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Average intensity and coherence properties of a partially coherent Lorentz-Gauss beam propagating through oceanic turbulence

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ABSTRACT

Based on the Huygens-Fresnel integral and the relationship of Lorentz distribution and Hermite-Gauss function, the average intensity and coherence properties of a partially coherent Lorentz-Gauss beam propagating through oceanic turbulence have been investigated by using numerical examples. The influences of beam parameters and oceanic turbulence on the propagation properties are also discussed in details. It is shown that the partially coherent Lorentz-Gauss beam with smaller coherence length will spread faster in oceanic turbulence, and the stronger oceanic turbulence will accelerate the spreading of partially coherent Lorentz-Gauss beam in oceanic turbulence.

1. Introduction

In recently years, the diode lasers have been widely used in practical applications, and a model called Lorentz beam has been provided to describe the light field of diode laser [1]. Since then, the laser beams based on the Lorentz distribution have been widely investigated. The propagation properties of Lorentz beam, radial phased-locked Lorentz beam and Lorentz-Gauss beam in uniaxial crystal, free space, ABCD optical system and turbulent media have been illustrated [2–7].

On the other hand, due to the potential application in underwater optical communication and remote sensing, the propagation properties of various laser beam in oceanic turbulence have been widely illustrated [8–20], such as partially coherent radially polarized doughnut beam [8], Gaussian Schell-model vortex beam [9], electromagnetic vortex beam [10], partially coherent flat-topped vortex hollow beam [11] and flat-topped vortex hollow beam [12], partially coherent four-petal Gaussian vortex beam [13], partially coherent Hermite-Gaussian linear array beam [14], Gaussian array beam [15] and M × N Gaussian array beam [16], multimode laser beam [17], partially coherent cylindrical vector beam [18], chirped Gaussian pulsed beam [19] and partially coherent four-petal Gaussian beam [20]. To the best of our knowledge, the propagation properties of a partially coherent Lorentz-Gauss beam in oceanic turbulence have not been reported. In this paper, the influences of beam parameters and oceanic turbulence on the average intensity and coherence properties of a partially coherent Lorentz-Gauss beam have been examined by using the numerical examples in detail.

2. Propagation of partially coherent Lorentz-Gauss beam through oceanic turbulence

In the Cartesian coordinate system, assume the beam propagates along the z-axis, then the light field of a Lorentz-Gauss beam at the source plane z = 0 can be read as [5]:

$$E(\mathbf{r}_0,0)=\frac{1}{w_{0x}w_{0y}\left[1+\left(\frac{x_0}{w_{0x}}\right)^2\right]\left[1+\left(\frac{y_0}{w_{0y}}\right)^2\right]}\exp\left(-\frac{\mathbf{r}_0^2}{w_0^2}\right) \tag{1}$$

where $\mathbf{r}_0=(x_0,y_0)$ is the position vector at the source plane z = 0; w_0 is the waist of the Gaussian part for Lorentz-Gauss beam; w_{0x} and w_{0y} are the parameters related to beam widths of Lorentz part for Lorentz-Gauss beam in x-axis and y-axis, respectively. In Eq. (1), recalling the relationship of Lorentz distribution and Hermite-Gauss function [21]:

$$\frac{1}{(x_0^2+w_{0x}^2)(y_0^2+w_{0y}^2)}=\frac{\pi}{2w_{0x}^2w_{0y}^2}\sum_{m=0}^{N}\sum_{n=0}^{N}a_{2m}a_{2n}H_{2m}\left(\frac{x_0}{w_{0x}}\right)H_{2n}\left(\frac{y_0}{w_{0y}}\right)\times\exp\left(-\frac{x_0^2}{2w_{0x}^2}-\frac{y_0^2}{2w_{0y}^2}\right) \tag{2}$$

where N is the number of the expansion. a_{2m} and a_{2n} are the expanded coefficients and are given in Ref. [18], with the increasing the even

