Report on the 7th DAE-BRNS Workshop on EXFOR Compilation of Nuclear Data

SINGH Jagjit
Meme Media Laboratory, Nuclear Reaction Data Centre, Faculty of Science, Hokkaido University

Abstract

In this report, contents of 7th DAE-BRNS Workshop on Compilation of Experimental Nuclear Data, are discussed. This workshop is aimed towards making EXFOR entries and in nurturing the EXFOR data compilation activity of the Nuclear Data Physics Center of India (NDPCI) along with training attendees over the compilation of data with series of lectures and seminars.

1 Introduction

Seventh DAE-BRNS Workshop cum Theme meeting on EXFOR compilation of experimental nuclear data is jointly organized by the Nuclear Data Physics Center of India (NDPCI), BRNS-DAE, Mumbai and Department of Physics, North-Eastern Hill University (NEHU), Shillong, Meghalaya, India. India is a member of the Nuclear Reaction Data Center network of 12 Nations. A server in BARC, Mumbai [2], is at present mirroring the nuclear data services (NDS) of IAEA, Vienna [1]. EXFOR, one of the nuclear data bases of NDS is used for the compilation of the published experimental nuclear reaction data for incident neutron, gamma radiation and charged particles on various targets. EXFOR database has wide applications for nuclear data evaluators, applied users, theoretical nuclear physicists and experimentalists. NDPCI, with active support from DAE-BRNS has successfully conducted, six EXFOR training workshops at BARC, Mumbai (2006, 2007), University of Rajasthan, Jaipur (2009), Panjab University, Chandigarh (2011), Banaras Hindu University, Varanasi (2013) and Bangalore University, India (2015) respectively where nuclear scientists, university faculty, research scholars and students took active part. This workshop was held in NEHU and is the first in East India.

EXFOR is an international effort under the auspices of NRDC, IAEA towards exhaustive collection and dissemination of experimental nuclear data. India is one of the member states of NRDC and has been actively contributing to EXFOR database through Nuclear Data Physics Centre of India (NDPCI), which is the nodal centre of nuclear data activity in India. This 7th DAE-BRNS Workshop on Compilation of Experimental Nuclear Data (EXFOR-2017), was attended by 40+ participants from various parts of India, IAEA and JCPRG, Japan. This report presents the briefs of 7th DAE-BRNS Workshop on Compilation of Experimental Nuclear Data (EXFOR-2017). The report is organized as follows: section 2 describes the objectives of workshop. Section 3 describes the main topis discussed by various resource persons from the Austria and India. Section 4 presents the report on Indian EXFOR compilation activities. Finally, section 5 presents conclusions.

2 Objectives

- Scope, contents, objectives and importance of EXFOR database.
- Indian nuclear data mirror website of NDS.
- Basic introduction: How to use EXFOR.
- Editor and Digitization software for EXFOR applications.
- Indian nuclear physics and nuclear data experiments.
- Tutorials and EXFOR coding exercises.
- Creation of new EXFOR entries and their review.
- Practical computer sessions with feedback.

3 Main Topics of the Agenda

3.1 Introduction to IAEA Nuclear Data Services

Figure 1: International Atomic Energy Agency (IAEA) Nuclear Data Services (NDS) web page snapshot [1].

In first lecture **N. Otsuka** briefly introduced about the IAEA Nuclear Data Services. The various data bases available are shown in Fig 1. The biblographic data bases are Computer Index of Nuclear Reaction Data (CINDA) and Nuclear Science References (NSR). The bibliography of measured, calculated, reviewed and evaluated cross-sections and other microscopic neutron data is indexed in CINDA. CINDA database is extended by photo nuclear and charged particle reaction data, since 2005. This data base is managed by NDS, International Atomic Energy Agency, Vienna, Austria. The bibliography of nuclear physics articles of more than 80 journals, of past 10 decades is indexed in NSR data base. This data base is managed by National Nuclear Data Center (NNDC), Brookhaven National Laboratory, USA. The Experimental Nuclear Reaction Data (EXFOR) and Evaluated Nuclear Data File (ENDF) are nuclear reaction data bases. The compiled experimental neutron nuclear reaction data, since the discovery of neutron is contained in EXFOR data base. As per statistics on 10 May, 2017, EXFOR library contains data from 21623 experiments. Evaluated cross sections, spectra, angular distributions, fission product yields, photo-atomic and thermal scattering law data, with emphasis on neutron induced reactions is maintained in ENDF data base.

