W State

Contents

1 Definition and Implementation

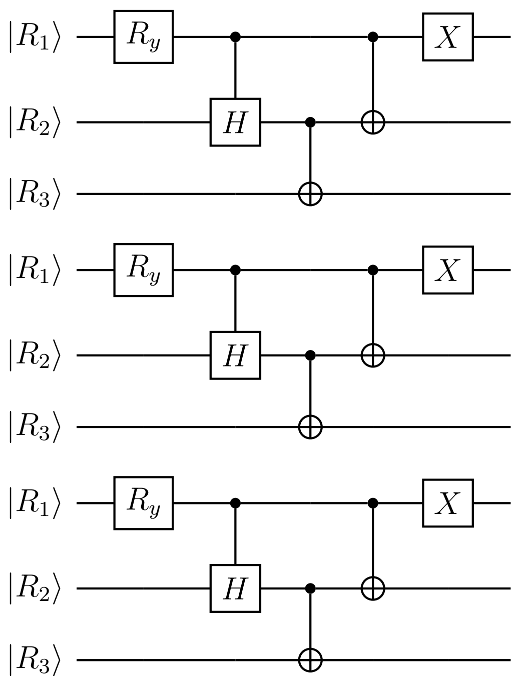
A W state [1] is a quantum state defined by

$$|W\rangle = \frac{1}{\sqrt{3}}(|001\rangle + |010\rangle + |100\rangle) \tag{1}$$

This can then be generalised (while maintaining equal weighting).

$$|W_n\rangle = \frac{1}{\sqrt{n}} \sum_{i=1}^{n} |i\rangle \tag{2}$$

The terms $|i\rangle$ in equation 2 correspond to states $|000...1...\rangle$ where the 1 is in the i^{th} position, with n positions in total. For the rest of this report, it will be taken for granted that $n = 3$. Given a 9 qubit system (3 spins and 3 sites), the W state is implemented in the following way:



The R_y gates all take the same parameter:

$$\theta = 2\arccos[\frac{1}{\sqrt{3}}] = 1.91063323 \tag{3}$$

https://web.wpi.edu/Pubs/E-project/Available/E-project-051620-220950/unrestricted/Construc
States.pdf

2 Performance Comparison

The following table compares performance of the VQE using an initial W state for each spin and an initial $|100100100\rangle$ state, with the number of function evaluations being the metric.

Function Evaluations		
Layers	$\|100100100\rangle$	$\|W\rangle$
1	2425	1056
2	48622	8944
3	65057	53504

It is probably also worth comparing the values they had the VQE converging to, given that they're different.

Energy Values		
Layers	$\|100100100\rangle$	$\|W\rangle$
1	14.336170	18.033637
2	14.246540	14.296050
3	14.153630	14.153678

3 References

1. Dür W, Vidal G, and Cirac JI. Three qubits can be entangled in two inequivalent ways. Physical Review A 2000 Nov; 62. DOI: 10.1103/physreva.62.062314. Available from: https://doi.org/10.1103%2Fphysreva.62.062314