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Experimental memory control in continuous variable optical quantum reservoir computing

Forecasting complex processes requires efficient learning from temporal data. Reservoir computing platforms enable such learning with minimal training cost. Quantum reservoir computing (QRC) extends this framework into the quantum domain, offering promising capabilities for online, quantum-enhanced machine learning tailored to temporal tasks. As in the classical case, photonics provides a natural platform for QRC. However, implementing native memory capabilities in practical photonic quantum systems remains a significant challenge.

Here, we demonstrate a photonic QRC platform based on deterministically generated multimode squeezed states, exploiting spectral and temporal multiplexing in a continuous-variable (CV) setting with controllable fading memory. Data is encoded via programmable pump phase shaping in an optical parametric process and retrieved through mode-selective homodyne detection. Real-time memory is implemented through feedback via electro-optic modulation, and expressivity is boosted via spatial multiplexing.

This architecture enables nonlinear temporal tasks, including parity check at different delays and chaotic signal forecasting. All results

are supported by a high-fidelity Digital Twin. Leveraging the entangled multimode structure enhances expressivity and memory capacity, establishing a scalable CV photonic platform for quantum-enhanced information processing.