Materials for Quantum Nanotechnologies and Nano-Analytical Methods

SS 2022, Ursula Wurstbauer (https://www.uni-muenster.de/Physik.PI/Wurstbauer/teaching/teaching.html)

Basic facts:

- Thursdays: 10:15-11:45, first lecture on 7. April
- 2 SWS
- Language: English
- Hybrid:
  - In person: lecture hall 87 (IG1, Wilhelm-Klemm Str 10)
  - Zoom lecture: entry information on learnweb (contact Prof. Wurstbauer for enrollment key)
- Materials: lecture slides will be provided before the lecture on learnweb (MFQUNM-2022_1)
- Literature: Research related literature provided in the lecture and advanced solid-state text-books, e.g.
  - Rudolf Gross und Achim Marx, Festkörperphysik De Gruyter Oldenbourg, 2014 doi:10.1524/9783110358704 (sorry, only in german)
  - Peter YU, Manuel Cardona, Fundamentals of Semiconductors, Springer Berlin, 2016, ISBN 978-3-642-00710-1 (excellent book, but I recommend to us it together with a standard solid-state textbook)
    - *Both books are available as e-book at the WWU library*
- Active participation via discussion, quiz and project (last week)
- Consultation hour: upon request (just drop me a note)

Content:

In this lecture we will discuss solid state-based quantum materials, materials and concepts for quantum technological applications as well as selected nano-analytical methodologies applied to quantum materials. The lecture covers advanced solid-state physics topics as well as modern concepts for quantum technology such as:

- Introduction to quantum materials and materials for quantum technology including emergent functionality due to interaction physics (examples are superconductivity, Bose-Einstein condensation that also happens in ensembles of atoms)

- Electronic properties of (quasi) 0D, 1D and 2D solid state systems

- Overview of major methods to create quantum materials and materials for quantum-technologies:
  a) creation by quantum confinement
  b) creation by local electrostatic confinement (local gates)
  c) by geometry
  d) crystal growth e.g. by molecular epitaxy
  -> The concepts as well as suitable nano-analytical methods are elaborated

- Transport phenomena in 0D, 1D and 2D systems:
  a) Transport through a 0D quantum state: Coulomb Blockade and Coulomb Diamonds
  b) Quantized conductance through 1D wires
  c) Weal localization and quantum interference phenomena
  d) Classical and Quantum Hall Effect in 2D
  e) Optional: Introduction to (non-abelian) Fractional Quantum Hall effect states

- Hand-on experience in data analysis of magnetotransport data on two-dimensional electron systems in the Quantum Hall regime using e.g. origin

Preconditions

There are no access requirements beyond the ones for the master study as in particular basic knowledge in solid-state physics and quantum mechanics.