Quantum Networks with Optical Frequency Combs

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Photonic architectures have emerged as a viable candidate for the development of quantum information processing protocols. Photons are immune from environmental disturbances, readily manipulated with classical tools, and subject to high efficiency detection. While strong nonlinear interactions at the single photon level are difficult to achieve, it is possible to initiate an interaction among photonic channels through the act of measurement. Such measurement-induced nonlinearities are the basis of linear optical quantum computing.

Similarly, the nature of a quantum network is governed not only by the light quantum state, but also by the measurement process, and can then in particular be chosen after the light source has been generated. Multimode entanglement is not anymore an intrinsic property of the source but a complex interplay between source, measurement and eventually post processing. This new avenue paves the way for adaptive and scalable quantum information processing[1], but a lot remains to be understood in the many possibilities offered by such flexible schemes.

We present here the versatile generation of multipartite quantum networks from optical frequency combs and parametric down conversion[2]. Frequency resolved multimode detection is employed to characterize the multipartite entanglement[3]. This highly entangled source can be turned into any type of quantum network benefiting from the versatility of the measurement and the shaping of the pump of the parametric process. We demonstrate the perspectives for experimental complex quantum networks implementation.

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[2] Roslund, J. *et al.* Wavelength-multiplexed quantum networks with ultrafast frequency combs. *Nature Photon.* **8,** 109-112 (2014).

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