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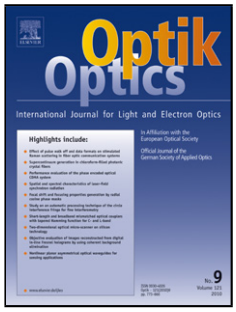

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Analysis on the focal spot characteristics of random Gauss phase plate

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Abstract: Gaussian phase plate (GPP) is a special kind of continuous phase plate, which surface figure can be described as a Gaussian random process. In this paper we propose an analysis model to discuss the statistical characteristics of GPP's focal spot. Using the gradient histogram instead of the diffract integral, the variance of the focus light intensity is analyzed. And the variance reflects the stability of the intensity envelope of the focal spot. Both the deducing process and the numerical simulation are presented. And the results show that the stability of intensity distribution in the focal spot is directly proportional to the correlation length of the phase plate.

Key words: continuous phase plate; Gauss random process; correlation length; focal spot

1. Introduction

Just like random phase plate [1,2], continuous phase plate (CPP) is a typical kind of optical element with random surface distribution, which is employed widely in high power laser system [3,4]. To describe the surface feature of a CPP we need regard the surface of such element as a random process (random function). While the surface of a phase plate can be described as a random Gaussian function, it can be named as Gaussian phase plate (GPP)[5]. Mathematically, compare with other kind of random function, Gaussian function is convenient for creating and derivation and can achieve the analytical solution easier. So discussing the characteristics of GPP can help us to understand the statistical properties of general CPP more clearly.

The far-field of a GPP is related with its surface figure, more precisely, the spatial frequency of the surface directly. As shown in Figs.1(a) and 2(a), there are two surface profiles with different spatial frequency or correlation length. Because the surface is regarded as random function, every surface profile represent as a set of surfaces. Fig.1(a) shows a surface of GPP with long correlation length, and the intensity envelope of the focal spot has obvious fluctuations as shown in Fig.1(b). The surface with short correlation length is shown in Fig.2(a), and the focal spot envelope is more stable as shown in Fig.2(b). Up to now, this phenomenon is not well explained theoretically.

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