Generation of Laguerre-Gaussian Beams Using a Diode Pumped Solid-State Digital Laser

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Electrical field of Laguerre-Gaussian beams

$$U_{p,l} = \sqrt{\frac{2p!}{\pi(p+l)!}} \times \frac{1}{w}\left(\frac{\sqrt{2}r}{w}\right)^{l} \times L_p^l\left(\frac{2r^2}{w^2}\right)$$

$$\times e^{\frac{-r^2}{w^2} - \frac{ikr^2}{2R(z)}} \times e^{-i(2p+l+1)} \times arctan\left(\frac{z}{z_R}\right) \times e^{-il\phi}$$

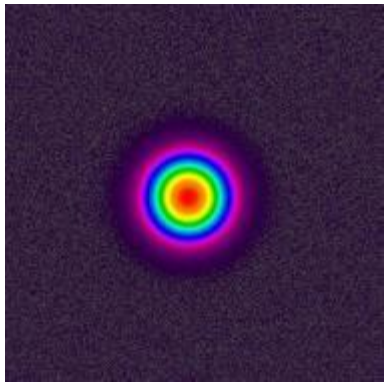
p and l are radial and azimuthal indices, respectively,

w is the beam radius,

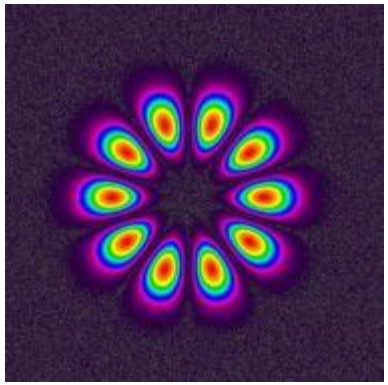
L_p^l is the Laguerre polynomial of order p & l.

All other parameters are defined from Gaussian mode.

