Optical Isolation with Nonlinear Topological Photonics

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Outline

- Optical Isolation
  - What is optical isolator
  - Why we want optical isolator
  - How to achieve optical isolation
- Topological Photonics
  - Topological state
  - Realizing Topological Edge State in Photonic System
- Topological Optical Isolation
  - 1D SSH model
  - 2D Haldane model
  - 2D lattice of coupled ring waveguides

What is Optical Isolation

Optical isolators are devices that allow light to pass in one direction (e.g., along a waveguide), while blocking transmission in the other direction, thus acting as the analogues of diodes in electronic circuits

- Facilita

Why We Need Optical Isolator

Reason

- In modern fibre communication networks it is an essential device to prevent interference between different parts of the networks.

Why need on-chip size optical isolator

- Nowadays people become more and more interested in large-scale on-chip networks, so optical isolation on-chip size is becoming increasingly important.

How to Achieve Optical Isolation

Lorenz Reciprocity

For linear, static and non-magnetic material,

$$\nabla \cdot (E' \times H'' - E'' \times H') = j\omega(E''\epsilon E' - E'\epsilon E'' - H''\mu H' + H'\mu H'') = 0 \quad (1)$$

Here, (E', H') and (E'', H'') are two sets of excitation.

Ways to break Lorenz Reciprocity

Magneto-Optical Effect

For magneto-optical material so ϵ and μ are non-symmetric tensor.

Optical Nonlinearity

For nonlinear material, right side of Eq.(1) =
$j\omega(E''\epsilon(E')E' - E'\epsilon(E'')E'' - H''\mu(H')H' + H'\mu(H'')H'')$

Spacial-temporal Modulation

For ϵ and μ depend on time, the derivation is not valid, so does Lorentz Reciprocity.

How to Achieve Optical solation

Lorenz Reciprocity

For linear, static and non-magnetic material,

$$\nabla \cdot (E' \times H'' - E'' \times H') = j\omega(E''\epsilon E' - E'\epsilon E'' - H''\mu H' + H'\mu H'') = 0 \quad (2)$$

Here, (E', H') and (E'', H'') are two sets of excitation.

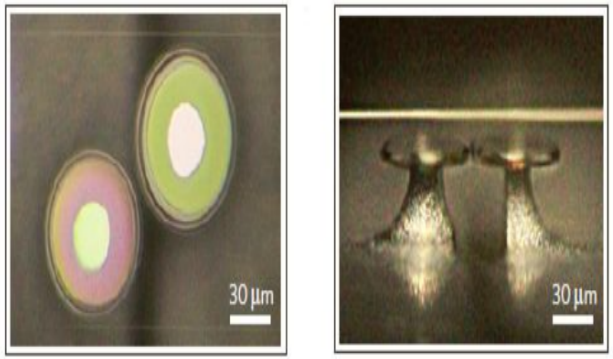
Magneto-Optical Effect

For magneto-optical material so ϵ and μ are non-symmetric tensor.

Figure 1: Commercial Faraday Optical Isolator

Optical Nonlinear Material

For nonlinear material,ϵ and μ depend on E and H



Peng, Bo, et al Nature Physics 10.5 (2014): 394

Spacial-temporal Modulation

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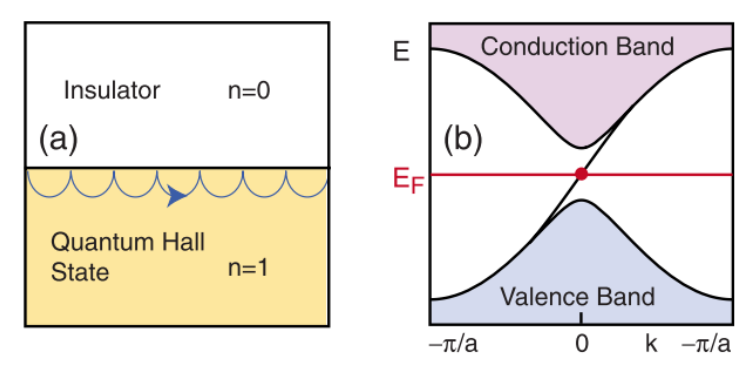
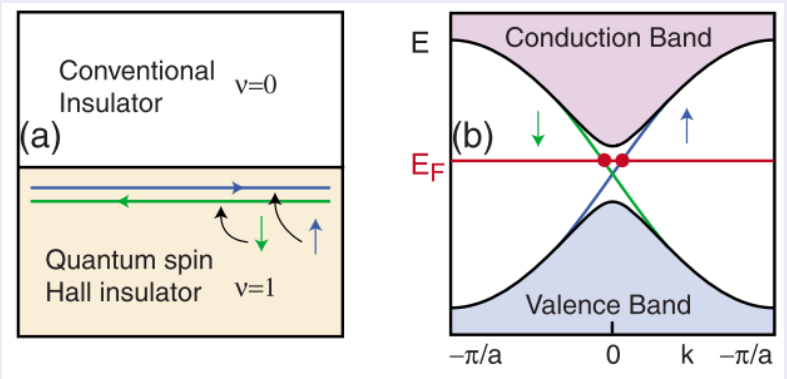
Topological Photonics

Discover of Topological State

Insulating in the bulk while conducting in the surface without backscattering even in the presence of impurities.



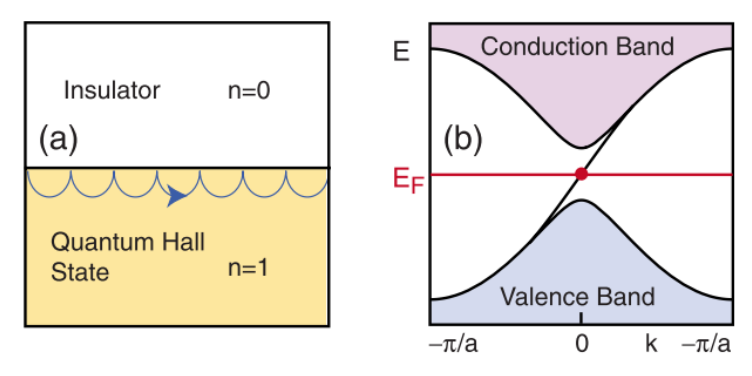
(a) Quantum Hall Effect. Time reversal symmetry is broken. Hasan and Kane, RMP, 2010



(b) Quantum Spin Hall Effect. Time reversal symmetry is preserved. Hasan and Kane, RMP, 2010

Topological Photonics

Realize Topological State in Photonic System



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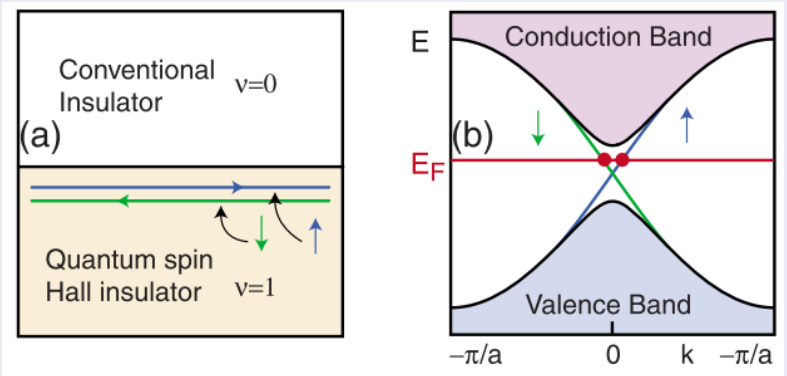

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