Multi-Reference In-Medium SRG

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Motivation

- In-Medium SRG (IM-SRG) is a very efficient many-body method
  [K. Tsukiyama, S. K. Bogner, A. Schwenk, PRL 106, (2011)]

- 3N interaction included by normal-ordered 2-body approximation (NO2B)
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- IM-SRG constructed for **closed-shell** nuclei

- MR-IM-SRG applicable to **even-even** open-shell nuclei
  (because limited to Hartree-Fock-Bogoliubov reference states)
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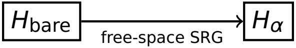
Our Goal

extension to arbitrary reference states $|\Psi\rangle := \sum_i c_i |\Phi_i\rangle$
with good total angular momentum,
e.g. NCSM reference state, ...

Schematical Overview



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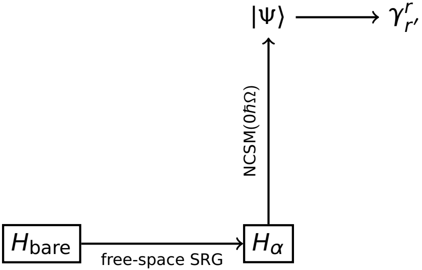

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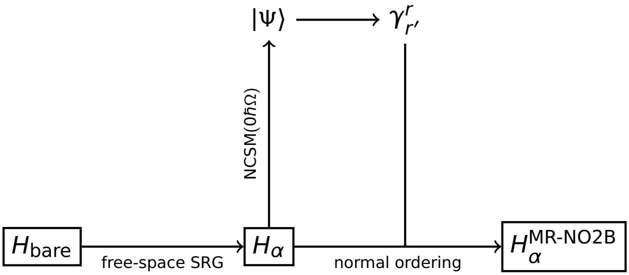

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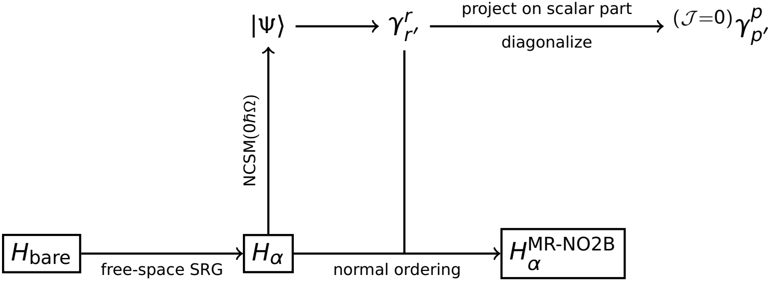

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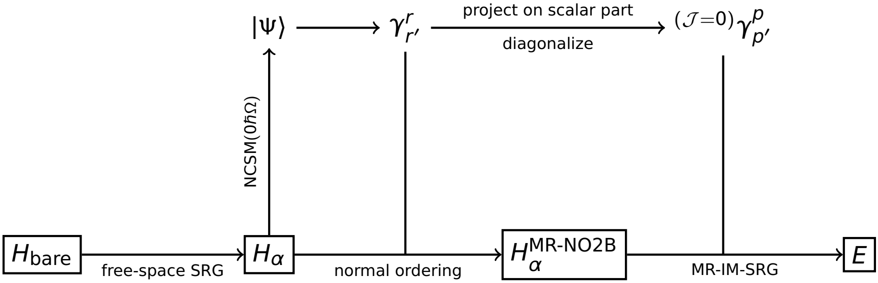
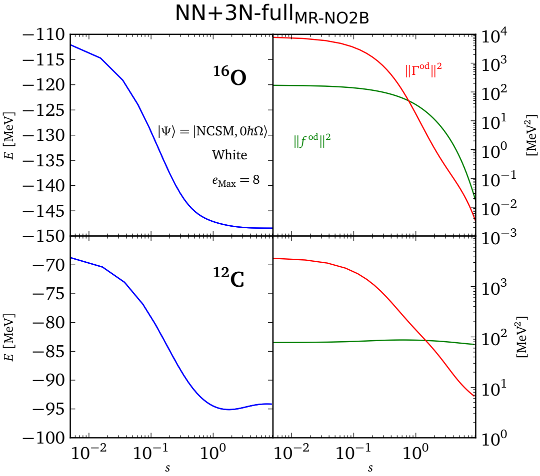


MR-IM-SRG Evolution



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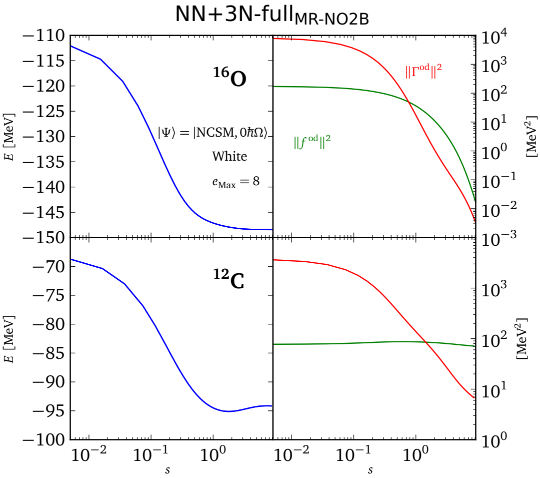

