Deterministic implementation of two mode cubic coupling

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Abstract

We present a general technique for deterministically implementing a multi-mode nonlinear coupling between several propagating microwave or optical modes in quantum circuits [1]. The measurement induced technique combines specifically prepared resource states together with feasible feed-forward operations. We explore several ways of generating the suitable resource states and discuss their difference on an illustrative example of cubic coupling between two modes. We also show that the required entangled states with requisite nonlinear properties can be already generated in the present day experiments.

In the paper [1], we present a general description of a class of non-Gaussian couplings between several propagating field modes together with a measurement induced method for experimental implementation in quantum circuits. The method is a final generalization of the original GKP proposal. The architecture of the N mode coupling is based on N sequential Gaussian quantum nondemolition interactions with N auxiliary modes prepared in a specific nonlinear state, homodyne detection of the ancillary modes, and nonlinear feedforward control applied to the modes that remain.

We consider a third-order non-Gaussian coupling as an example and discuss several different approaches towards the entangled resource state generation. Ultimately we show that genuinely non-Gaussian coupling between several harmonic oscillators is feasible, which opens up the avenue of both quantum technologies and fundamental research of highly nonlinear quantum mechanics and thermodynamics.

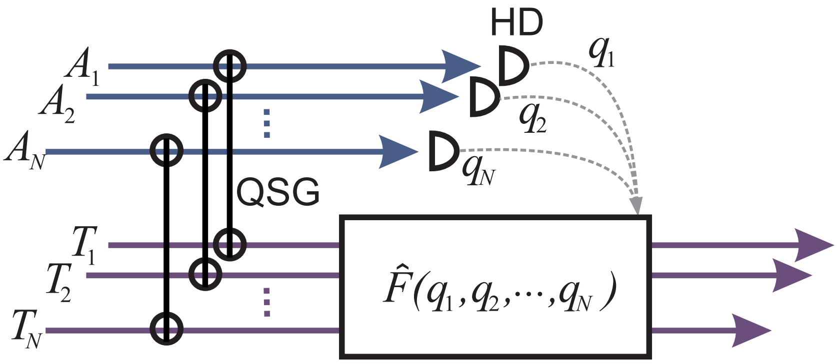

Figure 1: Schematic depiction of the measurement induced implementation of a mono-quadrature multi-mode coupling. The input modes interact with the auxiliary modes $A_1, \cdots, A_N$ through a sequence of quadrature sum gates (QSG). The auxiliary modes are then measured by homodyne detectors (HD), yielding values $q_1, \cdots, q_N$, which are then used for the corrective feed-forward $\hat{F}(q_1, \cdots, q_N)$ in order to produce the output.

[1] S. Sefi, P. Marek, R. Filip *Deterministic multi-mode nonlinear coupling for quantum circuits*, **arXiv**:1901.10753.