Creation of Random Phase Structure for Light

Benjamin Schreyer | Dmitri Kaganovich

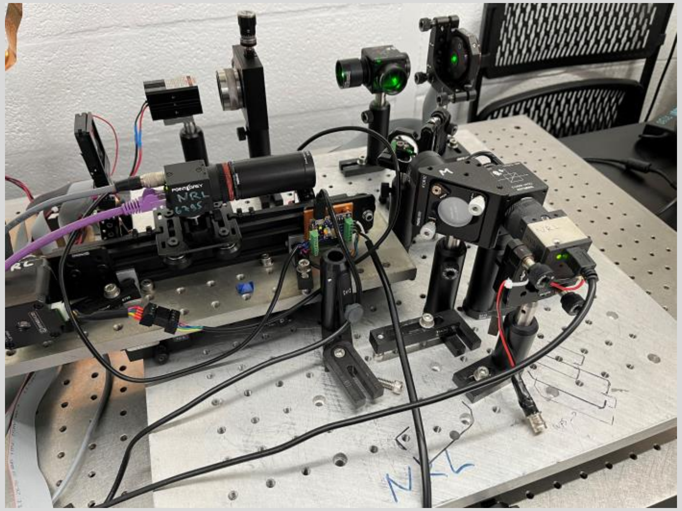
NREIP
NAVAL RESEARCH ENTERPRISE INTERNSHIP PROGRAM

Project Objective and Intern Contribution:
Our aim is to explore propagation of partially coherent light through nonlinear media. Giving statistical structure to laser light shows promise to increase propagation stability against collapse or divergence. Nonlinear non-instantaneous systems are hard to model even computationally. This endeavor may reveal useful properties not seen in more common Gaussian correlated forms of randomly structured light.

A light shaping device, used first in Astronomy, the deformable mirror efficiently reflects light with spatial dependence. Such a mirror can be used to rapidly (kHz) create laser beams that have random but spatially correlated structure. The electronically actuated mirror surface can change faster than nonlinear SBN:75 crystals can react.

Controlling the deformable mirror, and measuring the wavefront and laser parameters is crucial for exploring nonlinear propagation. Determining which random phase structures the experimental system could realize was the primary goal. In my project I used computational linear algebra (SVD methods) to generate statistically structured light. I then realized this light in the lab by applying regression control modeling for non-bijective control and response variables to a deformable mirror and wave front sensor pair.

When shaping light at such a rate and precision, a manual experiment is not sufficient. I implemented control and measurement libraries for the entire system. With this code measurements of beam parameters, and raw phase statistics were automatically executed.



Experimental apparatus

1. **Answer: What are you most proud of this summer [with respect to your experience/project]?**

Providing expertise in Physics and Computer Science that complemented my team members skills. This allowed us to overcome significant technical barriers in experiment and computations.

2. Answer: Why was the internship valuable?

With my team I tackled many of our major experimental and computational issues, revealing limits and setting new ones. I learned to better communicate and do science.

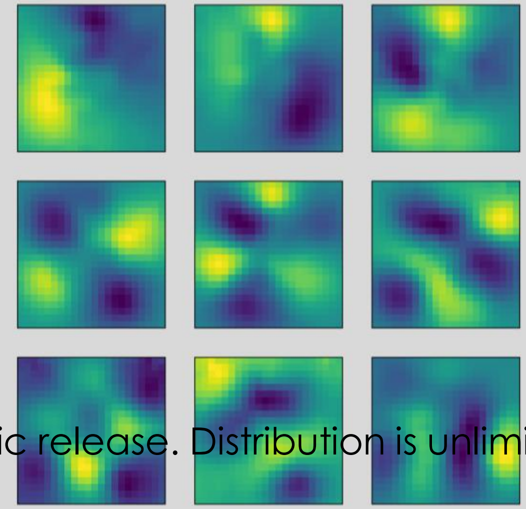
3. Answer: Advice for future cohorts?

Take measured steps, and collaborate constantly with your team. Don't forget to enjoy the wonder of the scientific process along the way.

Results / Accomplishments / Next Steps:
Automated control and measurement in experiment allowed structured incoherence to be generated. Importantly two distinct types of random structured light were realized, with low order polynomial and exponential decay of correlation.

Randomly structured light may enable more efficient energy delivery or communications for naval use of lasers. The work done launches future efforts in randomly structured light in the Plasma Physics division. The project will move forwards by sending this structured light into an SBN:75 nonlinear optical crystal. This will allow untested and potentially highly useful specialized statistical light structures in nonlinear media to be explored in the lab, and compared to theoretical understanding.

Deformable mirror deformation modes



Distribution Statement A: Approved for public release. Distribution is unlimited.