Condensed Matter Physics

Institute for Theoretical Solid State Physics

Institute for Theory of Statistical Physics

Institute for Quantum Information

SFB 917

ML4Q
Matter and Light for Quantum Computing

Research Training Group: Quantum Many-Body Methods in Condensed Matter Systems

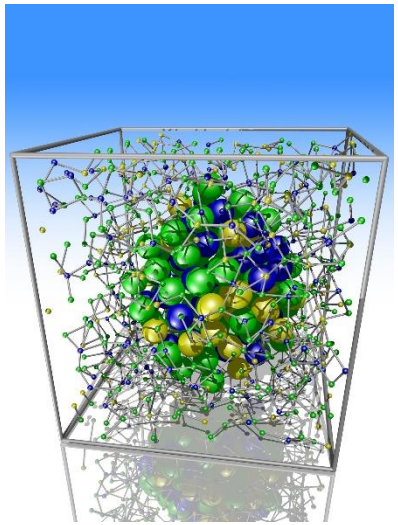
Institute for Theoretical Solid State Physics

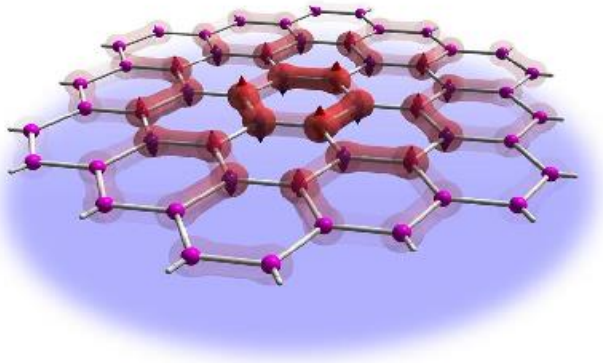
(Honerkamp, Wessel, Mazzarello)

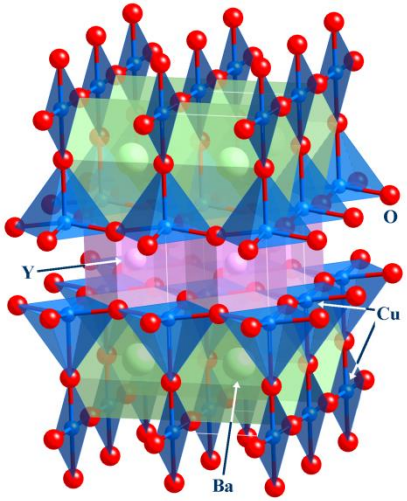
Themes: - Magnetism, superconductivity, novel functional materials, 2D materials

