

# Disordered topological phases in alloys, quasicrystals, and amorphous materials

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# Phenomenology of topological insulators

## Bulk-boundary correspondence



Charles L. Kane

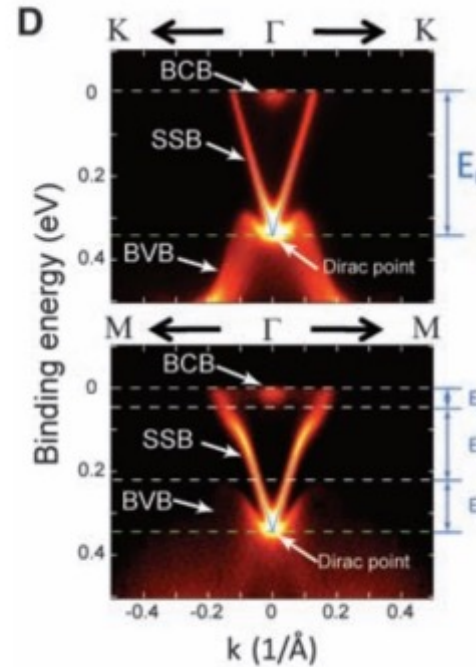
Chocolate: insulating interior



Wrapper:  
Metallic surface



Topological interior is always covered by metallic surface!



Trivial insulator (air)  
Metallic surface  
Topological insulator

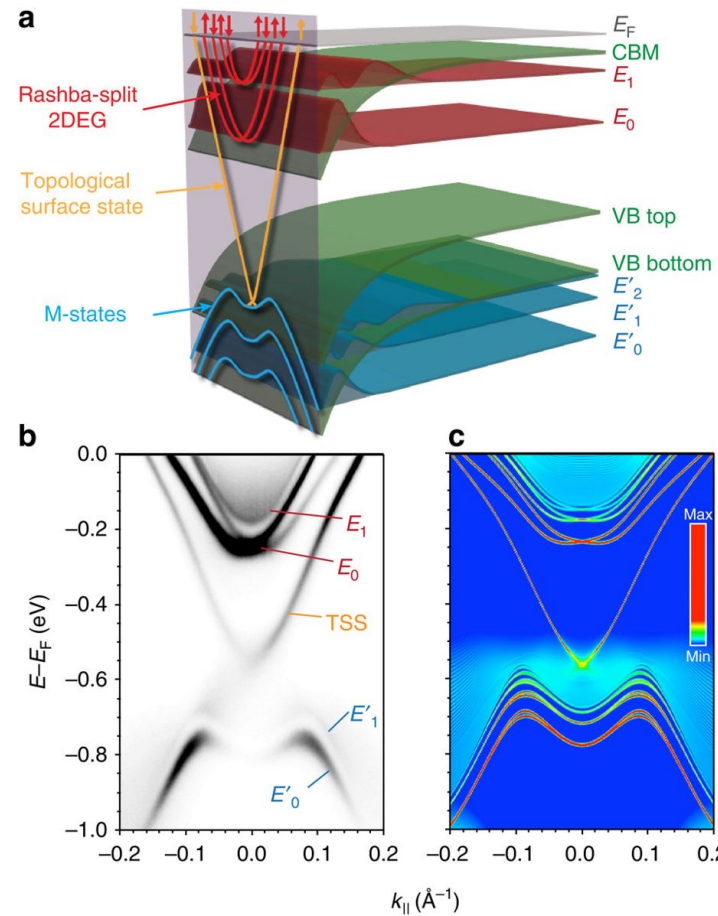
# Phenomenology of topological insulators

What if someone ate the chocolate and left the wrapper?

