Distribution of multipartite Einstein-Podolsky-Rosen steering in Gaussian systems

Yu Xiang[1 2 3], **Yin Cai**[4 5], **Yang Liu**[4], **Qiongyi He**[1 2 3], **Nicolas Treps**[5]

[1] *State Key Laboratory for Mesoscopic Physics and Collaborative Innovation Center of Quantum Matter, School of Physics, Peking University, Beijing 100871, China*
[2] *Beijing Academy of Quantum Information Sciences, Haidian District, Beijing 100193, China*
[3] *Collaborative Innovation Center of Extreme Optics, Shanxi University, Taiyuan, Shanxi 030006, China*
[4] *Key Laboratory for Physical Electronics and Devices of the Ministry of Education & Shaanxi Key Lab of Information Photonic Technique, Xi'an Jiaotong University, Xi'an 710049, China*
[5] *Laboratoire Kastler Brossel, Sorbonne Universite, UPMC, ENS, College de France, CNRS, 4 place Jussieu, 75252 Paris, France*

Abstract. Understanding how quantum resources can be quantified and distributed over many parties has profound applications in quantum communication. As one of the most intriguing features of quantum mechanics, Einstein-Podolsky-Rosen (EPR) steering is a useful resource for secure quantum networks. Here, we present experimental generation of a highly versatile and flexible repository of multipartite steering using an optical frequency comb and ultrafast pulse shaping [1]. Simply modulating the optical spectral resolution of the detection system, this scheme is able to produce on-demand 4, 8 and 16-mode Gaussian steering without changing the photonics architecture. We observe a very rich structure for the steering distribution, which offers a powerful foundation for constructing quantum networks in real-world scenario.

Keywords: EPR steering, quantum frequency comb, continuous variable system, monogamy relations

Here, we experimentally investigate properties of multipartite steering within one experiment system, a multimode state via a quantum frequency comb [1] (see Fig. 1). By reconstructing the covariance matrix of the Gaussian state, we measure the quantifier of EPR steering under Gaussian measurements among the four spectral bands ABCD when the whole spectrum is divided into 4, 8 or 16 pixels.

We find that although the spectral components are fixed, the steerability raises sharply with the increase of measurement resolutions, especially when the steering party or the steered party comprises more than one mode (see Fig. 2). This phenomenon can be understood as a consequence of a unique property of our generation system that more individual squeezed eigenmodes can be extracted from the down-conversion process by using higher spectral resolutions of pulse shaping without resorting to modification of the photonics architecture. Such a property contributes to the quantum comb being a powerful candidate to construct quantum communication networks in real-world.

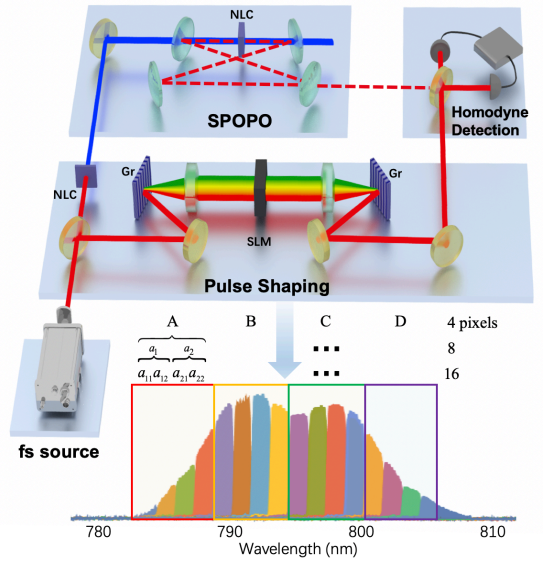

Figure 1 Experimental set-up of the multimode quantum resource via synchronously pumping an optical parametric oscillator (SPOPO).

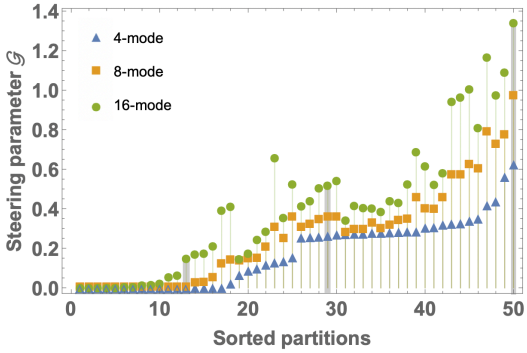

Figure 2 Multipartite EPR steering among four spectral bands ABCD are measured experimentally with 4 (blue triangles), 8 (orange squares), 16 (green dots) spectral pixels, respectively.

References

[1] Yin Cai, Y. Xiang, Yang Liu, Q. Y. He, N. Treps, Versatile multipartite EPR steering via a quantum frequency comb, accepted by Phys. Rev. Research.