Contribution ID: **35** Type: **not specified**

Estimation of preplasma properties via time-resolved spectroscopy of back-reflected light

Tuesday, 28 January 2020 10:35 (25 minutes)

Nowadays research on laser-driven proton acceleration is focusing on the interaction of relativistic-intensity laser pulses with sub-micrometer targets, aiming for advanced acceleration mechanisms. Despite very positive estimates delivered by numerical simulations, a significant discrepancy is found in the experimental realization so far, which requires further investigations. The predicted mechanisms rely on well-defined plasma conditions at the time of the maximum laser intensity. These conditions, especially the preplasma scale length are extremely hard to measure and remain mostly not known, which prevents a detailed study and an efficient use of these acceleration mechanisms.

During the interaction of the laser and plasma, a part of the laser pulse is reflected back at the critical plasma density, carrying important information about the interaction process itself. The spectrum is modulated due to effects such as relativistic self-phase-modulation and is additionally Doppler-shifted by the moving critical density occurring during hole boring or plasma expansion. The interplay between these effects is intimately related to the plasma density gradient in the vicinity of the reflection point as well as the plasma temperature. A shallow plasma gradient will favor hole boring, leading to a red Doppler-shift for instance, whereas a steep plasma gradient will impose a strong electron-pressure, counteracting the laser pressure.

To study these effects and corresponding time scales, a diagnostic for back-reflected light based on frequency resolved optical gating (FROG) has been commissioned at the PHELIX facility where intensities above 1020 W/cm² and pulses with ultra-low temporal pedestal are available. We have conducted measurements for different plasma conditions: at first with the standard temporal profile of the laser pulse, then with a double plasma mirror setup that dramatically steepens the pulse.

As a support to the experimental data, we have performed 2D simulations using the particle-in-cell code EPOCH, with parameters as close as possible to the experiment, including a pre-expanded target. We varied the scale length and temperature of the plasma and monitored its effect on the time dependent spectrum of the back-reflected pulse. With decreasing scale-length around or below 1 µm, a transition from a red shifted spectrum to a blue shifted one at even higher gradients is visible, as observed experimentally.

We believe that this method can deliver some estimates on the preplasma expansion on a sub-micrometer scale, a spatial range which can be hardy covered by other experimental methods like shadowgraphy or interferometry (though more complex Frequency Domain Interferometry can access similar ranges). This result is of particular interest for the understanding of experiments aiming at laser-driven ion acceleration, which mostly rely on unexpended foils to maximize the acceleration process.

Primary author: HORNUNG, Johannes (GSI, Darmstadt)

Co-authors: KLEINSCHMIDT, Annika (GSI, Darmstadt); ZEPF, Karl Matthäus (GSI, Darmstadt); Dr BAGNOUD, Vincent (GSI, Darmstadt); ZOBUS, Yannik

Presenter: HORNUNG, Johannes (GSI, Darmstadt)

Session Classification: High-Intensity Lasers and Applications in HED Science II