Continuous-Variable Instantaneous Quantum Computing is hard to sample

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Instantaneous Quantum Computing (IQP) is a sub-universal class of computation that has been defined for Discrete Variables (DV) in [1]. In the original formulation, an IQP circuit requires the following ingredients: the input states are Pauli-X eigenstates, each gate in the circuit is diagonal in the Pauli-Z basis and the output corresponds to a Pauli-X measurement. Since all the gates commute they can be performed in any order and possibly simultaneously, hence the name of IQP.

We study the translation of this class of circuits to the Continuous-Variable (CV) formalism. From an experimental point of view, CVs offer the possibility of deterministically preparing resource states, such as squeezed states or cluster states, and typical measurements, such as homodyne detection, have higher detection efficiencies as compared to e.g. photon counting. In order to map the IQP paradigm from DV to CV, we use the correspondence between the universal set of gates described e.g. in [2]. CV IQP circuits have thereby the following structure: the input states are momentum-squeezed states, gates are diagonal with respect to the position quadrature and measurements are homodyne detections in the momentum quadrature. Following the lines of [1], we analyse the computational power of the CV IQP class by exploring the properties of post-selected CV IQP circuits, and we prove that CV IQP circuits are hard to sample [3]. In order to deal with post-selection in CV we consider finite resolution homodyne detectors, which leads to a realistic scheme based on discrete probability distributions of the measurement outcomes. A further peculiar element of CV that necessitate a careful analysis is the finite squeezing of the input squeezed states. We deal with this aspect by adding to the model ancillary GKP states and by relying on a GKP encoding of quantum information, which was shown to enable fault-tolerant CV quantum computation [4]. Finally, we show that, in order to render post-selected computational classes in CVs meaningful, a logarithmic scaling of the squeezing parameter with the circuit size is necessary, translating into a polynomial scaling of the input energy.

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