Quantum computing with continuous quantum systems

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Continuous-variable quantum computers [1,2] encode information and perform calculations with the help of continuous degrees of freedom, such as e.g. position or momentum. Despite the enormous resources available in a continous quantum system, typical encodings for quantum computation only exist for single qubits as, for instance, the Gottesman-Kitaev-Preskill (GKP)-states [3].

In this talk, we present an encoding scheme for two-qubit operations in a single continous quantum system. We introduce elementary logical gates which are characterized by continuous transformations, such as displacement, rotation and shearing. The action of these operations on the respective states is illustrated in phase space. With a representation-free theory we then analyze the implementation of the resulting gates by taking into account current experimental limitations. Finally, we discuss several challenges for the identification of states and operations when encoding more than two qubits within a single continous quantum system.

[1] S. Lloyd and S.L. Braunstein, Phys. Rev. Lett. 82 (1999) 1784.

[2] S.L. Braunstein and P. van Loock, Rev. Mod. Phys. 77 (2005) 513.

[3] D. Gottesman, A. Kitaev and J. Preskill, Phys. Rev. A 64 (2001) 012310.