Analysis and Computations of Topological Edge States in Photonic Graphene

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Topological materials have been very popular research topics in different fields. Their novel and subtle properties have attracted a lot of theoretical and experimental studies. In this talk, the speaker will introduce his research group's recent results on the analysis and computation of the topological edge states in photonic graphene, which is an easily realizable topological material and has wide applications. Specifically, they study the propagation of electromagnetic waves governed by the two-dimensional Maxwell equations in honeycomb media. Thanks to the symmetries of the media, existence of Dirac points and corresponding Dirac dynamics are rigorously analyzed. Moreover, the introduction through small and slow variations of a domain wall across a line-defect gives rise to the bifurcation from Dirac points of highly robust (topologically protected) edge states. Via a rigorous multi-scale analysis, they give an explicit description (to leading order) of the edge states. Unfortunately, the multi-scale analysis only applies in the regime where the line defect is small and adiabatic. For large and non-adiabatic line defects, they propose a novel gradient recovery method based on Bloch theory for computation of such edge states. Compared to standard finite element methods, this method provides higher order accuracy with the help of gradient recovery technique. This higher accuracy is highly desired for constructing the full electromagnetic fields under propagation.