Topological Description for Optical Mirrors

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Metametarials with designed permittivity ε and permeability μ have attracted great interesting for their unusual properties of controlling light. In general, optical materials can be classified into two parts depending on the sign of $\varepsilon \bullet \mu$, i.e. optical conductors for both double-positive materials ($\varepsilon > 0, \mu > 0$) and double-negative materials ($\varepsilon < 0, \mu < 0$); optical insulators or mirrors for both ε-negative (ENG) materials ($\varepsilon < 0, \mu > 0$) and μ-negative (MNG) materials ($\varepsilon > 0, \mu < 0$). Inspired by recent studies on novel properties of electronic topological insulators, we have developed a topological description for optical mirrors based on the mapping between the Dirac equation and Maxwell's equation in 1D systems [1,2]. It is shown that there exists topological difference between ENG and MNG mirrors as the result of mass inversion in the Dirac equation, and it can be realized by tailoring the permittivity and permeability of metamaterials in the approach of microwave transmission lines. Photonic analogs of topological excitations of the Dirac equation have been observed, such as: (1) soliton excitation as a domain wall in a pairing structure with ENG-MNG mirrors; (2) the end state coming from the Berry phase in a 1D stack of ENG-MNG mirrors. Extensions to 2D systems are also discussed.

Reference

[1] S.Q. Shen, *Topological insulators: Dirac Equation in Condensed matters*, Springer-Verlag, Berlin, 2012.

[2] Tan, W., Sun, Y., Chen, H. & Shen, S.-Q. Photonic simulation of topological excitations in metamaterials. Sci. Rep. 4, 3842; DOI:10.1038/srep03842 (2014).