Emergent Phenomena in Topological Flat Bands

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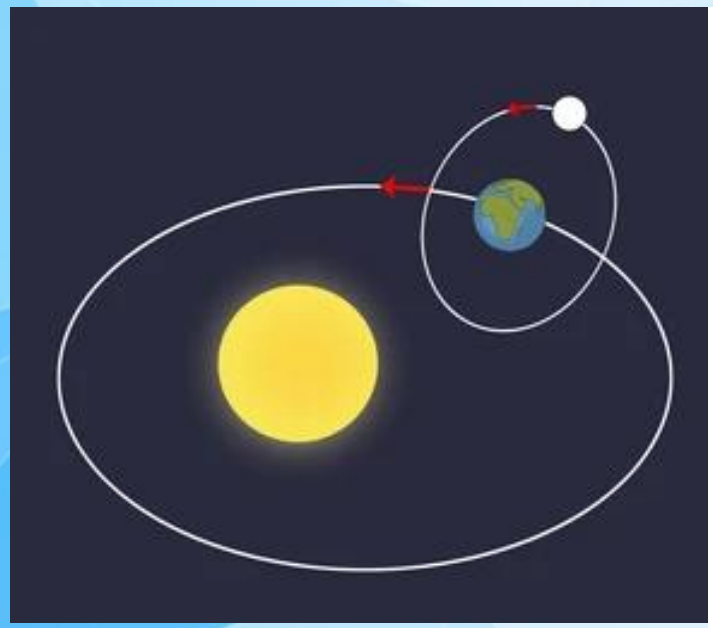
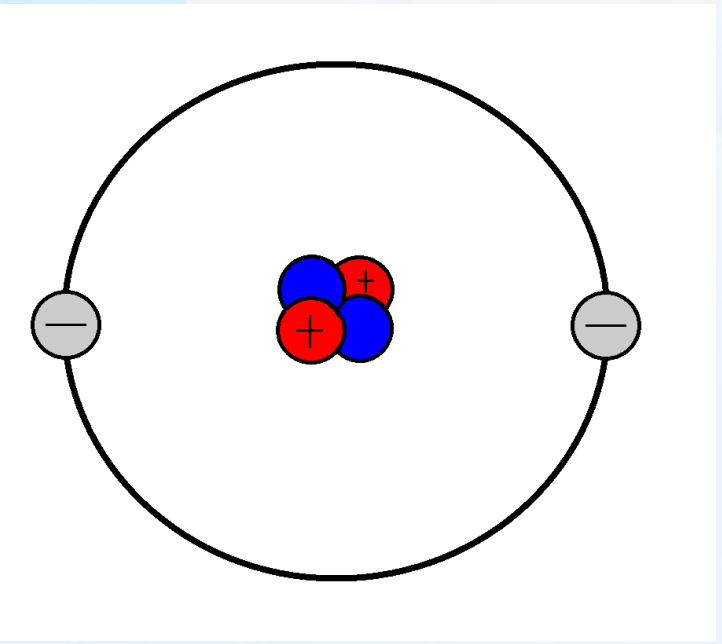
The N-Body Problem

N =

- 1 ✓
- 2 ✓
- 3 ~
- 4 ✗

- 10^{23} Particles..?!

