Quantum Computing in NP: Nuclear Structure and Dynamics

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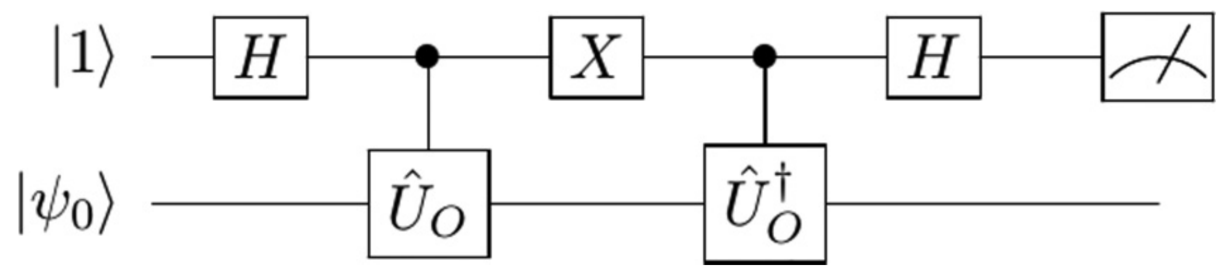
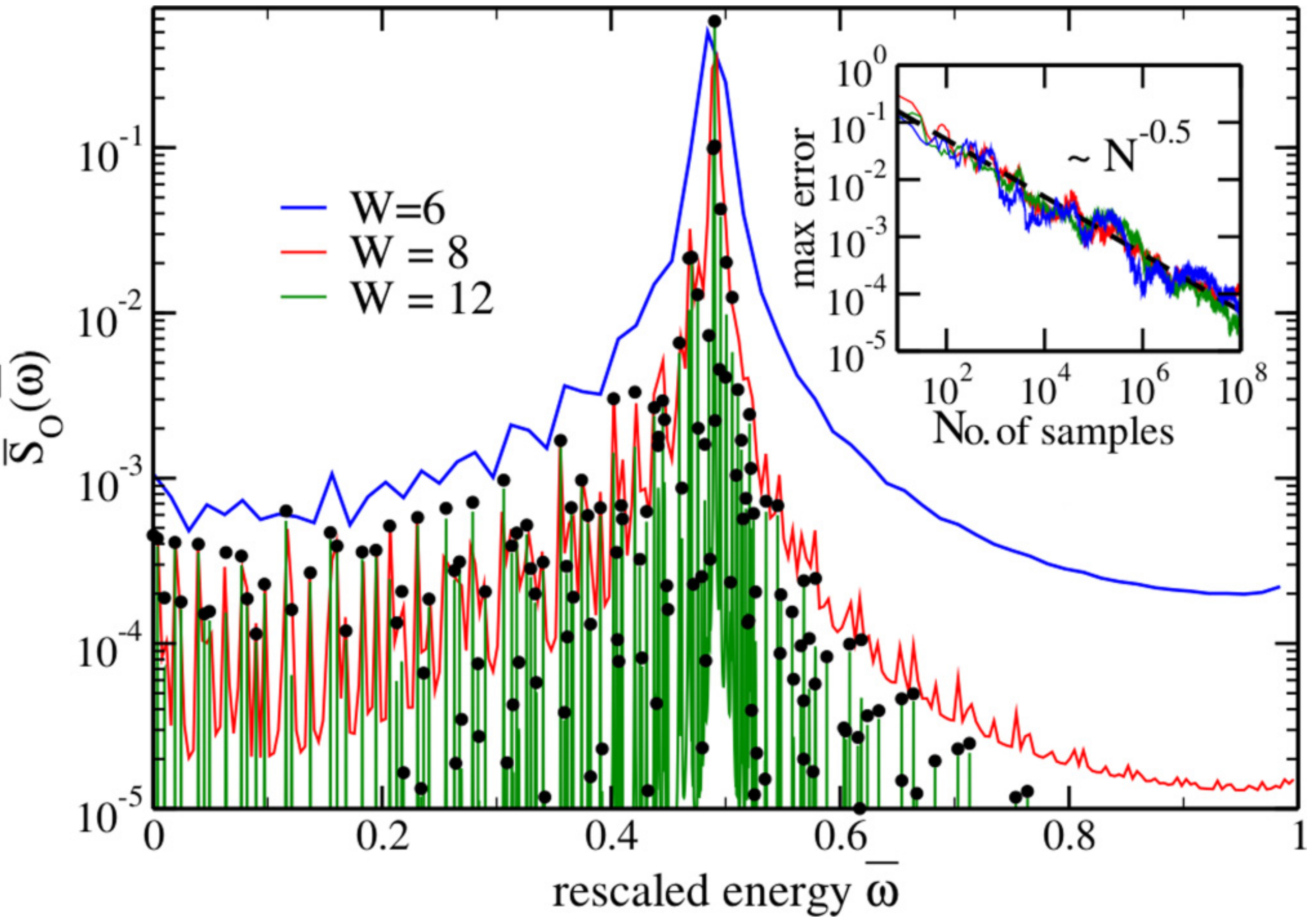
Promise of Quantum Computing: Scattering and Dynamics

