Chern Insulators: from Design, toward Realization

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Magnetotransport measurements when high magnetic fields were applied to highly conducting two dimensional electron gases (2DEGs) resulted in the discovery of the integer quantum Hall effect (IQHE). At integer band fillings the bulk of the 2DEG becomes insulating, leaving boundary states to carry spin and charge currents. This bulk-boundary dichotomy is an example of topological connections that can produce remarkable behavior in magnetic insulators, akin to analogous boundary transport in topological insulators. A phase related to the quantum Hall and topological insulator classes is the Chern insulator, or quantum anomalous Hall insulator, which displays the characteristics of IQHE systems without the need for an external magnetic field, which is replaced by a spontaneous ferromagnetic insulating phase. Entanglement of valence and conduction bands across the bulk bangap of the ferromagnetic insulator is required to produce a Chern insulator, with this being obtained from integration of the Berry curvature and encoded in the Chern topological invariant (Chern number). A summary of proposed Chern insulators will be provided. Then the discussion will focus on two transition metal oxide systems, on a hexagonal and a honeycomb lattice, that has led to the computational design (prediction) of Chern insulating phases with bulk gaps of up to 130 meV.[1] The design process required understanding the interplay of many energy scales in these compounds: bandwidths, intra-atomic repulsion strength, spin-orbit coupling, crystal field splittings and subsplittings, and Jahn-Teller distortions forces.

References:

[1] H. Guo *et al.*, Wide gap Chern Mott insulating phases achieved by design, npj Quantum Materials 2, **4** (2017)

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