Interference between vector vortex beams

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Abstract: We numerically demonstrate that interfering two paraxial monochromatic beams corresponding to orthogonal states on the higher-order Poincaré sphere leads to the disappearance of the interference pattern. This extends the concept of quantum eraser to vector vortex beams.

1. Introduction

In 1816, Fresnel and Arago established that two orthogonally polarized beams do not interfere [1]. Homogeneous polarization states of light are often represented as points spanning the surface of the Poincaré Sphere (PS), diametrically opposite points representing orthogonal states. Interfering a state B with a state A corresponds to transporting B to A along the shorter geodesic on the PS, performing a "projection". Orthogonal states do not interfere as their phase difference is undefined [2]. Recently, beams with inhomogeneous polarization and phase distributions such as vector vortex (VV) beams have received considerable attention [3]. To account for both spin and higher dimensional orbital states, Milione et. al. introduced higher-order Poincaré spheres (HOPS) [4]. Such representation features orthogonal circularly polarized optical vortex (OV) beams at the poles and cylindrical vector (CV) beams at the equator. Relying on Jones formalism, we study the interference between pairs of vector vortex beams spanning the surface of an HOPS (see Fig.1.a). VV beams are defined as follows [5]:

$$E(r,\Phi,\Theta) = \cos\left(\tfrac{\Phi}{2}\right) \mathrm{LG}_0^{\ell}\, e^{-i\Theta/2}\ \ \hat{\mathbf{R}} + \sin\left(\tfrac{\Phi}{2}\right) \mathrm{LG}_0^{\ell}\, e^{i\Theta/2}\ \ \hat{\mathbf{L}} \qquad (1)$$

With $\hat{\mathbf{R}}$ and $\hat{\mathbf{L}}$ being the unitary vectors of the right and left CP basis and with $\Phi \in [0,\pi]$ and $\Theta \in [0,2\pi]$.

2. Numerical results and discussion

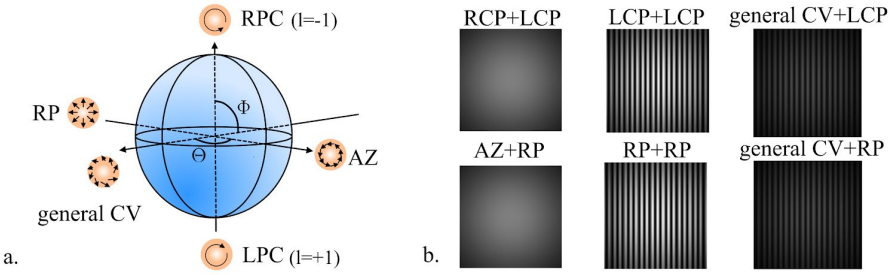

Fig.1. a. Higher order Poincaré sphere for $\ell = \pm 1$ OV beams at the poles, the arrows indicate the polarization distribution. b. Interference patterns of various combination of VV beams spanning the higher order Poincaré sphere.

We evidence that the interference of two orthogonal states on the higher order Poincaré sphere leads to the disappearance of the interference fringes (see Fig.1.b). Our results are in agreement with the experimental work of I. Nape et al. [6]. Such interference studies opens perspectives to exploring higher-order Pancharatnam-Berry phases.

3. References

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