Some Remarks on Multigroup Library

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Some remarks on the multigroup library were found from the comparison of the DORT calculations with the MCNP calculation for the benchmark experiment on a copper slab.

1. Introduction

The new analysis by two-dimensional Sn transport code DORT3.1[1] with JENDL-3.2[2] was performed for the benchmark experiment[3,4] on a copper slab assembly of 630 mm in effective diameter and 608 mm in thickness bombarded by D-T neutrons. Some remarks on the multigroup library were found from the comparison of the DORT calculations with the calculation by continuous energy Monte Carlo code MCNP-4A[5].

2. Calculation Procedure

Two multigroup libraries (neutron 125 groups, γ 40 groups and P_5 Legendre expansion with self-shielding correction) were made from JSSTDL-295n-104γ[6] of JENDL-3.2 and matxs files newly processed from JENDL-3.2 by the NJOY94.66[7] code. The DORT calculations with these two libraries will be presented as DORT(JSSTDL) and DORT(NJOY) in this section, respectively. The angular quadrature of S_{16} and theta-weighted (theta : 0.9) were adopted in the DORT calculations. The FSXLIB-J3R2[8] library processed from JENDL-3.2 was used for the MCNP-4A calculation.

3. Insufficient self-shielding correction in JSSTDL system

Figure 1 shows the measured and calculated neutron spectra at the depths of 228 and 532 mm. The MCNP calculation overestimates neutrons from 10 keV to 1 MeV by 10 - 40 % and underestimates neutrons below 1 keV by a factor of 2 - 3. Probably some improvement of the copper data in JENDL-3.2 will be required. Here we focus our attentions on the difference among the calculations. All the calculations agree each other in the neutron energy above 40 keV. On the contrary, the discrepancy among the calculations appears in the neutron energy

below 40 keV. of the discrepancy was due to the incomplete self-shielding correction for the scattering matrix. The f-table (self-shielding correction coefficient) for elastic scattering cross section is used for the scattering matrices in the JSSTDL system, while the f-table for the scattering matrix in the NJOY system is appropriately prepared. As a result, the factors of Legendre expansion of the scattering matrices in the JSSTDL system are different from those in the NJOY system as shown in Fig. 3, which shows the P_0 factors of the in-group scattering matrices of copper in JENDL-3.2 multigroup libraries processed from JSSTDL and NJOY system. Since this insufficient self-shielding correction method is adopted not only for copper but also for all nuclei in the JSSTDL system, it should be noted that Sn calculations with the JSSTDL library sometimes give incorrect results.

4. Overcorrection of self-shielding for the resonance around 500 eV in copper

From Fig. 1 it is also noted that the neutron spectra of MCNP and DORT(NJOY) are different below 500 eV, while they are the almost same above 500 eV. This reason is probably the overcorrection of the self-shielding of the large sharp resonance around 500 eV in copper as shown in Fig. 2. In order to confirm this idea, we performed DORT calculation with the multigroup library (neutron 138 groups) of the finer group structure around 500 eV. This DORT calculation agrees with the MCNP calculation better as shown in Fig. 4. It is considered that the self-shielding correction in the multigroup library is not so perfect for a large sharp resonance even in the NJOY system.

5. Self-shielding correction for multigroup dosimetry cross section

The agreement of the DOT3.5[9] calculation and measurement in the reaction rate of $Cu(n,x)^{64}Cu$, which is sum of $^{63}Cu(n,\gamma)^{64}Cu$ and $^{65}Cu(n,2n)^{64}Cu$, was very poor (the ratio of the calculation to the experiment was 2.5 at the depth of 532 mm) compared with the MCNP calculation in the previous paper[3] for this benchmark experiment. The reaction rate of $Cu(n,x)^{64}Cu$ was given by using the multigroup dosimetry cross section of $Cu(n,x)^{64}Cu$ without self-shielding correction in the DOT calculation, while it was obtained by using the continuous energy dosimetry cross section of $Cu(n,x)^{64}Cu$ in the MCNP calculation. We thought out that the reason of the discrepancy between the DOT and MCNP calculations was due to the multigroup dosimetry cross section of $Cu(n,x)^{64}Cu$ without self-shielding correction. In order to test this idea, we made the 125-group dosimetry cross sections of $Cu(n,x)^{64}Cu$ with and without self-shielding correction, which are shown in Fig. 5, by the TRANSX2.5[10] code from the ^{63}Cu and ^{65}Cu data in ENDF/B-VI[11], which were used since isotope libraries in JENDL-3.2 are incomplete. Figure 6 shows the ratio of the calculation to the experiment (C/E) for the reaction rate of $Cu(n,x)^{64}Cu$. The DORT calculation is almost the same as the MCNP calculation if the self-shielding corrected multigroup dosimetry cross section is adopted. The self-shielding correc-

