

ABSTRACT

Using the digital laser one can generate various types of modes, like, Laguerre-Gaussian modes. The digital laser was forced to generate high-order radial Laguerre-Gaussian modes, LG_p , with zero azimuthal order, by loading a digital hologram on the spatial light modulator. Digital holograms contain p absorption rings that matches the zeros of Laguerre polynomial. The purity modes were demonstrated and it was shown that the mode volume is directly proportional to the mode order p. In this work we demonstrated that we can generate radial Laguerre-Gaussian modes up to radial order 3.

INTRODUCTION

Since high power solid-state lasers are the most developing branches of laser science and they have become an increasingly important tool for modern technology [1]. A new design of these lasers in the form of a digital laser was recently discovered [2]. However, the digital laser is limited in the output power, which leads to lower power efficiency compared to standard solid state lasers. Nevertheless, the digital laser is found to be a stable intra-cavity beam shaping tool, without the use of any optical elements inside the cavity [2].

On this poster we report on generating high-order radial Laguerre-Gaussian modes up to radial order 3, by selectively encoding digital holograms on a phase-only spatial light modulator (SLM) that acts as an end mirror.

BACKGROUND AND CONCEPT

Radial Laguerre-Gaussian modes, where p is the radial order and with no azimuthal order, is the solution to the wave equation in circular symmetry geometries. The electric field of these modes can be mathematically represented by the following equation:

$$u_{p,0} = \sqrt{\frac{2}{\pi}} \times \frac{1}{w} \times L_p^0 \left(\frac{2r^2}{w^2}\right) \times e^{\frac{-r^2}{w^2} - \frac{ikr^2}{2R(z)}} \times e^{-i(2p+1)atan(\frac{z}{z_R})}$$

where r is the radial coordinates, and L_p^0 is the Laguerre polynomial. All other parameters have their usual meaning [3].

To generate LG_p beams we impose the position of the p zeros (Fig 1) of intensity using a digital hologram that is encoded on the SLM.

