Progress of International Evaluation Cooperation

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The international evaluation cooperation started to remove the differences among major nuclear data libraries such as JENDL, ENDF, and JEF. The results obtained from the cooperation have been used to improve the quality of the libraries. This paper describes the status of the ongoing projects and several remarkable results so far obtained from the projects already finished.

1. Introduction

It is eight years since the international evaluation cooperation started under the NEA Nuclear Science Committee. The objective of the cooperation was to remove the differences among major nuclear data libraries such as JENDL, ENDF, and JEF. Moreover, the problems common to the libraries have been also examined.

There are two working parties (WPs) under the NEANSC auspices, i.e., a working party on evaluation cooperation (WPEC) and a working party on measurements activities (WPMA). There exist four subgroups within the framework of WPMA: standards, activation cross section, inelastic scattering cross section of ^{238}U, and intermediate energy data. In WPEC, more than ten subgroups and two standing groups have been formed.

This paper summarizes the outcome obtained from the subgroup activities in WPEC as well as the status of the ongoing projects.

2. Outcome of WPEC

2.1 Comparison of evaluated data for ^{52}Cr, ^{56}Fe and ^{58}Ni [1]

Comparison of the cross section data for the three nuclei was made among the libraries JENDL-3, ENDF/B-IV, JEF-2 and EFF-2. It was found that the data on the $^{58}Ni(n,\alpha)$ reaction were most discrepant, as shown in Fig. 1. As for ^{58}Ni, the (n,p) reaction cross section is almost comparable to the (n,n') cross section except for the threshold energies. An investigation showed that the discrepancy came from the use of different level density parameters. Therefore, a new subgroup was proposed to deal with the level density parameters for structural material nuclei.

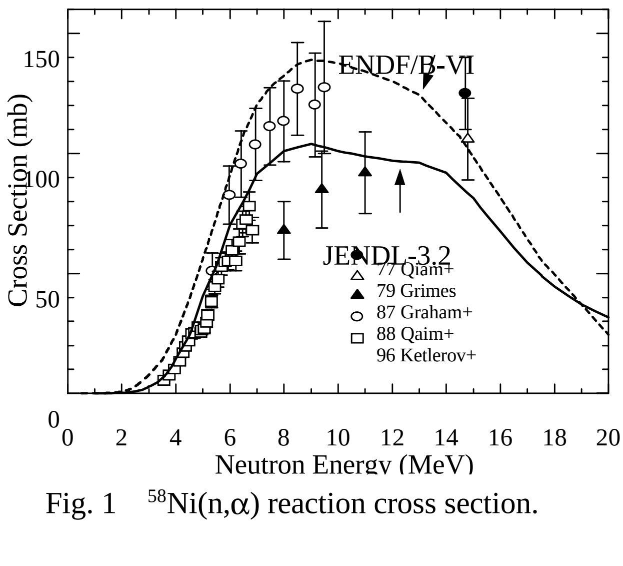

Fig. 1 $^{58}Ni(n,\alpha)$ reaction cross section.

2.2 Generation of covariance files for ^{56}Fe and natural iron [2]

Covariances were generated by Japan, USA and EU with different methods. A large difference was shown among the results obtained. The subgroup did not draw any conclusion, but raised several problems concerning the data format and the covariances of nuclear model calculations.

2.3 Actinide data in the thermal range [3]

Thermal data on ^{232}Th, ^{233,235,238}U, and ^{239,240}Pu were reviewed. The energy dependence of η for ^{235}U was carefully examined. There had been a discrepancy of the η measurements between the Geel-ILL data [4,5] and Harwell-ORNL data [6,7] below 100 meV. The discrepancy was resolved by using a new measurement [8] of α at Geel and by R-matrix analyses using the resonance parameters given by Leal et al. [9] It was found that the η value should be energy-dependent below 100 meV. This energy dependence was also taken into account in JENDL-3.2, as shown in Fig. 2.