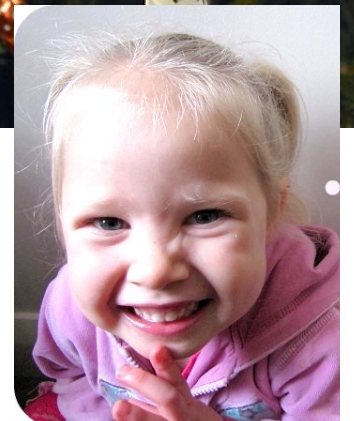
Trivial surface states

Need bulk topological invariant

chocolate ? air



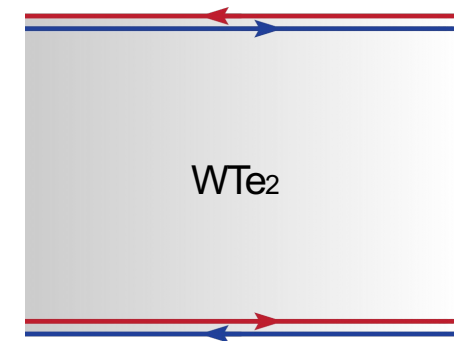
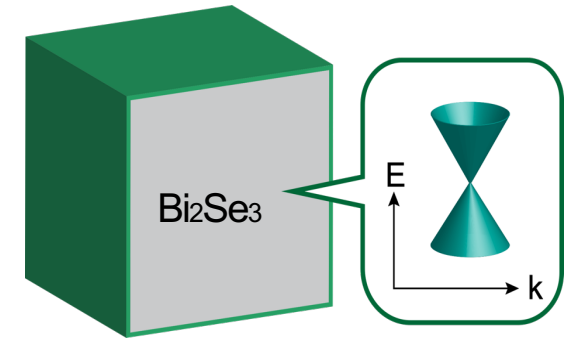
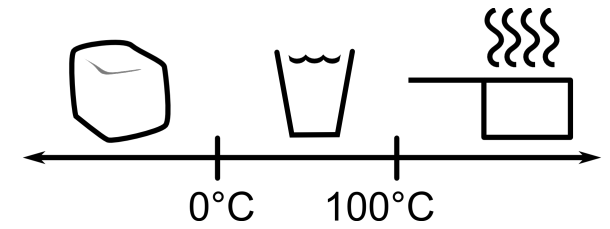
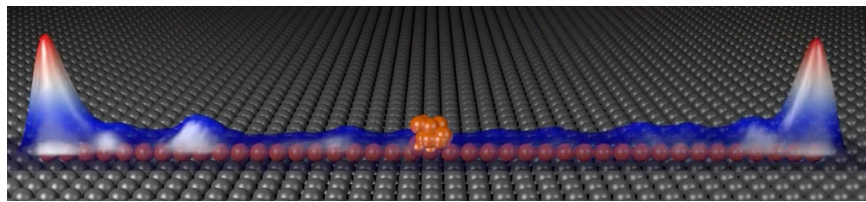
M.S. Bahramy et al., *Nat Comm* **3**, 1159 (2012)



# What are topological phases?

Phases of matter beyond the Landau paradigm

- Topological field theory, entanglement
- Quantized response (Quantum Hall Effect)
- Impossible gapless boundary modes
- Applications in (quantum) computing

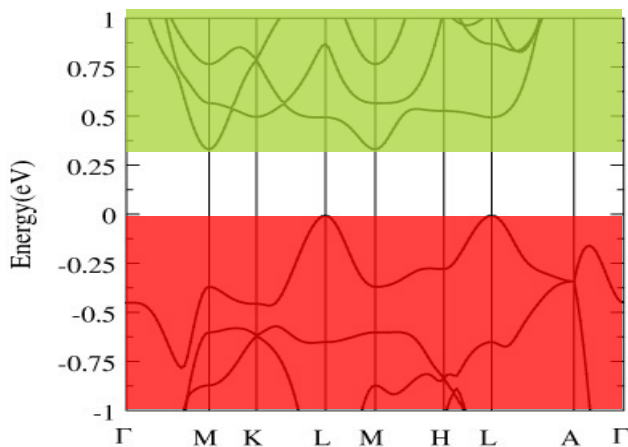


# What is topological about them?

Classification of “things” up to continuous deformations

We classify gapped Bloch Hamiltonians (band structures)

