

# Certifying quantum correlations of photon subtracted two-mode squeezed vacuum states

Armando Perez-Leija,<sup>1,2</sup> Roberto Leon-Montiel,<sup>5</sup> and Kurt Busch<sup>1,2</sup>

<sup>1</sup> Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin, Germany

<sup>2</sup> Humboldt-Universität zu Berlin, Institut für Physik, AG TOP, Newtonstraße 15, 12489 Berlin, Germany

<sup>3</sup> Instituto de Ciencias Nucleares, UNAM, A.P. 70-543, 04510 Cd. Mx., México

The successful implementation of functional quantum photonic technologies hinges on our ability to generate, manipulate, and measure complex multiphoton states. A crucial step for the faithful utilization of multiphoton states is the certification of the non-classicality of correlations among the modes [1, 2]. Here, we describe a method to uncover nonclassical correlations of two-mode multiphoton states. This scheme is based on the second-order moments which are directly obtained from measured photon statistics. To illustrate the method we apply it to experimental photon-subtracted two-mode squeezed vacuum states (TMSVS) [3]. These TMSVS were generated by conditionally subtracting the same amount of photons from each mode of a bright spontaneous-parametric-down-conversion source. The photon statistics was obtained using photon number resolving detectors based on transition edge sensors [4].

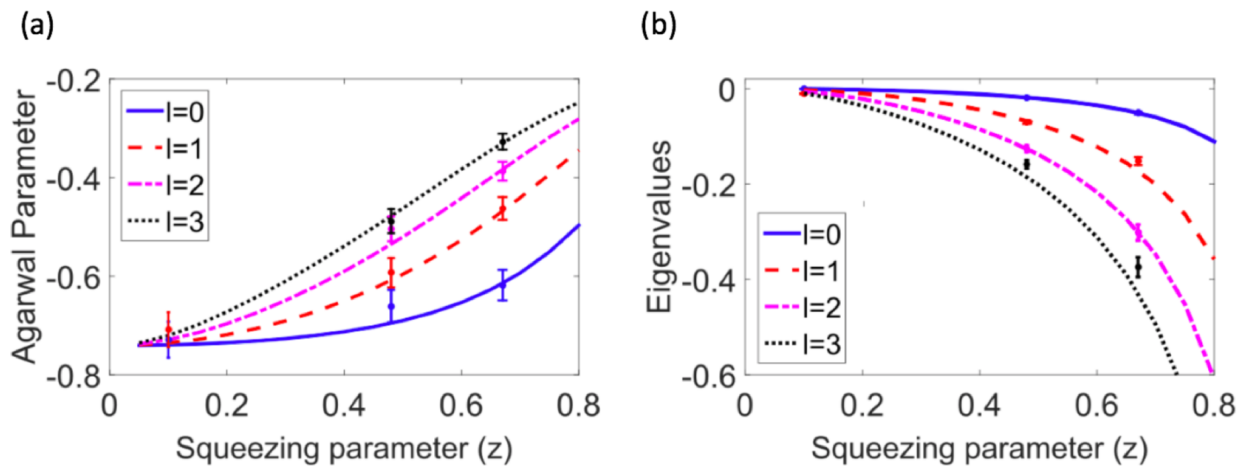


Figure 1: The Agarwal parameter in (a) certifies the nonclassical nature of P-function corresponding to the generated photon-subtracted states for different number of subtracted photons  $l$ . The eigenvalues in (b) demonstrates the possibility of tuning the degree of quantum correlations by controlling the squeezing parameter of the source and the number of subtracted photons. The curves represent our theoretical predictions for  $l = 0$  (blue solid line),  $l = 1$  (red dashed line),  $l = 2$  (pink dash-dotted line), and  $l = 3$  (black dotted line).

- [1] G. S. Agarwal and K. Tara, “Nonclassical character of states exhibiting no squeezing or sub-Poissonian statistics,” *Phys. Rev. A* **46**, 485 (1992).
- [2] J. Sperling, M. Bohmann, W. Vogel, G. Harder, B. Brecht, V. Ansari, and C. Silberhorn, “Uncovering Quantum Correlations with Time-Multiplexed Click Detection,” *Phys. Rev. Lett.* **15**, 023601 (2015).
- [3] O. Magana-Loaiza, *et al*, “Multiphoton Quantum-State Engineering using Conditional Measurements,” arXiv:1901.00122v1.
- [4] A. E. Lita, A. J. Miller, and S. W. Nam, “Counting near-infrared single-photons with 95% efficiency,” *Opt. Express* **16**, 3032-3040 (2008).