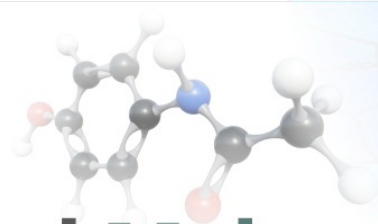


PMM

Physics of Materials and Molecules

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Presentation September 2025
Homepage of the [MME 2nd year Master Track](#) (to be updated soon)



Introduction for PMM

Generalities

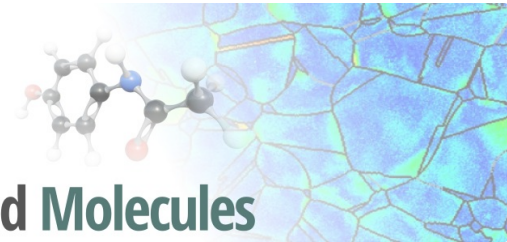
- PMM = “Physics of Materials and Molecules”
- 2-years track, part of the “Applied and Fundamental Physics” master’s program
- Some classes shared with
 - “Quantum and Photonic Technologies” master track
 - “Bio and pharmaceutical materials” master track
- Number of students: up to 15 for “Physics of Materials and Molecules”

Entry requirement

- In first year
 - Bachelor or 3rd year university degree in physics or physical chemistry
- In second year
 - Master or 4th year university degree in physics or physical chemistry

Jobs and careers

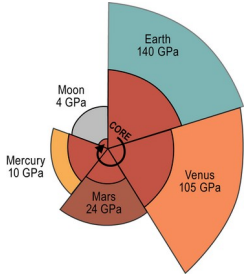
- Research in academia
- Public or private research laboratories
- Industry



Training objectives

Science for discovery

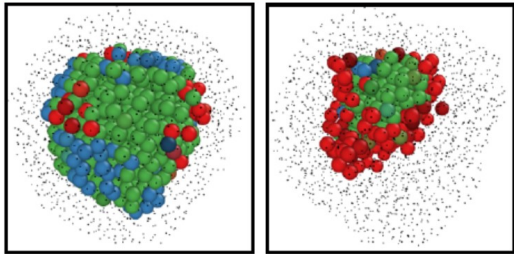
Planetary building blocs
Molecules in the solar system



Design advanced
experiments



npj | computational materials



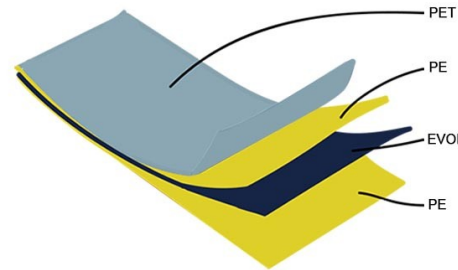
Advanced
atomistic
calculations

Science for solutions

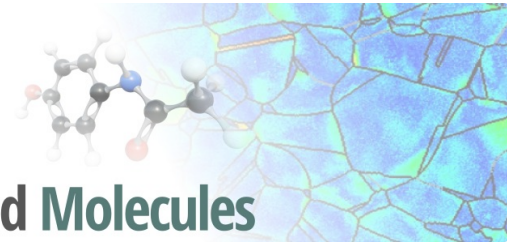
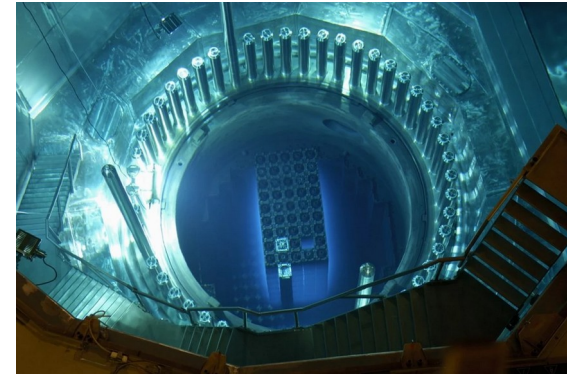
Metals, applications,
and limitations



Advanced polymers
for new packaging



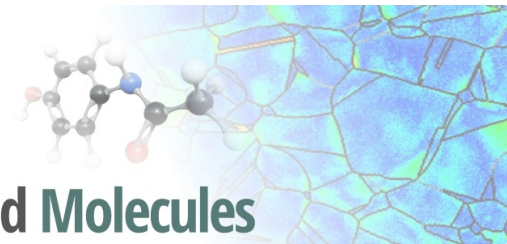
Materials for novel
energy sources



Training objectives

Physicists and chemical-physicists capable of tackling the major scientific questions of the 21st century

