Linear and Angular Momentum of Classical Particles Interacting with a Laguerre-Gauss Laser Pulse

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We have investigated the evolution of an ensemble of classical charged particles interacting with a Laguerre-Gauss laser pulse. We have integrated numerically the relativistic equations of motion for the particles which at the initial moment (before the arrival of the laser pulse) are at rest, distributed uniformly in a disk in the focal plane of the laser.

We have studied the evolution in time of the linear and the angular momentum of the particles, and its dependence on the laser parameters (radial and azimuthal indices of the LG mode, waist, duration, and intensity) and also on the initial position of the particle in the focal plane. We have shown that in the low-intensity regime, the net transfer of linear momentum is parallel to the focal plane, while at large intensities the dominant component of the momentum is along the laser propagation direction. We have also identified scaling laws obeyed by the net transfer of linear and angular momentum to the particles as a function of the field intensity.

Finally, we present the relativistic ponderomotive force approximation approach for calculating the final state of the particles and study the influence of the laser pulse waist, duration, and intensity on its validity. The scaling laws presented before are discussed in the context of this approximation.