Evaluation of nuclear data using the Half Monte Carlo technique

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Abstract: The Total Monte Carlo (TMC) technique has proven to be a powerful tool to propagate uncertainties in nuclear data to the uncertainty in macroscopic quantities, such as neutron fluxes at detector positions and the criticality of reactor cores, and radiation damages in materials in the presence of radiation.

The uncertainties of nuclear data can be used to create self-consistent sets of cross-sections. Each set contains files that are generated by variations of nuclear model parameters to properly fit the model to the nuclear data, accounting for their uncertainty. These files are called random files. The random files will reflect the covariances of cross sections due to the variations of model parameters.

TMC uses Monte Carlo transport codes to transport particles through arbitrarily complex geometries. Each set of random files is used in a separate Monte Carlo transport code run. This allows for the propagation of uncertainties in nuclear data, which otherwise could be hard to account for in the transport codes. However, Monte Carlo techniques are well-known to be computationally expensive.

The Half Monte Carlo (HMC) technique uses the random files of the TMC technique but does not rely on Monte Carlo transport codes to propagate the uncertainties of nuclear data to the uncertainty of the sought macroscopic quantity. Instead, it uses pre-calculated sensitivity matrices to calculate the difference in a macroscopic quantity, given the difference of the random files relative to the best estimate of the nuclear data evaluation. This calculation is based on the assumption that the Monte Carl transport code can be replaced with a first order Taylor expansion.

In this work, we demonstrate how to use the HMC technique to calculate the deviation of macroscopic quantities in integral experiments for a set of random files relative to the best nuclear data evaluation. Furthermore, we show how these results can be used to incorporate integral experiments into an automated nuclear data evaluation.