2020年秋の大会

Computational Science and Engineering Division Session

International Framework for Utilization of Computer Codes and Databases and its Future Evolution

(2) Nuclear Data Activities of the IAEA Nuclear Data Section

*Shin OKUMURA[1]

[1]NAPC-Nuclear Data Section, International Atomic Energy Agency

1. Introduction

The IAEA assists its Member States in using nuclear science and technology for peaceful purposes and facilitates the transfer of such technology and knowledge in a sustainable manner to Member States. The Nuclear Data Section (NDS) in the International Atomic Energy Agency (IAEA) is responsible for providing accurate and reliable nuclear data for nuclear energy and related application fields. The IAEA-NDS assembles, evaluates and recommends specific nuclear data, and also maintains nuclear structure, decay, and reaction databases, associated computer codes and infrastructures with collaborating actively with scientists from Member States. In this presentation, we describe recent activities in IAEA-NDS.

2. Nuclear Data/Database/Web Service

2-1. Medical Isotope Browser

The IAEA-NDS launch a new web application product, Medical Isotope Browser, for the prediction of medical isotope production yield of any diagnostic, therapeutic or theranostic isotope with accelerators. The Medical Isotope Browser gives a first guess to users who aim to find a new production route, an optimal incident energy, and so on. The isotope production yield can be calculated for any isotope production route for many targets, natural or enriched, reacting with incident protons, deuterons, tritons, helions or alpha particles. The Medical Isotope Browser can be reached via IAEA-NDS web site (https://nds.iaea.org/mib).

2-2. Experimental Nuclear Reaction Database

The experimental nuclear reaction data played crucial role in nuclear physics research and application development. The Experimental Nuclear Reaction Database (EXFOR database) is the publicly available large collection of experimental data which was established in 1967. Standardizing these experimental data formats promises to enable scientists to use for nuclear data evaluations, model predictions, or comparison of the experimental results across labs. The EXchange FORmat (EXFOR) is the exchange format for the transmission of data. These data have been compiled by a worldwide cooperation of 13 nuclear data centres, Nuclear Reaction Data Centres (NRDC) [1], under the auspices of the IAEA and been disseminated through the web-based user interface and an application programming interface [2]. The EXFOR database contains the nuclear reaction data of various nuclides with neutron-, proton-, photon-, and charged particles-induced reactions with low to high energies. The physical quantities are diverse, *e.g.* cross section, differential data with respect to angle, double differential cross section, resonance parameters, thick target yields, and fission observables such as fission product yields. The EXFOR database presently contains data from 23,577 experimental works.

2-3. Machine Learning Approaches to EXFOR Compilation Process

In order to reduce the amount of compilation work and to make it automated as possible in the future, IAEA-NDS took a first step to exemplify how advanced machine learning algorithms can be adopted to EXFOR data compilation process using open resources. The EXFOR compilation usually starts with identifying the relevant experimental work from publication web sites such as Physical Review C of American Physical Society

(https://journals.aps.org/prc/). The publication title is the principal information to identify a potential candidate of EXFOR relevant article. First, we tried a new approach to find potential EXFOR relevant articles with their titles only. Generally, such predictions rely on data mining, and the process of discovering patterns in large data sets using statistical methods is crucial. Fortunately, the EXFOR database contains all titles of original publications in their entries, so we put these titles as positive training examples by breaking the title into words. The algorithm generates the score based on the words constituting the titles of new publications.

3. Development of Nuclear Data

Nuclear data requirements are constantly monitored and identified through the International Nuclear Data Committee (INDC). A Coordinated Research Project (CRP) or Consultancy Meeting (CM) can be dedicated to the development and assembly of specific nuclear data files or database. Each CRP involves typically a period of 3-4 years with 5-15 scientists/groups from different countries working together to discuss the progress to deliver the products such as evaluated or recommended nuclear data library, decay data library, Reference Input Parameter Library (RIPL), and *etc*.