- Topological phases of matter

- Computational and field theoretical methods



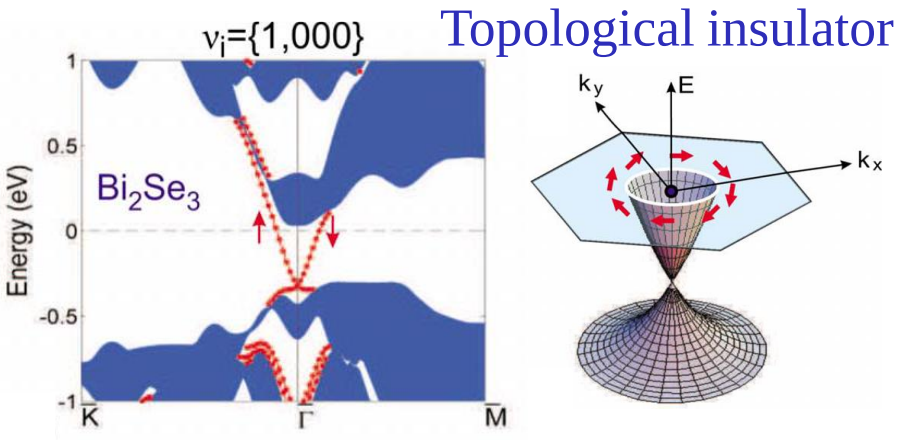


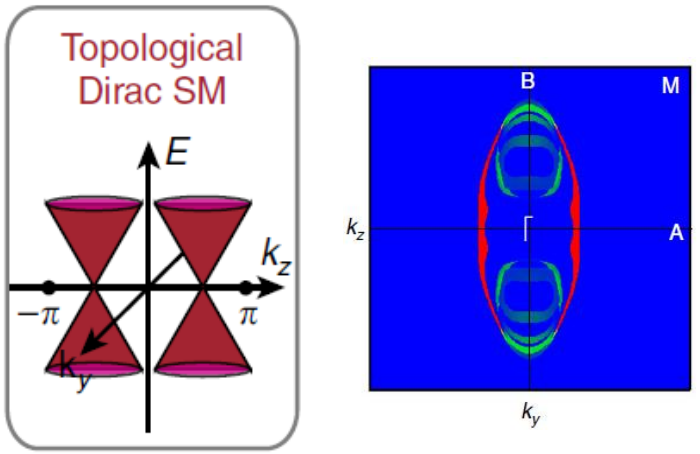


Topological phases of matter

- Topological insulators are insulators with interesting "exotic" properties, such as conducting surface states

- Topological Dirac semimetals exhibit "protected" 3D Dirac cones

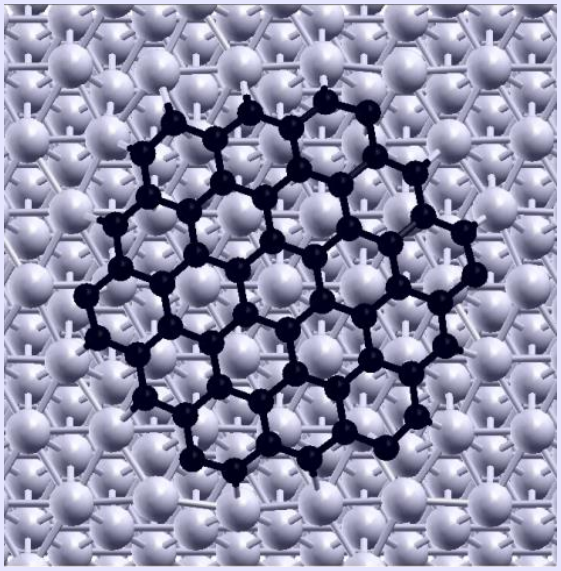




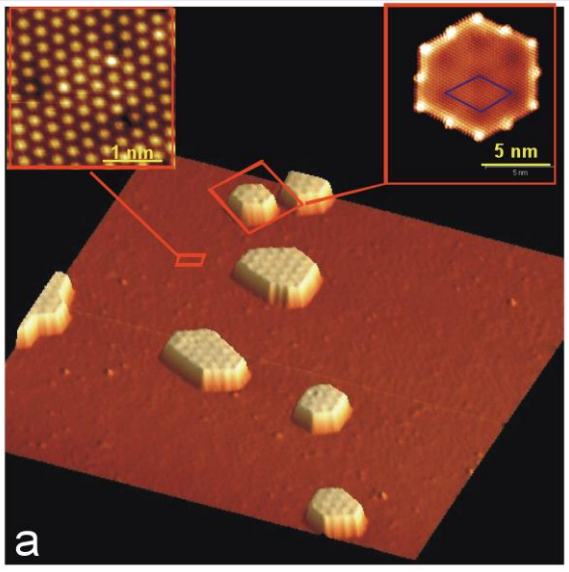
- Further examples: Weyl semimetals, topological superconductors…

Edge magnetism in graphene nanostructures

- Zigzag edges possess magnetic edge states, with potential spintronics applications. Robustness of edge magnetism?
- Study of edge magnetism by several approaches: effective models, quantum Monte Carlo, density functional theory
- Collaborations with the group of Prof. Morgenstern and Prof. Stampfer (Institute IIB)



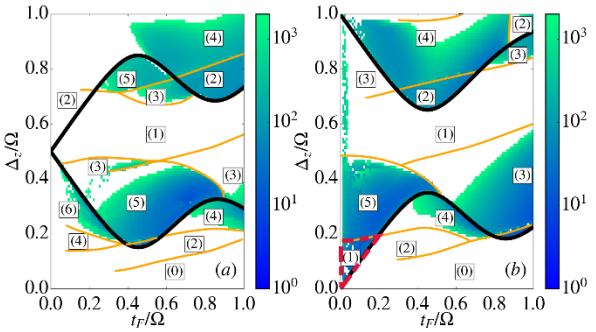
Graphene flake on Ir(111)

