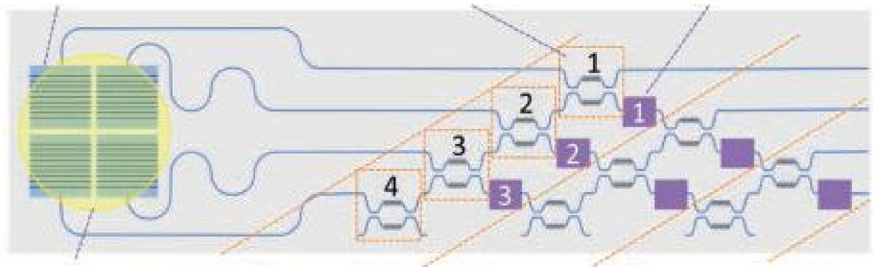
OPTICAL DESIGN

# Designing Linear Optical Components




Schematic of a self-aligning mode coupler and splitter.

Though we have many useful linear optical components, like lenses, mirrors and gratings, as well as opportunities with micro- and nano-fabrication for new devices, we have not known how to design "legal" optics. Is it even possible to separate arbitrary overlapping modes, such as the multi-fiber modes of current communications interest, without loss? Classic approaches to complex optical functions, like planar holograms with imaging or Fourier transform optics, cannot generate such arbitrary linear optics.[1]

We recently reported that a mode converter capable of separating arbitrary overlapping modes could produce any physically legal linear optical component.[2] We then demonstrated how to make an arbitrary mode converter, proving any such optical component is possible in principle.[3,4] Our design method is completely progressive, without complex global optimization. Also, the design doesn't require calculations—it self-configures with simple local feedback.[3,4]

The core idea is a new device concept; a self-aligning beam coupler that couples an arbitrary input beam into a single mode guide.[3] We can theoretically divide the beam into enough patches, each approximately uniform in intensity and phase.[1] Then, we couple power from the different patches to the single output with a set of controllable phase shifters and reflectors (as shown in the video), or more practically, with a set of Mach-Zehnder (MZ) waveguide interferometers. We progressively work along row 1, from MZ4 to MZ1, while nulling powers in detectors 3 to 1.

The second key concept to our design is that a second orthogonal input beam will be entirely transmitted through detectors 1 to 3, where it can be aligned similarly with row 2 to the second output, and so on, thus separating multiple overlapping orthogonal beams without loss. If we use a second device, running it backward, we can convert these single modes to any output modes, and interspersed modulators can set the coupling strengths to give a completely arbitrary spatial linear optical device. Such schemes are well suited to silicon photonics, for example. Extensions include spatial add-drop multiplexers and fully arbitrary linear optical devices, including polarizations and different frequencies, at least in theory.[4,5]

Hence, any physically legal linear optical device can be designed without calculations. OPN

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