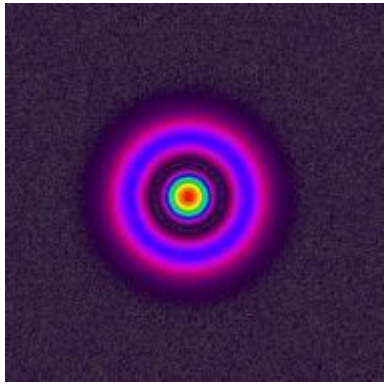
Simulated intensity profiles



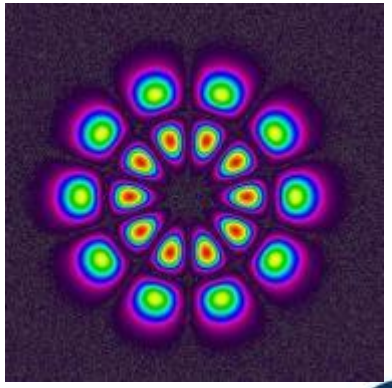
p=0, l=0



p=0, l=5

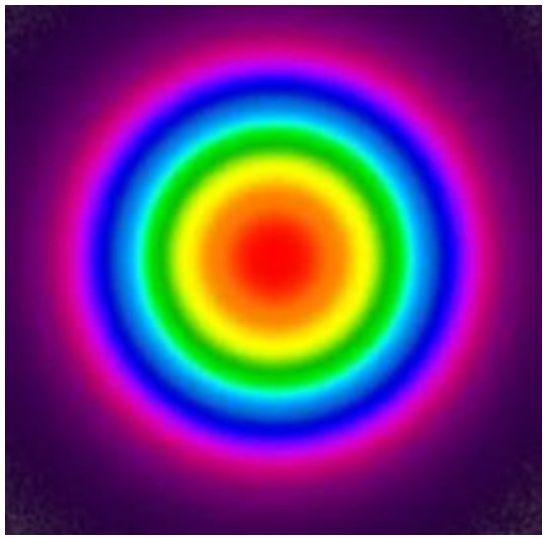


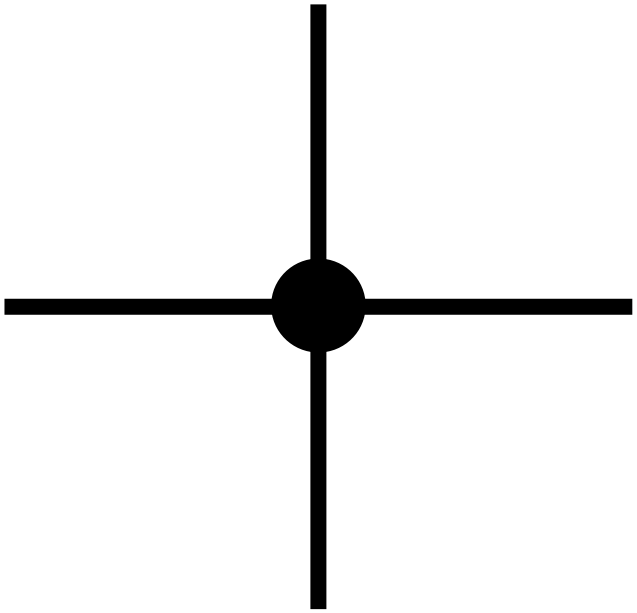
p=1, l=0

