Super Gaussian-Laguerre Accelerating Beams

Ioannis M. Besieris,* [(1)] Amr M. Shaarawi [(2)]

(1) ECE Department, Virginia Tech, Blacksburg, Virginia 24061, USA

(2) Physics Department, American University in Cairo, New Cairo, 11835, Egypt

A finite-energy *bending* Airy beam solution to the paraxial equation in free space was first formulated analytically by Siviloglou and Christodoulides and subsequently demonstrated experimentally by Siviloglou, Broky, Dogariu and Christodoulides. This work was motivated by the infinite-energy (nonspreading) *accelerating* Airy solution to the Schrödinger equation introduced by Berry and Balazs in the context of quantum mechanics. An Airy beam is slowly diffracting; it can retain its intensity properties over several diffraction lengths while bending laterally along a parabolic path despite the fact that its centroid is constant. Another feature, which has been demonstrated both analytically and experimentally, is that an Airy beam propagating in free space can perform ballistic dynamics akin to those of projectiles moving under the action of gravity. These exotic properties suggest various physical applications, such as Airy beam-mediated particle cleaning and vacuum electron acceleration. Ultra-intense Airy beams have been used to create curved plasma channels. Airy beams have been studied in connection with unbiased photorefractive media. Accelerating spatiotemporal Airy wavepackets can defy effectively both dispersion and diffraction.

Both bending Airy beams and accelerating Airy wavepackets are characterized by self-healing properties; they tend to reform in spite of the severity of imposed perturbations. The robustness of such beams in scattering and turbulent environments has been studied numerically and experimentally in the optical regime.

Several studies of accelerating beams in the presence of deterministic inhomogeneities have already been undertaken, illustrating, in particular, that the inherent self-healing properties of such beams are preserved. The specific purpose in this presentation is to examine new classes of accelerating (parabolically bending) beam solutions in the presence of canonical deterministic inhomogeneities. Special choices for the "potential function" $V(x,z)$ of the two-dimensional paraxial equation will result in the following two general classes of super Gaussian-Laguerre accelerating beams:

$$\psi_I(x,z) = \exp\left(-\frac{\xi^{N+2}}{N+2}\right) L_n^{-\frac{1}{N+2}}\left(2\frac{\xi^{N+2}}{N+2}\right)\exp\left[i\left(Axz-\frac{2}{3}A^2z^3\right)\right],$$

$$\psi_{II}(x,z) = \exp\left(-\frac{\xi^{N+2}}{N+2}\right)\xi L_n^{\frac{1}{N+2}}\left(2\frac{\xi^{N+2}}{N+2}\right)\exp\left[i\left(Axz-\frac{2}{3}A^2z^3\right)\right],$$

$$\xi \equiv x - Az^2;\ N = 0,2,4,6,...;\ n = 0,1,2,3,...$$