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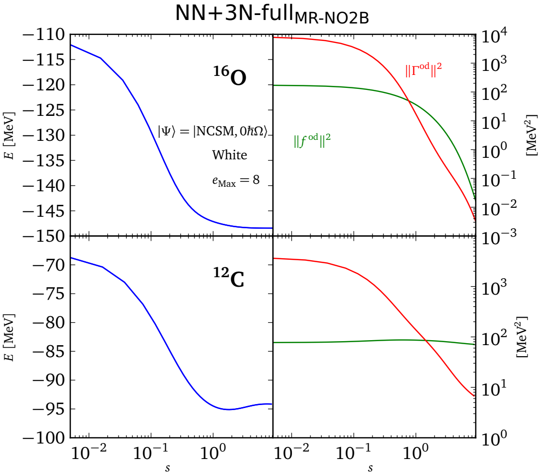

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- one-body part unchanged
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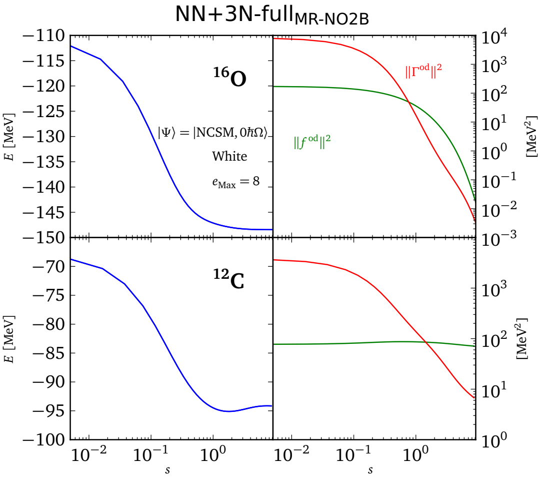

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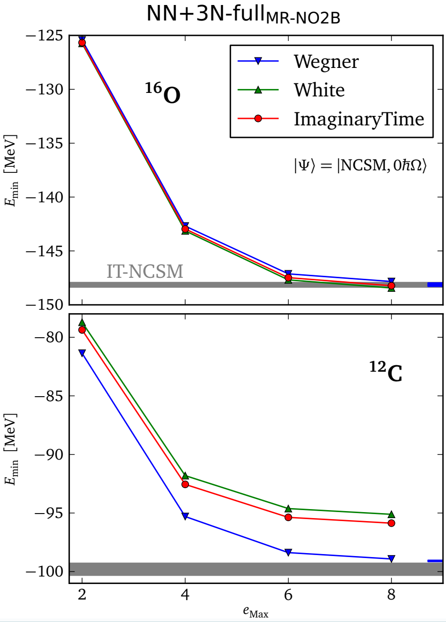
Convergence?
→ take the first minimum

e_{Max} Convergence and Comparison to IT-NCSM



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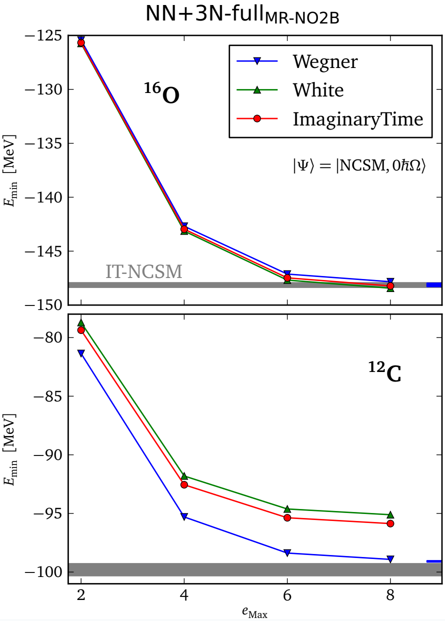

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- only Wegner reproduces the IT-NCSM result
- White and Imaginary-Time **not** consistent with IT-NCSM

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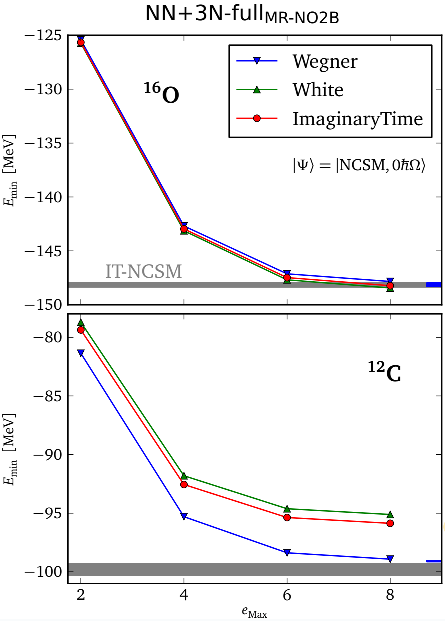

