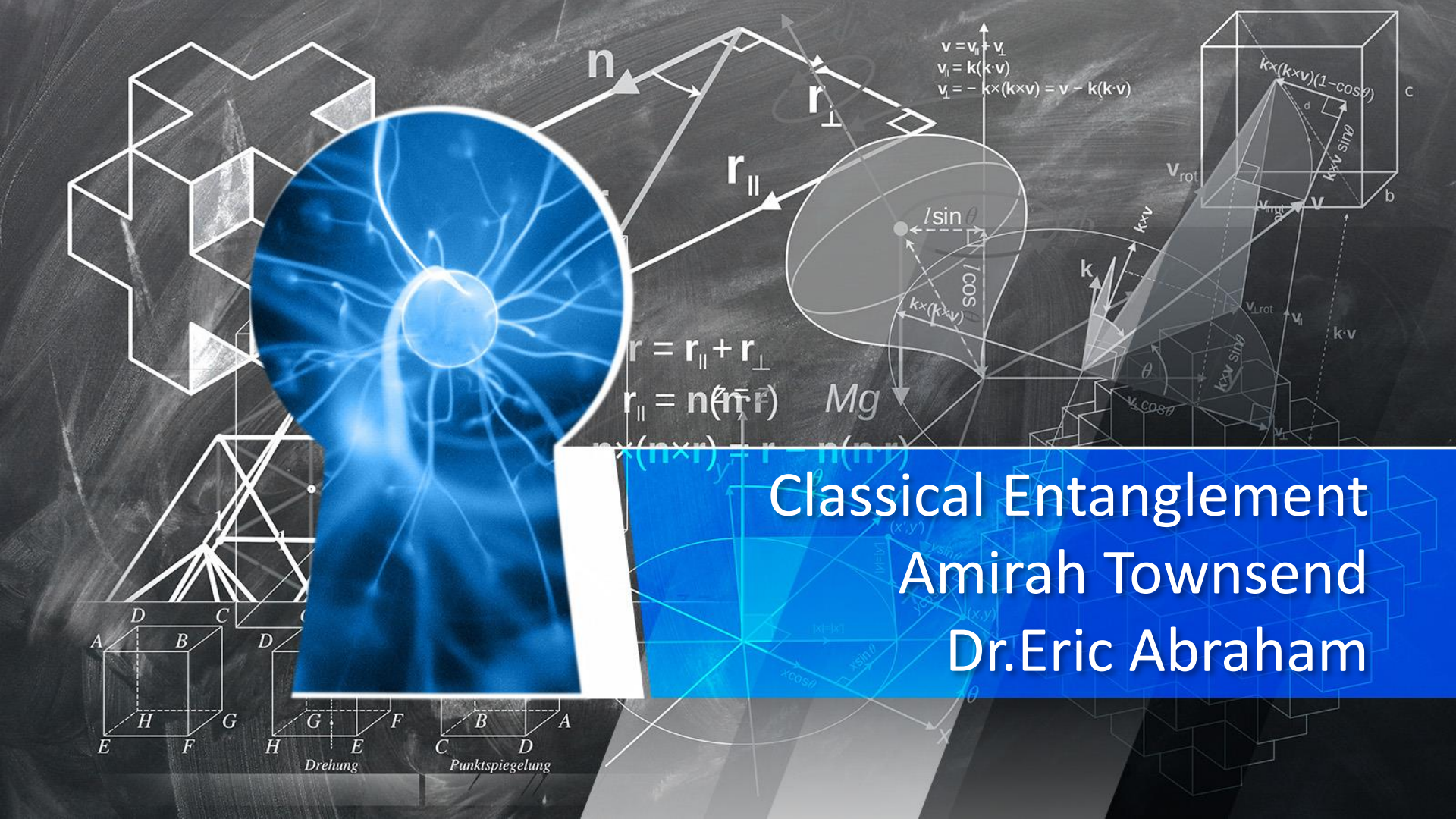
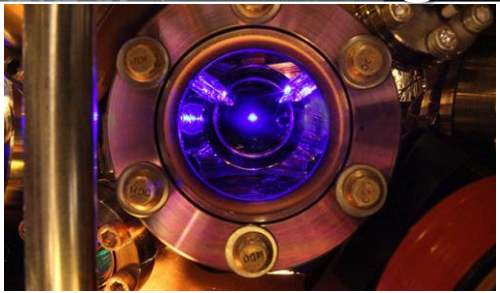
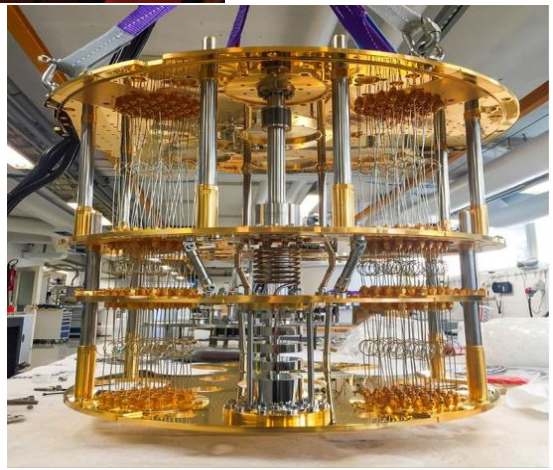

Classical Entanglement
Amirah Townsend
Dr.Eric Abraham

What is Quantum entanglement?

