ON INTRODUCTION OF PARTIAL ADJOINT CONTRIBUTION FOR NEUTRONICS BENCHMARK PERFORMANCE ANALYSIS WITH POINT DETECTOR

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The author's group has been investigating as to how the performance estimation of nuclear data benchmark using experiment and its analysis by a Monte Carlo code should be carried out especially in case of 14 MeV neutron incidence.[1,2,3] It was vaguely thought that benchmarking works only against neutrons producing the final detector contributions through nuclear reactions. However, in reality, this was not the case. We have recently made clear that the detector contribution plays a benchmark role not only to the neutron producing the detector contribution but also equally to all the neutrons created during the neutron history.[4] In the present study, we propose an evaluation function to give how well the contribution can be utilized for benchmarking, and describe that it is deeply related to the "partial adjoint contribution" composing of the so-called adjoint function.

Here, the point detector was adopted which is used commonly in benchmark analysis. The partial adjoint contribution is defined as follows: Value of adjoint function at a certain point for a neutron of energy, E, is evaluated by summing up deterministic detector contribution, c, for all the scattering points made by the neutron and its progenies in the rest history of the neutron, and by averaging the summed-up detector contribution over the histories in the calculation. The adjoint function is thus given as a function of place and energy, E. The authors previously defined the above summed-up detector contribution as "adjoint portion" C_k for a certain neutron of energy E_k at a certain scattering point k, as in the next equation:[5]

$$C_k = c_{k,1} + c_{k,2} + c_{k,3} + \ldots + c_{k,i} + \ldots + c_{k,N},$$

where N is the total number of scatterings and $c_{k,i}$ is a deterministic detector contribution from each scattering point i appearing after the scattering point k. Then this $c_{k,i}$ is called partial adjoint contribution in this study. Every $c_{k,i}$ has information of energy, E'_i, the virtual neutron has, which conveys the contribution to the detector. The "benchmark performance function" is therefore defined by summing up $c_{k,i}$ with E'_i throughout the histories in the calculation (meaning for all k and i). The benchmark performance function can thus be plotted for energy, E'. For each energy bin j of E' in the benchmark performance function, the "benchmark performance density function", $\eta_j(E)$, can hence be defined such that the integral of $\eta_j(E)$ over E becomes the value of the benchmark performance function at energy group j of E'. This benchmark performance density function gives how well and which neutron energy E is benchmarked for the measured neutron spectrum at energy bin of E'_j.

[1] M. Ohta et al., *Fusion Eng. Des.*, 84, 1446-1449 (2009).

[2] M. Ohta et al., "Effect of spectrum shifter for nuclear data benchmark in MeV energy region on $LiAlO_2$ with D-T neutrons," *Proc. of 2008 Symposium on Nucl. Data,* Nov. 20-21, 2008, RICOTTI, Tokai-mura, Ibaraki-ken, Japan, *JAEA-Conf* 2009-004, pp.157-162 (2009).

[3] I. Murata et al., "Performance Analysis of Fusion Nuclear-Data Benchmark Experiment for Heavy Materials in MeV Energy Region with a Neutron Spectrum Shifter," *Proc. 14th Int. Conf. on Fusion Reactor Materials(ICFRM-14)*, Sept. 6-11, 2009, Sapporo, Japan, to be published.

[4] I. Murata et al., "Thought Experiment Regarding Benchmark Performance for Nuclear Data," *Int. Conf. on Nucl. Data for Sci. and Technol.(ND2010)*, April 26-30, 2010, Jeju Island, Korea, to be presented.

[5] I. Murata et al., *Nucl. Sci. Eng.*, 159, 273-283 (2008).