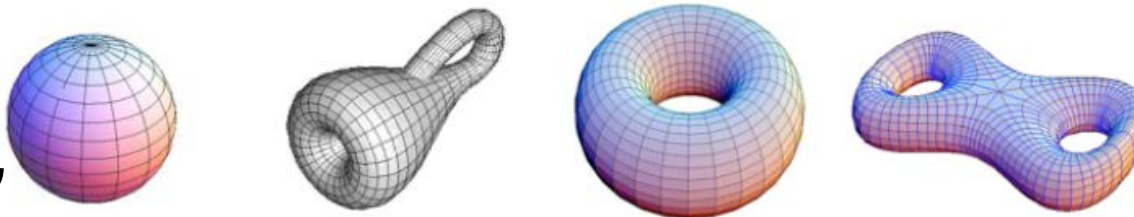


Crash Course on Topology in Condensed Matter

$$\underbrace{\frac{1}{4\pi} \int \kappa dA}_{\text{differential geometry}} = \underbrace{\frac{\Omega}{4\pi}}_{\text{topology}} = (1 - g)$$



$g=0, \Omega=4\pi$ $g=1, \Omega=0$ $g=2, \Omega=-4\pi$ $g=3, \Omega=-8\pi$

Differential geometry of Bloch wavefunctions:

$\Psi_n(\mathbf{r}) = e^{i\mathbf{k}\cdot\mathbf{r}} u_{n\mathbf{k}}(\mathbf{r})$ Brillouin zone plays the role of the "surface"

$$\mathcal{A}_{n\mathbf{k}} = \langle u_{n\mathbf{k}} | -i\nabla_{\mathbf{k}} | u_{n\mathbf{k}} \rangle$$
 "Berry connection" defines "Berry curvature" which replaces Gaussian curvature

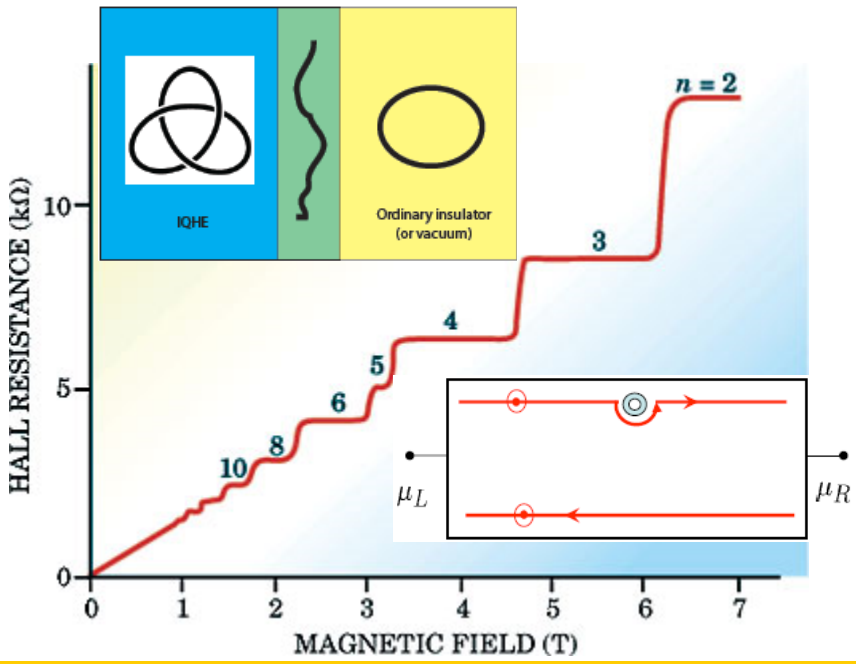
$$\phi_n^{\text{Berry}} = \oint_{\partial\text{BZ}} \mathcal{A}_{n\mathbf{k}} \cdot d\mathbf{k}$$

$$\mathcal{F}_{n\mathbf{k}} = \nabla \times \mathcal{A}_{n\mathbf{k}}$$

$$\sigma_{xy} = \frac{e^2}{\hbar} \sum_n \int_{\text{BZ}} \frac{d^2k}{2\pi} f(\varepsilon_{n\mathbf{k}}) \mathcal{F}_{n\mathbf{k}} \cdot \mathbf{e}_z = \frac{e^2}{h} N_{\text{Chern}}$$

Bulk-boundary correspondence: Identify Chern number N_{Chern} with the number of conducting edge states

Topological phases of matter initiated by Integer Quantum Hall Effect:



Topological Protection of Edge State Transport in Monolayer OsCl_3 as Quantum Anomalous Hall Insulator

RAPID COMMUNICATIONS

PHYSICAL REVIEW B 95, 201402(R) (2017)

Monolayer of the 5d transition metal trichloride OsCl_3 : A playground for two-dimensional magnetism, room-temperature quantum anomalous Hall effect, and topological phase transitions

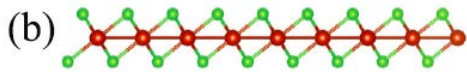
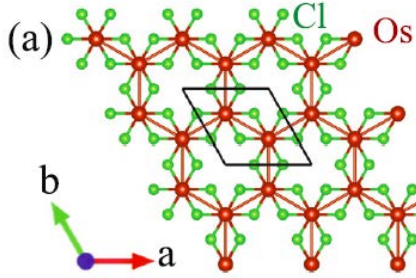
Xian-Lei Sheng^{1,2} and Branislav K. Nikolić^{1,*}

¹Department of Physics and Astronomy, University of Delaware, Newark, Delaware 19716-2570, USA

²Department of Applied Physics, Beihang University, Beijing 100191, China

TABLE I. Interlayer binding energy E_b (in $\text{meV}/\text{\AA}^2$) of selected transition metal trichlorides MCl_3 . For comparison, E_b of typical layered materials like graphite (note that computed value for graphite is comparable to experimental estimate $E_b = 23.3 \pm 1.9 \text{ meV}/\text{\AA}^2$ [20]) or Bi_2Se_3 is also included.

	OsCl_3	VCl_3	FeCl_3	RuCl_3	graphite	Bi_2Se_3
E_b	14.4	17.3	18.1	19.3	26.4	23.9



Topological phase transition detected by Chern number change due to increasing on-site Coulomb interaction U

zigzag

armchair

