Quantum Computing for Nuclear Physics:

Improving Hamiltonian Encodings with the Gray Code

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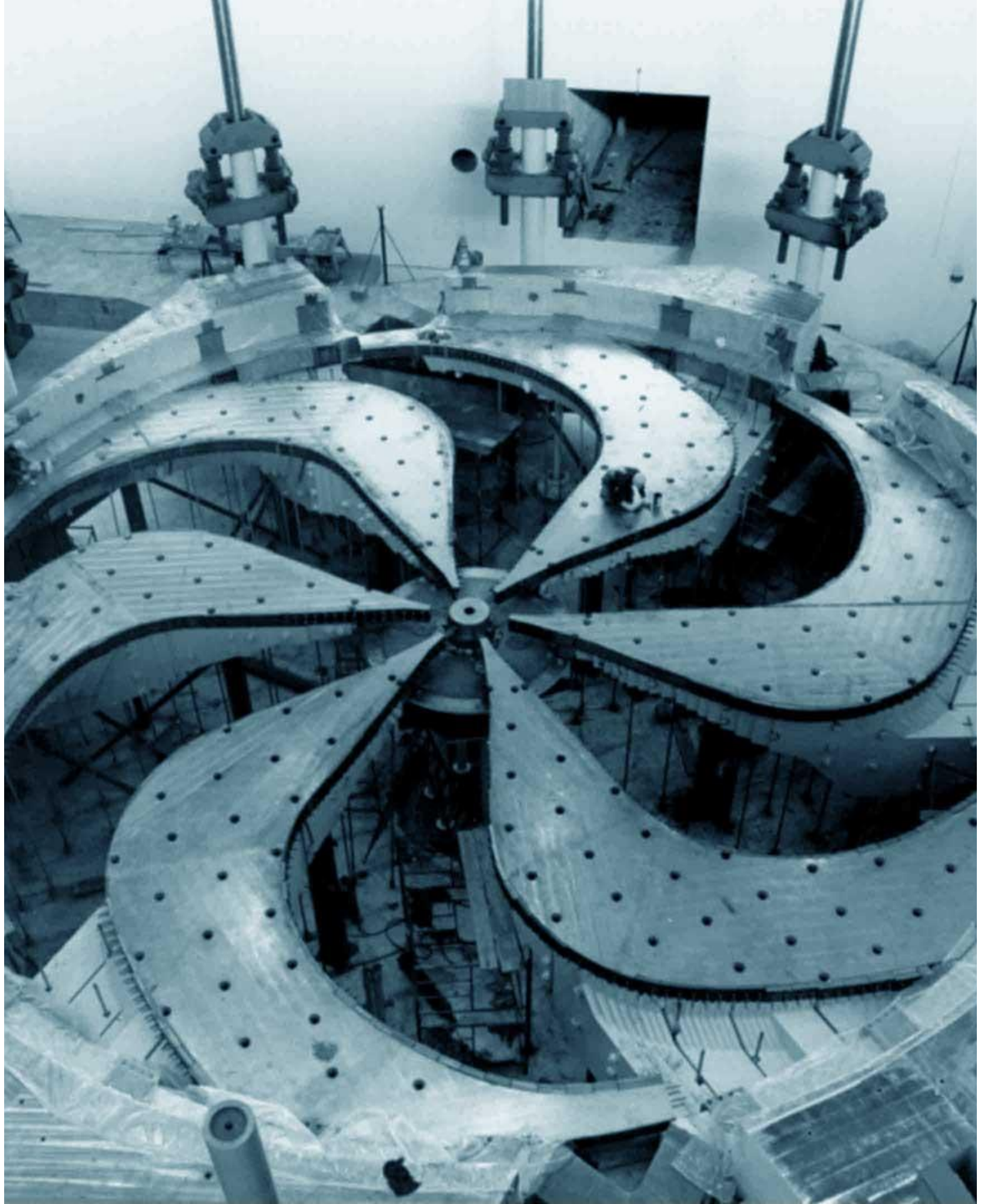
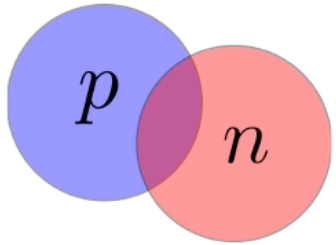


