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How are CEP effects affected by the injection mechanism in a Laser Wakefield Accelerator driven by near single-cycle laser pulses

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Our group has developed a laser wakefield accelerator (LWFA) based on a near-single-cycle laser driver, producing up to 10 MeV electron beams at kHz repetition rates [1]. For near-single-cycle laser pulses, the ponderomotive approximation breaks down and the plasma response becomes sensitive to the waveform of the laser field so that the carrier-envelope phase (CEP) can affect electron injection in the wake. In previous work, we showed that the CEP modifies the dynamics of self-injection by triggering a transversely oscillating plasma bubble, resulting in CEP dependent electron beam pointing [2]. In contrast, this talk will focus on very recent experimental results where electrons are injected by ionization injection. Ionization injection directly depends on the amplitude and phase of the laser field and is, therefore, particularly sensitive to the CEP. In this regime, we show that the electron beam undergoes an angular CEP dependent splitting in 2 sub-beams, reflecting the dynamics of ionization injection at the sub-cycle level. Finally, we also show experimentally that CEP effects can be strongly mitigated by relying on density down-ramp injection instead of self-injection of ionization injection.

[1] Monzac et al., PRR 6, 043099 (2024)
[2] Huijts et al., PRX 12, 011036 (2022)

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