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Relaxation and Dynamics in Non-Equilibrium Topological Quantum Matter

The field of topological matter has made great promises for what could be achieved for applications, and in fundamental research regarding exotic states, if only the topologically protected modes that exist in topological systems can be made and controlled. Aside from the experimental challenges, there remain many open theoretical questions which need to be addressed before this project can be fulfilled. In this project we propose to address several of these crucial questions.

Topology may seem a strange area of mathematics to help us understand solid matter, dealing as it does with what one can say when things are twisted, deformed, and molded. Nonetheless in recent years it has become one of the pillars of our understanding of matter. In this case the topology tracks those things that stay the same when a materials parameters are changed, rather than when the shape of the material is deformed. For example one may wish to apply a magnetic field, change the temperature, squeeze the material, or simply try and push more electrons inside it. when we do these things, under certain conditions, we can write a topological invariant which tells us which different systems can be changed into each other in a continuous manner.

Much interest has been spawned by two different ideas, firstly that this topology tells us directly about strongly protected and hard to destroy states which live on the edges of a material. Secondly some of these "edge modes" could be helpful for building a topological quantum computer. It is therefore not only an interesting question, but also a crucial question for certain applications as to how we can understand the topology and edge modes in all sorts of potential useful or interesting material structures.

One way of manipulating these systems is to push them far from thermal equilibrium. In this way the edge modes can be moved, changed, destroyed or created. The aim of this project is first to investigate how these edge modes behave out of equilibrium and to develop tools for understanding them. Second we will find out how to extend the concept of topology of these systems, which is based on quantities that can only be defined in thermal equilibrium and at low temperatures, when these conditions no longer hold.