Compressed sensing of twisted photons

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Abstract

The ability to completely characterize the state of a quantum system is an essential element for the emerging quantum technologies. Here, we present a compressed-sensing inspired method to ascertain any rank-deficient qudit state, which we experimentally encode in photonic orbital angular momentum. We efficiently reconstruct these qudit states from a few scans with an intensified CCD camera. Since it requires only a few intensity measurements, our technique would provide an easy and accurate way to identify quantum sources, channels, and systems.

In past years, we witnessed the emerging phenomena of quantum technologies for quantum computing, quantum algorithms, quantum key distribution, etc. The orbital angular momentum (OAM) states of a single photon is recognized as a preeminent platform for such applications. Although generation of photons with OAM is relatively simple, the full characterization of a quantum state in the OAM Hilbert space still stands as a challenging task. Even though there exist methods based on projective measurements, they works well only in determining pure OAM states. The case of mixed state requires full state tomography and so projections on arbitrary superpositions of two or more OAM eigenstates, which is still challenging. Our approach [1] incorporates the idea of compressed sensing, originally introduced in the context of quantum state tomography in work [2] applied on a convenient measurement consisting with just few scans with intensified CCD camera Fig. (1). In other words, one can use a very simple setup for a characterization of a quantum state, which is robust to noise and informationally complete among low-rank quantum states.

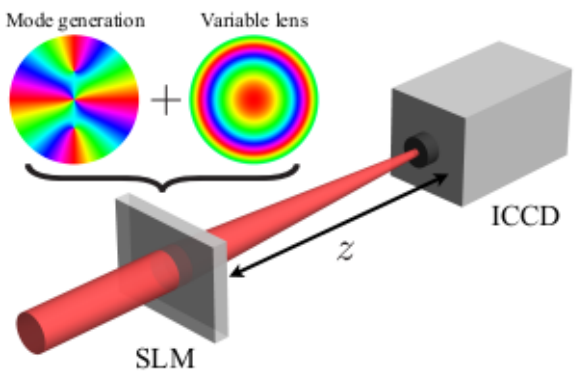

Figure 1: Schematic of the experiment. The photonic state preparation and measurement are performed using an SLM and ICCD camera. The ICCD camera has a fixed position and records intensity scans. Inset shows the state and lens phase patterns, [0, 2), in a hue color

[1] F. Bouchard, et. al., *Compressed Sensing of Twisted Photons*, arXiv:1812.04127 (2018).

[2] D. Gross, et. al., *Quantum State Tomography via Compressed Sensing*, Phys. Rev. Lett. **105**, 150401 (2010).