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Uncertainty Estimation for R-matrix Evaluations

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In nuclear astrophysics, the accurate determination of nuclear reaction cross sections at astrophysical energies is critical for understanding stellar evolution and nucleosynthesis. This study focuses on the $^{12}C(p,\gamma)^{13}N$ reaction, which takes part in the CNO cycle and is significant for determining the $^{12}C/^{13}C$ ratio in stellar interiors. Data from various studies, including recent LUNA measurements, reveal high discrepancies in cross section values, underscoring the need for robust fitting approaches. Utilizing the R-matrix theory, we compare different frequentist and Bayesian methodologies for estimating reaction cross sections and their uncertainties. The analysis evaluates the strengths and weaknesses of different statistical techniques, highlighting the importance of systematic uncertainty treatment and the estimate of covariance matrix estimation to enhance the reliability and reproducibility of uncertainty estimates in nuclear astrophysics.

Primary author: SKOWRONSKI, Jakub (Università degli Studi di Padova)

Presenter: SKOWRONSKI, Jakub (Università degli Studi di Padova)

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