14. Current status of Nuclear Reaction Data File for Astrophysics (NRDF/A)

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Abstract

Recent activities in JCPRG for compilations of EXFOR and Nuclear Reaction Data File (NRDF) have been introduced. As an extension of such activities, a preparation of new nuclear data libraries: Nuclear Reaction Data File for Astrophysics (NRDF/A) has been planned. The framework of the data table has been almost built. As the next step, evaluations by using cluster models have been planned.

Introduction

The main activity of JCPRG is compilation of experimental nuclear reaction data. Compilation works of observed data are done in the following steps: compilers input bibliography, experimental condition and numerical data from experiment and complete the EXFOR compilations. This is usually done within few weeks after publications of the articles if they agree with JCPRG responsibility of compilations. If the numerical data are not available from authors, we make digitization of the figures of experimental data. As the next step, we transmit compiled data to IAEA Nuclear Data Section. After that, EXFOR reviewers check the compiled data and obtain author's proof. Finally, the nuclear data in the articles will be released about six month after publication. The total number of charged particle reaction experiments for EXFOR compilation is about 3000. Our compilations contribute about 10 percent of the whole EXFOR data.

Besides EXFOR, we have been developing the original format, Nuclear Reaction Data File (NRDF). Recently, the charged-particle nuclear data become more and more important, due to the increase of astrophysical interest and medical use. By using NRDF, we can specifically treat physical quantity even if they correspond to the integrated cross section (which astrophysical and medical applications usually use) or nuclear structure data (typically differential cross section). The NRDF format has flexibility which does not much depend on characteristic data in fields of study because of its large capacity of construction of compilation codes.

Astrophysical nuclear reaction is one of the applications of NRDF where the nuclear network calculation plays an important role [1]. For such reactions, we focus on neutrons, protons, alpha, gamma, or neutrino as incident or emitted particles. To study the evolution of the early universe, the reactions concerning with light nuclei below the pf shell are important. Some of these astrophysical reactions occur at very low temperature, which are difficult to reproduce by experiments because of the very small reaction rates. The evaluations based on the theoretical calculations are indispensible to make up for the experiments. NACRE (Nuclear Astrophysics Compilation of Reaction rates) is one of the most widely used evaluated astrophysical nuclear reaction data base [2]. However, it becomes much better to take into account the most recent experimental data and use more sophisticated calculation in order to obtain more reliable evaluation.

Construction of the data table

We construct a new database for this study: we call this file as Nuclear Reaction Data File for Astrophysics (NRDF/A). In the previous version of NRDF/A (2006), we have assembled only 31 reactions for nuclei from C to Mg. In the present new version (2008), the astrophysical important light nuclei up to Si are included to achieve the coverage for NACRE. As a result, the number of reactions to be compiled is about 200.

We are planning to use cluster model calculations for evaluation. As one of such models, we use Anti symmetric Molecular Dynamics (AMD) [3]. This can be a good candidate for the models because of its wide scope of application below the pf shell nuclei. Here, we can treat two important pictures, shell model like configuration and cluster configuration by taking proper parameters for effective nuclear interactions.

Before making the evaluation, we are now preparing the data table. For each reaction, we search for the corresponding articles in order to obtain the numerical data for future works of evaluation. Here, we utilize the bibliographic information from Nuclear Science References (NSR) of National Nuclear Data Center (NNDC). The data table consists of reaction information, energy range, information of physical quantity and bibliographic information.

In the reaction information, energy ranges are given in addition to reaction equations. We also compile how the physical quantities (cross section, reaction rate, S-factor, spectrum, electro-magnetic transition strength and log(ft)) are obtained. Here, we must notice that the numerical values have not been compiled at the present stage. In compensation, we distinguish the analyzed, deduced, measured and calculated data. The bibliographic information consists of key-number, journal name, volume number, publications year and author name. For the convenience, we make the link to pdf files of articles by using digital object identifier (D.O.I.) if it is available.

In order to choose the articles which are needed to assemble the numerical data for the evaluation, we check the NRDF/A against EXFOR. This is because that we would like to directly use the numerical values which is already appears in EXFOR. For this purpose, we put the coverage information against EXFOR into each data set. After construction of the data table including numerical values, the evaluation based on cluster model will be performed.

References

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Table 1 Example of data table in NRDF/A