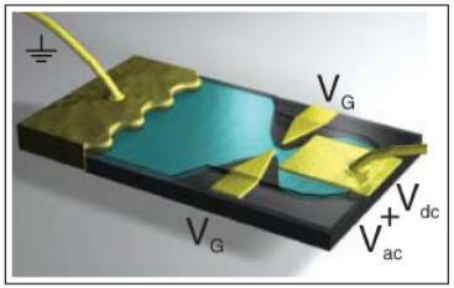


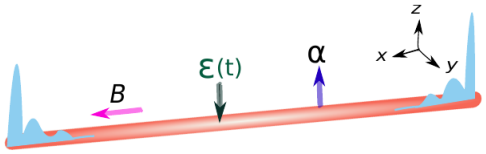
Institute for Theory of Statistical Physics

(Schoeller, Meden, Kennes, Wegewijs)

Themes:
- Many body effects in 1D and (quasi)-2D systems
- Mesoscopic physics
- Topological systems
- Quantum field theoretical methods

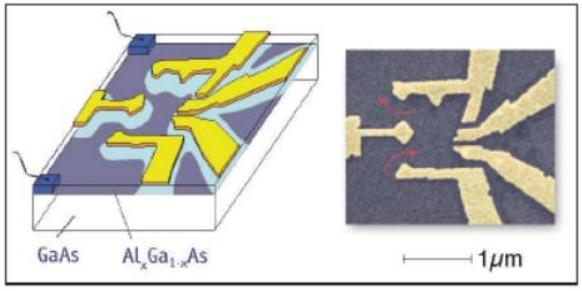


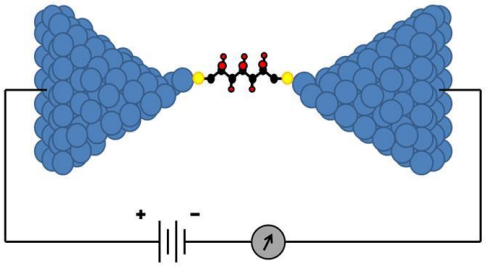


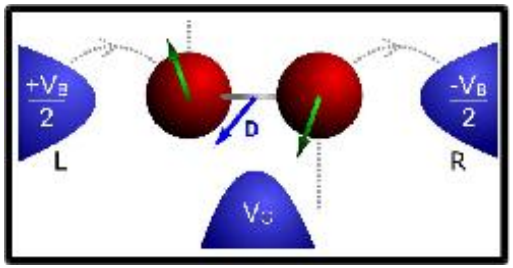


Transport in quantum dots and single-molecule junctions

- Many body effects: Kondo effect
- Non-equilibrium transport, spin-polarized transport
- Methods: renormalization group, Feynman diagrams, quantum kinetic equations
- Applications: molecular electronics, spintronics