Can't “untangle” the bands



Conduction band

Gap

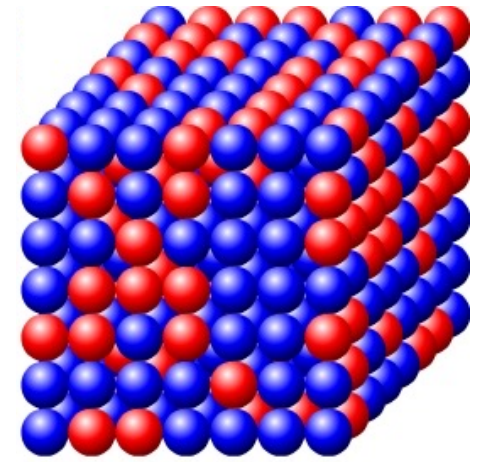
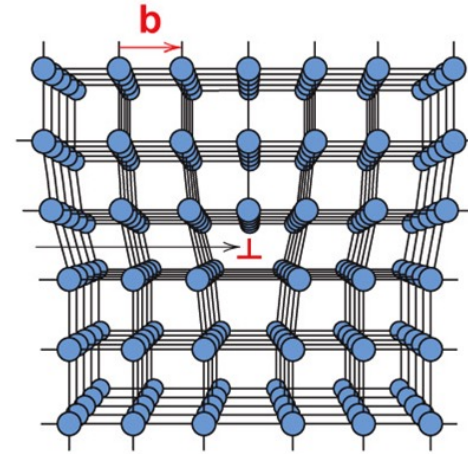
Valence band



# Topological phases beyond perfect crystals

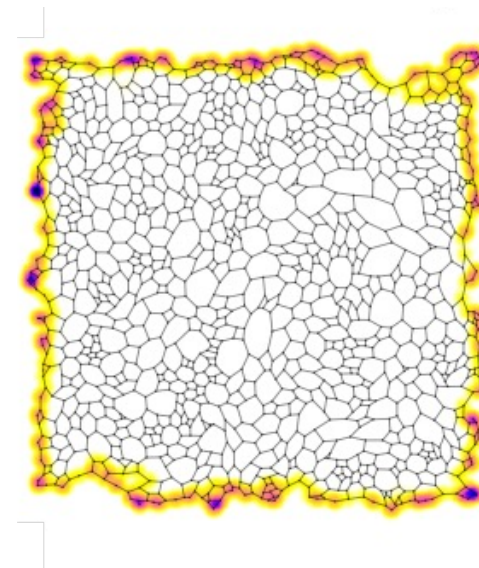
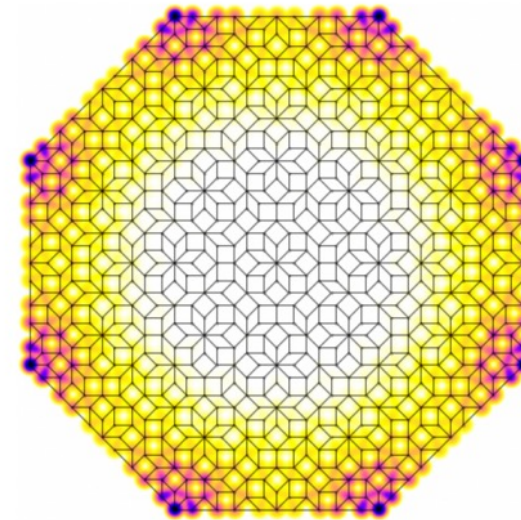
There is still uncharted territory!

- Disordered crystals
- Quasicrystals
- Amorphous materials



Questions:

- Are there new non-crystalline topological phases?
- How to classify them?
- What are their characteristic physical responses?
- Can we design such materials?



