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Feng Liu[1]
Tomoaki Kameda[1], Katsunori Wakabayashi[1,2]
[1]Department of Nanotechnology for Sustainable Energy, School of Science and Technology, Kwansei Gakuin University, Gakuen 2-1, Sanda, Hyogo 669-1337, Japan
[2]National Institute for Materials Science (NIMS), Tsukuba, Ibaraki 305-0044, Japan
Ruserzzz@gmail.com

Topological dipoles and quadrupoles

Topology offers us a unique dimension of designing solid-state materials. One famous example is the Quantum spin Hall effect (QSHE) where electrons of opposite spins propagate oppositely. The origin of QSHE comes from a geometric field strength in momentum space that is the so-called Berry curvature. Besides QSHE, the geometric vector potential whose curl yields the Berry curvature – the Berry connection, can induce an electric dipole even under zero Berry curvature. The topological electric dipoles result fractional surface charges that manifest as topological edge states, which are robust to defects and edge roughness. Furthermore, a pair of such the topological dipoles can form a high order multipole – quadrupole, which corresponds to the topological corner states.

In this talk we will discuss a simple tight-binding model that possesses topological dipoles and quadrupoles in zero Berry curvature [1]. Experimental realizations based on solid-state material and dielectric photonic crystal are proposed [2]. Furthermore, we show that in a pure quadrupole phase, topological edge state is pseudo-spin polarized in general [3].

References

[1] F. Liu and K. Wakabayashi, Phys. Rev. Lett. **118**, 076803 (2017)
[2] F. Liu, H.-Y. Deng and K. Wakabayashi, Phys. Rev. B 97, 035442 (2018)
[3] F. Liu, H.-Y. Deng and K. Wakabayashi, arxiv: 1809.10824

Figures

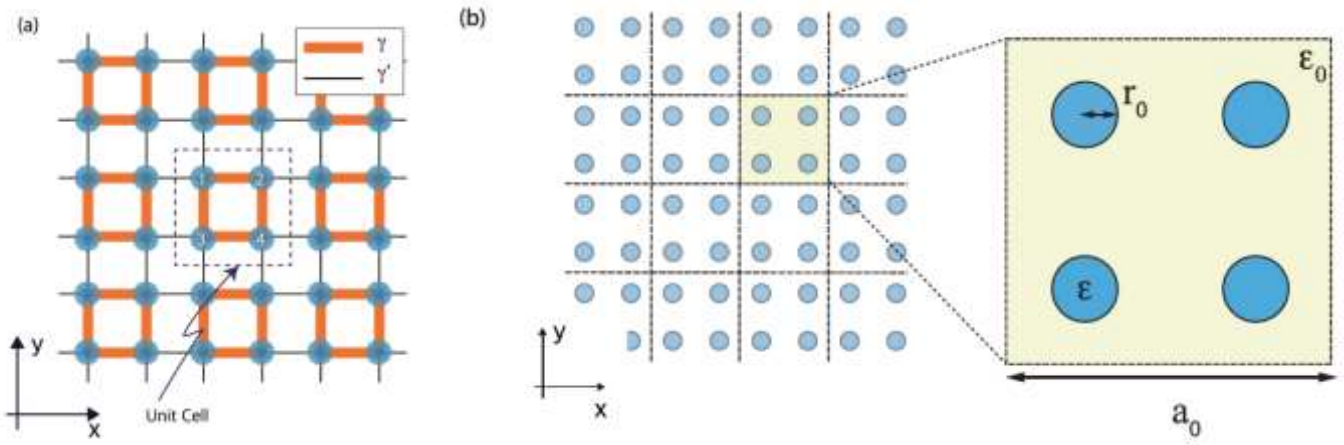

Figure 1: (a) Schematic lattice structure of the 2D SSH model. The model is specified by the intracellular hopping γ and the intercellular hopping γ'. (b) Schematic of the dielectric crystal mimicking the 2D SSH model. The unit cell consists of four identical dielectric cylinders of radius r_0 placed at $(\pm 0.25, \pm 0.25)r_0$. The lattice constant is a_0.