neutron irradiation of ^{165}Ho. Two metallic foils of ^{165}Ho were irradiated for 2 weeks and two others for 3 weeks at the Kyoto University Reactor. A high purity Ge detector was employed for activity measurement. The samples irradiated were cooled for 3 months to reduce the activity of ^{166g}Ho. One of the samples irradiated for 2 weeks was irradiated again with Cd cover sheets and the other one without a Cd cover sheet. For the samples irradiated for 3 weeks, the same irradiation was performed. The ^{167}Ho nuclei were produced at the second irradiation via the neutron capture of ^{166m}Ho and the double neutron capture of ^{165}Ho. The amount of ^{167}Ho via the double capture was estimated from the difference between the data of 2 week irradiation and 3 week irradiation, and corrected. The reaction rate to produce ^{167}Ho from ^{166m}Ho was analyzed by Westcott's convention. A resonance at 0.274 eV was considered in the analysis. The results obtained were 3.11 ± 0.82 kb for the σ_0 and 10.0 ± 2.7 kb for the I_0 of ^{166m}Ho.

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1 Research Reactor Institute, Kyoto University

III-A-3

Measurement of Thermal Neutron Capture Cross Section and Resonance Integral of the $^{109}Ag(n, \gamma)^{110m}Ag$ Reaction

S. Nakamura, H. Wada, O. Shcherbakov, K. Furutaka, H. Harada, and T. Katoh

A paper on this subject was submitted in J. Nucl. Sci. Technol. with the following abstract.

In order to develop a neutron flux monitor for long-term neutron irradiation, the thermal neutron(2,200 m/s neutron) capture cross section (σ_0) and the resonance integral (I_0) of the $^{109}Ag(n,\gamma)^{110m}Ag$ reaction were measured by the activation and γ-ray spectroscopic methods. Silver foils were irradiated with and without a Cd shield capsule at the Rikkyo Research Reactor. The Co/Al and Au/Al alloy wires were irradiated together with silver foils in order to monitor the thermal neutron flux and the fraction of the epi-thermal neutron part (Westcott's index). A high purity Ge detector was used for the γ-ray measurements of the irradiated samples. The σ_0 and the I_0 of the $^{109}Ag(n,\gamma)^{110m}Ag$ reaction are 4.12±0.10 b and 67.9±3.1 b, respectively. The σ_0 is 12% smaller than the tabulated one (4.7±0.2 b). On the other hand, the I_0 is in agreement with the tabulated one (72.3±4.0 b) within the limits of error.

III-A-4

Thermal Neutron Capture Cross Sections and Resonance Integrals of ^{80}Se, ^{94,96}Zr, and ^{124}Sn

S. Nakamura, K. Furutaka, H. Harada, and T. Katoh

A paper on this subject was submitted in J. Nucl. Sci. Technol. with the following abstract.

In order to obtain fundamental data for research on the nuclear transmutation of radioactive wastes, thermal neutron capture cross sections (σ_0) and resonance integrals (I_0) were measured using an activation method for the reactions shown in the following; ^{80}Se(n,γ) $^{81m,\ 81g}$Se, ^{94}Zr(n,γ) ^{95}Zr, ^{96}Zr(n,γ) ^{97}Zr, and ^{124}Sn(n,γ) $^{125m,\ 125g}$Sn. Targets of high purity (99.99%) selenium oxide, zirconium oxide, and tin oxide were irradiated in the research reactor of Rikkyo University. The irradiations using cadmium shielded targets were also done in order to obtain the I_0. Wires of Co/Al alloy and Au/Al alloy, which have different sensitivities to neutrons in thermal and epithermal energy regions, were irradiated together with the targets in order to monitor the thermal neutron flux and the fraction of the epithermal component (Westcott's index) at the target position. Gamma rays from the irradiated targets and flux monitors were measured by using a high purity Ge detector. For each reaction, the results of the σ_0 and the I_0 were the following; 0.0460±0.0017 (b) and 0.148±0.008 (b) for the ^{80}Se(n,γ)^{81m}Se reaction, 0.536±0.043 (b) and 0.839±0.077 (b) for the ^{80}Se(n,γ)^{81g}Se reaction, 0.0478±0.0013 (b) and 0.278±0.015 (b) for the ^{94}Zr(n,γ)^{95}Zr reaction, 0.0438±0.0056 (b) and 4.94±1.00 (b) for the ^{96}Zr(n,γ)^{97}Zr reaction, 0.0825±0.0051 (b) and 7.14±0.74 (b) for the ^{124}Sn(n,γ)^{125m}Sn reaction, 0.00418±0.00126 (b) and 0.0858±0.0265 (b) for the ^{124}Sn(n,γ)^{125g}Sn reaction.

III-A-5

Measurement of Thermal Neutron Capture Cross Section and Resonance Integral of the $^{237}Np(n, \gamma)^{238}Np$ Reaction

T. Katoh, S. Nakamura, K. Furutaka, H. Harada,
K. Fujiwara[1], T. Fujii[1], and H. Yamana[1]

A paper on this subject is in preparation for the publication in J. Nucl. Sci. Technol. The content is as follows.

The thermal neutron capture cross section(σ_0) and the resonance integral(I_0) of ^{237}Np have been measured by an activation method as data for transmutation of nuclear waste. The reactor at Research Reactor Institute, Kyoto University, was used for the neutron irradiation of ^{237}Np. Samples of ^{237}Np were irradiated between two Cd sheets or without a Cd sheet. Since ^{237}Np has a strong resonance at the energy of 0.49 eV, the Cd cut-off energy was set at 0.3 eV(thickness of the Cd sheets: 0.125 mm). A high purity Ge detector was employed for activity measurement. The reaction rate to produce ^{238}Np from ^{237}Np was analyzed by the Westcott's convention. Results obtained were 144.1 $\pm$5.4 barns for the σ_0 and 806 $\pm$50 barns for the I_0 above 0.3 eV of ^{273}Np.

[1] Research Reactor Institute, Kyoto University

IV. Kyoto University

A. Research Reactor Institue

IV-A-1

Measurement of Neutron Capture Cross Section of ^{237}Np by Linac Time-of-Flight Method and with Linac-driven Lead Slowing-down Spectrometer

Katsuhei Kobayashi [1], Samyol Lee [1], Shuji Yamamoto [1], Hyun Je Cho [1†] and Yoshiaki Fujita [1]

A paper on this subject was published in the Journal of Nuclear Science and Technology, Vol.39, No.2, 111-119 (2002) with the following abstract.

The neutron capture cross section of ^{237}Np has been measured relative to the ^{10}B(n,α) standard cross section by the neutron time-of-flight (TOF) method in the energy range of 0.005 eV to 10 keV using a 46 MeV electron linear accelerator (linac) at the Research Reactor Institute, Kyoto University (KURRI). In order to experimentally prove the result obtained, the supplementary cross section measurement has been made from 0.15 eV to 1 keV using the Kyoto University Lead slowing-down Spectrometer (KULS) coupling to the linac. The relative measurement by the TOF method has been normalized to the reference value (181 b) at 0.0253 eV and the KULS measurement to that by the TOF method.

The existing experimental data and the evaluated capture cross sections in ENDF/B-VI and JENDL-3.2 have been compared with the current measurements by the linac TOF and the KULS experiments. The energy dependency of the KULS data is close to that of the TOF data which are energy-broadened by the resolution function of the KULS.

It has been found that the data measured by Weston and Todd and evaluated in ENDF/B-VI and JENDL-3.2 are in general agreement with each current measurement, although those data are systematically lower by about 15 % above about 0.2 eV. However, the data by Hoffman et al. are low obviously in the relevant energy region.

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IV-A-2

Neutron Capture Cross Section Measurement of Rhodium in the Energy Region from 0.003 eV to 80 keV by Linac Time-of-Flight Method

Samyol Lee [1], Shuji Yamamoto [1], Katsuhei Kobayashi [1], Guinyun Kim [2], and Jonghwa Chang [3]

A paper on this subject will be published in the Nuclear Science and Engineering, soon, with the following abstract.

The neutron capture cross section of rhodium has been measured in the energy region from 0.003 eV to 80 keV by the neutron time-of-flight method with a 46 MeV electron linear accelerator of the Kyoto University Research Reactor Institute. An assembly of $Bi_4Ge_3O_{12}$ (BGO) scintillators, which was composed of 12 pieces of BGO and placed at a distance 12.7 ± 0.02 m from the neutron source, was employed as a total energy absorption detector for the prompt capture gamma-ray measurement from the sample. In order to determine the neutron flux impinging on the capture sample, a plug of ^{10}B powder sample and the $^{10}B(n, \alpha \gamma)$ standard cross section were used.

The existing experimental data and evaluated cross sections in ENDF/B-VI, JENDL-3.2, and JEF-2.2 have been compared with the current measurement. Popov and Shapiro obtained poor energy resolution data in the resonance region with a lead slowing-down spectrometer. Furthermore, their data are a little higher than the current values above ~1 keV. The experimental data measured by Weston et al., Hockenbury et al., Macklin and Halperin, Fricke et al., and Block et al. are somewhat higher than the current values. The data measured by Moxon and Rae are somewhat lower than the current values above ~100 eV. The data measured by Wisshak et al. and Bokovko et al. are in general agreement with the measurement above 4 keV within the experimental error. The evaluated data in ENDF/B-VI, JENDL-3.2, and JEF-2.2 have been in good agreement with the current result, although the JENDL-3.2 and the JEF-2.2 values are somewhat lower than the measurement in the cross section minimum region from 10 to 100 eV.

