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Multimode resources based on optical frequency combs and implementation of quantum complex network

Abstract: Recently, quantum complex networks, i.e. collections of quantum systems in a non-regular topology, have been explored leading to significant progress in a multitude of diverse contexts including, e.g., quantum transport, open quantum systems, quantum communication, extreme violation of local realism, and quantum gravity geometries. However, the question on how to produce and control general quantum complex networks in experimental laboratory has remained open. The Multimode Quantum Optics group at Laboratoire Kastler Brossel developed in the last years experimental multimode systems based on parametric processes pumped by optical frequency combs. The spectrum of these lasers is constituted by hundreds of thousands of frequencies components. The parametric process in the non-linear crystal couples all these optical frequencies, and generates non-trivial multimode Gaussian quantum states. This strategy demonstrated its potential in multipartite entangled states [1] and cluster states generation [2]. Here we address a more general scenario and a specific mapping, with additional tools, including pulse shaping and multimode measurements for the implementation of quantum complex networks [3]. The scheme allows for the arbitrary control of a large number of the nodes (optical modes) and topology of the links (interactions between the modes) within the network. We describe the dynamics within the complex network of coupled harmonic oscillators and then show in detail how this can be mapped to the optical platform. We finally discuss the implementation of a probing technique for complex network.

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