Application of eigenvector continuation to the pairing Hamiltonian and nuclear many-body problems

Phys. Rev. C 109, 024311

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European Research Council
Established by the European Commission

Motivation

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- Goal: solve the nuclear many-body problem
- Modern nuclear Hamiltonians from EFT
  - interactions $\hat{V} = \hat{V}(\{c_i\})$ depend on LECs c_i
  - need to be fixed by experimental data
- large number of combinations of LEC values
  - finding exact solution or approximations has a high computational cost

$\Longrightarrow$ Emulator very useful for obtaining solutions for different LEC values

König et al., PLB (2020)
A. Ekström, G. Hagen, PRL (2019)

Pairing Hamiltonian

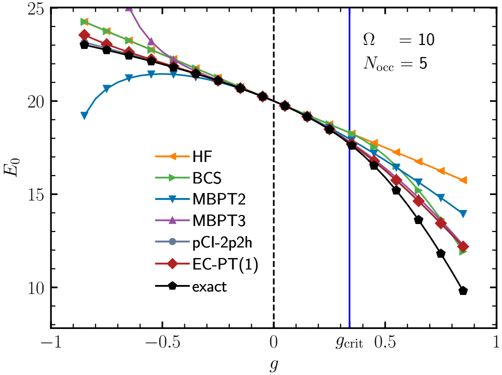
Phys. Rev. C 109, 024311 (2024)

- ☐ Pairing Hamiltonian for model-space size Ω and pair states p and $\bar{p}$

$$\hat{H}_{\text{pairing}} \equiv \sum_{p}^{\Omega} \epsilon_p (c_p^\dagger c_p + c_{\bar{p}}^\dagger c_{\bar{p}}) - g \sum_{pq}^{\Omega} c_p^\dagger c_{\bar{p}}^\dagger c_{\bar{q}} c_q \,,$$

$\Longrightarrow$ exactly solvable due to Richardson without large-scale diagonalization
e.g. Richardson *et al.* PL (1964)

- ☐ Phase transition to superfluid state for $g > g_{crit}$



Pairing Hamiltonian

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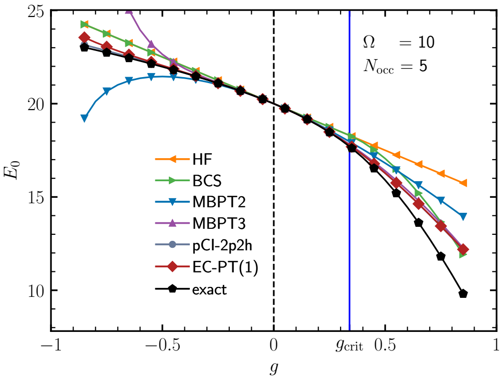
- Phase transition to superfluid state for $g > g_{crit}$

$$E^{(2)} = -\frac{1}{2} \sum_{ai} \frac{g^2}{f_i - f_a} \quad \text{with } f_p = \epsilon_p - n_p g$$

- Singularity at $g = -\Delta\epsilon = -1$
- pCI-2p2h and EC-PT(1) both are diagonalizations on 2p2h-spaces



$\Longrightarrow$ EC gives good approximations for large coupling range, although HF and MBPT(2) do not

Pairing Hamiltonian

Training vectors

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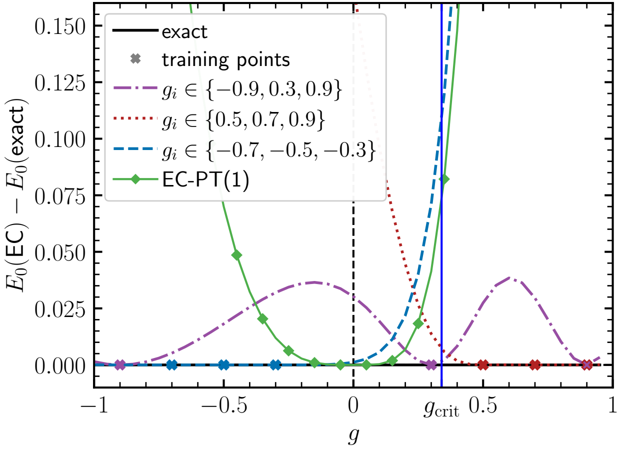
- ☐ EC from PT state corrections only good around $g = 0$
  - ▷ EC-PT(1) has two dimensional EC basis: HF and first order state correction
- ☐ One-sided training points only approximate the same side well
- ☐ Training points from both sides of the interval give good results



