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Title:	Exploring topological transitions and majorana fermions using kwant
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Keywords:	Transitions Fermions Kwant
Issue Date:	28-Jul-2021
Publisher:	IISERM
Abstract:	<p>In this thesis, we study and derive the topologically robust edge states for the Quantum Hall Effect in a 2D electron gas. We then extend this model and try to derive a system which produces topologically robust edge states just like Quantum Hall Effect but without the application of a magnetic field which we call Quantum anomalous hall effect and the device we call Chern Insulator. We study the various symmetries possessed by graphene and break them one by one to create Quantum anomalous hall effect out of graphene. We combine a Chern insulator and its time reversed form and derive what we call Quantum spin hall insulator and study the robustness of its edge states from scattering. We extend the model for this Quantum spin hall insulator which is also called 2D topological insulator and derive a mathematical model for a 3D topological insulator by stacking together these 2D-topological insulators in three dimensions. We study the experimental imaging methods which can be used to study the surface states of a 3D topological insulator. We next study various methods which can be used to obtain Majorana fermions in topological systems including vortices of a p-wave superconductor, a quantum spin hall insulator, and a 3D topological insulator. Later we lay out a step by step procedure by which starting from a 1D Kitaev chain model we derive a mathematical model for the realisation of Majorana fermions in semiconductor-superconductor heterostructures by applying an external magnetic field and having the Rashba spin orbit coupling in the system. After that we explain various developments that have taken place in the field since 2010 after the theoretical model for the experimental realisation of Majorana fermions in semiconductor-superconductor heterostructures was proposed. We also discuss the shortcomings which experiments face and why it has still not been possible to truly realise Majorana fermions in the experiments.</p>
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