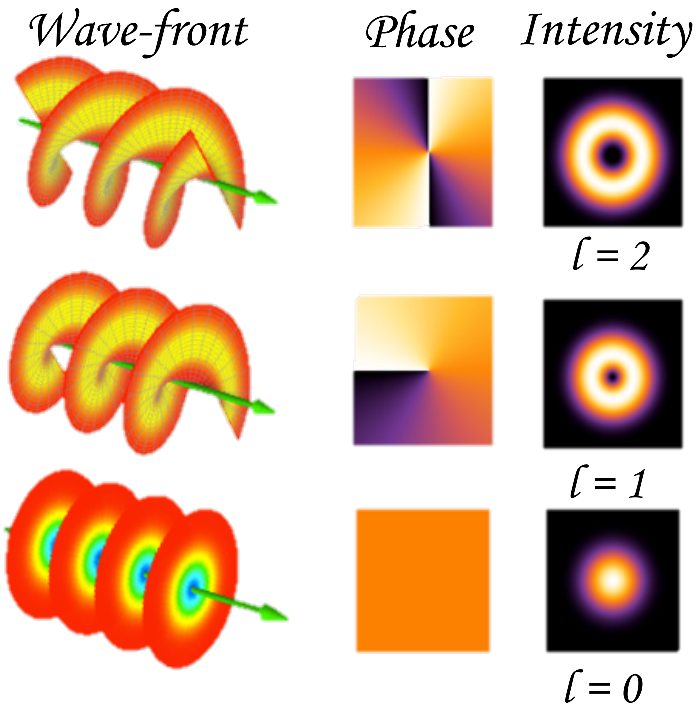
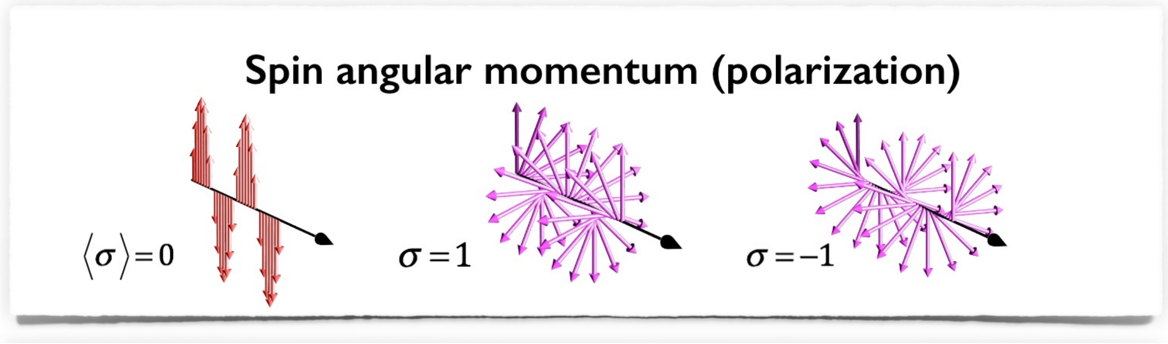
A Comprehensive Characterization of Orbital Angular Momentum Beams using Gerchberg-Saxton

Allison Liu
Kapteyn-Murnane Group
Graduate Student Mentor: David Couch

What are OAM beams?

1992- Visible orbital angular momentum (OAM) laser beams.





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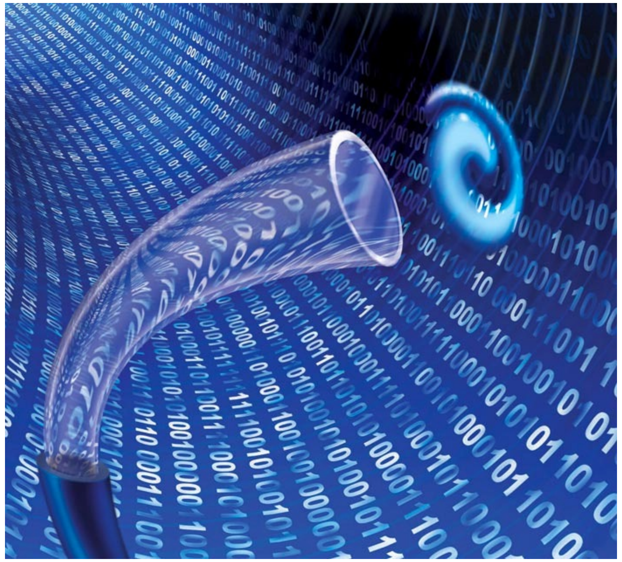
Motivations

