

Topological Superconductivity

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I. INTRODUCTION

The present review will focus on the basic properties of topological insulators with time-reversal symmetry.

II. BERRY PHASE

Notion of holonomy in the phase of Bloch state transported in the Brillouin zone around a closed loop under the effect of the Berry connection.

III. KRAMER'S THEOREM

1. Definition of the time reversal operator.
2. Description of the relation between pairs of opposite Bloch momentum in the Brillouin zone for time reversal symmetric systems.
3. Introduction of the notion of a Kramer pair of Bloch states and of time reversal invariant momenta.
4. Summary of the main consequences of the existence of time reversal moments on the band structure. (Topology of edge modes)

IV. INVARIANTS AND CLASSIFICATION

1. Description of the \mathbb{Z}_2 invariant its relation with the Berry phase.
2. Summary of the types of Topological insulator.
3. Bulk-boundary correspondence.

V. TOPOLOGICAL INSULATORS EXEMPLES

1. Description of simple models for two time reversal invariant topological insulators in 2 and 3 dimensions.
2. Link with real materials.

A. 2D

B. 3D

VI. CONCLUSION

1. Opening on other topological systems (topological Superconductivity and charge pumps)

[1] [2] [3] [4] [5] [6] [7] [8] [9] [10]

[1] Masatoshi Sato and Yoichi Ando. Topological superconductors: a review. *Rep. Prog. Phys.*, 80(7):076501, July 2017. arXiv: 1608.03395.

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[2] Rasoul Ghadimi, Takanori Sugimoto, K. Tanaka, and Takami Tohyama. Topological superconductivity in quasicrystals. *Phys. Rev. B*, 104(14):144511, October 2021.
[3] Di Xiao, Ming-Che Chang, and Qian Niu. Berry Phase Effects on Electronic Properties. *Rev. Mod. Phys.*, 82(3):1959–2007, July 2010. arXiv: 0907.2021.
[4] M. Z. Hasan and C. L. Kane. Topological Insulators. *Rev.*

- Mod. Phys.*, 82(4):3045–3067, November 2010. arXiv: 1002.3895.
- [5] *Topological Insulators and Topological Superconductors*. July 2013.
 - [6] Ning Sun and Lih-King Lim. Quantum Charge Pumps with Topological Phases in Creutz Ladder. *Phys. Rev. B*, 96(3):035139, July 2017. arXiv: 1703.03104.
 - [7] Ming-Che Chang. X 5 Berry phase in solid state physics. page 30.
 - [8] C.L. Kane. Topological Band Theory and the z_2 Invariant. In *Contemporary Concepts of Condensed Matter Science*, volume 6, pages 3–34. Elsevier, 2013.
 - [9] Dia’aaldin J Bisharat, Robert J Davis, R Bandaru, and Daniel F Sievenpiper. Photonic Topological Insulators: A Beginner’s Introduction. page 10.
 - [10] Yoichi Ando. Topological Insulator Materials. *J. Phys. Soc. Jpn.*, 82(10):102001, October 2013. arXiv: 1304.5693.