Observation of carrier-envelope phase (CEP) effects in a kiloHertz laser-wakefield accelerator

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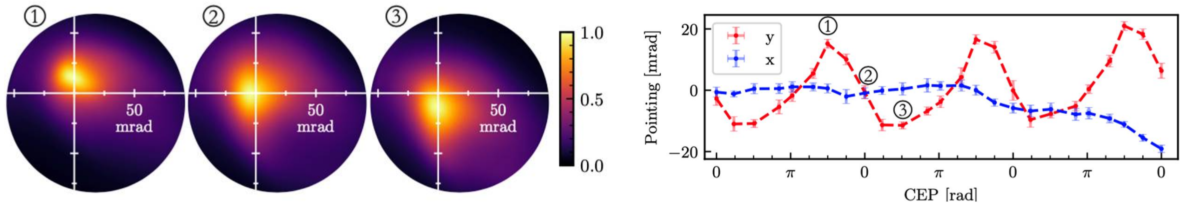

Figure 1: Effect of the CEP on the electron beam. Left : 3 different electron beam profiles for 3 different CEP (1. CEP $= -\pi/2$, 2. CEP $= 0$, 3. CEP $= \pi/2$).
Right : the variation of the beam pointing with the CEP, obtained in a systematic manner.

In this talk, we will present the effects of the laser CEP on relativistic electron beam generated by a high-repetition rate laser-wakefield accelerator. These accelerators are driven by sub-5 fs pulses and can produce 1 to 10 MeV electron beams at a kilo-Hertz repetition rate [1, 2, 3]. Our kHz laser-plasma accelerator is driven by kHz near-single cycle pulses as short as 3.5 fs. The commonly used ponderomotive approximation, in which the effect of the laser field is averaged on the optical cycle, is no more valid for such short pulses and the actual waveform of the laser has to be taken into account.

We used near-single-cycle laser pulses with a controlled CEP [4], focused in a Nitrogen plasma, and we observed that the beam pointing and the charge of our relativistic electron beam oscillates in phase with the CEP of the laser, at an amplitude of 15 mrad, or 30% of the beam divergence, see Figure 1 [5]. More recently, we replaced Nitrogen with Helium, and found similar results but with higher electron energy. This entirely excludes ionization injection as a possible mechanism for explaining CEP effects [6]. We will explain the underlying physics through PIC simulations : these oscillations appear because of asymmetries in the injection and acceleration of the electron beam, which are locked to the CEP [7]. We will also show preliminary results obtained in a He/Ar mixture, in which ionization injection is predominant.

References

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