Radiation emission in laser-wakefields driven by structured laser pulses with OAM

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Light with orbital angular momentum (OAM) has received great interest in recent years and has shown great potential in several applications at low intensities notably in optical communications, quantum computing and super-resolution microscopy [1] as well as at ultra-high intensities for positrons acceleration in nonlinear plasma waves and generation of high OAM harmonics [2]. Schulz et al. [3] showed that by combining properly tailored pairs of lasers with symmetric OAM modes, a pulse with a petal-like intensity profile is produced with a nonlinear angular dependence that leads to rotational acceleration/ deceleration of the intensity pattern. Interaction between spin and orbital angular momentum inside a fibre has also been shown to lead to rotation of the intensity pattern under certain conditions [4]. In this work, we explore the use of complex pulses resulting from the combination of modes carrying different OAM (in pairs of symmetric/asymmetric index values) to drive multiple wakefields. We focus on the properties of the betatron radiation obtained in this regime. The detailed motion of the laser pulses, the wakefield structure and the electron bunch dynamics are explored through three-dimensional particle-in-cell simulations performed with the OSIRIS framework [5]. The radiation generated by the accelerated bunches is determined by post-processing the electron trajectories with the radiation diagnostic code jRad [6] fully accounting for spatial coherence effects.

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