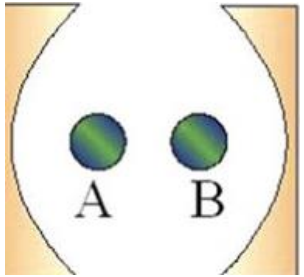
- Take two separate atoms
- They can be either spin up or spin down
  - For the two atoms: one MUST be spin up and the other MUST be spin down
- To entangle them, or combine them each becomes a superposition of up and down





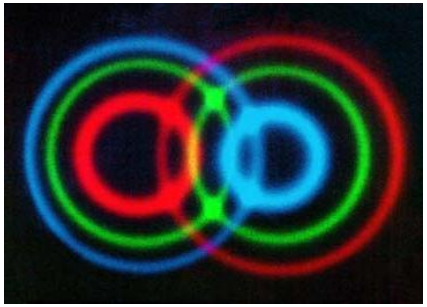
How does this classical experiment play a role?

- Two different light modes

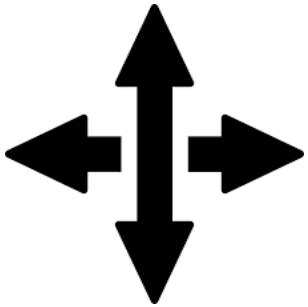


- With either a vertical polarization or a horizontal polarization

- They become entangled and each is a superposition of horizontal or vertical

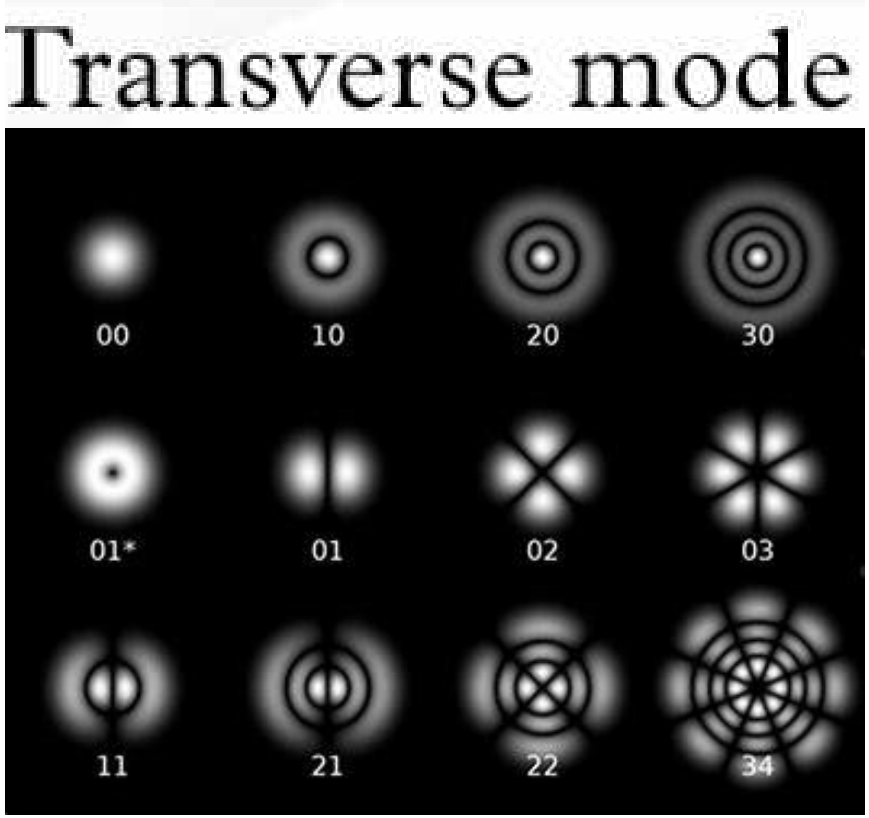


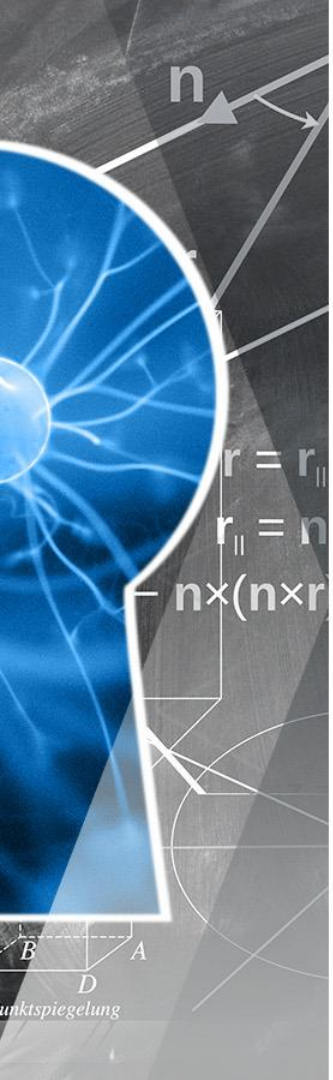
- For the two light modes: one MUST be vertically polarized, and the other MUST be horizontally polarized