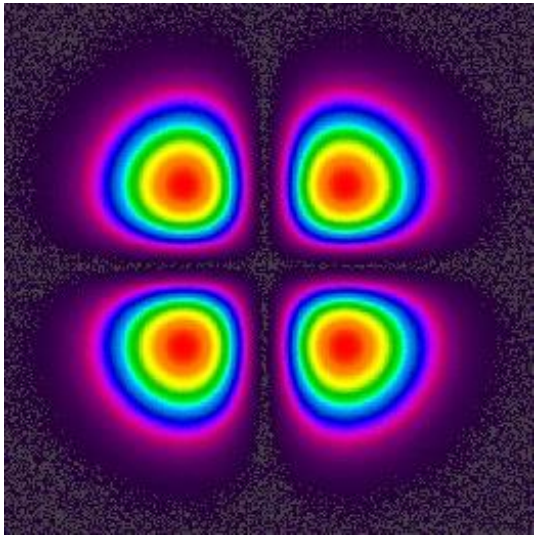


p=1, l=5

Concept of generating LG_{0l} beams



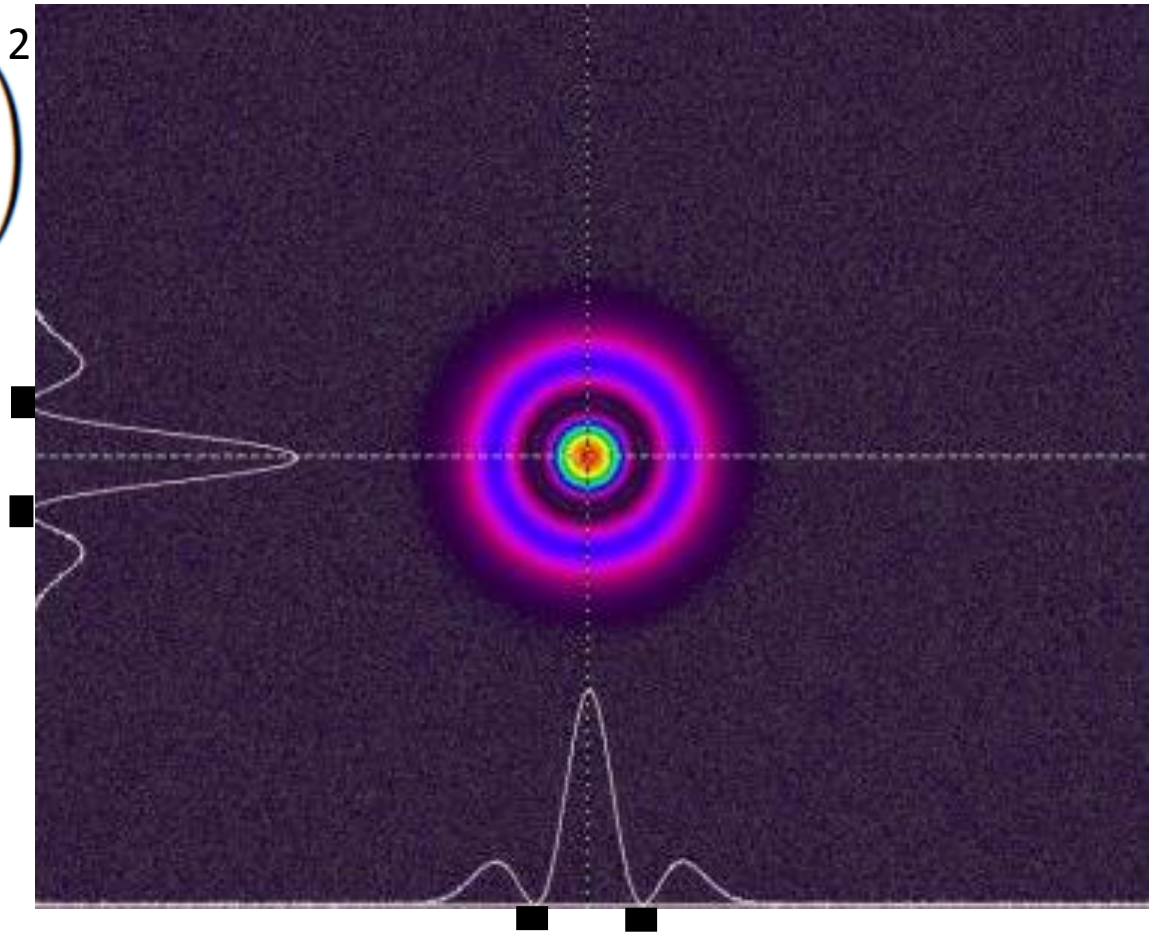




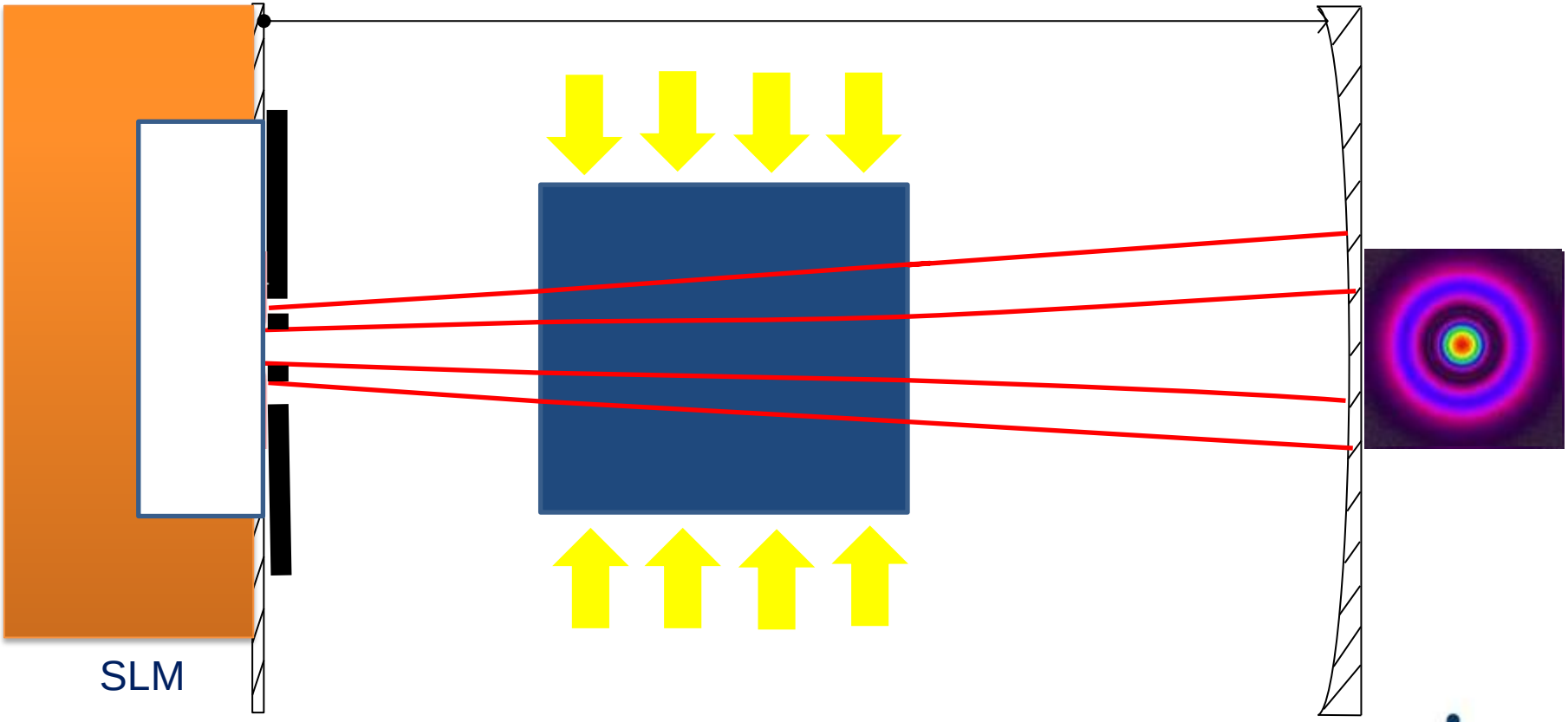
$e^{-il\phi} \times e^{+il\phi}$