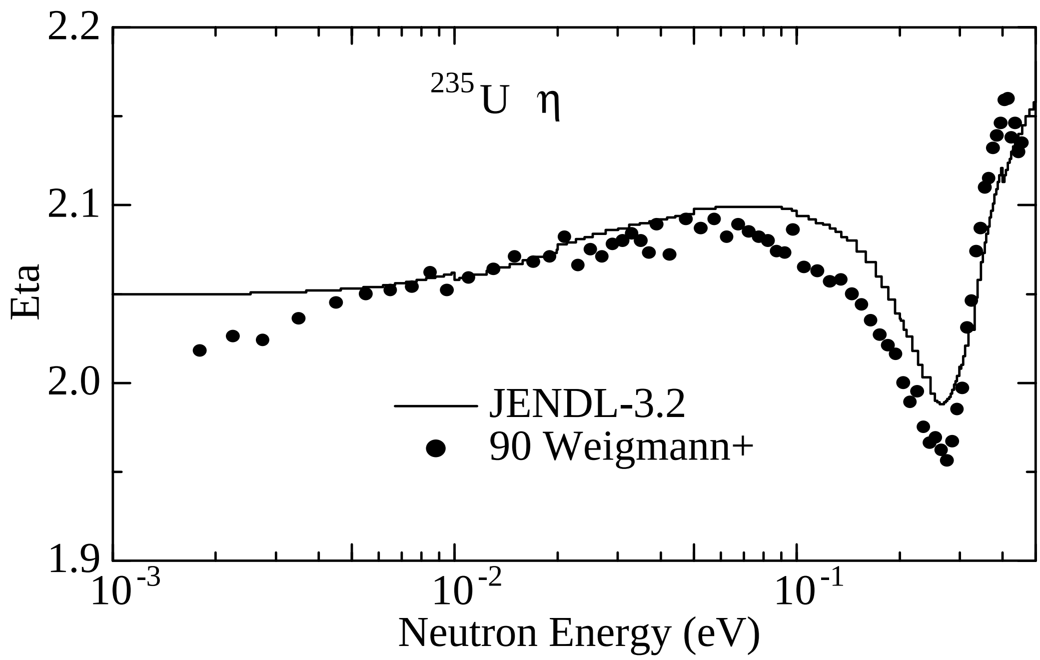

Fig. 2 η values of ^{235}U

2.4 Fission cross section of ^{239}Pu between 1 and 100 keV [10]

The fission cross section measured by Weston and Todd [11] was 5% lower than recent measurements and major evaluations in the energy region from 1 to 100 keV. This discrepancy led to two new experiments [12,13] at ORNL and Geel. The two measurements were consistent with each other giving the fission integral between 100 and 1000 eV, I_f = 9275 b•eV, but higher than the Weston-Todd data with I_f = 8996 b•eV. It was concluded that there was a normalization problem in the Weston-Todd experiment.

2.5 Cross section fluctuations and self-shielding effects in the unresolved resonance region [14]

The objectives of the subgroup were to understand the effects of self-shielding above the resonance region of structural materials, to determine the importance of a correct treatment of the effects, and to recommend procedures representing the physics in this region.

High resolution total cross section data on structural materials were measured at ORNL and Geel. It was found that the measured fluctuations of the iron total cross section is predicted by the Hauser-Feshbach theory, although the calculated relative spread is less than 10% above 4 MeV. The fluctuations of the measured cross sections above 4 MeV mainly come from counting statistics. Benchmark calculations [15,16] with and without fluctuations in the iron cross sections were performed at Petten and Frascati. The main result was that self-shielding effects are important up to 2 or 3 MeV, but negligible above 4 to 5 MeV. Therefore, the subgroup recommended that the high resolution data should be stored unsmoothed in data files up to 4 MeV. Above 4 MeV where self-shielding effects are not quite important, it is better to store smoothed cross sections.

3. Status of Ongoing Activities

3.1 ^{238}U capture and inelastic cross sections

The capture cross section was already fixed, but there is still an open problem for the inelastic scattering cross section. Prof. Kanda, the coordinator of the subgroup, proposed that the evaluation by V. Maslov [17] should be adopted. However, the WPEC has not reached the consensus of opinion yet. At present, it seems that there is nothing to do until new measurements appear. The WPEC concluded that a final report should be written and circulated to members of the subgroup.

3.2 FP inelastic cross sections

This subgroup started to investigate the inconsistency with the STEK integral experiments [18] for weak absorbers. In JENDL-3.1, no direct-interaction process was not taken into account. Considering the direct-interaction process with DWBA, the inelastic scattering cross sections of FP in JENDL-3.2 were much improved [19]. However, there is an opinion that the coupled-channel method should be extensively used. Figure 3 shows the ^{92}Mo(n,n$_1$) cross section. Between 2 and 3 MeV, the JENDL-3.2 data are larger than the latest measurements at Geel. The overshoot near the threshold might be due to the inappropriateness of DWBA. The applicability of DWBA is examined by the working group on evaluation and calculation system, Japanese Nuclear Data Committee, and recommendation would be given before the next WPEC meeting.

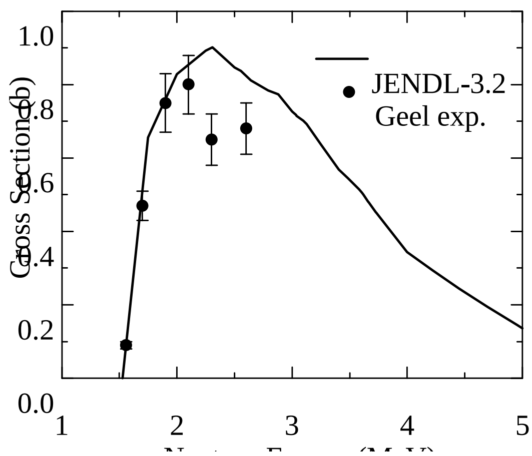

Fig. 3 ^{92}Mo(n,n$_1$) cross section.

3.3 Epithermal cross sections of ^{235}U

The subgroup aims at improving the accuracy of the ^{235}U capture cross section in the epihthermal region. Two preliminary evaluations, one by L. Leal et al. and the other by M.

