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Deployment of Gaussian Surrogate Model for Ad-Hoc Adjustments to Elastic Scattering Angular Distributions

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Neutron scattering reactions, specifically elastic scattering angular distributions, are an often neglected aspect of nuclear data evaluations. Difficulties in representing scattering distributions from both theoretical as well as formatting perspective and a lack of validating experiments leaves a largely unconstrained physics space that has proven to contribute significantly to critical integral experiments. To bypass the traditional evaluation pipeline, empirically fit angular distributions based on Gaussian surrogate models have been explored as an alternative method for adjustments to angular distributions. Monte Carlo neutron transport simulations of the RPI Quasi-Differential Scattering Experiment formed the basis of analysis with the goal of minimizing the difference between simulation and experiment. Design variables are the Legendre polynomial coefficients, an, and the objective function is a chi-square figure of merit between the experimental and simulated data. Due to the inherent noise of Monte Carlo calculations and processing procedures for tallies, a surrogate model built in MATLAB was deemed the simpler approach over common optimization algorithms such as Steepest Descent or Genetic Algorithms. Likelihood maximization utilized in the surrogate model development ensured an accurate recreation of the objective's hyper surface. After model construction, a gradient optimization using MATLAB's fmincon performed the minimization of the objective function and therefore shrunk the distance between simulation and experimental data. Validation of the method was demonstrated using the 814 keV resonance in 208Pb and further adapted to fix angular distributions at the energy threshold for (n,2n) reaction for 9Be. Results show that this method works for well isolated resonances where elastic scattering is the dominant component. Future work includes expanding the surrogate model to fit multiple regions at once or training neural networks to recognize the needed adjustments to angular distributions.

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