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# Topological Insulators, Superconductors and Majorana Fermions

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Following original idea[1] leading to a discovery of Topological Insulatorswe describe the recent developments of the subject in a detail. In particular we focus on TopologicalSuperconductors and Majorana Fermions. SuchMajoranashave strong potential to be used in various graphene devices[2] as well as infuture topological adiabatic quantum computers[3] due to their non-Abelianbraiding statistics. We describe the theory of topological insulators and superconductor and show how Majorana fermions and topological superconductivity may arisethere considering thespinless$p_x \pm ip_y$ superconductors and hybrid systems.Graphene is not flat and has microscopic lattice nano-corrugations inherent to all two-dimensional crystals[4]. We showthat such corrugations may provide channeling opportunities for electrons[5] that can be used in a new design of p-n junctions and transistors[2] or for a creation of Majoranas. The graphene lattice distortions can not only generate the state of topological insulator but also induce the magnetization oscillations and the Hofstadter butterfly in graphene flakes[6]. We discuss also physical properties of Zenertunnelling nano-devices[7] and Aharonov-Bohm effect in graphene nanoring focusing on the case when there are arising levitons[8]. Graphene bubbles is another example where topological states may exist[9]. We also discuss tunneling, stochastic and extraordinary magnetoresistance phenomena arising in these systems[10,11,12].

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