Control of photon indistinguishability in resonantly-driven semiconductor quantum dots

R. Proux, M. Maragkou, E. Baudin, C. Voisin, Ph. Roussignol and C. Diederichs*
Laboratoire Pierre Aigrain, École Normale Supérieure, CNRS (UMR8551), Université Pierre et Marie Curie, Université Paris Diderot, 24 rue Lhomond, 75231 Paris Cedex 05, France

*E-mail: carole.diederichs@lpa.ens.fr

Single photons have been under extensive investigation regarding their possible role as ideal flying qu-bits in a quantum network. Numerous applications for single photon sources have already been proposed but most of them require consecutive photons to have identical wave packets, i.e. to be indistinguishable. In semiconductor epitaxial quantum dots (QDs), an important general issue is to reach the so-called fundamental radiative limit. Several strategies have been followed in that sense such as the shortening of population lifetime induced by the Purcell effect [1] or the reduction of pure dephasing by resonant excitation [2]. The latter studies on resonantly-driven QDs have recently caught the attention of the community as it can generate in the peculiar resonant Rayleigh scattering regime high quality, dephasing-free photons which inherit the laser properties in terms of coherence [3].

In this work, we study the indistinguishability of photons emitted from a single quantum dot (QD) under resonant cw excitation. Well below the saturation of the QD, the emitted photons undergo elastic scattering in the resonant Rayleigh scattering regime and inherit the long coherence times of the excitation laser, while exhibiting sub-Poissonian statistics. We perform two-photon interference measurements with a Hong-Ou-Mandel (HOM) interferometer [4,5] to study the evolution of the indistinguishability of the photons emitted in this peculiar regime. The imprint of the long coherence time of the laser in the QD dynamics allows for a clear demonstration that indistinguishability and coherence are tightly entwined [6]. We thus show that the photon indistinguishability is not limited anymore neither by the intrinsic QD coherence time nor by the system time response. Furthermore, original HOM experiments performed for different coherence times of the excitation laser show that photon indistinguishability can be driven by the excitation source, offering an unprecedented level of control.

References

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