Positron acceleration in non-linear doughnut wakefields driven by higher order lasers

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When a laser pulse propagates in an underdense plasma, it can excite relativistic plasma waves capable to accelerate particles to high energies in distances that can be up to three orders of magnitude shorter than in conventional accelerating devices. Important achievements in this field have been reached in the so called bubble or blowout regime, where the laser radiation pressure is sufficiently strong to expel all plasma electrons at its passage, forming a spherical plasma wave with linear accelerating and focusing wakefields. Although being ideally suited for electron acceleration, it has been recognized that non-linear regimes are not adequate to accelerate positrons. New configurations enabling positron acceleration in non-linear regimes would therefore open new research paths for future plasma based collider configurations.

In this work, we will present simulation results using the particle-in-cell code OSIRIS [1] exploring a novel configuration for positron acceleration in strongly non-linear laser wakefield excitation regimes. We will show that Laguerre-Gaussian lasers carrying orbital angular momentum can drive doughnut wakefields [2] with positron focusing and accelerating fields [3]. We will also demonstrate that positron focusing-fields can be up to an order of magnitude larger than electron focusing in the spherical blowout regime. The amplitude of the accelerating fields is similar to the spherical blowout. Three-dimensional OSIRIS simulations demonstrate laser self-guiding and stable positron acceleration until the laser energy has been exhausted to the plasma.

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