Linear Response is a natural early application

Short time evolution contains a lot of information

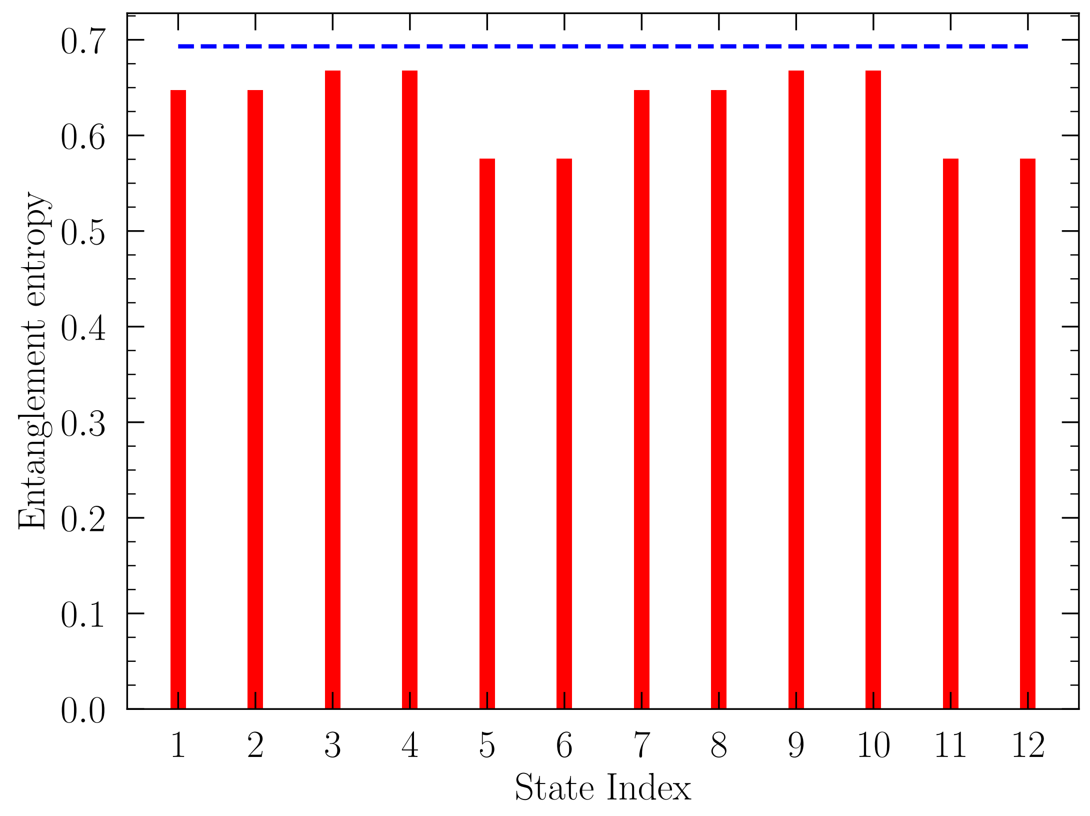
Minimal Requirements on auxiliary qbits

