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Chiral Four-Nucleon Force in Ab Initio Nuclear Structure

Stefan Schulz and Robert Roth

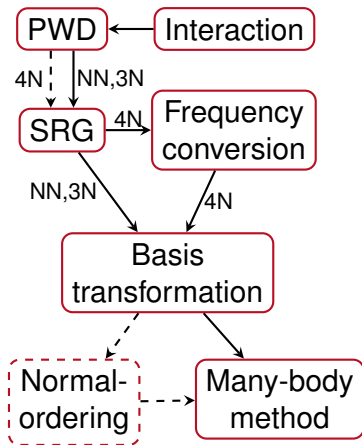
Technische Universität Darmstadt

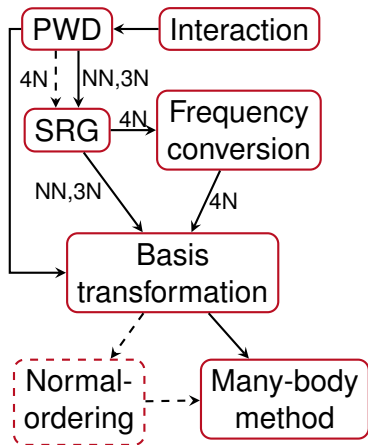


Why Four-Body Forces?



- ▶ Effect of SRG-induced 4N contributions increases with number of nucleons
 - ▶ Fine-tune interaction
 - ▶ Change SRG generator
- ▶ Effect of initial 4N contributions?
 - ▶ Similar scaling with number of nucleons?
- ▶ Goal: Consistent order-by-order calculations for chiral Interactions
 - ▶ Chiral 4N interaction necessary starting from $N^3\text{LO}$!

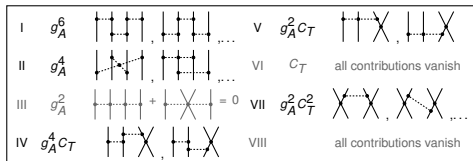




Chiral 4N at $N^3\text{LO}$

- ▶ PWD for 5 classes
 - ▶ 11 different operator structures
 - ▶ Crosschecks: Monte-Carlo integration
- ▶ Limit on partial wave & E_4^{\max}
- ▶ Local regulator \Rightarrow speedup

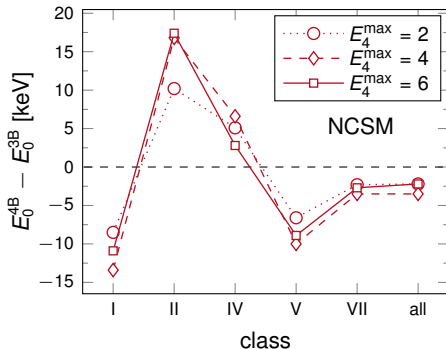
$$\exp \left[- \left(\frac{(\bar{\pi}'_1 - \bar{\pi}_1)^2 + (\bar{\pi}'_2 - \bar{\pi}_2)^2 + (\bar{\pi}'_3 - \bar{\pi}_3)^2}{3\Lambda^2} \right)^2 \right]$$



Ground State of ${}^4\text{He}$

- ▶ Cancellation between different classes
- ▶ Not completely converged
- ▶ Differs from previous estimate
 - ▶ Sensitive to NN+3N interaction
 - ▶ Different regulator, model space, ...
- ▶ Weak overall effect

A. Nogga et al., EPJ Web of Conferences 3, 05006 (2010).

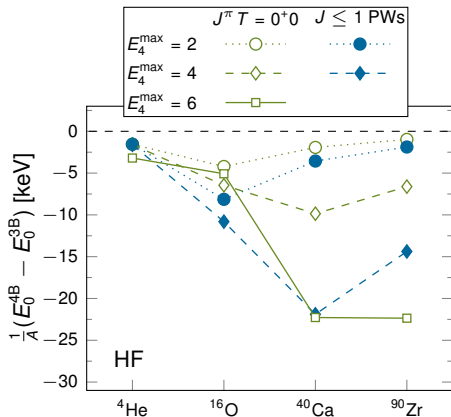


$$N_{\max} = 20, \hbar\omega = 24 \text{ MeV}, \alpha_{2B} = \alpha_{3B} = 0.08 \text{ fm}^4$$

NN interaction at $N^3\text{LO}$ with $\Lambda = 500 \text{ MeV}/c$ D. R. Entem et al., PRC 68, 041001 (2003)

3N interaction at $N^2\text{LO}$ with $\Lambda = 400 \text{ MeV}/c$ R. Roth et al., PRL 109, 052501 (2012)

4N interaction with $\Lambda_{4B} = 400 \text{ MeV}/c$ and $C_T = 0.21 \text{ fm}^2$ E. Epelbaum, The EPJ A 34, 2, 197 (2007).



- ▶ Contribution increases with number of nucleons
- ▶ Not converged w.r.t. E_4^{\max} or J
- ▶ Weak overall effect

$$e_{\max} = 8, \hbar\omega = 24 \text{ MeV}, \alpha_{2B} = \alpha_{3B} = 0.08 \text{ fm}^4$$

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