Projection-based emulators for quantum continuum states: type-II with complex energies

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FACILITY FOR RARE ISOTOPE BEAMS

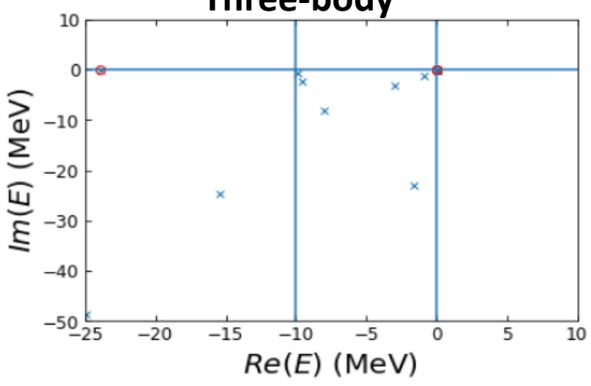
Objectives

- Previous continuum state emulators work for a given real energy at a time. Their generalization to many-body systems are difficult.
- Here, we consider the complex plane of the total energy E variable as part of the parameter space, in addition to the Hamiltonian (H) parameters.
- The training calculations at complex energies (above the real axis) can be performed using structure methods, because the training solutions are bound-state like.
- The projection-based emulators use those training solutions as basis to project the full problem to a low-dim subspace.
- These emulators are then used to extrapolate continuum physics from the training energies to the real energy axis and even below where the resonance poles are located.
- The essential idea is not only being explored in the context of ab initio general-body calculations but also in the response function computations within nuclear density functional theory framework.

Impact

- Such complex-E emulation creates a new continuum computing method, which works for general-body systems as long as the structure methods exist.
- The emulation for the H parameters are achieved automatically. Thus, we have developed a continuum emulation approach for general-body systems.
- The emulators compress continuum spectra, generating novel insights into physical meanings of the eigenvalues of a discretized H (see the figure). Such understanding is critical when the discretized H is non-Hermitian and its eigenvalues don't have clear ordering.
- The emulation method not only works in ab initio calculation context, but also in the density functional theory framework.
- The developed emulators will be useful not only in FRIB science but also for other areas affected by nuclear continuum physics.
- **Therefore, broad impact of this study is expected.**

Three-body



The crosses are the eigenvalues of the emulator-H matrix, which is non-Hermitian, while the full H is Hermitian. The eigenvalue on the negative real-E corresponds to the ground state, while the other crosses hints on two branch cuts of the continuum observables as functions of E.

Accomplishments

[1] "Recent developments on projection-based emulators for quantum continuum states," invited talk at TRIUMF Workshop: "Progress in Ab Initio Nuclear Theory," TRIUMF, Vancouver, BC, Canada, Feb. 2023

[2] "Nuclear continuum states and their emulators," invited talk at FRIB-TA Program:"Theoretical Justifications and Motivations for Early High-Profile FRIB Experiments," FRIB,, East Lansing, MI, May. 2023