Status of the JENDL Project

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General

After the establishment of the Japan Atomic Energy Agency (JAEA), we are carrying out research work based on the mid-term project, which will be completed FY2009. Our mission is to compile the fourth version of JENDL (JENDL-4), where minor actinide and fission product data are much emphasized for the development of innovative nuclear reactors. Moreover, we have continued to produce JENDL High Energy File and Photonuclear Data File mainly for the development of ADS and accelerator shielding. The compilation of these evaluated data is made in cooperation with the Japanese Nuclear Data Committee.

Japanese Nuclear Data Committee

The Japanese Nuclear Data Committee (JNDC) was reformed when JAEA was born in October 2005. In the former JAERI, JNDC had two aspects: one is a research committee for JAERI, and the other is a special committee for the Atomic Energy Society of Japan (AESJ). The current JNDC plays the role of the former one only, and the latter one is operated independently by AESJ. Of course, we are seeking mutual cooperation of the two committees.

JNDC, which is chaired by Prof. T. Yoshida (Musashi Institute of Technology), has two subcommittees: Subcommittee on Nuclear Data and Subcommittee on Reactor Constants. Each subcommittee has five groups:

Subcommittee on Nuclear Data (chaired by K. Shibata)

High Energy Nuclear Data Evaluation WG (chaired by T. Fukahori, JAEA)

FP Nuclide Data Evaluation WG (chaired by K. Shibata, JAEA)
Quality Assurance Group (chaired by N. Yamano, Tokyo Inst. Tech.)
ENSDF Group (chaired by H. Iimura, JAEA)
Editorial Group of Nuclear Data News (chaired by T. Nakagawa, JAEA)
Subcommittee on Reactor Constants (chaired by N. Yamano, Tokyo Inst. Tech.)
Reactor Integral Test WG (M. Ishikawa, JAEA)
Shielding Integral Test WG (chaired by N. Yamano, Tokyo Inst. Tech.)
WG on Preservation of Reactor Physics Experimental Data (chaired by T. Misawa, Kyoto Univ.)
Decay Heat Evaluation WG (chaired by T. Yoshida, Musashi Inst. Tech.)
WG on Evaluation of Nuclide Generation (chaired by K. Suyama, JAEA)

A total of 76 researchers is involved in JNDC as of FY2006.

Activities for JENDL-4

Evaluation of Actinide Data

Evaluation is in progress for JENDL-4. Resonance parameters have been updated by considering recent measurements for 20 nuclei, *i.e.*, ^{231,233}Pa, ^{229}Th, ^{234,236}U, ^{237}Np, ^{236,238,242}Pu, ^{242g,242m}Am, ^{242,243,244,245,246,247,248}Cm, and ^{250,251}Cf. As an example, the fission cross section of ^{243}Cm is illustrated in Fig. 1. The average number of prompt neutrons emitted per fission (υ_p) was improved for ^{239,240,241,242}Pu and ^{232,233,235,238}U. The least-squares fitting code GMA was used to re-evaluate fission cross sections of 5 nuclei: ^{233,237}U, ^{242,244}Pu, ^{247}Cm. The capture cross section of ^{235}U was re-evaluated in order to improve the C/E values of criticalities for fast-neutron critical assembly BFS using UO_2 fuels. Figure 2 shows the revised capture cross section of ^{235}U.

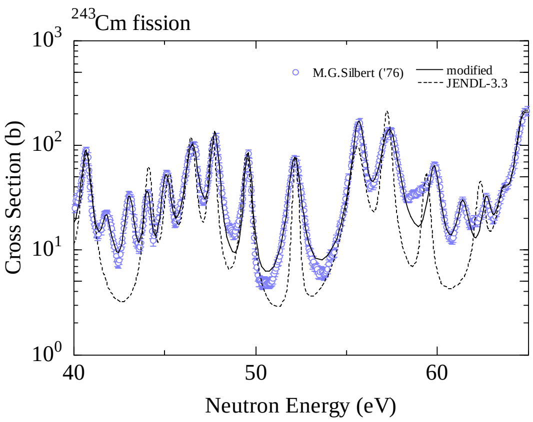

Fig. 1 Fission cross section of ^{243}Cm.

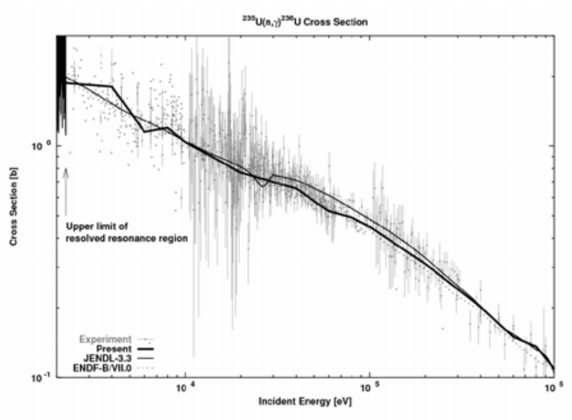

Fig. 2 Capture cross section of ^{235}U.

