Phase space characterization of optical quantum states and quantum detectors

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Abstract

We are in the midst of a second quantum revolution fueled by "quantumness" of physical systems and the sophisticated measurement devices or detectors to produce and characterize these exotic systems. Thus, characterization of quantum states and the detectors is a key task in optical quantum science and technology. The Wigner quasi-probability distribution function provides such a characterization. In this talk, I present our recent results on quantum state tomography of a single-photon Fock state using photon-number-resolving measurements using superconducting transition-edge sensor [1]. We directly probe the negativity of the Wigner function in our raw data without any inference or correction for decoherence, which is also an important indicator of the "quantum-only" nature of a physical system.

For the second part of the talk, we discuss a method to characterize quantum detectors by experimentally identifying the Wigner functions of the detector positive-operator-value-measures (POVMs), a set of hermitian operators completely describing the detector [2]. The proposed scheme uses readily available thermal mixtures and probes the Wigner function point-by-point over the entire phase space from the detector's outcome statistics. In order to make the reconstruction robust to the experimental noise, we use techniques from convex quadratic optimizations.

References

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2. R. Nehra and K. Valson Jacob (2019), "Characterizing quantum detectors by Wigner functions," [arXiv:1909.10628].