Arbitrary and Reconfigurable Optics – New Opportunities for Integrated Photonics

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Abstract: Recent understanding shows how to make universal linear components, beyond conventional optics. Fundamental consequences include new radiation laws. Practical integrated Mach-Zehnder meshes can be self-configured for arbitrary linear functions.

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Historically, optics was based on materials formed into regular shapes, such as a lens, mirror, or grating, but neither these approaches nor recent extensions like metamaterials are “universal” – we did not know, for example, how to perform many “legal” optical operations using such approaches, such as separating arbitrary overlapping “orthogonal” light beams without loss. Recently work, however, shows how to break down any legal linear optical component into a mesh of “two-beam” devices [1–12] such as Mach-Zehnder interferometers (MZIs). Surprisingly, there is even a way to have such a mesh design itself, without any calculations, opening up a new field of self-configuring, self-correcting, and self-stabilizing optics [3–11], and these meshes are well-suited to silicon photonics implementations. Potential applications include mode multiplexing/demultiplexing in telecommunications [6], self-aligning beam couplers [3], automatic tracking of targets [5], and potentially many others. Extensions of such self-configuring mesh ideas allow for the automatic perfecting of imperfect beam-splitter ratios in MZIs [8,11], which could enable mass-manufacture of field-programmable linear arrays that could be compensated for imperfections after manufacture and configured in the field for arbitrary linear functions. Related mesh concepts have also been proposed for microwave photonics applications [13,14]. This different way of looking at optics has also led to a surprising fundamental advance in rewriting and extending Kirchhoff’s law of thermal radiation [15].

The talk will introduce these ideas and related new directions in optics.