OAM beams are useful in optical communications, imaging, magnetics, and quantum information science

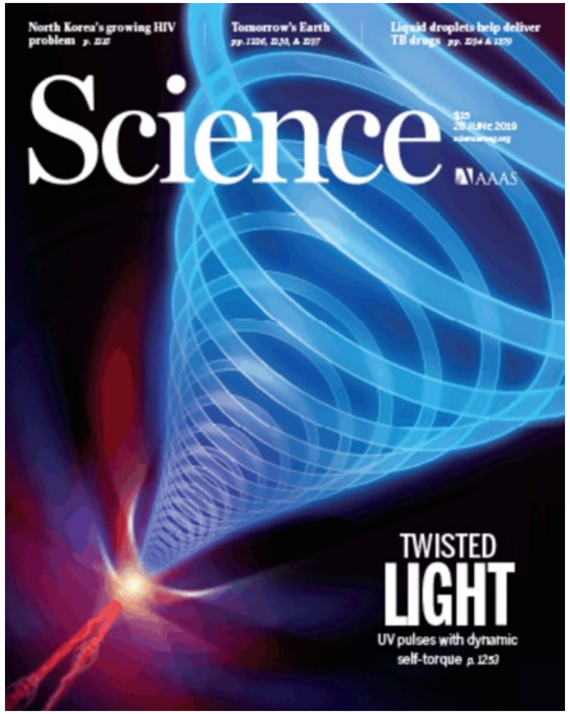
Reliable phase detection is essential for development of future technologies

Our basic GS algorithm from last summer is already being used

- But not yet optimized!



https://physicsworld.com/a/twisted-light-carries-data-over-1-km-in-optical-fibre/



