Recent Advancements and Perspectives for High-Field QED Studies in the Field of an Intense Laser

G Sarri[1]

[1]*School of Mathematics and Physics, Queen's University Belfast, Belfast, UK. Contact Phone: +442890973573*
Contact Email: g.sarri@qub.ac.uk

The fast-paced advance in the high-power laser technology has recently allowed reaching focussed intensities in the range of 10^{21} Wcm^{-2}, with realistic plans to reach $> 10^{23}$ Wcm^{-2} in the near-term, large-scale laser facilities worldwide. While these intensities are still orders of magnitude lower than those needed to produce an electron-positron pair from a vacuum, this limitation can be overcome by focussing the laser pulse onto an ultra-relativistic electron beam. In this case, the electric field in the rest frame of the electron is relativistically boosted by its Lorentz factor. As an example, a 1 GeV electron beam interacting with a laser focussed intensity of 10^{21} Wcm^{-2} will experience, in its own rest frame, an electric field of the order of 20% of the Schwinger field. GeV-scale electron beams suitable for these experiments can be provided either by laser-wakefield or radio-frequency accelerations.

At these unique field intensities, a plethora of exotic processes can be triggered and studied, including highly non-linear Compton scattering, quantum radiation reaction, and Breit-Wheeler pair production. Detailed experimental characterisation of these phenomena will not only advance our fundamental understanding of this branch of fundamental physics but will also be instrumental for astrophysics, cosmology, and plasma physics.

An international collaboration led by UK scientists has recently performed the first experiments in this area at the Rutherford Appleton Laboratory, unveiling quantum signatures of radiation reaction [1,2]. Several other campaigns at different world-class physics laboratories, including the E-320 experiment at SLAC [3], the LUXE experiment at the Eu-XFEL [4], and experiments at the Extreme Light Infrastructure and the Astra-Gemini laser, are currently in their preparation stage and aim at pushing our experimental capabilities even beyond the Schwinger field.

In this talk, an overview of the current status of these experiments will be given, with a particular focus on the theoretical and experimental challenges in studying this fascinating area of physics.

References

[1] K Poder, M Tamburini, G Sarri, *et al.*, Phys. Rev. X **8**, 031004 (2018)

[2] J M Cole, K T Behm, E Gerstmayr, *et al.*, Phys. Rev. X **8**, 011020 (2018)

[3] `facet.slac.stanford.edu/sites/facet.slac.stanford.edu/files/E320_PAC2020_Meuren.pdf`

[4] H Abramowicz, U Acosta, M Altarelli, *et al.*, arXiv:2102.02032 (2021)