HyperCells and HyperBloch: software packages for hyperbolic tight-binding models

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Hyperbolic lattices constitute a new kind of synthetic matter with an enhanced connectivity between the sites, resulting in an emergent negative curvature (Fig. 1). Such systems were in recent years realized in a range of experimental platforms, including coplanar microwave resonators, electric-circuit networks, and silicon photonics. This progress has also inspired questions into theoretical characterization of models on hyperbolic lattices, including an effective description of their energy bands and the nature of hyperbolic topological systems. Such analyses are complicated by the non-commutativity of hyperbolic translations and by appearance of non-Abelian Bloch states.

In this poster, I will present a computationally efficient way of computing bulk hyperbolic spectra that properly accounts for the non-Abelian Bloch states. Our approach is based on extracting Abelian eigenstates on increasingly larger hyperbolic supercells [1]. I demonstrate the method with applications to hyperbolic Haldane model (Figs. 1 and 2) [2], to hyperbolic non-Abelian semimetal [3], and to a hyperbolic Kitaev spin liquid [4].

References

[1] P. M. Lenggenhager, J. Maciejko, and T. Bzdušek, Phys. Rev. Lett. 131, 226401 (2023).

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[3] T. Tummuru, A. Chen, P. M. Lenggenhager, T. Neupert, J. Maciejko, and T. Bzdušek, Phys. Rev. Lett. 132, 206601 (2024).

[4] P. M. Lenggenhager, S. Dey, T. Bzdušek, and J. Maciejko, arXiv: 2407.09601 (2024).

Figures

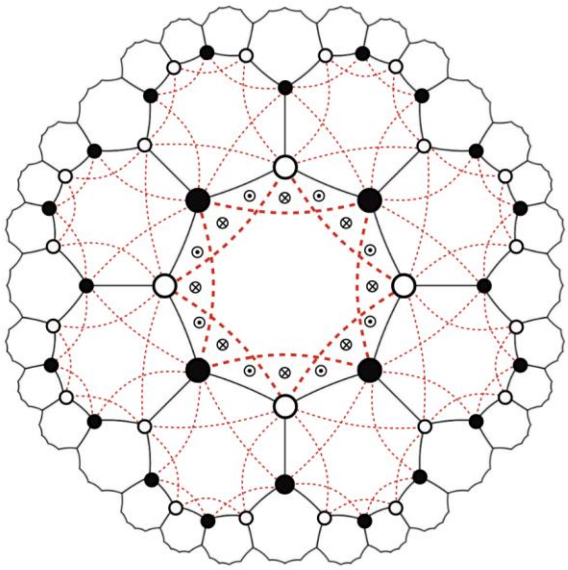

Figure 1: Haldane model on the hyperbolic {8,3} lattice, i.e. three octagons meeting at each vertex. Solid (dashed) lines show nearest (next-to-nearest) hoppings, the solids vs. empty circles indicate two sublattices, and the symbols inside the triangular regions indicate magnetic fluxes.

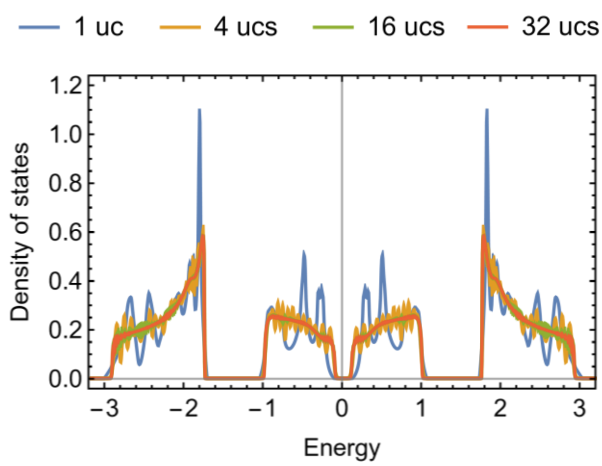

Figure 2: Spectrum of the hyperbolic Haldane model in Fig. 1 for specific model parameters, computed using the supercell technique with an increasingly larger supercell (measured in multiples of the primitive unit cells “ucs”).