Concept of generating LG_{p0}

$$L_p^l\left(\frac{2r^2}{w^2}\right)^2$$

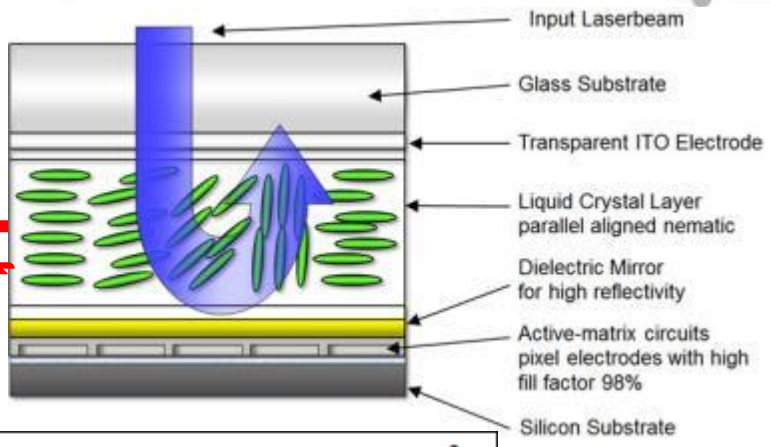


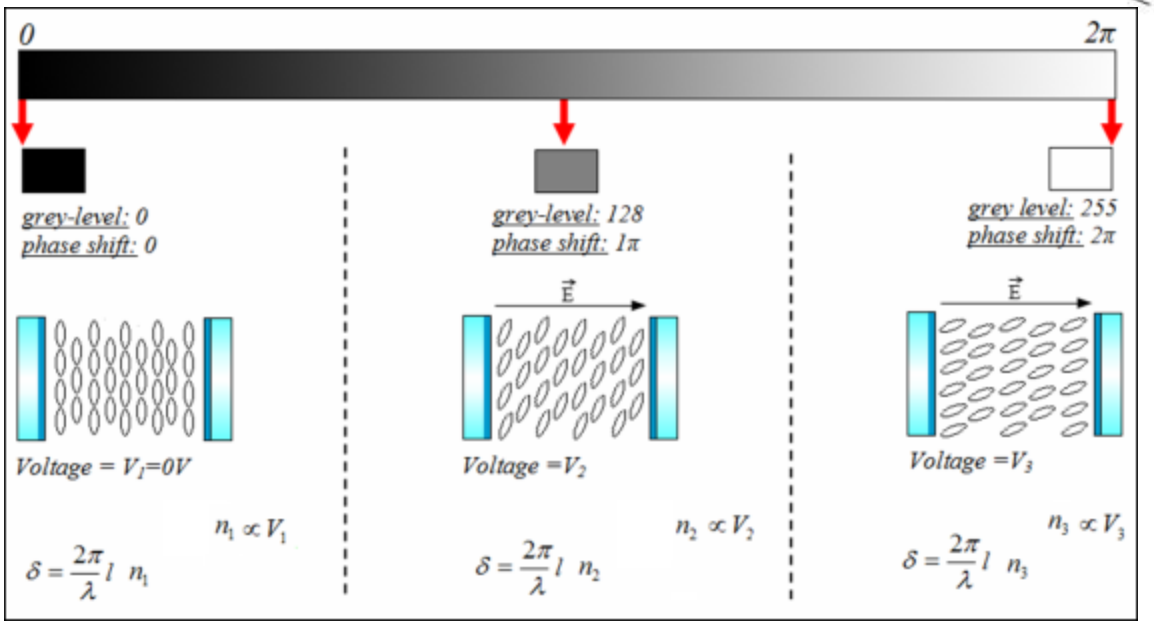
Concept of implementing intracavity amplitude beam shaping to generate LGp beams



