Systematic Invesitagtion of Optical Eigenmodes in Turbulent "Free-Space" Channels

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Abstract

Free space optical systems do not truly operate in free space. Turbulence in the atmosphere causes spatially and temporally varying phase shifts on the transverse profile of an optical mode throughout the path of propagation. These phase shifts result in errors when using optical modes for communication. Recent technologies such as adaptive optics have improved our ability to compensate for such turbulence, however these systems are limited in their ability to correct for higher order aberrations. Recent work

1 Introduction

2 Theory

2.1 Hermitian "Transfer Matrix"

If we take the transfer matrix, $\mathcal{T}$, and multiply by the complex conjugate, $\mathcal{T}^*$, we obtain a Hermitian matrix, $\mathcal{T}_H$. By finding the eigenvalues of this matrix, instead of those of $\mathcal{T}$, we obtain a different set of modes that are guaranteed to be orthogonal to one another. These modes are not exactly eigenmodes of the channel however. They propagate through the channel and are distinguishable from one another at all times. If you try to measure in the basis of the original mode however, there is high crosstalk as the mode does not stay the same in propagation.

Eigenmodes however are not guaranteed to be orthogonal so it is a tough thing to know what to do with that information. Should we use the 'Hermitian' eigenmodes that are orthogonal but change form in propagation, or should we use the 'non-Hermitian' eigenmodes that are not guaranteed to be orthogonal, but maintain their exact mode throughout the channel?

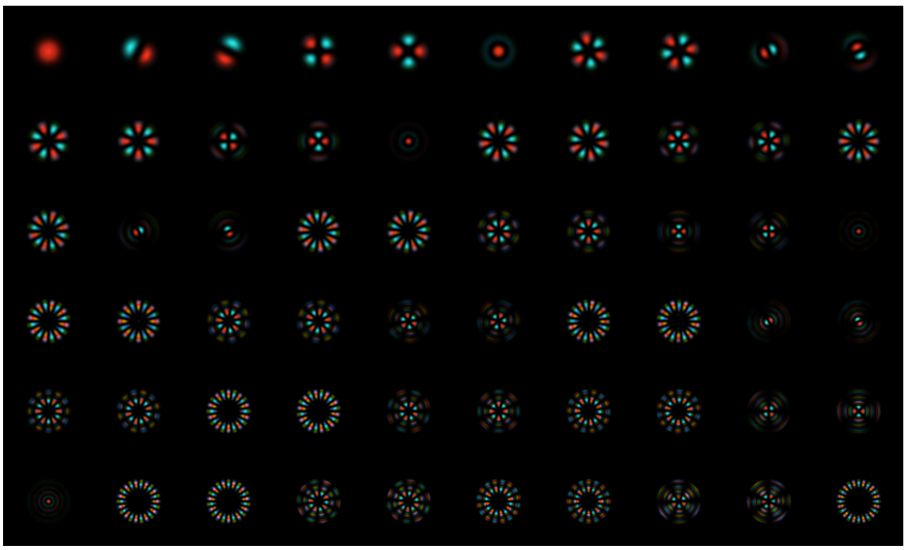

Figure 1: Eigenmodes of free-space propagation with a resolution of 96×96 pixels

Number of Pixels	Time to Calculate Eigenvalues	Quality
32	00:00.70	Bad
48	00:04.10	Okay
64	00:17.60	Good
96	02:55:00	Good
128		Good

Table 1: Table of the times it takes to calculate the eigenvalues.

3 Simulations

Using a larger simulation window, but reducing the aperature that is actually being used allows for simulations where the boundary conditions are not causing strange errors.

4 Experiment

5 Conclusion