Concepts for studying strong-field QED using laser-electron colliders

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Current and upcoming laser facilities in combination with laser-driven or conventional electron accelerators open up an opportunity for probing and studying the processes of quantum electrodynamics (QED) in extreme regimes of strong electromagnetic fields [1, 2]. These regimes are characterized by the quantum nonlinearity parameter $\chi \gg 1$ and can reveal signatures of unexplored physics beyond the conjectured breakdown of perturbative methods at $\chi \gtrsim 1600$. Nevertheless, in the required range of field intensities and electron energies the interaction can lead to cascaded generation of electrons, positrons and photons at $\chi \lesssim 1$, which obscures the sought after signal. In our work we propose and assess optimised geometries and concepts that provide a way to differentiate and separate informative signals formed by electrons that have emitted only one high-energy photon and at $\chi \gg 1$ or by photons emitted by original electrons at $\chi \gg 1$ [3]. We analyse prospects for making statistical inferences and consider how machine learning methods can be used to reinforce the studies. Our analysis offers a framework for statistical studies of strong-field QED and outlines criteria for designing corresponding experiments at the existing and future facilities in a wide range of parameters, including electron energies from 100 MeV to 1 TeV and laser powers from 100 TW to 100 PW.

References

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