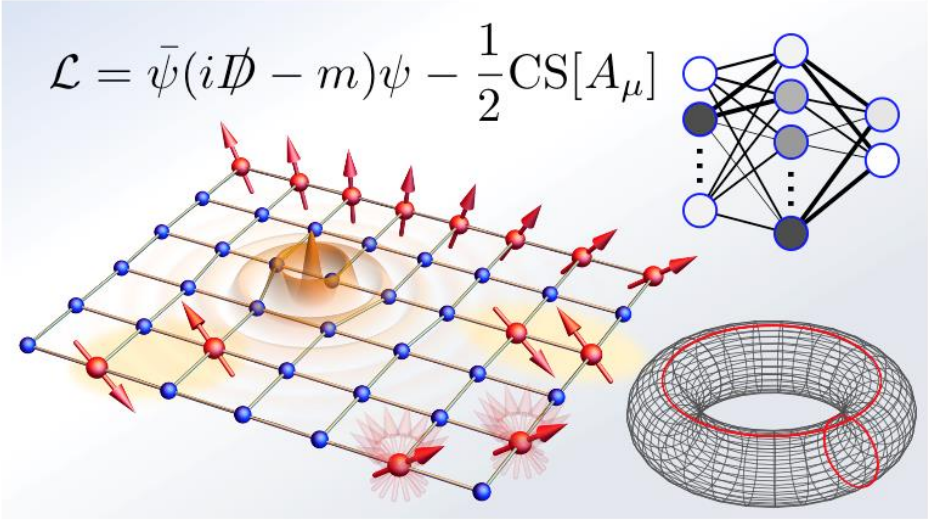
Quantum condensed matter theory

Mathias S. Scheurer
Institute for Theoretical Physics
Office: 2S11
Mathias.Scheurer@uibk.ac.at

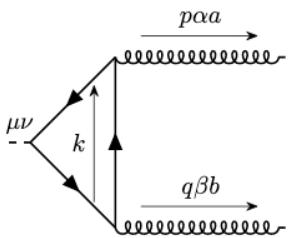
University of Innsbruck
Thursday, 01/13/2022



Group site: https://www.uibk.ac.at/th-physik/mscheurer/

“Spectrum” of condensed matter theory

or: the slide I should have seen earlier

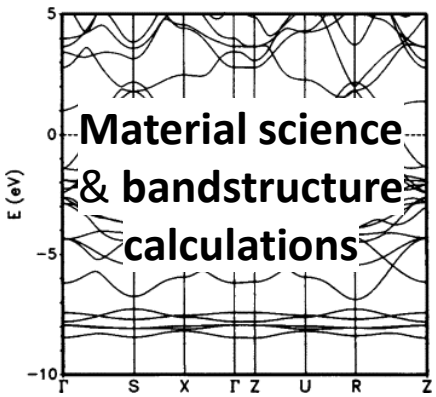


Quantum field theory

e.g., non-Abelian gauge theories, Higgs mechanism, dualities, …

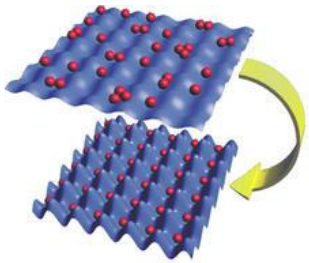
Interesting math:

