Affects of binary and continuous phase modulations on the structure of Bessel beams

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Abstract: We implement a novel technique to operate a phase-only spatial light modulator (SLM) in amplitude mode, allowing us to reproduce Durnin's ring slit on a liquid crystal display (LCD). The affects of binary and continuous phase modulations on the structure of a zero-order Bessel beam is investigated.

1. Introduction

By addressing alternating sets of pixels on the LCD of the SLM with phase values that are out of phase by π, we are able to distribute the light reflected from the SLM off of its propagation axis. Therefore, the amplitude of the beam along the propagation axis disappears. By appropriately adjusting the ratio between the two phase values of the alternating sets of pixels, we can control the amplitude which is transmitted along the propagation axis. This allows us to operate the SLM in both phase and amplitude mode, permitting us to reproduce Durnin's ring slit[1] on the LCD of the SLM.

It is well-known that illuminating a ring-slit aperture with a plane wave produces a zero-order Bessel beam[1]. However, with the dynamic addressing of SLMs, we are able to introduce random phase modulations within the ring slit. We investigate the affect on the resulting zero-order Bessel beam when the random phase modulation is either binary or continuous. The influence of different random distributions, used to describe the phase modulation, on the zero-order Bessel beam are also investigated.

2. Results

Experimental results illustrating the change in the zero-order Bessel beam, when a continuous or a binary phase modulation is introduced into the ring slit, are depicted in Fig. 1 and 2, respectively.

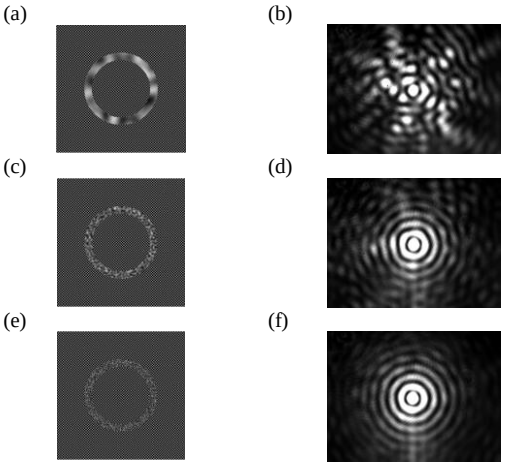

Fig. 1. Column 1: Image of the ring slit, containing a continuous random phase modulation for an increasing correlation radius ((a) 10, (c) 50, (e) 100), applied to the LCD. Column 2: The corresponding field produced by a Gaussian beam illuminating the LCD which is addressed with the image given in column 1.

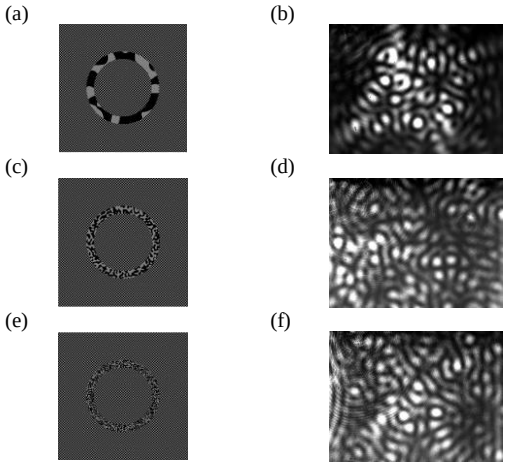

Fig. 2. Column 1: Image of the ring slit, containing a binary random phase modulation for an increasing correlation radius ((a) 10, (c) 50, (e) 100), applied to the LCD. Column 2: The corresponding field produced by a Gaussian beam illuminating the LCD which is addressed with the image given in column 1.

It is evident that in the case of the continuous phase modulation the zero order Bessel beam starts to reconstruct as the phase modulation (or correlation radius) increases. However, in the case of the binary phase modulation, the field remains as a random speckle field and no reconstruction is observed. Comparisons between Durnin's ring slit experiment and our approach are compared, illustrating very good agreement (results not shown).

3. References

[1] J. Durnin, J.J. Miceli and J.H. Eberly, "Diffraction-free beams," Phys. Rev. Lett. **58**, 1499-1501 (1987).