Computational modelling of ultra-relativistic high harmonic generation using proton mass reduced solid targets

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Present understanding of high harmonic generation (HHG) produced from solid targets in the relativistic regime is underpinned by the Oscillating Mirror Model (OMM) and its variations. In the OMM, the density of interacting electrons is modelled via a step function oscillating through a static ion background [2].

Extensions include the sliding mirror model for thin targets and the Spiky Mirror Model (SMM) in which harmonic emission occurs due to peaks in the relativistic factor $\gamma$ of electrons in the mirror [1]. These approaches result in different characterisations of HHG emission spectra. This is particularly true in the cutoff frequency beyond which the intensity of produced harmonics rolls off exponentially, namely $4\gamma^2$ for the OMM and $\sqrt{8}\gamma^3$ for the SMM [3].

Our interest is in the effect of ultra-relativistic pulses ($a_0 >> 10$) on solid targets of a high density ($100n_e$). Even a short pulse of such a high intensity is likely to induce proton acceleration effects which will distort any returning pulse and disrupt the assumptions underlying the OMM. However, assuming scaling laws as above, resolving the cutoff through brute calculation using the particle in cell method is extremely difficult without significant computer resources since the highest harmonic must be completely resolved on the grid and the highest harmonic scales roughly on the order of $a_0$. To overcome this challenge, we have employed a reduction of ion mass to simulate the effect of high degrees of background ion motion on produced harmonics.

This poster presents the results of 1D and 2D particle in cell simulations of HHG in the case of ultra-relativistic, direct-incidence laser irradiation of solid density targets through the use of reduced proton masses. Comparisons are made between an immobile ion case representing the ideal OMM and progressively reduced mass models taken to the limit case of an ultra-dense electron-positron plasma. The returning field structures are presented and analysed for harmonic content using post processing routines.

References