The data were analyzed by experienced nuclear physicists to produce recommended libraries for one of the national nuclear data projects (USA, Europe, Japan, Russia and China). These data bases are managed by NDS, International Atomic Energy Agency, Vienna, Austria. He also briefly introduced about Evaluated Nuclear Structure Data File (ENSDF) and Live Chart of Nuclides.

3.2 Introduction to EXFOR

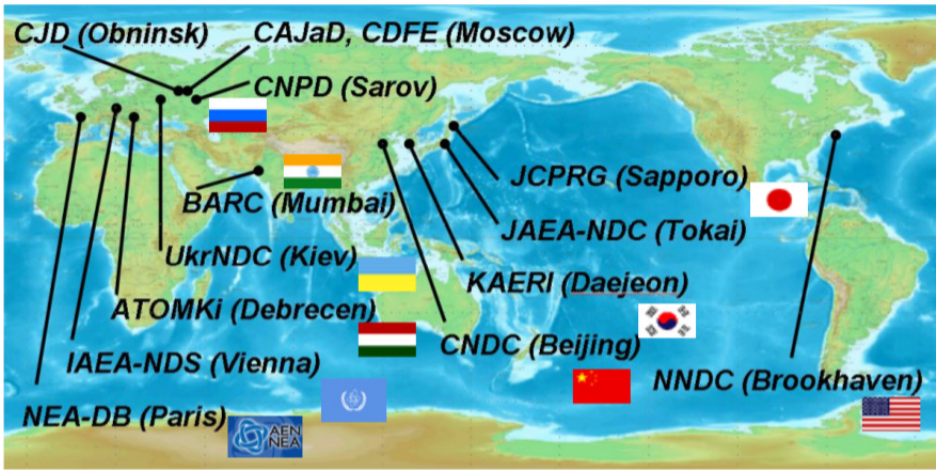

Figure 2: The International network of Nuclear Reaction Data Centers (NRDC) across the world under auspices of Nuclear Data Services (NDS)- Atomic Energy Agency (IAEA) [1].

The second lecture of **N. Otsuka** was devoted towards introduction to EXFOR. 12 centres from 8 countries (China, Hungary, India, Japan, Korea, Russia, Ukraine, USA) and 2 international organisations (NEA, IAEA) are collaborating for EXFOR compilation under the auspices of IAEA NDS. Indian Centre (NDPCI, coordinated by Prof. A. Saxena, BARC) is responsible to neutron, charged-particle and photonuclear reaction data measured in India. He put light on statistics of experiments of EXFOR- compilation. He also explained the scope of EXFOR compilation along with very minute details of an EXFOR entry.

3.3 EXFOR/ENDF database

Third lecture of **N. Otsuka** was devoted towards EXFOR/ENDF data base. In this lecture he described the various aspects of EXFOR/ENDF data base along with full fledge exercise session. This lecture was really successful in the sense that, attendees got their hand over extracting data of cross section from EXFOR data base and comparison with Evaluated Data Libraries.

3.4 EXFOR Comiplation

Last lecture of **N. Otsuka** was devoted towards compilation of an common article for all attendees to have hand on the EXFOR editor. He explained all the sections of an EXFOR entery very detailed manner to train new compilers.

3.5 Introduction of GSYS 2.4.7 Digitizer

This lecture was given by one of former colleague from JCPRG **Vidya Devi**. She explained installation of GSYS 2.4.7, introduced the digitization of numerical data, symmetric, asymmetric

error and output with very detailed manner in an exercise session.

3.6 Checking tools and finalization of an EXFOR entry

This session was taken by **B. Lalremruata**. He explained very common errors which one can case during compilation, like Illegal reaction pointer(Editor Specific error), Nonmonatonic data field, WARNING Extinct code found etc. He also explained very briefy the checking tools, CHEX and Janis Trans Checker.

3.7 Other topics covered

There are other wide variety of interesting lectures by various resource persons given. **D. Raj** reported about Nuclear Data and Its Application in Nuclear Fuel Cycles along with brief introduction of Indian nuclear reactors.
G. Mukhrjee reported about ENSDF another data base.
P. K. Joshi reported about how to handle statistical data.

4 A Status report on Indian EXFOR compilation activities

This session was reported by **B. K. Nayak**, to conclude the workshop. Figure **??** reports the contribution from India to EXFOR, in last couple of years. In this biannual workshop at NEHU, 40+ new Indian articles are compiled. He also took feedback from attendees for improvement of the organization of future workshops. In nut shell this workshop was really successful in learning new things about EXFOR compilation.

