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Hyperbolic topological band insulators

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The recently formulated hyperbolic band theory allows to describe single-particle energy states of tight-binding models in negatively curved spaces. The most salient feature of this theory is the unusually large dimension of the momentum space: the spectrum of particles on a two-dimensional hyperbolic lattice necessitates a characterization with an at least four-dimensional Brillouin zone. Such higher-dimensional momentum spaces imply the existence of a larger set of topological band invariants than for the Euclidean lattices, suggesting potentially new types of topological hyperbolic matter. In our theoretical work [1], we formulate hyperbolic versions of two paradigm topological tight-binding models, namely of (1) the Haldane model of Chern insulator, and of (2) the Kane-Mele model of time-reversal-symmetric topological insulator. These modifications are achieved by replacing the hexagonal cells of the honeycomb lattice by octagons. For both models, we analyze the correspondence between the bulk invariants in the 4D Brillouin zone, the real-space invariants in the 2D position space, and the appearance of metallic in-gap states at the boundaries. Our results provide pivotal steps towards unravelling topological aspects of models on hyperbolic lattices.

[1] D. M. Urwyler, P. M. Lenggenhager, I. Boettcher, R. Thomale, T. Neupert, and T. Bzdušek, "Hyperbolic topological band insulators", arXiv:2203.07292 (2022).