

FCI Problem Statement

Solve eigenvalue problem in large enough basis to converge

$$\begin{aligned} H &= T_{rel} + V_{NN} + V_{3N} + \dots \\ H|\Psi_i\rangle &= E_i|\Psi_i\rangle \\ |\Psi_i\rangle &= \sum_{n=0}^{\infty} A_n^i |\Phi_n\rangle \\ \text{Diagonalize } &\{ \langle \Phi_m | H | \Phi_n \rangle \} \end{aligned}$$

Employ eigenvectors to calculate experimental observables

$$\text{Transition Rate } (i \rightarrow k) \propto \left| \langle \Psi_k | \hat{O} | \Psi_i \rangle \right|^2$$

- Test fundamental strong interaction forces in nature
- Test fundamental symmetries - standard model and beyond

What is the FCI approach to solving the problem?

- Adopt a realistic NN (and 3N) interaction & renormalize via SRG or Vlowk as needed
- Adopt the 3-D Harmonic Oscillator (HO) for the single nucleon basis states, α, β, \dots
- Evaluate the nuclear Hamiltonian, H, in basis space of HO (Slater) determinants (manages the bookkeeping of anti-symmetrization)
- Diagonalize H in sufficiently large basis to achieve converged results
- Evaluate observables and compare with experiment

$$|\Phi_n\rangle = [a_\alpha^+ \dots a_\zeta^+] |0\rangle$$

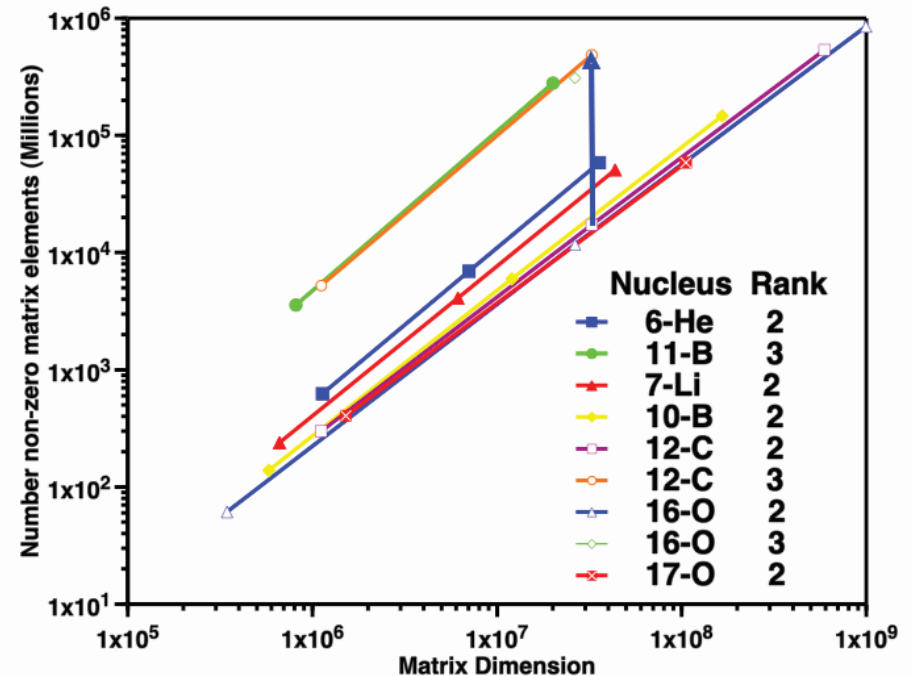
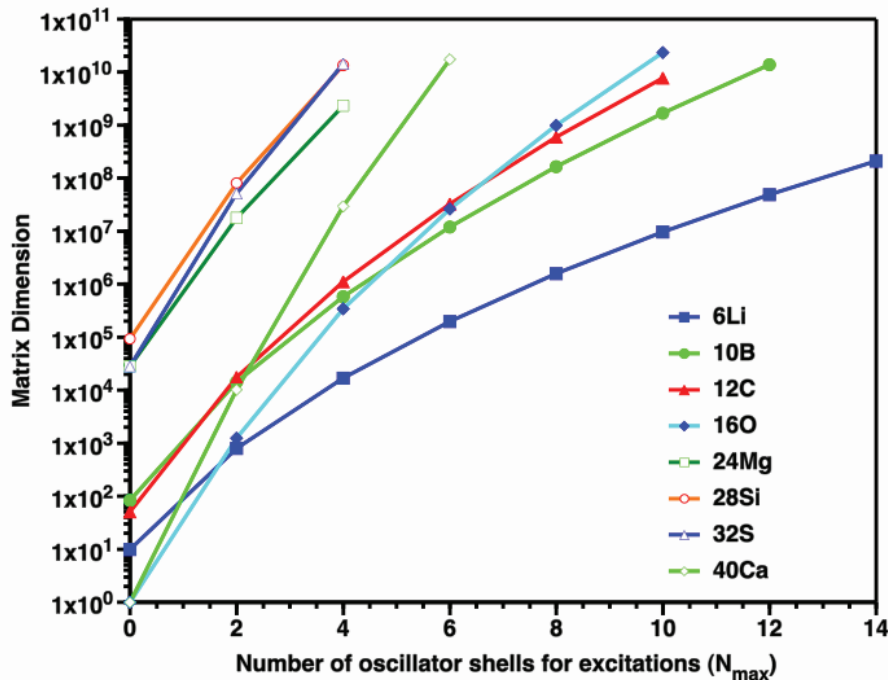
$n = 1, 2, \dots, 10^9$ or more!

Comments:

- Straightforward but computationally demanding \Rightarrow new algorithms/computers
- Requires convergence assessments
- Achievable for nuclei up to $A=16$ (40) today with largest computers available

Challenge

Exponential increase in dimension (D)



Opportunities

- Memory/cpu time grows only as $D^{3/2}$
- Algorithm development (UNEDF/SciDAC funding)
- Petaflop machines on order (Japan, US-NSF, US-DOE, ...)
- Improved understanding of H & RN (Chiral EFT, others)
- Developing methods for extrapolating $D \rightarrow \infty$