

Towards Multi-Shell Valence Spaces

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Valence-Space Shell Model

- successful method for the description of spectroscopic observables using phenomenological effective interactions
- limitations:
 - huge valence-space dimensions in eigenvalue problem
 - traditional effective interactions lack consistent framework for treatment of observables other than the energy

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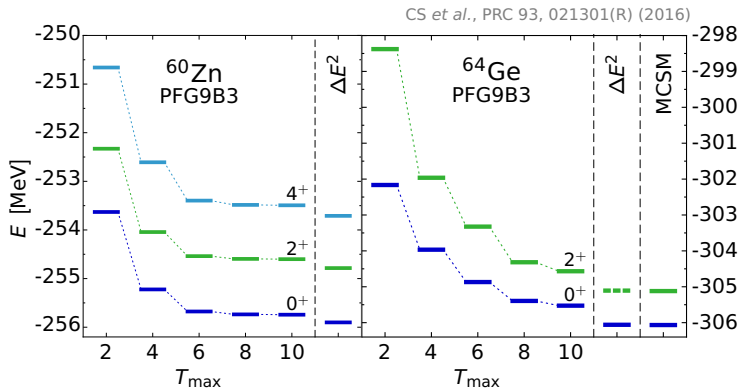
Improvements on Traditional Approach

- IT-SM: simple and straightforward extension of the shell model to larger valence spaces
- new effective interactions derived in IM-SRG

Importance Truncation

- introduce adaptive truncation criterion: importance threshold κ_{\min}
- construct IT model space including only most relevant basis states for basis expansion of target state
- solve eigenvalue problem in IT model space and obtain approximation for target state
- vary κ_{\min} and extrapolate to account for effects of basis states excluded from IT model space
 - threshold extrapolation
 - energy-variance (ΔE^2) extrapolation

Highlights: pfg_{9/2}-shell nuclei ⁶⁰Zn and ⁶⁴Ge



- shell-model calculations for ⁶⁰Zn and ⁶⁴Ge not feasible in pfg_{9/2}-shell
- slow convergence for ⁶⁴Ge due to strong deformation
- variance extrapolation corrects for different truncations employed
- variance-extrapolated energies in excellent agreement with MCSM

Effective Interactions from IM-SRG

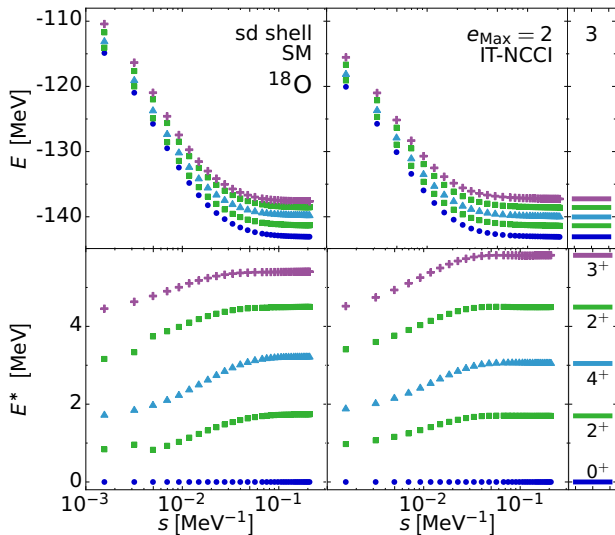
- extension of IM-SRG to nonperturbative derivation of effective shell-model Hamiltonians and operators from chiral potentials

K. Tsukiyama *et al.*, PRC 85, 061304 (2012)

S. Bogner *et al.*, PRL 113, 142501 (2014)

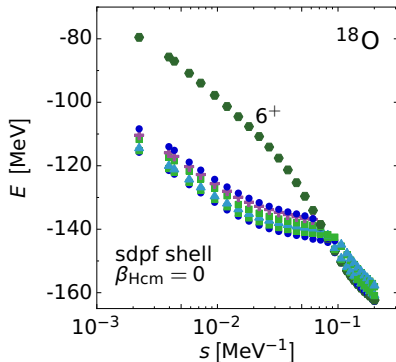
- IM-SRG flow equation
 - decouples inert core from all possible excitations
 - decouples states with A_V valence nucleons from excluded space
- test new effective interactions using IT-SM and IT-NCCI in single- and multi-shell valence spaces

IM-SRG Interactions for sd Shell



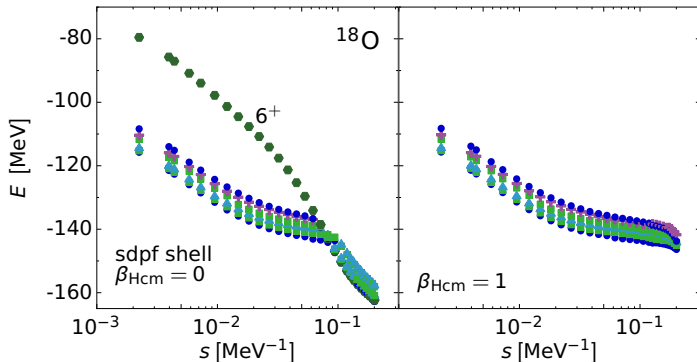
- very similar convergence behavior for SM and IT-NCCI
- good agreement of SM and IT-NCCI results
- successful decoupling of valence space from core and excluded space

IM-SRG Interactions for sdpf Shell



- spurious intruders destroy spectrum

IM-SRG Interactions for sdpf Shell



- spurious intruders destroy spectrum
- removal of intruding spurious states not sufficient to remedy IM-SRG effective interactions for sdpf shell