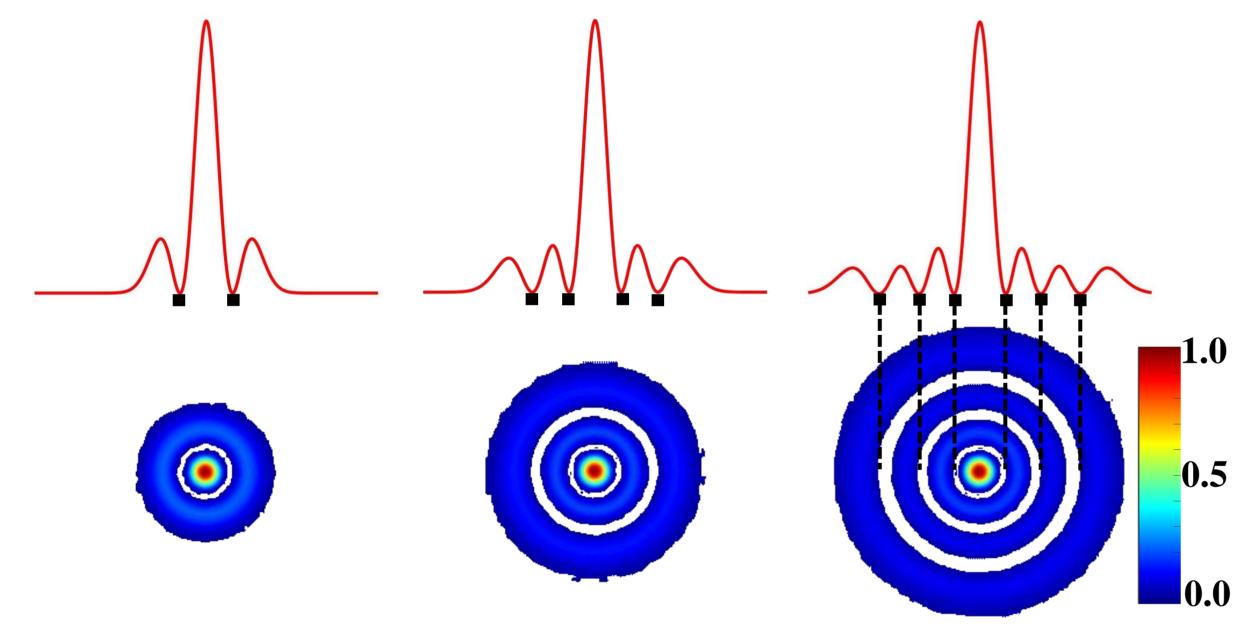
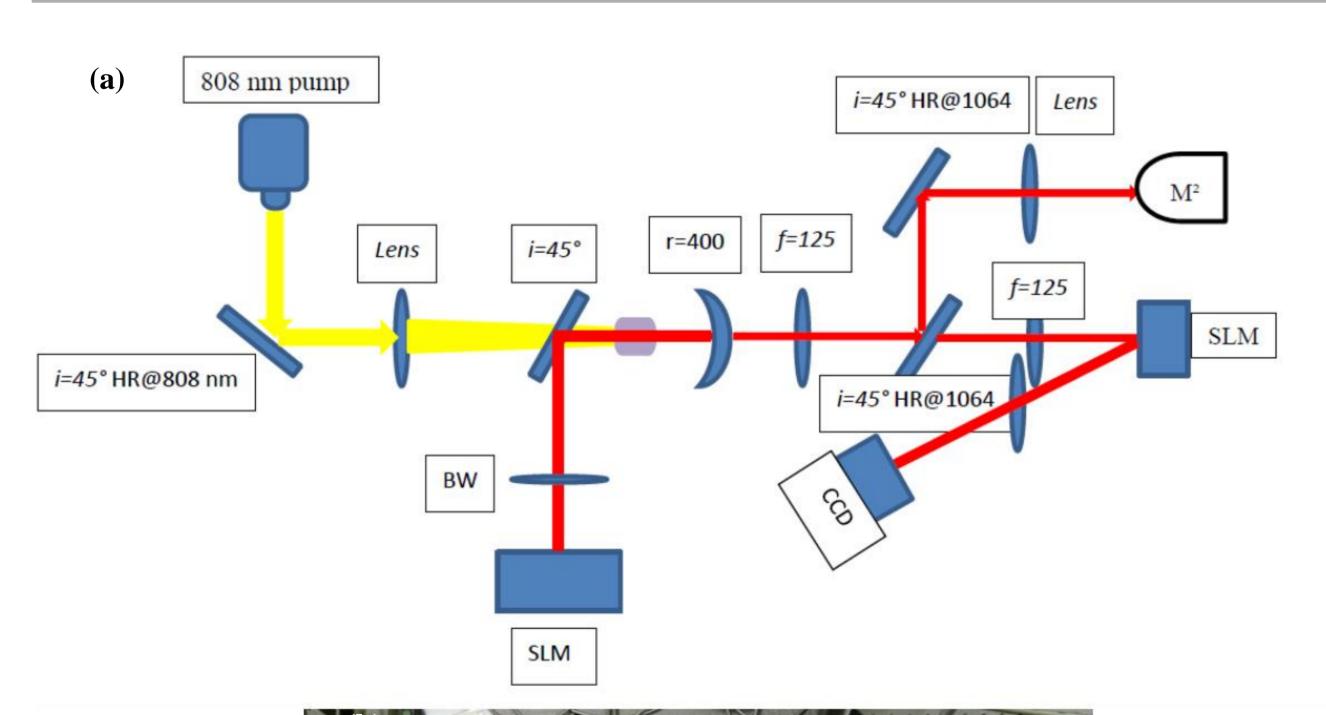


Figure 1: Intensities and cross-sections, when a digital hologram with p rings is encoded to the SLM, for p=1 to 3



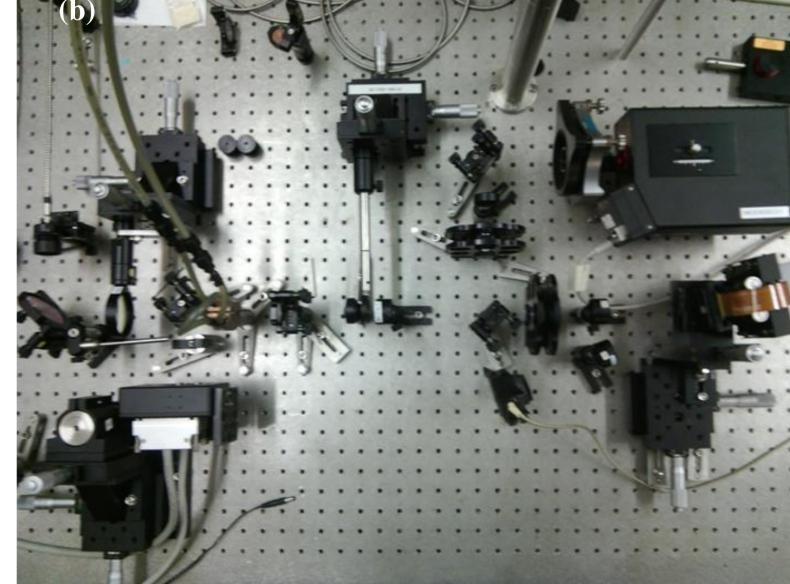


Figure 2: (a)Schematic of a diode Pumped Digital Laser, with the output beam 1:1 imaged using two lenses of 125 mm focal length to the Meadowlark optics spatial light modulator (used for modal decomposition), and ModeScan Model 1780 used for beam profiling. (b) Photograph of the experimental setup.

