Arbitrary nonparaxial accelerating beams and applications to femtosecond laser micromachining

Accelerating beams are a novel class of optical waves where the localized intensity maximum propagates along a curved trajectory with applications in nonlinear optics and optical manipulation. While initial studies of the paraxial regime have demonstrated Airy beams propagating along arbitrary trajectories, recent extensive work as focused on solutions of the wave equation in the *nonparaxial* regime. Two main approaches have been used to find the solutions. Derivation of exact solutions from Maxwell or Helmholtz wave equation provides closed-form solutions. However, another approach is based on the association of the target trajectory with an optical caustic, and this allows us to engineer a phase mask such that an incident beam further evolves on a predefined *arbitrary nonparaxial* trajectory. We report a method for accelerating beam generation in the Fourier domain and experimentally demonstrate arbitrary accelerating beam in two and three dimensions. Specifically, we report the experimental generation of optical beams propagating on the surface of a sphere of 50 μm radius and covering more than 95° of arc. In two dimensions, we also report the experimental generation of arbitrary accelerating beams with uniform illumination over more than a quadrant of a circle. Moreover, we show that our method is compatible with amplitude modulation and the generation of periodic accelerating beams is reported with excellent agreement with numerical simulations. Finally, we report the use of femtosecond laser machining of arbitrary curved profiles using nonparaxial accelerating beams.