DORT Analysis of Iron and Concrete Shielding Experiments at JAERI/TIARA with P_7 and P_9 Approximated LA150 Multigroup Libraries

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The accuracy of DORT calculations with P_7 and P_9 approximated LA150 multigroup libraries for tens MeV neutrons was investigated through the analysis of the shielding experiments on iron and concrete for 43 and 68 MeV p-^{7}Li quasi-monoenergetic neutrons at JAERI/TIARA.

1. Introduction

In the 1998 Symposium on Nuclear Data we presented [1] analyses of the shielding experiments [2,3] on iron and concrete for 43 and 68 MeV p-^{7}Li quasi-monoenergetic neutrons performed at JAERI/TIARA with the two-dimensional Sn Code DORT and P_5 approximated LA150 [4] multigroup library. It was noted that these DORT calculations were very different from the MCNP calculations [5] with LA150. This discrepancy was considered to be due to the P_5 approximation in the multigroup library since the P_5 Legendre expansion can not present forward-peak angular distributions of higher energy neutrons precisely. This time we modified the NJOY97 and TRANSX codes so as to produce higher order Legendre expanded multigroup libraries than the fifth order, generated P_7 and P_9 approximated LA150 multigroup libraries and investigated the effects of P_7 and P_9 approximated LA150 multigroup libraries through analyses of the shielding experiments at JAERI/TIARA.

2. Overview of Shielding Experiments on Iron and Concrete at JAERI/TIARA

The shielding experiments were performed with collimated 43 and 68 MeV p-^{7}Li neutron source at Takasaki Ion Accelerator for Advanced Radiation Application (TIARA), at JAERI. Figure 1 shows the experimental arrangement. The test shield of iron and concrete from 10 cm up to 200 cm in thickness was located at the end of the collimator with or without an additional iron shield. Neutron spectra were measured with a BC501A scintillator and Bonner Ball detectors on the beam axis and at 20 and 40 cm off the beam axis behind the test shield.

3. Calculation Procedure

The Sn code DORT3.2 [6] was used in the analysis. Only the collimated source neutrons and experimental assembly, which was modeled as a cylinder instead of a rectangular parallelepiped, were adopted in the analysis according to Ref. 2. The first collision source was calculated from collimated source neutrons with the GRTUNCL code [7]. P_5, P_7 and P_9 approximated multigroup libraries were generated from LA150 with NJOY97.95 [8] and TRANSX2.15 [9] modified for higher order P_L expansion. Its group structure was 100 groups of 1 MeV interval from 0.5 MeV to 100.5 MeV. As well as the previous paper [1], we used the multigroup libraries with and without the extended transport approximation (TA) [9], which was devised mainly for fast breeding reactors in order to mitigate the effects of truncating the Legendre expansion at finite order. MCNP-4B calculations [5] with the continuous energy library processed from LA150 were adopted as a reference.

4. Results and Discussion

The comparison between the calculations and measurements for neutron spectra above 10 MeV on the beam axis is carried out in this paper. The ratios of the calculated values to the experimental ones (C/E) of integrated neutron flux at peak and continuum regions are plotted in Figs. 2 - 9. These C/E figures indicate the followings;

1) The discrepancy between the MCNP and DORT calculations generally becomes smaller with the Legendre order of multigroup libraries used in the DORT calculations.
2) Effect of extended transport approximation is smaller in the P_7 and P_9 approximated DORT calculations, but the DORT calculation with extended transport approximation is more similar with the MCNP calculation.

Figure 10 shows angular distributions of elastic scattering in the original library and MCNP library of LA150 and in-group scattering in P_5, P_7 and P_9 approximated LA150 multigroup libraries for ^{56}Fe at 60 MeV. The angular distribution of in-group scattering in the P_5 approximated LA150 multigroup library is very different from that of elastic scattering in the original LA150 library, while angular distribution of in-group scattering in the P_9 approximated LA150 multigroup library is similar with that of elastic scattering in the original LA150 library. It is considered that the P_9 approximation is enough for transport calculations for tens MeV neutrons.

5. Concluding Remarks

We analyzed the shielding experiments on iron and concrete for 43 and 68 MeV p-^{7}Li quasi-monoenergetic neutrons at JAERI/TIARA with the DORT code and P_5, P_7 and P_9 approximated LA150 multigroup libraries which were generated by using modified NJOY and TRANSX codes. The discrepancy between the MCNP and DORT calculations in the case of P_5 approximated LA150 multigroup library became much smaller in P_7 and P_9 approximated DORT calculations. Effect of extended transport approximation is smaller in P_7 and P_9 approximated DORT calculations, but the DORT calculation with extended transport approximation is more similar with MCNP calculation. It is concluded that P_5 approximation is not adequate in multigroup library and P_7 or P_9 approximated multigroup library is required in transport calculations of neutrons of more than a few tens MeV with Sn codes.