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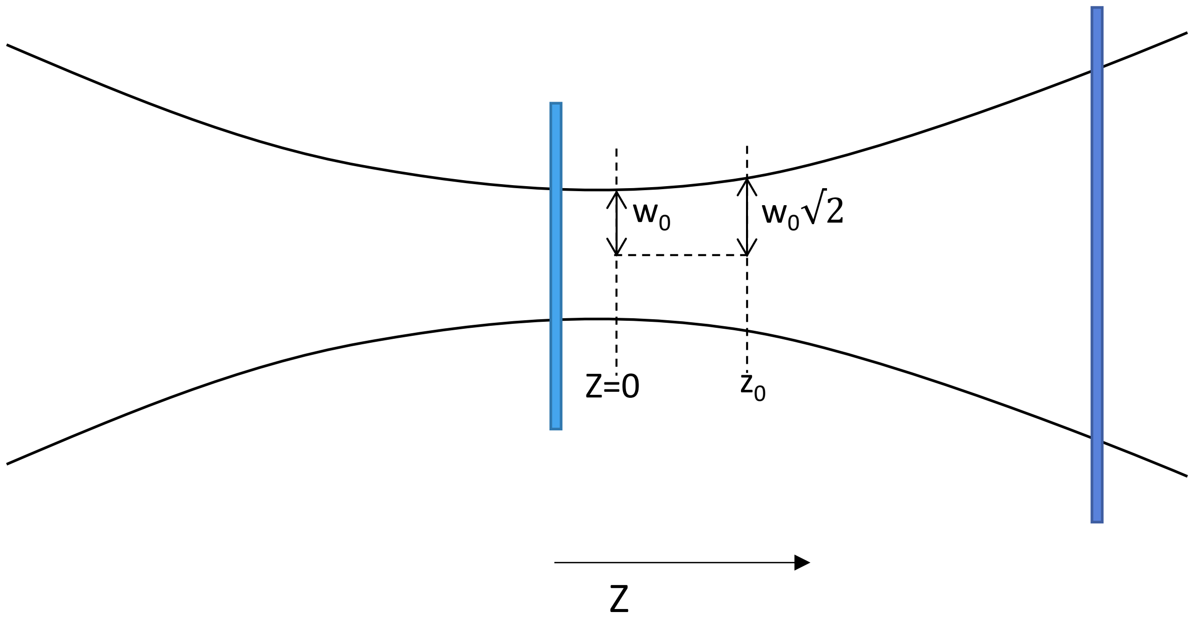
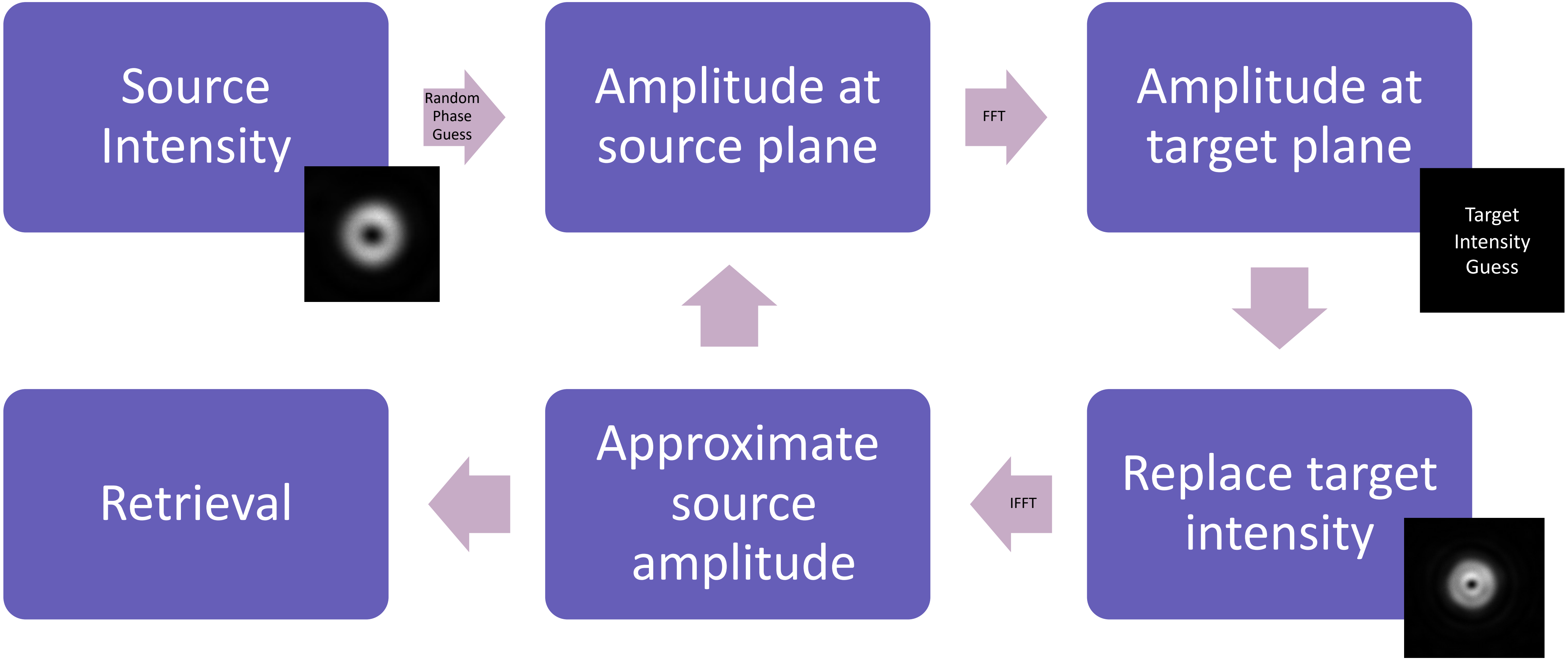
Gerchberg-Saxton Phase Retrieval



