Kähler geometry and Chern insulators

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Abstract

The notion of topological phases has dramatically changed our understanding of insulators. There is much to learn about a band insulator beyond the assertion that it has a gap separating the valence bands from the conduction bands. In the particular case of 2d, the occupied bands may have a nontrivial topological twist determining what is called a Chern insulator. This topological twist is not just a mathematical observation, it has observable consequences—the transverse Hall conductivity is quantized and proportional to the 1st Chern number of the vector bundle of occupied states over the 2d Brillouin zone. Finer properties of band insulators refer not just to the topology, but also to their geometry. Of particular interest is the momentum-space quantum metric and the Berry curvature. The latter is the curvature of a connection on the vector bundle of occupied states. Both of these quantities can be extracted by periodically driving the system and measuring the transition rates.

The study of the geometry of band insulators can also be used to probe whether the material can host stable fractional topological phases. In particular, for a Chern band to have an algebra of projected density operators which is isomorphic to the W_∞ algebra found by Girvin, MacDonald and Platzman in the context of the fractional quantum Hall effect, certain geometric constrains are naturally found which enforce a compatibility relation between the quantum metric and the Berry curvature of the band endowing the Brillouin zone with a flat Kähler structure.

Motivated by the above, we will provide an overview of the geometry of Chern insulators from the perspective of Kähler geometry, introducing the notion of a Kähler band. Furthermore, we will provide a prescription, borrowing ideas from geometric quantization, to generate a flat Kähler band in some appropriate asymptotic limit. Such flat Kähler bands are potential candidates to host and realize fractional Chern insulating phases.

References

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