2SC5592 – Quantum cascade lasers

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Department: DOMINANTE - PHYSIQUE ET NANOTECHNOLOGIES
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 27,00

Description

The aim of this course is to learn new concepts in modern maths and physics and to realize how they enable technological breakthroughs that can be industrialized. This course is also a first opportunity to tackle the basic principles of nanotechnologies. In addition to scientific knowledge, it will also develop the soft skills of the engineer job through teamwork, written and oral communications.

Quantum cascade lasers are nanodevices invented twenty years ago. Engineering miracle their operation is possible because of the lattest advances in quantum mechanics, optics and thermics. In a team work, the students will get familiar with these concepts and implement an engineer approach to turn them, numerically, in an object reality-constrained.

Quarter number

ST5

Prerequisites (in terms of CS courses)

Quantum and Statistical Physics , Partial Differentieal Equations

Syllabus

- quantum physics (electronic transport, band structures, semiconductors)
- optics (mode guiding, cavities, emission)
- lasers
- basics of nanotechnologies
- partial differential equations
- numerical simulations through MATLAB or Python

Class components (lecture, labs, etc.)

This course is open to fourty students and will take place over a full week.

The students will be divided into two teams of twenty people, each team having to deliver a numerical quantum laser. The teams will be composed of four groups of five students, each group being more specifically responsible for developing a basic unit of the device.

Grading

Group oral presentation (skills C1.2, C1.3, C4.1, C6.1, C7.2)
Personal report (skills C1.1, C1.4, C4.2, C7.1)
Quiz (skills C2.1, C2.2)
Personal contribution to the group (skills C2.3, C2.4, C2.5, C7.3, C7.4)

Course support, bibliography

A list of books available at the documentation center will be given dureing the first session.

Resources

- Exchanges with engineers who are experts in the various fields covered
- Bibliographic Resources
- Use of MATLAB or Python

Learning outcomes covered on the course

- turn a theoretical concept into an actual object
- pose the problem
- estimate orders of magnitude and iterate
- criticize a result
- know how to tackle multi-physics systems

Description of the skills acquired at the end of the course

- Specify, design, build and validate all or part of a complex system
- Mobilizing a broad scientific and technical base in the framework of a transdisciplinary approach
- Transpose to other disciplinary fields, generalize knowledge

- Identify and rapidly acquire new knowledge and skills needed in relevant technical, economic and other fields
- Evaluate the effectiveness, feasibility and robustness of proposed solutions
- Choose solutions and act pragmatically, with a view to achieving tangible results
- Making complex content intelligible. Structure one's ideas, one's argumentation.
- Synthesize and take a step back
- Building buy-in and ownership
- Master scientific and technical communication. Be precise, relevant.
- Gather relevant and reliable information to support an argument.
- Teamwork/collaboration

ST5 – 56 – MULTI-ENERGY SYSTEMS

Dominante : ENE (Energy) and GSI (Large Interacting Systems)
Langue d'enseignement : French
Campus où le cours est proposé : Paris-Saclay

Engineering problem

The objectives of reducing energy consumption and polluting emissions make it necessary to use energy systems that call on sources with complementary yields and characteristics. This is the case for electricity production systems, where the growth of intermittent renewable production requires more flexibility from conventional production means, and also for the transport sector, where electric and thermal engines complement each other advantageously.

These multi-energy systems require advanced control modes to take advantage of the complementarity of energy sources, and to satisfy the needs of users and the economic, technical and environmental constraints.

Advised prerequisites

It is strongly advised to have taken at least one of the SPI Transfer Sciences or Electrical Energy courses.

Context and issue modules: This part is organized around half-days of training aiming to present the sequence, the integration teaching and to introduce the stakes and associated bottlenecks, in particular under the economic aspects and related to the social and geopolitical environment of the topic.

Specific course (60 HEE) : *Introduction to energy production*

Brief description: the course is structured in two parts:

1. Mechanical energy production

- Internal combustion engines: introduction to internal combustion engines (architecture, thermodynamic cycle, operation and control, pollutant emissions, basic sizing)
- Turbomachinery (wind turbines, hydraulic turbines, gas turbines): introduction to turbomachinery (architecture, operation, control modes, interest)

2. Electrical energy conversion

- Structure of alternating current machines, motor/generator operation
- Electronic converters.
- Principles for speed variation of machines (machine and converter system)

Challenge week n°1: *Regulation and control of energy production and conversion systems*

- Associated partners: EDF, GE Converteam

- Location: Paris-Saclay campus

Brief description: the objectives are :

- To be able to model an industrial physical system for a control purpose

- Understand the impact of the regulation of an installation on the overall operation of the electrical system

- To do functional modeling to determine the control strategy of a system

- Be able to develop a control law that meets the specifications

- Take into account the specificities of the conversion elements to associate them and create a system

Challenge week n°2: *Hybrid powertrain*

- Associated partner: to be confirmed

- Location: Paris-Saclay campus

- Brief description: the objectives are :

- Implement a systemic model of the hybrid powertrain

- Implement numerical processing tools under Matlab/Simulink

- Implement a control approach of the whole hybrid chain from the driver to the wheels

- Introduction to cycle sizing: complexity of the system and contradiction of several objectives to be achieved

Challenge week n°3: *Hybrid aeronautical propulsion*

- **Associated partner:** Safran Tech

- **Location:** Paris-Saclay campus

- **Brief description:** The integration course deals with power management in the context of a small single-engine aircraft with a hybrid battery/fuel cell energy architecture. The aircraft is propelled by a propeller powered by an electric motor and electricity is either directly drawn from batteries or generated by the combination of H_2 and O_2 in a fuel cell. The objectives are as follows:

- Realize a part and then assemble the whole systemic model of the energy architecture of the considered hybrid aircraft

- Implement the numerical resolution tools via Simulink and analyze the data collected

- Develop the regulation strategy of the system according to the given constraints

- Critique the model used in relation to the state of the art