Morphology of Airy Symmetric beams

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Abstract: A study about the morphology of two dimensional (2D) and three dimensional (3D) Airy Symmetric (AS) beams is presented, both in the paraxial and non-paraxial regimes. Geometrical Optics and Singular Optics tools allow the identification of interesting features: for 2D AS beams (i) lines connecting intensity maxima and minima are found in terms of rays selected through the derivative of the phases, in fact the number of rays at any given point can get values from 1 to 5 for the non-paraxial case; (ii) the faint component of the electric field along the main direction of propagation exhibits complementary features with respect to the dominant component; for 3D AS beams (i) vortices with topological charge two arise; (ii) caustics and dislocation lines may show sub wavelength structures in the non-paraxial regime.

Airy symmetric beams are defined in terms of the angular spectrum $S_{a_1,a_2}(k_{s_1},k_{s_2})$ that involves a cubic power of the transversal components of the wave vector, like Airy beams, supplemented by the condition of symmetry under reflection [1,2], $S_{a_1,a_2}(k_{s_1},k_{s_2}) = \exp((a_1 - i|k_{s_1}|)^3/3)\delta(k_{s_2})$ for the 2D case and $S_{a_1,a_2}(k_{s_1},k_{s_2}) = \exp((a_1 - i|k_{s_1}|)^3/3)\exp((a_2 - i|k_{s_2}|)^3/3)$ for the 3D case. They have been generated and used for the manipulation of microparticles [3]. It has been shown that 2D AS beams have a rich structure in the paraxial regime [4]. In this work we extend such an analysis for the 2D non-paraxial regime. Geometric optics features like the number of rays at a given point and the morphology of the caustics differ significantly from that of the Airy beams: AS beams show a cusp like caustic structure, self-healing and autofocusing properties. The number of rays inside the cusp of 2D AS beams could be 5, in contrast to the 3 rays for the paraxial case. For 3D AS beams, the paraxial case shows open dislocation lines with unitary topological charge located in planes perpendicular to the direction of propagation, that could give rise to dislocation points with topological charge 2, while in the non-paraxial case there are open and closed dislocation lines, some of them with subwavelength dimensions.

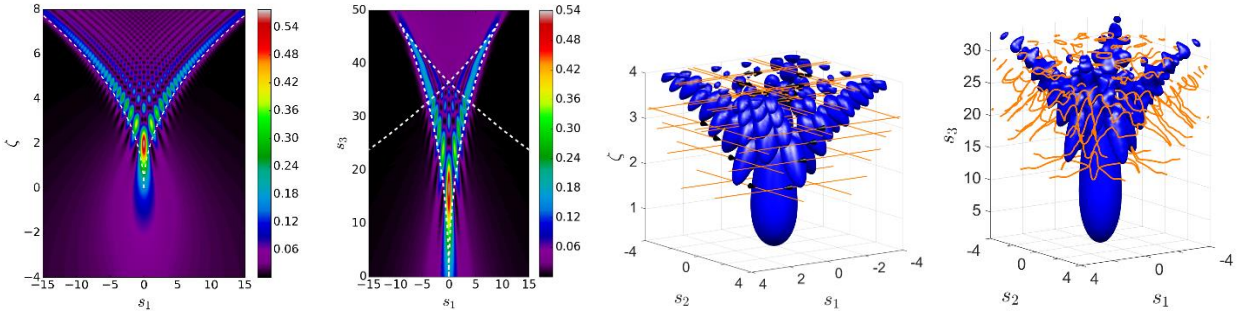

Fig. 1.(From left to right) Intensity pattern of a 2D paraxial ($a_1 = 0.03$) and non-paraxial ($a_1 = 0.05$) Symmetric Airy beam with its caustic curve showed with white dashed lines. Isointensity surfaces for 3D paraxial ($a_1 = a_2 = 0.03$) and non-paraxial ($a_1 = a_2 = 0.05$) Symmetric Airy beam along with its dislocation lines in orange color.

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