NUSTAR monthly Seminar

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Heavy, Exotic, Deformed: Recent Advances in Ab Initio Nuclear Structure

Modern ab initio nuclear theory combines systematically improvable many-body methods with interactions derived from chiral effective field theory, providing access to controlled theoretical uncertainties [1]. Leveraging this framework, first-principles calculations have in recent years extended to heavier nuclei and increasingly exotic systems near the neutron drip line.

In this talk, I will provide an overview of the current status of ab initio nuclear structure calculations. I will present recent applications to heavy nuclei [2], explore the emergence of collective phenomena in light sd-shell systems [3], and highlight new insights into transitional nuclei around A∼80 using tensor networks and quantum information theory [4]. I will also discuss emulator techniques, which serve as low-cost surrogates for computationally expensive calculations, enabling large-scale statistical studies of how the nuclear phenomenology is linked to the underlying low-energy couplings of chiral interactions [5].

Finally, I will address key challenges facing ab initio theory in the coming years, with a particular focus on extending these methods to heavy, strongly deformed systems.

[1] H. Hergert, Front. in Phys. 8 (2020) 379
[2] A. Tichai, P. Demol, T. Duguet, Phys. Lett. B 851, 138571 (2024)
[3] G. Hagen et al., Phys. Rev. C 105, 064311 (2022)
[4] A. Tichai et al., Phys. Lett. B 855, 138841 (2024)
[5] M. Companys Franzke, A. Tichai, K. Hebeler, A. Schwenk, arXiv:2510.08362 (2025)

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