tion for multigroup dosimetry cross section is essential for the precise activation calculations including (n,γ) reactions for principal material with DORT, e.g. the activation estimation of type 316 stainless steel in International Thermonuclear Experimental Reactor.

6. Concluding Remarks

The following remarks were deduced through the DORT analysis of the benchmark experiment on a copper slab.

1) The self-shielding correction for the scattering matrix in the JSSTDL system is inadequate. It should be noted that Sn calculations with the JSSTDL library sometimes give incorrect results.
2) The self-shielding correction in the multigroup library is not so perfect for a large sharp resonance, e.g. a resonance around 500 eV in copper, even in the NJOY system.
3) The self-shielding correction for multigroup dosimetry cross section is essential for the precise activation calculations including (n,γ) reactions for principal material with DORT.

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References

[1] Rhodes W.A. and Mynatt F.R. : Nucl. Sci. Eng., 99, 88 (1988).
[2] Nakagawa T. et al. : J. Nucl. Sci. Technol., 32, 1259 (1995).
[3] Konno C., et al. : Fusion Engineering and Design, 28, 745 (1995).
[4] Maekawa F., et al. : Fusion Engineering and Design, 28, 753 (1995).
[5] Briesmeister J.F. (edited): LA-12625-M, Los Alamos National Laboratory, (1993).
[6] Nakagawa T. : private communication (1995).
[7] MacFarlane R.E. and Muir D.W.: LA-12740-M (1994).
[8] Kosako K., et al. : JAERI-Data/Code 94-20 (1994).
[9] Rhodes W.A. and Mynatt F.R. : ORNL-TM-4280 (1973).
[10] MacFarlane R.E. : LA-12312-MS (1992).
[11] Rose P.F. (edited) : BNL-NCS-17541 (1991).

