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Angular Momentum transfer by relativistic ponderomotive force in tightly focused beams

In the context of magnetic field generation in plasma, we study the process of Angular Momentum (AM) transfer from a laser beam to electrons, treated here as test particles. In particular, we investigate the case of the Laguerre-Gaussian beam with Orbital Angular Momentum (OAM). For a moderately relativistic regime (dimensionless field strength $a_0 < 5$) we show that the AM transfer is mainly provided by the ponderomotive force from longitudinal fields inherent to focused beams. While most AM transfer models [1,3,4] rely on perturbative methods and are valid only at non-relativistic intensities ($a_0 < 1$), we develop a model based on the relativistic ponderomotive force. Our model predicts the amplitude and overall shape of the AM distribution and demonstrates a good agreement with Smilei [5] particle simulations in the relativistic regime. We also show that the total AM transferred to electrons is not zero and has the same sign as the laser OAM. However, the net gain is small for $a_0 \sim 1$, and we discuss the numerical challenges on its extraction from simulations.

We are using Smilei to obtain a quantitative and accurate comparison between our model and the exact particle trajectories and AM distribution. Indeed, as the effect is small, prescribed fields are not accurate enough to observe the effect of AM transfer. Thus, we used smilei capabilities to efficiently solve Maxwell in 3D on clusters. Although only test-particles were used in this first approach, Smilei was used with the goal to include the self-consistent fields and understand how the induced magnetic fields are produced when plasmas effects are not neglected.

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