Relativistic Doppler-boosted γ-rays in High Fields

R. Capdessus[1] M. King[1], D. Del Sorbo[2], M. J. Duff[1], C. P. Ridgers[2] and P. McKenna[1]

[1.] *Department of Physics SUPA, University of Strathclyde, Glasgow G4 0NG, United Kingdom*

[2.] *York Plasma Institute, Department of Physics*

The relativistic Doppler effect is one of the most famous implications of the principles of special relativity and is intrinsic to moving radiation sources, relativistic optics and many astrophysical phenomena. It occurs in the case of a plasma sail accelerated to relativistic velocities by an external driver, such as an ultra-intense laser pulse. The construction of several international multi-petawatt laser facilities (e.g. APOLLON in France, ELI-NP in Bucharest and ELI-Beamlines in Prague) are anticipated to produce field intensities on the order of 10^{23}-10^{24} W/cm^2, where the gamma ray emission and pair production will be copious [1]. In such interaction regimes involving ultra-strong electromagnetic fields, the ions can no longer be considered as "background plasma particles" since the quiver electron energy can be comparable with the ion rest mass [2]. Through an analytical model and 2D QED-PIC simulations, we show that the relativistic Doppler effect on the high energy synchrotron photon emission ($\sim$ 10 MeV), strongly depends on the intrinsic properties of the plasma (charge state and ion mass) and the transverse extent of the driver [3]. When the moving plasma becomes relativistically transparent to the driver, we show that the γ-ray emission is Doppler-boosted and the angular emission decreases; optimal for the highest charge-to-mass ratio ion species (i.e. a hydrogen plasma). This new fundamental insight into the generation of γ -ray sources in various extreme conditions will be significant for experiments on multi-petawatt laser facilities.

[1] A. Di Piazza, C. Müller, K. Z. Hatsagortsyan, and C. H. Keitel Mod. Rev. Phys. **84** (2012).

[2] R. Capdessus, E. d'Humieres, and V. T. Tikhonchuk Phys. Rev. Lett. **110** , 215003 (2013).

[3] R. Capdessus, M. King, D. Del Sorbo, M. J. Duff, C. P. Ridgers, and P. Mckenna, submitted to Scientific Reports.