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Integrated Quantum Photonics

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Of the various approaches to quantum computing [1], photons are particularly appealing for their low-noise properties and ease of manipulation at the single qubit level [2]. Encoding quantum information in photons is also an appealing approach to quantum communication, metrology (eg. [3]), measurement (eg. [4]) and other quantum technologies [5]. However, the implementation of optical quantum circuits with bulk optics has reached practical limits. We have developed an integrated waveguide approach to photonic quantum circuits for high performance, miniaturisation and scalability [6]. Here we report high-fidelity silica-on-silicon integrated optical realisations of key quantum photonic circuits, including two-photon quantum interference and a controlled-NOT logic gate [7]. We have demonstrated controlled manipulation of up to four photons on-chip, including high-fidelity single qubit operations, using a lithographically patterned resistive phase shifter [8]. We have used this architecture to implement a small-scale compiled version of Shor's quantum factoring algorithm [9] and demonstrated heralded generation of tuneable four photon entangled states from a six photon input [10]. We have combined waveguide photonic circuits with superconducting single photon detectors [11]. Finally, we describe complex quantum interference behaviour in multi-mode inter- ference devices with up to eight inputs and outputs [12], and quantumwalks of correlated particles in arrays of coupled waveguides [13].

[1] T. D. Ladd, F. Jelezko, R. Laflamme, Y. Nakamura, C. Monroe, and J. L. OBrien, Nature 464, 45 (2010).
[2] J. L. O'Brien, Science 318, 1567 (2007).
[3] T. Nagata, R. Okamoto, J. L. O'Brien, K. Sasaki, and S. Takeuchi, Science 316, 726 (2007).
[4] R. Okamoto, J. L. O'Brien, H. F. Hofmann, T. Nagata, K. Sasaki, and S. Takeuchi, Science 323, 483 (2009).
[5] J.L.O'Brien,A.Furusawa, and J.Vuckovic, NaturePho- ton. 3, 687 (2009).
[6] A. Politi, M. J. Cryan, J. G. Rarity, S. Yu, and J. L. O'Brien, Science 320, 646 (2008).
[7] A. Laing, A. Peruzzo, A. Politi, M. R. Verde, M. Halder, T. C. Ralph, M. G. Thompson, and J. L. O'Brien, arXiv:1004.0326
[8] J. C. F. Matthews, A. Politi, A. Stefanov, and J. L. O'Brien, Nature Photon. 3, 346 (2009).
[9] A. Politi, J. C. F. Matthews, and J. L. O'Brien, Science 325, 1221 (2009).
[10] J. C. F. Matthews, A. Peruzzo, D. Bonneau, and J. L. O'Brien, arXiv:1005.5119
[11] C. M. Natarajan, A. Peruzzo, S. Miki, M. Sasaki, Z. Wang, B. Baek, S. Nam, R. H. Hadfield, and J. L. O'Brien, Appl. Phys. Lett. 96, 211101 (2010).
[12] A. Peruzzo, A. Laing, A. Politi, T. Rudolph, and J. L. O'Brien, arXiv:1005.5119
[13] A. Peruzzo, M. Lobino, J. C. F. Matthews, N. Matsuda, A. Politi, K. Poulios, X.-Q. Zhou, Y. Lahini, N. Ismail, K. Worhoff, Y. Bromberg, Y. Silberberg, M. G. Thompson, and J. L. O'Brien, Science 329, 1500 (2009)