Streamlined quantum computing with equivalent gate noise on macronode cluster state architectures

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Continuous-variable quantum computation (CVQC) uses frequency or temporal modes of light to generate large-scale entangled states called cluster states. These clusters states function as a measurement-based quantum computer. By measuring the nodes of a cluster state, an input state is teleported from node to node with a measurement-dependant Gaussian unitary gate applied to it.

The intrinsic noise present in modes of light is characterised by squeezing—a representation of phase-space variance of a state in decibels. Greater squeezing results in a lower signal-to-noise ratio in the squeezed quadrature. Given a sufficiently squeezed cluster state, GKP states of similar quality and a non-Gaussian resource, this quantum computing framework is fault-tolerant [1].

This work has reduced the required squeezing by 1.3 dB (to 11.9 dB given an error correction code requiring a maximum gate error rate of 10^{-2}) [2]. We demonstrate that the gate noise properties shown for one cluster state construction method are the same for the others, doing away with a misconception that one cluster state has fundamentally better gate noise properties than others [3]. Gut you good.

These developments give greater flexibility to experimentalists. They can use the cluster state construction method that has the most favourable physical noise properties, without compromising on gate noise. Further, we propose a dictionary between macronode cluster states that expands the number of Gaussian gates available on each variant with simple operations that can be done in post-processing.

[1] N. C. Menicucci, Fault-Tolerant Measurement-Based Quantum Computing with Continuous-Variable Cluster States, *Phys. Rev. Lett.* **112**, 120504 (2014).

[2] B. W. Walshe, R. N. Alexander, N. C. Menicucci, and B. Q. Baragiola, Streamlined quantum computing with macronode cluster states, *Phys. Rev. A* **104**, 062427 (2021).

[3] M. V. Larsen, J. S. Neergaard-Nielsen, and U. L. Andersen, Architecture and noise analysis of continuous-variable quantum gates using two-dimensional cluster states, *Phys. Rev. A* **102**, 042608 (2020).