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Discrete quantum geometry and intrinsic spin Hall effect

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The topological classification of continuous manifolds in real space and reciprocal space has been extensively discussed for solid-state materials. This has led to the discoveries of many intriguing materials hosting non-trivial topological orders such as helical magnets, skyrmion magnets, Chern insulators, Z2 insulators and Weyl semimetals. However, the discrete topology and geometry in these scenarios have attracted much less attention. Here I will introduce our efforts in practicing the discrete geometry and topology in solid-state physics. Such discrete perspective not only refreshes our conventional understanding, but it also resolves many difficulties encountered by their continuous counterparts. In particular I will discuss (i) the topological transition of spin textures defined on a discrete lattice, and (ii) the geometry and the topology of gapless topological materials by considering the Fermi surface as a 3D quantum manifold.