Simultaneous, full characterization of a single-photon state

T. Thomay[1], S. V. Polyakov[2], O. Gazzano[1], E. Goldschmidt[1], V. Loo[1], T. Huber[1], and G. S. Solomon[1,2]

[1]Joint Quantum Institute, National Institute of Standards and Technology, & University of Maryland, Gaithersburg, MD, USA.
[2]National Institute of Standards and Technology, Gaithersburg, MD, USA.

E-mail: gsolomon@umd.edu

As single-photon sources become more mature and are used more often in quantum networks and measurement applications, the details of their characterization become more important. Single-photon-like light is often characterized by the device's photon flux—its brightness, and two quantum properties: the suppression of multi-photon components and the photon indistinguishability. While it is desirable to obtain these quantities from a single measurement, currently two or more measurements are used.

Here we simultaneously determine the brightness, the suppression of multi-photon content, the indistinguishability, and the statistical distribution of number states to third order for a quantum light source [1]. We use the light emitted from a single InAs quantum dot resonant with a planar microcavity and pumped by a pulsed-laser side-coupled to the cavity. However, the measurement is not source specific. The measurement uses a pair of two-photon ($n = 2$) number-resolving detectors, here modeled using single-photon detectors. Using a Fisher-information analysis, we show that the new method extracts more information per experimental trial than a conventional measurement for most input states, and is particularly more efficient for statistical mixtures of photon states. Furthermore, $n \geq 3$ number-resolving detectors provide no additional advantage in the single-photon characterization. Thus, using this $n=2$, number- resolving detector scheme will provide new advantages in a variety of quantum optics measurements and system characterization.

References

[1] T. Thomay, *et al.*, Phys. Rev. X **7**, 041036 (2017).