Chip-integrated Visible-Telecom Entangled Photon Pair Source for Quantum Communication

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Photon pair sources are fundamental building blocks for quantum entanglement and quantum communication. Recent studies in silicon photonics have documented promising characteristics for photon pair sources within the telecommunications band, including sub-milliwatt optical pump power, high spectral brightness, and high photon purity. However, most quantum systems suitable for local operation (e.g., storage/computation) support optical transitions in the visible or short nearinfrared bands. In comparison to telecommunications wavelengths, the significantly higher optical attenuation in silica at such wavelengths limits the length scale over which optical-fiber-based quantum communication between such local nodes can take place. One approach to connect such systems over fiber is through a photon pair source that can bridge the visible and telecom bands, but an appropriate source, which should produce narrow-band photon pairs with a high signal-to-noise ratio, has not yet been developed in an integrated platform. Here, we demonstrate a nanophotonic visible-telecom photon pair source for the first time, using high quality factor silicon nitride resonators to generate narrow-band photon pairs with unprecedented purity and brightness, with coincidence-toaccidental ratio (CAR) up to 3,780 ± 140 and detected photon-pair flux up to (18,400 ± 1,000) pairs/s. We further demonstrate visible-telecom time-energy entanglement and its distribution over a 20 km fiber, far exceeding the fiber length over which purely visible wavelength quantum light sources can be transmitted. Finally, we show how dispersion engineering of the microresonators enables the connections of different species of trapped atoms/ions, defect centers, and quantum dots to the telecommunications bands for future quantum communication systems.