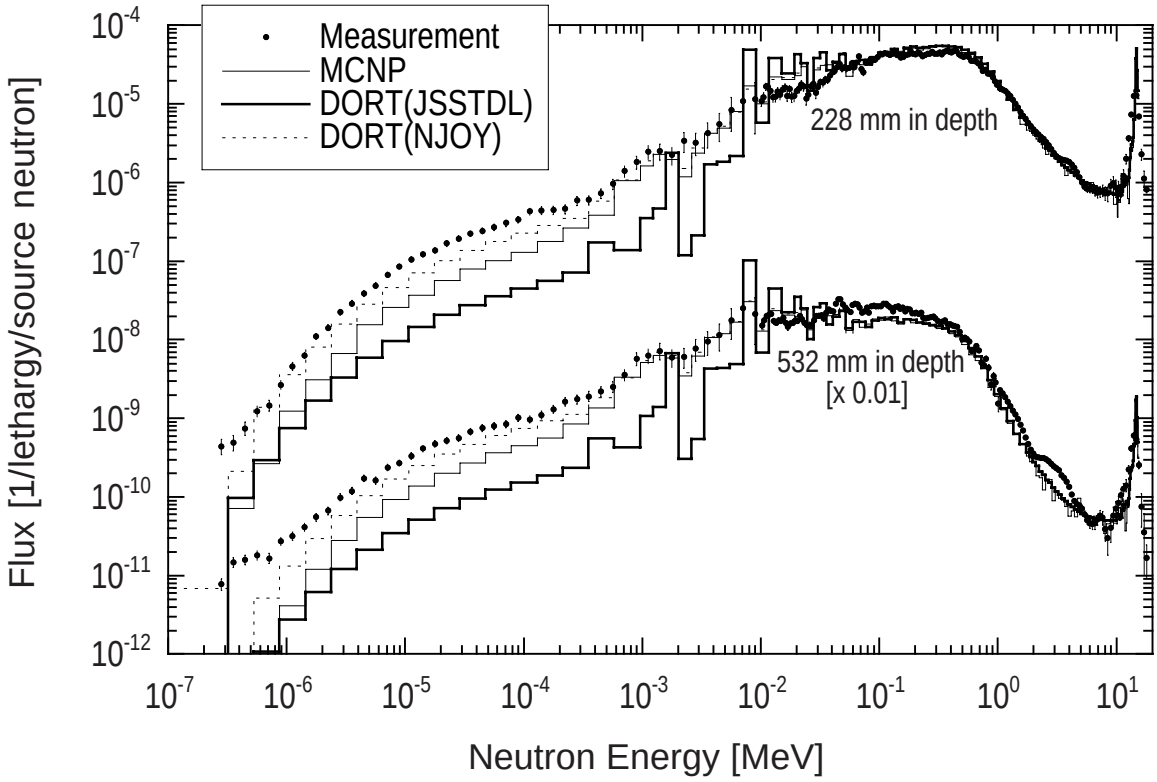

Fig. 1 Measured and calculated neutron spectra at the depths of 228 and 532 mm.

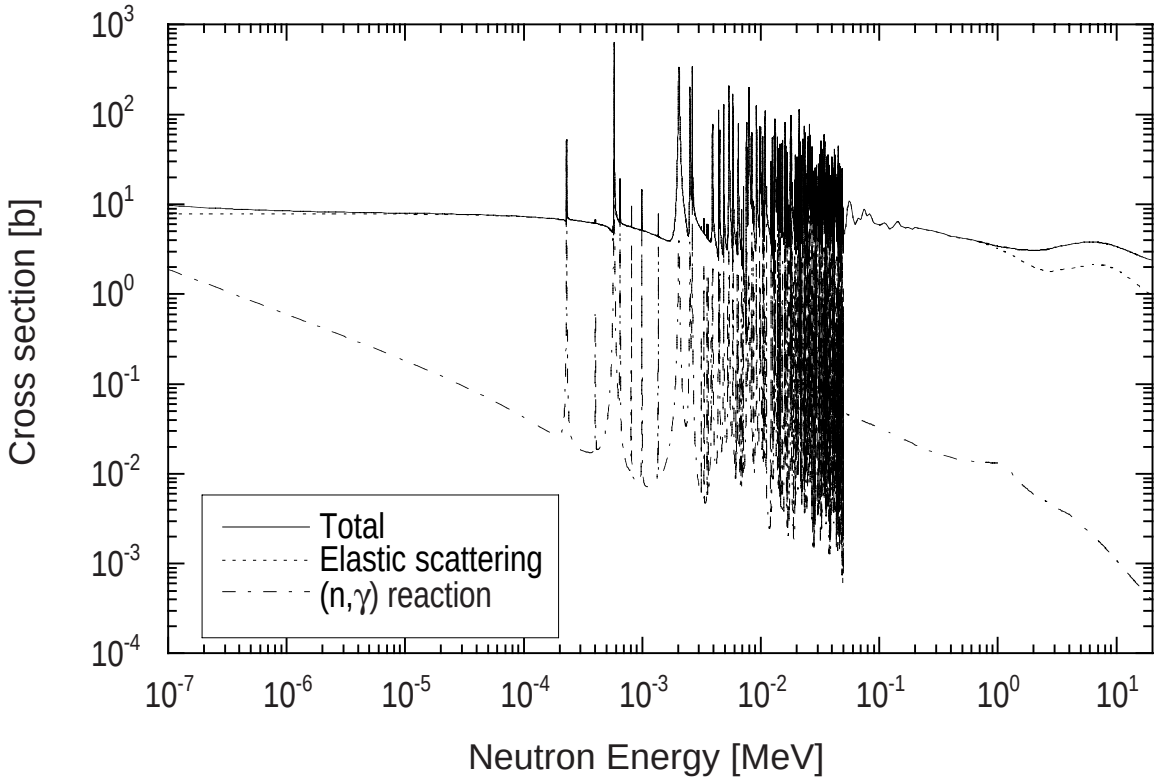

Fig. 2 Cross sections of copper in JENDL-3.2.

