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Self-Configuring Optical Networks for Continuous-Variable Quantum Information Processing

The Stanford team invented a self-configuring network (SCN) that makes large-scale quantum photonic systems practical. The team achieved a scalable, hardware-efficient platform capable of handling tens to hundreds of modes, enabling robust multimode entanglement—a critical resource for measurement-based quantum computing and advanced photonic signal processing.

Current frequency-bin and spatial-mode architectures struggle with complexity and poor scalability, requiring extensive calibration and a quadratic growth in components. The SCN overcomes these limitations by using adaptive interferometer arrays, modulated cavities, and feedback-driven optimization to automatically configure multimode interactions without prior knowledge of the system. By reducing calibration demands and component overhead, the SCN offers faster deployment, lower costs, and greater reliability. Its ability to dynamically identify and optimize dominant quantum modes enables high scalability, paving the way for fault-tolerant quantum computing and next-generation photonic technologies.

Stage of Development: Proof of Concept

Applications

- **Quantum information processing**
- **Optical communications**
- **Adaptive spectroscopy & sensing**
- **Reconfigurable spectral filtering** - for real-time material analysis
- **Quantum-enhanced metrology** - for high-precision sensing applications
- **Dynamically tunable** frequency-bin multiplexing and demultiplexing

- **Programmable dispersion compensation** - for high-speed optical links
- **Adaptive homodyne detection for scalable multimode quantum networks** - the system can adaptively find the leading supermode carrying the most amount of squeezing
- **Compensating for scattering channels** - the network can be configured to undo scattering by random media, extracting the correct quantum states

Advantages

- **Scalable** to tens to hundreds of modes
- **Hardware-efficient**
- **Faster deployment**
- **Reduce hardware complexity** from O(M2) to O(M).

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