As a result of the re-evaluation, the calculated criticalities were somewhat improved as compared with the JENDL-3.3 calculations. However, the sodium-voided reactivities for the same BFS cores remain unchanged. Further investigation is required.

A nuclear model code CCONE was used to evaluate smooth cross sections of 21 nuclei: ^{237}Np, $^{236-242,244}$Pu, ^{241,242g,242m,243}Am, and $^{242-248,250}$Cm. A fission channel is included in the statistical model calculation. The calculated capture cross section of ^{237}Np is shown in Fig. 3, where the cross section is multiplied by the square root of incident energy.

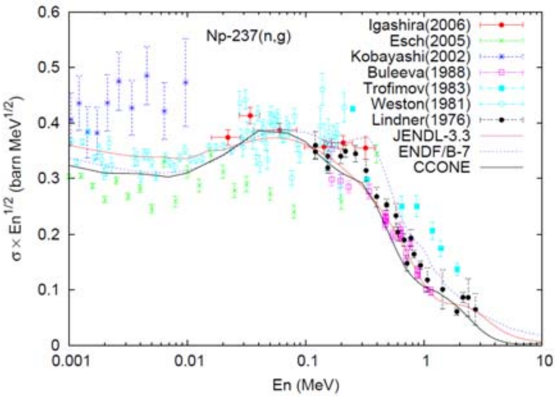

Fig. 3 Capture cross section of ^{237}Np.

Evaluation of FP and Medium-weight Nucleus Data

Resolved resonance parameters have been updated for 45 FP nuclei. The parameters for a negative resonance were adjusted so as to reproduce the thermal cross sections recommended by Mughabghab 2006 or measured recently. Two important measurements were published in the beginning of 2007, thermal capture cross sections of ^{107}Pd and ^{91}Zr measured by Nakamura *et al*., although they give only the lower limit of the cross sections. The thermal cross sections calculated from the resonance parameters are compared with Mughabghab 2006 in Table 1.

Table 1 Comparison of thermal capture cross sections (b).

	Present	Nakamura *et al.* 07	Mughabghab 06
^{91}Zr	1.260	≥1.30±0.04	0.83±0.08
^{107}Pd	9.241	≥9.16±0.27	2.54±0.20

Statistical model calculations were performed for Zn and Nd isotopes by using the CCONE code. The coupled-channel optical model parameters, which were obtained by Kunieda *et al*. last year, were used in

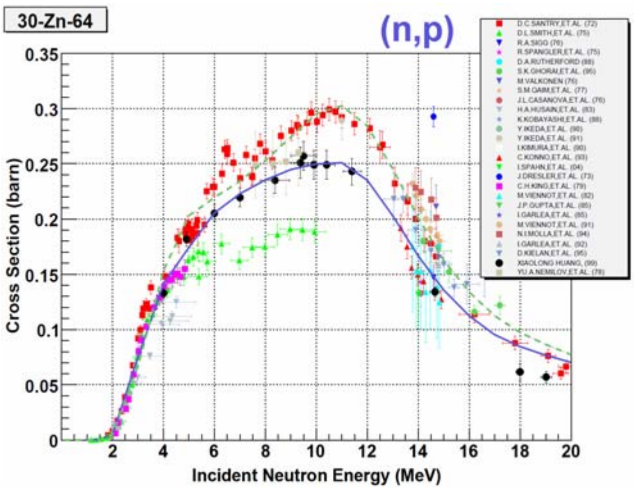

Fig. 4 (n,p) reaction cross section of ^{64}Zn.

these calculations. Figure 4 shows the calculated (n,p) reaction cross sections of ^{64}Zn.

As for medium-weight nuclei, the reaction cross sections of Ca isotopes were calculated by using the TNG code, since Ca is an ingredient of concrete and its neutron cross-sections are important from the viewpoint of nuclear engineering. In this case, we used the spherical optical model parameters obtained by Koning and Delaroche. It is found from Fig. 5 that the calculated gamma-ray emission spectra reproduce the experimental data measured by Dickens *et al*.

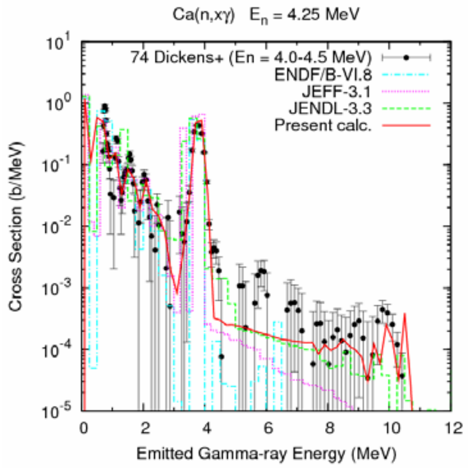

Fig. 5 Gamma-ray emission spectra from elemental Ca.