The thermal neutron cross sections (2200 m/s values) measured by Seren et al. and Walker et al. are in good agreement with the current measurement (113.0 ± 0.93 b) within the experimental error. Other experimental data and the evaluated data are discrepant by 9 to 29 % from the measurement.

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IV-A-3

Neutron Capture Cross Section Measurements of ^{129}I, ^{133}Cs and ^{141}Pr with Linac Time-of-Flight Method

Katsuhei Kobayashi [1], Samyol Lee [1], Shuji Yamamoto [1], and Masayuki Igashira [2]

A paper on this subject was submitted to the Eleven-th International Symposiun on Reactor Dosimetry (ISRD-11), held at Brussels, August 19-23, 2002, with the following abstract.

The neutron capture cross sections of ^{129}I, ^{133}Cs and ^{141}Pr have been measured relative to the $^{10}B(n,\alpha)$ standard cross section at energies below several tens of keV by the neutron time-of-flight (TOF) method with an electron linear accelerator (linac) at the Research Reactor Institute, Kyoto University (KURRI). The capture gamma-ray measurements have been made with a pair of C_6D_6 liquid scintillators or twelve $Bi_4Ge_3O_{12}$ (BGO) scintillators. The relative measurements of ^{129}I and ^{141}Pr have been normalized to the reference cross section at 0.0253 eV. The capture cross section of ^{133}Cs has been absolutely obtained with the BGO scintillation assembly as a total energy absorption detector. The results of these cross section measurements have been compared with the existing experimental values and the evaluated data in ENDF/B-VI, JENDL-3.2 and JEF-2.2.

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V. Kyushu University

A. Department of Advanced Energy Engineering and Science

V-A-1

Theory for Multistep Direct $(p, p'x)$ and (p, nx) to Continuum

K. Ogata[†], M. Kawai[†], Y. Watanabe, Sun Weili[‡], and M. Kohno[¶]

A paper on this subject was published in *Nucl. Phys. A*, **703**, 152–166 (2002) with the following abstract:

The semiclassical distorted wave (SCDW) model of multistep direct processes is extended to calculate the double differential inclusive cross section (DDX) and the complete set of spin transfer coefficients (D_{ij}) at energies of 350–400 MeV, taking account of one- and two-step processes. The DDX for $(p, p'x)$ on ^{40}Ca at 392 MeV is calculated and compared with experimental data. The calculated D_{ij} and the DDXs for (p, nx) on ^{12}C and ^{40}Ca at 346 MeV for the emission angle of 22° are compared with the measured ones. Features of the calculated D_{ij}, the contribution of two-step processes in particular, are discussed in terms of the comparison with those of the DDX. The calculated DDX and D_{ij} are analyzed in terms of the choice of the bare NN force on which the effective interaction is based, the difference in the methods of the calculation of G matrices, and the in-medium modification of effective interactions.

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V-A-2

Continuum Cross Sections for Proton-induced Reactions on Biologically-Important Target Nuclei

G.F. Steyn[†], A.A. Cowley[‡], Y. Watanabe, Weili Sun[¶], S.V. Förtsch[†], and J.J. Lawrie[†]

A paper on this subject was published in *J. Nucl. Sci. and Technol.*, **Suppl. 2**, 291–294 (2002) with the following abstract:

Continuum spectra from the (p, p') reaction on ^{12}C, ^{14}N and ^{16}O at incident energies of 150 and 200 MeV have been measured at scattering angles of 20° to 150°. The angular distributions at several emission energies are compared with theoretical predictions by means of the semiclassical distorted wave (SCDW) model. It is found that a statistical multistep direct (MSD) interpretation is appropriate also for these very light target nuclei.

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V-A-3

Light Charged-Particle Production in Proton-Induced Reactions on ^{12}C, ^{27}Al, ^{58}Ni, ^{90}Zr, ^{197}Au, and ^{209}Bi at 42 and 68 MeV

M. Harada[†], Y. Watanabe, Y. Tanaka, Y. Matsuoka, K. Shin[‡], S. Meigo[†], H. Nakashima[†], H. Takada[†], T. Sasa[†], O. Iwamoto[†], T. Fukahori[†], S. Chiba[†], and S. Tanaka[†]

A paper on this subject was published in *J. Nucl. Sci. and Technol.*, **Suppl. 2**, 393–396 (2002) with the following abstract:

Double-differential cross sections (DDXs) have been measured for light-charged particle production in proton-induced reactions on ^{12}C, ^{27}Al, ^{58}Ni, ^{90}Zr, ^{197}Au, and ^{209}Bi at incident energies of 42 and 68 MeV. The measured DDXs for ^{12}C, ^{27}Al, and ^{58}Ni are compared with the LA150 evaluation. Good overall agreement is found except for the (p, xd) reaction. The dependence of total yields of secondary charged-particles on target mass number is investigated.

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[‡]Department of Nuclear Engineering, Kyoto University

V-A-4

Semiclassical Distorted Wave Model Analysis of Inclusive $(N, N'x)$ Reactions for Incident Energies up to 400 MeV

Y. Watanabe, Weili Sun[†], K. Ogata[‡], M. Kohno[*] and M. Kawai[¶]

A paper on this subject was published in *J. Nucl. Sci. and Technol.*, **Suppl. 2**, 750–753 (2002) with the following abstract:

The semiclassical distorted wave (SCDW) model with the Wigner transform of a one-body density matrix is applied to analyses of multistep direct processes in $(p, p'x)$ reactions on ^{12}C, ^{90}Zr, and ^{197}Au at incident energies near 150 MeV, and 392 MeV $(p, p'x)$ and 346 MeV (p, nx) reactions on ^{40}Ca. The calculations show good agreement with experimental double-differential cross sections over a wide mass range of target nuclei, except at backward angles.

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V-A-5

Calculation of Light-Hadron Induced Single-Event Upset Cross Section for Semiconductor Memory Devices

T. Ikeuchi, Y. Watanabe, Weili Sun†, and H. Nakashima

A paper on this subject was published in *J. Nucl. Sci. and Technol.*, **Suppl. 2**, 1380–1383 (2002) with the following abstract:

Light-hadron induced single-event upset (SEU) cross sections for semiconductor memory devices are calculated by the Burst Generation Rate (BGR) method using LA150 data and JQMD calculation in the incident energy range between 20 MeV and 3 GeV. The calculated results are compared with experimental SEU cross sections, and the validity of the calculation method and the nuclear data used is examined. The range of the incident energy and the atomic and mass numbers of the reaction products that provides the important effects on SEU are investigated.

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V-A-6

Uncertainty Analyses in the Resolved/Unresolved Resonance Regions

T. Kawano and K. Shibata†

A paper relating to this subject was presented at the 11th Int. Symp. on Reactor Dosimetry, 19–23 Aug. 2002, Brussels, Belgium, with the title of "Evaluation of Covariance Matrices for Resolved and Unresolved Resonance Regions," and the study on the resolved region part was published in *J. Nucl. Sci. Technol.*, **39**, 807–815 (2002), with the following abstract:

A simple method to estimate covariances for resolved resonance parameters was developed. Although a large number of resolved resonances are observed for major actinides, uncertainties in averaged cross sections are more important than those in resonance parameters in reactor calculations. The method developed here derives a covariance matrix for the resolved resonance parameters which gives an appropriate uncertainty of the averaged cross sections. The method was adopted to evaluate the covariance data for ^{235}U, ^{238}U, and ^{239}Pu resonance parameters in JENDL-3.2, with the Reich-Moore R-matrix formula.

† Japan Atomic Energy Research Institute

B. Department of Applied Quantum Physics and Nuclear Engineering

V-B-1

Light Output Responses of GSO(Ce) Scintillator to Protons and Deuterons

Fuminobu Saiho, Shinya Hohara, Tadahiro Kin, Katsuhiko Ikeda,
Yusuke Uozumi, Genichiro Wakabayashi, Masaru Matoba, Norihiko Koori[1]

We have measured statistically the preequilibrium reaction process by (p,p'x) and (p,dx)reaction in intermediate energy region using the cerium-doped gadolinium orthosilicate, Gd2SiO5-GSO(Ce) scintillation detector. In order to carry out energy calibration of the measured proton and deuteron spectra, the light output responses of the GSO(Ce) scintillator to protons and deuteron were investigated.

The beam experiment was performed using 400 MeV ^{4}He beam and 392 MeV proton beam from the ring cyclotron at the Research Center for Nuclear Physics (RCNP), Osaka University. Polyester target of 17.5 mg/cm^2 or CD_2 target of 50 mg/cm^2 were placed in the center of the scattering chamber. A stacked GSO(Ce) scintillator spectrometer was designed such that we could measure proton spectra up to 400MeV and identify particles. The size of GSO(Ce) scintillators used were 43 × 43 × 43 mm^3 for cube and 62mm in diameter and 120mm long for cylinder. The maximum energy deposited in a cubic GSO(Ce) crystal are 161 MeV and 215 MeV at a proton and a deuteron, respectively.