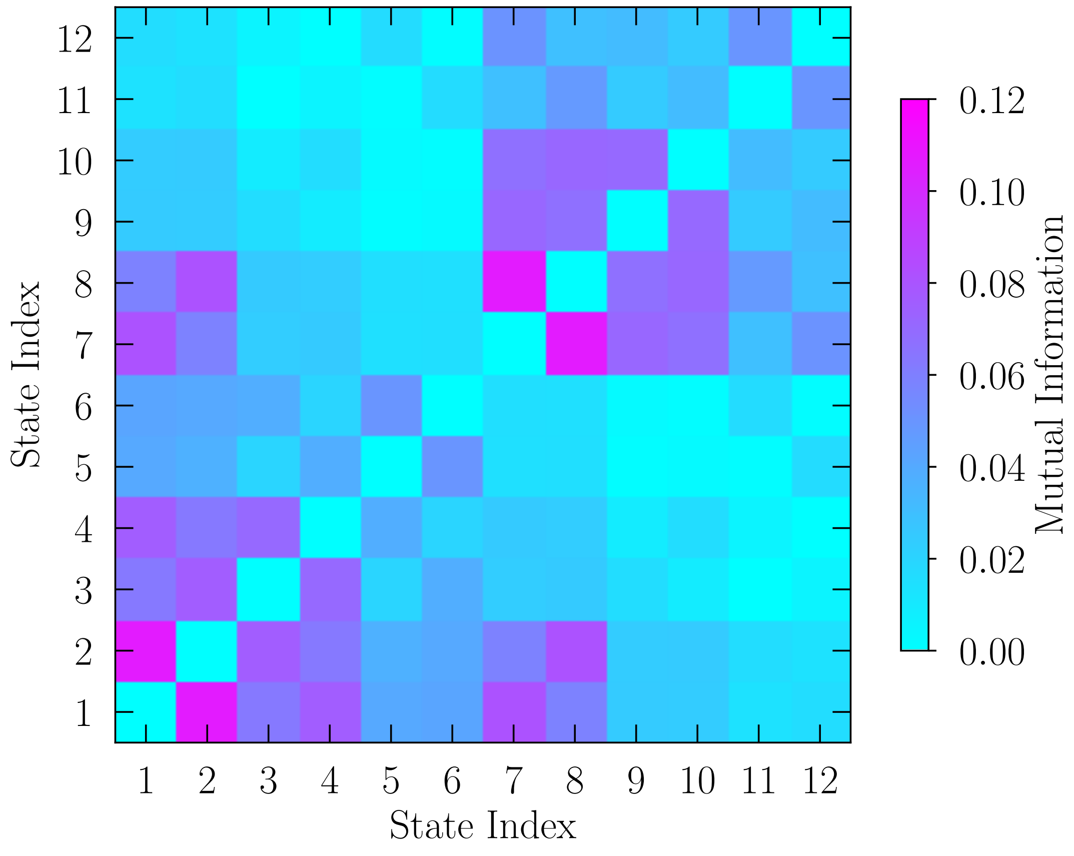




In response & spin models doing what we can now and planning for QC

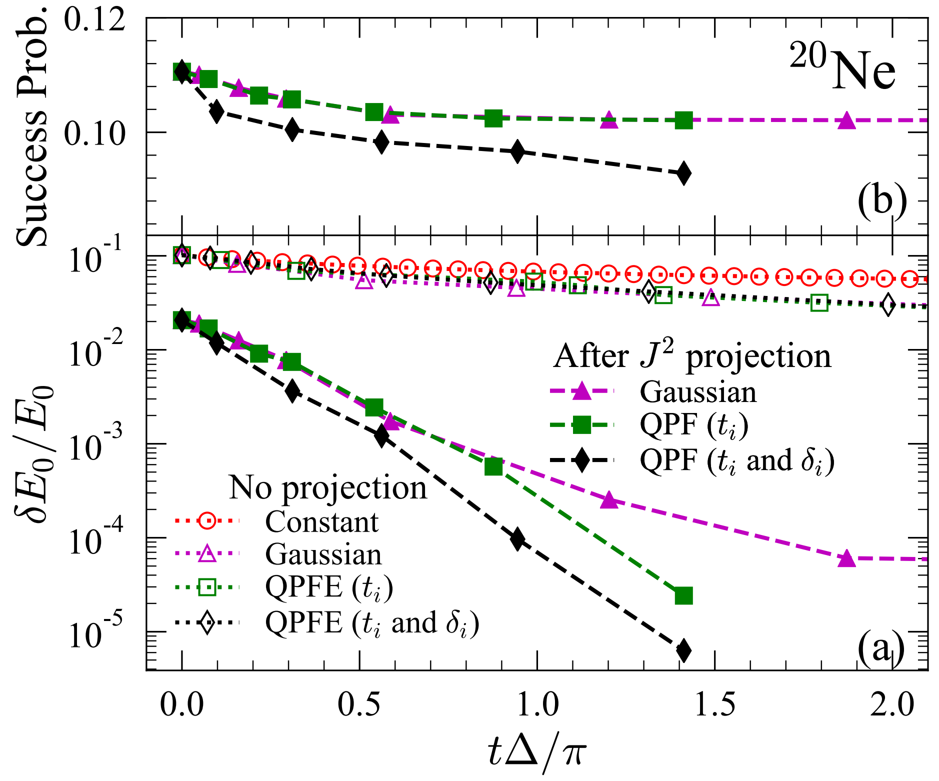
State Preparation on QC: variational for Shell Model

