Proposition de sujet de stage M2 (2022) à l'Institut Pluridisciplinaire Hubert Curien (IPHC)

OPTIMIZING NUCLEAR MASS MODELS PREDICTIONS USING BAYESIAN NEURAL NETWORKS

The nuclear mass is the basic quantity characterizing the atomic nucleus. It is also an ingredient of primordial importance in a number of applications ; in nuclear astrophysics the knowledge of masses enters all applications as it is necessary to estimate the rate and energetics of any transformation. In particular, the knowledge of masses of around 5000 nuclei is necessary to study the nucleosynthesis r-process. While the number of experimentally known nuclei augments constantly, those of special role for astrophysical modeling are usually very neutron-rich and inaccessible to measurement. Therefore, reliable theoretical predictions are necessary for those nuclei far from the stability.

While several modern mass models fit the known data with a rms deviation of 500keV or less, their predictions in the regions very far from the stability line can be completely different and of lesser accuracy. In the recent years it was explored wether the machine learning (ML) could help to reduce the discrepancy between experiment and theory by supplementing various mass models with neural networks. In particular, Bayesian Neural Networks (BNN) were employed to perform such a study with several mass models in [1]. Another work employed Gaussian regression method combined with neural network to optimize predictions from the Duflo-Zuker (DZ10) mass model [2,3].

The aim of the internship is to acquire the understanding of the DZ10 mass model, update its predictions with respect to the latest experimental mass table AME2020 [4] and refit its parameters, if required. Then a BNN approach will be added to reduce the rms deviation of the mass formula and to provide predictions far from the stability.

This work can be continued as a PhD project, aiming in the developments of nuclear structure mass models and to study the consequences of using the refined predictions in the astrophysics simulations of the r-process nucleosynthesis carried out in collaboration with Université Libre de Bruxelles and GSI Darmstadt. Further applications of machine learning in predictions of nuclear structure observables will be explored.

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[4] AME2020, Meng Wang *et al,* 2021 *Chinese Phys. C* **45** 030003.

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