The energy dependence of the GSO(Ce) light output for protons and deuterons has been measured by using *pp*, *pd* and αd scattering. Fig. 1 shows the measured light output, in arbitrary units, as a function of the energy for protons and deuterons. The error bars of the present data correspond to FWHM of the peaks in measured energy spectra. The curves are results of calculations proposed by Birks[3] for inorganic scintillators. The light output per unit length, dL/dx, is defined as

$$\frac{dL}{dx} = \frac{S(dE/dx)}{1 + kB(dE/dx)} \tag{1}$$

where S is the absolute scintillation factor, BdE/dx represents the density of quenching centers per unit distance and k is a quenching parameter (kB is Birks parameter). The light output difference between the stopping and the penetrating particles has been reasonably described by Birks' formula. The parameters were obtained $S = 6.6$ (arbitrary unit) and $kB = 1.70 \times 10^{-5}$ (MeV/m)$^{-1}$ for both protons and deuterons. The parameters, S and kB, were not dependent on a particle.

Fig. 2 shows the energy spectra for 247 MeV monoenergetic protons and 256 MeV monoenergetic deuterons. A horizontal axis is the energy which changed the channel obtained by ADC by the relation between light output and energy in Fig. 1. The full energy peaks agree quite well with the energy calculated by elastic scattering calculation code.

References

[1] V.V. Avdeichikov, *et al.*, *J. Nucl. Instrum. Methods Phys. Res. A* **349**, 216 (1994).

[2] K. Anami, *et al.*, *J. Nucl. Instrum. Methods Phys. Res. A* **404**, 327 (1998).

[3] J. B. Birks, *The Theory and Practice of Scintillation Counting*, Pergamon Press, Oxford, 187 (1964).

[1]University of Tokushima

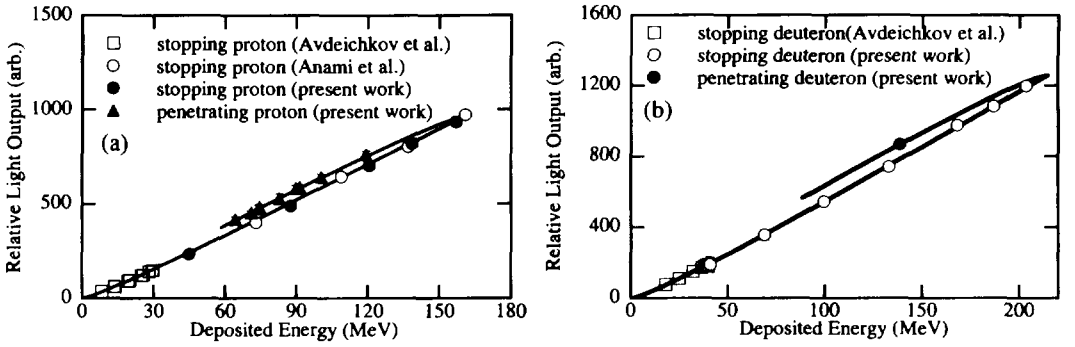

Figure 1: Light output of the GSO(Ce) to (a) penetrating prptons as well as stopping protons and (b) penetrating deuterons as well as stopping deuterons.

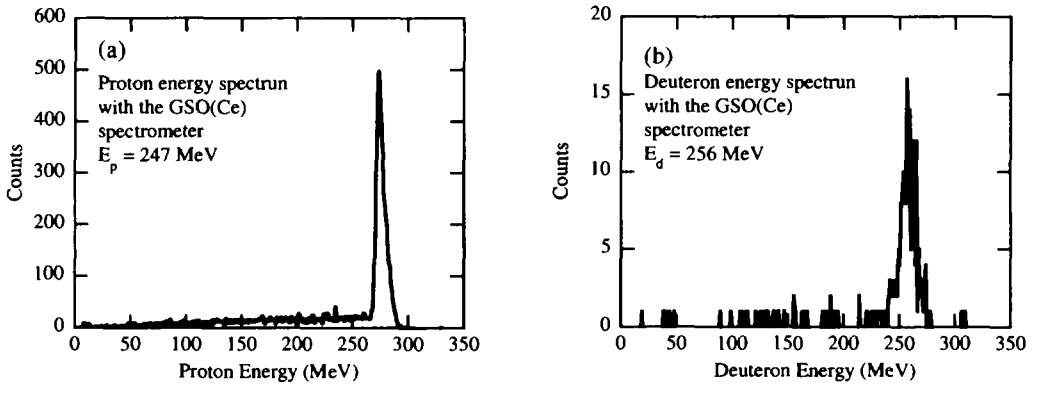

Figure 2: Energy spectrums for (a) 274 MeV monoenergetic protons and (b) 256 MeV monoenergetic deuterons

V-B-2

The Measurement of Proton Production Cross Section Induced by Intermediate Energy Protons

Tadahiro KIN, Fuminobu Saiho, Shinya HOHARA, Katsuhiko IKEDA, Fumiaki KONDO, Ikuo Fukuchi, Kiyohisa ICHIKAWA, Genichiro WAKABAYASHI, Yusuke UOZUMI, Nobuo IKEDA, Masaru MATOBA, Norihiko KOORI[1]

Recently, nuclear data which are measured by using intermediate energy accelerators are needed in many fields of engineering, medicine, science and so on. In particular, they are required to estimate exposed dose of human in the spacecraft and cancer therapy. However only few studies have so far been made at the intermediate energy region on (p,p'x) reaction. There are many simulation codes for nuclear reaction: for example INC, QMD and AMD etc. Especially, QMD model code is widely applied for not only simulation but also evaluation of nuclear data. But because of short of data, we don't confirm its accuracy well.

Therefore we measured the (p,p'x) reaction DDX of some targets at intermediate energy 300MeV and 392MeV and compared them with QMD and INC models calculation.

Measurements of proton production reactions were carried out at RCNP. Energy spectra of emitted protons were measured by using stacked scintillators detectors[1)], which were developed in our laboratory. In this work, we employed the JQMD code[2)] for the QMD model calculation. The INC code used presently was developed in our laboratory.

We compared the measured data with the QMD code. But the reproducibility or spectra are not very good. By using light targets, at forward angles, the width of a quasi-free peak is narrower than that of experiment and at backward angles, the simulated cross sections are smaller. Then we paid notice to the ground state in the QMD. Both of momentum and density distribute within narrower regions than that of measured one. To enlarge the distributions, we changed parameters of the density dependent potential for nucleon interactions. Standard and modified distributions of ^{9}Be are shown in **Fig.1**.

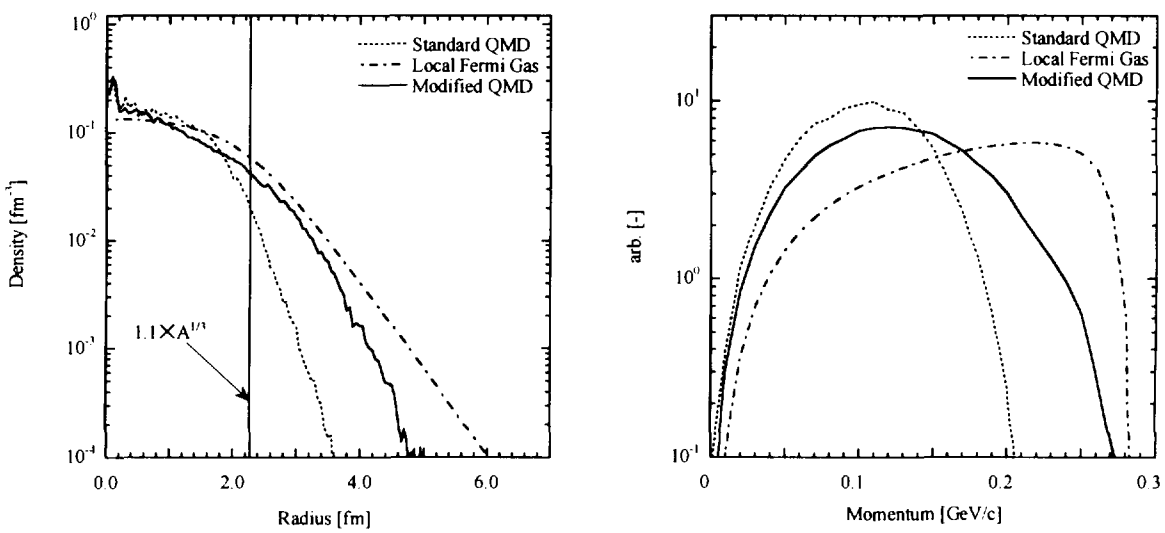

Fig.1 The Density and Momentum Distributions in ground state of ^{9}Be in modified and standard QMD

Energy spectra of ^{9}Be(p,p'x) induced by 392MeV protons with the standard and the modified QMD and the INC are shown in **Fig.2**. With the standard QMD at 50 and 45 degrees there are quasi-free peaks around 200 MeV and 150 MeV respectively but the measured spectra are smooth. With the modified QMD, energy spectra of ^{9}Be(p,'x) are better than the standard QMD in all angles. Especially the spectra

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of 50 and 60 degrees show good experiment reproducibility. With INC, at forward angles in lower energy range the cross sections are close to experiment value. At backward angles they resemble to the modified QMD. In particular the spectrum of 25 degrees shows good experiment reproducibility.