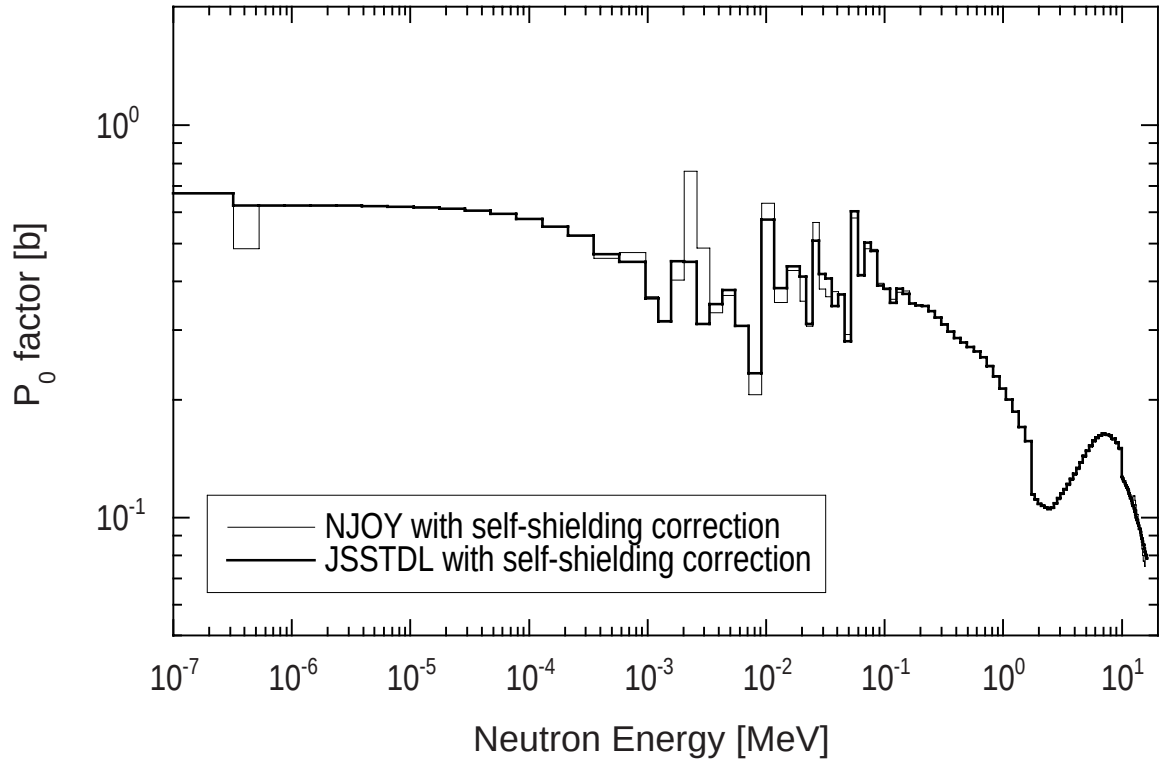

Fig. 3 P_0 factors of the in-group scattering matrices of copper in JENDL-3.2 multigroup libraries processed from JSSTDL and NJOY system.

