Gouy phase modulated morphology of fractional vortex beams

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Abstract: Fractional topological charged vortex beams are generated using computer generated holograms with mixed screw-edge dislocation. Effect of Gouy phase on the locus of the point singularity in far-field and the morphology of the vortex phase is investigated. This enables independent control of the polar and azimuthal degrees of freedom on an orbital Poincaré sphere.

1. Introduction

Fractional optical vortex (FOV) beams evolved from fractional helicoidal phase steps are very promising because of their intricate phase structure and optical current flow [1]. Apart from the birth of a point singularity at half-integer topological charge (TC) [2], the associated topological transformation with varying TC in fractional step has enabled the fine structure details of these beams [1]. The structured darkness and resulting extrinsic orbital angular momentum (OAM) has enabled explanation of the measured total OAM of the FOV beams [3]. In the far field, the FOV beams contains off-axis point singularities that have anisotropic phase gradients around them [4]. At the singular points zero contours of the real and imaginary components of the field crosses, with crossing angle deviating from quadrature. Higher deviation angle implies higher anisotropy [1]. In the present work, the effect of Gouy phase on two angular parameters (ψ, ϕ) [5], describing the magnitude and orientation of anisotropy of the FOV beams is investigated. Each morphological state of the FOV beam is mapped by a point on the orbital Poincaré sphere.

2. Experimental details and Results

A Gaussian beam is focused on the fractional order computer generated hologram displayed on a spatial light modulator (SLM) and the output FOV beam is interfered with a reference Gaussian beam to reconstruct the field of the FOV beam. The Gouy phase of the beam is controlled by translating the lens such that the fractional phase generating optic scans the transverse field of the focused Gaussian beam near waist plane ($-2z_R$ to $+2z_R$; z_R is the Rayleigh length), where the Gouy phase evolution is maximum. From the reconstructed field (u), the morphology parameters are calculated using [5],

$$\psi = \cos^{-1}\left(\frac{|u_-|^2 - |u_+|^2}{|u_-|^2 + |u_+|^2}\right) \text{ and } \phi = \frac{i}{2}\ln\left(\frac{u_+ u_-^*}{u_+^* u_-}\right); \text{ where } u_\pm = \partial_\pm u(x,y) \text{ and } \partial_\pm = \frac{1}{\sqrt{2}}\left(\frac{\partial}{\partial x} \pm \frac{\partial}{\partial y}\right).$$

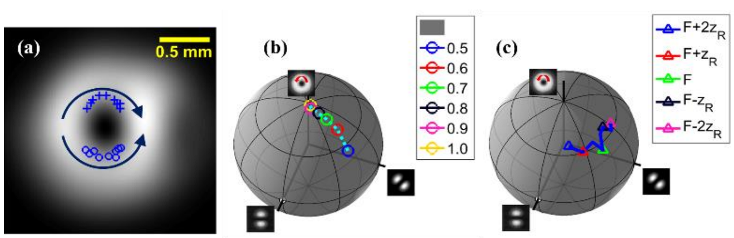

Fig. 1. (a) Locus of point singularity with varying Gouy phase (for TC=0.5): '+' for +ve TC and 'o' for –ve TC. Projection of the vortex morphology on the orbital Poincaré sphere for (b) varying TC and (c) Gouy Phase (Lens Position).

The TC controls the magnitude of anisotropy and the Gouy phase affects the orientation represented by the polar angle and azimuthal angle on the orbital Poincaré sphere respectively.

3. References

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