Relativistic high harmonic generation with a PW short pulse laser as a laser-plasma interaction diagnostic

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A promising application of high intensity laser interactions with solid density plasmas is the generation of radiation sources. High fields, extreme temperatures and coupling between laser light and plasma waves cause the emission of energetic particle beams, x-rays and coherent XUV radiation.

The performance and parameters of such radiation sources depend strongly on interaction conditions. In particular, in the field of laser proton acceleration, recent studies [1] have shown a consistent increase in maximum proton energies when tailoring the shape of a 30fs laser pulse, thus showing the high sensitivity of the acceleration mechanisms with respect to small changes on the laser and plasma conditions even in the sub-ps scale.

Similarly, high sensitivity to the interaction conditions during the main part of the pulse has been consistently measured and observed through simulations for relativistic High Harmonic Generation (HHG). Different mechanisms have been sugested [2] for the generation of harmonics of the laser light up to the soft X-ray range. Most of them are particularly sensitive to the pre-plasma generation, as well as to small changes in the laser phase properties during the fraction of the pulse with relativistic intensity.

The response of the plasma to these small changes poses both a great opportunity for optimization, as well as a challenge when it comes to the experimental characterization and understanding of the ultrafast microscopic picture the laser-plasma interactions.

In order to gain insight into the proton acceleration dependence on the target front side plasma conditions, a XUV spectrometer was installed at the Draco PW laser ($5.4x10^{21}W/cm^2$, 30fs, 810nm pulse) to monitor the HHG performance for different laser and target configurations. The emission of harmonics in the XUV (57nm-17nm) range was first characterized for different laser energies and target materials (glass substrates, metal and plastic foils). Simultaneous measurements of proton acceleration and HHG were then taken while varying laser parameters.

This study extends the range in which relativistic harmonics have been experimentally studied to the short pulse PW regime and thin foil targets, and looks further into the recently explored direction of using relativistic high harmonic generation as a gauge for ultrafast relativistic laser-plasma interactions [CHOPINEAU], in this case focused in laser proton acceleration.

References

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