Invited talk

Revisiting and exploiting spontaneous emission with solid-state artificial atoms

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A single atom coupled to a single mode of the electromagnetic fields is probably the most fundamental system to study light-matter interaction at the quantum level. It is also a fantastic resource for quantum technologies, allowing both the generation and manipulation of quantum light, with applications in quantum computation and networking. We investigate such atom-photon interface in the form of semiconductor quantum dots coupled to micropillar cavities [1].

In this talk, I will first describe the high level of control we have gained on our artificial atoms, funneling their spontaneous emission into a single optical mode and isolating them from the fluctuations of their solid-state environment. We exploit them to generate highly indistinguishable single photons, now within plug-and-play fiber-pigtailed systems at unparalleled rates [2], allowing small scale quantum information processing [3]. In a second part, we exploit the spin of a single electron trapped in a quantum dot and the optical selection rules to generate spin-multi-photon entangled states [4,5], key resources for measurement based quantum protocols. Finally, we revisit the process of spontaneous emission itself and explore how it allows to generate more exotic states of light, such as the quantum superposition of zero and one photon [6] or the generation of entanglement in the photon number basis [7].

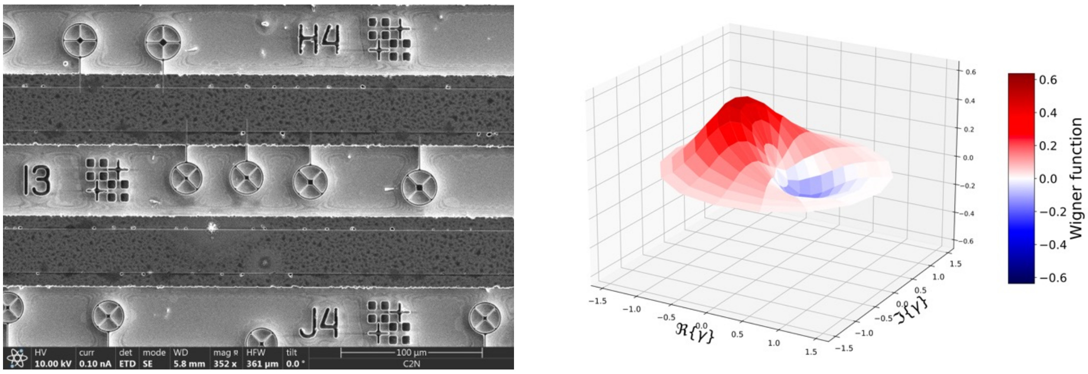

Figure 1: Left: SEM image. The wheel shaped structures are microcavities where a single quantum dot sits on the axis of the wheel. Right: measured Wigner function of a superposition of zero and one photon.

[1] N. Somaschi, V. Giesz et al, Nature Photonics 10, 340 (2016)

[2] N. Margaria et al, arXiv:2410.07760

[3] N. Maring et al., Nature Photonics 18 (6), 603-609 (2024)

[4] N. Coste et al., Nature Photonics 17, 582 (2023)

[5] H. Huet et al, arXiv:2410.23518

[6] J. Loredo et al, Nature Photonics 13 (11), 803-808 (2019)

[7] S.C. Wein et al, Nature Photonics 16 (5), 374-379 (2022)