

Laser-Driven Higher Chern Number And Spin Chern Number States in the Quantum Spin Hall Phase of α-T3 Model

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α - T3 Model

- Interpolation between honeycomb lattice and dice lattice
- A, B and C sites in alpha-t3, where alpha is a variable parameter controlling the strength of the hopping between B and C
- Quantum spin hall in the alpha-t3 supports a higher spin chern number



Our System

- We want to control the chern number or edge states
- Use lasers since they are powerful tools in controlling the phase of matter
- Laser used is high frequency and is represented by A. A ~ intensity/frequency < 1



Hamiltonian

- Conventional NN hopping, Intrinsic SOI and light dressed Haldane terms are considered
- Hamiltonian can be used to get the energy distribution and to calculate the Chern and Spin Chern Numbers (involves the integration over the Berry Curvature)

$$\begin{split} H &= J_0(K_A a)t \sum_{\langle i,j \rangle} C_i^{\dagger} C_j + J_0(K_A a)t' \sum_{\langle j,k \rangle} C_j^{\dagger} C_k + J_0 \left(\sqrt{3}K_A a\right) \frac{i\lambda}{3\sqrt{3}} \sum_{\langle i,j \rangle = ij} C_i^{\dagger} \sigma_z C_j \\ &+ J_0 \left(\sqrt{3}K_A a\right) \frac{i\lambda'}{3\sqrt{3}} \sum_{\langle j,k \rangle = ij} C_j^{\dagger} \sigma_z C_k + J_1(K_A a)i\sqrt{3}t \sum_{\langle i,i \rangle = ij} C_i^{\dagger} \sigma_z C_i \\ &+ J_1(K_A a)i\sqrt{3}(t+t'') \sum_{\langle j,j \rangle = ij} C_j^{\dagger} \sigma_z C_j + J_1(K_A a)i\sqrt{3}(-t'') \sum_{\langle k,k \rangle = ik} C_k^{\dagger} \sigma_z C_k \end{split}$$



 $\int_{k}^{T} \sigma_{z} C_{k} + H_{onsite}$

Results

- Can obtain different Chern Numbers/Edge states by changing the A and alpha values! And this is supported analytically
- Potential applications of the α-T3 model lattice in Floquet engineering topological electronics by exploiting the topological properties of matter in devices with extended functionalities.



Results



Results

With Onsite Energy (U and SZ type)



A = 0.235, α = 0.2 C₁= 0, C₁= 1





A = 0.2, α = 0.175 C_↓ = 0, C_↑ = 1





Misc Plots

Graphene and Alpha-T3 band structures w/o incident laser



References :

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