Strong Correlation Effects in Topological Quantum Phase Transitions

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Abstract

Topological Quantum Phase Transitions (TQPT) are characterized by changes in global topological invariants. These invariants classify quantum systems beyond the conventional paradigm of local order parameters. For noninteracting electrons, it is well understood that such transitions are continuous and always accompanied by a gap closing of the energy gap, as long as the symmetries protecting the topological phase are preserved.
However, the recent progress in engineering and predicting non-trivial topological states in heavy-elements compounds or transition metal oxides heterostructures, pushed attention to the effects of large electronic interaction in Topological Insulators (TI).

Here, we demonstrate that a sufficiently strong electron-electron interaction can fundamentally change the conventional portrait of TQPT: we uncover a topological transition of first-order character in the genuine thermodynamic sense occurring for strong enough interaction. Our theoretical study reveals the existence of a quantum critical endpoint, associated with an orbital instability, on the transition line between a TI and a trivial band insulator either in 2D or in 3D. Following the evolution of the transition line we show that the conventional paradigm of continuous TQPT breaks down in presence of interaction: The change of the topological invariants takes place without energy gap closing and without breaking of any of the symmetries underlying the non-trivial phase.

Finally we show how the Time-Reversal Symmetry, protecting the gapless helical edge states in TIs, opposes to the large electronic interaction via edge states reconstruction mechanism: The progressive penetration of the helical states into the bulk.

[1] A. Amaricci, J. C. Budich, M. Capone, B. Trauzettel and G. Sangiovanni, Phys. Rev. Lett. **114**, 185701 (2015)
[2] A. Amaricci, J. C. Budich, M. Capone, B. Trauzettel and G. Sangiovanni, Phys. Rev. B **93**, 235112 (2016)
[3] A. Amaricci, G. Sangiovanni, L. Privitera, J. C. Budich, M. Capone and B. Trauzettel, in preparation (2016)