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Nonlinear Airy and Airy-like wavepackets

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Ideal Airy beams are non-diffracting wavepackets carrying infinite energy while their envelope is described by an Airy function Ai(s) centered on a parabolic trajectory as predicted by Berry and Balazs [1]. They are unique since they are the only non-diffracting solutions in one dimension. The most interesting attribute of Airy beams is that their intensity lobes shift transversely in a quadratic fashion during propagation [2]. In addition they exhibit a self-healing property, being able to reconstruct their profile after truncation [3]. A possible way to realize a finite energy version of such beams by introducing an exponential decay function $\mathrm{Ai}(s)\exp(\alpha\, s)$, was only recently introduced [4, 5]. The experimental implementation of such beams relies on the fact that the Fourier transform of a Gaussian beam modulated with a cubic phase is an exponentially truncated Airy. Thus optical finite energy Airy beams are generated by imprinting a spatial cubic phase onto a Gaussian beam [4, 5] and then Fourier transforming it using a spherical lens. These truncated Airy wavepackets still retain all the characteristics of the ideal Airy beams only for a finite propagation distance [5]. Furthermore it has been demonstrated that for weakly truncated ($\alpha \approx 0.05$) intense Airy wavepackets [6] the propagation dynamics are mainly driven by linear effects. We study numerically the dynamics of Airy and Airy-like beams in XYZ and radial geometry both in the linear [7, 8] and nonlinear regime [9, 10]. After a brief introduction to the linear propagation attributes of the Airy beam, the dynamics that arise at high power are showcased. The competition between linear and nonlinear effects is shown to give rise to a new complex propagation regime, especially in the radial symmetric Airy beam case. Last, the nonlinear dynamics of the single spatio-temporal collapse

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of two oppositely accelerating ring-Airy[3] as it shown in Fig. 1 (ring-Airy in space, Airy in time). Presented results are expected to have important impact on numerous applications in the fields of nonlinear optics and femtosecond filamentation.

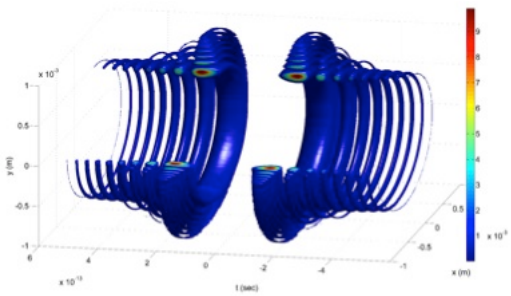

Figure 1: Double ring-Airy[3] wavepacket. The two co-propagating wavepackets have an ring-Airy field profile in space, and Airy in time.

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