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Proximity-induced magnetization dynamics, interaction effects, and phase transitions on a topological surface[1]

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When a ferromagnetic or antiferromagnetic insulating layer is grown on the surface of a three-dimensional topological insulator, ferromagnetic order is induced on its surface. In the case of an out-of-plane magnetization, the Dirac fermion surface states become gapped. Quantum fluctuations of the Dirac fermions significantly affect the dynamics of the magnetization at the interface between the topological insulator and the magnetic material. In this talk we will discuss different aspects of the proximity-induced effective action on the topological surface and show that the Coulomb interaction between the Dirac fermions play a crucial role. In the case of a ferromagnet inducing an out-of-plane magnetization, the magnetization dynamics is modified due to a fluctuation-induced Chern-Simons term in the effective action. Such a topological term leads to a topological magnetoelectric torque in the Landau-Lifshitz-Gilbert equation, which is coupled to a non-local Poisson equation for the fluctuating electric field associated to the Coulomb interation. At finite temperature this leads to a downwards shift of the Curie temperature on the topological surface relative to the Curie temperature of the ferromagnet in the absence of the topological insulator. We also analyze the influence of the chemical potential on the magnetization dynamics and phase transitions at finite temperature and show that a thermoelectric screening takes place depending on the magnitude of the fermionic gap. For the case of an in-plane magnetization, a quantum phase transition occurs as the strength of the Coulomb interaction is varied, leading in this way to a semimetal-insulator transition on the topological surface. A Chern-Simons term is generated only when the Coulomb interaction is large enough. In this case parity and time-reversal symmetries are spontaneously broken. A semimetal insulator transition also happens when the magnetic layer is antiferromagnetic. In this case there is quantum criticality with unconventional critical exponents, and the magnetic susceptibility features a large anomalous dimension.

[1] F. S. Nogueira and I. Eremin, Phys. Rev. Lett. **109**, 237293 (2012).
[2] F. S. Nogueira and I. Eremin, Phys. Rev. B **88**, 085126 (2013).
[3] F. S. Nogueira and I. Eremin, arXiv:1309.3451.

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