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Photon Number-Resolving Detectors for Integrated Quantum Sensing

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We present the design of a hybrid photon number-resolving detector (PNRD) on a lithium niobate-on-insulator (LNOI) platform, aiming to combine superconducting nanowire single-photon detectors (SNSPDs) in a multiplexed configuration for high-fidelity quantum sensing. Finite element method (FEM) simulations have been conducted to assess key performance factors such as propagation losses, detector dark counts, and waveguide geometry, providing a comprehensive framework for the device's development.

The proposed detector will integrate up to 130 SNSPDs along a thin-film lithium niobate waveguide, targeting photon number resolution for up to 20 photons with >90% efficiency. Simulations predict low propagation losses (0.3 dB/cm) and near-ideal absorption with optimized nanowire lengths. This modular architecture is designed to overcome challenges such as current crowding and bending losses while ensuring scalability and precision.

This platform represents a significant step toward fully integrated quantum sensing systems, with future applications in quantum metrology, state engineering, and continuous-variable quantum technologies.

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