Charged particle acceleration with structured light

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This talk delves into the innovative application of Laguerre-Gaussian (LG) modes [1] for generating high-quality proton beams characterized by their exceptionally low divergence (~0.7 mrad), a significant improvement over the more traditional Gaussian beams. We explore experimentally relevant scenarios where the laser driver, boasting ultra-high intensities (~10^{20} W/cm^2) and an energy output of approximately 3 J, engages with a double-layer target to optimize energy absorption [2]. Our insights, derived from a combination of analytical methods and comprehensive three-dimensional particle-in-cell simulations conducted via OSIRIS [3], underscore the efficacy of LG modes in accelerating protons to high energies (~ 40 MeV), while maintaining low divergence [4]. The underlying mechanism benefits from the LG mode's diminished critical power ratio for relativistic self-focusing, compared to a Gaussian laser pulse [5]. Furthermore, we demonstrate that this approach can be scaled to achieve higher proton energies without compromising the distinct low divergence feature.

We also explore the realm of hollow beams characterized by azimuthal and radial polarizations [6]. These beams, which mirror the hollow characteristics of the first-order LG mode, albeit devoid of angular momentum, offer novel insights into laser energy depletion, nonlinear optics, and intense magnetic field generation.

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