# Amorphous materials

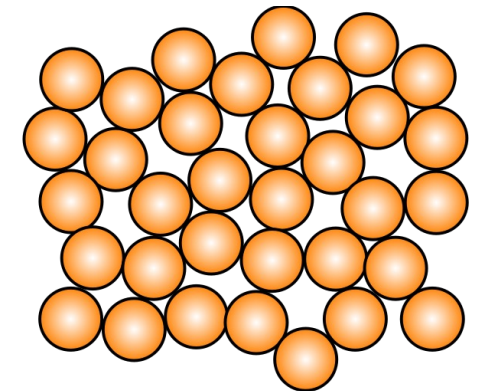
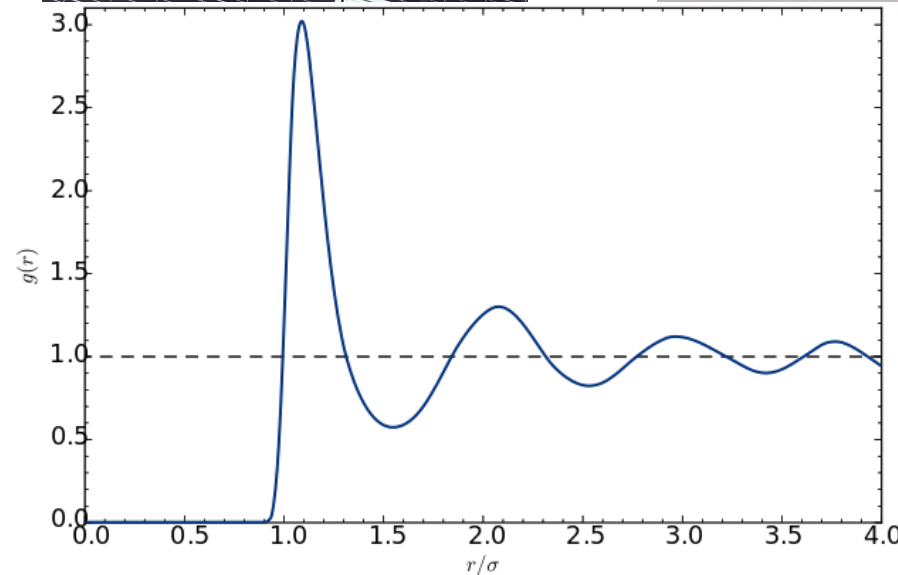
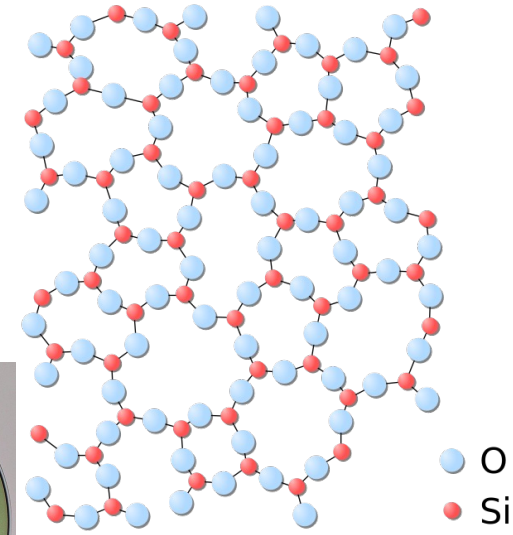
Very common in technology