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need better understanding of generators

Appendix

Outlook

- cross check with MR-IM-SRG using Hartree-Fock-Bogoliubov reference states
- perform IT-NCSM calculation using MR-IM-SRG evolved Hamiltonians
  - analyse the IT-NCSM energies as a function of the flow parameter s
  - quantify the violation of the unitarity
- study effect of non-scalar density matrices

Definition of the Generators

Wegner

$$\eta = [H, H^{\mathrm{od}}]$$

$$(f^{\mathrm{od}})^1_2 := n_1 \bar{n}_2 \, f^1_2 + [1 \longleftrightarrow 2],$$
$$(\Gamma^{\mathrm{od}})^{12}_{34} := n_1 n_2 \bar{n}_3 \bar{n}_4 \, \Gamma^{12}_{34} + [(12) \longleftrightarrow (34)]$$

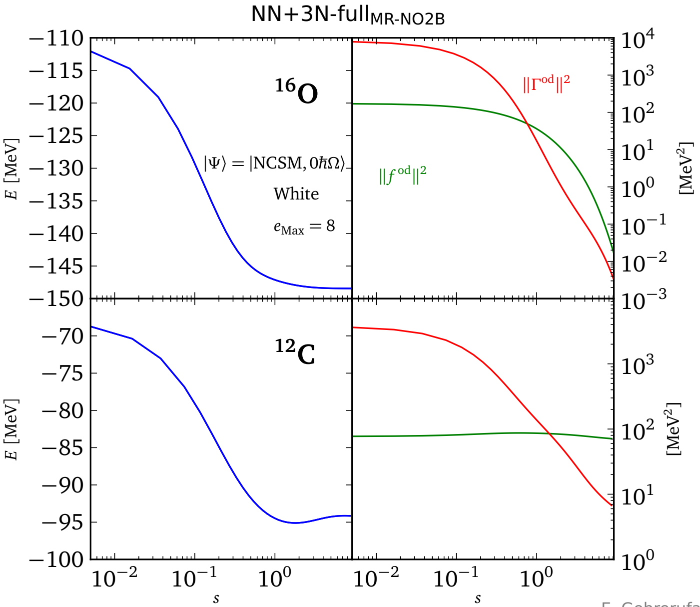
White and Imaginary Time

$$\eta^1_2 := \mathcal{F}(\Delta^1_2)\, n_1 \bar{n}_2 f^1_2 - [1 \longleftrightarrow 2]$$
$$\eta^{12}_{34} := \mathcal{F}(\Delta^{12}_{34})\, n_1 n_2 \bar{n}_3 \bar{n}_4 \Gamma^{12}_{34} - [(12) \longleftrightarrow (34)]$$

$$\Delta^1_2 := \langle \Psi | \, \tilde{a}^2_1 H \tilde{a}^1_2 \, | \Psi \rangle \qquad \Delta^{12}_{34} := \langle \Psi | \, \tilde{a}^{34}_{12} H \tilde{a}^{12}_{34} \, | \Psi \rangle$$

$$\mathcal{F}(\Delta) := \begin{cases} \frac{1}{\Delta} & \text{for White} \\ \mathrm{sgn}(\Delta) & \text{for Imaginary Time.} \end{cases}$$

MR-IM-SRG Evolution



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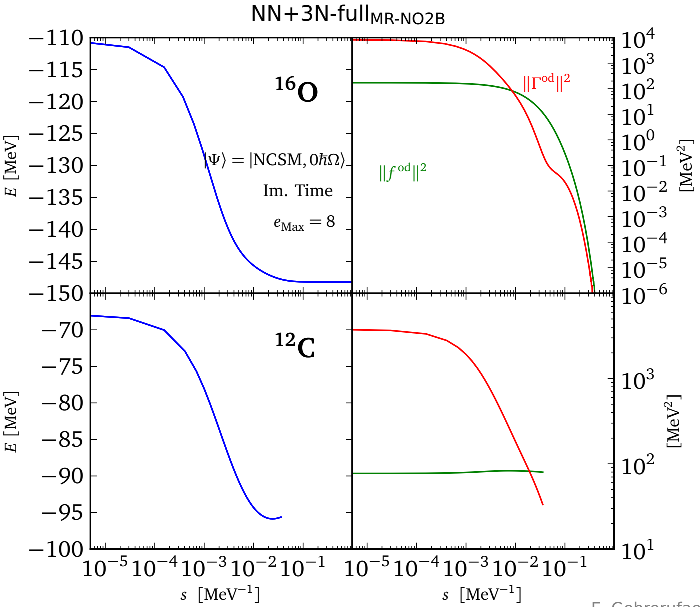

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