The Nuclear Many-Body Problem

- General goal: solve the Schrodinger equation

$$E\,|\Psi\rangle = H\,|\Psi\rangle$$

- This project: the deuteron

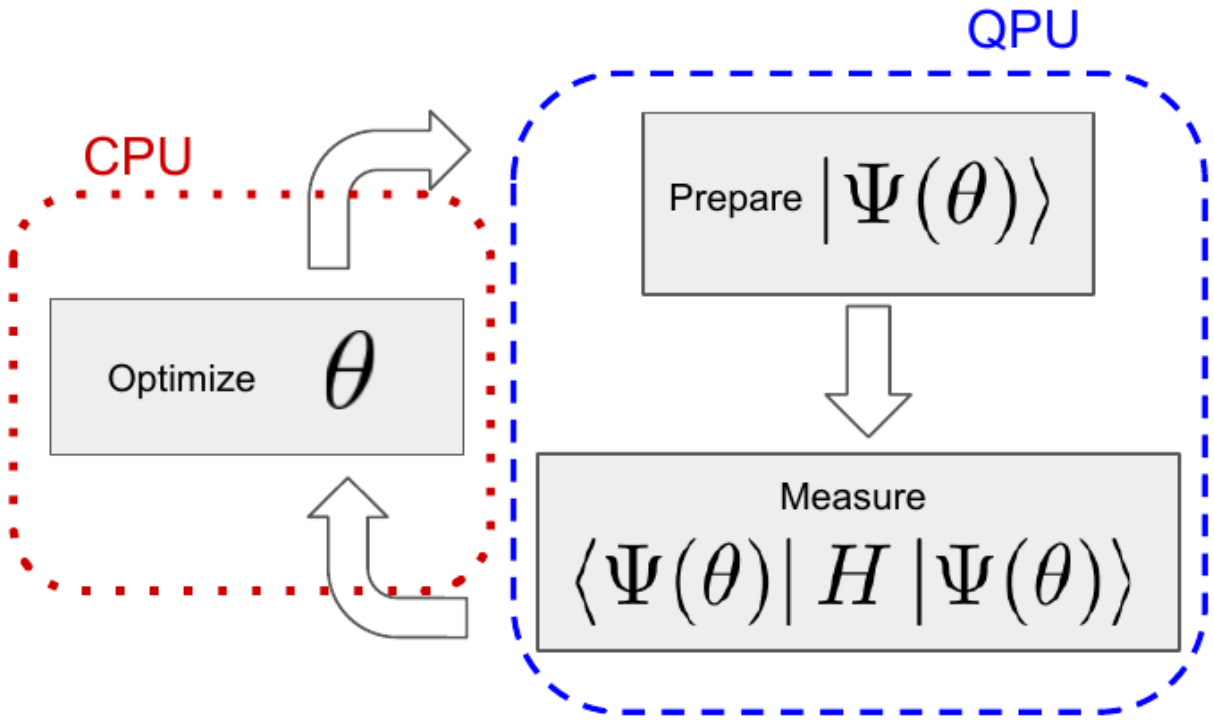


- Method: solve for coefficients of an ansatz

$$|\Psi(\theta)\rangle = \sum_{n=0}^{N-1} c_n(\theta)\,|n\rangle$$

Variational Quantum Eigensolver (VQE)

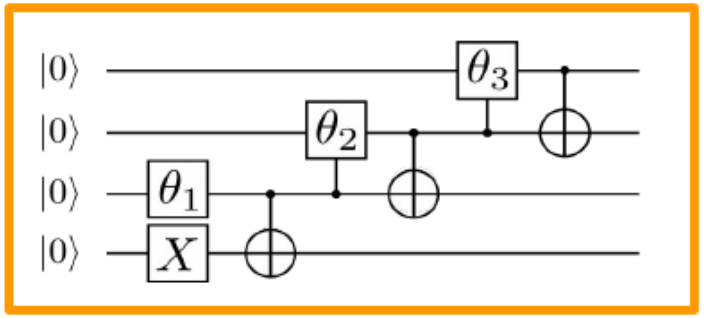
- Hybrid algorithms are most useful on current (noisy & small) devices

