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Polarisation singularities in photonic crystals for an on-chip spin-photon interface DARYL M. BEGGS, ANDREW B. YOUNG, ARTHUR C. T. THIJSSEN, RUTH OULTON, University of Bristol — Integrated quantum photonic chips are a leading contender for future quantum technologies, which aim to use the entanglement and superposition properties of quantum physics to speed up the manipulation of data. Quantum information may be stored and transmitted in photons, which make excellent flying qubits. Photons suffer little from decoherence, and single qubit gates performed by changing photon phase, are straightforward. Less straightforward is the ability to create two qubit gates, where one photon is used to switch another's state; inherently difficult due to the extremely small interaction cross-section between photons. The required deterministic two-qubit interactions will likely need a hybrid scheme with the "flying" photonic qubit interacting with a "static" matter qubit. Here we present the design of a photonic crystal waveguide structure that can couple electron-spin to photon path, thus providing an interface between a static and a flying qubit. We will show that the complex polarization properties inherent in the photonic crystal eigenmodes supports polarization singularities – positions in the electric field vector where one of the parameters describing the local polarization ellipse is singular – and that these singularities are ideal for a range of quantum information applications. In particular, we will show that by placing a quantum dot at one of these singularities, the electron-spin becomes correlated with the photon emission direction, creating an in-plane spin-photon interface that can transfer quantum information from static to flying qubits.

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