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Constraints on the Symmetry Energy from Neutron-Removal Cross Sections

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An experimentally constrained equation-of-state (EoS) of neutron-rich matter is one of the fundamental goals in nuclear physics that has not been reached yet.The asymmetry term of the EoS is usually expressed by the symmetry energy, with its parameters representing its value J and slope L at saturation density. To date, in particular the parameter L is still poorly known. One method to bring insight into this open issue is to relate nuclear observables as theoretically predicted using well-calibrated energy-density functionals (EDF) with the corresponding L-value. The challenge is to find observables that are sensitive to L and experimentally accessible. Two appropriate candidates, \textit{i.e.}, the neutron-skin thickness Δr_{np} and the ground-state dipole polarizabillity α_D have been identified in recent years. The accurate experimental determination of these observables, however, remains as a challenging task in particular for neutron-rich nuclei.

Several publications by Roca-Maza \textit{et al.} demonstrate the feasibility of this method on the basis of a large set of EDF. The reachable constraint on L naturally scales with the experimental uncertainty of the measured observable while the model-dependence, \textit{i.e.}, the scatter of theory points sets a hard limit that is in the order of ± 10 MeV [1]. The latest analysis [2] limits the symmetry-energy slope parameter to 20-66 MeV by comparing available data for α_D with calculations in the random-phase approximation.

Following the idea described above we have recently proposed a new method to constrain L that might allow to reach the theoretical limit, namely, the measurement of neutron-removal cross sections $\sigma_{\Delta N}$ of neutron-rich nuclei [3]. In our fist systematical study we show the sensitivity of $\sigma_{\Delta N}$ to Δr_{np} and L for the Sn isotopic chain using a parameter-free eikonal reaction-theory and modified versions of the DD2 interaction where L is systematically varied. We conclude that L can be potentially constrained down to $\pm$ 10 MeV, given that both the measured and calculated cross-section are known to a 2\,\% accuracy.
Being aware that this seems to be an ambitious goal, both aspects, \textit{i.e.}, the status and perspectives of the reaction theory as well as the requirements of the experiments proposed to be performed at R^3B will be discussed to show that this goal is definitely not out of reach.

References:

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Summary

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