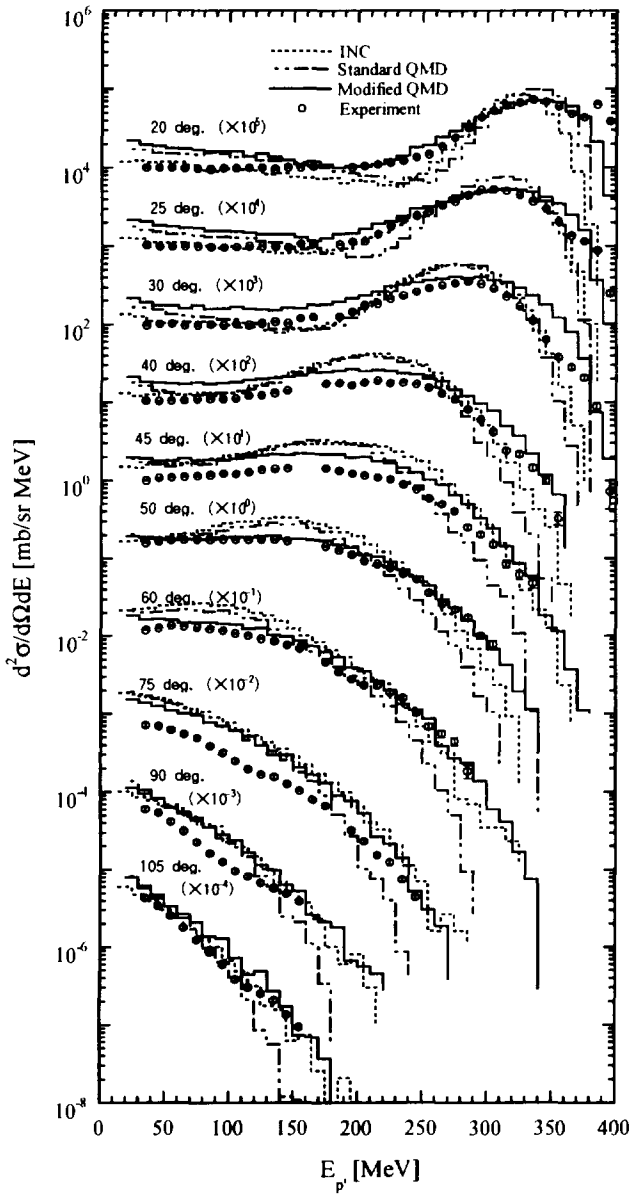

Fig.2 Energy Spectra of ^{9}Be(p,p'x) at 392 MeV

It is found that the theoretical spectra are sensitive to ground state parameters of the target nucleus. And with the INC code that we developed the experiment reproducibility is better than standard the QMD.

References

1) H. Yoshida, D. Konishi, K. Anami. *et.al.*, Nuc. Ins. **A** 411, 46 (1998).

2) K. Niita, S. Chiba, T. Maruyama, H. Takada, T. Fukahori, Y. Nakahara, and A.Iwamotohys. **C** 52, 2620 (1995).

VI. Nagoya University

A. Department of Energy Engineering and Science

VI-A-1

Measurement of activation cross-sections of (n, np+d) reactions producing short-lived nuclei in the energy range between 13.4 and 14.9 MeV using an intense neutron source OKTAVIAN

H. Sakane, Y. Kasugai[1], M. Shibata, T. Iida[2],
A. Takahashi[2], T. Fukahori[1] and K. Kawade

A paper on this subject was published in Annals of Nuclear Energy 29 (2002) 53-66, with the following abstract.

Activation cross sections for seventeen (n,np+d) reactions producing short-lived nuclei with half-lives between 42 s and 23 min, were measured in the energy range between 13.4 and 14.9 MeV by an activation method. The measured target isotopes were ^{26}Mg, ^{29,30}Si, ^{53,54}Cr, ^{67}Zn, ^{87}Sr, ^{98,100}Mo, ^{102}Ru, ^{105,106,108}Pd, ^{123}Te, ^{163}Dy, ^{179}Hf and ^{189}Os. Eleven cross sections for ^{26}Mg, ^{30}Si, ^{87}Sr, ^{100}Mo, ^{102}Ru, ^{105,106}Pd, ^{123}Te, ^{163}Dy, ^{179}Hf and ^{189}Os were obtained for the first time, and four cross sections for ^{53,54}Cr, ^{67}Zn and ^{108}Pd were obtained at six-point energies for the first time.

An intense 14 MeV neutron source, OKTAVIAN at Osaka University was used for irradiation. All cross section values were relatively obtained on the basis of the standard cross section of ^{27}Al(n,α)^{24}Na reaction (ENDF/B-VI). To obtain reliable neutron activation cross sections, careful attention was paid to neutron irradiation and induced activity measurement.

The present results were compared with the evaluated data in JENDL-3.2, JENDL-Activation File and ENDF/B-VI. The cross sections are underestimated for ^{102}Ru and ^{108}Pd in JENDL-3.2.

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VI-A-2

Q_β determination of neutron-rich isotope ^{144}La with a total absorption detector

M. Shibata, T. Shindoh, A.Taniguchi[1], Y. Kojima,
K. Kawade, S. Ichikawa, and Y.Kawase[1]

A paper on this subject was published in J. Phys. Soc. Japan, 71 (2002) 1401-1402.

The Q_β of the neutron-rich isotope ^{144}La (t1/2=40.8 s) produced with thermal neutron induced fission of ^{235}U was determined to be 5.54 (10) MeV with a total absorption detector composed of two large volume twin BGO scintillators (12 cm $^{\phi}$ x 10 cm^{t}) . Three different values of 5.3 (3) MeV, 4.3 (1) MeV and 5.882 (180) MeV were previously reported by using β–γ coincidence technique, which required the information of the decay schemes. However, unfortunately, their results were determined on the based on different decay schemes. The present method does not require the information of the decay scheme, so we believe that the present result is more reliable than the previous results.

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VI-A-3

Measurement of activation cross-sections of (n, np+d) reactions producing short-lived nuclei in the energy range between 13.4 and 14.9 MeV

H. Sakane, Y. Kasugai[1], M. Shibata, Y. Ikeda[1], K. Kawade

A paper on this subject was published in Annals of Nuclear Energy 29 (2002) 1209-1224, with the following abstract.

The Activation cross sections for nine (n,np+d) reactions were measured by an activation method in the energy range between 13.4 and 14.9 MeV. The irradiated targets were lanthanide isotopes: ^{146,148}Nd, ^{152}Sm, ^{155,158}Gd, ^{164}Dy, ^{170}Er, and ^{174,176}Yb. The cross sections, except for ^{170}Er were obtained for the first time. The D-T neutron source of the fusion neutronics source (FNS) at the Japan Atomic Energy Research Institute was used for irradiation. All cross section values were determined relative to that of the ^{27}Al(n,α)^{24}Na reaction (ENDF/B-VI). To obtain reliable activation cross sections, careful attention was paid to the corrections of the neutron irradiation and induced activity measurement, as well as the effective neutron energy determination at the irradiation positions. To measure weak activities, a high efficient measuring technique with a well-type HPGe detector was applied.

The present results were compared with the comprehensive evaluated data in JENDL-3.2, JENDL-Activation File, ENDF/B-VI and FENDL/A-2.0. The most of evaluated were overestimated or by more than 30%. Especially, there were the large underestimations for ^{164}Dy, ^{170}Er, ^{174}Yb and ^{176}Yb in FENDL/A-2.0.

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VI-A-4

Decay scheme of ^{126}La isomers

Y. Kojima*, M. Asai[1], M. Shibata, K. Kawade,
A. Taniguchi[2]A. Osa[1], M. Koizumi[1] and T. Sekine[1]

A paper on this subject was published in Appl. Radiat. Isot. 3 (2002) 187-190 with the following abstract

The decay of ^{126}La has been studied using the isotope separator on-line connected to an AVF cyclotron. For the ^{126}La radioactive sources produced by the ^{94}Mo (^{36}Ar, 3pn) reaction. γ-γ singles, γ-γ angular correlation and internal conversion electron measurements were carried out. From analysis of these data, 138 new γ-transitions were found for the decay of ^{126}La, and the decay scheme containing 137 γ-rays and 50 excited states was constructed. The probable spin and parity of the two b-decaying states in ^{126}La were found to be $4^{\pm}$, $5^{\pm}$ for the high-spin isomer with a half-life of 52(2) s and $0^{\pm}$, $1^{\pm}$, $2^{\pm}$ for the low-spin isomer with a half-life far shorter than 50 s.

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VI-A-5

Decay studies of neutron-deficient Am, Cm, and Bk nuclei using an on-line isotope separator

M. Asai[1], M. Sakama[2], K. Tsukada[1], S. Ichikawa[1], H. Haba[1], I. Nishinaka[1], Y. Nagame[1], S. Goto, K. Akiyama[1], A. Toyoshima[1], Y. Kojima[3], Y. Oura[4], H. Nakahara[4], M. Shibata and K. Kawade

A paper on this subject was published in J. Nucl radiochem.Sci., 56 (2002) 543-556 with the following abstract.

