Centre de Nanosciences & de Nanotechnologies C2N

Seminar

Thursday
Thursday

Thursday October 10th 2019 - 14h 00

Room A003 of C2N

"Programming multiphoton entanglement: theory and practice."

Jeremy Adcock

Bristol University

Quantum computers promise a paradigm shift humanity's information processing capability. Graph states are the predominant language of entanglement between qubits. Modern quantum error correction—a crucial component of large-scale quantum computation—relies centrally on graph state entanglement. Different graphs enable different computational tasks, and so the generation of arbitrary graph states is powerful.

Meanwhile, silicon quantum photonics is a high-performance, scalable quantum technology platform, boasting circuits of unparalleled size. However, integrated quantum photonics has so far been constrained to two on-chip generated photons. Here, we present the first device to wield four-photon entanglement, and measure high-visibility on-chip quantum interference. We also develop rules for the successful postselection of graph states, and probe which states are inaccessible. Further, we identify optimal photonic circuits capable of generating all accessible graph states up to 8 qubits. This provides an endgame strategy for the final era of postselected experiments, before heralded devices become a necessity.

On our silicon chip, four sources of spontaneous four-wave mixing generate two Bell pairs in four dual-rail qubits. These are entangled using a two-qubit gate, programmably generating either star- or line-type graph states. Reconfigurable single-qubit gates then access the remaining four-qubit graph states and implement projective measurements. Finally, the photons are routed off-chip to superconducting nanowire single photon detectors. Our star and line graph states have fidelities 0.78 ± 0.01 and 0.68 ± 0.02 respectively. Our results represent an important step on the road to truly scalable quantum photonics.

Jeremy Adcock:

Jeremy's Ph.D thesis was focused on scaling up entanglement in integrated quantum photonics, via the generation of graph states---quantum states with ubiquitous application in quantum information protocols. In his thesis, he establishes rules for the successful postselection of linear optical experiments, and in doing so uncovers new, fundamental limitation of postselected gates and sources. Further, he demonstrated the first integrated device to generate four-photon entanglement in dual-rail qubits, overcoming the two-photon barrier. The silicon chip generated both types of four-qubit graph state on the same device (a first in optics) and demonstrated high visibility on-chip quantum interference. Jeremy is now a postdoc in QETLabs University of Bristol, working on integrated photonics for quantum information, graph state entanglement, and architectures for linear-optical quantum computing.

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