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Finding magic in continuous variable quantum computing states

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Background

Quantum computing is in the process of becoming a technology capable of doing certain calculations that classical computers would take millennia to solve. For now, most of these quantum computers use qubits as their fundamental building blocks. A qubit is a quantum system which has two discrete levels. For example, the qubits at Chalmers use the direction of a superconducting current as their state.

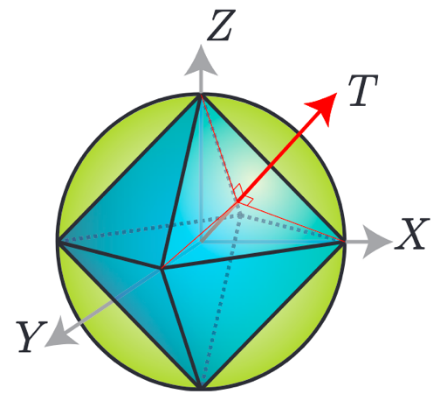
However, it is also possible to build a quantum computer which uses continuous variables (CV) to encode the quantum information, such as the position and amplitude quadrature of the quantized electromagnetic field. Not only do CV architecture allow us to encode more information, but they can simulate regular qubit quantum computing by encoding qubits into CV modes.

Project Description

The reason why quantum computers are so much faster than classical computers is still not fully understood. In fact, many quantum algorithms can be efficiently simulated on a regular classical computer.

For discrete variable quantum computation, it is known that unless we have a supply of "magic" states, a quantum computer will never have an advantage over regular computers. Similarly, for CV quantum computation, we know that there are some input states which can be described classically and simulated with a regular computer.

We are interested in understanding which CV states cannot be described classically. We would like to know which encoded qubit these states are closest to. Do the encoded states possess magic?



For qubits, magic states are well defined as states that are not along the main axes, such as the T-state represented in the figure. If a quantum computer has access only to Clifford operations and a supply of T-states, it can achieve universal quantum computation. Image from arXiv:0908.0838

For this project, we will work within the CV theory group at the AQP division and interact with theorists and experimentalists within WACQT.

References

[1] arXiv:quant-ph/0008040
[2] arXiv:1903.00012
[3] arXiv:2005.12026