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Demonstration of Quadrature Squeezed Surface-Plasmons in a Gold Waveguide

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The first experiment demonstrating the quantum optical properties of SPPs was the preservation of entanglement under plasmon assisted transmission through sub-wavelength holes in a conductor [1,2].

In this contribution we present an experiment demonstrating the generation of non-classical SPPs by exciting them with a squeezed optical light field generated using a bow-tie shaped optical parametric oscillator operating below threshold. Free space optics and end-fire coupling are used for the excitation of long-range SPPs (LR-SPPs) [3] on gold stripes embedded in lossless transparent polymer BCB. The gold stripes have a length, width, and height of 2mm, 1µm, and 14nm, respectively. At maximum, we measure a total transmission of 33.2±0.5% through the sample. The squeezed vacuum input mode and the LR-SPP output mode are characterized using an optical homodyne detection system. We employ the maximum likelihood method to reconstruct the density matrices of the squeezed vacuum input state and the LR-SPP output state. The noise power of the LR-SPP output state as a function of relative phase is presented in Fig. 1(a). We simulate the impact of the LR-SPP mode by applying a beam-splitter operation on the squeezed vacuum input mode. The overlap between the calculated output mode and the LR-SPP mode is evaluated by calculating the Fidelity between the two states, which peaks for a transmission of $\eta=33\%$, as shown in Fig. 1(b). This result is in very good agreement with the transmission measured classically and proves the validity of the beam-splitter model in the limit of low photon number excitation.

(a)   (b)
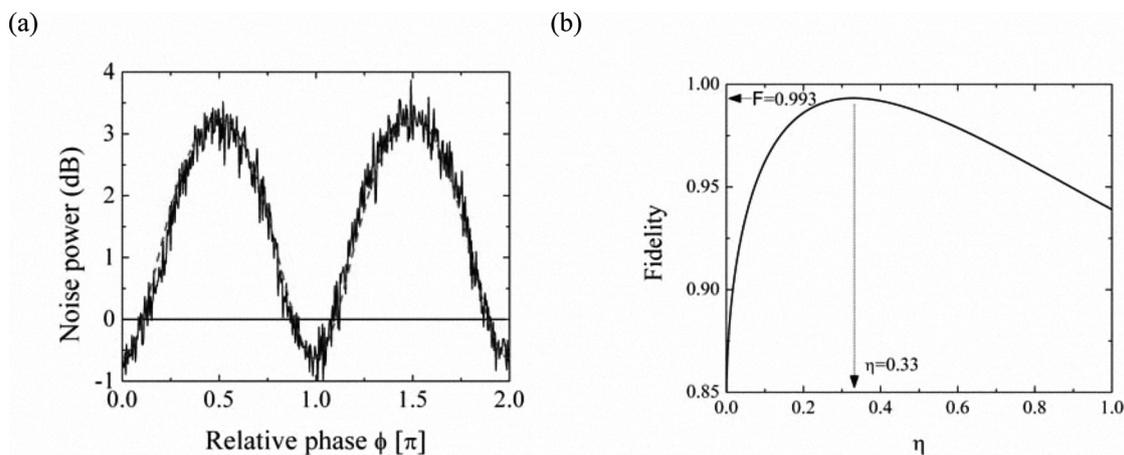
Fig. 1 (a) Noise variance of the LR-SPP output state calculated from the time resolved data (black solid line) and from the reconstructed LR-SPP states density matrix (red dashed line). (b) Calculated overlap between the squeezed vacuum input state and the LR-SPP output state for various transmissions η through a beam splitter.

Furthermore, we also demonstrate the excitation of LR-SPP modes with a priori two photon Fock states generated by spontaneous parametric down-conversion.

In conclusion, we demonstrated the excitation of non-classical LR-SPPs and verified, that the transmission of LR-SPP modes in a metallic waveguide can be described by a beam-splitter operation.

References

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