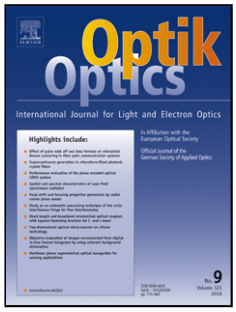

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Numerical aperture influences on image speckle fields near a random surface

Xiaoyi Chen[a,b,*], Chuanfu Cheng[b,*], Zhenyu Rong[a], Yujing Han[a], Li Zhang[a]

[a]*School of Physics and Technology, University of Jinan, Jinan,250022, China*
[b]*College of Physics and Electronics, Shandong Normal University, Jinan, 250014,China*

*Corresponding author E-mail address: ss_chenxy@ujn.edu.cn(X. Chen)
*Corresponding author E-mail address: chengchuanfu@sdnu.edu.cn(C.Cheng)

Abstract: In order to reveal influences of numerical aperture on image speckle fields near a random surface, we adopt a convenient and practical method to make it. We choose an interference pattern of a reference light and an image speckle field, and then obtain its first-order frequency spectrum by Fourier transform. In inverse Fourier transform, we change the range of the frequency spectrum, and different distributions of speckle intensities, phase and phase vortices are presented. In addition, their statistical properties are also given. It is shown that with a decrease of range of the first-order frequency spectrum, equivalent to numerical aperture reduced, image speckle fields take on different features. Moreover, their statistical properties are distinct from each other. This paper is significant to understand influences caused by numerical aperture on image speckle fields and helpful for applications of speckle fields near a random surface.

Keywords: image speckle field; numerical aperture influence; frequency spectrum

1. Introduction

When a beam of laser light is transmitted or reflected by a rough surface, random intensity distributions named speckles are generated[1].Speckle fields near a surface have attracted great interest[2-9] since the seminal work of M. Giglio [10-11].Information of scattering surfaces has been successfully extracted [12-15] based on speckles located in this region. In these researches, microscopic imaging system is usually used to observe speckle fields. As we all know, distribution characteristics and statistical properties of an image speckle field depend on many factors, such as temporal coherence and spatial coherence of light source, surface properties, parameters of viewing systems, and so on. Numerical aperture of microscopic imaging system is a key factor among them. Undoubtedly, extracted information based on speckle intensity will be influenced by numerical aperture of imaging systems. All sorts of methods [16-18] have been used to decrease numerical aperture influences. In our previous study on speckles [7-8], we adopted Mach–Zehnder interference system to obtain interference patterns of speckle fields and reference light, and recorded the patterns with CCD. Based on Fourier-transform method [19], we extracted intensities, real parts, imaginary parts, and phase of these speckle fields. In the experiment system, microscopic imaging system was designed to observe speckle fields. In the following, we explore the dependences of an image speckle field on numerical aperture of the microscopic imaging system.