Symmetry Protected Z_2 Berry Phase in Massless Dirac Fermion Systems

T. Kariyado and Y. Hatsugai

Division of Physics, University of Tsukuba

A bulk topological number in the usual sense cannot be well defined in massless Dirac fermion systems owing to the gapless nature of the energy spectrum. Instead of some bulk topological number, Berry phases defined with the one-dimensional momentum as a parameter are useful in developing "topological" arguments, such as the bulk-edge correspondence, in massless Dirac fermion systems. By definition, the Berry phase can take any value (modulo 2π), but it is quantized into Z_2 (0 and π) and becomes topological when the Hamiltonian respects some symmetry. The chiral symmetry has been often employed for this purpose[1].

In this study, we show that the symmetries existing in more general situations, namely the inversion and time reversal (or reflection) symmetries, are sufficient for quantizing the Berry phase, and developing topological arguments in massless Dirac fermion systems. We show the intimate relation between the quantized Berry phase and the topological stability of the massless Dirac fermions in two dimension. We also demonstrate the bulk-edge correspondence, which is the connection between the Berry phase and existence of edge modes, using a model having the massless Dirac fermions, but having no chiral symmetry[2].

[1] S. Ryu and Y. Hatsugai, Phys. Rev. Lett. **89**, 077002 (2002).
[2] T. Kariyado and Y. Hatsugai, arXiv:1307.7926.