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A novel laser-driven electron acceleration scheme based on a plasma-mirror injector

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Nowadays, laser-driven accelerators can accelerate electron beams to multi-GeV energies over a few centimeters. [1] The development of advanced injection schemes (e.g., ionization injection, shock injection⋯) has made it possible to increase the amount of accelerated charge or to improve the quality of the accelerated beams. However, the principal limitation of laser-driven electron accelerators is that they cannot provide electron beams with, at the same time, high charge and high quality, which is necessary for most envisaged applications of these techniques, such as, for instance, FLASH radiotherapy/radiobiology.[2]
The main issue is that in conventional injection schemes electrons are injected from a low density gas, and thus injecting a large amount of charge is very challenging.
We propose a new concept for a laser-plasma acceleration injector, which could provide high quality and high charge electron beams. This concept is based on an optical device called a "plasma mirror" to inject a substantial amount of charge. [3] This plasma mirror is coupled with a gas-jet, so that electrons extracted from the plasma mirror can be injected in the accelerating structure created by the laser in the gas-jet and can be further accelerated. In this contribution we will present numerical simulation results and preliminary proof-of-principle experimental results that confirm that high-quality, high-energy, and high-charge beams can be accelerated with this technique.[5]

References:
[1] Petawatt Laser Guiding and Electron Beam Acceleration to 8 GeV in a Laser-Heated Capillary Discharge Waveguide, A.J. Gonsalves et al., Physical review letters [2019]
[2] Radiobiology of the FLASH effect, A.A.Friedl & al. Med Phys.49(3) [2022]

[3] Vacuum laser acceleration of relativistic electrons using plasma mirror injectors, M. Thévenet et al., Nature Communications, 12, pp.355-360 [2016]
[5]Pushing the Frontier in the Design of Laser-Based Electron Accelerators with Groundbreaking Mesh-Refined Particle-In-Cell Simulations on Exascale-Class Supercomputers, Luca Fedeli, Axel Huebl, France Boillod-Cerneux, Thomas Clark et al., SC22 [2022]

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