Periodic state revivals in commensurate waveguide arrays

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Emerging optical and quantum computers require hardware capable of coherent transport of and operations on quantum states. Here, we investigate finite optical waveguide arrays with linear coupling as means of efficient and compact coherent state transfer. Coherent transfer with periodic state revivals is enabled by engineering coupling coefficients between neighbouring waveguides to yield commensurate eigenvalue spectrum. Particular cases of finite arrays have been actively studied to achieve the perfect state transfer by mirroring the input into the output state [1, 2]. We explore a much wider scope of coherent propagation and revivals of both the state amplitude and phase.

We analytically solve the inverse eigenvalue problem to find the corresponding array coupling coefficients and use them to construct optical waveguide arrays that support full state revivals. We present analytical solutions for general arrays with 4 and 5 waveguides and for symmetric arrays with 7 and 9 waveguides [3]. These solutions include previously proposed families of solutions based on equidistance between eigenvalues.

Applications of analytic solutions are numerically demonstrated on experimentally accessible optical waveguide arrays, Fig. 1. Coupling coefficients are controlled by controlling inter-waveguide separations. It is shown that the same array can perform coherent transport of a vector state and different coupling functions if different input ports are excited [4]. It is further shown that the coupler output is sensitive to fabrication imperfections and that the accuracy required is nearly within the reach of the state-of-the-art laser writing techniques [5]. The proposed WGAs can also be of interest as directional 1xN couplers in optical circuits, input and output couplers in integrated multipath interferometers and simulators of atomic angular momenta.

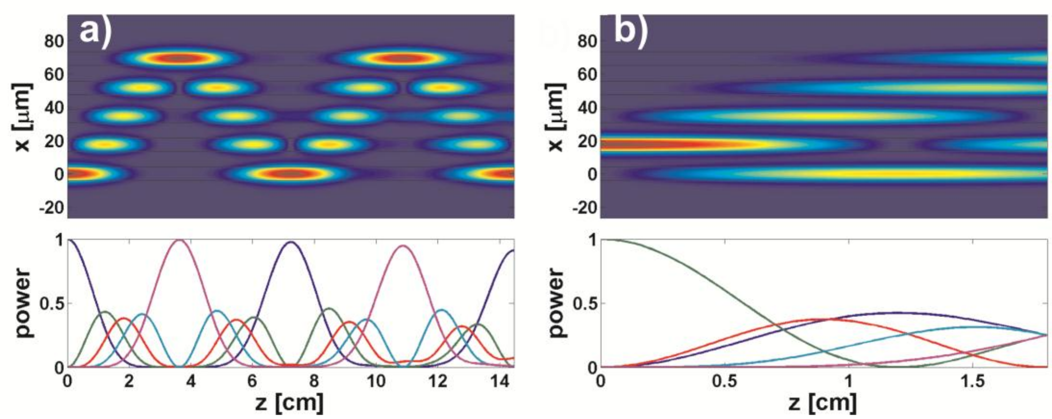

Fig. 1 Numerical simulation of a commensurate 5-waveguide array with a) the input state (1, 0, 0, 0, 0) and arbitrary length, b) the input state (0, 1, 0, 0, 0) and the length that renders equal 1x4 coupler.

Besides the mathematical challenge to find analytical solutions arrays with larger and even number of waveguides, there is a considerable interest in coherent transfer through two dimensional arrays (optical lattices) and closed chains (multicore fibres), which are outlined as compelling subjects for future work.

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