General Physics: Electromagnetism

Electromagnetism (14 semaines)

for CGC and SIE sections

Prof. Pasquale Scarlino (SB IPHYS HQC)

Profile: *ahead of the Hybrid Quantum Circuit group studying light-matter coupling at the fundamental level and for applications in quantum computing and quantum simulation*

Moodle

Physique, Bachelor, PHY-201(e)

Course slide (pdf)

Exercises and solutions to exercises (pdf)

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Practical information

Course of Physique Generale III: **Electromagnetism**

for CGC and SIE sections

By Prof. Pasquale Scarlino (HQC, Quantum Technology)

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Always email me and TAs (English/French)
writing "**PHYS-201**" in subject line (to distinguish from spam)

1. Onsite lectures in CE 1 3 every Wednesday 8:15-10h,

   The conference will be opened for joining about 15 min in advance

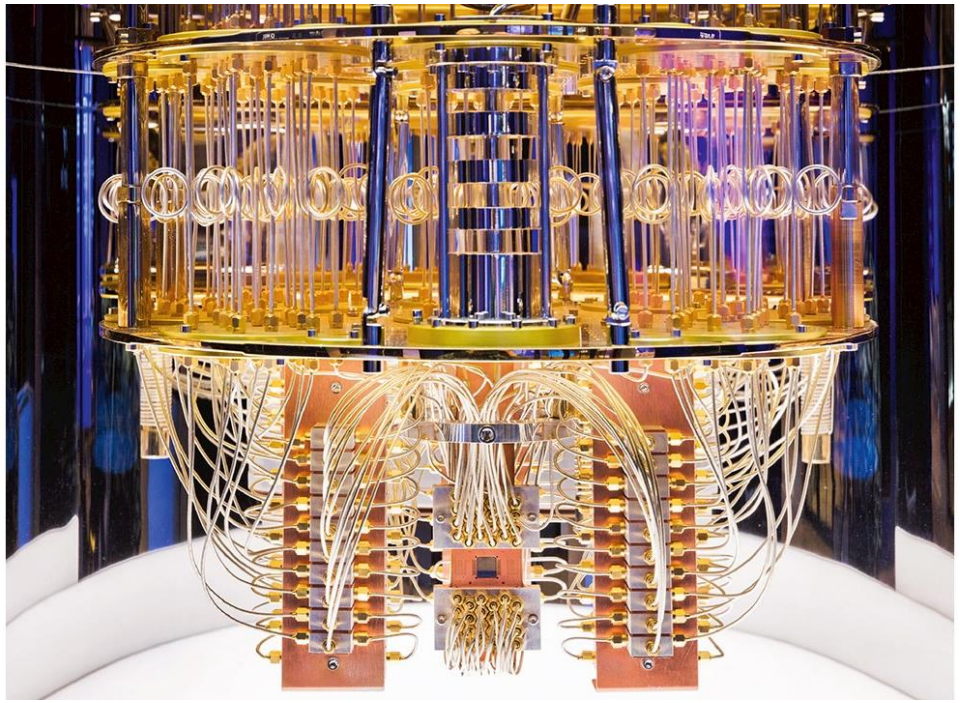
2. Recorded online lectures from Prof. Oleg Boyarkine

   (will be linked in Moodle);

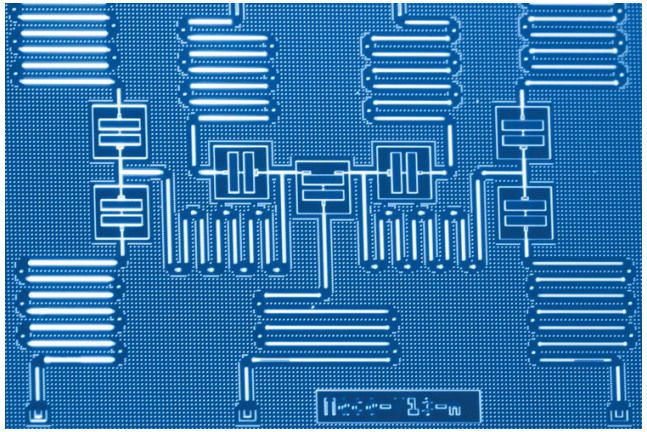
3. Office hours (also on Zoom on request) every Tuesday from 4 to 6 p.m.