Sandile Ngcobo, Kamel Aït-Ameur, Nicolas Passilly, Abdelkrim Hasnaoui, and Andrew Forbes, "Exciting higher-order radial Laguerre–Gaussian modes in a diode-pumped solid-state laser resonator," Appl. Opt. 52, 2093-2101 (2013)

Phase-only spatial light modulator (LCD Screen)





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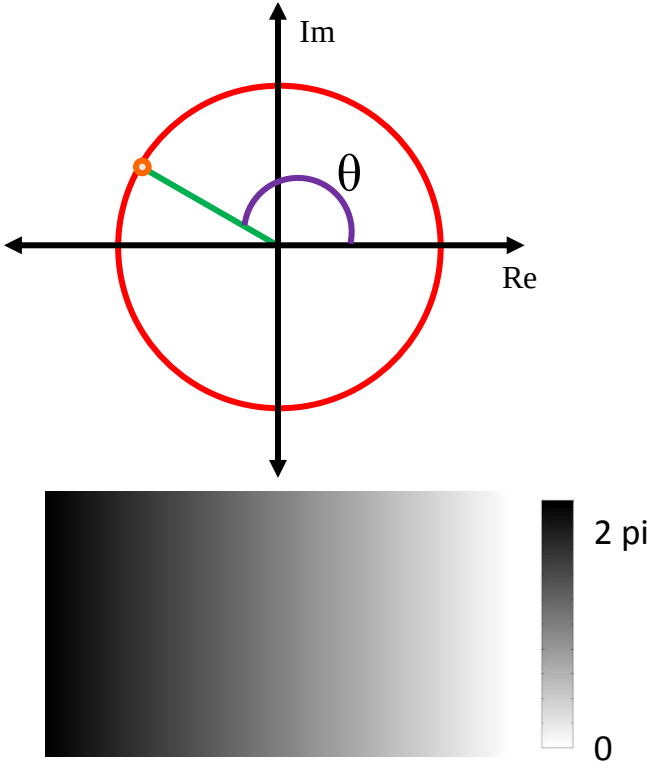
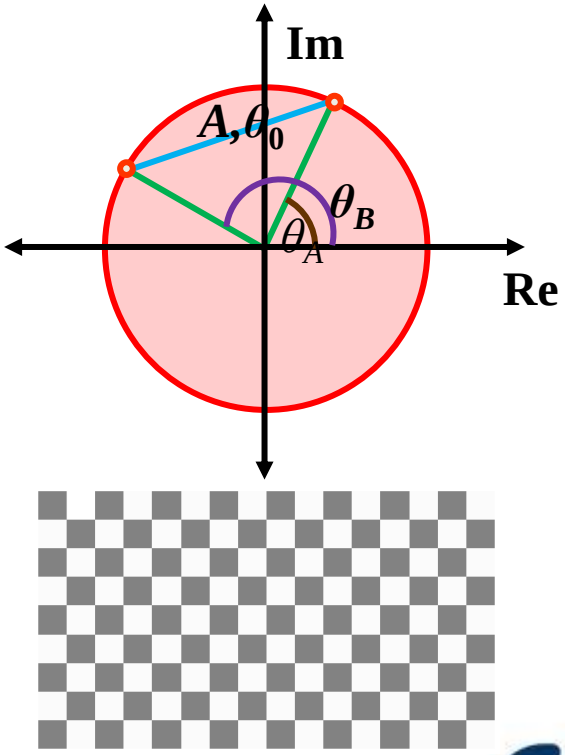
Spatial light modulator

Phase beam shaping:



Amplitude beam shaping:



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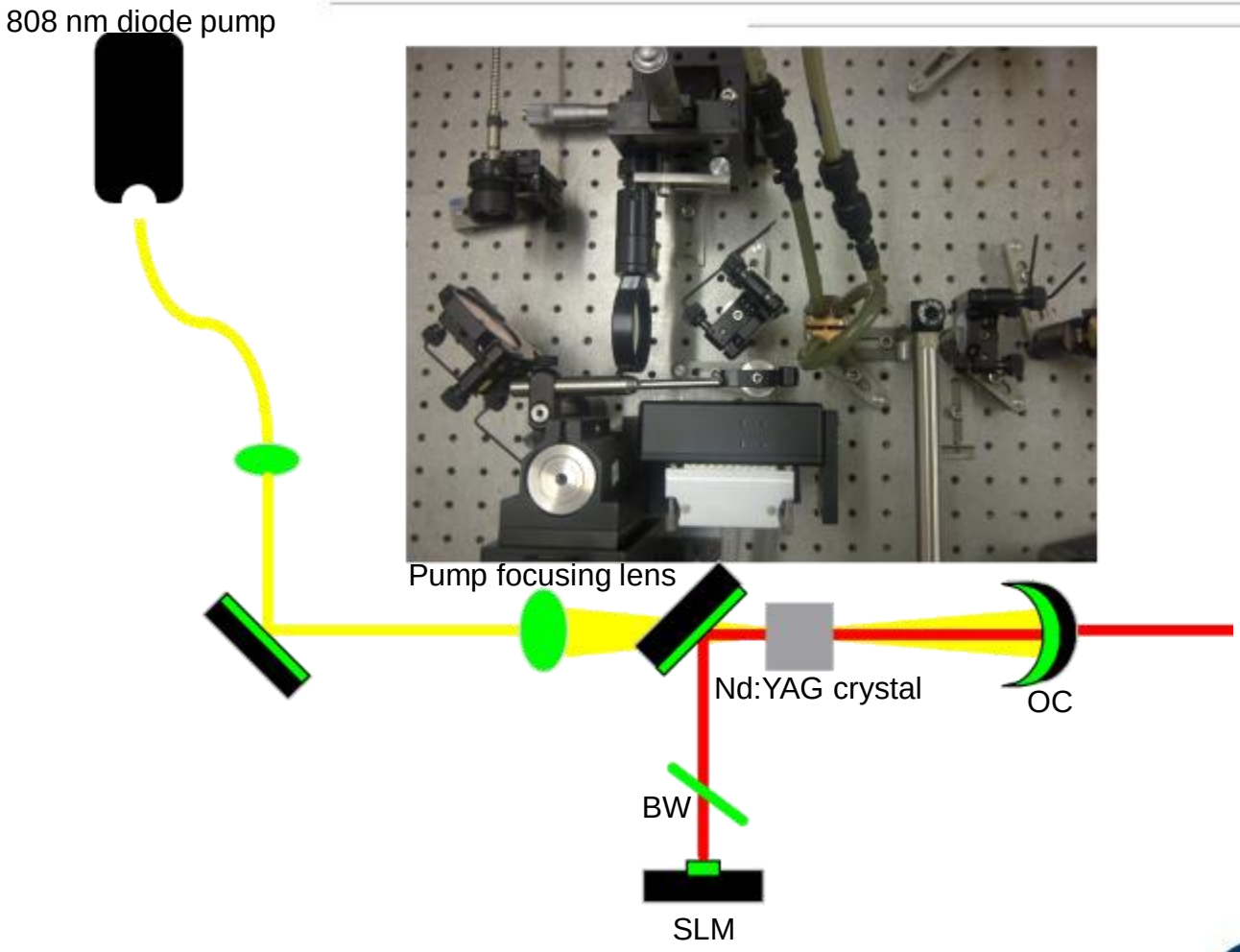
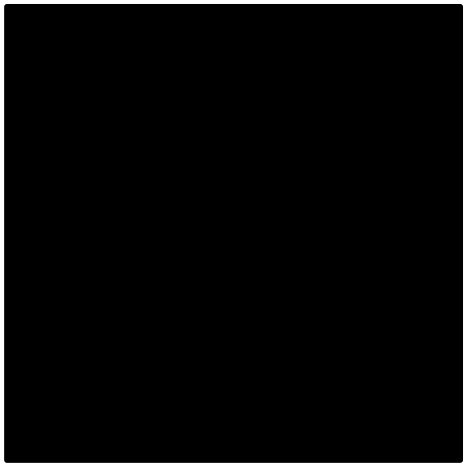
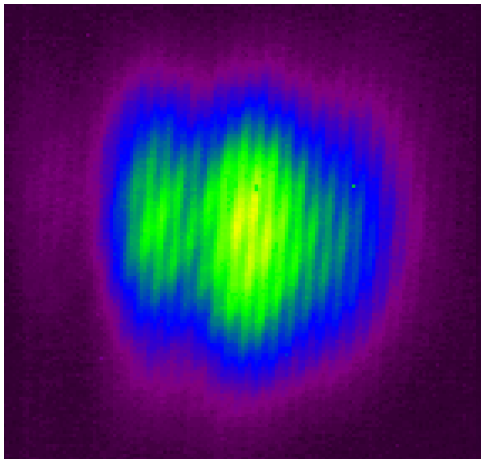
Experimental setup

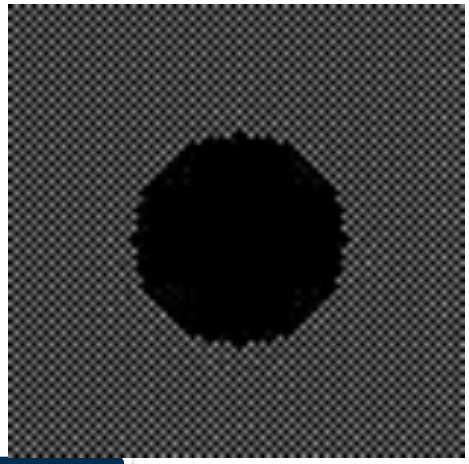


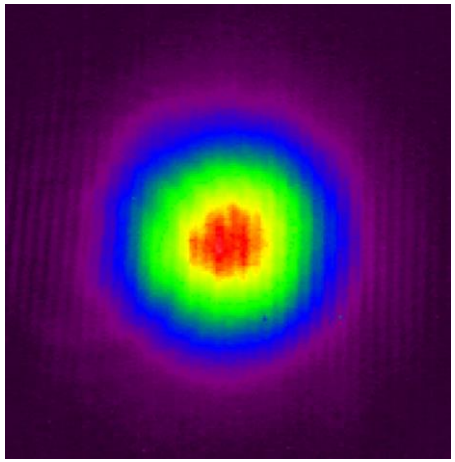
Ngcobo, S., Litvin, I., Burger, L., & Forbes, A. (2013).
A digital laser for on-demand laser modes. *Nature communications*, *4*.

