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Generation of quantum light in a photon-number superposition

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The ability to generate light in pure quantum states is central to the development of quantum- enhanced technologies. Recently, artificial atoms in the form of semiconductor quantum dots have emerged as an excellent platform for quantum light generation [1-2]. Although controlling the photon number is the backbone of many applications, the generation of pure quantum superpositions in the photon-number basis has remained elusive. Here, we report on the generation of light pulses in a pure quantum superposition of zero, one-, and even two- photons, using a single quantum dot in a microcavity [3].

Through coherent control of the artificial atom transition, a pure quantum superposition of vacuum and one-photon is generated with a full control of their relative populations. Driving the system even stronger, with 2π-pulses, a coherent superposition of vacuum, one- and two-photons is generated, with the two-photon part exceeding the one-photon part-, a state that shows phase super-resolving interferometry. Our experimental demonstration revisits the well-known Hong-Ou-Mandel experiment.

[1] Near optimal single photon sources in the solid state, N. Somaschi *et al*. Nature Photonics **10**, 340-345 (2016)

[2] High-performance semiconductor quantum-dot single-photon sources, P. Senellart, G. Solomon, A.G. White, Nature Nanotechnology **12**, 1026-1039, (2017)

[3] Generation of non-classical light in a photon-number superposition, J. C. Loredo, C. Anton *et. al*, arXiv:1810.05170