LPAW 2023
Laser and Plasma Accelerators Workshop 2023
lpaw23@tecnico.ulisboa.pt

First Electron Acceleration with an Axiparabola

Aaron Liberman[1], Slava Smartsev[1,2], Sheroy Tata[1], and Victor Malka[1]
[1] *Department of Physics of Complex Systems, Weizmann Institute of Science, Rehovot, Israel*
[2] *LOA, CNRS, Ecole Polytechnique, ENSTA Paris, Institut Polytechnique de Paris, France*

aaronrafael.liberman@weizmann.ac.il

The axiparabola, a long-focal-depth reflective optical element that produces a quasi-Bessel beam [1], has generated interest in its potential to both overcome the beam diffraction and electron dephasing limitations of laser-wakefield acceleration [2,3]. The former is accomplished by the diffraction-free propagation properties of the Bessel beam. The latter, meanwhile, through a combination of the dynamics imposed by the axiparabola itself and a manipulation of the pulse-front curvature (PFC) of the incoming beam [2,3]. Experimentally, axiparabolas have been used to generate a plasma waveguide for guiding a parabola-focused beam for electron acceleration [4]. Here, we demonstrate a proof-of-concept result: the first one-beam acceleration of electrons using an axiparabola, combined with a system for manipulation of the laser beam's PFC. This is the first experimental setup that promises to take advantage of the dephasingless acceleration properties of the axiparabola. We also show experimental measurements of the axial energy deposition velocity of the axiparabola and its dependence on the PFC of the incident beam. This proof-of-concept experiment shows the feasibility of using the axiparabola and presents a roadmap for further optimization towards the eventual goal of dephasingless laser-wakefield acceleration.

[1] S. Smartsev et al. "Axiparabola: a long-focal-depth, high-resolution mirror for broadband high-intensity lasers," Optics Letters 44, 3414-3417 (2019)

[2] C. Caizergues et al. "Phase-locked laser-wakefield electron acceleration," Nature Photonics 14, 475-479 (2020)

[3] J.P. Palastro et al. "Dephasingless Laser Wakefield Acceleration," PRL 124, 134802 (2020)

[4] K. Oubrerie et al. "Controlled acceleration of GeV electron beams in an all-optical plasma waveguide," Light: Science and Applications 11,180 (2022)