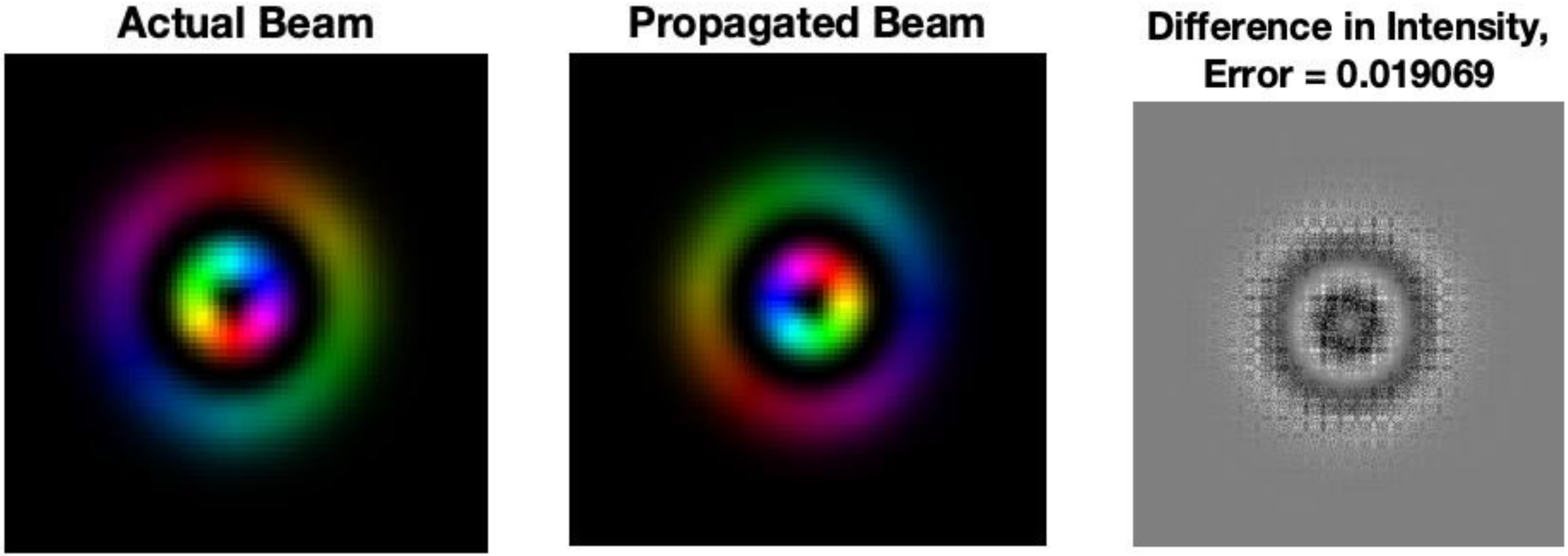
- Intensity and phase in one plane allows propagation of beam to another plane
- Intensity in two different planes allows the calculation of the phase in the two planes
- **Original GS:** use a focal point and an image infinitely far away from the focal point
- **Our technique:** oversampled intensity measurement