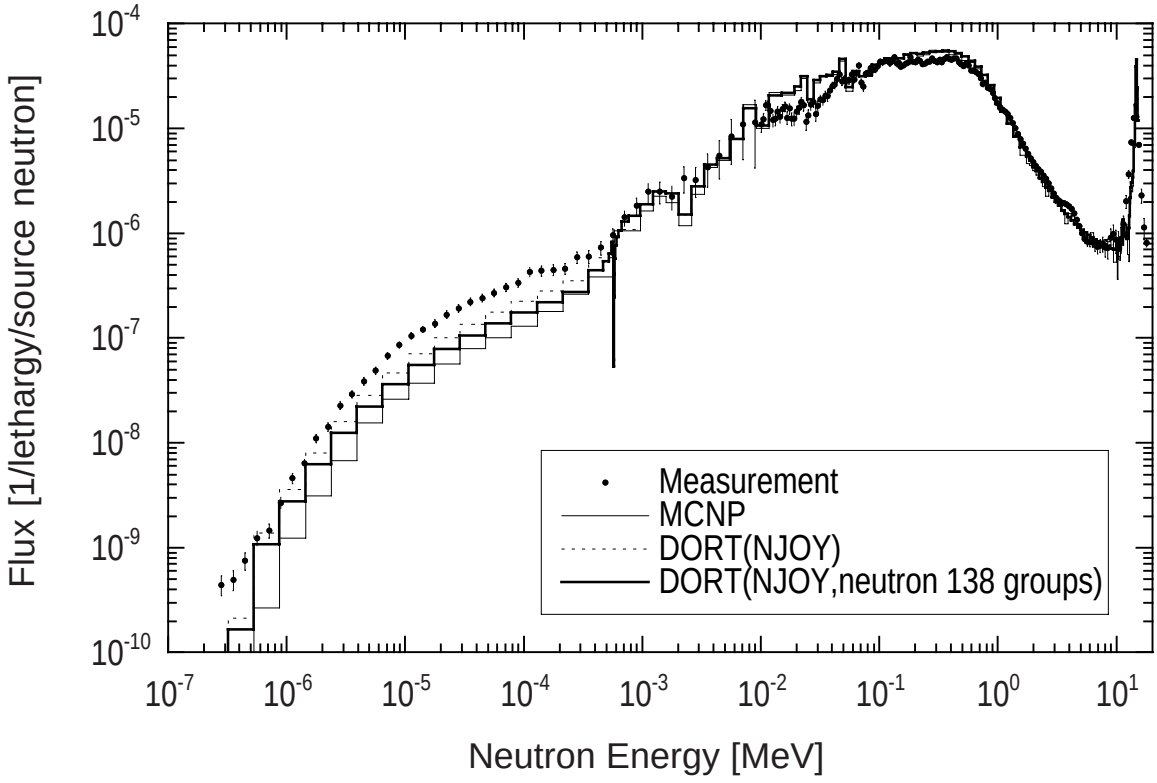

Fig. 4 Measured and calculated neutron spectra at the depth of 228 mm.