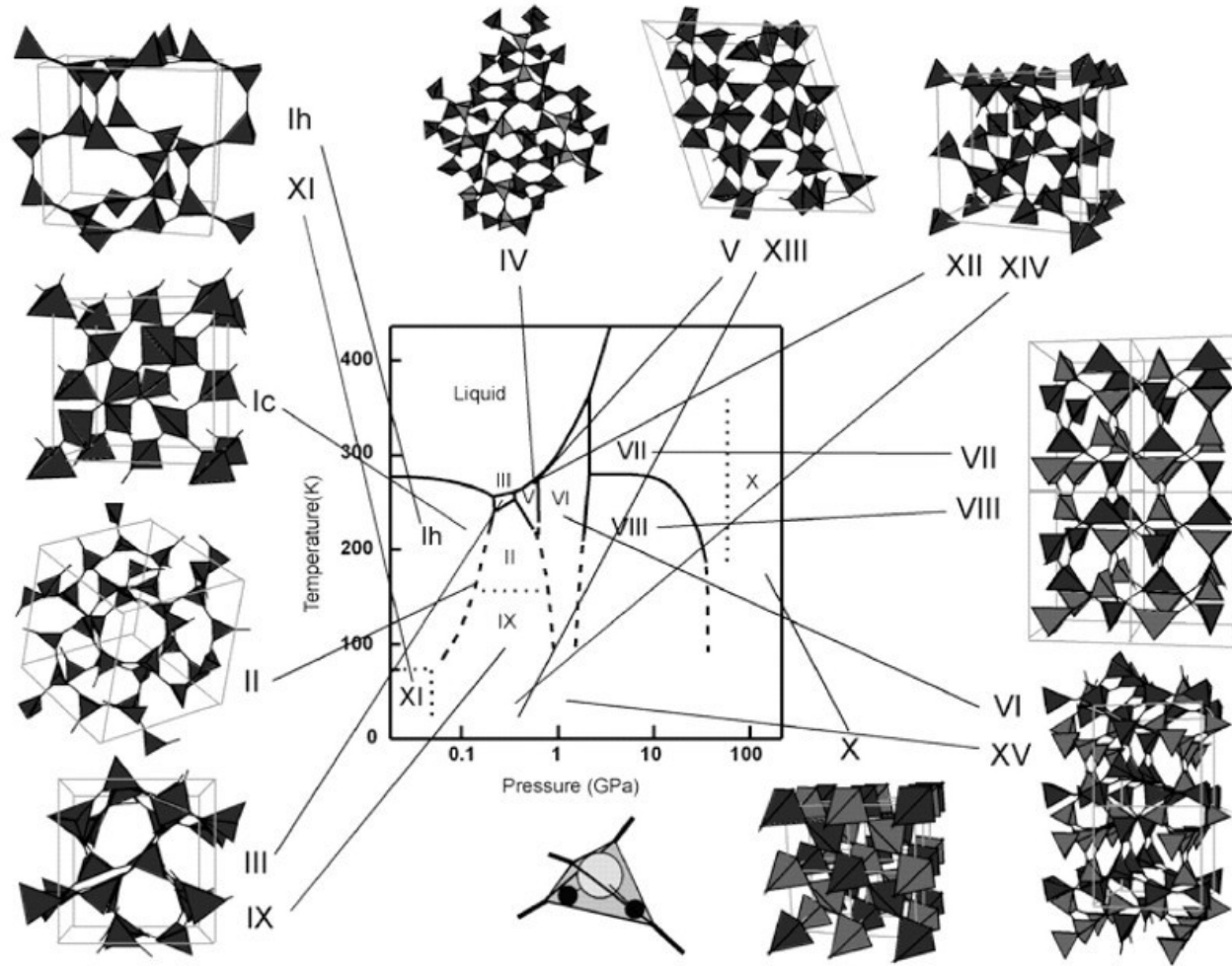
- *Solve concrete problems*
 - Design new materials for tomorrow's industry
 - Improve materials properties in their conditions of use
 - New materials for new energy sources
- *Address fundamental questions*
 - Matter within planets and atmospheres
 - Defects and materials thermodynamics
 - Calculations and theories for the atomic scale
 - Use of major international research instruments