e.g. topology and group theory

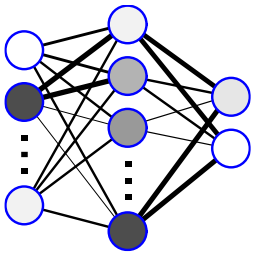


Condensed Matter Theory

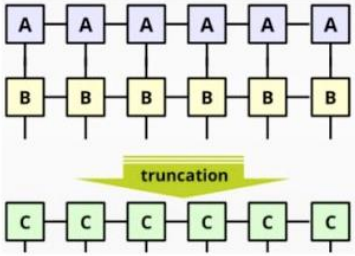
Quantum information & simulation



Data Science/ Machine Learning

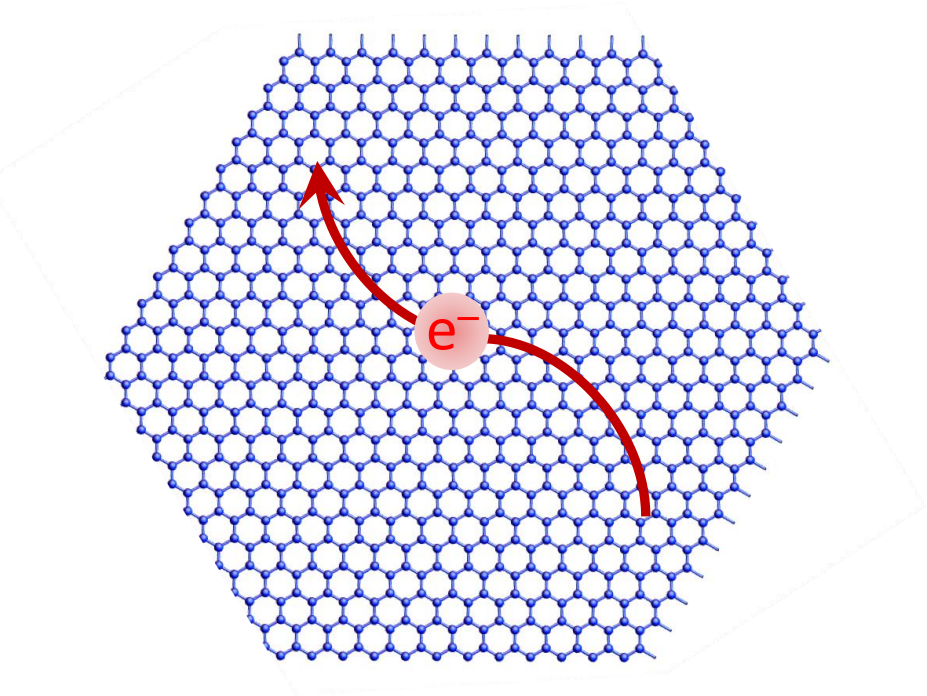


Computational physics



Topic I: Electrons in moiré graphene

Dirac equation: $E(\boldsymbol{k}) \sim v|\boldsymbol{k}|$
(emergent relativitics)



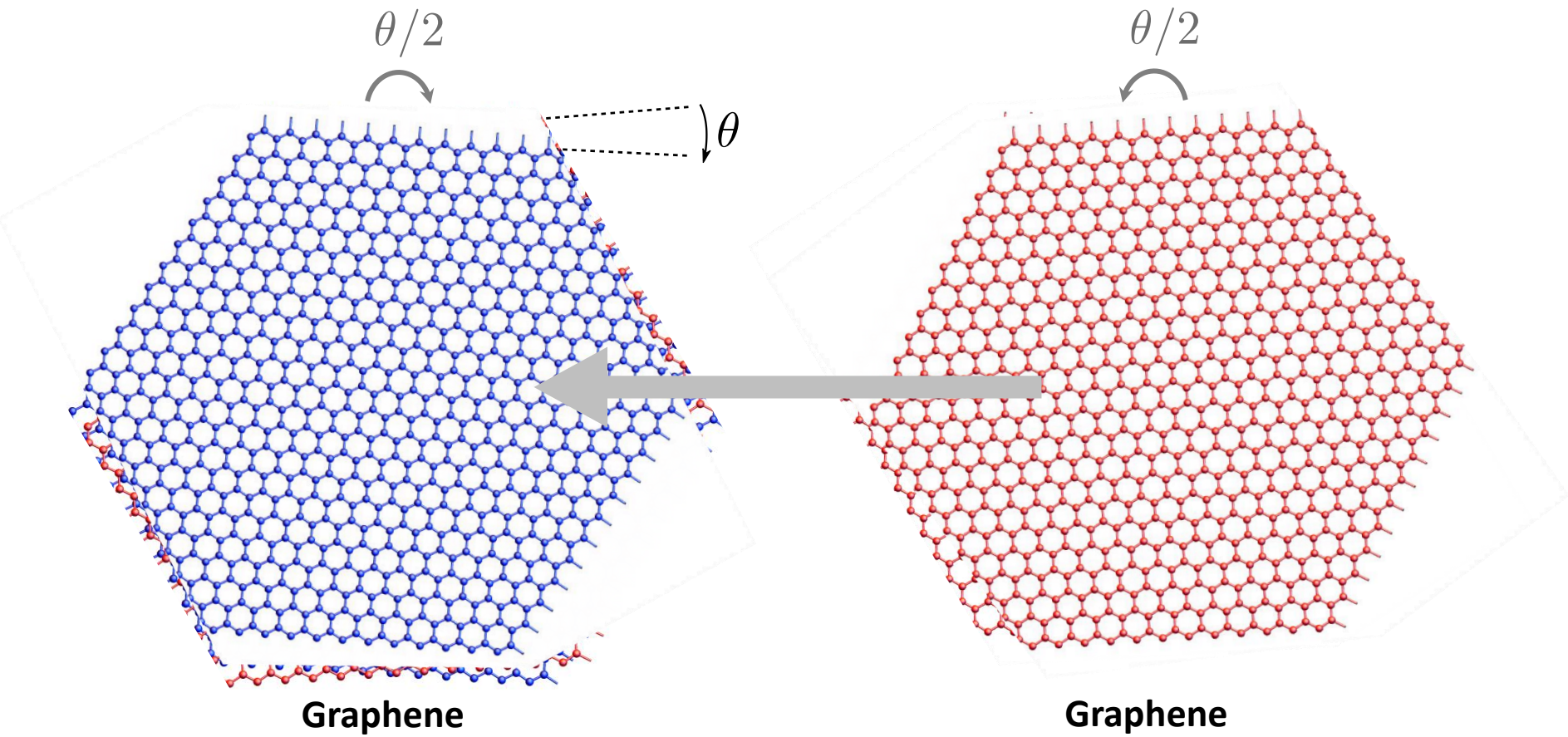
Graphene

"… they move through the graphene as a wave."

