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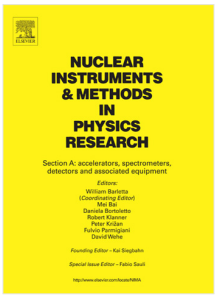

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K. Hartling, B. Ciungu, G. Li, G. Bentoumi, B. Sur

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The effects of nuclear data library processing on Geant4 and MCNP simulations of the thermal neutron scattering law

K. Hartling[a], B. Ciungu[a,b], G. Li[a], G. Bentoumi[a], B. Sur[a]

[a] *Canadian Nuclear Laboratories, Chalk River, ON, K0J 1J0, Canada*
[b] *University of Toronto, Toronto, Ontario, M5S 2J7, Canada*

Abstract

Monte Carlo codes such as MCNP and Geant4 rely on a combination of physics models and evaluated nuclear data files (ENDF) to simulate the transport of neutrons through various materials and geometries. The grid representation used to represent the final-state scattering energies and angles associated with neutron scattering interactions can significantly affect the predictions of these codes. In particular, the default thermal scattering libraries used by MCNP6.1 and Geant4.10.3 do not accurately reproduce the ENDF/B-VII.1 model in simulations of the double-differential cross section for thermal neutrons interacting with hydrogen nuclei in a thin layer of water. However, agreement between model and simulation can be achieved within the statistical error by re-processing ENDF/B-VII.I thermal scattering libraries with the NJOY code. The structure of the thermal scattering libraries and sampling algorithms in MCNP and Geant4 are also reviewed.

Keywords: Thermal neutron scattering, Scattering law, Double-differential cross section, Geant4, MCNP6, NJOY

1. Introduction

Monte Carlo simulation codes such as Geant4 and MCNP have the ability to simulate neutron transport through materials. They rely on sophisticated physics models as well as evaluated nuclear data files (ENDF). The ENDF files contain nuclear data parameters such as cross sections which are based both on experimental measurements and quantities predicted by nuclear data models [1]. Each Monte Carlo code requires that the ENDF data be provided in a particular library format. The process by which nuclear data in the standard ENDF-6 format is converted into the specific library format of a Monte Carlo code can alter the accuracy of the data represented within the library and affect the ability of the code to reproduce the original data or model in simulations.

Geant4 [2, 3] is an open-source Monte Carlo program that was originally developed for high-energy particle physics applications, but has since been extended for applications in medical physics, nuclear engineering, and reactor physics [4]. Few studies investigate its performance below 15 MeV [5–15] and even