Nonclassical Pulses for Subcycle Quantum Optics

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This work shows how few-cycle femtosecond pulses with tailored group delay dispersion can pump efficient parametric down-conversion to produce bright entangled light pulses with more than 80% occupancy of a single ultrafast temporal mode. This corresponds to pulse durations shorter than 4 optical cycles at near-infrared frequencies (center wavelength around 1300 nm). Access to such states motivates novel opportunities in quantum metrology, such as nonlinear quantum optics and subcycle sampling of mid-infrared quantum fields.

Few-cycle nonclassical wavepackets complement traditional frequency-domain approaches to quantum optics and promise to pave the way to new paradigms in quantum communication, computing, and sensing. One prominent method to produce bright nonclassical light is parametric down-conversion (PDC) [1], where a strong optical pump pulse mixes nonlinearly with the electromagnetic quantum vacuum to produce entangled multi-photon (twin) beams at a lower frequency.

Common strategies to achieve high parametric gain rely on long nonlinear crystals and pump pulse durations of over 1 ps [2,3]. This leads to the generated broadband entangled states occupying many (often > 1000) temporal modes. In this work, we employ sub-10-fs pump pulses with tailored group delay dispersion for efficient parametric amplification of a single few-cycle temporal mode of the vacuum field. Containing on average around 10^7 photons, these pulses promise access to nonlinear quantum optics, for example, with an appeal of efficiently probing non-Gaussian states of quantum light [4].

References

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