Moxon, had been provided to the subgroup for testing. The most prominent difference was found in the g-factor for capture (0.99 for Leal et al. vs. 0.95 for Moxon). Final data will be provided for benchmark testing at ORNL and Cadarache. Table 1 summarizes the present status of ^{235}U data.

Table 1 Present status of ^{235}U data

	I_γ (b)	I_f (b)	α	$<\Gamma_\gamma>$ (meV)
Mughabghab[20]	144±6	275±5	0.523±0.24	
JENDL-3.2	134	279	0.478	35
ENDF/B-VI.2	133.5	279.1	0.478	35
Leal-Derrien	140	275	0.509	41.9

3.4 Delayed neutron data

The subgroup activity will be terminated after having identified the most important delayed neutron precursors for actinides, proposed a new representation of the time dependence more accurate than six groups, and written a report giving recommendations of the best delayed neutron yield data for major actinides. A new subgroup will start on the isotopes for transmutation and Th fuel cycle applications.

3.5 Intermediate energy nuclear data evaluation

The objectives of the subgroup were to investigate data needs, to recommend new measurements, to compile experimental data, to perform benchmark calculations, and to propose data format. Some of them were already achieved. However, the activity has become too vast for one group to deal with. Therefore, the group will be divided into several groups with small specific tasks.

3.6 Nuclear model validation

It was decided to limit the scope of the subgroup and to concentrate on the status of nuclear model codes used for evaluation work for incident nucleon energies below 150 MeV. After completing the work, the subgroup will be closed and a new one could be opened on a specific subject.

3.7 FP cross sections

The lumped one-group cross sections were compared, and systematic differences were found among data libraries. However, it was concluded that the status of the lumped cross sections is satisfactory for fast systems.

3.8 Minor actinide data

There had been no progress in the work. It was proposed to write a final report on the results available and to close the subgroup.

3.9 Resonance parameters of ^{52}Cr, ^{56}Fe, ^{58}Ni, and ^{60}Ni

There had been no progress in the work. The coordinator would be asked to write a final report.

3.10 Level density parameters of ^{52}Cr, ^{56}Fe and ^{58}Ni

There had been no progress in the work. The coordinator had written a draft report, and it would be reviewed for the final report.

3.11 Data for the Th fuel cycle

This subgroup has just started, but manpower is lacking.

4. Concluding Remarks

A brief review was given of the subgroup activities in the international evaluation cooperation. Useful results have been obtained, and some of them were already taken into account in the JENDL-3.2 evaluation. Some results will be considered in the new version JENDL-3.3. There are still open problems in nuclear data. New proposals for the international evaluation cooperation are anticipated.

References

[1] Fu C.Y. and Larson D.C.: “Comparison of Evaluated Data for Chromium-52, Iron-56 and Nickel-57”, NEA/WPEC-1, OECD/NEA (1996).

[2] Vonach H. and Gruppelaar H.: ”Generation of Covariance Files for Iron-56 and Natural Iron”, NEA/WPEC-2, OECD/NEA (1996).

[3] Tellier et al.: “Actinide Data in the Thermal Energy Range”, NEA/WPEC-3, OECD/NEA (1996).

[4] Wartena J.A. et al.: Report IAEA Tecdoc 491, 123 (1987).

[5] Wartena J.A. et al.: Report NEANDC(E) 312, III (1989).

[6] Moxon M. et al.: Proc. Int. Conf. Nuclear Data for Science and Technology, Mito 1988, p. 75 (1988).

[7] Moxon M. et al.: Private communication (1990).

[8] Weigmann H. et al.: Proc. Int. Conf. Nuclear Data for Science and Technology, Juelich 1991, p.38 (1992).

[9] Leal L.C. et al.: Nucl. Sci. Eng., **109**, 1 (1991).

[10] Fort E. and Salvatores M.: “Plutonium-239 Fission Cross Section between 1 and 100 keV”, NEA/WPEC-5, OECD/NEA (1996).

[11] Weston L.W. and Todd J.: Nucl. Sci. Eng., **88**, 567 (1984).

[12] Weston L.W. et al.: Nucl. Sci. Eng., **115**, 164 (1993).

[13] Wagemans C. et al.: Nucl. Sci. Eng., **115**, 173 (1993).

[14] Froehner F.H. and Larson D.C.: “Cross-Section Fluctuations and Self-Shielding Effects in the Unresolved Resonance Region”, NEA/WPEC-15, OECD/NEA (1996).

[15] Hogenbirk A.: ECN-C-95-045 (1995).

[16] Petrizzi L.: Private communication (1994).

[17] Maslov V. et al.: “U-238 Inelastic Scattering Cross Section”, presented at Int. Conf. Nuclear Data for Science and Technology, Trieste 1997, to be published.

[18] Veenema J.J. and Janssen A.J.: ECN-10 (1976).

[19] Nakagawa T. et al.: J. Nucl. Sci. Technol., **32**, 1259 (1995).

[20] Mughagbghab S.F.: “Neutron Cross Sections”, Vol. 1, Part B, Academic Press (1984).