3-1. IAEA Photonuclear Data Library 2019

The first version of IAEA Evaluated Photonuclear Data Library was a product of a Coordinated Research Project (CRP) under the title "Compilation and Evaluation of Photonuclear Data for Applications" between 1996 and 1999 [3]. The new CRP was endorsed by the INDC meeting in 2014 and was initiated by the IAEA under the title "Updating the Photonuclear Data Library" [4]. All the 164 isotopes in the previous library were revised and re-evaluated and new evaluations were performed for another 37 isotopes for which experimental data are available, as well as for the 9 isotopes identified as relevant for medical applications. In IAEA Photonuclear data library 2019 (IAEA/PD-2019), 219 isotopes in total were evaluated and energies were extended up to 200 MeV [5]. Information is available on (https://nds.iaea.org/photonuclear/) and ENDF-6 format library data files can be retrieve from Github repository (https://github.com/IAEA-NDS/IAEA-PD2019).

3-2. New CRP on Fission Product Yield

Fission product yields (FPY) are important for both basic nuclear sciences and application fields. In basic sciences, FPY give fundamental aspects of the probability of fragment formation and therefore play an important role in our understanding of the nuclear fission process. FPY are also directly related to the understanding of the abundances of elements through the nucleosynthesis. In reactor design and operation, FPY are used in criticality and reactivity calculations performed for fuel and reactor core management, for reactor safety and for determining the limits of safe operation in new plants and for materials transport. The IAEA-NDS intends to start a new CRP on “Fission Yields of Actinides” in 2020. The experimental data are always been the foundation of the FPY data evaluations, where a complete set of the experimental FPY data are important as a common basis of new evaluation. Due to some reasons, many experimental FPY data have known to be missing in EXFOR. One of the reasons is because some FPY measurements have been classified and unclassified in recent years. Therefore, we conducted the completeness assessment of FPY data in EXFOR by comparison with the dataset used for ENDF-B/VI [6] and UKFY3.0 [7] evaluations. It was found that approximately 194 references are relevant to new compilation of EXFOR entry, and about 54 references must be checked with the existing EXFOR entries to ensure that the all experimental FPY data are properly compiled.

4. Conclusion

This presentation provides a summary of selected recent activities of IAEA-NDS. The IAEA-NDS assembles, develops, evaluates and recommends nuclear data, and maintains and disseminates the data libraries and

databases. The IAEA-NDS launch Medical Isotope Browser which calculates and visualizes isotope production yield. The IAEA-NDS has maintained EXFOR database with Nuclear Reaction Data Centres (NRDC) under the auspices of the IAEA. The IAEA-NDS took a first step to test the machine learning algorithms using EXFOR data as the feasibility study. The IAEA Photonuclear Data Library 2019 has been released as a result of CRP. New CRP on fission product yield will be launch in 2020.

References

[1] N. Otuka, E. Dupont, V. Semkova, B. Pritychenko, A.I. Blokhin, M. Aikawa, et al., “Towards a More Complete and Accurate Experimental Nuclear Reaction Data Library (EXFOR): International Collaboration Between Nuclear Reaction Data Centres (NRDC).” Nuclear Data Sheets. 2014;120:272 – 276.

[2] V. Zerkin, B. Pritychenko, “The experimental nuclear reaction data (EXFOR): Extended computer database and Web retrieval system.”, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. 2018;888:31 – 43.

[3] Handbook on photonuclear data for applications. Cross-sections and spectra. Final report of a coordinated research project 1996 – 1999. IAEA-TECDOC-1178, 2000.

[4] S. Goriely and P. Dimitriou, “Updating the IAEA Photonuclear Data Library and Generating a Reference Database for Photon Strength Functions”, Summary Report of the 2nd RCM 16-20 October 2017, IAEA Report INDC(NDS)-0745, January 2018.

[5] T. Kawano, Y.S. Cho, P. Dimitriou, D. Filipescu, N. Iwamoto, et al., “IAEA Photonuclear Data Library 2019”, Nuclear Data Sheets,163, 109-162, (2020).

[6] T.R. England, B. Rider, Evaluation and Compilation of Fission Product Yield, Tech. Rep. ENDF-349, LA-UR-94-3106, Los Alamos National Laboratory (1994).

[7] R. Mills, Fission product yield evaluation, Ph.D. thesis, University of Birmingham (1995).