References

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[6] DOORS3.2 : One, Two- and Three-Dimensional Discrete Ordinates Neutron/Photon Transport Code System, RSICC CODE PACKAGE CCC-650 (1998).

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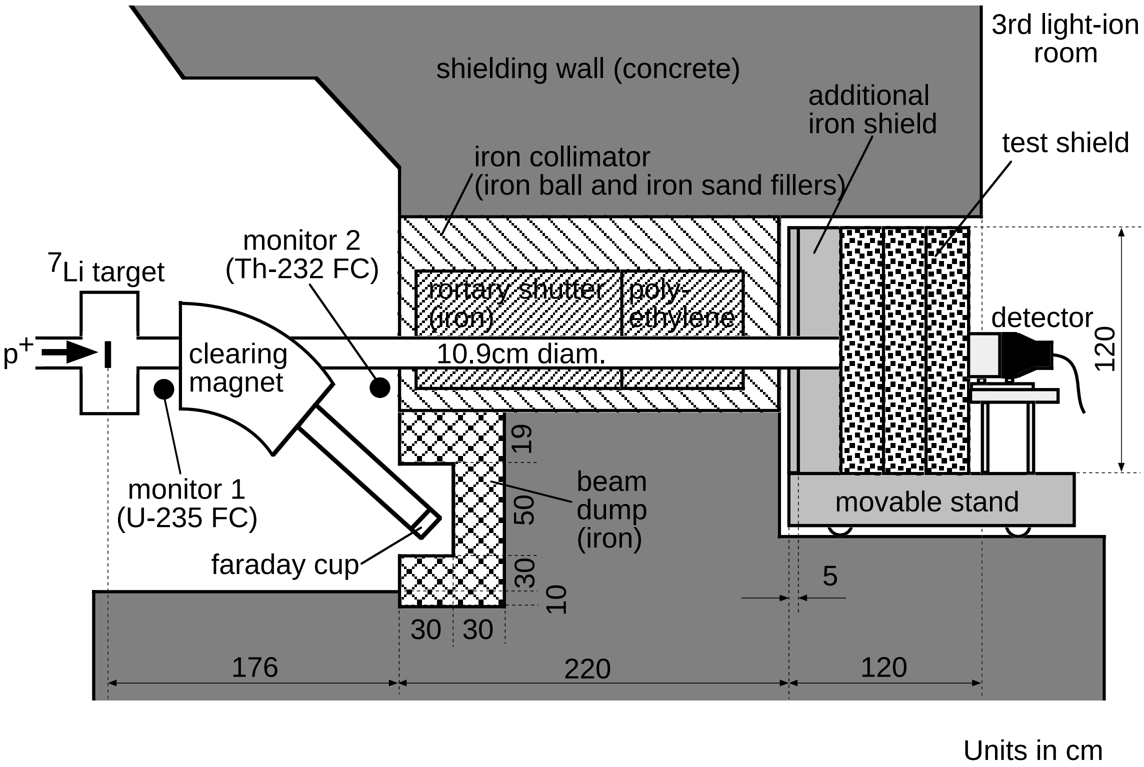


Fig. 1 Experimental arrangement of shielding experiments at JAERI/TIARA.

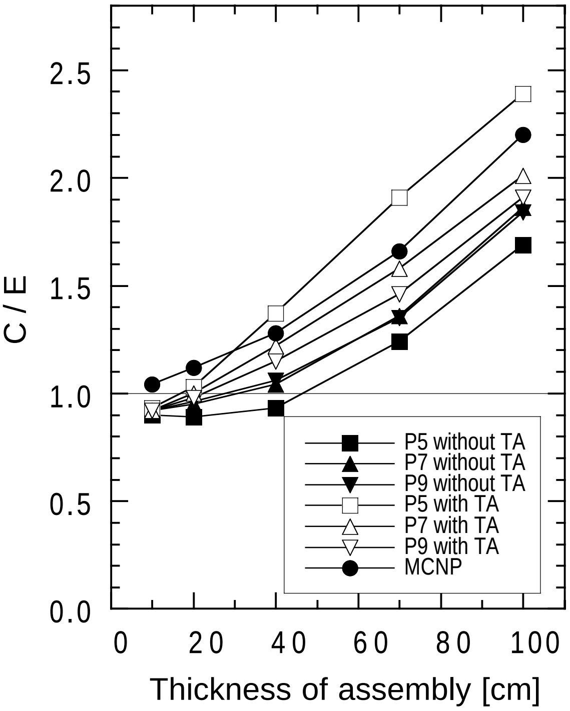


Fig. 2 C/E of peak neutron flux (35 - 45 MeV) of the iron experiment for 40 MeV neutrons.