Digital end mirror

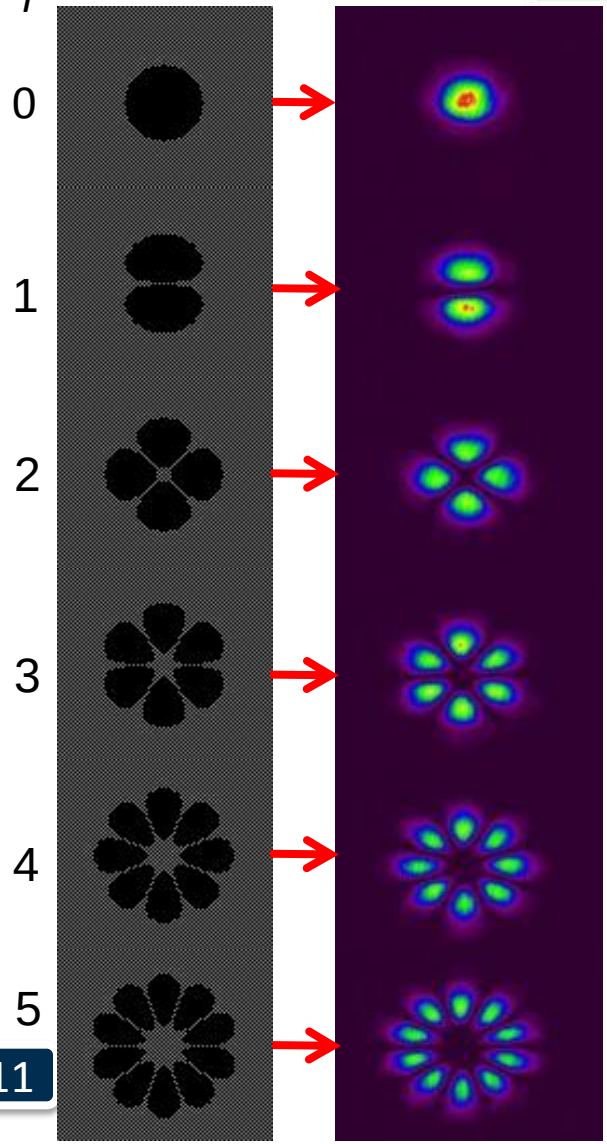


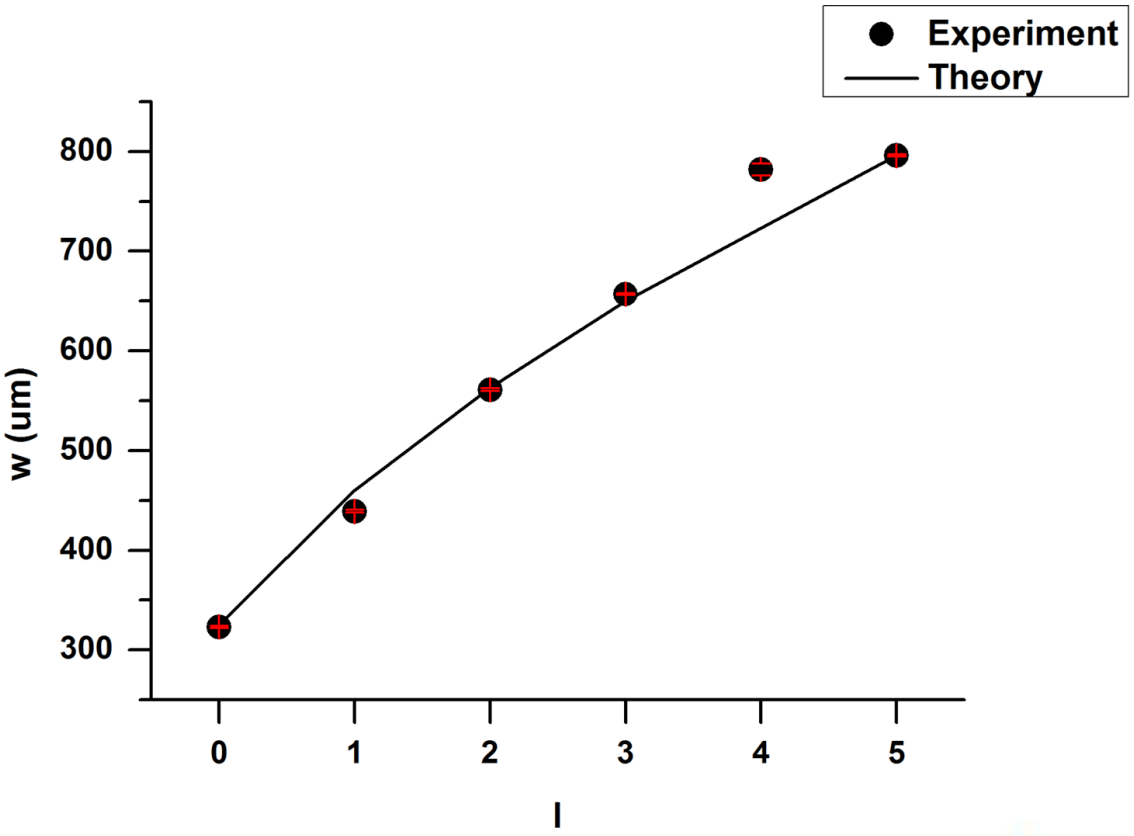






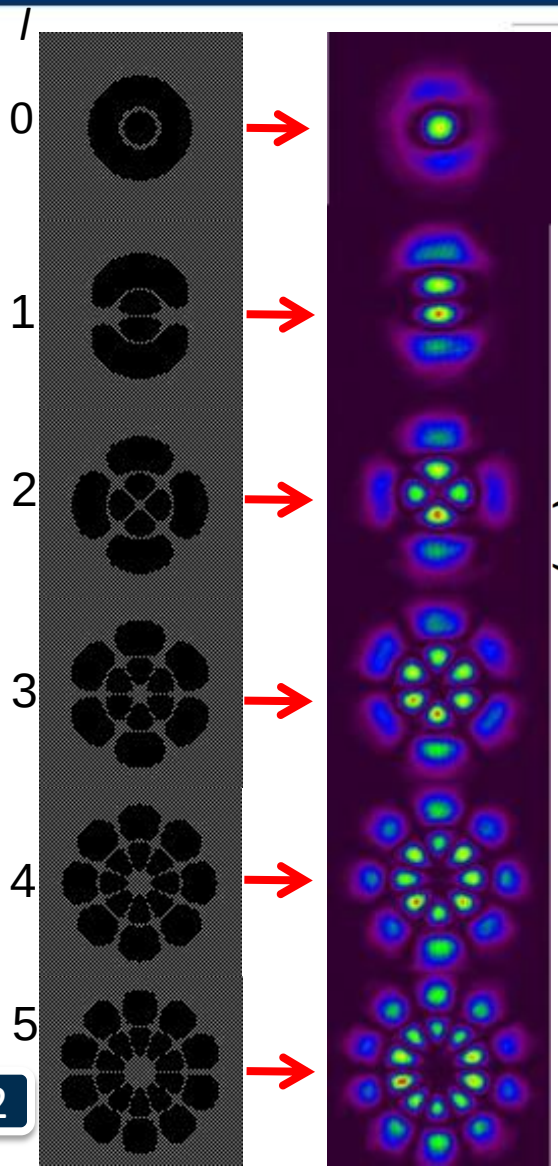
Observed Intensity Profiles with zero radial order