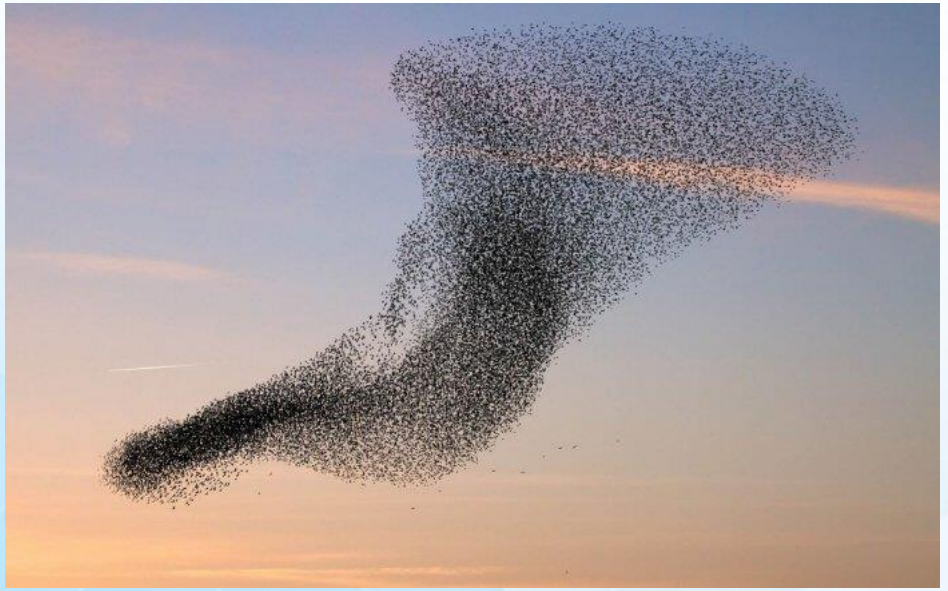




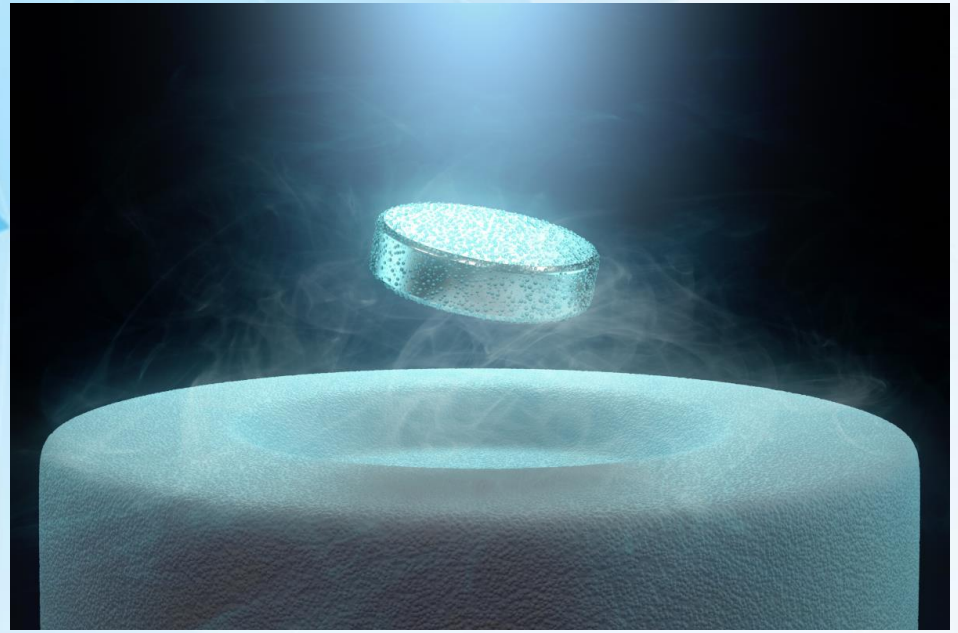
Emergent Phenomena

- “More is different”

- Superconductors
- Superfluids
- Topological Insulators
- Semiconductors
- Quantum Spin Liquids



Naturally occurring emergent phenomena (1)