A “simple” material: H₂O

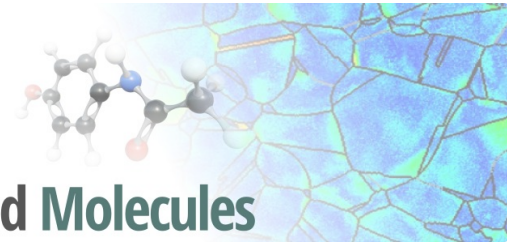
H₂O phase diagram

Umemoto Rev. Miner. Geochem. (2015)

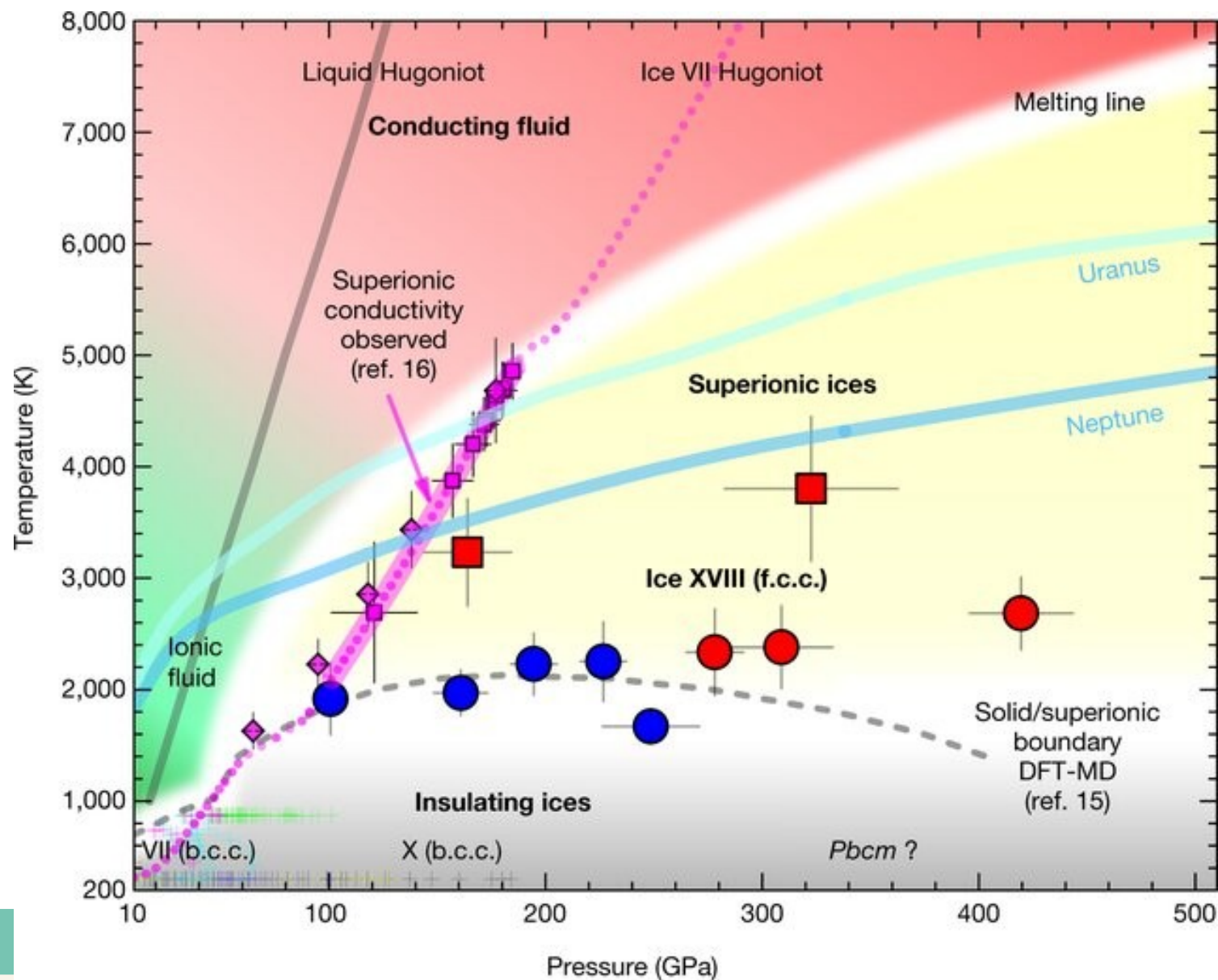


Effect of pressure and temperature on H₂O

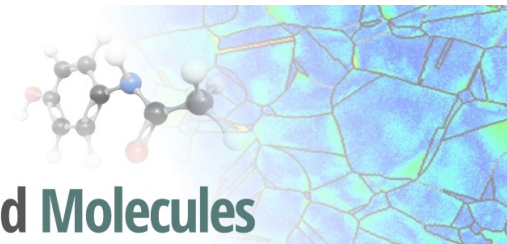
- Over 15 known solid crystal phases
- Requires
 - Thermodynamics
 - Solid state physics
