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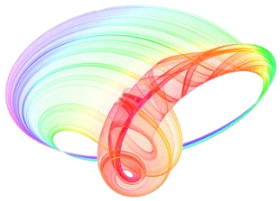

PHOTONICA2021

VIII International School and Conference on Photonics

& HEMMAGINERO workshop

23 - 27 August 2021,

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Editors

Mihailo Rabasović, Marina Lekić and Aleksandar Krmpot

Institute of Physics Belgrade, Serbia

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Bend-free photonic integrated circuits with the crosstalk as a resource

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We challenge the current thinking and approach to design of photonic integrated circuits (PICs), which are marked as drivers of the future information processing.

Standard quantum PICs are composed of the unit cells based on directional couplers. The couplers typically consist of two waveguides bent to exhibit coupling in the proximity region. They conveniently produce the maximally entangled Bell state and have been used to construct functional optical quantum PICs [1]. However, their full exploitation faces the conceptual and technical challenges including the non-intrinsic scalability that requires waveguide branching, the radiation loss at waveguide bends and the therewith associated high-density packaging limit [2].

Arrays of linearly coupled parallel waveguides have been considered a viable alternative. However, the intricate inverse design of the corresponding Hamiltonians has limited their applications to the particular instances of the quantum logic gates obtained by numerical optimization procedures and machine learning [3, 4] and the simulators of the condensed matter systems, such as spin and Bloch arrays with the Wannier-Stark ladder spectrum [5]. A generic design solution based on a common physical and mathematical principle has not been reached.

We propose a new concept for the design of bend-free high-density PICs composed exclusively of the linearly coupled *commensurable* waveguide arrays (CWGA). Their operation is based on the *periodic continuous quantum walk of photons* and leverages on the engineered waveguide coupling. We discuss the class of analytically accessible designs with the eigenspectra that randomly sample the Wannier-Stark ladder [6, 7]. *The free choice of eigenfrequencies marks a clear distinction from the current photonic simulators and provides a variety of novel circuit layouts and functionalities.* In particular, we rework the designs of interconnects for qubits and qudits, multiport couplers, entanglement generators and interferometers. The analytical results are corroborated numerically. Finally, we test the robustness of the proposed building blocks to the random variations in design parameters, with a view to defining acceptable fabrication tolerances.

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