Gaussian mode

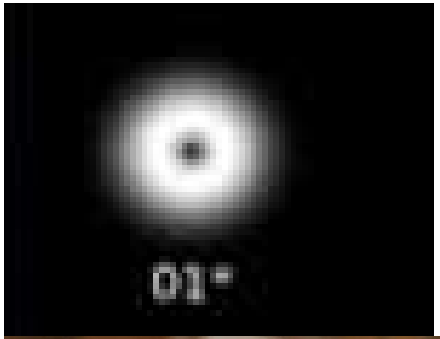
- Beam of electromagnetic radiation whose transverse electric field and intensity distributions are approx. by Hermite-Gaussian functions
- Laser is operating on transverse mode

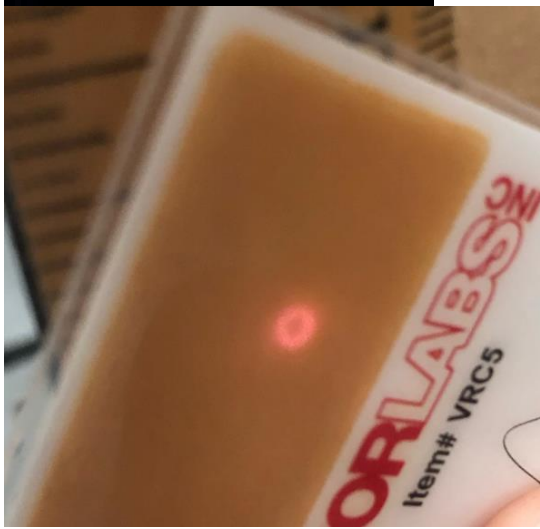


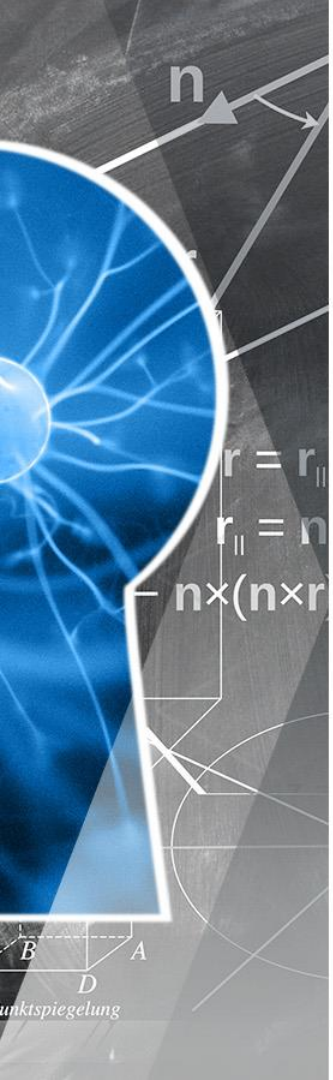


Laguerre-Gaussian laser mode

- Set of propagation modes
- Radial electric field proportional to the product of a Gaussian and Laguerre polynomial

