APPLICATION OF THE DECOUPLING SCHEME ON COMPLEX NEUTRON-GAMMA SHIELDING PROBLEMS

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I. Introduction

Coupled neutron-gamma shielding calculations using $S_n$ transport theory can be time consuming, especially for two- and three-dimensional geometries. In general, the CPU time of these calculations increases stronger than linear with increasing number of neutron and gamma energy groups, and depends on the order of Legendre expansion and number of $S_n$ directions used. This fact induced the idea of the decoupling method, which seems applicable to accelerate coupled neutron-gamma shielding calculations. The data included in a combined neutron-gamma library can be readily separated into a library containing neutron data only and another library containing gamma data only. Separate calculations for neutrons and gammas are performed on complex geometries using a different Legendre order expansion for neutrons and gammas. CPU savings of 60 to 85% can be achieved for the two-dimensional DORT and three-dimensional TORT calculations respectively.

KEYWORDS: shielding, neutron, gamma, neutron-gamma, decoupling, transport theory, $S_n$, Legendre, calculations, two-dimensional, three-dimensional

After the separation of the library, first a standard neutron calculation is performed using the neutron data library. The neutron flux distribution resulting from this neutron calculation is saved for subsequent use in the generation of a volumetric source file of secondary gammas. The next step is the generation of this volumetric gamma source file in which all the neutron processes producing secondary gammas (including fission, capture, inelastic scattering, $(n,2n)$, $(n,3n)$ reactions etc.) have to be taken into account. The photon production cross section data required for this step is read from the original coupled neutron-gamma library. The final step is a standard gamma calculation with a fixed source using the separated gamma data library.

Of course, this calculation principle is only correct, if the neutron induced secondary gamma photons have no directional anisotropy upon emission. Fortunately, in evaluated nuclear data files like ENDF/B-VI, JENDL-2.2, and JEF-2.2 only few materials show this kind of anisotropy, thus the differences in gamma fluxes calculated by a time consuming coupled calculation compared to a significantly shorter decoupled one are negligible. Photoneutrons cannot be treated in any case because data is not available yet in the evaluated files.

CPU time measuring tests have been performed using one-, two-, and three-dimensional simple geometries. These tests have shown the applicability of the decoupling scheme for simple geometries\textsuperscript{11}. The average relative differences using decoupling observed in the calculated gamma fluxes were in the order of $10^{-6}$ to $10^{-5}$, while the maximum differences occurred in the range of $10^{-3}$ to $5.10^{-3}$. An...