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Programmable continuous-variable photonic quantum computing in the time domain

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Abstract

Photonic quantum computing has recently been dramatically scaled up, demonstrating quantum supremacy and large-scale entangled state generation. Such progress has been made by an approach combining continuous-variable and multiplexing schemes. The continuous-variable scheme offers more efficient quantum light sources and detectors than the traditional qubit-based scheme. On the other hand, the multiplexing schemes in time, frequency, and spatial modes enable us to scale up quantum computation in compact photonic circuits. The combination of these schemes is a promising route to large-scale quantum computers.

We are pursuing programmable and scalable photonic quantum computers based on the continuous-variable and time-multiplexing schemes. In particular, we proposed a loop-based photonic quantum computing architecture where a single quantum processor sequentially performs gates on time-multiplexed optical pulses arranged in a loop (Physical Review Letters 119, 120504 (2017)). In this talk, we introduce our recent development in this direction, including the demonstration of a programmable multi-step quantum processor (Science Advances 7, eabj6624 (2021)), the development of a programmable time-multiplexed quantum light source (arXiv:2209.09458), and the implementation of a quantum algorithm using a programmable photonic circuit (arXiv:2206.07214).