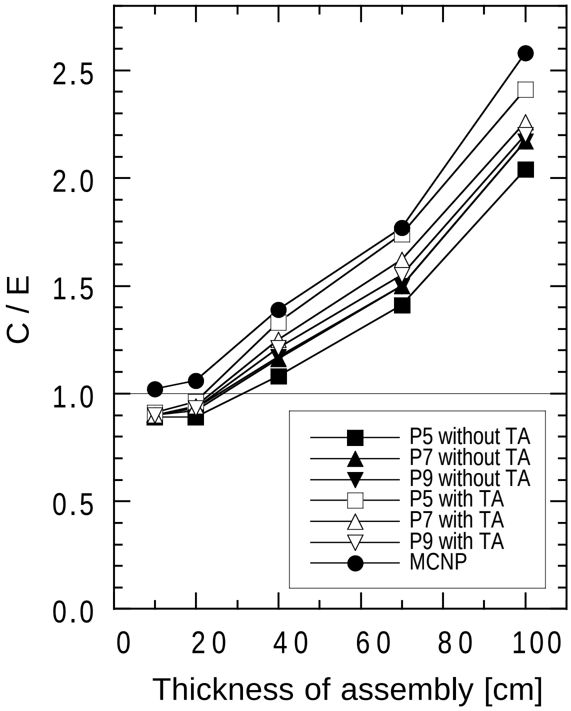


Fig. 3 C/E of continuum neutron flux (10 - 35 MeV) of the iron experiment for 40 MeV neutrons.

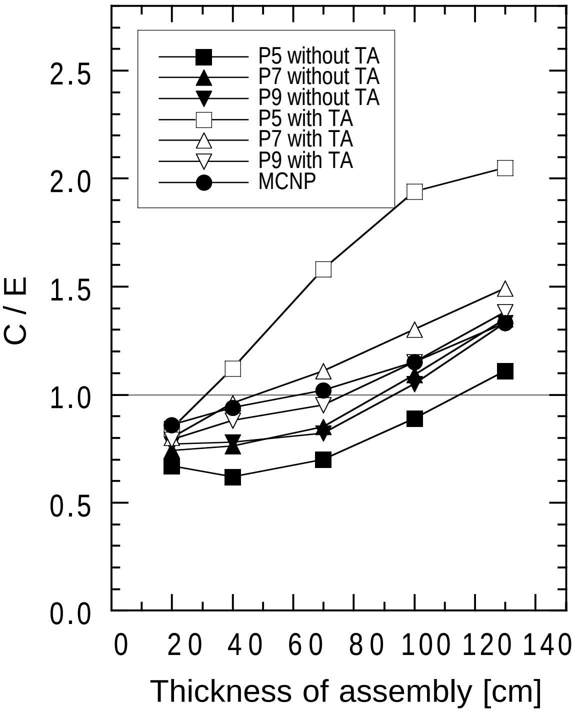


Fig. 4 C/E of peak neutron flux (60 - 70MeV) of the iron experiment for 65 MeV neutrons.

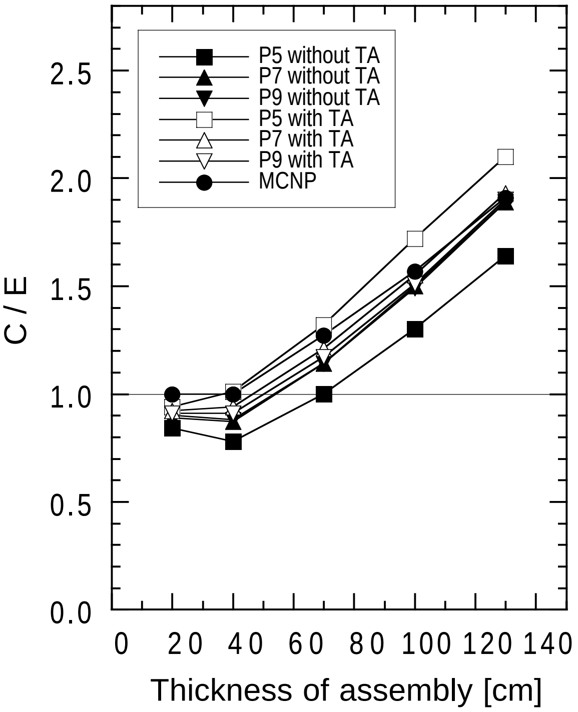


Fig.5 C/E of continuum neutron flux (10 - 60 MeV) of the iron experiment for 65 MeV neutrons.

