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Strong-field physics meets quantum optics

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There has been recent experimental evidence demonstrating quantum optical signatures in nonperturbative, extremely nonlinear optical processes such as high-order harmonic generation (HHG). These results came as a surprise, as typically, quantum optics deals with single or few-photon states; light states with increasing photon numbers behave more and more classically. Strong-field physics commonly deals with extremely high photon numbers (>1013-1016 photons per shot). With a conversion efficiency of about 10-5 - 10-9 for HHG, bright photon states in very different energy(and frequency) ranges could be obtained. The theoretical foundation to describe these intuitively orthogonal physical disciplines is still in its infancy. Fundamental questions on the origin of the nonclassicality of the observed quantum signatures remain open –which role does the measurement process play? What it the role of the generation medium/material, e.g., why do many-particle matter systems with fast and efficient decoherence processes still enable quantum characteristics of the emitted light? How can we characterize such many-photon quantum light states? Can we increase the "quantumness"of the generated harmonics? And how can we theoretically and numerically describe these processes? In this talk, I will give an overview over the state of the art of this very new field at the intersection of two previously disjunct fields of physics and provide first ideas how to approach some of the challenges.

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