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Probing the Quantum Vacuum at the High-Intensity Frontier

In contrast to many highest-precision tests of Quantum electrodynamics (QED) in low-energy experiments, the high-intensity frontier has remained largely unexplored in the laboratory so far. Ultra-intense lasers coming online these days and in the near future have the potential to discover the nonlinear response of the ground state of nature - the quantum vacuum - to macroscopically controlled strong fields for the first time. I review basic properties of the quantum vacuum based on the Heisenberg-Euler effective theory and report about current efforts towards discovery experiments.
In a second part, I present a novel theoretical exploration of the strong-field limit of QED. Using the functional renormalization group, indications for the the existence of a global solution to the RG equations are provided. The solution corresponds to a fixed function, analogous to a multi-dimensional fixed point, with a strong-field limit being governed by the anomalous dimension of the photon field. The solution is stable on all scales as long as the electric field components remain subcritical.

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