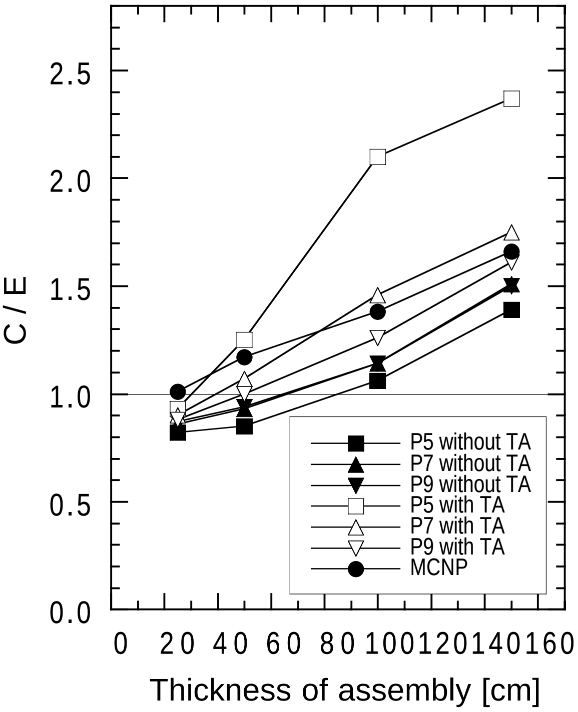


Fig. 6 C/E of peak neutron flux (35 - 45 MeV) of the concrete experiment for 40 MeV neutrons.

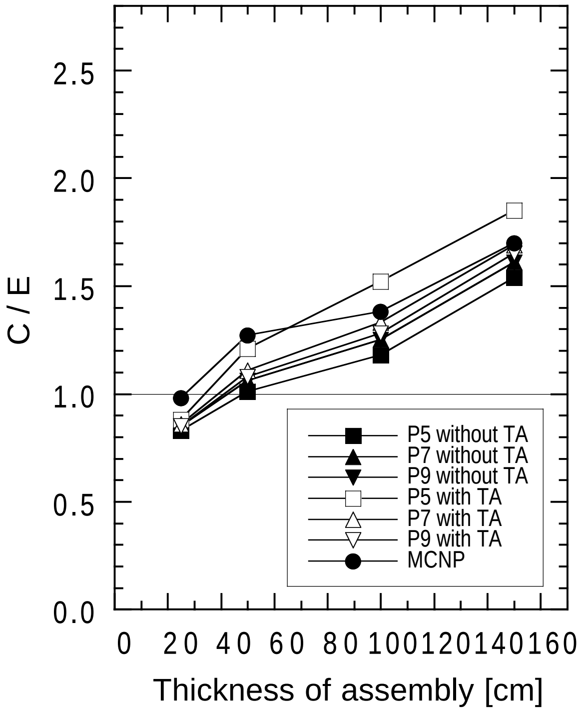


Fig. 7 C/E of continuum neutron flux (10 - 35 MeV) of the concrete experiment for 40 MeV neutrons.

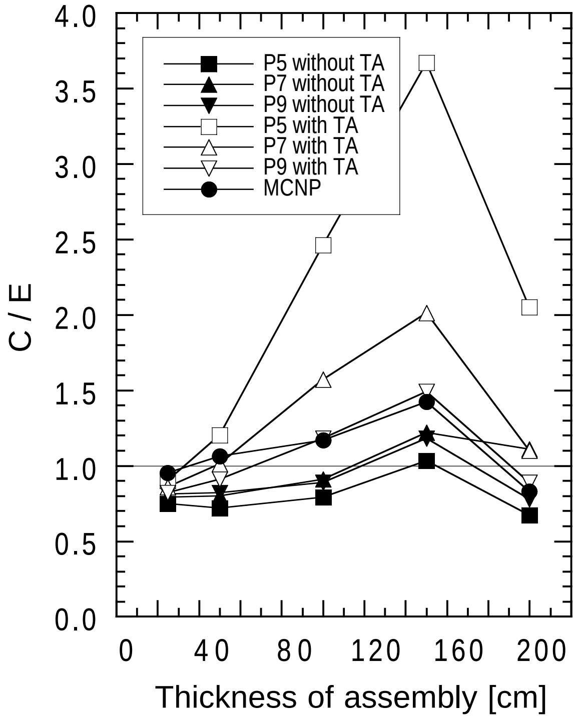


Fig. 8 C/E of peak neutron flux (60 - 70 MeV) of the concrete experiment for 65 MeV neutrons.

