Experiments in quantum plasmonics

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Surface plasmon polaritons (SPPs) are bosonic quasiparticles. As such, they show specific quantum properties, some of which have already been observed. Here we report experimental results from two sets fundamental tests on SPPs : a clear observation of the wave-particle duality of a single SPP, and a first direct experimental evidence of entanglement between a SPP and a single photon.

Both our experimental setups are based on a plasmonic platform that can convert photon into plasmon, and separate or recombine them on a plasmonic beamsplitter [1]. This platform is used as output beamsplitter of a Mach-Zehnder (MZ) interferometer. We use a source of photon pairs in order to shine the platform with a single photon α, heralded by the second photon of the pair, β.

In the first experiment, the polarization of α is chosen so that it excites either one single arm, or both arms of the MZ with equivalent probabilities, thus exhibiting either antibunching (particle-like behaviour) or interferences (wave-like behaviour) [2]. In the second experiment, α and β are entangled. By carrying out a projective measurement of the polarization of β, we show that we can control the interference state of the single SPP on the plasmonic platform, and make fringes appear or disappear in the interferograms, thus demonstrating entanglement between both particles (see Fig 1.).

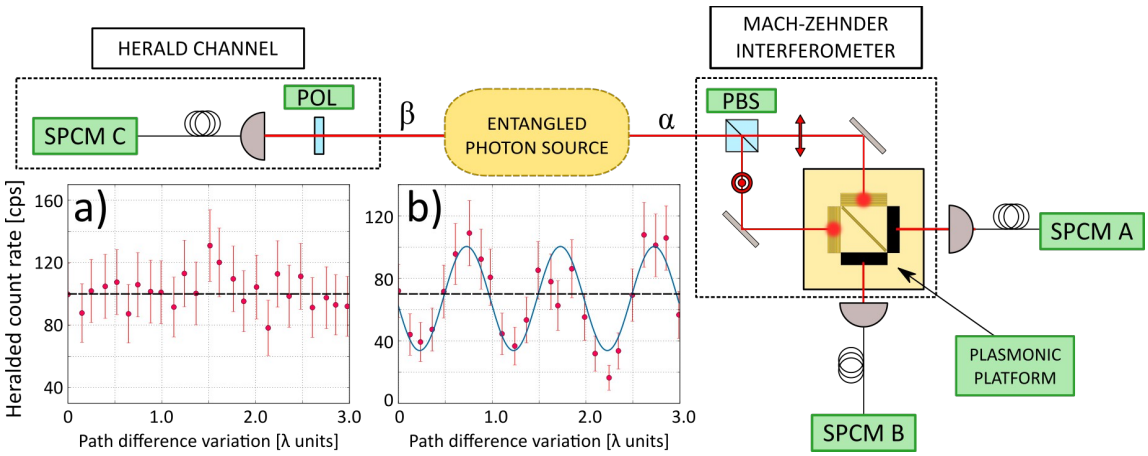

Fig. 1: Photon-Plasmon entanglement experimental setup. Bottom left, MZ interferograms of the heralded count rates on SPCM A. POL is the herald channel polarizer. It allows to choose the polarization of the detected herald β, so the heralded α can excite a) only one arm of the MZ , or b) both arms of the MZ with equivalent probabilities. In the latter, fringes are visible.

[1] A. Baron et al., *Nano Lett.*, **vol. 11**, p. 4207 (2011)
[2] M-C Dheur et al., *Science Advances,* **vol. 2** n°3 (2016)