 - Advanced experiments (spectroscopy, diffraction)
 - Quantum calculations
- Applications
 - Extreme environments
 - Planetary interiors

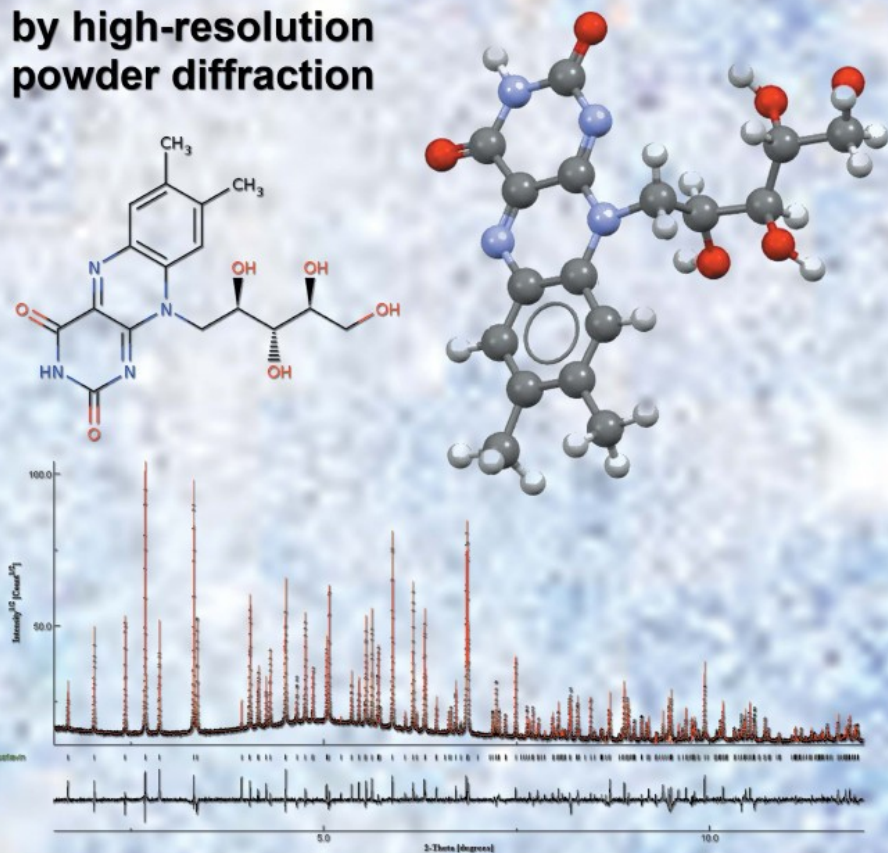


Ice, again!



Millot, Coppari
et al, 2019



**Structure of riboflavin
by high-resolution
powder diffraction**

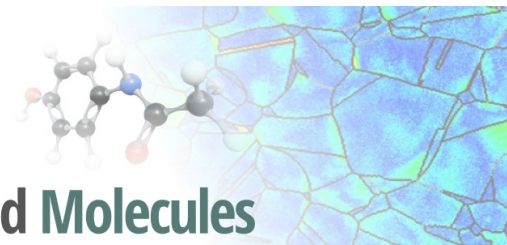
Vitamins?