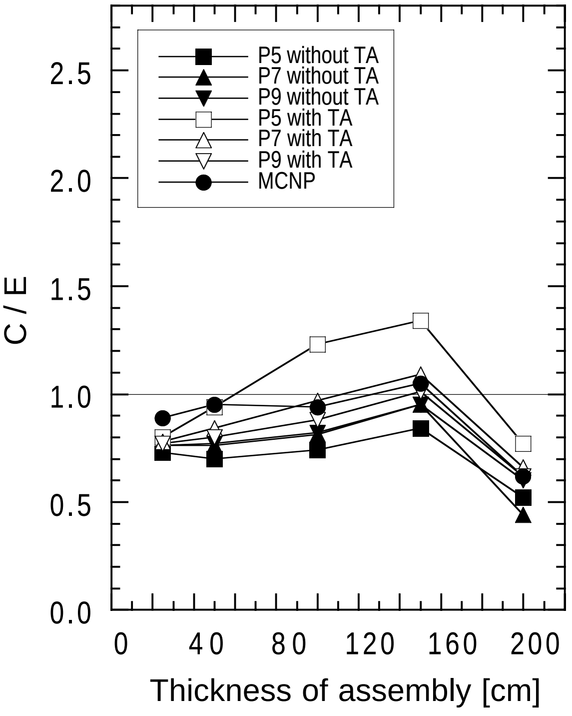
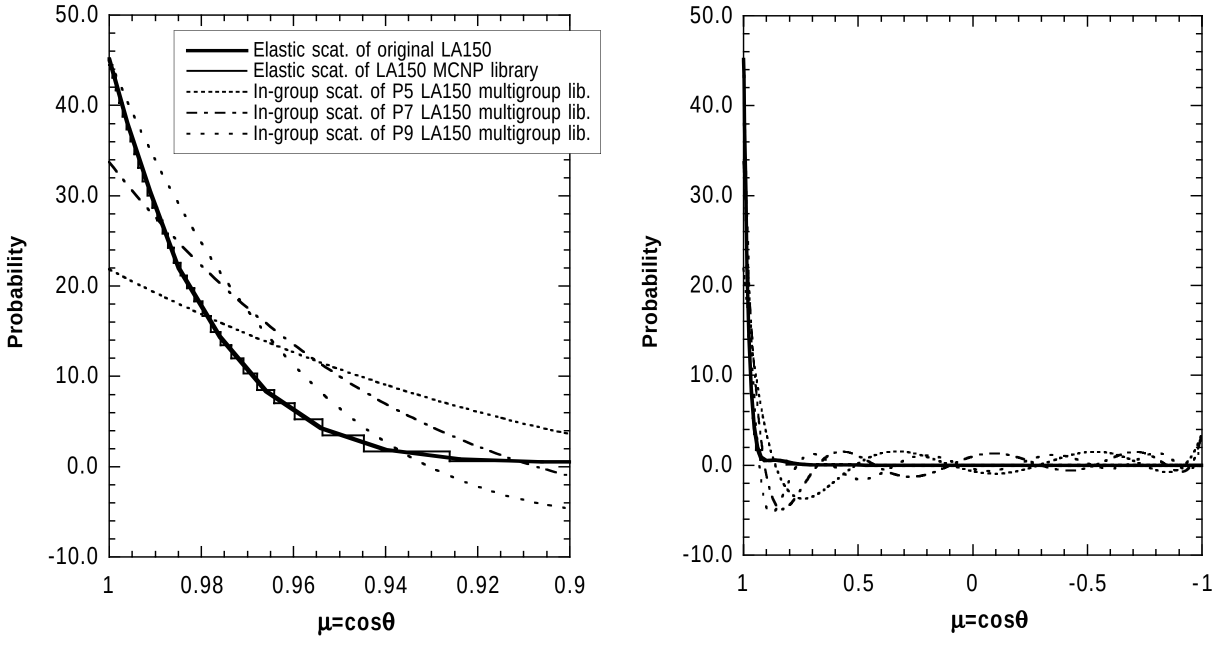


Fig. 9 C/E of continuum neutron flux (10 - 60 MeV) of the concrete experiment for 65 MeV neutrons.



(a) 0 - 25.8 degree

(b) 0 - 180 degree

Fig. 10 Angular distribution of elastic and in-group scattering for ^{56}Fe at 60 MeV.