Optimal Filtering of Spatial Modes of Light

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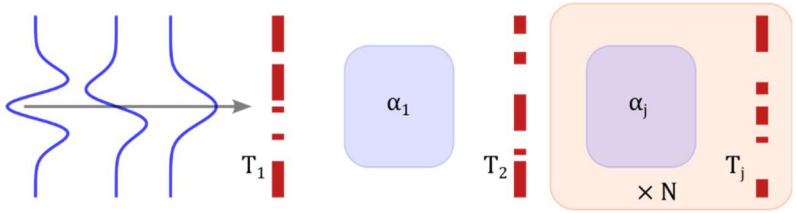

This project aims to determine the optimal configuration of a sequence of structured masks (T_j) and free-space propagation steps (α_j) for transmitting a target spatial mode while attenuating all other modes.

A common challenge in laser physics is mode cleaning: increasing the coherence of a beam of light by suppressing or eliminating higher-order modes. An ideal mode filter would transmit 100% of the desired mode, and completely block all remaining modes. In the spatial domain, such an ideal filter exists: a single-mode fiber (SMF). Over a propagation distance of only a few cm, all higher-order modes can be efficiently radiated away. However, a conventional single-mode fiber is not always an option: when the target modes are higher-order transverse modes, when filtering high-intensity lasers that would damage an SMF, when working with wavelengths for which SMFs are unavailable, or when filtering temporal rather than spatial modes of light. A simple, albeit imperfect, alternative to an SMF for mode cleaning is a “spatial filter” consisting of a single aperture between a pair of lenses. More generally, one can construct a mode filter out of a sequence of arbitrarily shaped masks separated by lenses and free space.

In this project, the student will simulate the generalized version of the spatial filter and optimize its performance by varying the positions and shapes of the constituent lenses and masks to maximize the transmission of the mode of interest while suppressing all others. The student will then experimentally verify the performance of the spatial filter they designed.