Scalable Measurements of Continuous-Variable Quantum Light

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Scalability is a key requirement for bringing quantum information technology to a practical level. Continuous-variable quantum optical systems offer a promising route to scalability by allowing the deterministic generation of large-scale entangled states. In contrast to the experimental progress in quantum state generation, realizing *quantum measurements at scale* has remained challenging, where quantum homodyne detection plays essential roles for continuous-variable quantum information processing.

In this talk, I will present large-scale quadrature measurements of quantum light by introducing a camera sensor for quantum homodyne detection. Our camera-based homodyne detection operates in the shot-noise-limited regime, achieving a clearance exceeding 24 dB with negligible crosstalk among different modes. We demonstrate the compatibility of the homodyne detection with multimode quantum light [**1**, **2**] by directly observing squeezing and entanglement across 60 optical modes. This scalable quantum measurement paradigm paves the way for large-scale quantum information processing, including fault-tolerant quantum computing, quantum teleportation, quantum imaging, quantum spectroscopy, and quantum tomography.

References

[1] C. Roh, G. Gwak, Y.-D. Yoon, Y.-S. Ra, "Generation of three-dimensional cluster entangled state," *Nat. Photon.* **19**, 526–532 (2025).

[2] G. Gwak, C. Roh, Y.-D. Yoon, M. S. Kim, Y.-S. Ra, "Completely characterizing multimode second-order nonlinear optical quantum processes," *Nat. Photon.* **20**, 156–162 (2026).