Generating higher-order radial Laguerre-Gaussian modes using a digital laser.

T. Bell^{1,2*}, S. Ngcobo¹, S. Haddadi³, K. Ait-Ameur³, & A.Forbes².

¹CSIR-NLC, PO Box 395, Pretoria, 0001, RSA. ²UKZN, Westville Private Bag X 54001, Durban 4000, RSA. ³Centre de Développement des Techniques Avancées, P.O. Box 17 Baba Hassan, Algiers.

*Email: tbell@csir.co.za

RESULTS

Since the planoconcave resonator is stable, the propagation factors were numerically analysed, and then compared to experimental factors. The results are illustrated by Figure 3(a) and Figure 4(a).

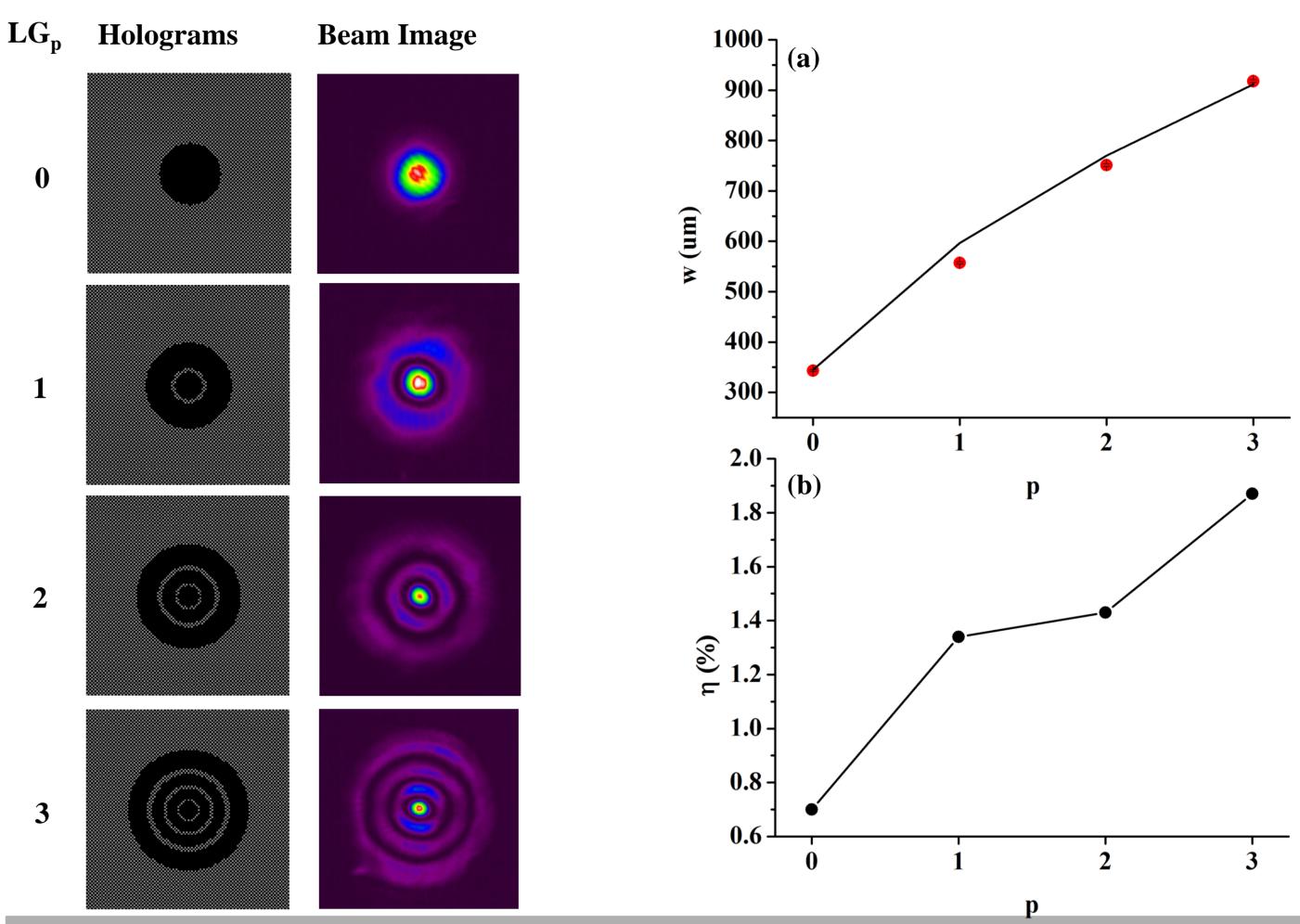


Figure 3: Observed Intensity profile and cross-section, for p=0-3, at the output coupler. (a) Beam width at the output coupler as a function of mode order, with theoretical $(w_p=w_0\sqrt{2p+1})$ results represented by a solid line. (b) Slope efficiency as a function of mode order.

The propagation factor, M², is on of the important characterization of the beams. Figure 4 (a), clearly shows that LGp beams generated are propagating as expected, and Modal decomposition was conducted to test the purity.

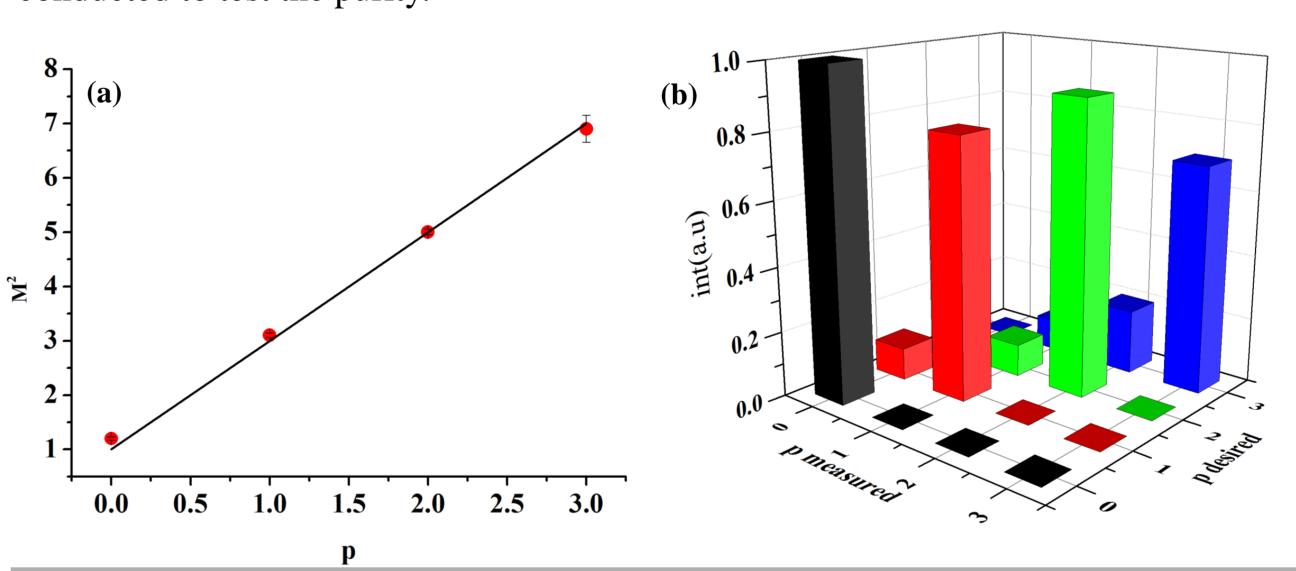


Figure 4: (a) Beam Propagation factor as a function of mode order. (b) Modal decomposition results for p=0 to 3. These results show high purity, but the purity is degrading slightly as the mode order increases.

Mode purity for 0≤p≤2 is over 90 %, dropping to 75% for p=3, one of the factors that contribute to this drop is the pump beam size overlapping with

0.160.140.120.100.080.060.04
Higher order compared to increase in measurement of the compared to

─LG₀

24 26

Pump Power (W)

Figure 5: Power extraction for p =0 and p=3, as the diode pump is pumped higher.

16 18 20

0.02

this drop is the pump beam size overlapping with higher order modes.

Higher order modes extract more power

Higher order modes extract more power compared to mode order p=0, this is due to an increase in mode volume. At the pump power of above 18.2 W, the power extracted from mode of order p=3 exceeds that of p=0, despite its higher losses. Extra gain compensate for extra loss in higher order.

CONCLUSION

We have shown that it is possible to selectively excite high purity, higher-order radial Laguerre-Gaussian modes using a digital laser, encoded with amplitude digital hologram. Our results show that one can digitally control higher order modes, by selectively exciting the modes, it is recommended to excite higher order mode due to higher power extraction.

ACKNOWLEDGEMENT

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