Entanglement spectrum of bismuth-based thin films

M. Brzezińska, M. Bieniek, P. Potasz, and A. Wójs

Department of Theoretical Physics, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370, Wrocław, Poland

We investigate topological properties of bismuth and bismuth-antimony bilayers by employing multi-orbital tight-binding model [1] and entanglement measures. Topologically non-trivial band structure implies the existence of symmetry-protected conducting edge states. Owing to strong spin-orbit coupling, bismuth-based systems are predicted to exhibit spin quantum Hall effect [2,3]. Global properties of topological insulators are characterized by a $\mathbb{Z}_2$ invariant. In order to obtain the topological invariant, bipartite quantum correlation measures can be used.

We compute the correlation matrix defined as the expectation value of single-particle operators in the ground state, which is related to the reduced density matrix for a particular subsystem in a real space [4, 5]. The spectrum of the correlation matrix enables to distinguish between trivial and non-trivial phases. We examine Bi and Bi_{1-x} Sb_x systems in both torus and ribbon geometries through entanglement spectrum. Composition-induced topological phase transition is considered. Effects of Zeeman splitting and applied external electric field on the systems are also discussed.

[1] Y. Liu and R. E. Allen, *Phys. Rev. B* **52**, 1566 (1995)
[2] S. Murakami, *Phys. Rev. Lett.* **97**, 236805 (2006)
[3] L. Fu and C. L. Kane, *Phys. Rev. B* **76**, 045302 (2007)
[4] A. Alexandradinata, T. L. Hughes, and B. A. Bernevig, *Phys. Rev. B* **84**, 195103 (2011)
[5] T. L. Hughes, E. Prodan, and B. A. Bernevig, *Phys. Rev. B* **83**, 245132 (2011)