Flat bands with non-trivial Hopf index

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We report the presence of exactly and nearly flat bands with non-trivial topology in three-dimensional (3D) lattice models. We first show that an exactly flat band can be realized in a 3D lattice model characterised by a 3D topological invariant, namely Hopf invariant. In contrast, both nearly and exact flat bands can be obtained in a 3D lattice, exhibiting both 2D Chern and 3D Hopf invariant. We find that such a Hopf-Chern model can be realized using a simple two-orbital 2D square lattice with in-plane nearest-neighbor and next-nearest hopping among different orbitals. Extending specific nearest and next-nearest hoppings along the third direction, we find both perfect and nearly perfect flat bands in all three planes at some special parameter values. While the nearly flat band carries a finite Chern number, the perfect flat bands have zero Chern number. Interestingly, such a 3D lattice construction from 2D allows finite Hopf invariant too. Finally, we show that higher Chern models can also be constructed in the same lattice setup with only nearest and next-nearest hopping, but the appearance of flat bands along high-symmetric path in the Brillouin zone requires long-range hopping. We close with a discussion on possible experimental platforms to realize the models.

References

[1] Ivan Dutta and Kush Saha, *Flat Bands in Three-dimensional Lattice Models with Non-trivial Hopf Index*, arXiv:2305.09616