Preliminary investigation of nuclear data sampling for the new Monte Carlo code TRIPOLI-5®

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Abstract: A new massively parallel Monte Carlo particle transport code devoted to novel HPC architectures is currently under development at CEA: TRIPOLI-5®. As a preliminary step towards extended verification of the implemented routines, we have accurately tested the sampling laws for the neutron physics as a function of nuclear data, first within the so-called « free-gas » model and then including thermal neutron scattering to probe crystallography or molecular bond-effects. For this purpose, a code-to-code comparison has been performed between TRIPOLI-5® and two other reference Monte Carlo transport codes, TRIPOLI-4® and OpenMC, over around 560 isotopes from the JEFF-3.3 nuclear data library. For the sake of simplicity, probability tables for the treatment of unresolved resonance range were initially inhibited. More than 5000 configurations have been tested for a simple benchmark, consisting in a sphere filled with a single isotope, with a pointwise, isotropic, single-energy source located at the center of the sphere (ten representative incident energies have been considered). The fiducial quantity for the benchmark is the flux per unit of lethargy: the tallies obtained with the three Monte Carlo codes have been compared using a Holm-Bonferroni statistical test. In order to systematically analyze the detected discrepancies, the energy and angle distributions for each isotope and reaction have been compared at various incident energies thanks to the Kolmogorov-Smirnov statistical test. Additionally, the microscopic cross sections and multiplicities read by each code in the nuclear data library have been carefully checked. TRIPOLI-5® and OpenMC rely on ACE files, which makes the comparison easier. TRIPOLI-4®, on the other hand, uses directly ENDF files without pre-processing, which is responsible of an increased number of discrepancies with respect to the two other codes. Overall, a very good agreement has been found between the three codes. This work has allowed validating the implementation of the free-gas model and thermal scattering laws in TRIPOLI-5®, mainly based on the almost perfect statistical agreement with respect to OpenMC. Besides, we have been able to highlight some inconsistencies in the nuclear data library and to detect and fix a few implementation errors in the sampling algorithms. Work is ongoing to perform a similar analysis on the unresolved resonance range for neutron physics, and on photon physics.