reaction	energy-min	energy-max	cross-section	S-factor	key-numbe	article	volume	page	year	first author
6Li(p,g)7Be	*8E+03	*1.3E+05		ded	2004PR09	PR/C	70	55801	2004	R.M.Prior
6Li(p,g)7Be	*1E+03	*1E+07	ana		2004MUZX	INDC(JPN)/U	192	156	2004	T.Murata
6Li(p,g)7Be	*8E+05		mes		2000SK02	ref[a]	5	198	2000	E.Skreti
6Li(p,g)7Be	*8E+04	*1.1E+05			2000KEZY	ref[b]		42	2000	J.H.Kelley
6Li(p,g)7Be				cal	2000BA09	PR/C	61	25801	2000	D.Baye
6Li(p,g)7Be	Not given	*2E+06			1997NO04	PR/C	56	1144	1997	K.M.Nollett
6Li(p,g)7Be	Not given				1996RE16	APP/B	27	231	1 6	H.Rebel 99
6Li(p,g)7Be		*8E+04		ded	1996LA10	PR/C	53	1977	1996	C.M.Laymon
6Li(p,g)7Be	*3E+04	*1.8E+05	mes	mes	1993BRZQ	ref[c]		169	19 3	R.Bruss 9
6Li(p,g)7Be	*4E+04	*1.8E+05		ded	1992CE02	NP/A	539	75	1992	F.E.Cecil
6Li(p,g)7Be	*4E+04	*1.8E+05			1991CEZZ	BAP	36	No.4, 1242, B10 12	1991	F.E.Cecil
6Li(p,g)7Be			cal		1990KUZW	ref[d]		90	1990	P.D.Kunz
6Li(p,g)7Be	*5E+05	*1E+06			1987TI05	AJP	40	319	1987	C.I.W.Tingwell
6Li(p,g)7Be	Not given				1983SEZT	BAP	28	No.7,965,AB7	1983	R.G.Seyler
6Li(p,g)7Be	*4E+05	*1.1E+06	*mes *cal		1983OS04	NC/A	76	73	1983	R.Ostojic
6Li(p,g)7Be	*2E+05	*1.2E+06	*mes		1979SW02	NP/A	331	50	1979	Z.E.Switkowski
6Li(p,g)7Be	*2E+05	*1.2E+06	mes		1978SWZZ	REPT UM-P	88	23	1978	Switkowski
6Li(p,g)7Be	low		cal		1974BAXA	REPT CONF	740218	36	1974	
6Li(p,a)3He	*9E+04	*5.8E+05	mes	ded	2008CR02	JP/G	35	14004	2008	J.Cruz
6Li(p,a)3He	low		ana	ana	2003SP02	NP/A	719	9 9 c	2003	C.Spitaleri
6Li(p,a)3He	low		ana		2002BA77	NP/A	707	277	2002	F.C.Barker
6Li(p,a)3He		1E+06		ana	1998AN18	NP/A	639	733	1998	C.Angulo
6Li(p,a)3He		*2E+06			1997NO04	PR/C	56	1144	1997	K.M.Nollett
6Li(p,a)3He		5E+05			1997BO12	NP/A	617	57	1997	Y.Boudouma
6Li(p,a)3He	Not given				1997BA95	NP/A	627	324	1997	A.B.Balantekin
6Li(p,a)3He	1E+04	1.004E+06	*mes	ded	1992EN01	PL/B	279	20	1992	S.Engstler
6Li(p,a)3He	*1.8E+05	*2.8E+05			1991BU14	NIM/A	301	383	1991	L.Buchmann
6Li(p,a)3He	*1.68E+08	*2.01E+08	*mes		1987BIZY	ref[e]		E82	1987	L.Bimbot
6Li(p,a)3He	*4.78E+07	*6.25E+07	*mes		1984NE05	YF	40	43	1984	O.F.Nemets
6Li(p,a)3He	*4E+09		*mes		1979FR12	PR/C	20	2257	1979	S.Frankel
6Li(p,a)3He	*1E+06	*2.6E+06	*mes		1977LI01	NP/A	275	93	1977	C.-S.Lin
6Li(p,a)3He	*4.5E+07		*mes		1972DE01	NP/A	178	417	1972	R.M.Devries
6Li(p,a)3He	*4.5E+07		*mes		1972BU16	JCP	50	1295	1972	S.N.Bunke
6Li(p,a)3He	*1.51E+05	*3.17E+05	*mes ded		1971SP05	NP/A	164	1	1971	H.Spinka
6Li(p,a)3He	*1.51E+05	*3.17E+05	*mes ded		1971SP05	ref[f]	196	6 34	1972	H.Spinka
6Li(p,a)3He	*4.5E+07		*mes		1971BU24	NP/A	178		1983	S.N.Bunker
6Li(p,a)3He	*4.5E+07		*mes ded		1971BR12	PR/C	3	1771	1971	K.H.Bray
6Li(p,a)3He	*6.65E+08		mes		1970KO25	YF	11	711	1970	V.I.Komarov
6Li(p,a)3He	*6.65E+08		mes		1970KO25	Sov.J.Nucl.Phys	11	399	1970	V.I.Komarov
6Li(p,a)3He	*1.36E+06		mes		1969LE08	NIM	69	115	1969	G.M.Lerner
6Li(p,a)3He	*2.3E+04	*5E+04	*mes		1967FI05	NP/A	96	513	1967	O.Fiedler
6Li(a,g)10B	Resonance				2004GYZZ	ref[g]			2004	Gy.Gyurky
6Li(a,g)10B	*1.17E+06	*1.185E+06			2004GY02	EPJ/A	21	355		Gy.Gyurky
6Li(a,g)10B		*2E+06			1997NO04	PR/C	56	1144	1997	K.M.Nollett
6Li(a,g)10B	Not given				1996RE16	APP/B	27	231	1 6	H.Rebel 99
6Li(a,g)10B	*1.085E+06	*1.175E+06	*mes		1989BA24	NP/A	499	353	1989	A.K.Basak
6Li(a,g)10B	*1.276E+06		mes		1987MU13	PRL	59	1088	1987	D.E.Murnick
6Li(a,g)10B	*1E+06	*18E+06			1986MYZZ	BAP	31	No.4, 787, BI5	1986	E.G.Myers
6Li(a,g)10B		*3.7E+06	ana		1986CE05	NIM/A	245	547	1986	F.E.Cecil
6Li(a,g)10B	Resonance				1985NE05	PR/C	31	2295	1985	J.E.Nelson
6Li(a,g)10B	*1.03E+06	*1.2E+06			1984NA07	NP/A	417	289	1984	J.Napolitano
6Li(a,g)10B	Resonance				1983NAZZ	BAP	28	No.4, 650, AG4	1983	J.Napolitano
6Li(a,g)10B	*1.14E+06	*1.25+E06	*mes		1979SP01	NP/A	318	21	1979	R.H.Spea

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