

Quantum Electrodynamics in the Strong Field Regime

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(as member of LUXE, QED at High Intensity Frontier. GEMINI and FACET SFQED collaborations)

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The development of lasers capable of intensities in the range of 10^{20} - 10^{23} Wcm⁻² allows the critical Schwinger field of QED $E_S \sim 10^{18}$ Vm⁻¹ to be reached in the rest frame of relativistic electrons, implying that the so-called quantum parameter $\chi = \gamma E/E_S$ approaches and exceeds unity. Under these conditions, QED becomes highly non-linear and to date only the onset of this regime has been studied experimentally (in the seminal E144 experiment at SLAC).

Under these conditions fascinating fundamental phenomena are open to experimental investigation. Examples are vacuum as an active optical medium (e.g. birefringence), spontaneous electron-positron pair production from the vacuum state photon-photon scattering of real photons (quantum reflection) to ‘Radiation Reaction’ where theories to describe the self-consistent dynamics of an electron in high fields are tested.

The presentation will review the recent developments and opportunities in the field, with a particular emphasis on ongoing and planned experiments at the FACET facility at the 10 GeV SLAC electron beam [3], the LUXE [1] collaboration to perform high precision experiments at the 17 GeV European XFEL electron beam and all optical experimental approaches at PW facilities such as CALA[2], ELI and Gemini [4,5], where laser produced GeV electron beams interact with high intensity lasers.

[1] Letter of Intent for the LUXE Experiment, arXiv:1909.00860

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[2] DFG Research Unit FOR 2783 “Probing the Quantum Vacuum at the High-Intensity Frontier”

<http://www.quantumvacuum.org/> H. Gies, F. Karbstein, S. Karsch, C. Müller, G.G. Paulus, H. Ruhl, J. Schreiber, M. Zepf, KU Bamberg, C. Bild, L. Doyle, P. Khademi, F. Salgado, L. Klar, Ricardo Oude Werninck, Annika Schmidt, C. Sundqvist.

[3] Probing Strong-field QED at FACET-II (SLAC E-320) https://conf.slac.stanford.edu/facet-2-2019/sites/facet-2-2019.conf.slac.stanford.edu/files/basic-page-docs/sfqed_2019.pdf S. Meuren, Thomas Koffas, Christian Nielsen, Allan Sørensen, Ulrik Uggerhøj Sébastien Corde, Pablo San Miguel Claveria Antonino Di Piazza, Christoph Keitel, Matteo Tamburini, Tobias Wistisen Harsh, Felipe Salgado, Christian Rödel, Matt Zepf Thomas Grismayer, Luis Silva, Marija Vranic Elias Gerstmayr, Stuart Mangles Niall Cavanagh, Gianluca Sarri California Robert Holtzapple, Felicie Albert, Dario Del Sorbo, Angelo Dragone, Frederico Fiuza, Alan Fry, Siegfried Glenzer, Tais Gorkhover, Carsten Hast, Christopher Kenney, Stephan Kuschel, SM, Doug Storey, Glen White Stanford University, Phil Bucksbaum, David Reis, Chan Joshi, Warren Mori, Brian Naranjo, James Rosenzweig, Michael Litos, Matthias Fuchs

[4] , Experimental Evidence of Radiation Reaction in the Collision of a High-Intensity Laser Pulse with a Laser-Wakefield Accelerated Electron Beam. J. M. Cole et al., Phys. Rev. X 8, 011020 (2018)

[5] Experimental Signatures of the Quantum Nature of Radiation Reaction in the Field of an Ultraintense Laser K. Poder et al. Phys. Rev. X 8, 031004 –(2018)