Topology and Geometry in Low Temperature Quantum Physics

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Some of the more unexpected developments in quantum condensed matter systems involve topologically-protected properties of exotic states that are robust against imperfections and disorder, because they are not dependent on the presence of unitary symmetries. The anomalous quantum Hall effect, or "Chern insulator", a system that can exhibit a quantum Hall effect without an applied magnetic field, is the simplest of the "topological insulator" models, and the simple 2D graphene-like model in which it was first identified has inspired not only models for time-reversal invariant topological insulators and their extension to 3D, but also analogs in photonics ("one-way waveguides"). There is also evidence for the exciting possibility that this lattice system may support an anomalous fractional Hall effect. Topology and geometry are intimately connected, through sum rules on curvature (Chern number and Berry curvature, genus and Gaussian curvature). I will also mention a recent development in the fractional quantum Hall effect that relates incompressibility to geometry, leading to a new description that combines topology and quantum geometry.

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