High stability electron beams from staged laser and plasma wakefield accelerators

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Compact, high-gradient plasma-based particle acceleration has recently made huge progress in terms of energy, current and spectral charge density. However, in Laser-Wakefield Acceleration (LWFA) it remains extremely challenging to generate stable and low emittance electron bunches. These challenges arise from the sensitive dependence of the accelerating gradients on driver fluctuations (i.e. energy, wavefront, etc.). In particle driven wakefield acceleration (PWFA), some of these problems can be overcome because the strength of the wakefield does not depend on the energy of the relativistic particle driver. Also, the influence of fluctuations of the drive beam current are dampened. However, in the past, such research was only possible on a few large-scale accelerator facilities. In past experiments we showed that high current LWFA-generated electron bunches [1] are well suited as drive beams for PWFA [2] and that witness beams can be accelerated in them [3, 4].

This presentation summarizes our recent experiments on stable witness beam generation using a robust optical injection method [5]. The stability of the hybrid LWFA-PWFA is comparable to pure LWFA and PWFAs driven by beams from conventional accelerators. Extensive sets of particle-in-cell simulations explain the experimental data and point the way to even more stable and high-quality electrons from future multistage experiments.

Overall, the hybrid approach combines and benefits from the availability of high-current bunches from LWFA and from the higher energy stability that can be achieved in PWFA, mitigating some of the stability issues of pure LWFA.

References

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