The Gerchberg-Saxton Algorithm



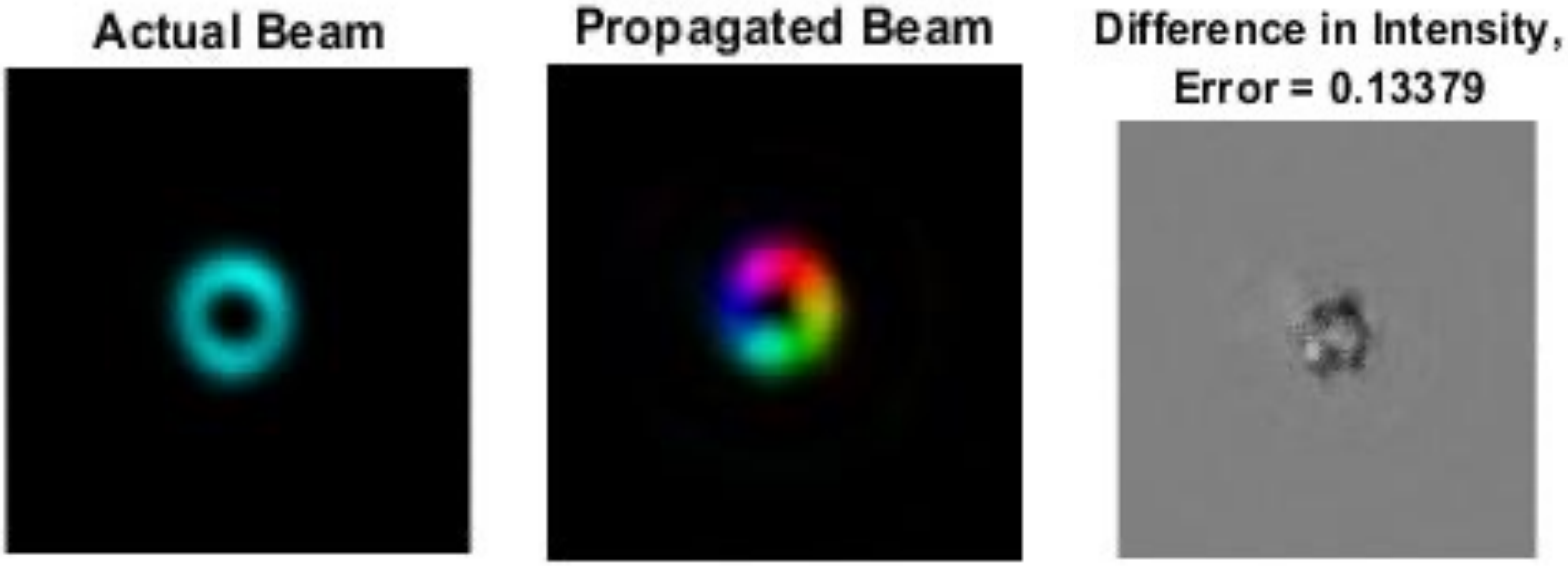
Data

Retrieval - Simulated Data



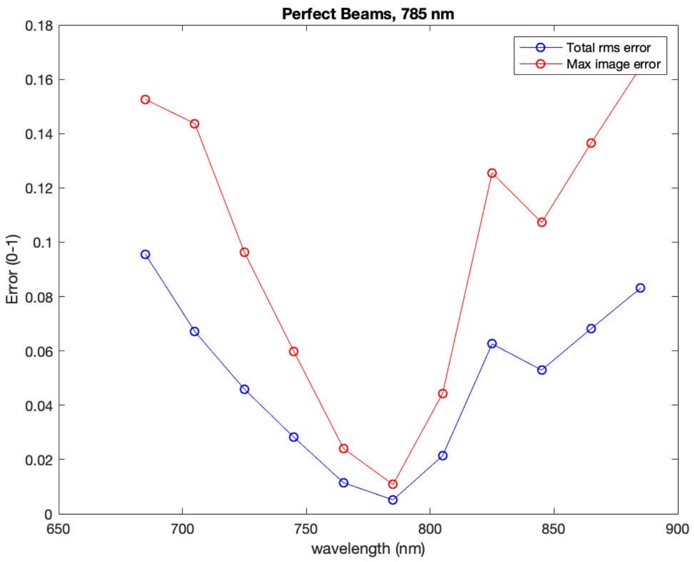
Data

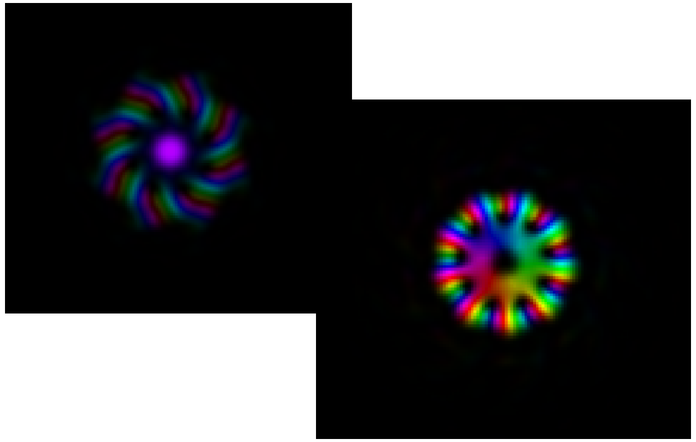
Retrieval- Experimental Data

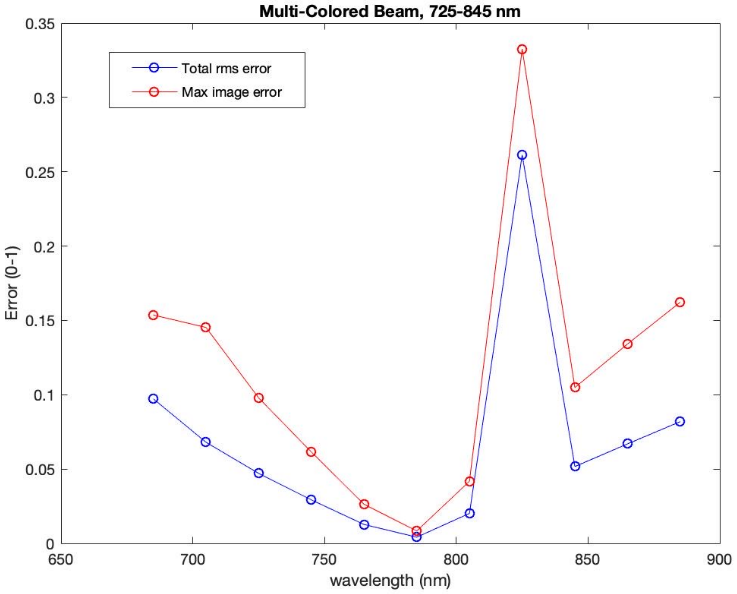


Handling wavelength

- In original GS and our main algorithm, the retrieval algorithm must know the wavelength of the laser
- For a single wavelength, the algorithm can reliably determine the wavelength within about 5 nm
- For multiple wavelengths, the algorithm does not perform very well