Glass/liquid

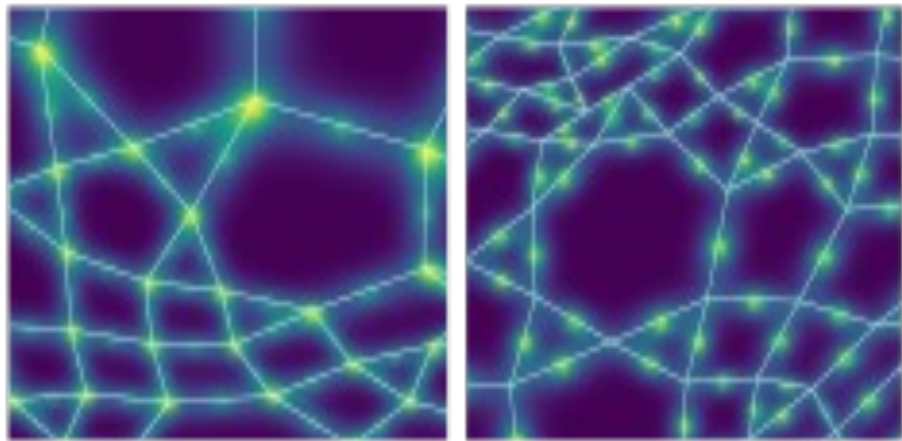
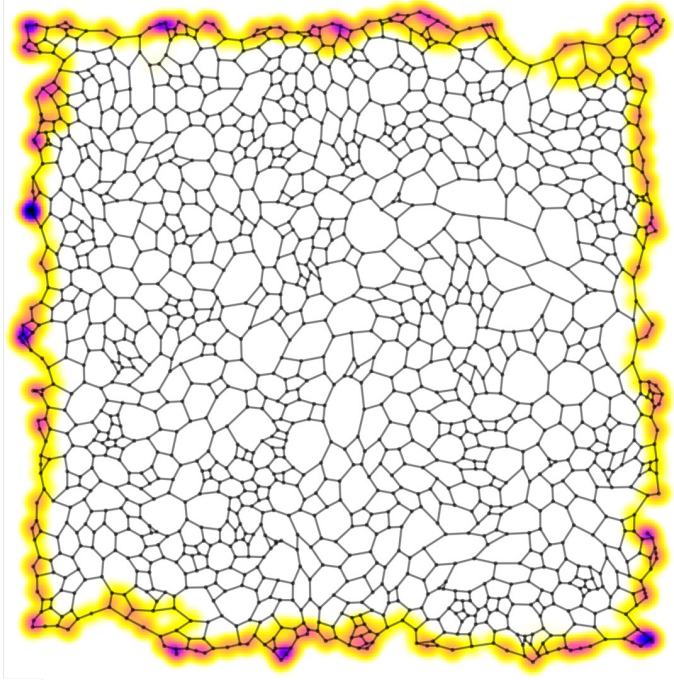
No long range order

