Physics 198 Term Paper

# Topological Order, Insulators, and Semiconductors

Keshav Balwant Deoskar

kdeoskar@berkeley.edu

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# 1 Introduction

In every-day life, we often talk about the different "phases" of matter such as solids, liquids, and gases. In condensed matter physics, there is a more precise meaning to the phrase "phase of matter" where materials can be classified based on their atomic arrangements. In the '80s, there emerged a powerful system for classifying the different orders: the Landau-Ginzburg-Wilson theory of Symmetry Breaking.

For example, the atoms of a gas in a container are uniformly distributed so that if we choose a point and then translate continuously in any direction, the density of particles at the new point is the same. The gas displays ***continuous symmetry***. Now if we reduce the temperature and/or apply pressure, causing the gas to form a crystalline solid, we no longer have continuous symmetry; Instead we have repeating patterns at regular intervals i.e. Crystals display ***discrete symmetry***. In carrying out the phase transition from gas to solid, we broke the continuous symmetry and obtained discrete symmetry.

In this regime, the hamiltonian has some symmetry group $G$ with subgroup $H \subset G$ which serves as the symmetry group of the system after phase change.

# 2 Landau-Ginzburg Theory of Symmetry-Breaking Phases

# 3 Beyond the Landau-Ginzburg Paradigm: Fractional Quantum Hall States and Topological Order

# 4 Topological Insulators

# 5 Topological Superconductors

## References