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Sub-Cycle Quantum Optics: Direct Access to Electric Field Vacuum Fluctuations. DENIS SELETSKIY, CLAUDIUS RIEK, ANDREY MOSKALENKO, JAN SCHMIDT, PHILIPP KRAUSPE, SEBASTIAN ECKART, STEFAN EGGERT, GUIDO BURKARD, ALFRED LEITENSTORFER, University of Konstanz — Vacuum fluctuations are fundamental to a variety of physical aspects ranging from spontaneous photon emission via the Casimir force all the way to cosmology. Study and manipulation of the ground state of the radiation field is a central subject in quantum optics. In common approaches, such as for example homodyne detection, the information is averaged over multiple cycles of light and amplification to finite intensity is mandatory. Usually, ultrashort pulses are applied for quantum measurements within a slowly-varying envelope approximation. We demonstrate direct detection of the vacuum fluctuations of the local electric field amplitude in free space. Broadband electro-optic sampling with sub-6 femtosecond gate pulses enables quantum-statistic readout [1]. Distinction from the detector shot noise is achieved by modification of the sampled space-time volume. Measuring with a bandwidth matching the 70 THz center frequency maximizes the vacuum amplitude since the ground-state energy approaches half a photon per optical cycle. Our findings open up a new avenue to quantum analysis and manipulation of light working in the time domain and with sub-cycle access to the electric field quadrature.
[1] C. Riek et al, Science **350**, 420 (2015).

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