Driving Electrons at Needle Tips Strongly with Quantum Light

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Over the last few decades, strong-field phenomena in gases, solids and at the surface of solids have been studied extensively. Virtually all strong-field experiments in the past had one feature in common: They used laser light to drive these highly nonlinear processes, which – in quantum-optical terms – can be described as a coherent state of light. The development of intense sources of non-classical light such as bright squeezed vacuum (BSV) [1] has recently made it possible to drive strong-field processes also with quantum light, facilitating the investigation of the influence of the driving state of light on strong-field phenomena. Such studies constitute one main approach to the emerging field of *strong-field quantum optics*, which aims at combining these two seemingly remote fields (strong-field physics and quantum optics) by understanding the role of the quantum-optical nature of light in strong-field processes.

Theoretical studies in this direction investigated the influence of the driving state of light on high harmonic generation (HHG) in gases, predicting a modification of the plateau and the cut-off when using quantum light as a driver [2]. At the same time, first experiments using quantum light as a driver of nonlinear light-matter interaction processes showed that the photon number statistics of the driving light state is imprinted on the number statistics of electrons photoemitted from a metal needle tip [3]. Recently, it was shown that HHG in solids can be driven by a bright squeezed vacuum state [4].

However, up to now, the famous plateau in the energy spectrum of either photons or electrons, representing *the* tell-tale feature of strong-field and attosecond physics, has not been measured under quantum light driving. Here, we present the measurement of energy spectra of electrons driven strongly at the apex of a nanometric metal needle tip by bright squeezed vacuum [5]. When averaging over many BSV pulses, we measure high-energy electrons, but neither a plateau nor the 10-U_p-cut-off can be observed. However, when post-selecting the electron energy spectra on fixed photon numbers in the individual BSV pulses, we clearly observe both plateau and cut-off in the spectra. We will discuss these experimental findings as well as their interpretation based on the theoretical frameworks developed in the realm of strong-field quantum optics.

References

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