Continuous-variable quantum computing and neural networks using the motional modes of trapped ions

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Quantum computing in continuous variables presents an alternative approach to the conventional qubit-based quantum computing, where qubits are enumerable and finite units of information. The "continuous information" can be represented by conjugated variables such as position and momentum, or amplitude and phase [1]. One of the advantages of quantum computing in this model is its ability to handle and process a potentially infinite number of quantum states. This can make certain tasks, such as simulating complex quantum systems, expected to be more efficient than the traditional approach, also known as digital quantum computing.

Using this model of quantum computing, it is possible to encode the aspects of a neural network, such as weight matrix and bias, into common operations of quantum optics, as shown by Killoran et al. [2]. In this work we use light-matter interaction to engineer the required operations to encode this neural network into the motional modes of a single trapped ion and show some preliminary results by applying it to a simple regression model.

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[2] N. Killoran, T. R. Bromley, J. M. Arrazola, M. Schuld, N. Quesada and S. Lloyd, Phys. Rev. Res. **1**, 033063 (2019).