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Why does the gapless state appear only on the surface?

Abstract:
Topological insulator is a recently established exotic state of matter that exhibits a "topologically protected" metallic surface state [or Dirac cone(s) in the surface spectrum (such as the ones in graphene)], though it behaves in the bulk of the sample just as "ordinary" band insulators do. The topological insulator is distinguished from other ordinary band insulators by possessing a non-trivial topological number characteristic to its (bulk) band structure, and in this sense regarded as belonging to a distinct *phase* even in the non-interacting limit. Theorists have so far considered why this non-trivial topological number defined in terms of the purely bulk quantities can be used to ensure the existence of a gapless state that appears when the crystal is cleaved to open a surface, leaving one fundamental question: why does such a gapless state appear only on the surface of the system? Here, we argue [1] that this is because of the spin connection [2,3] associated with a constraint on the spin of the surface state with respect to its real space geometry.

[1] K.-I. Imura, Y. Takane, "Noninvasive Metallic State", arXiv:1211.2088.
[2] K.-I. Imura, Y. Yoshimura, et al., "Spherical topological insulator", Phys. Rev. B 86, 235119 (2012).
[3] K.-I. Imura, Y. Takane and A. Tanaka, "Spin Berry phase in anisotropic topological insulators", Phys. Rev. B 84, 195406 (2011).