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Super-Poissonian light from indistinguishable single-photon emitters

Trapped ion crystals consisting of many individual photon emitters offer an ideal platform for the exploration of a wide range of fundamental quantum emission scenarios. We present the implementation of a new optical emission regime in which photons scattered incoherently from different ions collectively contribute to the observation of photon bunching and super-Poissonian photon number variance.

The second-order coherence of light has been explored in the experiment comprising a linear Paul trap with large crystals of Ca^+ ions. We realized the scattering geometry where light from many independent emitters – trapped ions can be collected into a single detection spatial mode with overall efficiency sufficient for the observation of photon-photon correlations. The correlations are measured using a Hanbury-Brown and Twiss detection setup with single-photon counting modules for a broad range of ion numbers ranging from a single to up to several hundred. The corresponding normalized intensity correlations at a zero-time delay gradually increase from sub-Poissonian to super-Poissonian values for single ion and large Coulomb crystals, respectively. We provide evidence that the indistinguishability of scattering contributions to a single detection mode provides the fundamental resource for photon bunching and, consequently, for the increased variance of the photon number above the Poissonian level. The realized experimental tests in the opposite - spatially multi-mode regime prove that the photon distinguishability is crucial for the feasibility of direct observation of nonclassical sub-Poissonian character in the limit of a large number of independent and mutually incoherent single-photon emitters. We develop a unified description of the corresponding measurements of photon correlations from a large, but fixed number of non-interacting and phase-randomized single-photon emitters.

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