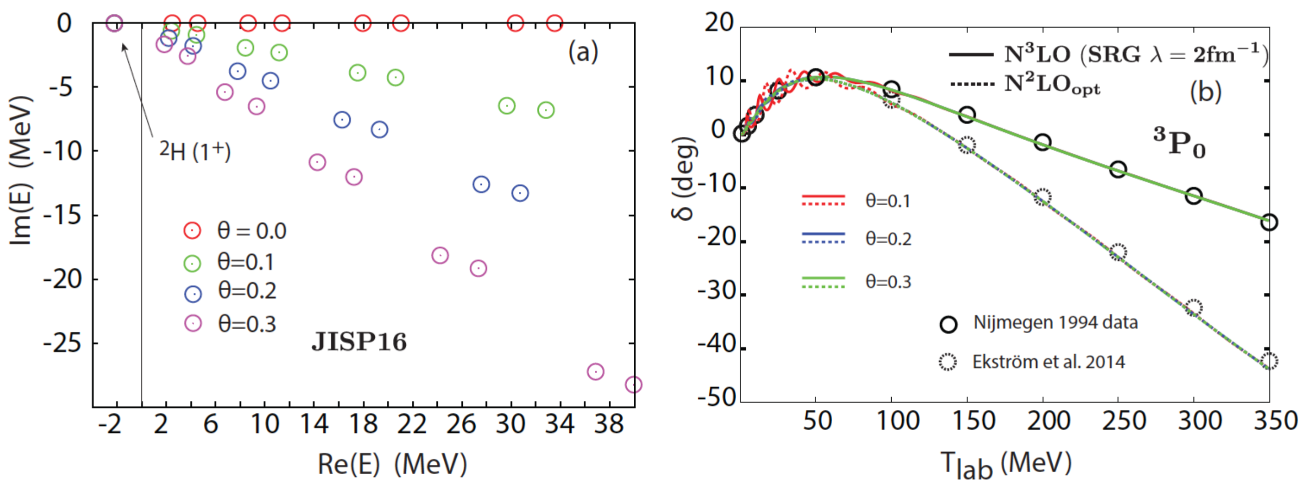
Nuclear Scattering Made Predictive and Convenient

Objectives

- Develop a convenient unified framework to solve nuclear structure and nuclear scattering using realistic nuclear interactions.
- Predict nuclear properties in the vicinity of the drip-lines where resonant states play critical roles.
- Leverage the increase of computing power and the new architectures at DOE-sponsored supercomputing facilities to achieve the efficient diagonalization of large complex symmetric matrices.

Impact

- Advances *ab initio* nuclear physics by implementing a powerful and convenient technique that will provide model independent predictions for structure and scattering properties.
- Use existing bound state many-body solvers and technology, developed for realistic two-nucleon and three-nucleon forces, to solve important scattering problems.
- Assess the quality of modern realistic nuclear forces in systems with high neutron to proton asymmetry and provide solid theoretical justification for new experiments.



(a) Distribution of eigenvalues of a Complex Scaled (CS) realistic JISP16 non-local interaction for the neutron-proton system. The deuteron bound state is invariant with respect to the rotation angle θ (indicated by the arrow) whereas continuum states are distinguished by their approximate 2θ trajectory. **(b)** Evaluation of the elastic scattering $^{3}P_{0}$ phase-shifts using CS chiral $N^{3}LO$ and $N^{2}LO_{opt}$ interactions. The convergence of the phase-shifts as a function of the CS rotation parameter θ is rapid. Accurate scattering observables are predicted with calculations performed in a convenient Harmonic Oscillator basis.

Accomplishments

1. First application of Complex Scaling (CS) with realistic nuclear interactions.
2. First demonstration of the validity of ABC theorem for non-local interactions. The ABC theorem is the cornerstone of CS method.
3. Solved for elastic scattering phase-shifts using complex-energy solutions from non-local interactions in a Harmonic Oscillator basis
4. Opened the pathway for *ab initio* description of nuclear scattering with a natural ability to include three-nucleon interactions and without the complication of imposing boundary conditions.

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NUCLEI — Nuclear Computational Low-Energy Initiative

References: G. Papadimitriou and J.P. Vary Accepted in Phys. Rev. C Rapid Communications 2015. arXiv:1412.0071

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