Short range correlations

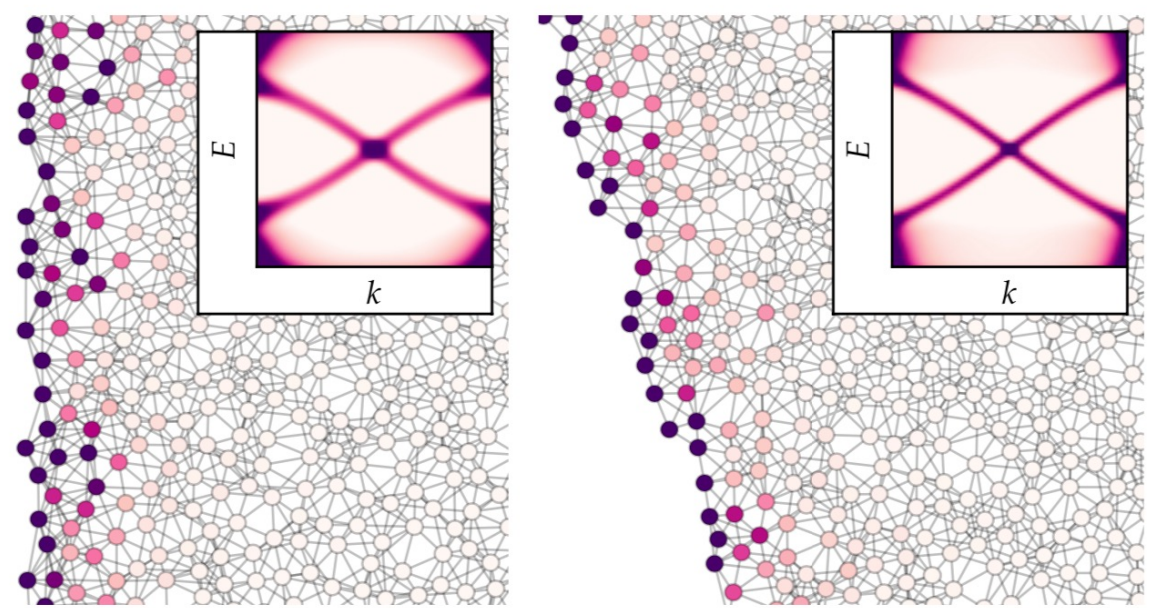
Uniform chemical environments



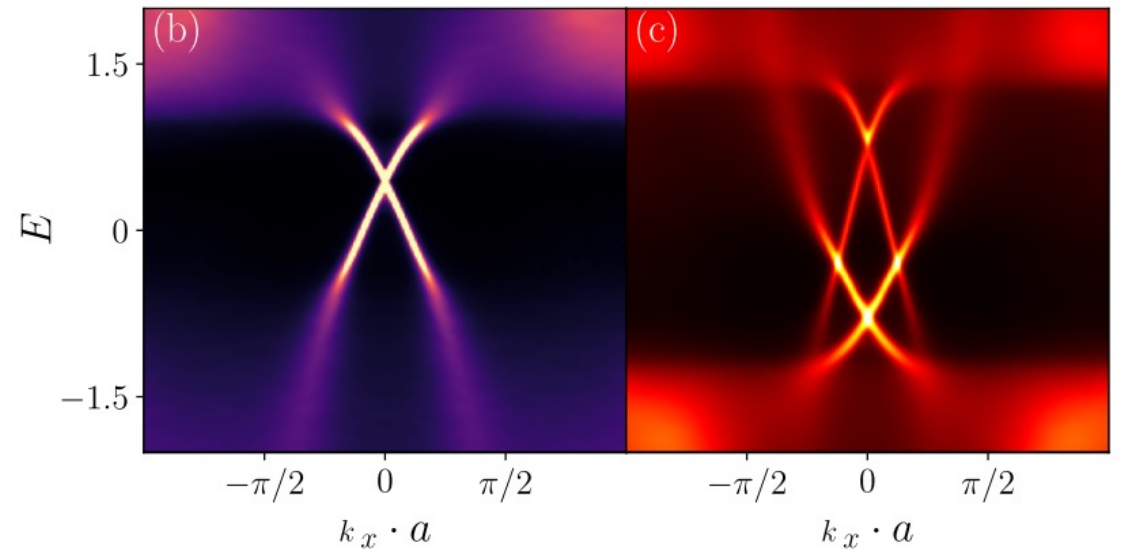
# Tight-binding calculations



Wannier centers



Spectral functions (ARPES)



Q Marsal, D Varjas, AG Grushin PNAS 117 (48), 30260-30265  
H Spring, AR Akhmerov, D Varjas SciPost Physics 11 (2), 022  
Q Marsal, D Varjas, AG Grushin Physical Review B 107 (4), 045119  
H Spring, AR Akhmerov, D Varjas arXiv preprint arXiv:2310.18400



# Collaboration partners



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Cosma Fulga



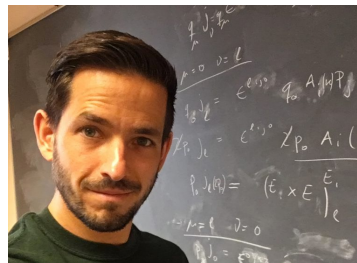
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