Vitamin B2

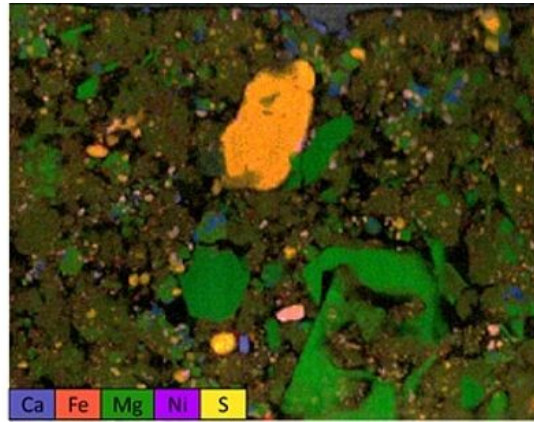
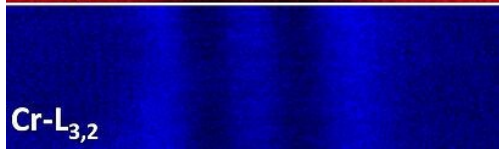
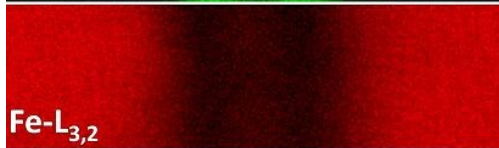
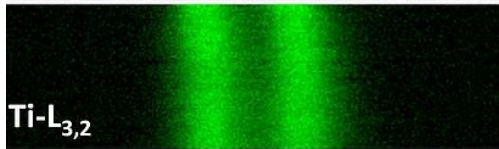
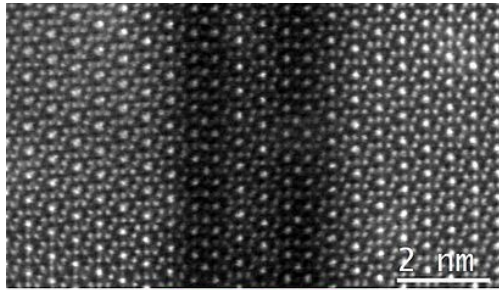
Riboflavine ($C_{17}H_{20}N_4O_6$)

Structure solved with

- X-ray diffraction
- Advanced quantum computer calculations



Advanced modeling and characterization techniques



Left: phase transformation in a Martian meteorite

Top: chemical mapping of a chondrite



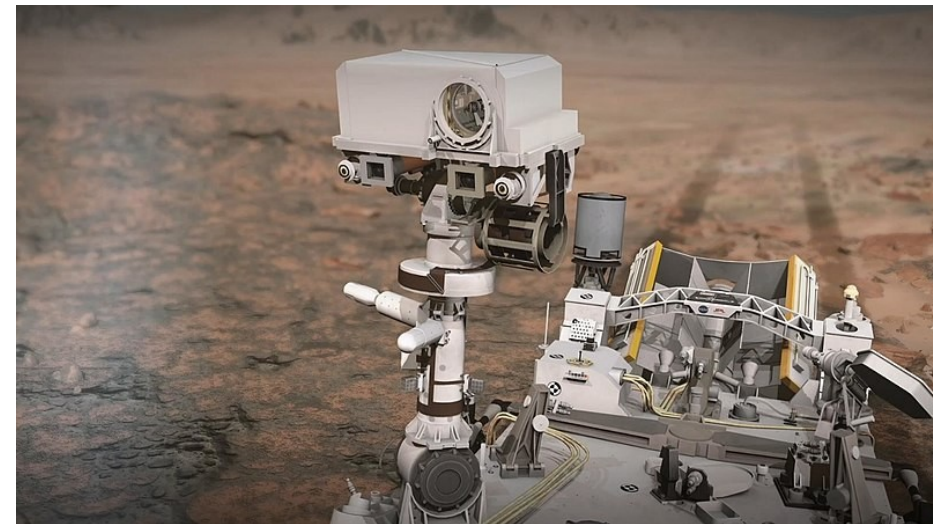
Electron microscopy

TEM at the Chevreul Institute (on campus)

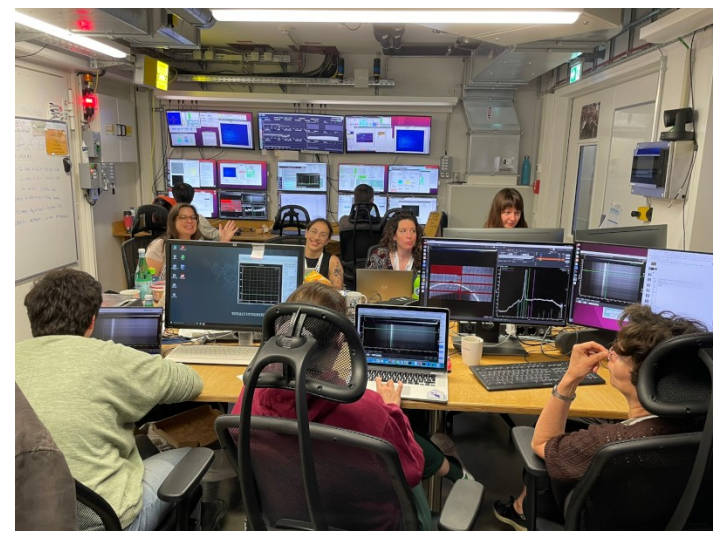
Spectroscopy

Supercam on Perseverance (artist rendering)

