Launching electromagnetic cascades in high-intensity laser fields

T. G. Blackburn[1], A. Ilderton[2], S. P. D. Mangles[3], C. D. Murphy[4], C. P. Ridgers[4], M. Marklund[1]

[1] *Department of Physics, Chalmers University of Technology, Gothenburg, Sweden*

[2] *Centre for Mathematical Sciences, Plymouth University, Plymouth, UK*

[3] *The John Adams Institute for Accelerator Science, Imperial College London, London, UK*

[4] *York Plasma Institute, Department of Physics, University of York, York, UK*

A cascade of photon emission and electron-positron pair creation is launched when a high-energy electron or photon traverses a region of sufficiently strong electromagnetic field, such as at the focus of a high-power laser. Cascades in the highly nonlinear regime, where the laser strength parameter $a_0 \gg 1$ and the quantum parameter $\chi \sim 1$, are relevant to the study of astrophysical plasmas, such as in pulsar magnetospheres, and will be a ubiquitous feature of high-intensity experiments at the next generation of laser facilities. When combined with the ultrarelativistic, ultrashort electron beams available from laser-wakefield acceleration, today's high-intensity lasers have the capability to probe this regime, where the recoil from emission of multiple photons (radiation reaction) dominates the electron dynamics [1, 2].

If the fields are strong enough that $\chi \sim 1$, the photons will produce electron-positron pairs, and the daughter electrons and positrons will lose energy to secondary radiation. We discuss the prospects for observation of such a cascade in two experimental geometries: one in which a multi-GeV, laser-wakefield accelerated electron beam collides directly with a laser pulse, producing photons via nonlinear Compton scattering [3]; and one in which the electron beam first collides with a high-Z foil, producing GeV photons via bremsstrahlung that go on to collide with a high-intensity laser pulse [4].

References

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

[2] K. Poder *et al.*, *Evidence of strong radiation reaction in the field of an ultra-intense laser*, arXiv:1709:01861 (2017)

[3] T. G. Blackburn, A. Ilderton, C. D. Murphy and M. Marklund, *Scaling laws for positron production in laser–electron-beam collisions*, Phys. Rev. A **96**, 022128 (2017)

[4] T. G. Blackburn and M. Marklund, *Nonlinear Breit-Wheeler pair creation with bremsstrahlung γ rays*, arXiv:1802.06612 (2018)