The EC and α decays of neutron-deficient Am and Cm nuclei have been using a gas-jet coupled on-line isotope separator. Decay schemes of the EC decay of ^{235,236}Am have been constructed, and weak α decays of ^{233,235,236}Am and ^{237,238}Cm have been observed. The efficiency of the on-line mass separation of Bk nuclei was measured to be ~1%. The Q_α values, α-decay partial half-lives, and proton-neutron configurations are discussed.

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VI-A-6

Performance of the multiple target He/PbI_2 aerosol jet system for mass separation of neutron-deficient actinide isotopes

S. Ichikawa[1], K. Tsukada[1], M. Asai[1], H. Haba[1], M. Sakama[2], Y. Kojima[3], M. Shibata, Y. Nagame[1], Y. Oura[4], K. Kawade

A multiple target He/pbI_2 aerosol jet system coupled with a thermal ion source was installed in the isotope separator on line (JAERI-ISOL) at the JAERI tandem accelerator facility. The neutron-deficient americium and curium isotopes produced in the $^{233,235}U$ (^{6}Li, xn) reactions were successfully mass-separated and the overall efficiency including the ioization of Am atoms was evaluated to be 0.3-0.4%. The identification of a new isotope ^{237}Cm with the present system is reported.

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VII. National Defense Academy

A. DEPARTMENT OF MATHEMATICS AND PHYSICS

VII-A-1

Valence-Model Calculation of Low-Energy Neutron Capture Cross Sections of ^{9}Be and ^{12}C

Takayuki Matsushima, Hideo Kitazawa, Masayuki Igashira[1], and Toshiro Ohsaki[1]

A paper of this title will be published in the Proc. 11th Int. Symp. on Capture Gamma-Ray Spectroscopy and Related Topics (Prague, 2002) with the following abstract.

We have calculated potential-capture cross sections of ^{9}Be and ^{12}C for low-energy neutrons, using the valence-capture model in the reactance matrix representation. The calculations are in satisfactory agreement with observed non-resonance capture cross sections of those nuclei.

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VII-A-2

Valence Process in Coherent Resonance and Non-Resonance Neutron Capture on ^{16}O

Hideo Kitazawa, Takayuki Matsushima, Masayuki Igashira[1], and Toshiro Ohsaki[1]

A paper of this title will be published in the Proc. 11th Int. Symp. on Capture Gamma-Ray Spectroscopy and Related Topics (Prague, 2002) with the following abstract.

The valence model in the reactance matrix representation is used for the calculation of low-energy neutron capture on ^{16}O. The results reproduce successfully an observed interference between the 434-keV $p_{3/2}$-wave resonance and non-resonance neutron capture processes.

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VIII-A-1

CHARACTERIZATION OF A THERMAL NEUTRON FIELD AT THE HEAVY WATER NEUTRON IRRADIATION FACILITY OF THE KYOTO UNIVERSITY REACTOR (II)

A. Uritani, C. H. Pyeon, K. Kudo, T. Yoshimoto[1], K. Kobayashi[1],
Y. Sakurai[1] and T. Kobayashi[1]

1. Introduction

The Heavy Water Neutron Irradiation Facility (HWNIF) at the Kyoto University Reactor (KUR) has been utilized since 1964 for many research fields such as physics, engineering, biology and so on. In 1996 the HWNIF was updated mainly for boron neutron capture therapy (BNCT). The main feature of the new facility is that it can provide both a thermal neutron field and an epi-thermal neutron field, or a mixed field of these two. The details of the facility and the fundamental characteristics of the neutron field were well described in the references [1, 2].

Prior to BNCT it is necessary to make a treatment plan for each patient for an effective therapy. It is desired to measure neutron flux distributions in a phantom for making the treatment plan, because the distribution and the intensity may vary due to reactor conditions or physical features of the patients. A gold wire or foil activation method is usually used for this purpose. It takes, however, long time to obtain the distribution. It is also desired to continuously monitor the neutron flux intensity in the vicinity of a tumor that is irradiated. Gold foils or wires, and TLD elements cannot be used for real time monitoring but only for integrated neutron fluence. In this paper we describe an application of a small neutron probe for these purposes.

2. Neutron Probe Detector

The probe detector used in this work was originally developed by C. Mori *et al.*[3] The detector consists of an optical fiber and a small neutron probe. The neutron probe is made of ZnS(Ag) scintillator and neutron converter, such as ^{6}Li or ^{235}U for thermal neutrons, and ^{232}Th or ^{238}U for fast ones. The powder of ZnS(Ag) and an appropriate neutron converter are mixed and bound with transparent adhesive material. The bound mixture is attached to an end surface of the optical fiber. The scintillation light photons are transmitted through the fiber and detected by a photomultiplier that is connected to the other end of the fiber. Because the probe is very small (less than about 1mm) and an active electronic circuit is

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not necessary near the probe, it can be used in small spaces, high radiation fields, or in fields where neutron flux distributions are disturbed by the existence of normal-size detectors. The small probe does not disturb the neutron field so much. The probe is mechanically moved so that neutron flux distribution can be obtained. The spatial resolution is almost the same to the physical dimension of the probe.

One of the problems of this detector is that the detector is sensitive to gamma rays or electrons because the energy deposited by an high-energy electron is considerably high, roughly on the order of a few tens to several hundreds keV, and is not far smaller than that deposited by an alpha particle and/or a triton that are nuclear reaction products of $^{6}Li(n, \alpha)t$. Although the Q-value of this reaction is 4.78 MeV, the apparent deposited energy in the probe is less than this value because of self-absorption within the LiF grains and opacity of the ZnS(Ag) scintillator. The pulse height spectrum of gamma-ray events and that of neutron ones overlap each other and cannot clearly be separated by an ordinary pulse height discrimination method. It was, therefore, necessary to conservatively set the discrimination level high enough to cut all gamma-ray or electron induced events. Another problem is that the pulse height spectrum of the probe is monotonically decreasing shape as shown in Fig.1. It is difficult to set the discrimination level at exactly same point at different runs for such a pulse height spectrum.

Kawata *et al.*[4] have proposed to use a thin ZnS(Ag) layer that is deposited on a transparent backing sheet. The scintillator is so thin that electrons cannot deposit high energy, a few tens keV at most. A thin plate or film of LiF is put on the ZnS(Ag). Figure 2 shows the pulse height spectrum of the new probe that a LiF thin plate with a thickness of 300 μm is contacted to the ZnS(Ag) layer with a thickness of 25 μm deposited on a cellulose acetate sheet with a thickness of 12 μm. The pulse height spectrum was taken at the mixed neutron and gamma-ray field of the HWNIF. The electron induced events could clearly be distinguished from the neutron induced ones. The shape of the pulse height spectrum of neutron events became rather flat and distinction between the gamma-ray events and neutron events was clear. It is, therefore, easier to set the discrimination level for different experiment runs.

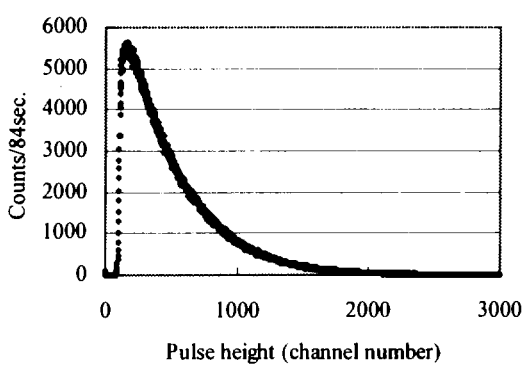

Fig.1. Pulse Height Spectrum of the Old-Type Neutron Probe.

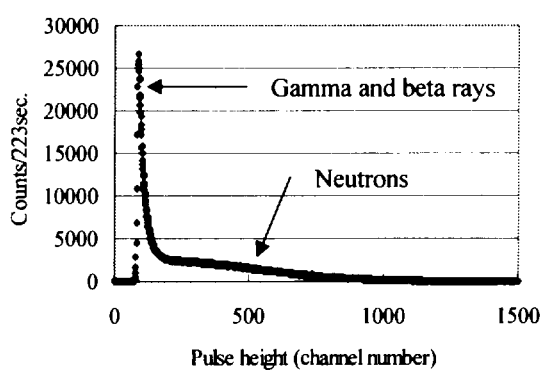

Fig. 2. Pulse Height Spectrum of the New-Type Neutron Probe.

3. Measurement of Thermal Neutron Flux Distribution

The neutron flux distributions were measured with the probe at three different positions; 1) in front of the Bi filter, 2) at the aperture of the clinical collimator, and 3) in a phantom placed in front of the clinical collimator. The phantom consisted of acrylic resin frames with a thickness of 3 mm and water inside the frame. The dimension of the phantom was 180 mm in diameter and 200 mm in length. In case 3), the relative thermal neutron flux distributions were also obtained with numerical calculations.

