Quantum interference between topologically protected edge states in a laser written waveguide array

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The topological properties of matter can strongly influence quantum transport in solid-state systems. These effects can be directly translated to topological photonics systems, where waveguide arrays or photonic crystal structures with a properly engineered band structure are capable of supporting topologically protected surface states of light [1,2]. Such systems, due to the remarkable features of robustness against scattering with lattice defects and imperfections offered by topologically protected states, potentially find important applications in the field of integrated quantum photonics, allowing for the fabrication of large-scale integrated optics devices for quantum computing, communication and metrology. In fact, several topological photonics systems have been studied experimentally [1,2], but the quantum interference between topological single photon states, which is the key ingredient in topological photonics-based quantum devices, is yet to be explored.

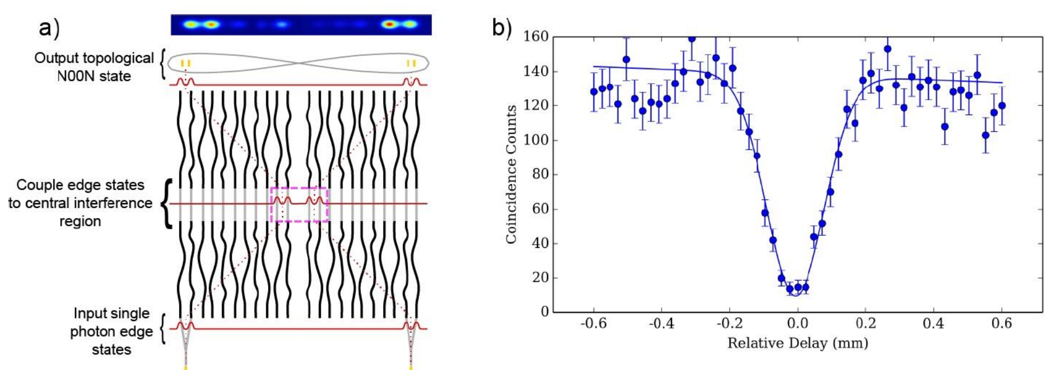

Figure 1: a) Schematic of the waveguide array that implements the beam splitter operation between the two topologically protected states localized at its edges. The waveguides inter-distance is continuously modulated for adiabatically overlap the two modes at the lattice center. b) Hong-Ou-Mandel interference dip measured when indistinguishable photons are used to excite simultaneously the two topological states at the device input.

In this work, we realize a linear array of evanescently coupled optical waveguides implementing the space-dependent Aubry, André and Harper (AAH) Hamiltonian [3], which behaves as beam splitter for the two topological states supported at the lattice edges. The interference between these modes is achieved by carefully modulating the waveguides inter-distances across the whole lattice, for transferring them adiabatically at the center of the device, as depicted in Fig. 1a. This device was realized by femtosecond laser micromachining, which is very effective in realizing highly engineered waveguide arrays [4]. First, we verified the correct functioning of the beam splitting operation with classical light. Then we probed the device by injecting indistinguishable single photon exciting simultaneously the two topological modes and we observed high visibility Hong-Ou-Mandel interference at the device output (see Fig. 1b.). Our experimental investigation benchmarks the use of topological photonics states for developing robust quantum technology integrated platforms

References

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