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Quantum Hall physics with photons and its application[1]

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Phenomena associated with the topological properties of physical systems can be naturally robust against perturbations. This robustness is exemplified by quantized conductance and edge state transport in the quantum Hall and quantum spin Hall effects. Here we demonstrate how quantum spin Hall Hamiltonians can be simulated with linear optical elements using a network of coupled resonator optical waveguides (CROW) in two dimensions. Key features of quantum Hall systems, including the characteristic Hofstadter butterfly and robust edge state transport, can be obtained in such systems. As a specific application, we show that topological protection can be used to improve the performance of optical delay lines and to overcome some limitations related to disorder in photonic technologies. Furthermore, the addition of an optical nonlinearity to our proposed system leads to the possibility of implementing a fractional quantum Hall state of photons, where phenomenon such as fractional statistics may be observable.

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