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Extrapolating Nuclear Masses using Bayesian Gaussian Process Regression

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The mass of a nucleus is its fundamental quantity. It dictates the stability of a particular nucleus, the type of decays and nuclear reactions it can undergo, and much more. Yet after decades of experimental efforts, we are unable to experimentally measure the masses of thousands of exotic isotopes. They cannot be produced in the laboratory so we have to rely on theoretical models. However, more than a dozen different physics-based models predict very different values for extrapolated nuclear masses because of different assumptions, missing physics, etc. in each of them. We use a data-driven approach to predict the masses of these exotic isotopes by modeling the residuals, i.e. the difference between the experimental masses and theoretically predicted masses accounting for the missing piece in theoretical models. In particular, we use Bayesian Gaussian Process Regression that also provides credibility intervals on our predictions and helps in uncertainty quantification. We further use Bayesian Model Averaging to combine the predictive powers of different models and also account for model selection uncertainty.

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