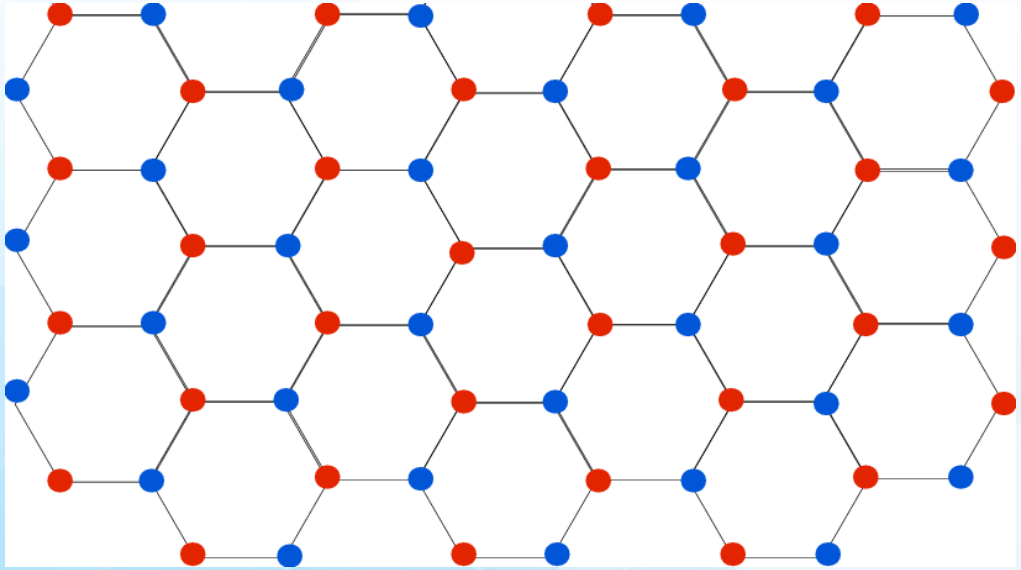


Quantum locking of magnet and superconductor (2)

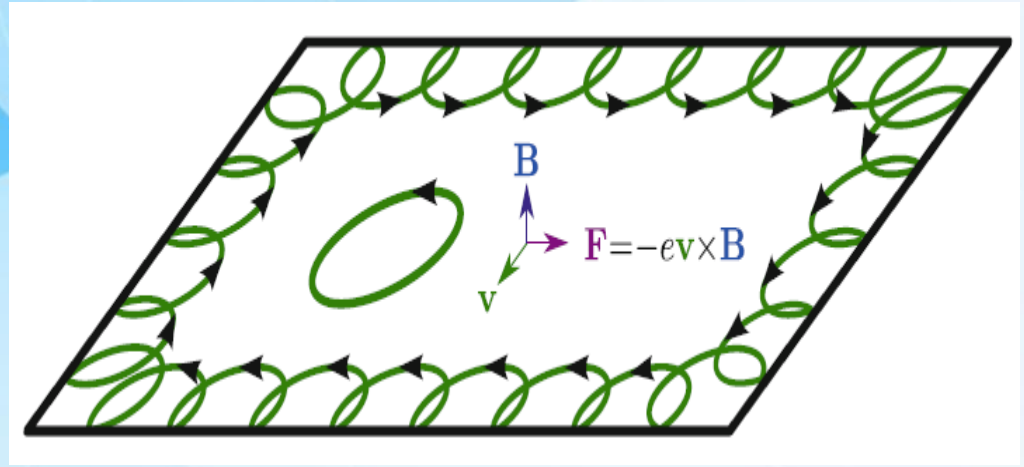
Topological Flat Bands

- "Flat bands" are systems where energy is independent of momentum

- Topology..?
  - Symmetries
  - Conserved Quantities



Honeycomb lattice structure of graphene (3)



Edge states in the quantum Hall effect (4)

Why does condensed matter…matter?

- Broad applications across many fields of study
- Describes the world we see around us
- Important technological applications
- Active area of research, many unanswered questions

Questions?

- Resources:

1. https://manyworlds.space/2019/02/14/all-about-emergence/
2. https://newscenter.lbl.gov/2022/03/24/exotic-superconductors-superpowers/
3. Hirotsu, Masaki & Onogi, Tetsuya & Shintani, Eigo. (2013). Position space formulation for Dirac fermions on honeycomb lattice. Nuclear Physics B. 885. 10.1016/j.nuclphysb.2014.05.014.
4. Shen, S.-Q. (2012). Topological insulators (2nd ed.). Springer Berlin Heidelberg.