Figure 3 shows the thermal neutron flux distribution in front of the Bi filter. Figure 4 shows the thermal neutron flux distribution in front of the clinical collimator. It took only about ten minutes to

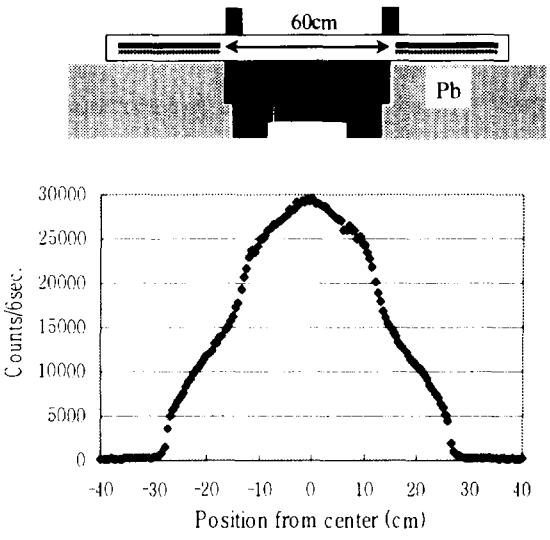

Fig.3. Thermal Neutron Flux Distribution in Front of the Bi Filter.

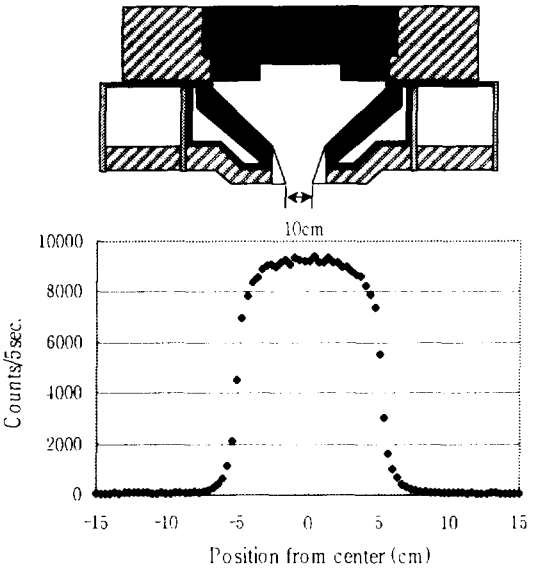

Fig.4. Thermal Neutron Flux Distribution in Front of the Clinical Collimator.

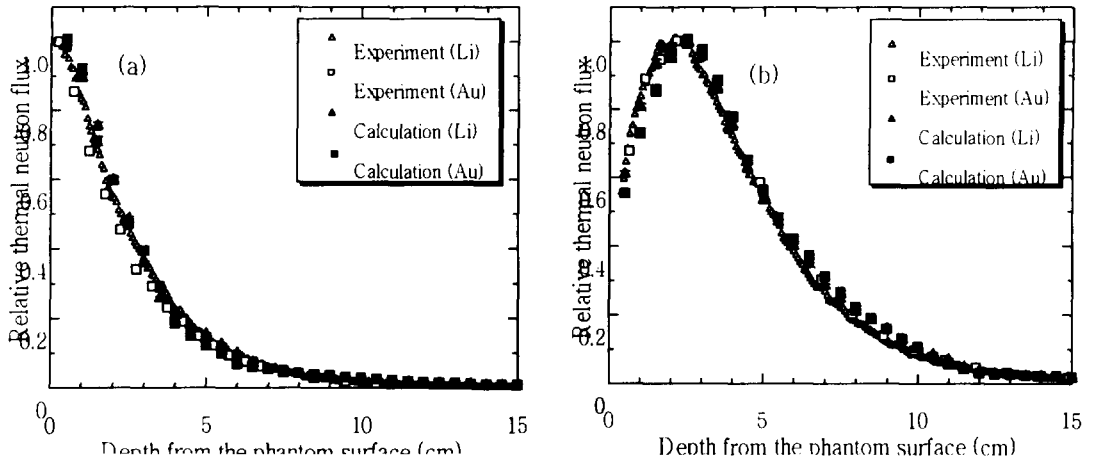

Fig. 5.Thermal Neutron Distribution Obtained with Experiments and Calculations under (a) Thermal and (b) Epi-Thermal Neutron Irradiation Mode.

obtain each profile. Figure 5 shows the thermal neutron flux distribution in the phantom region along the axial direction measured with the probe under the thermal and the epi-thermal neutron irradiation modes. Also shown in Fig. 5 are the thermal neutron flux distributions measured with the conventional gold wire activation method. For the thermal neutron irradiation mode, a bare gold wire with a diameter of 0.25 mm was used. The data obtained with the gold activation method for the epi-thermal neutron irradiation mode were taken from the reference[2]. The thermal neutron flux distributions obtained with the present probe and the gold wire activation method agreed well each other for both the thermal and the epi-thermal irradiation modes. If the absolute value must be measured with the probe detector, it should be calibrated before the measurement.

The numerical calculations were executed for the case 3 with the Monte Carlo calculation code MVP.[5] In the MVP calculation, the neutron spectrum[1] was given beforehand by the neutron transport calculation with 10-energy-group. The Cadmium subtraction technique, which was used in the experiments, was also used in the calculation for the Au wire under the epi-thermal neutron mode. For the thermal neutron irradiation mode, the experimental and calculated results agrees well as are seen in Fig.5(a). On the other hand for the epi-thermal irradiation mode, the calculated result for the Au wire are slightly different from other three results as shown in Fig. 5(b). It is considered that this discrepancy is related to the MVP calculation where the 10-energy-group are used. Although the gigantic resonance peak of the Au neutron capture cross section plays an important role in reaction of the gold wire, the effect of the resonance might not be handled properly in the calculation.

4. Summary

Several thermal neutron flux distributions at the HWNIF were measured with the small neutron probe detector that adopted the thin ZnS(Ag) layer instead of powder. The new probe detector was superior to the old one as regards the gamma-ray discrimination ability. The distributions obtained with the probe detector and those with the gold activation method agreed well each other. On the other hand the distribution obtained with the Monte Carlo calculation was slightly different from the experimental ones especially for the epi-thermal irradiation mode due to some problems of the calculation condition.

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IX. Osaka University

A. Department of Nuclear Engineering

IX-A-1

Measurement of (n,2n) reaction cross section using a 14MeV pencil beam source

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The (n,2n) reaction is of primary interest in the application for fusion reactors, because it is neutron multiplication reaction and has a large cross section value for light and heavy nuclides in the energy range of several MeV to 14MeV. In the past (n,2n) reaction cross section measurements, the foil activation method was generally used, and some other nuclide-dependent special methods such as the detection of charged-particles emitted following the (n,2n) reaction were used.

In the present experiment, a beam-type (2cm ϕ -collimated) DT neutron source at fusion neutron source (FNS) of JAERI was used, because we could arrange neutron detectors very close to the sample without any shielding. Two spherical NE213 (40mm ϕ) detectors were located at 10cm from the sample as shown in Fig.1. As the sample, a cylindrical manganese (1.5cm ϕ × 3cm long), the (n,2n) cross section of which was measured precisely with the foil activation method, was used to check the experimental method. Neutrons from (n,2n) reaction were measured with the coincidence detection technique and n/γ pulse shape discrimination technique. The former is a technique to selectively measure two particles emitted simultaneously such as two neutrons from (n,2n) reaction. The latter technique was employed to exclude coincident signals of nγ and $\gamma\gamma$ pairs through nuclear reactions by discriminating γ-ray signals with the rise-time spectrum of anode signals. The dynode signals were measured to obtain the neutron pulse height spectrum (PHS). The PHS was unfolded with FORIST code to convert it to energy spectrum. From the measured spectrum, slight forward angular distribution was seen, and integral cross section was fairly good agreement with JENDL fusion file.

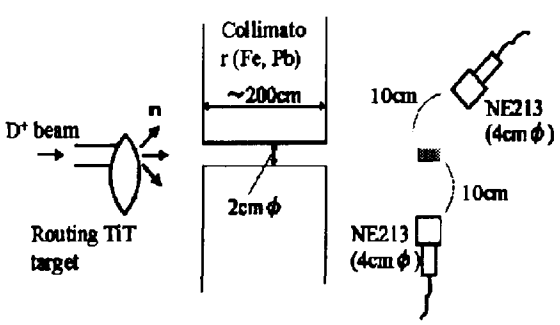

Fig.1 experimental arrangement

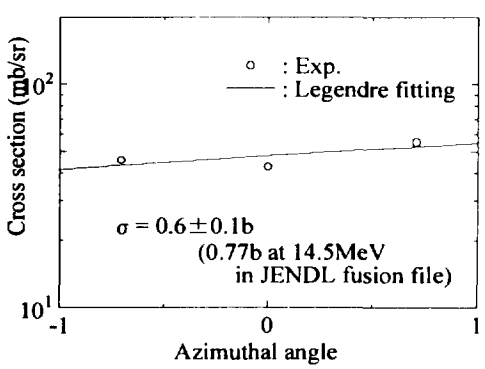

Fig.2 Measured angular distribution of Mn(n,2n) reaction cross section

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B. Faculty of Science

IX-B-1

Gamow-Teller Transitions from ^{23}Na to ^{23}Mg

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At intermediate energies ($\geq$ 100 MeV/nucleon) and at forward angles including 0°, Gamow-Teller (GT) states become prominent in (^{3}He, t) reactions, because of their $L = 0$ nature and the dominance of the $\sigma\tau$ part of the effective nuclear interaction [1]. In order to study the transitions to the GT states in ^{23}Mg, a ^{23}Na(^{3}He, t) experiment was performed at RCNP, Osaka by using a 140 MeV/nucleon ^{3}He beam from the $K = 400$, RCNP Ring Cyclotron and the Grand Raiden spectrometer [2] placed at 0°.

