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ABSTRACT

Uncertainty Quantification for Phenomenological Optical Potentials

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Tools for reliable uncertainty quantification (UQ) are increasingly important for combining knowledge across multiple domains of nuclear physics. For reaction modeling, theorists often rely on global phenomenological optical model potentials (OMPs) such as Koning-Delaroche (KD) and Chapel Hill ’89 (CH89), neither of which is equipped with well-calibrated uncertainty estimates. To address this gap, we revisited the classical KD and CH89 OMP analyses and identified two important statistical limitations that hampered the original efforts at UQ. We then developed a generic OMP-UQ framework using Markov-Chain Monte Carlo for parameter inference. Within this framework, we assigned well-calibrated uncertainties to KD and CH89, yielding two new UQ-OMP ensembles: KDUQ and CHUQ. Against the KD/CH89 training data and a large corpus of new test data, our UQ versions show improved reliability and interpretability, and in two case studies, we demonstrate how KDUQ and CHUQ can be gainfully "dropped in" anywhere KD and CH89 are already used. To expedite the inclusion of OMP uncertainty as a standard practice, we present digital copies of our potentials and related tools for forward uncertainty propagation [see PRC 107 014602 (2023)].

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