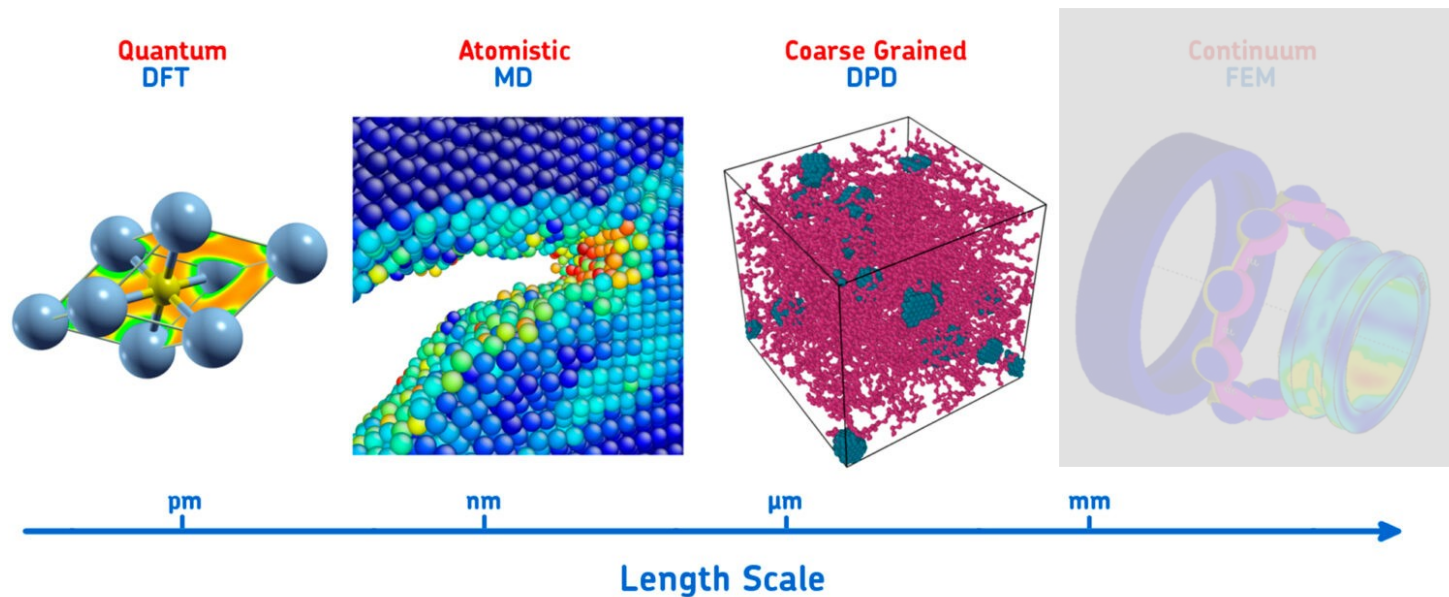
Raman spectroscopy, time-resolved fluorescence (TRF) spectroscopy, and Visible and InfraRed (VISIR) reflectance spectroscopy



Advanced modeling and characterization techniques



European X-ray laser in Hambourg

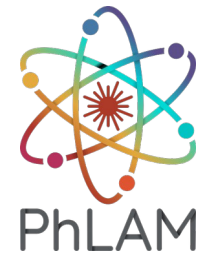


Atomic scale modeling

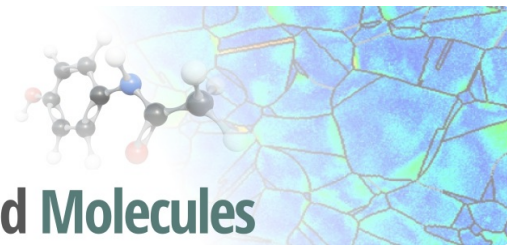
Research laboratories support

Attached laboratories in Lille

- UMET: Unité Matériaux et Transformations
 - Materials science, interface between physics and chemistry
 - Applications to polymers, metals, pharmaceutical materials, Earth and planetary science, etc
- PhLAM: Physique des Lasers, Atomes et Molécules
 - Molecular physics
 - Spectroscopy and applications
 - Theoretical Molecular Physico-Chemistry
- IEMN: Institut d'Electronique, Microélectronique et Nanotechnologie
 - Physics of nanomaterials
 - Wave propagation in structured materials
- LOA: Laboratoire d'Optique Atmosphérique
 - Physics and spectroscopy for the observation of atmosphere