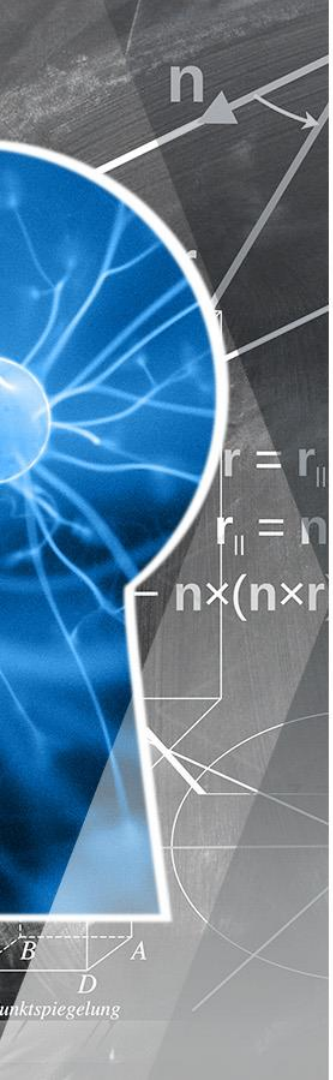






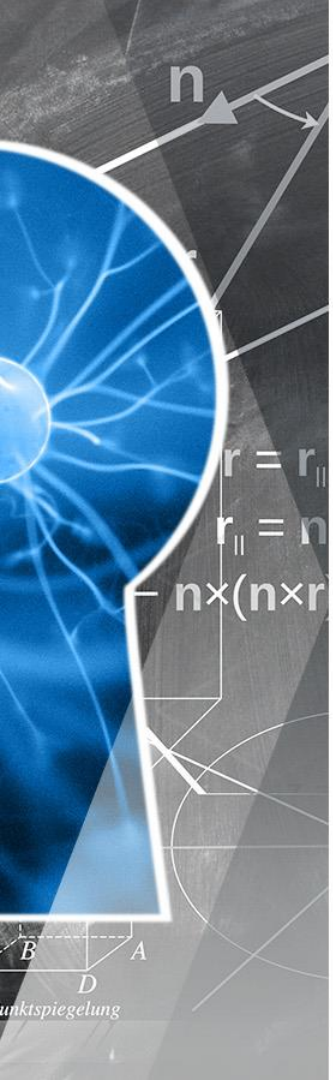
How to create an LG beam

- Fiber optics converts the laser into Gaussian
- Two diffractive optics
- Intensity
- Phase



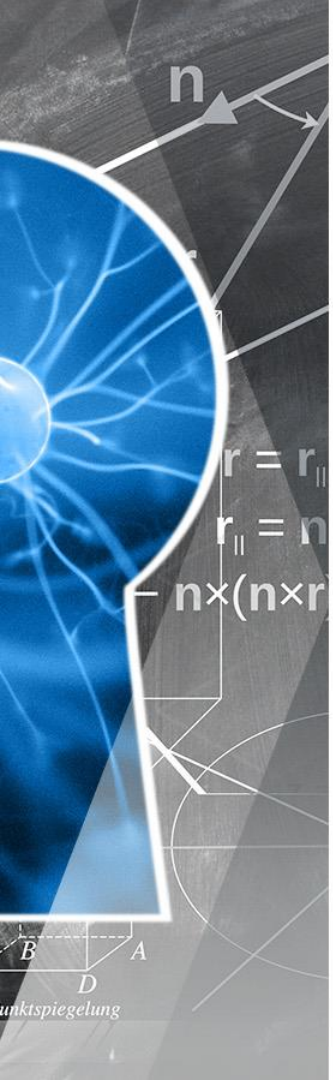
Goals

- Evaluate the quality, how they propagate.
- Compare lasing and non-lasing modes.



Diode Lasers

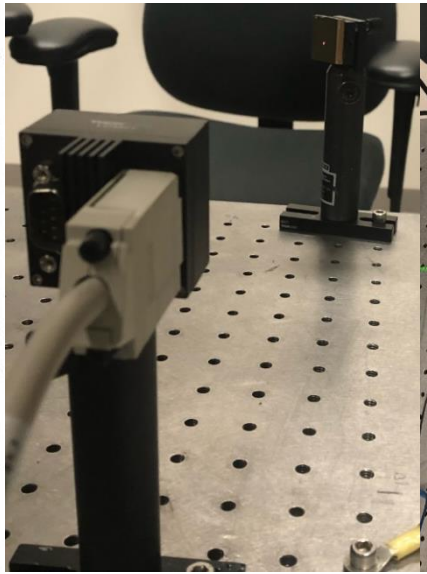
- Semi-conductor laser, current creates population inversion across the band gap and creates lasing.

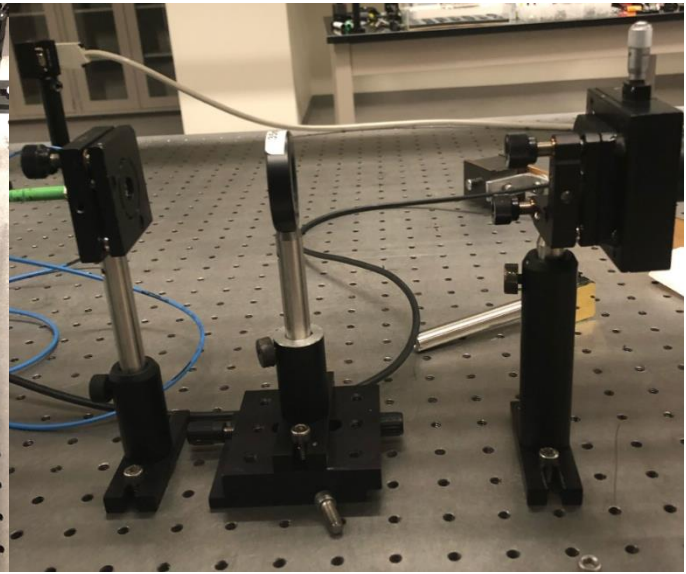


Why compare lasing vs. non-lasing?

