Precision modelling of high-intensity laser-matter interactions: radiation reaction, pair cascades and beyond

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Experiments that aim to explore laser-matter interactions in the regime of strong-field QED are underway in a host of laser facilities worldwide, with collisions between lasers and electron beams (see Fig. 1) playing an essential role [1]. Modelling of these experiments, with theory or simulations, provides a means of assessing their potential to make definitive measurements of radiation reaction, stochasticity effects, and nonlinear electron-positron pair production. In this talk I will present what lessons experiments and theoretical modelling have for each other, in the context of measuring quantum radiation reaction [2] and the γ-ray polarization dependence of QED processes [3], as well as extracting the properties of the collision itself [4]. I will also discuss the motivation for exploring strong-field QED at shorter wavelengths than those of typical high-intensity optical laser systems [5].

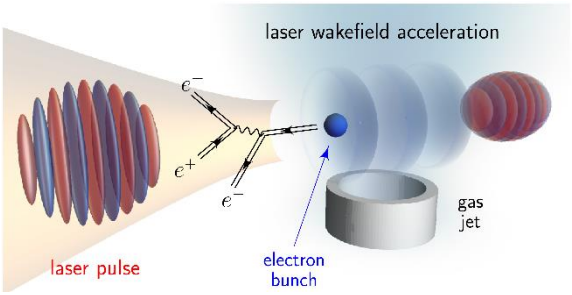

Figure 1: Exploring strong-field QED with an ultrarelativistic electron bunch, accelerated by a laser wakefield, that collides with a second high-intensity laser pulse. Reproduced from [1].

References

[1] A. Gonoskov, T. G. Blackburn, M. Marklund and S. S. Bulanov, Charged particle motion and radiation in strong electromagnetic fields, Rev. Mod. Phys. 94, 045001 (2022)

[2] T. G. Blackburn, Analytical solutions for quantum radiation reaction in high-intensity lasers, arXiv:2312.03592 [physics.plasm-ph]

[3] M. Samuelsson and T. G. Blackburn, Collision parameters needed to measure polarization-dependent pair creation (to appear)

[4] K. Fleck, T. G. Blackburn, E. Gerstmayr, M. Bruschi, P. Grutta, M. Morandin and G. Sarri, Dependence on laser intensity of the number-weighted angular distribution of Compton-scattered photon beams, arXiv:2402.03454 [physics.plasm-ph]

[5] J. Marangos (ed.), UK XFEL Science Case (2020)