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Constrained Optimization of Microscopic Nuclear Data via Integral Experiment-Informed Frameworks

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Current microscopic nuclear data face two major challenges: significant discrepancies among datasets from different sources and missing data points at specific energy levels. To maximize the utilization of existing data, this study proposes constraining differential experimental results through integral experiments, thereby enhancing data consistency and completeness.
Our investigation focuses on two microscopic physical quantities: fission yields and the Prompt Fission Neutron Spectrum (PFNS). In fission yield research, leveraging the analytical strengths of machine learning in complex data processing, we employ a Bayesian Neural Network (BNN) to model experimental data on neutron-induced 239Pu fission yields. The objective is to uncover latent energy-dependent correlations and establish an energy dependence framework. For optimizing the PFNS, we developed a random sampling methodology. The proposed methodology begins with generating PFNS candidate sets through randomized sampling that incorporates microscopic experimental measurements and their uncertainty ranges, followed by full-core neutron transport simulations using the JMCT code for critical benchmark configurations under these sampled PFNS conditions. The PFNS is then iteratively optimized through systematic comparison between calculated effective multiplication factors keff and experimental benchmark values, thereby establishing a self-consistent framework bridging microscopic data uncertainties and macroscopic reactor physics.
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Primary author: CHEN, Jiahao (Institute of Applied Physics and Computational Mathematics)

Co-authors: YE, Tao (Institute of Applied Physics and Computational Mathematics); YANG, Bo (Institute of Applied Physics and Computational Mathematics)

Presenter: CHEN, Jiahao (Institute of Applied Physics and Computational Mathematics)

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