Quantum-to-classical transition of single-photon counters

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Optical detectors play a central role in the development of future quantum technologies [1]. For example, measurement-driven information processing, quantum key distribution, and state engineering rely more and more on precisely mastering single-photon counting. Here, using quantum detector tomography, a method that provides a complete description of the measurement device, we experimentally demonstrate how the specific quantum features of two different counters are degraded under external parameters [2]. We thereby show in a quantitative way how the decoherence processes, well-known in the case of quantum states, act at the level of quantum detectors. Our work witnesses the transition between the full-quantum operation of the measurement device, where the quantum probabilities have no classical equivalent, to the “semi-classical regime”, described by a positive Wigner function, where the quantum fluctuations can be in principle classically described. The exact border between these two regimes is determined and experimentally measured. Moreover, we illustrate how such a transition manifests itself when the detector is used to herald the preparation of a target state, a paradigm for photonic quantum technologies.

[1] R.H. Hadfield, Single photon detectors for optical quatum information, Nature Photon. 3, 696 (2009)

[2] V. D’Auria et al., Quantum decoherence of single-photon counters, ArXiv:1105.4090