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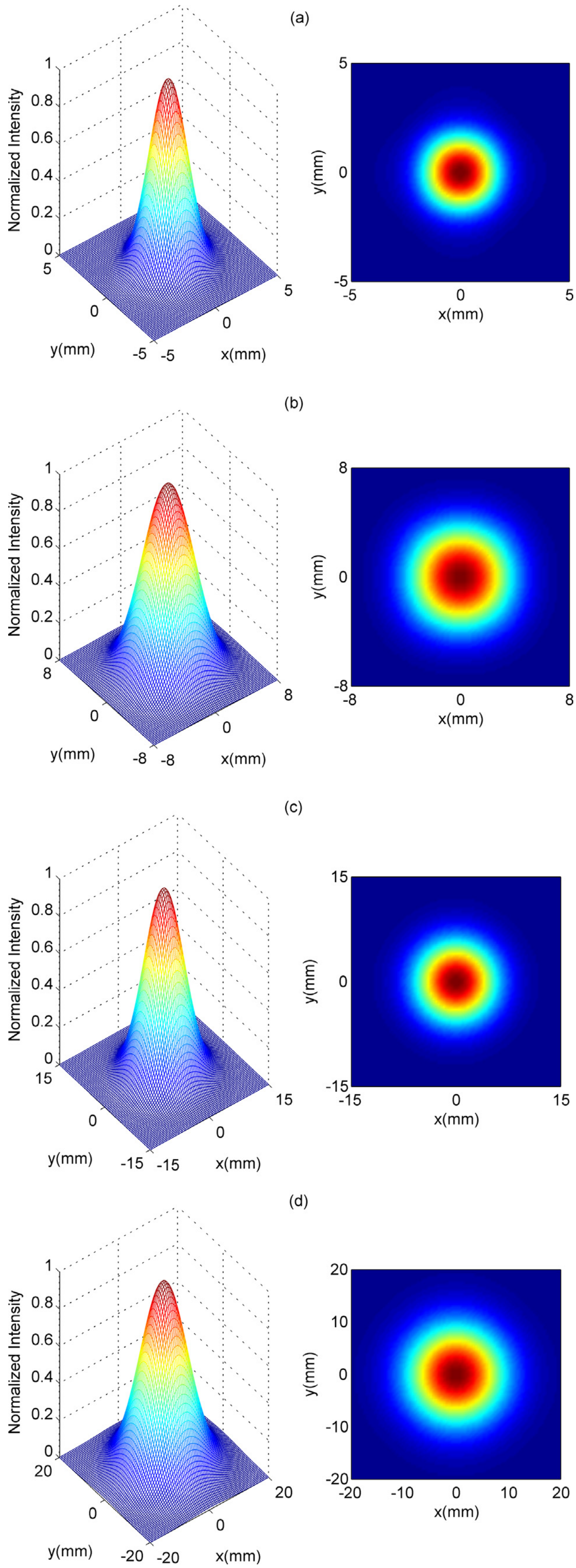

Fig. 1. Normalized average intensity and corresponding contour graphs of a partially coherent Lorentz-Gauss beam propagating in oceanic turbulence with $w_{0x} = w_{0y} = 2$ mm. (a) $z = 10$ m, (b) $z = 50$ m, (c) $z = 80$ m, (d) $z = 120$ m.

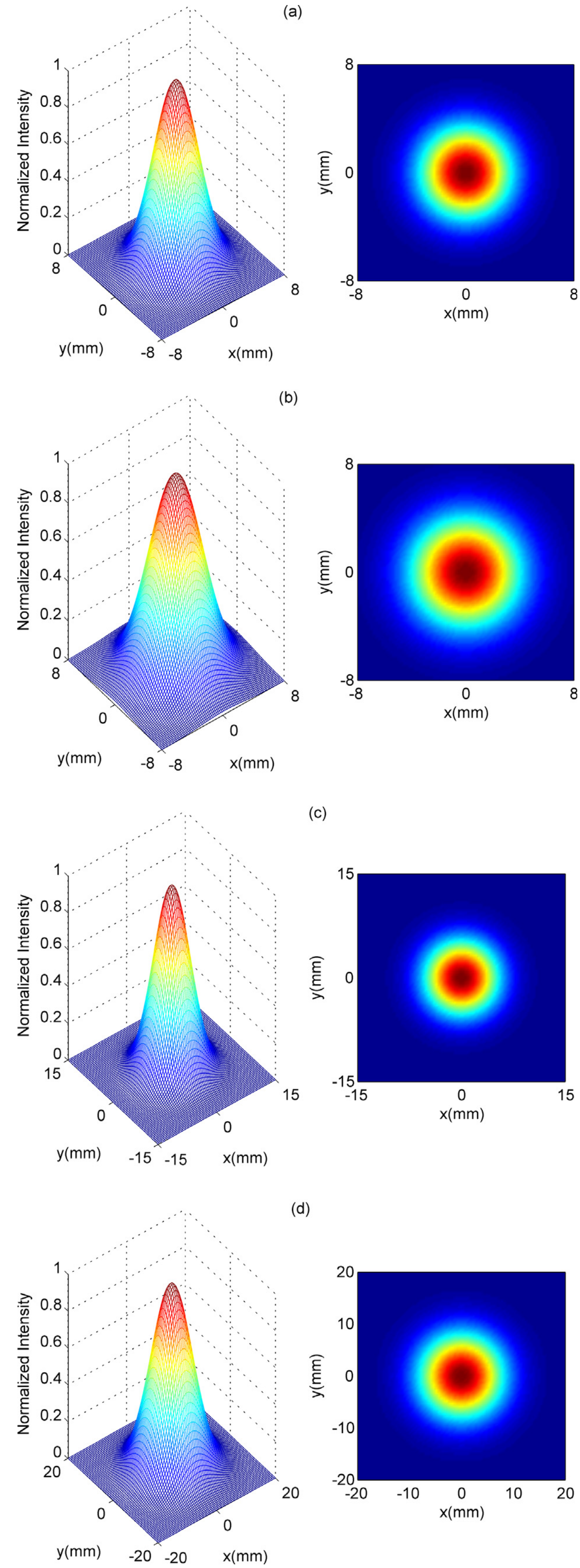

Fig. 2. Normalized average intensity and corresponding contour graphs of a partially coherent Lorentz-Gauss beam propagating in oceanic turbulence with $w_{0x} = w_{0y} = 15$ mm. (a) $z = 10$ m, (b) $z = 50$ m, (c) $z = 80$ m, (d) $z = 120$ m.