In order to make a thin Na target, an innovative method was used. The target was a thin foil of Na_2CO_3 using polyvinylalcohol as supporting material [3]. The total thickness of the target was approximately 2 mg/cm^2. The target is effectively a mixture of ^{23}Na, carbon isotopes ^{12}C and ^{13}C (natural abundance 98.9% and 1.1%, respectively), and oxygen isotopes ^{16}O and ^{18}O (natural abundance 99.8% and 0.2%, respectively). After the (^{3}He, t) charge-exchange reactions, these nuclei become ^{23}Mg, ^{12}N, ^{13}N, ^{16}F, and ^{18}F. The reaction Q values of them are $-4.08, -17.36, -2.24, -15.44$, and -1.67 MeV, respectively. Owing to the large difference of Q values, the low-lying states in ^{23}Mg are observed without being affected by the strongly excited states in ^{12}N and ^{16}F. Since the Q values of ^{13}C and ^{18}O nuclei are smaller than that of ^{23}Na, ground and excited states of ^{13}N and ^{18}F may disturb the ^{23}Mg spectrum. The identification of these states and the states of ^{23}Mg was possible due to the high resolution of this experiment.

A resolution far better than the momentum spread of the beam was realized by applying the *dispersion matching* technique [4]. Using the new high-resolution "WS" course [5] for the beam transportation and the "faint beam method" to diagnose the matching conditions [6, 7], an energy resolution of 45 keV [full width at half maximum (FWHM)] was achieved. With the improvement of resolution, states of ^{23}Mg up to $E_x = 11$ MeV were clearly resolved as shown in Fig. 1.

In accurately determining the scattering angle Θ near 0°, scattering angles in both x direction (θ) and y direction (ϕ) should be measured equally well, where Θ is defined by $\sqrt{\theta^2 + \phi^2}$. Good θ resolution was achieved by applying the *angular dispersion matching* technique [4], while that of ϕ by realizing the "over-focus mode" in the spectrometer [8]. The "0° spectrum" in Fig. 1 shows events for the scattering angles $\Theta \leq 0.8°$.

In order to identify the states originating from carbon and oxygen isotopes, a spectrum of a Mylar target was measured under the same condition as for the Na_2CO_3 target. From a comparison of both spectra, it was found that the peak at $E_x \approx 1.7$ MeV in Fig. 1 was the 3.50 MeV state of ^{13}N, and the peak at $\approx$ 10.1 MeV was partly the ^{13}N, 11.74 MeV state. It was also found that the small tail in the right side of the 6.91 MeV state was the 8.92 MeV state of ^{13}N. The peaks at $E_x \approx 11.4$ MeV and 11.8 MeV were identified as the ground and the 0.42 MeV states in ^{16}F. The ^{18}F ground state ($J^\pi = 1^+$) was also

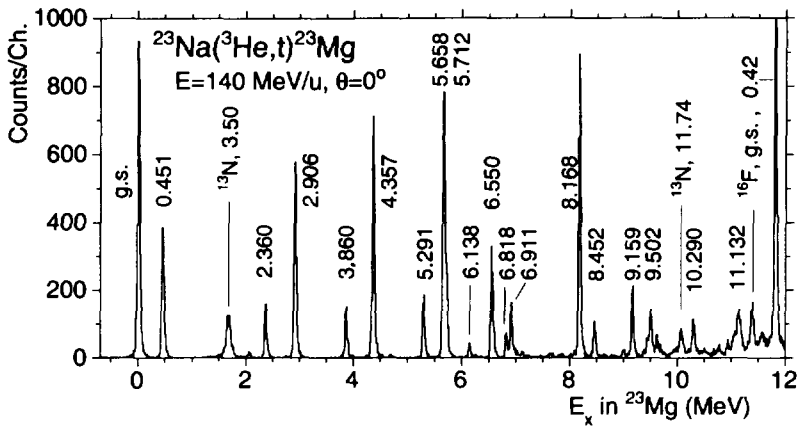

Figure 1: The ^{23}Na(^{3}He, t) spectrum measured at 0° by using a thin Na_2CO_3 target. A high resolution of 45 keV has been achieved. The states listed in Table 1 are indicated by their excitation energies. The 3.50 MeV state in ^{13}N is also indicated. For other details, see text.

observed, but it is outside the energy range of the spectrum due to the small Q value of the reaction.

An accurate E_x value is known only for the 0.451 MeV state of ^{23}Mg [9]. The E_x values of other excited states observed here were determined with the help of kinematic calculations. Known states of ^{13}N [10] and ^{16}F [11], which were observed in the spectrum of Mylar target, and the ^{26}Al states, which were observed in the ^{26}Mg(^{3}He, t)^{26}Al spectrum taken under the same condition as for the Na_2CO_3 target, were used as calibration standard. Owing to the small Q value of the (^{3}He, t) reaction on ^{13}C and the large Q value on ^{16}O, all E_x values of ^{23}Mg states were determined by interpolation. In addition, since the Q value of the (^{3}He, t) reaction on ^{26}Mg ($Q = -4.02$ MeV) is similar to that on ^{23}Na ($Q = -4.08$ MeV) and accurate E_x values of ^{26}Al states are known up to $E_x = 7.8$ MeV, E_x values of states up to 8 MeV in ^{23}Mg were determined especially with good accuracy. The excitation energies from Ref. [9] and those determined in the present work are listed in Column 4 and 6 of Table 1, respectively.

The intensities of individual peaks were obtained by applying a peak-decomposition program using the shape of the well separated peak at 4.357 MeV.

Owing to the *angular dispersion matching* and also to the overfocus mode of the spectrometer setting, it is estimated that an angle resolution of better than 8 mr was achieved [8]. In order to identify the $L = 0$ nature of states, relative intensities of peaks were examined for the spectra with the angle cuts $\Theta = 0° - 0.5°$, $0.5° - 1.0°$, $1.0° - 1.5°$, and $1.5° - 2.0°$. It was found that all states, except the 6.138 MeV state, listed in Table 1 showed a similar relative decrease of their strengths with increasing Θ. We judge that transitions to all of these states, except that to the 6.138 MeV state, are of $L = 0$ nature.

It is known that at 0° the CE cross section for a GT transition is approximately proportional to B(GT) [12],

$$\frac{d\sigma_{\rm CE}}{d\Omega}(0°) \simeq K\ N_{\sigma\tau}\ |J_{\sigma\tau}(0)|^2 B({\rm GT}), \tag{1}$$

Table 1: The GT transition strengths B(GT) from ^{23}Mg→^{23}Na β-decay and ^{23}Na(^{3}He, t)^{23}Mg reaction. Mirror symmetry of transition strengths is assumed in deriving the latter from the former. For details of the derivation, see text. Excitation energies are given in units of MeV, and their errors are given in units of keV in parentheses.

States in ^{23}Na			States in ^{23}Mg			
		β-decay			(^{3}He, t) [a]	
E_x [b]	$2J^\pi$ [b]	B(GT) [b]	E_x [b]	$2J^\pi$ [b]	E_x	B(GT)
0.0	3^+	0.190 ± 0.004	0.0	3^+	0.0	(0.340 ± 0.014)[c]
0.440	5^+	0.146 ± 0.006[d]	0.451	5^+	0.451	0.146 ± 0.006[d]
2.391	1^+	0.043 ± 0.006	2.359(2)	1^+	2.360(3)	0.055 ± 0.004
			2.908(3)	$(3,5)^+$	2.906(3)	0.193 ± 0.011
			3.864(4)	$(3,5)^+$	3.860(3)	0.055 ± 0.004
			4.354(4)	1^+	4.357(3)	0.250 ± 0.013
			5.287(4)	$(3,5)^+$	5.291(3)	0.066 ± 0.005
			5.656(6)	5^+	5.658(4)	0.270 ± 0.017[e]
			5.691(6)	$(1-9)^+$		
			5.711(6)	$(1-9)^+$	5.712(8)	0.061 ± 0.009[e]
			6.125(5)	$(1-11)^-$	6.138(3)	
			6.538(5)	$(1-9)^+$	6.550(3)	0.116 ± 0.007
			6.810(5)		6.818(3)	0.028 ± 0.003
			6.899(4)	5^+	6.911(3)	0.057 ± 0.004
			8.166(2)	5^+	8.168(4)	0.290 ± 0.015
			8.455(4)	$(3-13)^+$	8.452(5)	0.039 ± 0.003
			[9.138(6)]	$(3-13)^+$	9.159(6)	0.069 ± 0.005
			[9.465(6)]	$(1-9)^+$	9.502(6)	0.055 ± 0.004
					10.290(7)	0.046 ± 0.004
					11.132(8)	0.062 ± 0.005

[a]Present work.
[b]From Ref. [9].
[c]Including Fermi-transition strength. See text for details.
[d]B(GT) value used for the calibration of (^{3}He, t) values.
[e]Close doublet states.

where $J_{\sigma\tau}(0)$ is the volume integral of the effective interaction $V_{\sigma\tau}$ at momentum transfer $q = 0$, K is the kinematic factor, $N_{\sigma\tau}$ is a distortion factor. In (^{3}He, t) reactions, it was shown that the proportionality was valid for the transitions with B(GT) ≥ 0.04 from the study of analogous transitions in $A = 27$, $T = 1/2$ mirror nuclei ^{27}Al and ^{27}Si [13].