One side of focus

- For EUV OAM beams, like the Science article, optics have very poor efficiency
- Without optics, we cannot get a full profile of the focal point of these beams
- If we can measure only planes *after* the focus, ☺
    - Preliminary tests have shown this looks promising

Schematic of light exiting fiber

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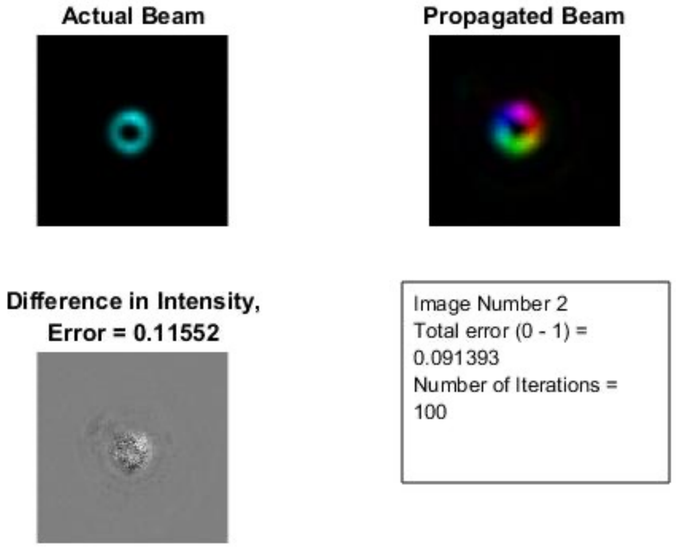
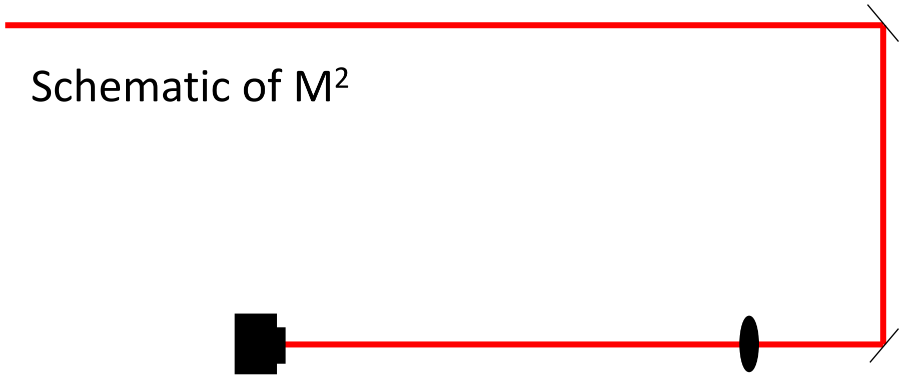
Results when half of the images are used:

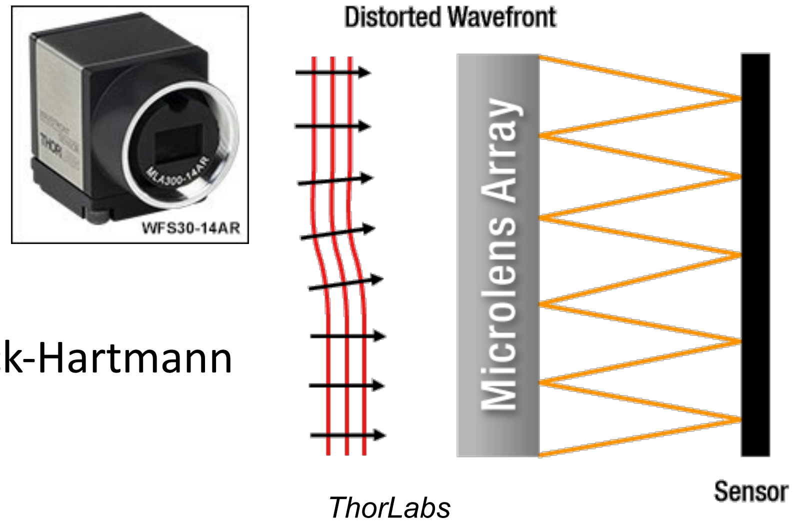


Comparison to other techniques

- M^2 uses the same information to compute beam divergence characteristics (2 numbers)
- Shack-Hartmann is an expensive (~$4000) wavefront sensor that can measure OAM content but has low spatial resolution and relatively narrow useful wavelength range (cannot be used in VUV/EUV)



Schematic of M^2



Shack-Hartmann

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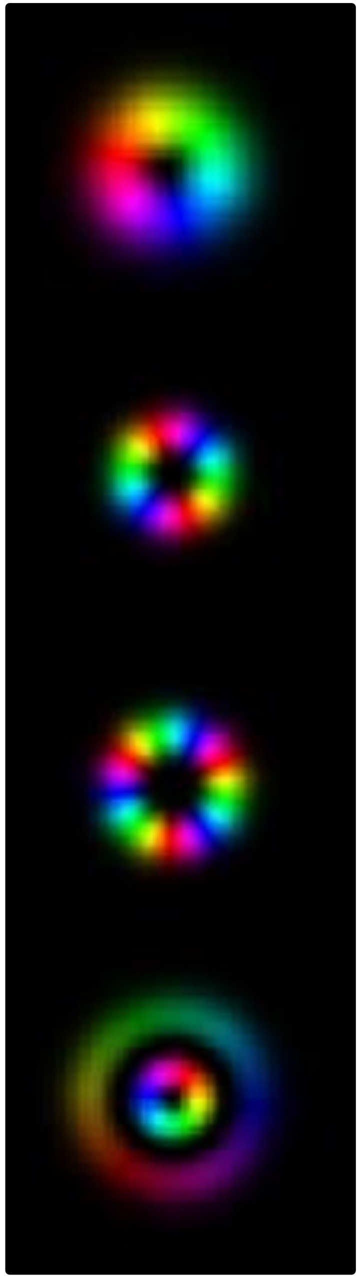
Conclusion