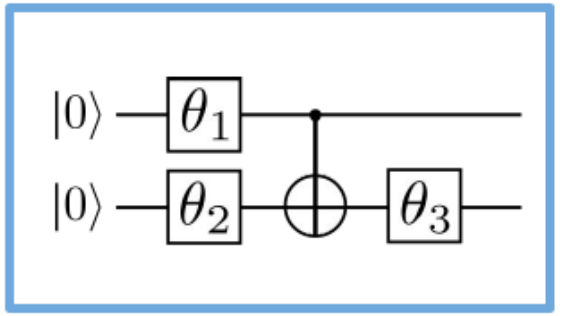


Encodings and Circuits

- Occupation (one-hot) encoding vs. Gray code encoding

Basis (N states)	Encoding: Occupation (N qubits)	Encoding: Gray Code ($\log_2(N)$ qubits)
$\|0\rangle$	$\|1000\rangle$	$\|00\rangle$
$\|1\rangle$	$\|0100\rangle$	$\|10\rangle$
$\|2\rangle$	$\|0010\rangle$	$\|11\rangle$
$\|3\rangle$	$\|0001\rangle$	$\|01\rangle$

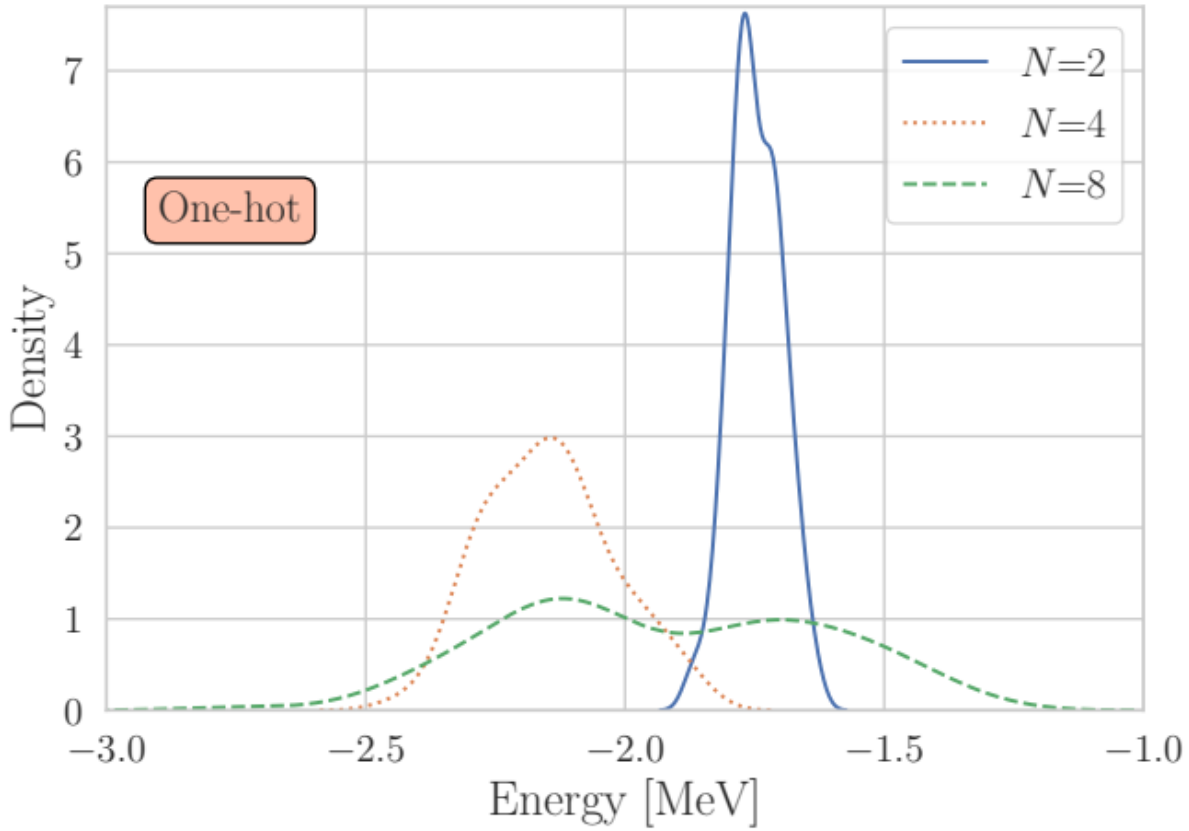


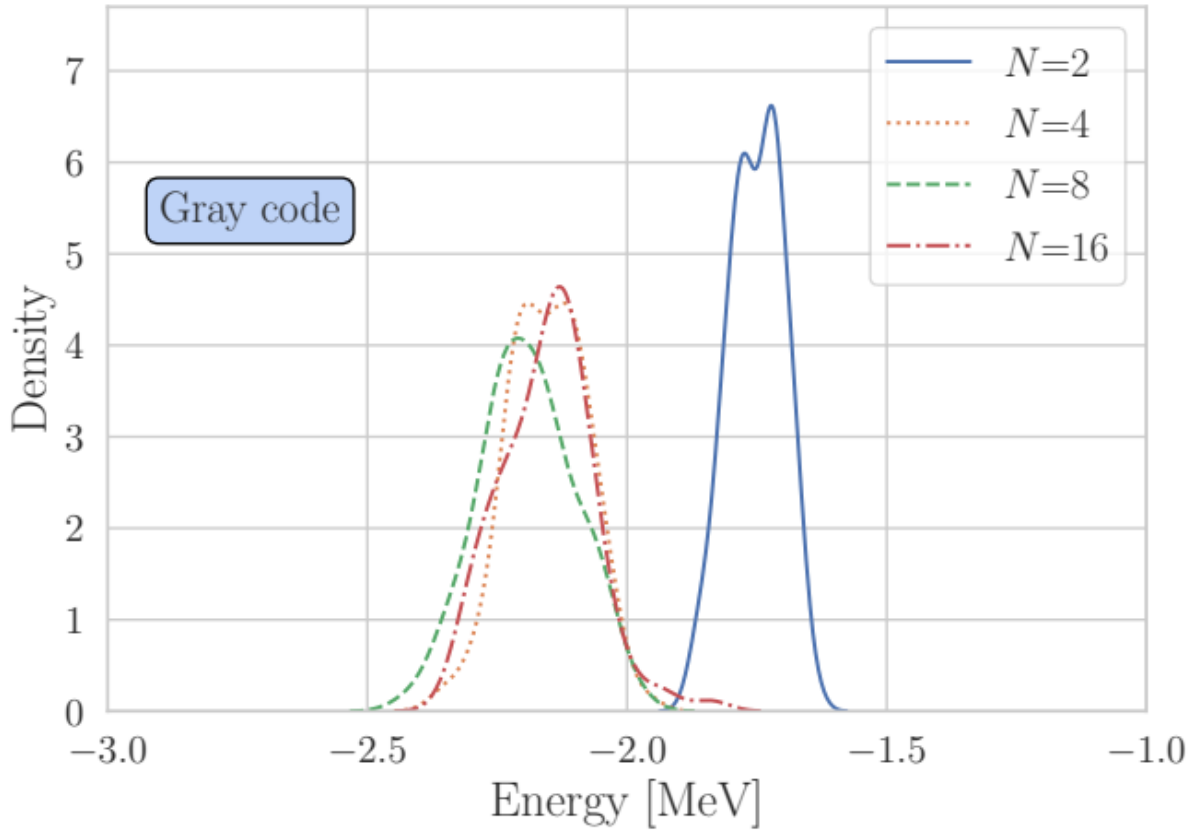


Results

- Occupation (one-hot) encoding vs. Gray code encoding

VQE trials: 100





Thank you
Merci

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