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Large-scale free-space photonic circuits in two dimensions

Optical degrees of freedom, such as those associated with spatial, spectro-temporal, or polarization features of the optical field, serve as a convenient resource for encoding information. The abundance of tools for their accurate manipulation established photonics as a versatile platform for both classical and quantum information processing tasks. Optical processors based on linear circuits, performing a variety of tasks, are often referred to as photonic circuits, in analogy with canonical circuits processing electrical signals. When used as optical simulators, the overall optical transformation maps to a unitary temporal evolution operator. By monitoring the system output one can observe directly optical analogues of classical or quantum dynamics. Here we realized a compact photonic circuit in free-space, implementing all-optical mode-coupler operations in a transverse two dimensional large-scale regime, as an alternative to the traditional integrated waveguides approach to optical information processing. We tested it by implementing unitary transformations associated with 2D quantum walks on transverse modes of structured light.

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