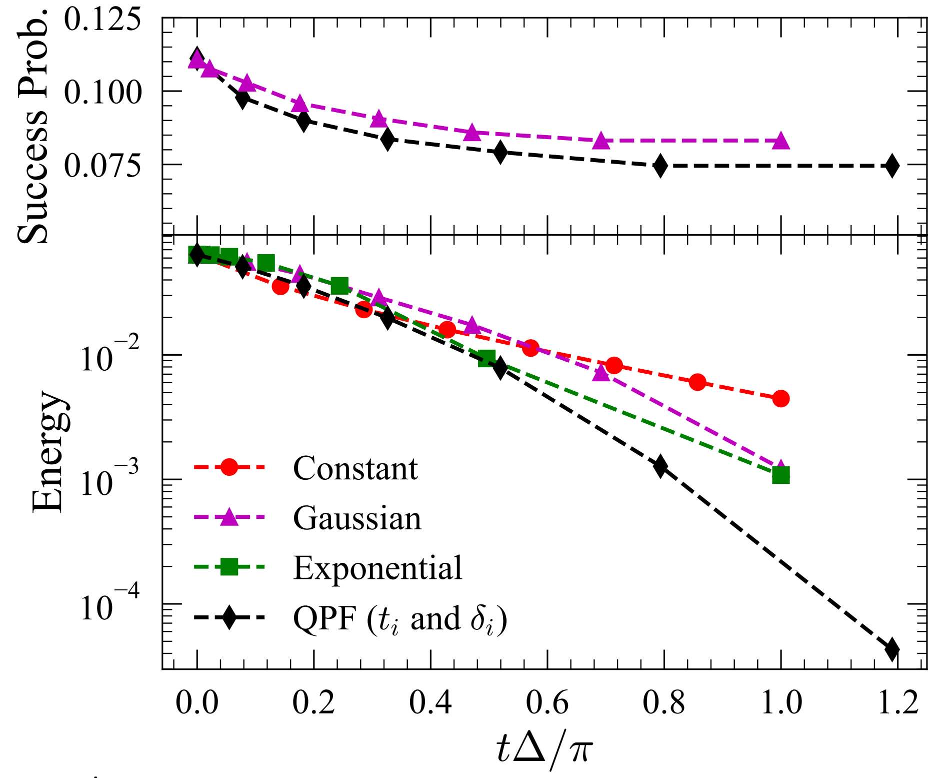




Single-particle entanglement (left) and mutual information for HF s.p. states

State Preparation on QC: exact (in preparation)





Time evolution required ~ 3/Δ (similar to QMC)

Projection on symmetries

Coherent Neutrino Evolution

B. Hall, J. Martin, A. Baroni, A. Roggero, H. Duan, V. Cirigliano, J.C.
(See also works by ORNL, M. Savage, …)

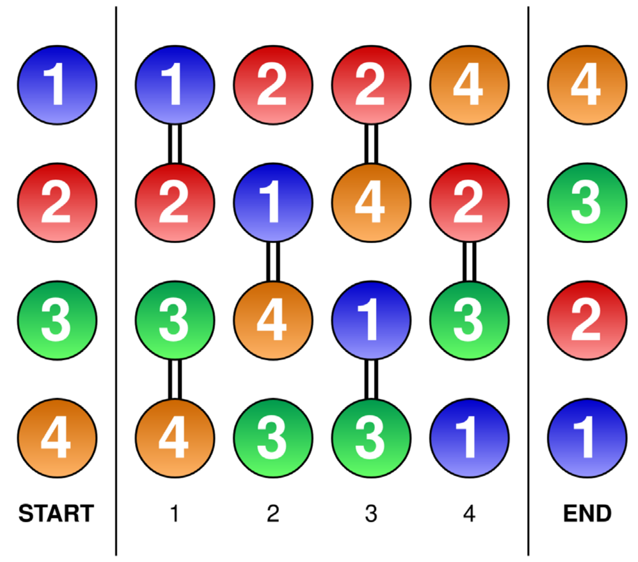
Vacuum oscillations + MSQ + $\nu - \nu$ forward scattering

$$H = H_1 + H_2$$

$$H_1 = \sum_i \left(-\left(\frac{\delta m^2}{2E_i}\right)\cos(2\theta_\nu) + A\right)\sigma_z(i) + \frac{\delta m^2}{2E_i}\sin(\theta_\nu)\sigma_x(i)$$

$$H_2 = \nu \sum_{i<j} (1 - \hat{q}_i \cdot \hat{q}_j)\ \sigma_i \cdot \sigma_j$$

