

Quantum Machine Learning Meets Predicting Nuclear Binding Energy

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Nuclear binding energy is a fundamental observable quantity for understanding nuclear structure, stability, and reaction energies across the nuclear table. Despite decades of theoretical advancements, obtaining fast and accurate binding energy predictions for a wide range of nuclei remains a challenging task due to strong nonlinear effects, shell effects, and region-dependent correlations. This study addresses the success of quantum-based and quantum-inspired machine learning approaches in predicting nuclear binding energy.

Experimental binding energies from the AME2020 database are used; the dataset is divided into Light, Medium, and Heavy mass regions to systematically analyze differences in data density, noise level, and physical behavior. As part of the methodology, hybrid architectures based on variational quantum circuits and quantum-inspired kernel methods are developed to decode the complex structure of nuclear data. The results reveal that the performance of quantum models exhibits characteristic differences depending on the mass regions.

Particularly in the heavy mass region, where data quality and linearity are improved, the developed quantum architectures have been observed to achieve high accuracy rates and possess a strong capacity for modeling nuclear data patterns. Conversely, the learning dynamics and noise sensitivities of the algorithms have been detailed in regions where the dataset is sparser and noisy. This research represents a significant step in integrating quantum computing techniques into nuclear data analysis and demonstrates that QML models are a promising approach for future simulations of nuclear physics problems.