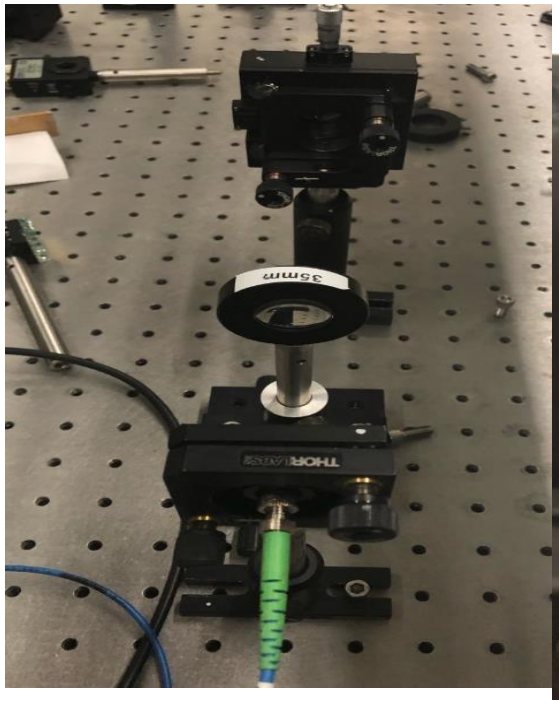
- Non-lasing is necessary for the entanglement
- The frequency distribution of the light is important.
- Optics that create LG beams were designed for *single-frequency* light.