HQC research topics: quantum technology

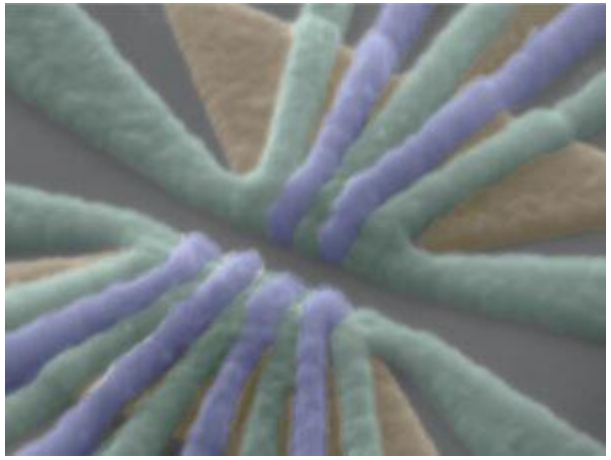
SPECIAL FRIDGE capable of reaching temperatures as low as 10 mK



SUPERCONDUCTIGN QUBITS



SPIN QUBITS



We study systems were **electromagnetic radiation of GHz frequency** interacts in cavites with the **electric dipole moment** of artificial atoms

For quantum computing and quantum simulation applications

Exercises class: What, Who and When

The exercises class will be every **Friday 8:15-10 h**

Group A: **Students from A to E (49)**
CE1 101, Assistants: fabian.oppliger@epfl.ch, filippo.ferrari@epfl.ch
pietro.giugiaro@epfl.ch, elie.khouryhanna@epfl.ch

Group B: **Students from F to M (60)**
CE1 103, Assistants: franco.depalma@epfl.ch, elena.acinapura@epfl.ch
alessandro.durso@epfl.ch, yelena.hohler@epfl.ch

Group C: **Students from N to W (44)**
GRA332, Assistants: guillaume.beaulieu@epfl.ch, adrien.cadet@epfl.ch
philippe.pache@epfl.ch, leo.carron@epfl.ch

This week 1st exercise class refreshing some fundamental math
and first exercises on Coulomb law !!!

Resources:

- Lecture pdf slides will be available on Moodle before a lecture
- Recorded lectures are accessible online from previous lecturer (link on Moodle)
- Solutions of the problems will be uploaded on Moodle after an exercise section
- Extra exercises slides: solved extra exercises and theory summaries
- Your own personal notes
- Books

Suggestions:

How to work on problem sets?

- Try to solve them by yourself first
- Discuss problems with friends and study group
- Write your own solution
- **DO NOT WAIT for the SOLUTION!**
- **DO many more exercises!**

Come and talk to us if you have problems or questions !
Math is your best friends !
Review all the concepts of previous course on classical mechanics
(we will add more forces, but the dynamics is always determined by Newton's Laws !)

Exam format

- On the exam (written) you can respond in English/French
  (problems will be in English)
- Announcements and all the material will be available on **MOODLE**
- course mark is based on the final written exam (3 hours long)
- the exam will consist of several problems to solve
- to be ready for the exam it is enough to solve all the exercises of the course
- **hence make the exercises session work for you in the best possible way!**

Books:

Physics for scientists and engineers with modern physics.

Serway/Jewett

This will be <u>our main book</u>; contains many solved exercises.

The corresponding chapters for each lecture will be indicated on Moodle

Physical copies are available in the EPFL library

Physics for scientists and engineers. **Giancoli**

more detailed for theory

We will post the relative chapters on Moodle

Fundamentals of Physics II : Electromagnetism, Optics, and Quantum Mechanics
R. Shankar

Introduction to Electrodynamics
David J. Griffiths

very nice references to go deeper in understanding
but harder from Math perspective

Topics to study

1. Charge, electrostatic interactions, Coulomb law, electrical field. Electrical units, conductors vs dielectrics.
2. Gauss law
3. Electric potential, capacitor, energy of electric field
4. Direct current and resistance
5. DC circuits
6. Static and dynamic Magnetic field
7. Faraday's law
8. Inductance
9. Alternating-current circuits
10. Electromagnetic waves

Syllabus of the Course

1. Electrostatics

Coulomb's law. The electric field E and potential due to a point charge and systems of point charges, including the electric dipole. The couple and force on, and the energy of, a dipole in an external electric field. Energy of a system of point charges; energy stored in an electric field. Gauss' Law; the E field and potential due to surface and volume distributions of charge (including simple examples of the method of images), no field inside a closed conductor. Force on a conductor. The capacitance of parallel-plate, cylindrical and spherical capacitors, energy stored in capacitors.

2. Magnetostatics

The forces between wires carrying steady currents. The magnetic field B, Ampere's law, Gauss' Law ("no magnetic monopoles"), the Biot-Savart Law. The B field due to currents in a long straight wire, in a circular loop (on axis only) and in straight and toroidal solenoids. The magnetic dipole; its B field. The force and couple on, and the energy of, a dipole in an external B field. Energy stored in a B field. The force on a charged particle in E and B fields.

3. Induction

Electromagnetic induction, the laws of Faraday and Lenz. EMFs generated by an external, changing magnetic field threading a circuit and due to the motion of a circuit in an external magnetic field, the flux rule. Self and mutual inductance: calculation for simple circuits, energy stored in inductors. The transformer.

4. Electromagnetic waves

Charge conservation, Ampere's law applied to a charging capacitor, Maxwell's addition to Ampere's law ("displacement current"). Maxwell's equations for fields in a vacuum (rectangular coordinates only). Plane electromagnetic waves in empty space: their speed; the relationships between **E**, **B** and the direction of propagation.