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Ab initio framework for nuclear fusion reactions

To advance our understanding of the universe, from physics beyond the Standard Model to cosmic events, a unified approach to nuclear structure and reactions is essential. This requires combining few-body techniques with ab initio many-body calculations of nuclear structure, supported by Effective Field Theory and Uncertainty Quantification. Reaction rates derived from first principles are vital for understanding the synthesis of light elements and terrestrial energy generation, which can power civilization for generations[1].
In this talk, I will outline recent successes in few-body systems aligned with these goals[2, 3]. I will then focus on the No-Core Shell Model with Continuum (NCSMC)[4] and its extensions, tailored to address challenges in heavier systems.
The main challenge is developing precise methods that scale with the number of nucleons A, while accounting for all relevant reaction channels. In a broader physics scope, this includes exotic many-neutron decay channels or processes involving exotic particles subject to the strong force.

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