

humans have always striven to find new materials

AgeS

stone \rightarrow bronze & iron \rightarrow silicon \rightarrow informet \rightarrow quantum

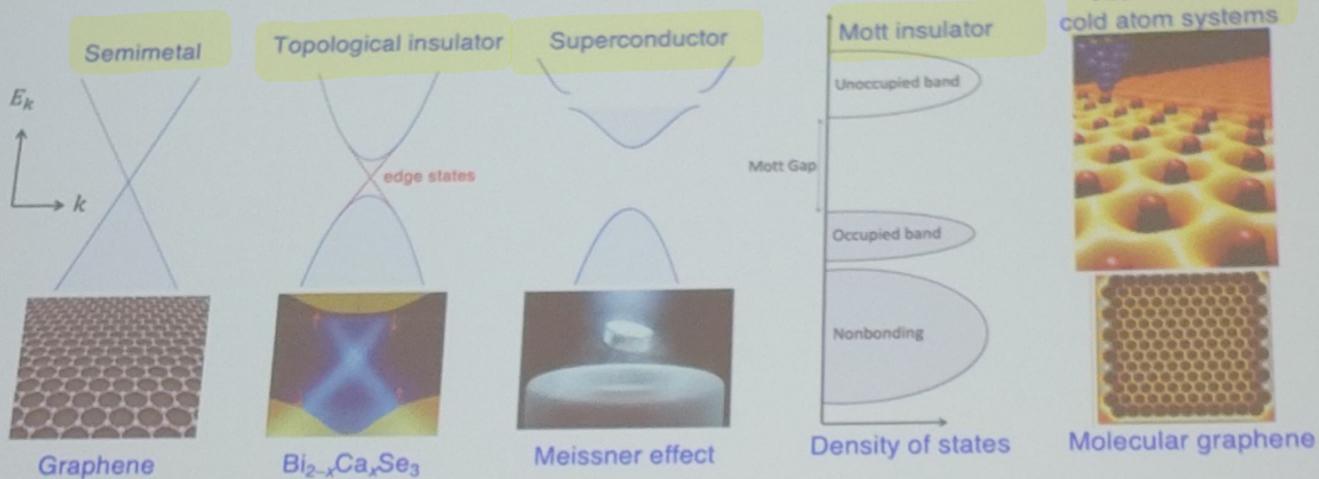
check for present^t on middle

qm useful \rightarrow explain insulation

core all modern tech
↑
superconductors

Quantum Materials

Quantum materials reveal properties with nontrivial topology, coherence, entanglement, and many-body correlations



Quantum Materials

Many-body correlation

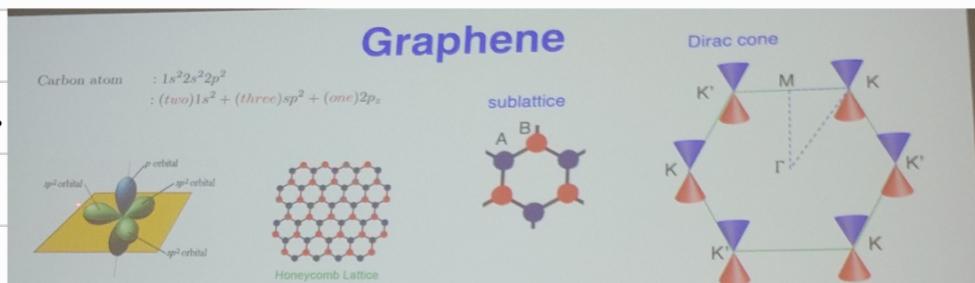
Emergence (symmetry breaking)

Topological entanglement



could do smth on topological error correct?
~ associate with non-linear?

(ex) topological material:



Conventional metal

$$H = \frac{p^2}{2m}$$

Berry phase = 0

Dirac metal

$$\hat{H} = v(p_x \hat{\sigma}_x + p_y \hat{\sigma}_y) = v \begin{pmatrix} 0 & p e^{-i\theta} \\ p e^{i\theta} & 0 \end{pmatrix}$$

$$E = vp$$

Berry phase = π

quantum materials

↓ non-linear optics

study scattering of light

multiphoton process - interact.

spectroscopy => probe widen topological / many body physics



unable to see with linear optics

• second harmonic generation

• optical rectification solar cells

• sum & difference frequency effects

infra-red
detected

optical amplifiers

• self-focusing & optical switching

• multiphoton absorption medical imaging

→ wave-packet dynamics & Berry phase effects

→ Non-linear Hall effect

- ↳ tilted Dirac fermions model
- ↳ non-linear Hall conductivity
- ↳ quantum spin Hall effect