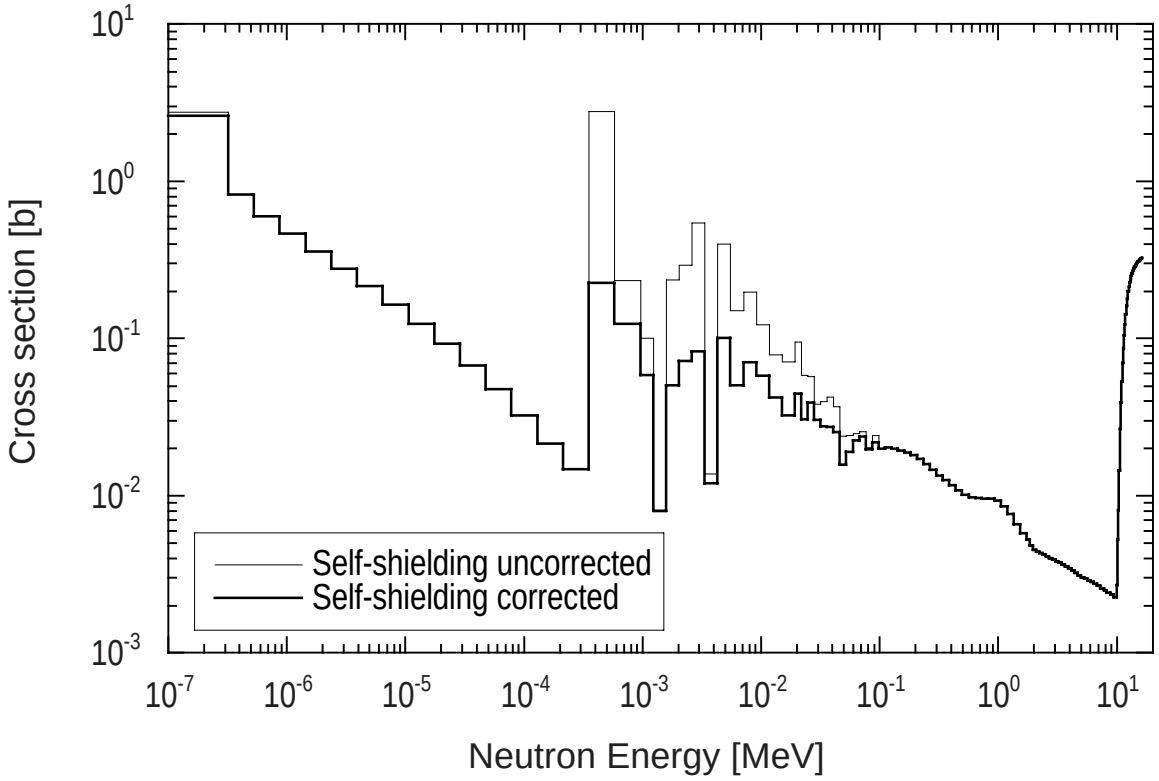

Fig. 5 Multigroup dosimetry cross sections of $Cu(n,x)^{64}Cu$ with and without self-shielding correction.

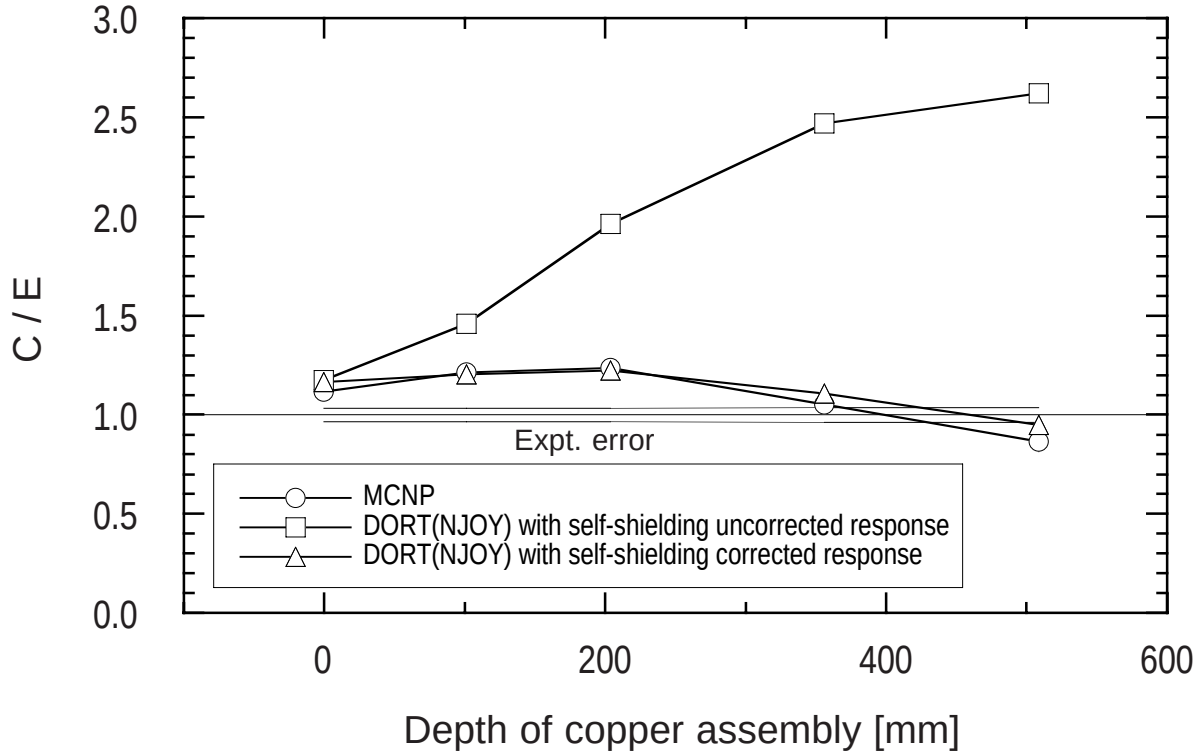

Fig. 6 C/E of the reaction rate of $Cu(n,x)^{64}Cu$.