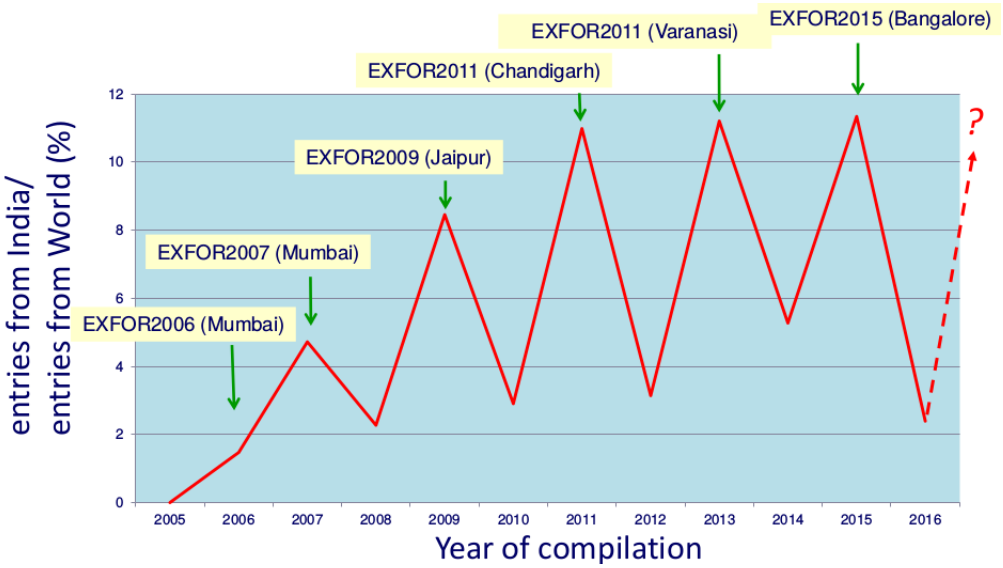

Figure 3: Contribution from India to EXFOR (Figure taken from slides presented by N. Otsuka in EXFOR-2017).

Figure 4: All resource persons of the EXFOR-2017.

Figure 5: Lectures in progress.

5 Summary

This workshop has drifted the nuclear data compilation activity and have resulted in substantial contributions to the IAEA-EXFOR database as well as encouraged Indian nuclear physicists to endeavor for international reckoning by making EXFOR compilation as an integral part of their research.

Acknowledgment

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References

[1] https://www-nds.iaea.org/.

[2] https://www-nds.indcentre.org.in/.

Annex. I

List of participants

Name	Affiliation
A. Bhattacharya	Bhabha Atomic Research Centre, Mumbai, India
V. Mishra	Banaras Hindu University, Varanasi, India
N. K. Rai	BanarasHindu University, Varanasi, India
A. Gandhi	Banaras Hindu University, Varanasi, India
A. Sharma	IET Bhaddal, Punjab, India
D. Choudhury	Saha Institute of NuclearPhysics, Kolkata, India
Imranpasha	Bangalore University, Bangalore, India
J. Singh	Nuclear Reaction Data Centre, Hokkaido University, Japan.
J. Gangadharan K	National Institute of Technology, Calicut, India
K. M. Eshwarappa	Government First Grade College, India
M. R. Karkera	Manipal University, Karnataka, India
Muhammed Shan P T	University of Calicut, India
M. R. Srinivasan	Ramaiah University ofApllied Sciences, India
R. Lalnuntluangi	Mizoram University, Aizawl, India
Rudraswamy B	Bangalore University, Bangalore, India
Sachhidananda H B	Siddaganga Institute ofTechnology, Tumakuru, India
T. K. Rana	Variable Energy Cyclotron Cenre, India
S. Kundu	Variable Energy Cyclotron Cenre, India
S. Biswas	Murshidabad College of Engineering and Technology, India
V. D. Bharud	Savitribai Phule Pune University, India
S. Parashari	Maharaja Sayajirao University, Baroda, India
J. Acharya	Maharaja Sayajirao University, Baroda, India
T. Selwyn G	Madras Christian College, University of Madras, India
S. Subramanian	V. O. Chidambaram College, India
N. Kalita	Assam Don Bosco University, India
M. P. Bora	Assam Don Bosco University, India
N. K. Deb	Guwahati University, India
M. Rahman	Assam Don Bosco University, India
N. Otsuka	International Atomic Energy Agency (IAEA), Vienna, Austria
D. Raj	Bhabha Atomic Research Centre, Mumbai, India
V. Devi	IET Bhaddal, Punjab, India
G. Mukherjee	Variable Energy Cyclotron Cenre, India
P. K. Joshi	Homi Bhabha Centre for Science Education (TIFR), India
B. K. Nayak	Bhabha Atomic Research Centre, Mumbai, India
S. Mukherjee	Bhabha Atomic Research Centre, Mumbai, India
D. Suchiang	Tura Govt. College, Tura, Meghalaya, India
E. M. L. Buam	St. Marys College, Shillong, Meghalaya, India

