Dominant couplings in qubit networks with controlled interactions

J. Maryška, J. Novotný, I. Jex

Department of Physics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Praha 1 - Staré Město, Czech Republic

Quantum networks can be viewed as a very general approach to solve a broad class of physics problems including the dynamics of interacting systems. In many of these networks, which are interesting for present day science, the interaction between particular nodes of a given network have random character. In our work we present the physical model of random unitary operations which is suitable for such a situation. Usually the interactions between elements of the network are considered bipartite, in real situations multipartite (for instance three body) interactions cannot be excluded. Our aim is to investigate the interplay between two-qubit and three-qubit interactions within quantum networks in the asymptotic regime, i.e. for long interaction times. As representatives of these interactions we choose controlled unitary two-qubit interactions and controlled unitary three-qubit interactions with one and two control qubits. Each type of interaction is studied in detail. Algebraic properties of the random unitary operations then enable us to carry out results about quantum network with all considered types of interaction present.

We show that for a certain class of interaction topologies enabling three-qubit transformations next to two-qubit transformations the asymptotic state remains the one of two-qubit interaction. Furthermore we show that qubit networks in which qubits interact with each other only via three-qubit interactions can be in the asymptotic indistinguishable from qubit networks equipped with two-qubit interactions. However, if we consider qubit network in which qubits interact with each other by a single type of controlled unitary three-qubit interaction (e.g. with one control qubit), the asymptotic dynamics is generally different from the case of controlled unitary two-qubit interactions. Our results can be generalized to higher order interactions or to include the free evolution of qubits.