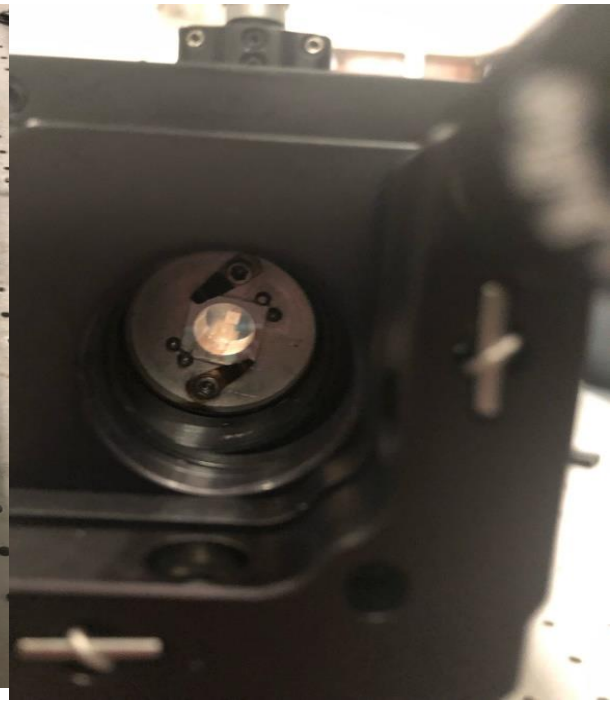
LG Propagation Experiment



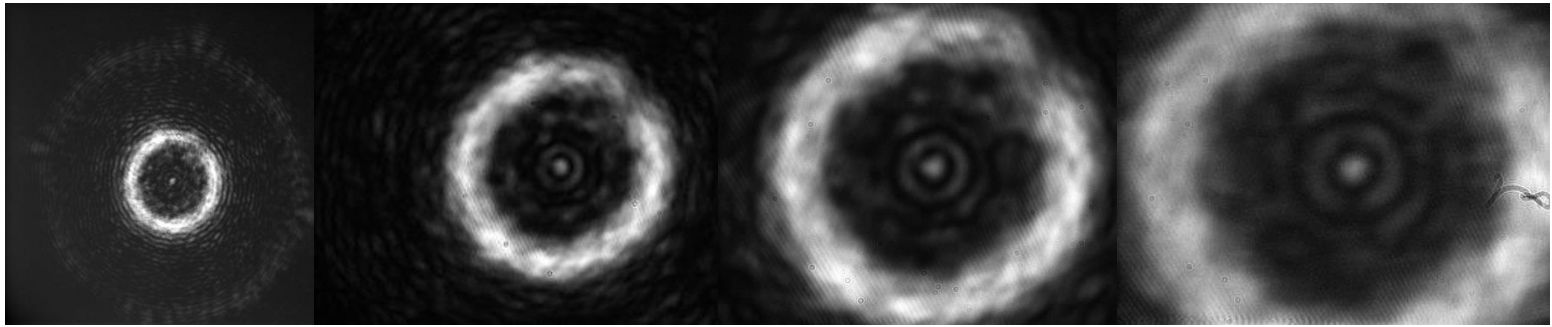


LG Propagation Experiment



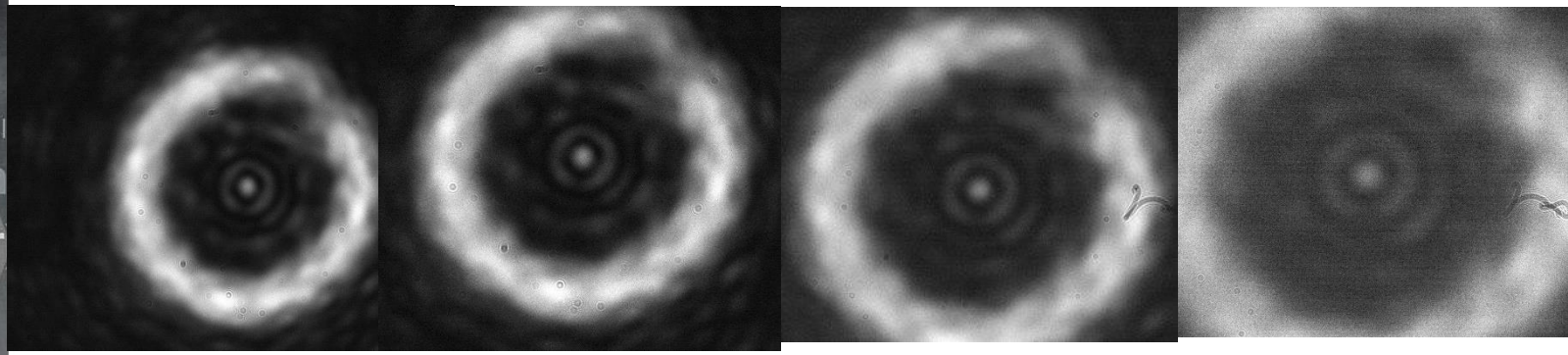


Lasing (LG Propagation)



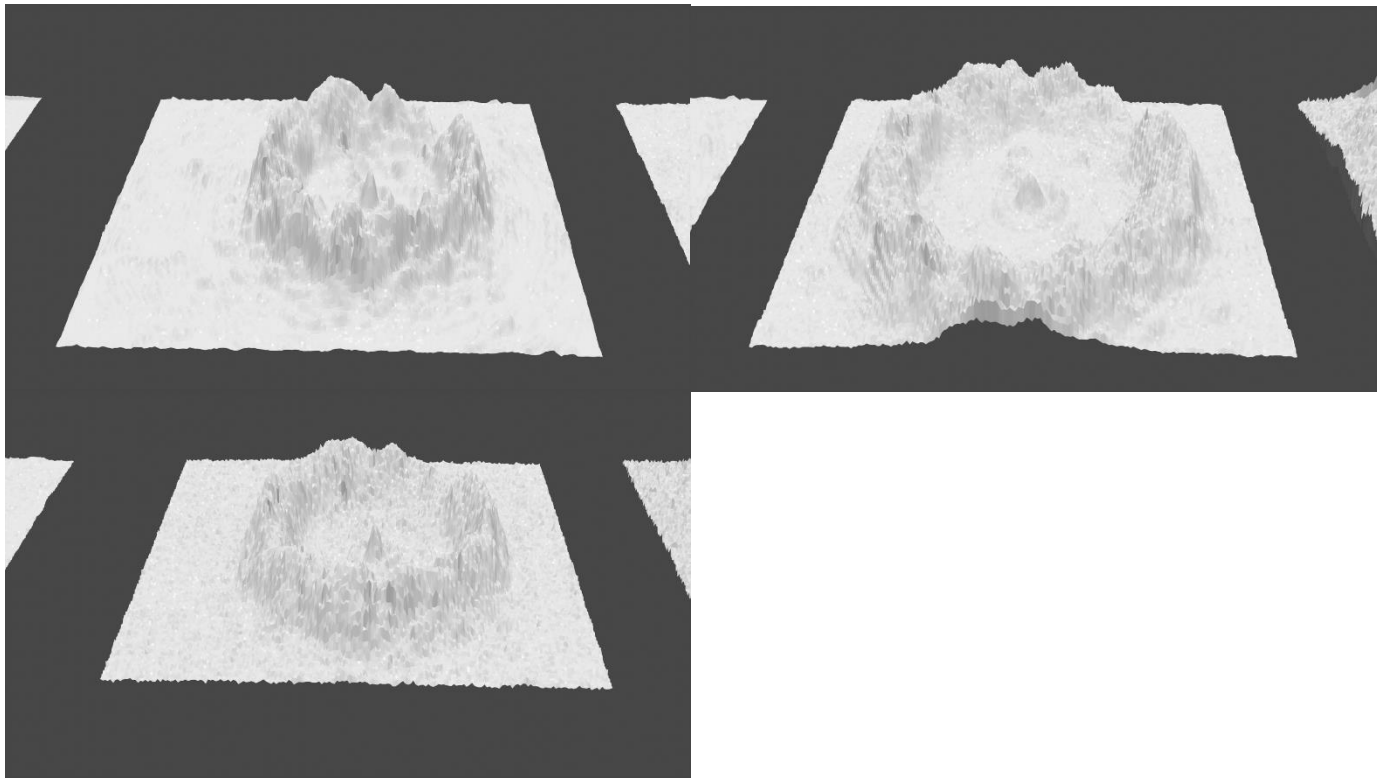
15 cm 30 cm 45 cm 60 cm

Non-Lasing (LG Propagation)

