Pair Creation in Laguerre-Gauss Beams: from Shower to Cascade

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When ultrarelativistic particles interact with ultra high-intensity laser pulses, two main phenomena become important, hard photon emission by nonlinear Compton scattering and electron-positron pair creation by the nonlinear Breit-Wheeler process. One of the simplest configurations to create pairs through these processes is the head-on collision of a high-intensity laser with high-energy gamma photons. It is then possible to predict with a simple model the expected number and energy of primary pairs for a given spatio-temporal configuration and identify the best condition for abundant pair production with this scheme. The proposed model [1] has been benchmarked against 3D SMILEI [6, 7] PIC simulations and can be applied to complex laser profiles such as Laguerre-Gauss (LG) beams. The ultimate goal is to reach a self-sustained cascade, in which gamma photon emissions and pair creation couple to produce an exponential growth of the number of particles.

A configuration with two counter-streaming laser beams generating a standing wave has been suggested as the optimal configuration to reach cascade. This configuration has been discussed in various theoretical and numerical studies [2–5] for Gaussian pulses, but a clear-cut conclusion on the optimal set-up and pulses characteristics is still lacking. Here we study the case of two counter-propagating LG beams. We explore how they can improve the onset of the cascade by considering the effect of the LG beam polarisation and order. Our study allows identifying the physical parameters relevant to triggering the cascade development and predicting the optimal field configuration to optimise the number of produced pairs.

References

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