Topological Field Theories of Weyl Semi-metal and Topological Superconductors

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Introduction/Abstract

Conventionally the topological states possess gapped spectrum, and their universal, low energy physics are described in terms of appropriate topological field theories, with quantized coefficients. The topological field theories capture the quantized, non-dissipative response of appropriate conserved quantity. Some interesting examples of topological field theories are (i) the Chern-Simons theory of the quantum Hall effect in (2+1)-dimensions, and (ii) the axionic description of the quantized magneto-electric effect for (3+1)-dimensional strong topological insulators. There are growing theoretical and experimental interests in the Weyl semi-metal phase, which is a gapless state with non-trivial momentum space topology. This phase may be realized in pyrochlore iridates, magnetically doped narrow gap semi-conductors, ferromagnetic superconductors etc. In our recent work [1], we have developed a topological field theoretic description of the anomalous transport properties of the Weyl semi-metal. Recently, superconductivity has been realized in copper intercalated bismuth selenide and indium doped tin telluride. The preliminary mean field theory studies and the point contact spectroscopy measurements have suggested the possibility of realizing an odd parity topological superconducting state in these materials. In paper [2], we have developed the effectivel field theory of odd parity topological superconductors, which captures the modifications of the Landau-Ginzburg theory due to the topological aspects.

Results and Conclusions

In paper [1] we have demonstrated that the electrodynamics of Weyl semi-metal is described by an axionic field theory. However, in contrast to the topological insulators, the axion angle is not quantized and it is proportional to the momentum space separation of the Weyl nodes. The axionic action correctly captures the semi-quantized anomalous charge Hall conductivity, the bulk boundary correspondence, and the existence of chiral surface states. Our results also show the robustness of the anomalous Hall conductivity in the presence of a chemical potential, finite temperature, disorder and electronic interaction. We have also explored the connection between the gravitational anomaly and the topological field theoretical description of anomalous thermal Hall conductivity.

In paper [2], we have showed that an axionic field theory again arises for the electrodynamics of odd parity topological superconductors. The axion angle for superconducting problem is one half of the axion angle for topological insulators. This correctly captures the existence of surface Andreev bound states (Majorana fermions), with linear dispersion. The novel electrodynamic effects due to the axion term have also been studied. In addition, we have shown the existence of linearly dispersing fermion zero modes along the line vortices, under generic conditions. These fermion zero modes give rise to T-linear specific heat in the mixed/vortex phase, which may be useful in determining such exotic topological paired state.

Acknowledgements

Supported by the NSF Cooperative Agreement No. DMR-0654118, and the State of Florida.

References

[1] Pallab Goswami and Sumanta Tewari, arXiv:1210.6352 (2012).
[2] Pallab Goswami and Bitan Roy, arXiv:1211.4023 (2012).