FCI Problem Statement

Solve eigenvalue problem in large enough basis to converge

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

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,…
- Evaluate the nuclear Hamiltonian, H, in basis space of HO (Slater) determinants (manages the bookkeeping of anti-symmetrization)

$$|\Phi_n\rangle = [a_\alpha^+ \bullet\bullet\bullet a_\varsigma^+]_n |0\rangle$$

- Diagonalize H in sufficiently large basis to achieve converged results

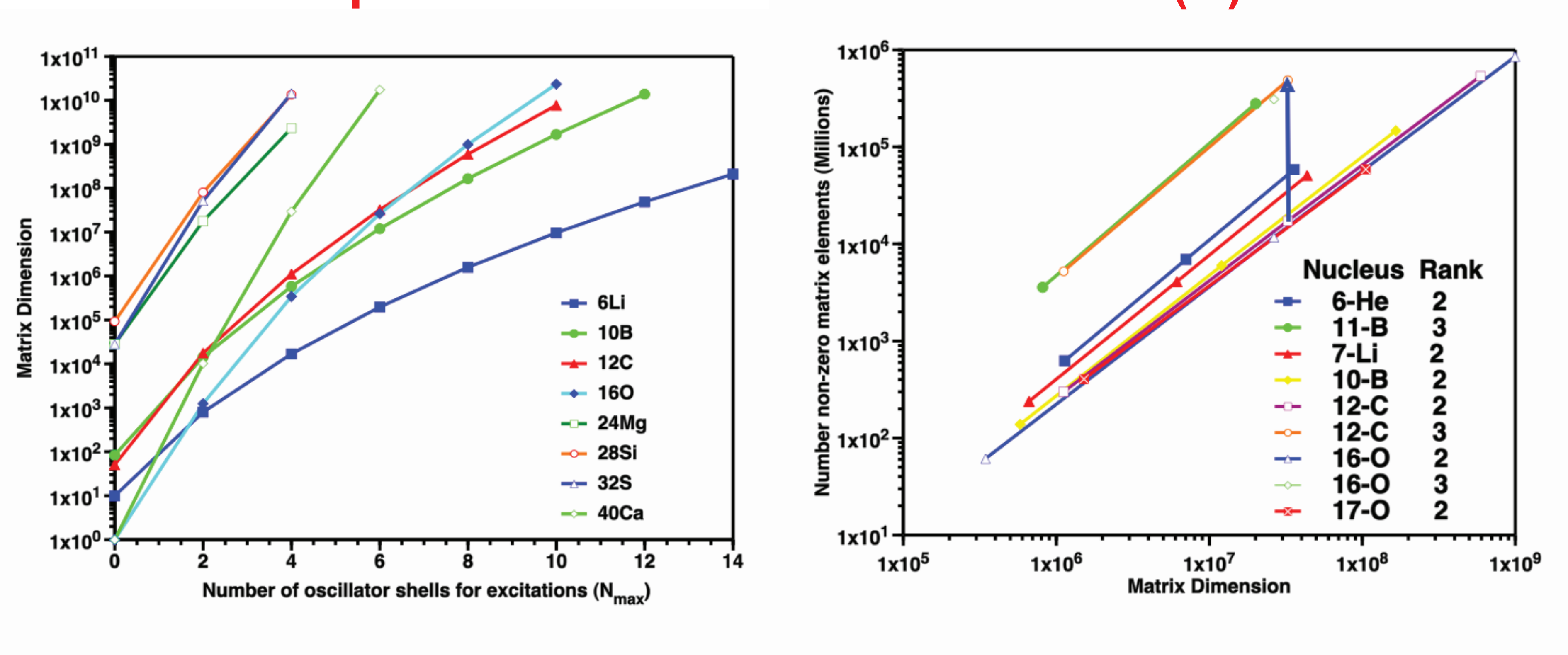
$$n = 1,2,\ldots,10^9 \text{ or more!}$$

- Evaluate observables and compare with experiment

Comments:

- Straightforward but computationally demanding => 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->inf