Photonic Floquet topological insulators

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In 2005, Srinivas Raghu and Duncan Haldane predicted [1] that the incredibly robust flow that electrons exhibit in the quantum Hall effect could be carried over to photonic systems by constructing magnetically active (non-zero Verdet constant) photonic crystals. Marin Soljacic's group showed theoretically [2] and demonstrated in a microwave photonic crystal experiment [3] that this robustness (enabled by so-called "topological protection from scattering") was indeed achievable. The hunt was on for optical topological protection, but using the Raghu-Haldane mechanism was impossible due to the weak magnetic response at wavelength scales. Many theoretical works proposed a range of different mechanisms to circumvent this problem.

Here, I will present the prediction and realization of a photonic topological insulator for light [4]. Topological insulators (TIs) are solid-state materials that are insulators in the bulk, but conduct electricity along their surfaces - and are intrinsically robust to disorder. In particular, when a surface electron in a TI encounters a defect, it simply goes around it without scattering, always exhibiting – quite strikingly – perfect transmission. The structure is an array of coupled helical waveguides (the helicity generates a fictitious – or artificial - circularly-polarized electric field that leads to the TI behavior), and light propagating through it is 'topologically protected' from scattering. Topological protection therefore has the potential to endow photonic devices with quantum Hall-like robustness.

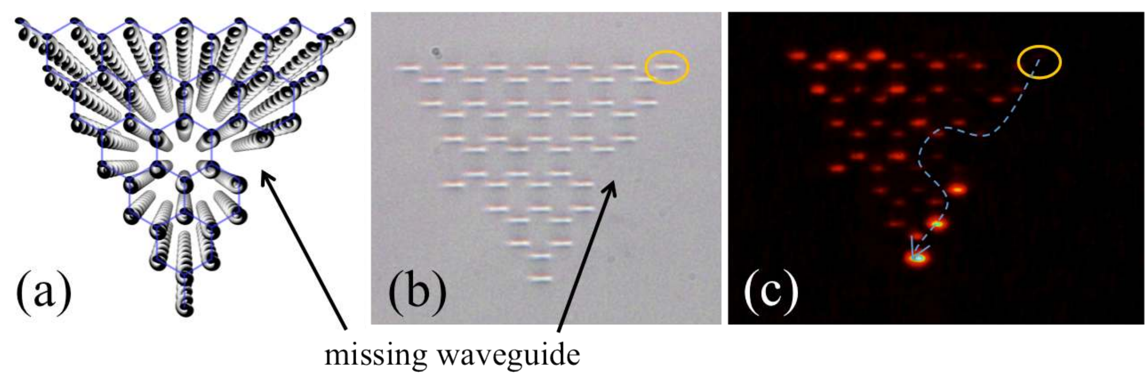

Fig. 1: (a) Schematic of photonic topological insulator structure composed of helical waveguides in a honeycomb lattice; (b) microscope image of input facet with an artificial defect (missing waveguide); (c) light propagates past the defect without backscattering.

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