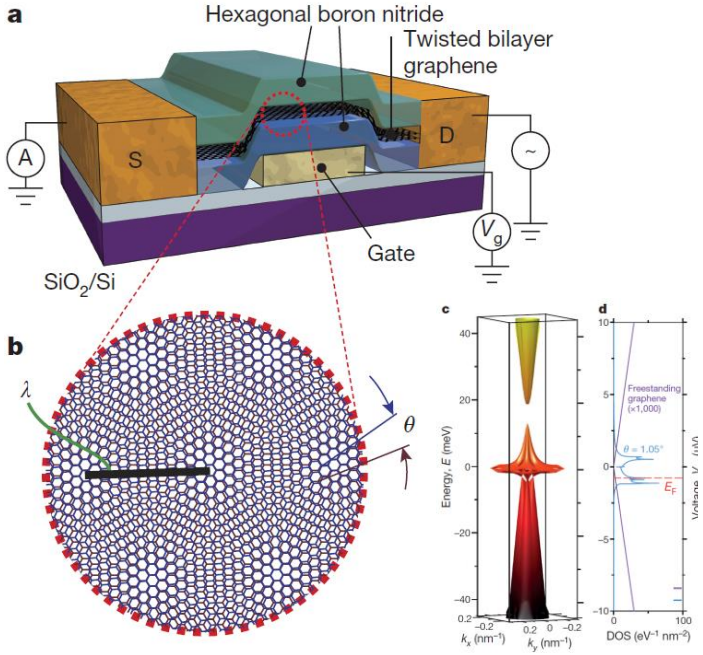


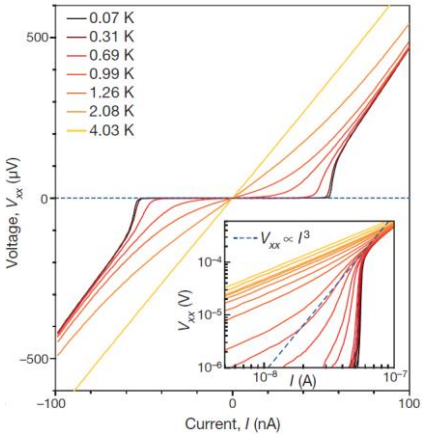


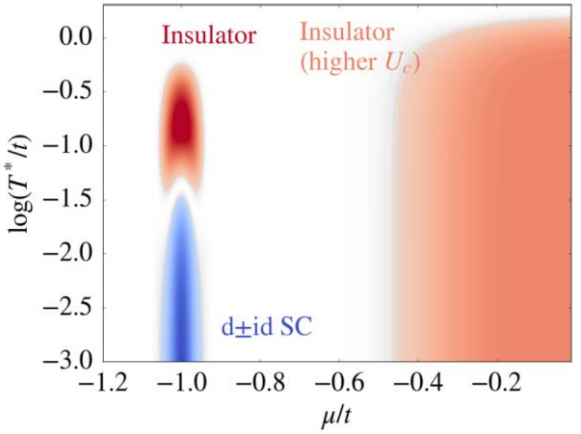
Twistronics

Study of how the angle between layers of two-dimensional materials affects their properties

Example: bilayer graphene becomes superconducting if one layer is rotated by a magic angle of 1.1° relative to the other





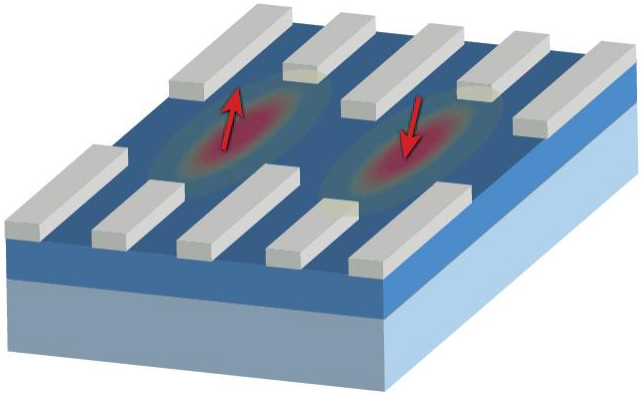


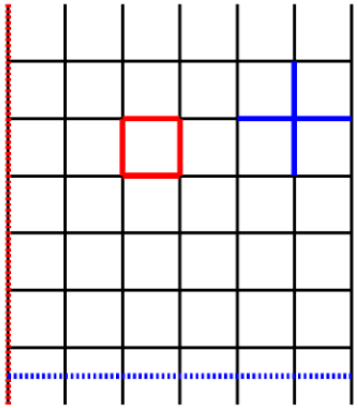
Institute for Quantum Information

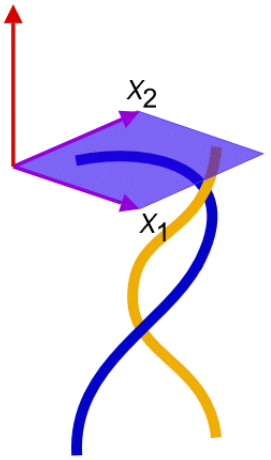
(D. DiVincenzo, F. Hassler)

