Quantum optics with surface plasmons

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This presentation reviews recent works on surface plasmons in the quantum regime. In the first part of the talk, I will present a core-shell gold plasmonic resonator (hereafter called golden quantum dot) used to tailor the spontaneous emission of a single quantum dot. In the second part of the talk, I will present a recent experiment performed with surface plasmons propagating along a metal/air interface. Here, we aim at reproducing with plasmons a seminal experiment of quantum optics demonstrating the waveparticle duality.

It has been known for decades now that the spontaneous emission rate is not an intrinsic property but depends on the environment. It is possible to use plasmonic strutures to tailor the environment. Here, we use a golden quantum dot which consists in a CdS/CdSe quantum dot covered with silica and a 20 nm gold shell. The system has been synthesized in the group of the ESPCI [1]. By properly designing the system, it has been possible to observe a significant spontaneous emission rate acceleration on the order of 10. This is due to the modification of the local density of states in the plasmonic cavity. A remarkable property of these golden quantum dots is that they do not blink. Furthermore, they are very robust against photobleaching even when they are illuminated in the saturation regime.

The second part of the talk reports a recent quantum optics experiment with surface plasmons. We have designed and fabricated a surface plasmon platform that includes couplers to convert photons into plasmons and surface plasmon beam splitters. We generate a pair of identical photons and detect one of them to herald the arrival of the second one. This heralded photon is converted into a plasmon which is sent onto a beam splitter. We then study the correlation of the outputs of the beam splitter and observe a very strong anti bunching. This single plasmon is subsequently sent into a Mach-Zehnder interferometer allowing the observation of interferences in the single plasmon regime.

References

[1] Non-blinking quantum dots with a plasmonic nanoshell resonator, B. Ji, E. Giovanelli, B. Habert, P. Spinicelli, M. Nasolawski, X. Xu, N. Lequeux, JP Hugonin, F. Marquier, JJ Greffet, B. Dubertret, Nature Nanotechnology, 10 (2015) 170.
[2] Wave-particle duality with nonclassical surface plasmons, MC Dheur, E. Devaux, T W Ebbesen, A. Baron, JP Hugonin, P. Lalanne, JJ Greffet, G. Messin, F. Marquier, in preparation.