Pairing Hamiltonian

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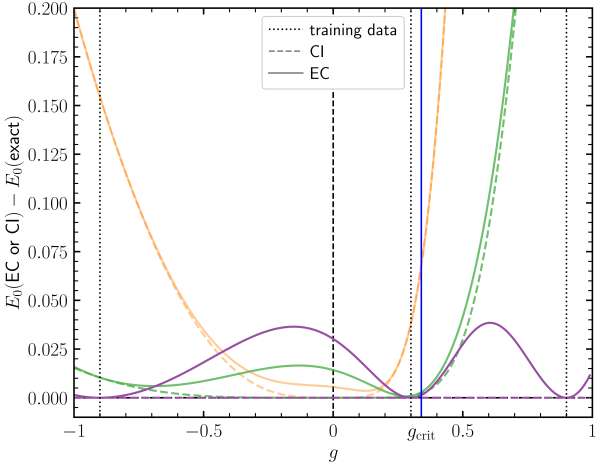
- ☐ One-sided training points only approximate the same side well
- ☐ Training points from both sides of the interval give good results
- ☐ EC approximates lower truncated CI better than higher truncated CI
- ☐ But higher truncated CI is more accurate



Outlook: Hartee-Fock based emulator

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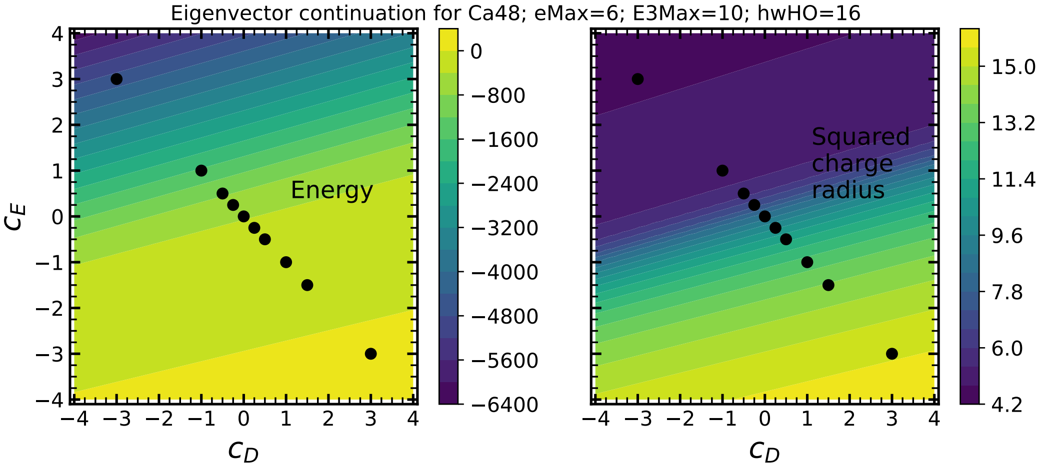
- ☐ Hartree-Fock approximations used for training
  - ▷ Training vectors are Slater determinants
  - ▷ Onishi formula for Slater determinants for overlap
  - ▷ Transition densities used for matrix elements
  - ▷ Thouless’ theorem used for transition densities
- ☐ Ground-state from EC can be used to extract other observables

Outlook: Hartee-Fock based emulator



Outlook: Hartee-Fock based emulator
Looking forward to discussing more at the poster!