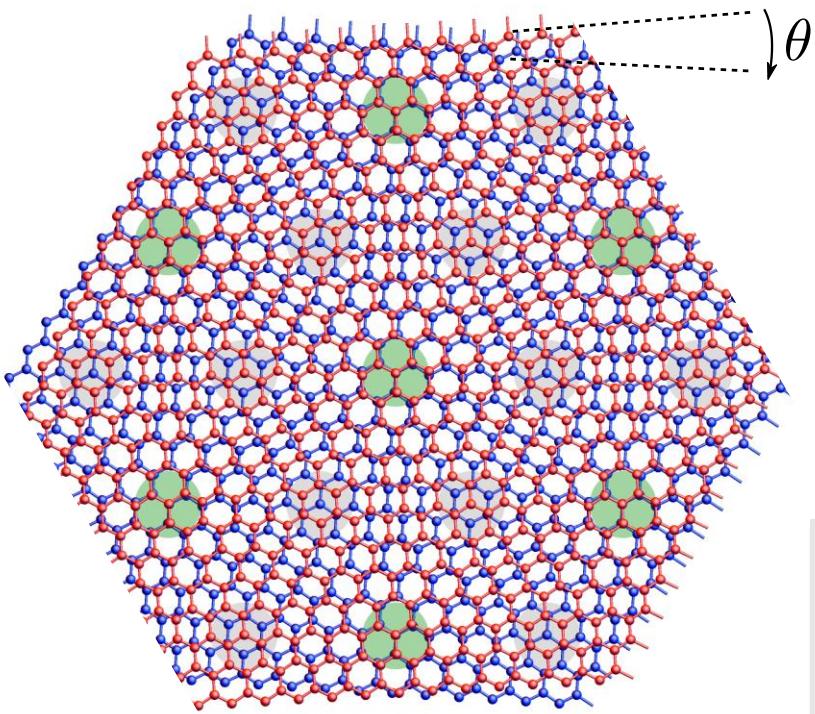
for groundbreaking experiments regarding the 2D material graphene

Geim & Novoselov, 2010

Topic I: Electrons in moiré graphene



Topic I: Electrons in moiré graphene



Twisted bilayer graphene

- ”Magic angle” $\theta \simeq 1°$: $E(\boldsymbol{k}) \approx$const.
- becomes superconductor or magnet

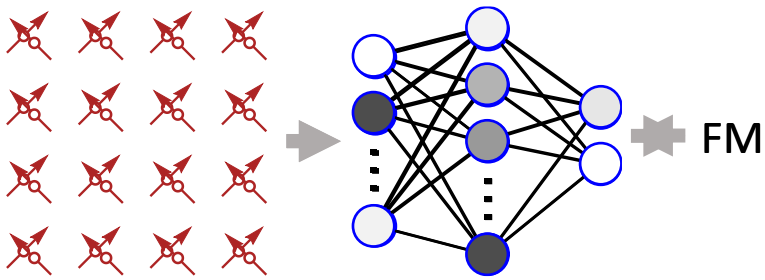
In this bachelor thesis:

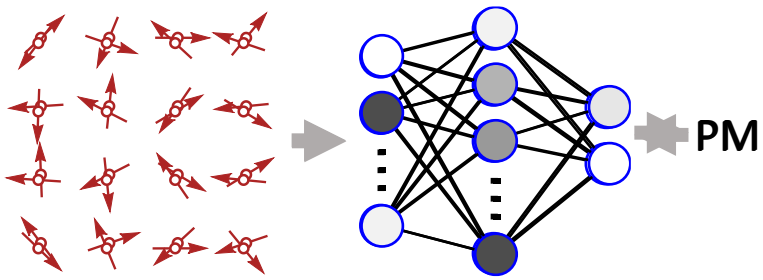
- Learn how to derive $E(\boldsymbol{k})$
- Compute it for one such twisted system

Topic II: Machine learning of phase transitions

Basic idea:

Carrasquilla & Melko, Nat. Phys. **13**, 431 (2017).





In this bachelor thesis:

- ➢ Learn how to **generate samples**
- ➢ Learn how to train a **neural network** with TensorFlow