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Topological properties of multiterminal Josephson junctions

Topological phases of matter have been a subject of intense studies in recent years. In many instances, topological properties are encoded in the band structure and one has to find the right material or combination of materials in order to realize them. More recently, an alternative approach to finding and exploring topological states of matter has emerged: namely, one can “imitate” necessary physical ingredients by using other degrees of freedom. Multi-terminal Josephson junctions are of interest both as probes of the topological properties of the superconducting leads and as synthetic topological matter. Using the superconducting phases of the terminals in n-terminal Josephson junctions as variables, one may realize topological band structures in d=n-1 dimensions. In particular, we show that a 4-terminal junction may realize the analog of a Weyl semimetal, whereas a 3-terminal junction may realize the analog of a Chern insulator. Extending the analogy to more terminals opens the possibility of realizing topological phases in arbitrary dimensions, not accessible in real materials. We classify possible phases and provide an example for a gapped 3-dimensional topological phase characterized by a Z2-invariant in symmetry class C using 5-terminal junctions.