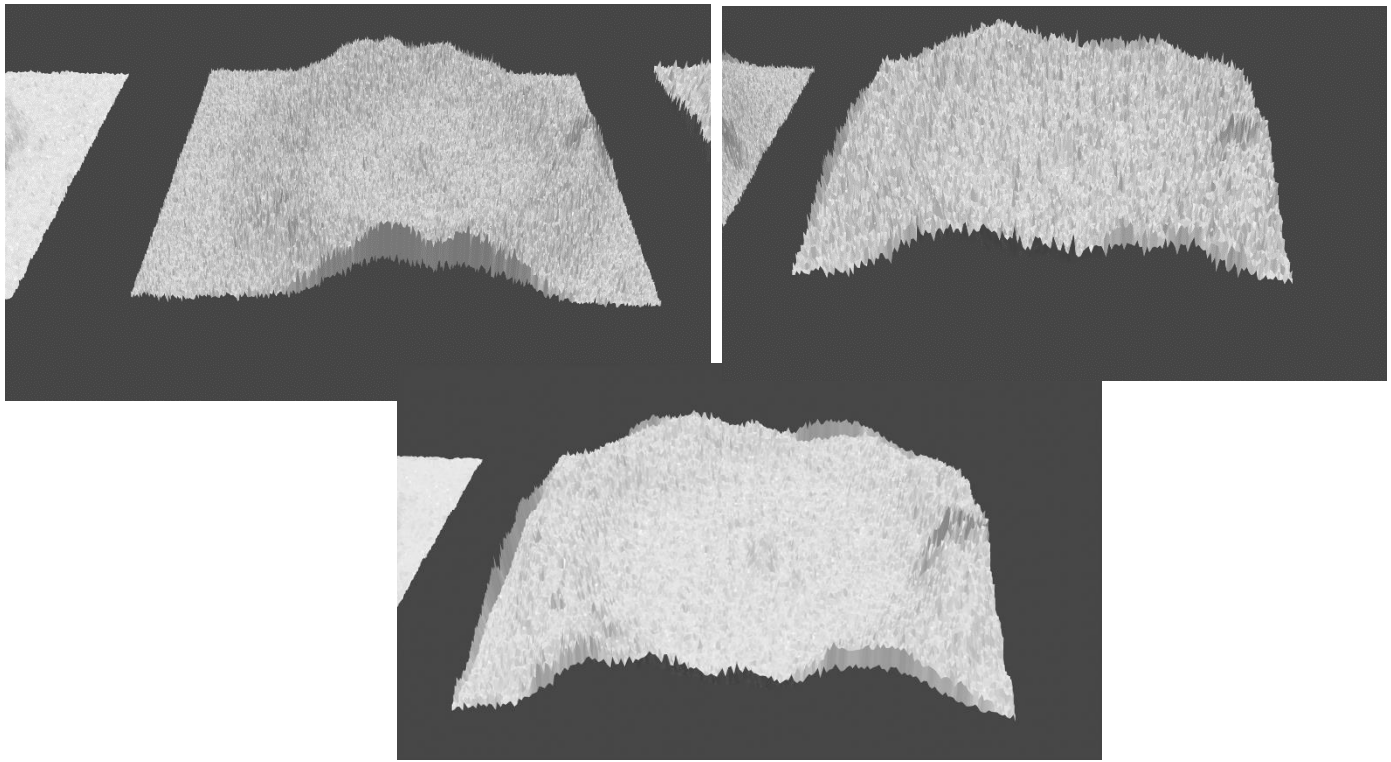


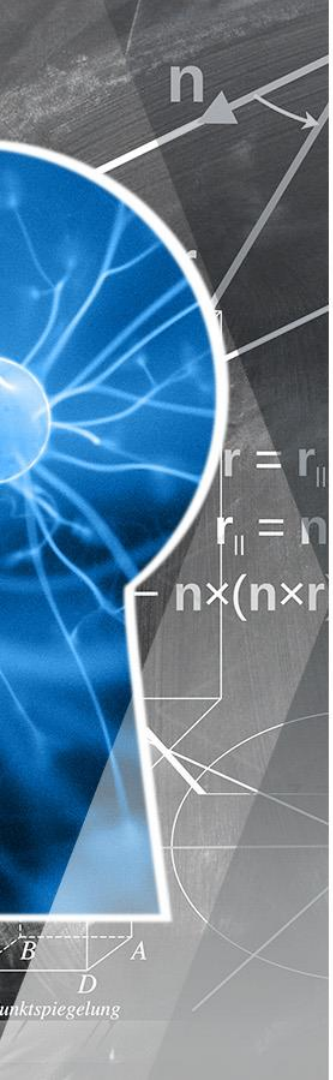
15 cm 30 cm 45 cm 60 cm

Lasing intensity plots



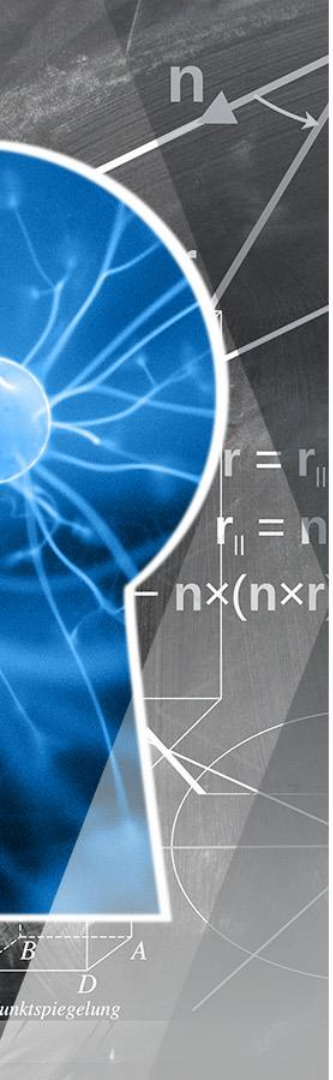
Non-lasing intensity plots





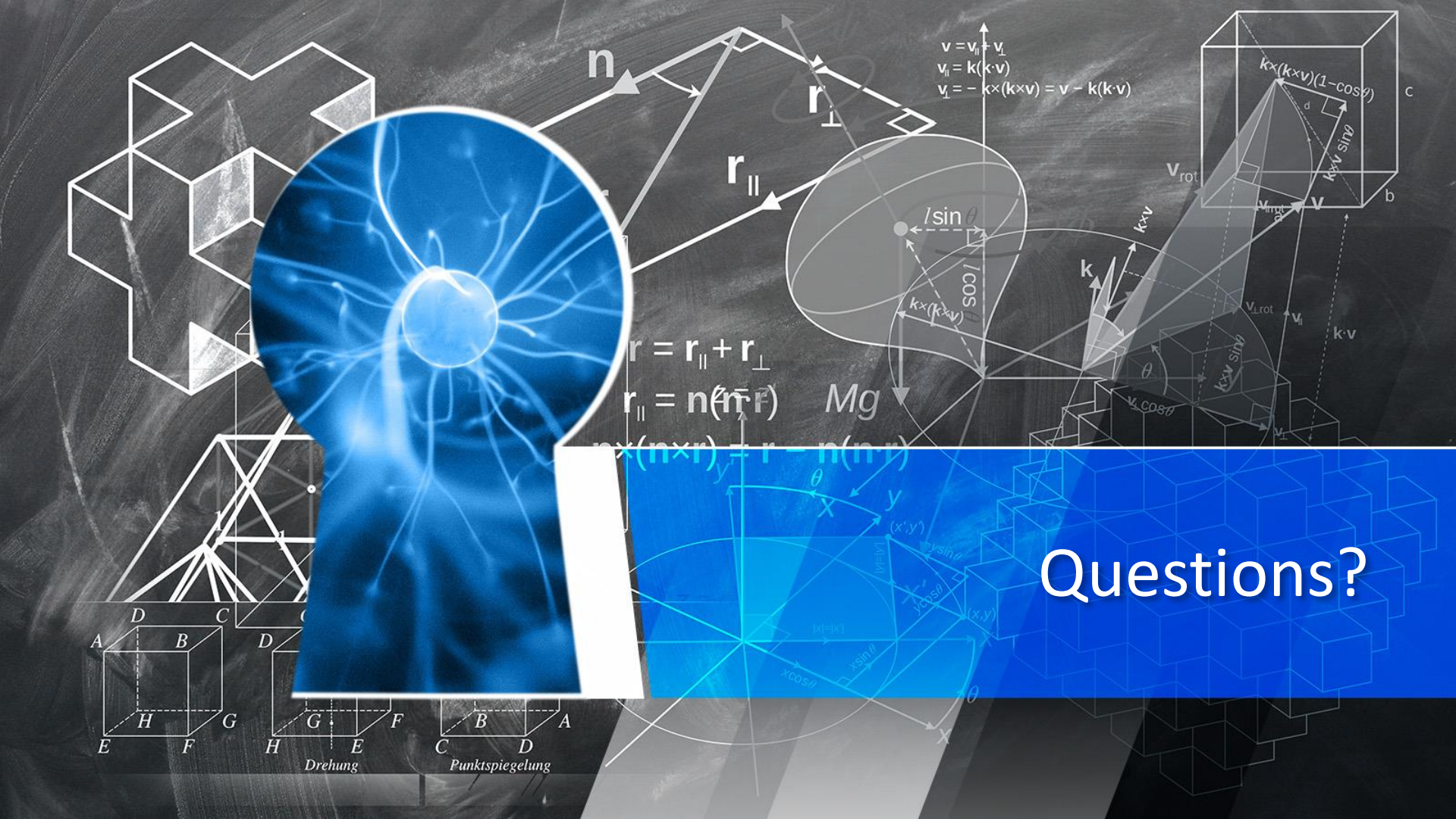
Conclusions

- To be an LG beam it will keep its donut-like shape for a trackable distance
- Proves Entanglement can be achieved in a classical experiment



Acknowledgments

- Dr. Eric Abraham
- Matthew Holtfrerich
- Oskar Novak
- Andy Schramka


Questions?