Crafting the core asymmetry to lift the degeneracy of optical vortices

Ashok Kumar,* Pravin Vaity, and R. P. Singh

Theoretical Physics Division, Physical Research Laboratory, Ahmedabad 380 009, India
*ashokk@prl.res.in

Abstract: We introduce an asymmetry in the core of a high charge optical vortex by using an appropriate computer generated hologram. The splitting of a high charge optical vortex core into unit charge vortices has been found to depend on the extent of the asymmetry. For a second order vortex, the trajectories of the split unit charged vortices and their separation have been recorded as a function of change in the asymmetry of the core. We find a good agreement between the experimentally obtained and numerically calculated results.

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References and links

1. Introduction

Vortices, which are manifestations of phase singularities, are generic to all the wave fields. Therefore, exploring their properties is important to many branches of physics [1]. In optics, these are called optical vortices or light beams having a helical wavefront [2].–[6]. Therefore, exploring their properties is important to many branches of physics [1]. In optics, these are called optical vortices or light beams having a helical wavefront [2]–[6]. The helical wavefront is characterized by an azimuthal phase term \( \exp(j m \theta) \) that varies in a corkscrew-like manner along the beam’s direction of propagation. Here, the factor \( m \) is known as the topological charge (can have both positive and negative sign depending on the sense of rotation of the corkscrew) or the order of the vortex. In such a beam of light, each photon acquires an orbital angular momentum of \( mh \) [6] and the transverse intensity profile looks like a ring of light with dark core at the centre.

Optical vortices can be found naturally on scattering of light through the rough surfaces. However, they can also be generated in a controlled manner. Diffraction of light through a computer generated hologram (CGH) is one of the most commonly used methods for making optical vortices in the laboratory [7]. Apart from using CGH, vortices can be generated with spiral phase plates, astigmatic mode converters, spatial light modulators [8] as well as interferometric methods [9]. These structures of light find a variety of applications in the fields of optical manipulation [10], optical communication [11], quantum information and computation [12], and astronomy [13].

The stability and the propagation dynamics of a vortex core may be of relevance to the field of optical communication using such beams. Therefore, a great deal of attention has been given to the dynamics and propagation properties of optical vortices in free space and in nonlinear media [14–20]. Ginzburg and Pitaevski [21] pointed out that a vortex with higher charge (say \( m \), where \( m > 1 \)) in a superfluid is energetically unfavorable compared to \( m \) vortices of unit charge. Hence, a vortex with higher charge always has a tendency to break up