Photon antibunching in surface plasmon radiation

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The nonclassical nature of surface plasmon oscillations and the intensity correlations in their radiation are theoretically analysed, and recent experimental results on transition from antibunching to bunching of photons stemming from spontaneously decaying surface plasmons are quantitatively interpreted. Due to the possibility of attenuated total reflection (ATR) and the associated generation of surface plasmon oscillations (SPOs), the responses of a dielectric-metal-vacuum system can considerably differ, depending on which boundary the incoming radiation impinges (see Figure 1).

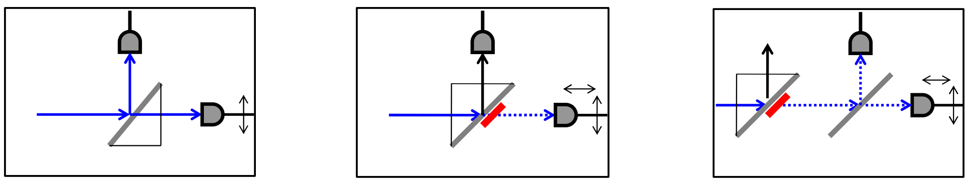

Figure 1. Illustration of three possible arrangements for measuring intensity (count number) correlations in split beams. Left: Vacuum→Metal→Dielectric ("V→M→D scattering"); ordinary beam splitter situation. Center: "D→M→V scattering"; ATR situation (the supressed reflection and the generated and decaying SPOs are symbolized by a vertical black arrow and a red thin oblique rectangle, respectively). Note that this system (being a sort of 'active beam splitter') offers also a natural possibility of studying some 'opposite output' correlations. Right: "V→M→V scattering"; The SPO generation is the same as shown in the centre figure, but now the light stemming from the SPO (left dotted blue arrow) is split by a second (ordinary) beam splitter, and the counters are at the opposite side of this beam splitter. This is a usual Hanbury Brown and Twiss type arrangement, where those secondary photons are probed which stem from the decaying plasmons.

Both the conversion of the incoming photons to SPOs [1] and the decay process [2], or simply the interaction of photons with the dense free electron gas in the layer can cause non-classical effects [3]. On one hand, we offer additional arguments for the non-classical nature of SPO excitations, and, on the other hand, we apply our new theory of correlations in counting experiments [4] to interpret recent measurements [5]. According to our analysis, in these experiments (see arrangement on the Right in Fig. 1) the metal layer functioned as a single–photon emitter, and the observed transition from antibunching to bunching in the correlations of photo–counts can be quantitatively explained.

References

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