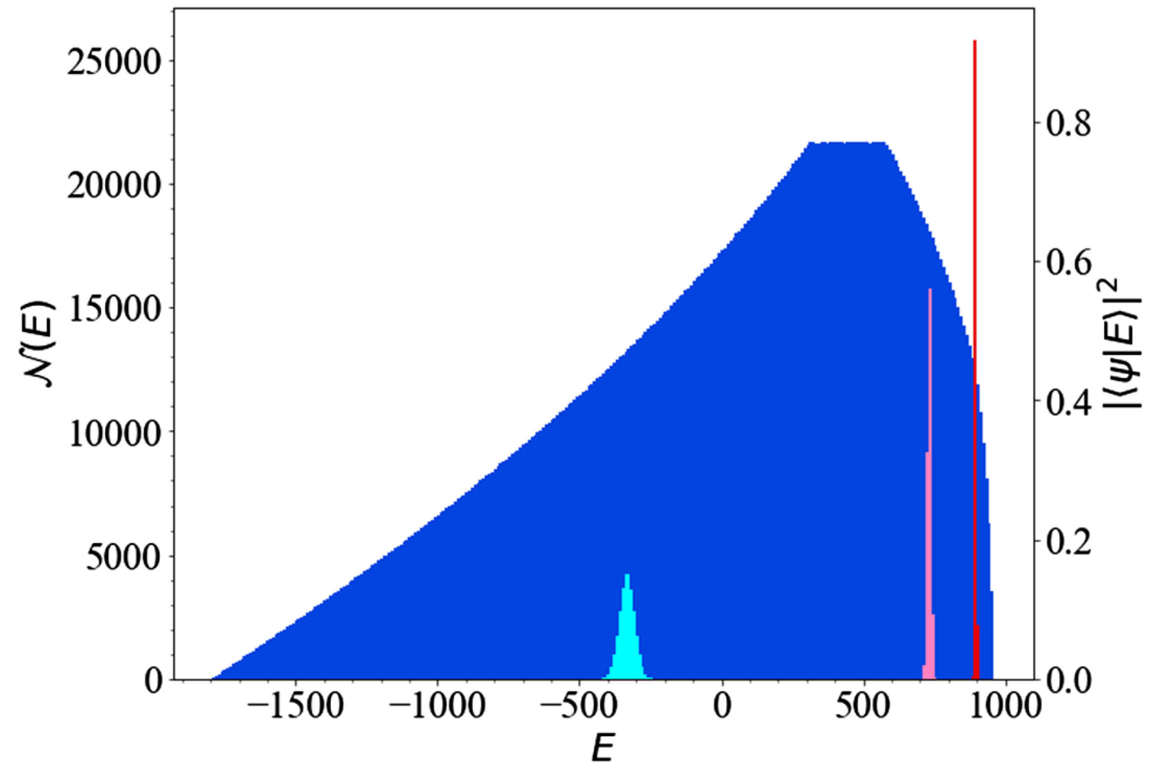
Simple mapping of spins to qubits
However, all-to-all coupling



Previously calculations in mean-field approximation

Register for LRP meeting on Quantum Computing
Jan 31-Feb 1; Santa Fe Hilton
See details on IQuS web site under workshops
Link for registration

Simple 2 beam model with quench (static H)
& initial product state
Enough symmetries that we can do 100's of spins



