Twirling VQE (4)

Meeting with Professor Schnetzer and Rikab
July 15, 2020

Two Implementations of Twirling VQE

Proper Approach

- Anytime you evaluate a circuit, you twirl it and amplify noise by a certain amount.
- If noise amplification is perfect, then its akin to running VQE on N quantum computers, one with noise rate (!) 1*c, the other with 2*c and ….n*c

(!) by noise rate, I am referring to error rate of the 2 qubit CNOT gates.

Fake Approach

- Finish doing VQE on a noisy quantum computer, obtaining the lowest energy and the corresponding optimal parameters, optimal circuit
- Now without changing the parameters, obtain the zero error energy by twirling the optimal circuit and extrapolating.

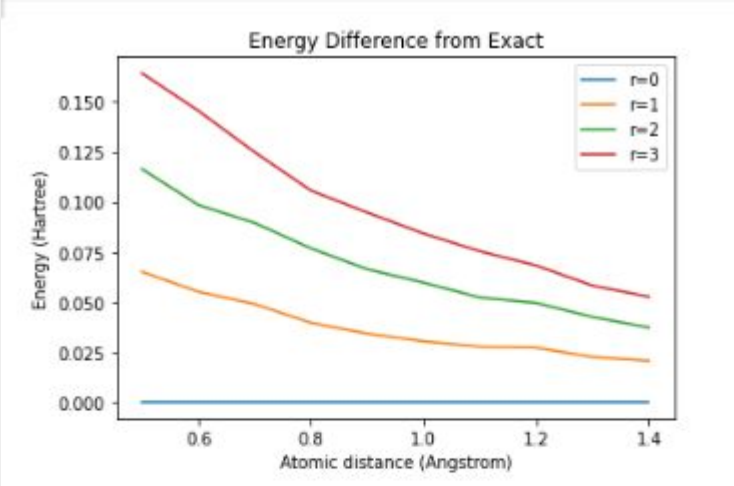
Proper Approach

Assumption: The noisier the device, the worse the energy difference from exact.

- With different noise scaling factors, you are most likely going to converge to different optimal parameters.
- This means that weights of the different excited state configurations will be different depending on noise rate
- So 2 things going on:
    - Amplification of Noise via twirling
    - Finding Optimal Parameters via VQE

Proper Approach

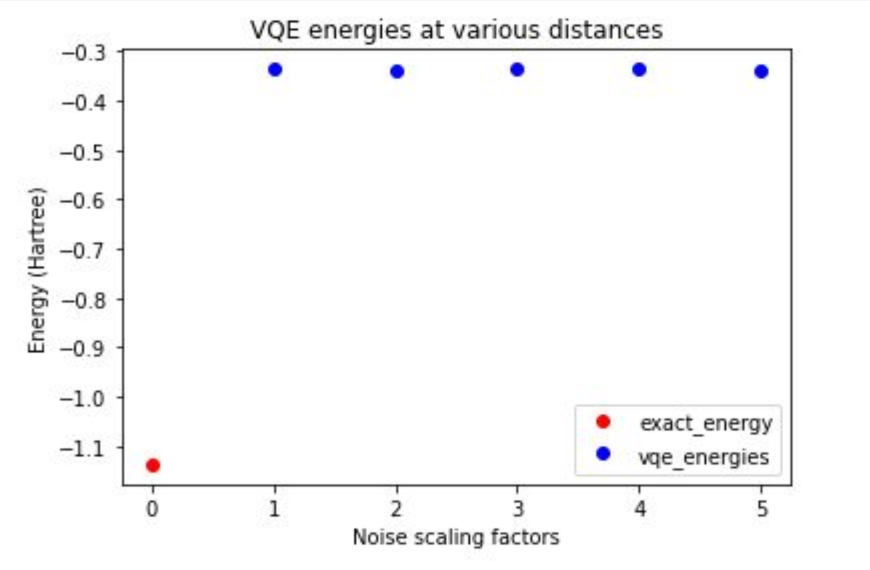
This assumption was validated when we had a very simple noise model and perfect noise amplification (no twirling here).



Proper Approach

Results: eek!

Even after amplifying noise through this method, energies don't change. The sharp rise from exact to r=1,2,3,4,5 is because the latter are ran on noisy simulator.



Proper Approach

Possible Next Steps

- Currently, I am using a noise model of the Yorktown machine which contains lots of different type of errors.
- What if I ran the same experiment but on a simpler noise model with only pauli/depolarizing noise
- If we then see energy differences, then the explanation could be that pauli noise doesn’t perform too well in presence of other types of noise.
- Also I forgot to put barriers!

Fake Approach

Assumption: Optimal parameters computed by VQE are invariant to noise level in the device.

- This is false; the opposite is true
- In fact, VQE converges upon different set of parameters on noisy quantum computer vs what it would converge upon in ideal simulation
- This makes VQE really powerful; adapting to different noise conditions to still try to find the lowest energy answer.

Fake Approach

Accepting the Assumption regardless

- Suppose you accept that assumption.
- The only thing going on is
  - Noise amplification via twirling
- There is no optimization of parameters because VQE is over by time we start amplifying noise .

Fake Approach

Results: These are much better! Could sample more times to reduce fluctuations !