Themes: - Solid-state based quantum information processing

- Topological quantum computation

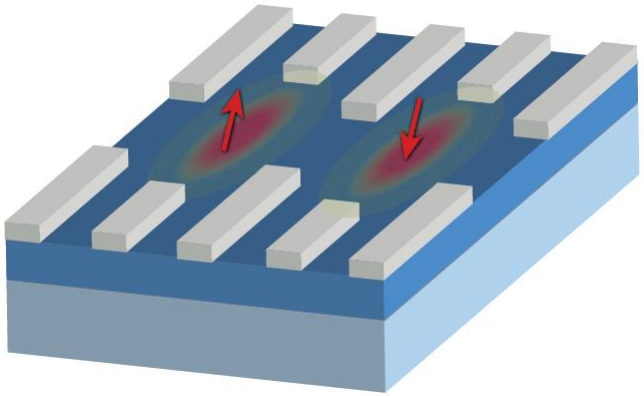


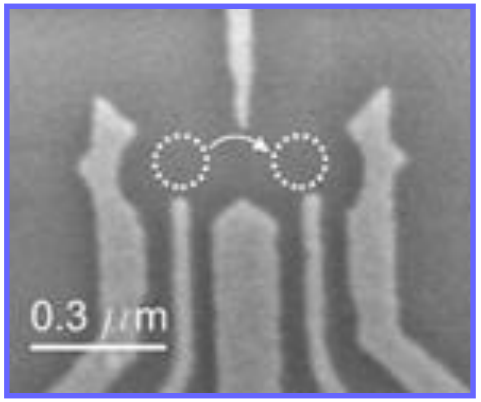


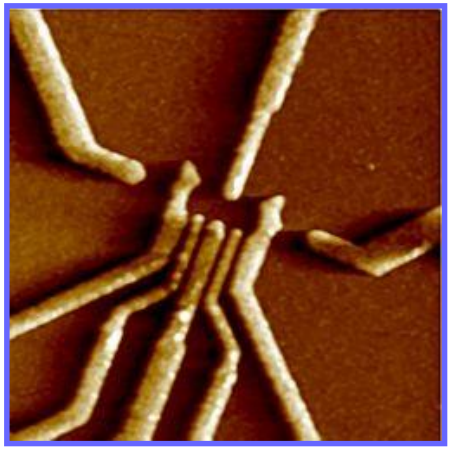


Quantum dots as spin qubits

- Spin of an electron confined in a quantum dot is a candidate for the realization of a qubit (Loss & DiVincenzo, PRA, 1998)
- Qubit operations implemented via local magnetic fields and gates
- Collaborations with the experimental groups of Prof. Bluhm and Prof. Stampfer (Institute IIB)







DFG research centers

Resistively Switching Chalcogenides for Future Electronics – Structure, Kinetics, and Device Scalability

Cluster of excellence involving RWTH Aachen University, University of Cologne, University of Bonn, and FZ Jülich

Research training group
Spokesperson: Volker Meden

Master's program: compulsory courses

1st term

- Quantum Theory of Condensed Matter I (Wessel)
- Theoretical Solid State Physics (Mazzarello)

2nd term (1 course out of the following 4 must be chosen)

- Quantum Theory of Condensed Matter II (Schoeller)
- Quantum Information (Wegewijs & DiVincenzo)
- Statistical Physics (Helias)
- Computational Physics (Michielsen & Mazzarello)

Theoretical Solid State Physics

Start: Thursday 10 October (10:30), Room: 28B 110

- Structure of crystalline solids
- Electronic band structure
- Electron-electron interactions
- Phonons
- Magnetism
- Modern theory of polarization
- Transport theory

Quantum Theory of Condensed Matter I

Start: Thursday 10 October (8:30), Room: 28B 110

- Second quantization
- Green's functions
- Diagrammatic methods
- Linear response theory
- Many-body physics
- Superconductivity

Master's program: elective courses (1st term)

- Advanced Molecular Dynamics Simulations (Winkler)

- Applied Quantum Mechanics (Koch)

- Density Functional Theory and Electronic Structure (Blügel)

- From Molecular to Continuum Physics I (Carloni)

- Non-Equilibrium Functional Renormalization Group (Jakobs)

- Open Quantum systems and Topological Systems (Schoeller)

- Statistical Mechanics of Neuronal Networks (Helias)

- Symmetries and the Many Electron Problem (Pavarini)