- We have created a powerful beam characterization device that is capable of comprehensively characterizing a wide variety of beams.
- It is able to gather more information than traditional characterization methods from the same data set and achieve higher resolution

- The algorithm can determine wavelength for a single-wavelength beam
- Preliminary results show difficulty with several wavelengths and with sampling only on one side of the focus



Next Steps

- Analyzing the algorithm performance
- Exploring the capabilities of the algorithm for multi-wavelength handling
- Optimizing for speed and accuracy, and extending this to handling images from only one side of the focus

Acknowledgements

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STROBE

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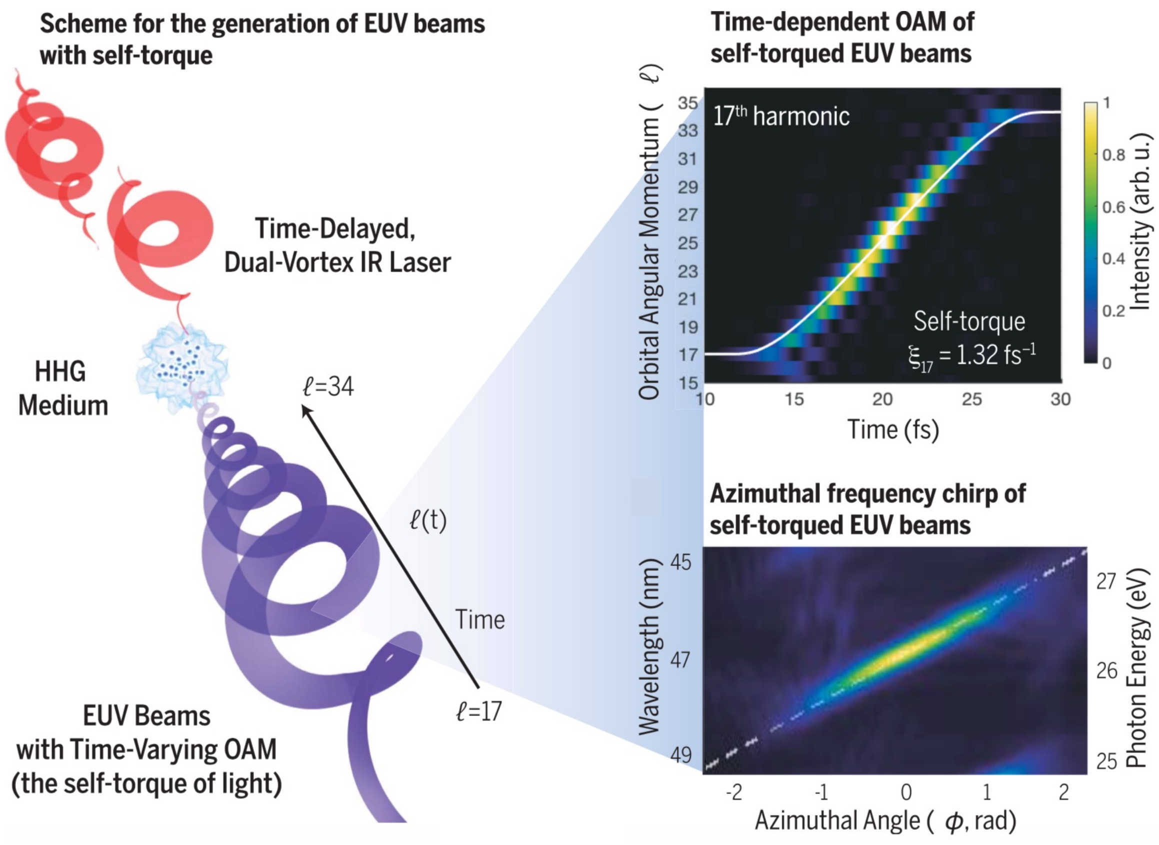
Setup

- The optical setup is identical to that of an M2. SIMPLE!

- M^2 is a measure of beam quality/astigmatism and ranges from 0-1



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