Spin and Orbital Angular Momentum in Topological Photonic Crystals

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Engineering local angular momentum in structured light fields enables unprecedented development in many fields, such as photonic quantum-information processing [1] and selective excitation of valleys in photonic crystals [2,3]. As a kind of structured light fields, pseudo-spin source is an indispensable issue for unidirectional transport in topological photonic crystals; however, it is difficult to construct, especially in optical frequency. Here, we show angular momentum of pseudo-spins in a silicon topological photonic crystal. Due to the fact that optical circularly polarized source is naturally in terms of electric fields, we restrict on transverse electric polarization in such two-dimensional photonic crystal with nontrivial topology. In this way, the pseudo-spin source is related to transverse spin and orbital angular momentum, a true spin that can be possible to achieve by either quantum dot or customized-fiber nanotip, which is totally different from those in previous literatures [4-6]. It is interesting to observe circularly polarized (CP) points at certain positions in the map of ellipticity angle between E_x and E_y components, near the interface of topologically nontrivial silicon photonic crystal; while the handedness of circular-polarization is locked to the direction of pseudo-spins. Meanwhile, we also find similar phase vortices with its handedness locking to the pseudo-spin direction for orbital angular momentum. The above findings enable to realize unidirectional robust transport of pseudo-spin edge states. For example, a right-handed circularly-polarized (RCP) source at the correct position will lead to the light flow leftward, while a left-handed circularly-polarized (LCP) source will excite the light flow towards the opposite direction. The simulation results are illustrated in Figure 1 below. Our work paves the way for observing unidirectional transport of light in optical regime and may lead to potential applications in integrated photonic circuits such as robust delay line.

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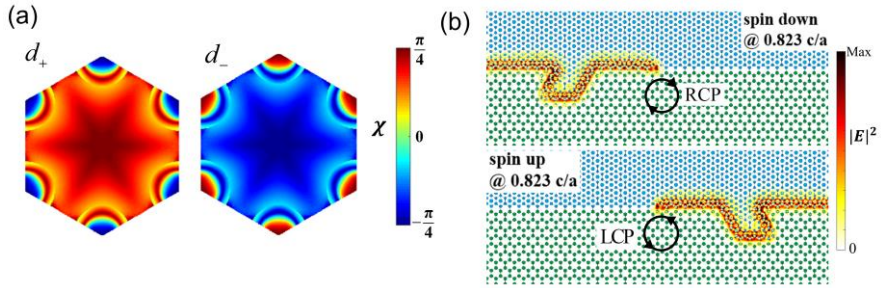

Fig. 1 Transverse spin angular momentum and unidirectional robust transport in silicon topological photonic crystals. (a) Ellipticity angle distribution of pseudo-spin up state d_+ *and pseudo-spin down state* d_-*. The rod radius is 0.33b, where b is the distance between the nearest rods. (b) Unidirectional pseudo-spin down and up edge states, which is excited by the right-handed circularly-polarized (RCP) and left-handed circularly-polarized (LCP) sources, respectively.*