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Periodic Self-Accelerating Beams along Convex Trajectories

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Curved or self-bending light has become a hot topic recently. It's triggered by a newly self-accelerating non-diffractive beam, named Airy beam that propagates along a parabolic trajectory. This peculiar beam has led to many potential applications such as for example optical trapping and manipulation, plasma guidance, generation of light bullets, and routing of electrons and surface plasmons. The state-of-the-art self-accelerating beams can be designed along any convex trajectory by engineering the phase of a light, in either real or Fourier space under both the paraxial and non-paraxial conditions. To the best of our knowledge, these beams generally propagate along smooth convex trajectories. Very recently, periodically oscillating or zigzag accelerating beams has been newly obtained by means of superposition of Bessel-like beams in the non-paraxial condition. Here, we propose another method to generate self-accelerating zigzag beams in free space in both paraxial/non-paraxial conditions through engineering both spectral phase and amplitude of a monochromatic coherent light source. We have demonstrated theatrically and experimentally that, in absence of either zero values or sharp variations in the spectral amplitude, the self-accelerating beam still propagates along a smooth convex trajectory while otherwise the convex trajectory tends to be modulated. To clarify the influence of the spectral amplitude on the beam evolution, we employed a simple "well"-shaped spectral amplitude, a distribution having a hole in a uniform spectrum for the first case. Under these conditions, the beam path can be approximately described by a curved and two straight lines joined together. Such a path structure is an elementary unit for building a zigzag beam along a convex trajectory. Using an array of these spectral "wells" , we realized several typical kinds of zigzag beams and analyzed their self-healing properties. Furthermore, the analysis in the paraxial condition can be readily extended to the non-paraxial regime, where we produced the zigzag beams along circular, elliptical and parabolic trajectories by carefully engineering the spectral amplitudes, respectively. Our findings may find applications in particle manipulation, laser-writing, electron acceleration as well as plasma generation.

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