UNIVERSITÀ DEGLI STUDI
DI TRENTO
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Room A108 – Polo Ferrari 1

Integrated Photonic Devices for Quantum Applications: From Communication to Neural Network

Abstract:

Quantum sources: Integrated photonics has recently become a leading platform for the realization and processing of optical entangled quantum states in compact, robust and scalable chip formats, with applications in long-distance quantum-secured communication, quantum-accelerated information processing and nonclassical metrology. However, the quantum light sources developed so far have relied on external bulky excitation lasers, making them impractical prototype devices that are not reproducible, hindering their scalability and transfer out of the laboratory into real-world applications. Here we demonstrate a fully integrated quantum light source that overcomes these challenges through the integration of a laser cavity, a highly efficient tunable noise suppression filter (>55 dB) exploiting the Vernier effect, and a nonlinear microring for entangled photon-pair generation through spontaneous four-wave mixing. The hybrid quantum source employs an electrically pumped InP gain section and a Si_3N_4 low-loss microring filter system, and demonstrates high performance parameters, that is, pair emission over four resonant modes in the telecom band (bandwidth of ~1 THz) and a remarkable pair detection rate of ~620 Hz at a high coincidence-to-accidental ratio of ~80. The source directly creates high-dimensional frequency-bin entangled quantum states (qubits/qudits), as verified by quantum interference measurements with visibilities up to 96% (violating Bell's inequality) and by density matrix reconstruction through state tomography, showing fidelities of up to 99%. Our approach, leveraging a hybrid photonic platform, enables scalable, commercially viable, low-cost, compact, lightweight and field-deployable entangled quantum sources, quintessential for practical, out-of-laboratory applications such as in quantum processors and quantum satellite communications systems.

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