トポロジカルフォトニック結晶一方向導波路を用いたＹ型合波器
Y-junction optical combiner composed of unidirectional waveguides utilizing topological photonic crystals

東大[1]　°(D)陸 広泰[1]，岩本 敏[1]

Univ. Tokyo[1], °(D) Guangtai Lu[1], and Satoshi Iwamoto[1]

E-mail: lugt@iis.u-tokyo.ac.jp

The phenomenon of destructive interference in light indicates that two out-of-phase light waves can cancel each other out. This principle, however, seems to challenge the concept of energy conservation, due to the inequality of input power and output power, which is also known as interference paradox (see Figure 1(a)). However, it is theoretically impossible to couple two such light waves into a single mode. For instance, when a beam splitter receives two out-of-phase incoming beams, it produces two outgoing beams: one that undergoes destructive interference and another that experiences constructive interference due to a phase shift. Traditional Y-junctions, shown in Figure 1(b), result in no light coupling to the output port due to destructive interference inside the waveguide but the energy leakage through radiation modes.[1] For photonic crystal Y-junctions, destructive interference is associated with energy reflecting back to the source (Figure 1(c)) or out-of-plane radiation.[2]

Recent advances in topological photonic crystals in quantum Hall phase have opened new possibilities for creating unidirectional waveguides that are immune to back scattering.[3] A Y-junction optical combiner based on these unidirectional waveguides can function differently because of no backscattering at the junction.

We consider a 2D structure composed of photonic crystals carrying different Chern numbers. Different from conventional Y-junction combiners, in the topological Y-junction combiner, two out-of-phase inputs are combined and guided to the output port as demonstrated in Fig. 1(d). The result reveals that energy conservation is held through bulk-edge correspondence. This principle necessitates that the output waveguide must be multimode. The destructive interference in one of the output mode is associated with the constructive interference in another output mode, keeping the energy conservation of the system.

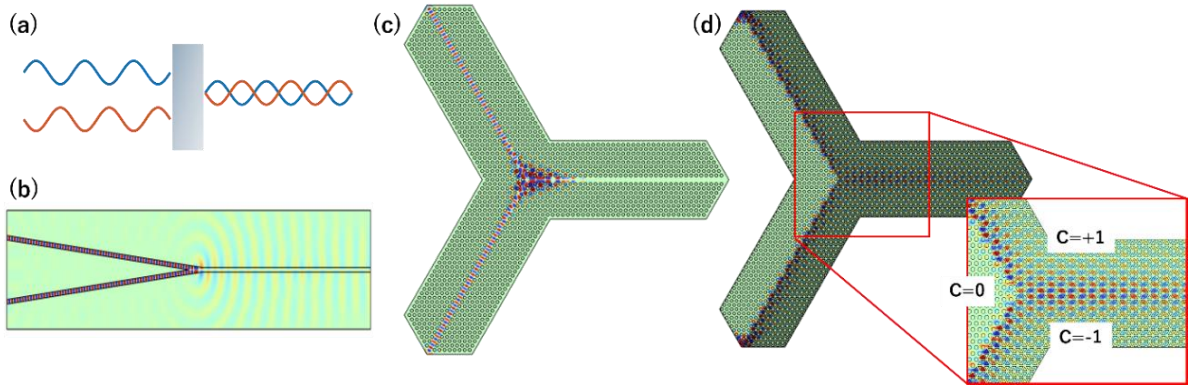

Figure 1. (a) Illustration of destructive interference. (b-d) Destructive interference by input out-of-phase waves in (b) traditional Y-junction. Energy leakage through radiation. (c) photonic crystal Y-junction. Energy leakage through reflection. (d) topological Y-junction. Energy is preserved due to its multimode nature. Chern numbers of photonic crystals are labeled.

References: [1] S. K. Burns, et al. IEEE J. Quantum Electron. QE-16 (1980): 446-454 [2] Y. Wu, et al. Physica B: Condensed Matter 405.7 (2010): 1832-1835. [3] Z. Wang, et al. Nature 461.7265 (2009): 772-775.