Spectrally-Selective Holography for Space-Division Modal-Demultiplexing and Dispersion Compensation in Multimode Fiber

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Abstract: Spatial-spectral holographic signal processing in cryogenically-cooled spectral-hole burning crystals allows modal-dispersion compensation of multiple orthogonally launched beams to enable wide-band mode-group multiplexing and demultiplexing in spatially-multiplexed multimode fiber networks.

We demonstrate that spatial-spectral holography (SSH) can be used to compensate for all orders of modal dispersion as well as mode coupling and to demultiplex spatially-multiplexed inputs that are launched into multi-mode (MM) fibers in order to achieve wide bandwidth in each spatially multiplexed modal channel. Wideband and multi-wavelength information can be encoded on orthogonal superpositions of the different spatial and polarization modes of a multi-mode fiber[1,2] and then unscrambled and dispersion compensated using SSH.[3] Previously encountered difficulties of broadband communication using modal multiplexing (MMux) in MM fibers are solved with this approach including the complexity of launching individual modes, the inevitable coupling of modes due to perturbations, the enormous modal dispersion, and the difficulty of separating out the superposition of modes at the multi-mode fiber output. In contrast, holographic techniques utilize field orthogonality at the fiber input and anywhere along the length of the fiber due to the unitarity of the modal propagation, (as shown in the intensity and field inner products calculated during simulated propagation shown in fig. 1) and are therefore capable of separating individual inputs that are launched initially as orthogonal inputs by making use of holographic recording of the output speckle fields in a volume hologram.[1] In this paper these holographic spatial modal multiplexing ideas are extended to account for the spectral dependence of the speckle,[4] and simulations are presented illustrating dispersion compensation and simultaneous modal unscrambling by using SSH.

References

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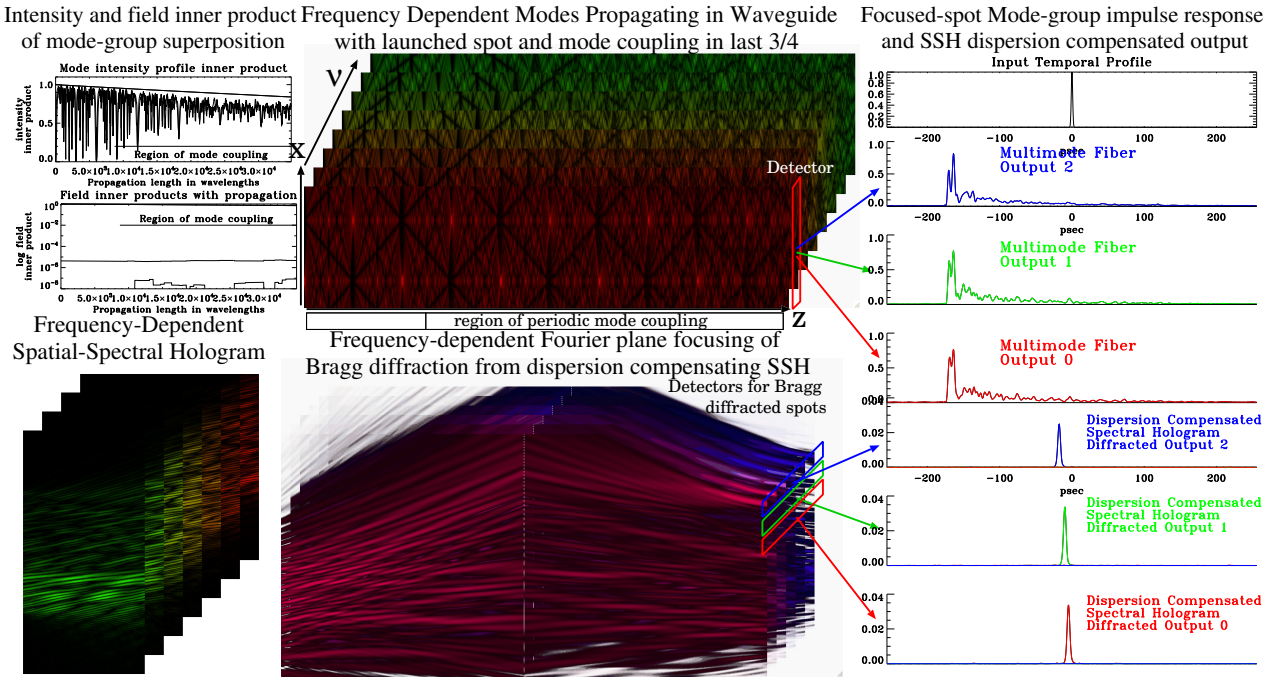

Figure 1: Frequency depenendent simulation demonstrating all the key steps of SSH dispersion compensation illustrated for the case of a 1-D step-index slab waveguide. In this case a simple focused spot is launched into a waveguide which has periodic modal coupling after the first 1/4, and the output temporal profiles seen by a large area detector have long extended tails. Bragg-matched spatial-spectral holograms are recorded at the waveguide output using 3 angle-multiplexed plane wave impulses. Upon readout, each frequency-dependent Bragg-diffracted beam is focused onto a photodetector, reproducing a dispersion compensated output impulse for each spatially-multiplexed launched bit, demonstrating the capabilities for multi-mode dispersion compensation and arbitrary mode-group demultiplexing.