Activities for Special Purpose Files

JENDL High Energy File

We have been working on high energy data which can be applied to neutron- and proton-induced reactions up to 3 GeV. We already released the 2004 version JENDL/HE-2004. The data of 25 nuclei were updated for the next version JENDL/HE-2007. Data for another 32 nuclei have been newly evaluated: ^{19}F, ^{23}Na, $^{35,37}Cl$, $^{36,38,40}Ar$, $^{92,94-98,100}Mo$, ^{181}Ta, ^{197}Au, $^{204,206-208}Pb$, ^{209}Bi, $^{235,238}U$, ^{237}Np, $^{238-242}Pu$, and $^{241,242g,242m}Am$. The 2007 version will include the data for about 100 nuclei, while JENDL/HE-2004 contains 66 nuclei.

JENDL Photonuclear Data File

The 2004 version, JENDL/PD-2004, contains the photon-induced reaction data for 68 nuclei up to 140 MeV. We updated the data for 6 nuclei: ^{3}He, ^{12}C, ^{55}Mn, ^{181}Ta, $^{182,184}W$. Moreover, the photonuclear data for 107 nuclei, which were produced at KAERI, are included in the 2007 version. Therefore, JENDL/PD-2007 contains the data for 175 nuclei.

JENDL PKA/KERMA File

The file is intended for the use in the radiation damage study. In addition to PKA spectra and KERMA factors, DPA cross sections and damage energy spectra will be evaluated. In principle, the data are produced from JENDL/HE-2007. The format of the data file was discussed by considering data needs and extensions to high energies. We determined the threshold energies ε_d of displacement for materials, which are the key parameters to evaluate KERMA factors and DPA cross sections.

Code Development

We have developed two computer codes POD and CCONE for evaluations of FP and actinide data, respectively. Both of them are based on the Hauser-Feshbach statistical model including pre-equilibrium effects, although POD is tuned for FP and CCONE for actinide. The codes are still under development. Figure 6 shows the fission cross section of ^{242}Cm calculated with the CCONE code.

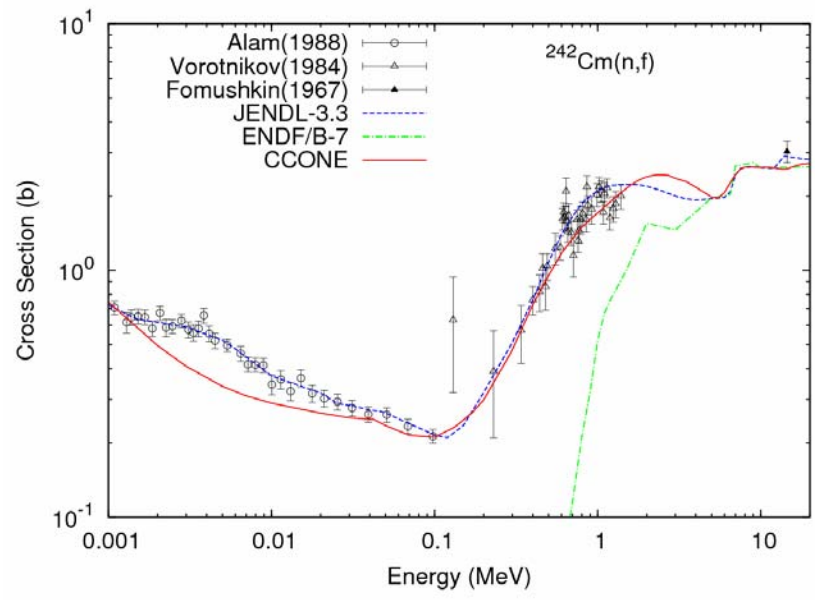

Fig. 6 Fission cross section ^{242}Cm.

Other Activities

<u>Developments of Utility Systems</u>

We developed the Combined System for Nuclear Data Utilization, Circulation and Transfer (CONDUCT). The system provides users with two functions, *i.e.*, 1) retrieval and plotting of nuclear data, and 2) data processing and benchmark calculations. The system has been completed.

We are also developing the Sensitivity Analysis System, which is used for nuclear data evaluation. The system will contain sensitivity coefficients for various reactor benchmarks with respect to nuclear data. Therefore, feedback to evaluation will become much easier than before. The system will be completed by the end of FY2009.

Nuclear Data Symposium in FY2006

The symposium was held with 84 participants on the 25th and 26th of January 2007. From this year, the symposium is organized by the Nuclear Data Division of AESJ. The first day was spent for tutorials: utilization of covariance data by M. Ishikawa (JAEA) and how to use the MVP transport code by T. Mori (JAEA). Oral and poster presentations were made on the second day. The topics of the oral presentation are given as follows:

- Non-energy applications
    - Nucleosynthesis
    - Cosmic-ray transport simulation in the atmosphere
    - Single-event upsets in semiconductors
- Data needs from nuclear reactor design.
    - LWR
    - Fast reactors
    - Advanced reactors