

PHYS-407

**Frontiers in nanosciences**

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Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Oral
Workload	90h
Weeks	14
<b>Hours</b>	<b>3 weekly</b>
Lecture	2 weekly
Exercises	1 weekly
<b>Number of positions</b>	

**Summary**

The students understand the relevant experimental and theoretical concepts of the nanoscale science. The course move from basic concepts like quantum size effects to **hot fields** such as spin transport for data storage applications (spintronics), carbon electronics, or nanocatalysis.

**Content**

- 1. Introduction to the concepts of nanoscale science**
- 2. The art of making nanostructures:**
  - a. Bottom-up assembly
  - b. Top-down fabrication
- 3. Quantum structures and devices:**
  - a. Current at the nanoscale
  - b. Quantum technology
- 4. Carbon nanotechnology:**
  - a. From fullerenes to graphene
  - b. Molecular electronics and machines
- 5. Microscopy and manipulation tools:**
  - a. Electron microscopy
  - b. Scanning probe microscopy: STM, AFM, MFM
- 6. Spectroscopy tools:**
  - a. Electron and photon spectroscopy: XPS, XAS, Auger
  - b. Electron and photon diffraction: LEED, TEM, SXRD
  - c. Synchrotron radiation
- 7. Magnetism at the nanoscale:**
  - a. Orbital and spin magnetic moment
  - b. Superparamagnetic limit in magnetic data storage
- 8. From electronics to spintronics:**
  - a. 2D electron gas at heterogeneous semiconductor interfaces
  - b. Single electron transistor
  - c. Spin transport: spin valve, GMR and TMR effects

**Learning Prerequisites****Recommended courses**

Solid state physics

**Learning Outcomes**

- Explain the differences between nanoscopic and macroscopic scale
- Analyze the results of a scientific experiment
- Design a scientific experiment

### Transversal skills

- Summarize an article or a technical report.
- Access and evaluate appropriate sources of information.
- Use a work methodology appropriate to the task.

### Teaching methods

Ex cathedra with visiting of laboratories at EPFL and the Max-Planck-Institute for Solid State Research in Stuttgart, Germany

### Assessment methods

oral exam (100%)

### Resources

#### Ressources en bibliothèque

- [Quantum Transport, Atom to Transistor / Datta](#)
- [Physics of surfaces and interfaces / Ibach](#)
- [Surfaces and interfaces of solids / Lüth](#)
- [Introduction to Nanoscience / Lindsay](#)
- [Physics at surfaces / Zangwill](#)

#### Websites

- <http://moodle.epfl.ch/course/view.php?id=7781>

#### Moodle Link

- <https://go.epfl.ch/PHYS-407>