Soutenance de thèse

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Wigner functions of Quantum Light emitted by Quantum Dot Sources

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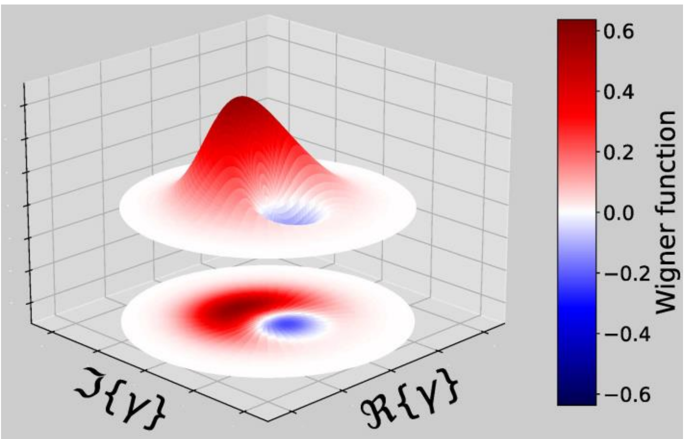
Abstract
Semiconductor quantum dots have emerged as excellent single-photon sources for optical quantum technologies. When inserted in an optical cavity, they have been shown to deterministically emit pure, indistinguishable single photons on demand with high emission rates. Quantum dot single-photon sources have so far been used to process the quantum information that is encoded in the discrete modes of the single photons; a framework known as discrete-variable encoding. Alternatively, the quantum information can be encoded on the continuous quadratures of the optical field in the continuous-variable framework. With their ability to generate deterministically complex non-Gaussian states of light and to provide optical non-linearity at the single-photon level, quantum dots in cavities could also bring new opportunities to process the information in continuous-variable approach.
In this Ph.D. thesis, we take the first step toward positioning our quantum dot sources as potential resources for continuous-variable optical quantum technologies. We report on the first Wigner function measurement of the single-photon state and photon-number superposition states generated by an optical solid-state quantum emitter. We achieved this goal by overcoming key challenges in operating in the low-transmission regime and in adjusting measurement techniques to the high rate of our single-photon sources: (i) the optimization of the quantum interference between the local oscillator (a weak coherent state) and the photonic states emitted by our quantum dot device, which leads to optimal displacement operations, (ii) the correction of photon loss, and (iii) the reconstruction of photon-number distribution from single-photon detection.



First demonstration of the Wigner function reconstruction of a coherent superposition between 0 and 1 photon emitted by our quantum dot device. The superposition state nearly balanced with a state fidelity of 98 % and a state purity of 97 %. The Wigner function is reconstructed at the quantum level before losses.