Evolution of the optical vortex density in phase corrected speckle fields

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Abstract

We numerically investigate the evolution of the optical vortex density in a speckle field after its continuous phase is removed, in other words, after it has been phase corrected. We found that it initially drops to 70% and then increases to 88% of the initial density. The rate of decrease is an order of magnitude faster than the rate of increase.

1 Introduction

In an attempt to understand the process whereby the phase modulation due to atmospheric turbulence causes phase singularities (also called optical vortices), we investigated the effect of phase perturbations in speckle beams. We perturb the phase by removing the continuous part of the phase from a speckle field. While optical vortices [1] are annihilated and created at equal rates in a speckle field [2], these rates vary in different way as a result of the phase perturbations. This allows one to determine the characteristic scales associated with these processes. Here we report the initial results and show how one can represent the evolution of the vortex density in the paraxial limit.

2 Results

The evolution of the optical vortex density for a phase corrected speckle field in the paraxial limit is shown in Fig. 1. The phase removal is performed at a plane represented by $z = 0$. Immediately after the phase removal the vortex density starts to drop, reaching a level of about 70% of the initial vortex density. It then rises again at a much slower rate to reach an equilibrium level of about 88% of the initial density. The rate of decrease is at least an order of magnitude faster than the rate of increase.

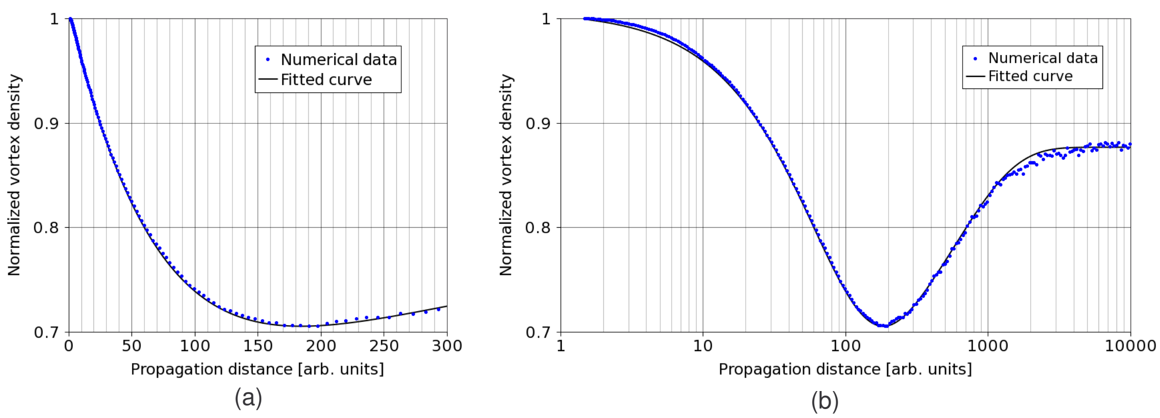

Figure 1: Normalized optical vortex density for a phase corrected speckle field, shown as a function of linear propagation distance (a), as well as logarithmic propagation distance (b) to see where the equilibrium value is reached.

The numerical data has been fitted by the function,

$$V(z) = A_0 + A_1 \exp(-K_0 z^2 - k_1 z) - A_2 \exp(-k_2 z),$$

where $A_0 = 0.877 \pm 0.003$, $A_1 = 0.386 \pm 0.004$, $A_2 = 0.256 \pm 0.006$, $K_0 = (0.50 \pm 0.07)\lambda^2/L_c^4$, $k_1 = (2.43 \pm 0.04)\lambda/L_c^2$ and $k_2 = (0.291 \pm 0.007)\lambda/L_c^2$, with λ being the wavelength and L_c being the coherence length of the phase corrected speckle field.

References

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