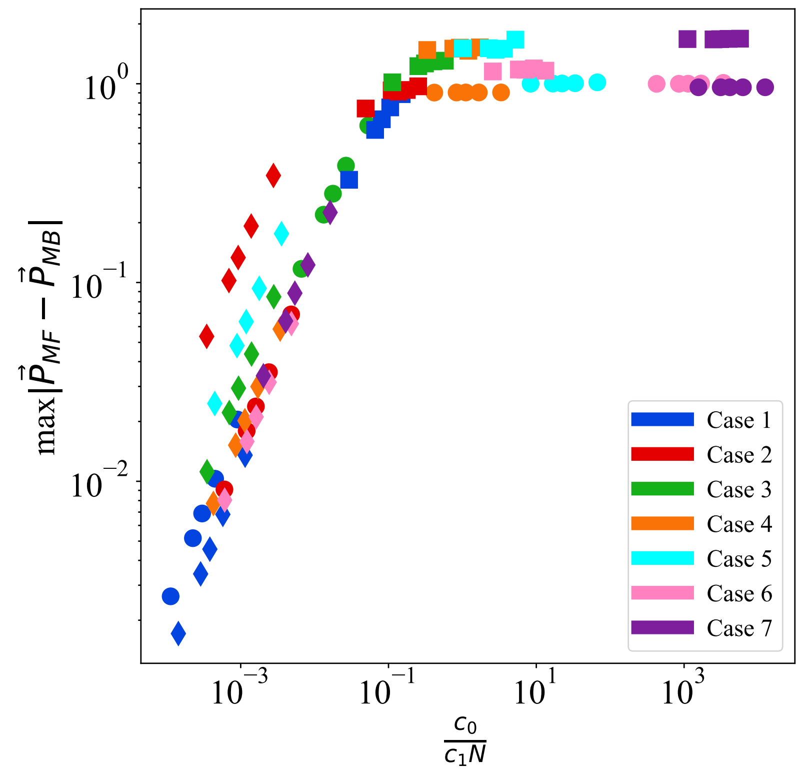
Initial state energy distributions

$$\frac{H}{\mu} = \frac{\Omega}{2}\vec{B}\cdot(\vec{J}_A - \vec{J}_B) + \frac{2}{N}\vec{J}_A\cdot\vec{J}_B,$$

$$\Delta H^2 = c_1 N + c_0.$$

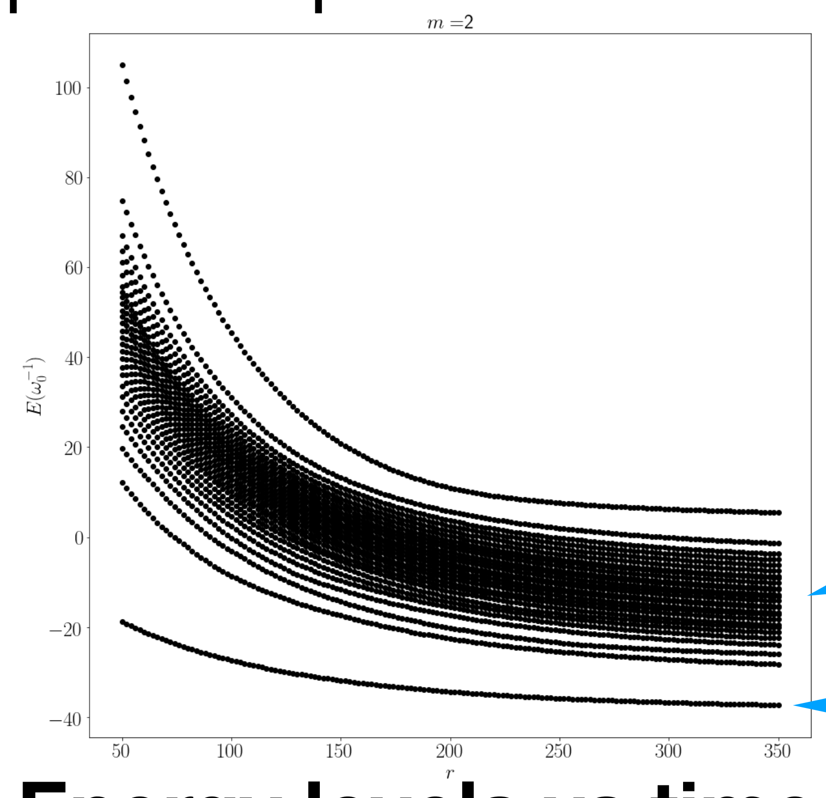
$$c_0 = \frac{N_A N_B}{4N^2}(1 - (\hat{n}_A \cdot \hat{n}_B))^2,$$

$$c_1 = c_{1,2}\Omega^2 + c_{1,1}\Omega + c_{1,0}.$$



Accuracy of mean field
Works well for large N

More 'realistic' dynamical model (B. Balantekin)
12 spins: 8 up and 4 down in flavor basis H_2 decays w/ time



Energy levels vs time

Avoided level crossing
More general dynamics

Large Gap / Adiabatic evolution
Spectral swap / Dynamical phase transition