It is known that the product $KN_{\sigma\tau}$ in Eq. (1) gradually changes as a function of excitation energy [12]. To estimate this effect, a DWBA calculation was performed by using the code DW81 [14] and assuming a simple $d_{5/2} \rightarrow d_{3/2}$ transition for the excited GT states.

In order to obtain B(GT) values by using Eq. (1), a standard B(GT) value is needed. As a standard, we used the B(GT) value of 0.146 obtained in the β-decay from the ^{23}Mg ground state to the 0.440 MeV state of ^{23}Na (see columns 1 and 3 of Table 1). Due to isospin symmetry of mirror nuclei, it is expected that the B(GT) values of mirror transitions are the same. We assumed that the transition to the 0.451 MeV state in ^{23}Mg have this B(GT) value in the ^{23}Na(^{3}He, t) reaction. The B(GT) values for other excited states were calculated by using the proportionality [Eq. (1)] from their peak intensities after excitation-energy correction was made. The resulting B(GT) values are listed in column 7 of Table 1.

Further discussions on the B(GT) strengths and the comparison with analogous $B(M1)$ strengths are found in Ref. [15].

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X. Tohoku University

A. Cyclotron and Radioisotope Center

X-A-1

Experimental studies on the neutron emission spectrum and induced radioactivity of the ^{7}Li(d,n) reaction in the 20-40 MeV region

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N. Kawata, A. Yamadera, H. Orihara

A paper of the title was published in J.Nuclear Material, **307-311** 1715-1718 (2002) with the following abstract :

To improve the data accuracy of the neutron emission spectrum of the ^{7}Li(d,n) reaction and the radioactivity (^{7}Be, ^{3}H etc) accumulated in the ^{7}Li target in IFMIF, we have measured the neutron emission spectrum and the radioactivity of ^{7}Be induced in the lithium target for 25 MeV deuterons at the Tohoku University AVF cyclotron (K=110) facility.

Neutron spectra were measured with the time-of-flight method at four laboratory angles by using a beam swinger system and a well collimated time-of-flight channel. Induced radioactivity was measured by detecting the gamma-rays from ^{7}Be with a pure Ge detector.

Experimental results are compared with other experimental data. The present result of neutron emission spectra are in qualitative agreement with other experimental data but that of ^{7}Be production was much larger than expected by the recent codes. Measurement will be extended to several incident energies up to 40 MeV.

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X-A-2

Experiments on Neutron Scattering and Fission Neutron Spectra

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H. NAKASHIMA[1], S. MEIGO[1], Su. TANAKA[2]

A paper of the title was published in the J. Nucl. Sci. and Technol. Supplement 2 (August 2002), p. 421-424, with the following abstract:

Experiments on the 1) neutron elastic scattering for 55, 65 and 75 MeV neutrons, and 2) prompt fission neutron spectrum for MeV neutrons are described. The neutron elastic scattering cross sections have been measured for C, Si, Fe, Zr, and Pb at the ^{7}Li(p,n) quasi-monoenergetic neutron source facility at TIARA, JAERI using the TOF method. Data were obtained at twenty-five laboratory angles between 2.6° and 53° that could clarify the angular distributions and angle-integrated values. Fission spectrum data were obtained for ^{233}U, ^{238}U and ^{232}Th at 0.6, 1.9 and 4.1 MeV. The data at 1.9 and 4.1 MeV were given in absolute scale by taking the ^{238}U data as the standard to clarify the problem of data files.

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2)Takasaki Establishment, Japan Atomic Energy Research Institute

X-A-3

Measurements of Fast Neutron-induced Prompt Neutron Fission Spectra of ^{233}U, ^{238}U and ^{232}Th

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A paper of the title was published in the J. Nucl. Sci. and Technol, Supplement 2 (August 2002), p. 409-412, wit the following abstract:

Prompt fission neutron spectra of ^{233}U, ^{238}U and ^{232}Th for mono-energetic fast neutrons were measured by usingthe time-of-flight (TOF) method at Tohoku University 4.5 MV Dynamitron accelerator facility. Data were obtained for at En=0.55, 1.9, 4.1 MeV, at En=1.9, 4.1 MeV, and at En=4.1 MeV using solid samples. The data of ^{233}U, ^{238}U and ^{232}Th were obtained in absolute scale (mb sr^{-1} MeV^{-1} by normalizing the data to the ^{238}U spectrum as a standard.

X-A-4

Double Differential Hydrogen and Helium Production Cross Section of Oxygen and Nitrogen for 75 MeV Neutrons

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A paper of the title was published in the J. Nucl. Sci. and Technol, Supplement 2 (August 2002), p. 204-209 wit the following abstract:

Double differential (n,xp), (n,xd), (n,xt) and (n,xa) cross section of oxygen and nitrogen were measured for 75 MeV incident neutrons at 25^0, 65^0 and 125^0 angles using a specially designed spectrometer. The spectrometer has three counter telescope consisting of a low pressure gas proportional counter, a thin SSD and a BaF_2 scintiulator. The energy dependence of the BaF_2 was calibrated with direct proton, deuteron and helium beams. The results were compared with the LA-150 data library. The library represent the experimental results of proton, triton and a-particle generally well, but shows the marked difference in the high energy part of deuteron one.

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X-A-5

Measurement of Neutron Non-elastic Cross Sections of C, Si, Fe, Zr and Pb in 40-80 MeV Region

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A paper of the title was published in the J. Nucl. Sci. and Technol, Supplement 2 (August 2002), p. 406-409, wit the following abstract:

Neutron non-elastic cross sections were measured for carbon, silicon, iron, zirconium and lead in 40-80 MeV region using the transmission method with a "close-geometry" using the quasi-monoenergetic neutron source at TIARA of JAERI. The results were favorably compared with other experimental data and the libraries.

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XI-1

Neutron Economy and Nuclear Data for Transmutation of Long-Lived Fission Products

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A paper of the title was published in Progress in Nuclear Energy, **40**, 555 (2002) with the following abstract.

In the study of Self-Consistent Nuclear Energy System, the following 29 long-lived fission products (LLFPs) have been selected to be transmuted into stable or short-lived nuclides: ^{106}Ru, ^{102}Rh, ^{109}Cd, ^{125}Sb, ^{134}Cs, ^{146,147}Pm, ^{154,155}Eu, ^{171}Tm, ^{85}Kr, ^{90}Sr, ^{93m}Nb, ^{113m}Cd, ^{121m}Sn, ^{137}Cs, ^{151}Sm, ^{152}Eu, ^{108m}Ag, ^{158}Tb, ^{166m}Ho, ^{79}Se, ^{93}Zr, ^{94}Nb, ^{99}Tc, ^{107}Pd, ^{126}Sn, ^{129}I, ^{135}Cs. In the present study, the number of neutrons necessary for the transmutation of the 29 LLFPs with an FBR was evaluated, and the present status of the (n,γ) and (n,2n) cross section data of the 29 LLFPs in JENDL-3.2 and ENDF/B-VI was investigated. The main results of the present study are as follows: (1)only 0.25 neutron per fission is necessary for the transmutation of the 29 LLFPs with isotopic separation, whereas 6.8 neutrons are necessary with chemical separation, (2)the accuracy of the cross sections is 30 to 100 % except for the (n,γ) cross sections of limited nuclides in limited incident neutron energy regions.

XI-2

Capture Cross Section Measurements of ^{161}Dy and ^{162}Dy in the Energy Region between 10 keV and 90 keV

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A paper of the title was published in J. Nucl. Sci. Technol., Supplement **2**, 303 (2002) with the following abstract.

The neutron capture cross sections of ^{161}Dy and ^{162}Dy have been measured in te neutron energy region from 10 to 90 keV, using the 3-MV Pelletron accelerator of the Research Laboratory for Nuclear Reactors at the Tokyo Institute of Technology. Puled keV neutrons were produced from the ^{7}Li(p,n)^{7}Be reaction by bombarding the lithium target with the 1.5-ns bunched proton beam from the Pelletron accelerator. The incident neutron spectrum on a capture sample was measured by means of a TOF method with a ^{6}Li-glass detector. Capture γ-rays were detected with a large anti-Compton NaI(Tl) spectrometer, employing a TOF method. A pulse-height weighting technique was applied to oberved capture γ-ray pulse-height spectra to derive capture yields. The capture cross sections were obtained by using the standard capture cross sections of ^{197}Au. The present results were compared with the previous measurements and the evaluated values of ENDF/B-VI.

XI-3

Comparison of Nuclear Reactions in Nuclear Energy Systems and in the Universe

T. Ohsaki and M. Igashira

A paper of the title was published in J. Nucl. Sci. Technol., Supplement **2**, 573 (2002) with the following abstract.

A similarity was studied between the production/transmutation process of fission products in a fast reactor and that of the s-process nucleosynthesis in a star. A long-period burnup calculation of fission products was performed with the one-group approximation to obtain the fission products distribution in an equilibrium state. The obtained fission products distribution was compared with the s-process products distribution, and similar structures were found in both the products distributions.