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Probing non-perturbative QED and new physics in laser-particle beam collisions at LUXE and prospects for a future Higgs factory

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The proposed LUXE experiment (Laser Und XFEL Experiment) at DESY, Hamburg, using the 16.5 GeV electron beam extracted from the European XFEL, aims to study collisions between high-intensity laser pulses and high-energy electron or secondary photon beams (unique feature at LUXE). This will elucidate quantum electrodynamics (QED) at the strong-field frontier, where the electromagnetic field of the laser in the probe particle rest frame is above the Schwinger limit. In this regime, QED is non-perturbative. This manifests itself in the creation of physical electron-positron pairs from the QED vacuum, similar to Hawking radiation from black holes. LUXE intends to measure the positron production rate in an unprecedented laser intensity regime. The strong-field QED effects probed by LUXE are expected to become relevant for beam-beam interactions at future electron-positron colliders. The LUXE setup also provides a unique opportunity to probe physics beyond the standard model by impinging the large photon flux from Compton scattering onto a beam dump, thereby probing axion-like-particles (ALPs) at a reach comparable to FASER2 and NA62. Furthermore, the extracted 16.5 GeV EuXFEL electron beam for LUXE can be used for studies of plasma boosting for plasma-enhanced future electron-positron collider concepts, such as HALHF.

In this contribution we will give an overview of the LUXE experimental setup and its challenges, as well as its implications for future electron-positron colliders. Finally, we discuss the prospects of a high-energy extracted electron beam facility for future collider developments and explore the potential of a LUXE-type experiment at a future Higgs factory.

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