Annex. II

PROGRAM

March 06	**Monday**
09 : 00 – 09 : 30	Registration
9 : 45 – 10 : 45	Inaugural Session
10 : 45 – 11 : 15	Tea/Coffee break
11 : 15 – 12 : 00	Lecture on Nuclear Data and Its Application in Nuclear Fuel Cycles, by D. Raj (BARC)
12 : 00 – 13 : 00	Lecture on Introduction to IAEA Nuclear Data Service, by N. Otsuka (IAEA-NDS)
	Exercise on NSR and Live Chart of Nuclides, by N. Otsuka (IAEA-NDS)
13 : 00 – 14 : 00	Lunch break
14 : 00 – 16 : 00	Lecture on Introduction to EXFOR, by N. Otsuka (IAEA-NDS
	Lecture on EXFOR/ENDF database, by N. Otsuka (IAEA-NDS)
16 : 00 – 16 : 30	Tea/Coffee break
16 : 30 – 18 : 00	Exercise on EXFOR/ENDF database, by N. Otsuka (IAEA-NDS)
18 : 00 – 20 : 00	Cultural Program
20 : 00	Dinner
March 07	**Tuesday**
09 : 30 – 10 : 30	Lecture by Dr. Gopal Mukhrjee (VECC)
10 : 30 – 11 : 00	Tea/Coffee break
11 : 00 – 13 : 00	Lecture on EXFOR FORMATS, by N. Otsuka (IAEA-NDS)
13 : 00 – 14 : 00	Lunch break
14 : 00 – 16 : 00	Lecture/ Exercise-EXFOR Editor + Common Article(RG- Compiling Subentry1)
16 : 00 – 16 : 30	Tea/Coffee break
16 : 30 – 18 : 30	Lecture/ Exercise-EXFOR Editor + Common Article (SB-Compiling Subentry2)
18 : 30 – 19 : 30	Assignment of articles to participants for new Indian entries
	Exercise-Compilation of new articles
19 : 30	Dinner
March 08	**Wednesday**
09 : 30 – 10 : 30	Lecture on how to handle statistical data by Dr. P. K. Joshi (TIFR)
10 : 30 – 11 : 00	Tea/Coffee break
11 : 00 – 13 : 00	Lecture/ Exercise- Digitization by V. Devi (IET-Bhaddal)
13 : 00 – 14 : 00	Lunch break
14 : 00 – 16 : 00	Exercise-Compilation of new Indian Articles
16 : 00 – 16 : 30	Tea/Coffee break
16 : 30 – 17 : 00	Lecture Checking tool and finalization by B. Lalremruata (Mizoram University)
17 : 00 – 19 : 30	Exercise Compilation of new Indian articles (ALL)
19 : 30	Dinner

Annex. II (contd..)

PROGRAM

March 09	**Thursday**
09 : 30 – 10 : 30	Lecture by Dr. Gopal Mukhrjee (VECC)
10 : 30 – 11 : 00	Tea/Coffee break
11 : 00 – 13 : 00	Exercise Compilation of new Indian articles (ALL)
13 : 00 – 14 : 00	Lunch break
14 : 00 – 16 : 00	Exercise Compilation of new Indian articles (ALL)
16 : 00 – 16 : 30	Tea/Coffee break
16 : 30 – 19 : 30	Exercise Compilation of new Indian articles (ALL)
19 : 30	Dinner
March 10	**Friday**
09 : 30 – 10 : 30	Exercise Compilation of new Indian articles (ALL)
10 : 30 – 11 : 00	Tea/Coffee break
11 : 00 – 13 : 00	Exercise Compilation of new Indian articles (ALL)
13 : 00 – 14 : 00	Lunch break
14 : 00 – 16 : 00	Exercise Compilation of new Indian articles (ALL)
16 : 00 – 16 : 30	Tea/Coffee break
16 : 30 – 19 : 30	Concluding Session
19 : 30	Dinner