SFB 1432
Colloquium

Jul 8, 2021
at 3:15 pm, via zoom
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Quantum optics at ultrafast time scales: subcycle-resolved quantum tomography and aspects of relativity

Quantum properties of light play one of the central roles for emerging quantum technologies. Usually they are characterized in the frequency domain in a vicinity of a well-defined carrier frequency. In this picture the Wigner function is used for a phase-space visualization of the states as well as for accessing their physical properties via the classical averaging of the corresponding quantities over the phase space. Extending this approach to pulsed ultrabroadband quantum light would lead to a quite involved description in terms of a large set of single-frequency or shaped temporal modes, where each mode has to be characterized separately while keeping the intermode phase relation fixed. An alternative approach is to consider the quantum fields directly in the time domain [1,2]. For example, we have shown that it is possible to formulate a time-domain theory of the generation and time-resolved detection of ultrabroadband pulsed squeezed states [3] and that it should be possible to get access to arbitrary rotated generalized quadratures of the field [4]. In this talk I will discuss how to define and retrieve then the corresponding subcycle-resolved Wigner function.
Further, I am going to address relativistic aspects arising when analyzing the generation and characterization of extremely short pulses of quantum light with durations on the order of a single oscillation cycle. Utilizing the concept of the so-called Unruh-DeWitt detector we argue that sampling of photon modes at subcycle time scales can resemble the detection of virtual photons from the electromagnetic vacuum [5]. There is also a relativistic interpretation of the squeezing process in terms of induced changes in the local flow of time [3]. The corresponding spectral properties can be related to the Unruh-Davies effect with a finite time of acceleration, characterized by the so-called diamond temperature T_D [6]. We will show that a transition to the regime featuring the well-known Unruh temperature T_U can also be realized.

[1] C. Riek et al., Science 350, 420 (2015) , [2] A.S. Moskalenko et al., Phys. Rev. Lett. 115, 263601 (2015), [3] M. Kizmann et al., Nat. Phys. 15, 960 (2019), [4] M. Kizmann et al., arXiv:2103.07715, [5] S. Onoe et al., arXiv:2103.14360, [6] T.L.M. Guedes et al., Phys. Rev. Lett. 122, 053604 (2019).

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