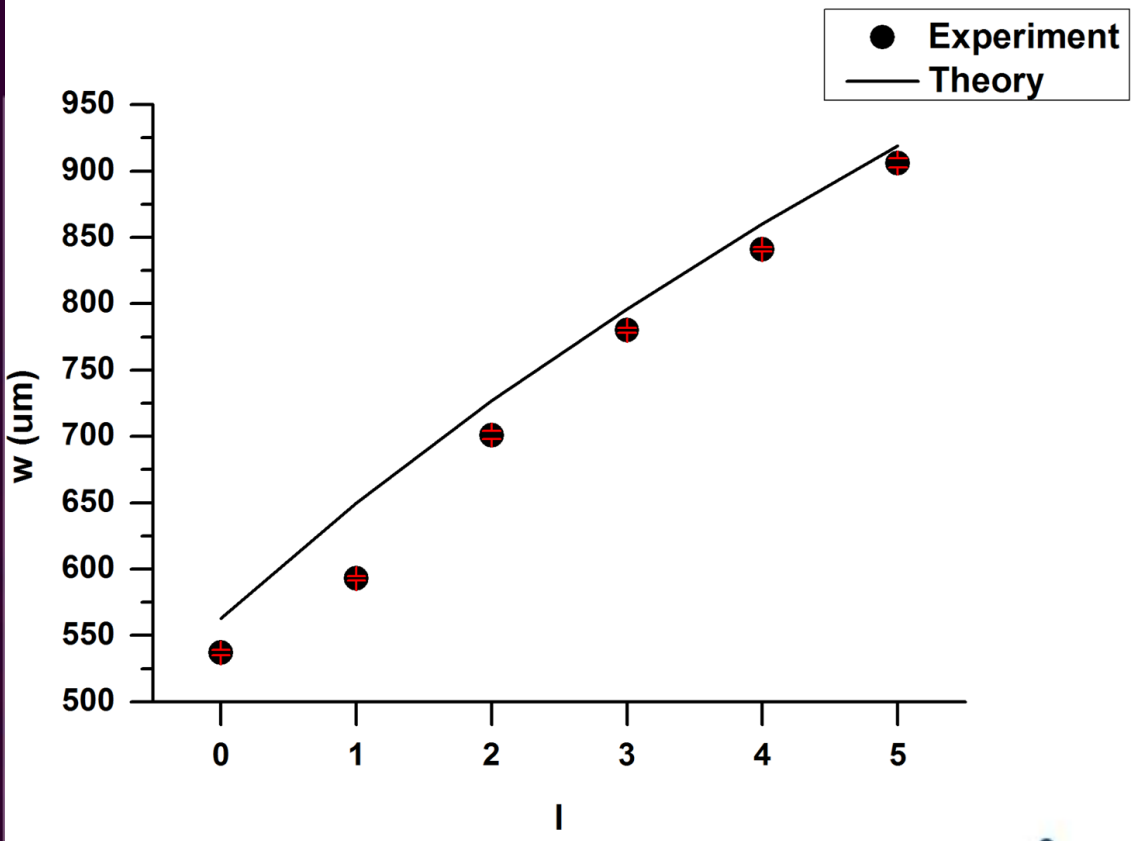




$$w_{pl}=w_0 \times \sqrt{2p+|l|+1}$$

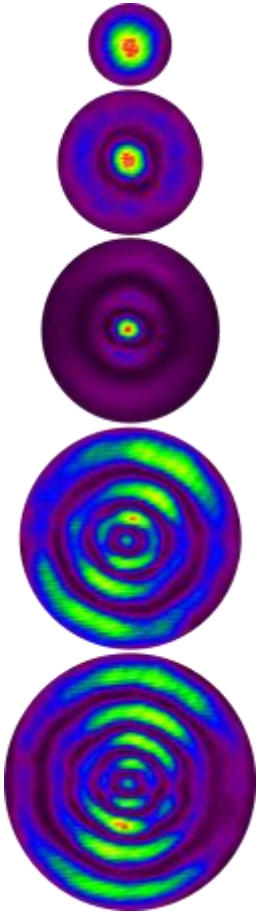
Observed Intensity Profiles with radial order

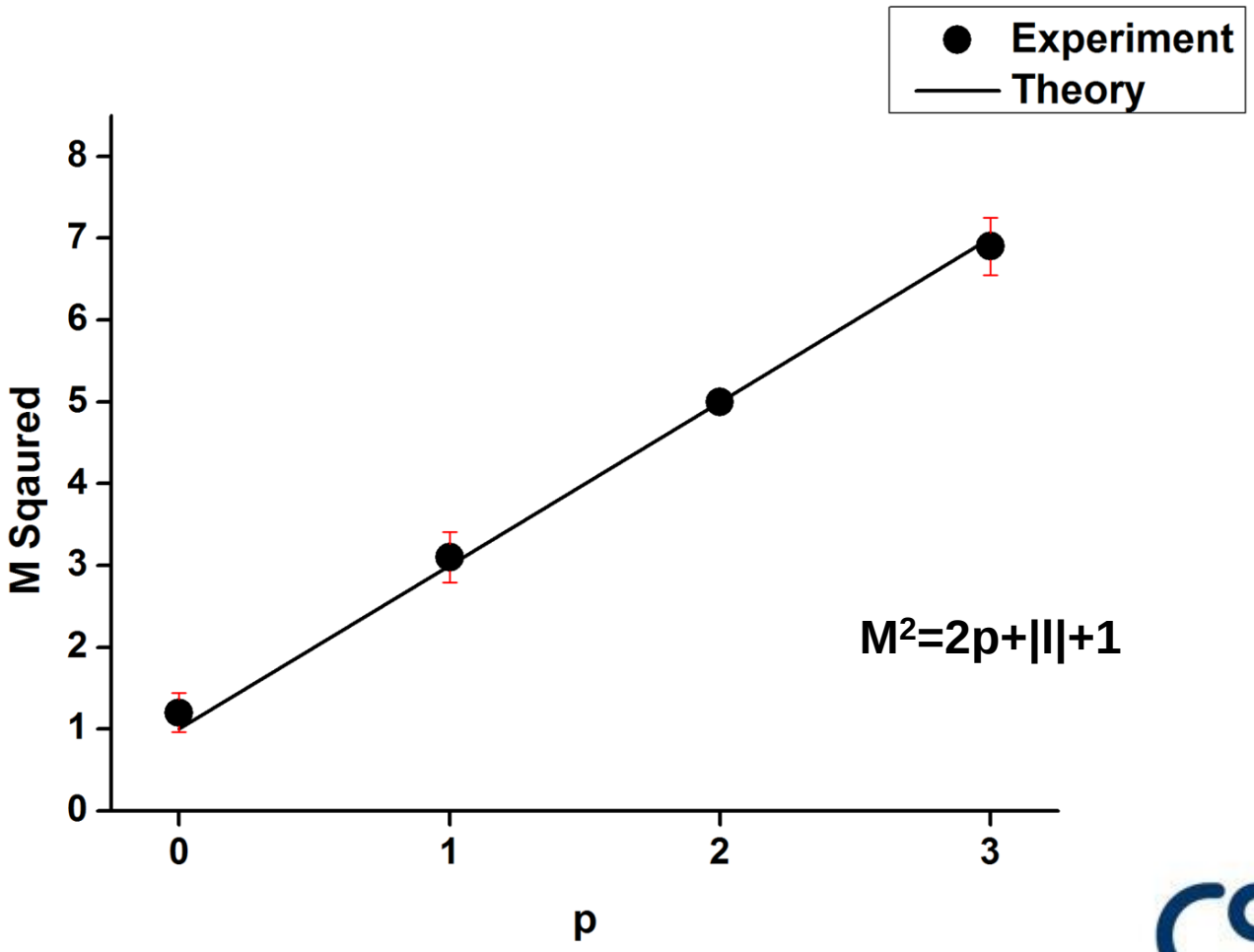




$$w_{pl}=w_0 \times \sqrt{2p + |l| + 1}$$

Quality of The Beams





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Conclusion

- ✓ LG beams of order p=0, with l=0 to 5, and p=1, with l=0 to 5, can be generated using solid-state digital laser.
- ✓ The beam sizes are in good agreement with the theory.
- ✓ Generated beams are of high quality.
- ✓ In future, Modal Decomposition will be conducted to test the purity of the beams,
- ✓ Frequency doubling 532 nm (Green laser) experiment is been conducted currently.

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Thank you!

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