Topological States of Quantum Matter

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What we do

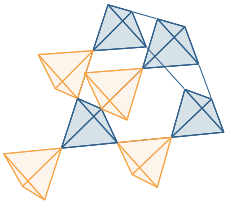
We study **crystalline materials** that exhibit robust and universal phenomena that can be understood with the mathematical tools of **topology**. These **novel states of quantum matter** may be useful for future low-power electronics or for quantum information processing.

Properties at low T determined by interactions

How strong are correlations?

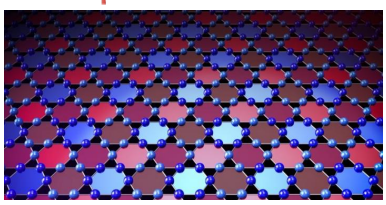
Non-interacting

Quantum magnets and spin liquids



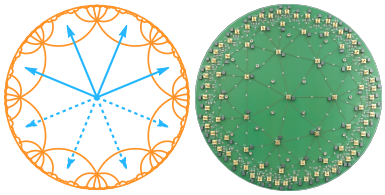
Neural Networks as variational Ansatz for wave functions of complex 3D magnets, called the **Neural Quantum States** method, can yield novel physical results in hard problems.

Kagome magnets and superconductors

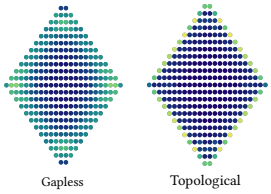


The kagome lattice is a well-known theoretical playground for exotic electronic phases. Recently, a novel material class was found which hosts sought after **unconventional charge order** and **superconductivity**.

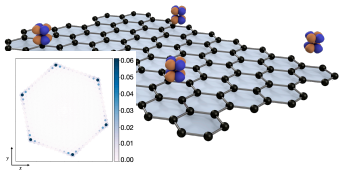
Topological states in artificial lattices



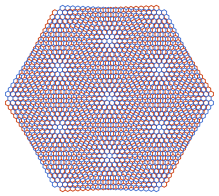
Hyperbolic lattices allow us to simulate physics in negatively curved space and can be realized, e.g., in electric circuits. The curvature can have peculiar consequences for topological states.



Magnetic atoms deposited on a superconducting surface can form **Shiba bound states**. When placed in an ordered lattice, they may realise topological phases with protected edge modes.

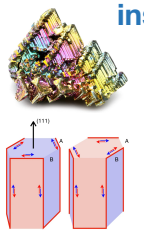


Can we engineer the physics of MATBG without applying a twist? We found corner-localized states related to non-trivial topology of the flat bands in a system of a **single graphene layer with adatoms**.



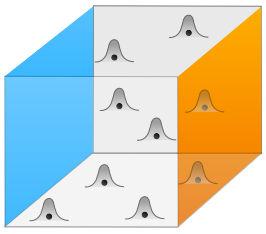
When **two graphene layers are twisted** by the 'magic angle' (MATBG), they become superconducting. Understanding this may shed light on high temperature superconductors.

Higher-order topological insulators



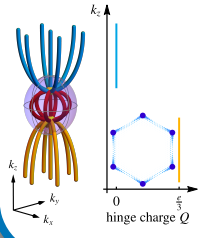
Instead of surface and edge states, higher-order topological matter has topological edge and corner modes, realised for example in Bismuth.

Disordered systems



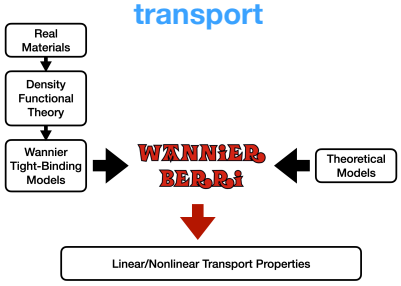
Not all insulating crystals are band insulators! We study the topological properties of crystals that are insulating because of disorder.

Topological semimetals



Band topology does not only play a role in insulators but also in semimetals: degeneracies of energy bands can give rise to conventional and higher-order topology.

Berry curvature induced transport



WannierBerri is a code to calculate linear/ nonlinear transport properties in real materials.

Study of abstract models

Real materials

How realistic are the materials studied?