ELI-NP SCIENTIFIC SEMINAR

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Probing quantum vacuum nonlinearities with strong laser fields

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The physical vacuum of a relativistic quantum field theory amounts to a non-trivial quantum state. It encodes information about the full particle content of the underlying microscopic theory in the form of virtual processes, also referred to as vacuum fluctuations. If the theory features charged particles, fluctuations of the latter give rise to nonlinear effective couplings between electromagnetic fields that vanish in the formal limit of a vanishing Planck constant, but persist for a nonzero physical value. In turn, they inherently modify Maxwell's linear theory of classical electrodynamics.

However, for the field strengths reached by macroscopic electromagnetic fields currently available in the laboratory the quantum vacuum nonlinearities induced by Standard Model particles are parametrically suppressed relatively to the linear contribution by inverse powers of the electron mass and thus very small. As a consequence, this fundamental tenet has remained experimentally challenging and is yet to be tested in the laboratory.

In this talk I will focus on promising scenarios allowing to study the leading QED vacuum nonlinearities in high-intensity laser experiments with state-of-the-art technology. The key challenge is to separate the small quantum vacuum signal from the large background of the driving laser photons.

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