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The Science and Applications of Photonic Topological Insulators: From Robust Delay Lines to Non-Reciprocal Metawaveguides[1]

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Electromagnetic (EM) waves propagating through an inhomogeneous medium inevitably scatter whenever the mediums electromagnetic properties change on the scale of a single wavelength. This fundamental phenomenon constrains how optical structures are designed and interfaced with each other. Our theoretical work indicates [1] that electromagnetic structures collectively known as photonic topological insulators (PTIs) can be employed to overcome this fundamental limitation, thereby paving the way to ultra-compact photonic structures that no longer have to be wavelength-scale smooth. Here I present the first experimental demonstration of a photonic structure that supports topologically protected surface electromagnetic waves (TPSWs) that are counterparts to the edge states between two quantum spin-Hall topological insulators in condensed matter. Unlike conventional guided EM waves that do not benefit from topological protection, TPSWs are shown to experience reflections-free time delays when detoured around sharply-curved paths, thus offering a unique paradigm for wave buffers and delay lines. I will also discuss how the photonic analogs of the quantum Hall and valley-Hall topological insulators can be realized and interfaced with each other. [1] T. Ma et. al., "Guiding Electromagnetic Waves around Sharp Corners: Topologically Protected Photonic Transport in Metawaveguides", Phys. Rev. Lett. 114, 127401 (2015).

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