Quantumness in plasmon assisted multiphoton photoemission

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Plasmon polaritons are resonant modes arise through the interaction of electromagnetic fields with conductive materials. As resonators they form energy reservoirs. Although it is common knowledge that such reservoirs must in principle be represented as quantum oscillators in most cases these excitations can well be conceived as classical entities. The direct identification of the quantum nature of plasmons has been prevented by the delicate nature of the quantum states, the nanoscale field confinement of plasmons, and a lack of appropriate probes. A recent experiment using coherent multidimensional spectroscopy with nanoscale spatial resolution allowed to directly probe a plasmon polariton quantum wave packet [1]. To reproduce these results an improved quantum model of photoemission was required, in which the coherent coupling between plasmons and electrons is accounted for with the plasmon excitations extending beyond a two-level model. In this contribution the experiment and its theoretical modelling serves as a starting point for discussing further plasmon assisted nanoscale quantum phenomena such as emerging plasmon assisted few-photon down conversion [2] and a novel parametric down conversion process involving bulk plasmon.

[1] S. Pres, B. Huber, M. Hensen, D. Fersch, E. Schatz, D. Friedrich, V. Lisinetskii, R. Pompe, B. Hecht, W. Pfeiffer, T. Brixner, Nature Phys. 19 (2023) 656.

[2] R. Pompe, M. Hensen, M. Otten, S. K. Gray, W. Pfeiffer, Phys. Rev. B 108 (2023) 115432.