INPC 2025
May 25-30, 2025
DCC, Daejeon, Korea

Contribution ID: **256** Type: **Contributed Oral Presentation**

NucleiML : A machine learning tool for finite nuclei properties

Friday, 30 May 2025 12:00 (15 minutes)

The relativistic mean-field (RMF) theory is a versatile framework widely employed in nuclear physics, offering applications that range from calculating finite nuclei properties, such as binding energies and charge radii, to generating the nuclear matter equation of state (EoS) for characterizing neutron star properties, including mass, radius, and tidal deformability. Recent studies have demonstrated that imposing explicit constraints on the finite nuclei properties significantly influences the global behavior of the EoS. However, the computational cost of RMF theory poses challenges for integrating these constraints within a Bayesian analysis framework. In this work, we address this challenge by employing machine learning techniques, specifically neural networks, to develop a predictive model termed NucleiML. This model is trained on an extensive dataset comprising nuclear matter parameters, neutron and proton numbers, and corresponding finite nuclei properties generated by the RMF model. NucleiML demonstrates exceptional accuracy in replicating finite nuclei properties across a wide range of nuclei, closely aligning with RMF theory predictions. Moreover, incorporating NucleiML into Bayesian analyses yields results that are consistent with those obtained using the RMF model, offering a computationally efficient alternative without compromising accuracy.

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Session Classification: Parallel Session

Track Classification: Nuclear Astrophysics