Internships can be made outside Lille. It is not required to stay on site, nor in France. First year internships can be outside of academia.

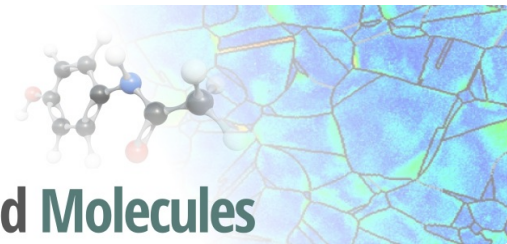


Student target

Background in fundamental physics or physical chemistry

Students in search of solutions, who will be trained in the latest advances in the sciences of matter, and will be able to develop and exploit new materials, the latest analytical methods, and the analytical tools to tackle today's societal issues;

Students in search of discoveries, who will be able to understand the fate of matter in a variety of environments and conditions, from the core of a nuclear power plant, to polymers, metals, pharmaceutical materials, up to the interior of planets or the atmosphere.



Former students: employers

Academia / Government agencies

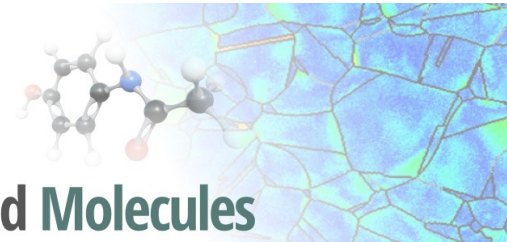
- CNRS
- Yale University, US
- Phoenix University, US
- Université Tours
- Univ. Lille
- Universitas 17 Agustus 1945 Surabaya, Indonesia
- Canadian Nuclear Laboratories
- CEA
- Onera
- Grenoble INP
- Université libre de Bruxelles

Private sector (industry)

- Siemens Energy
- Framatome
- EDF
- Decathlon France
- Altsom
- Raclot Industries
- AstraZeneca
- Imerys
- Groupe Institut de Soudure
- ITP Interpipe
- Blue Capsule Technology
- PPG

Consulting / computer industry

- Devoteam G Cloud
- Sopra HR Software
- Sopra Banking Software
- Groupe Luminess
- Axecom
- Calogena
- DEF
- Assystem
- Power Inside Data



What will you learn?

Fundamental physics

- Thermodynamics and statistical physics
- Solid state physics
- Atomic and molecular physics
- Materials science
- Light and matter interactions

Observation and experiments

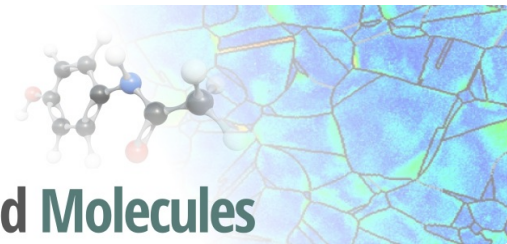
- Spectroscopy and diffraction
- Electron microscopy
- Large scale facilities (synchrotrons, accelerators, etc)
- Remote sensing, satellites

Computation methods

- IA and algorithms
- Molecular dynamics
- Quantum calculations (DFT)

Professional development

- Language courses
- Internships
- Tutored training on advanced topics
- Laboratory projects



BIOPHAM sister's program

Theoretical and applied high-level training in physics & chemistry of materials and their applications to pharmaceuticals and biopharmaceuticals

Read

X-Ray diffraction
 $n\lambda = 2d\sin\theta$

Crystal

Amorphous

Gibbs Free Energy

Glass

Crystal

Liquid

Tg

Tm

T

Welcome to BIOPHAM

The Erasmus Mundus Joint Master Degree BIOPHAM is a two-year master programme entirely taught in English. It aims at meeting an international demand for qualified graduates with theoretical and applied high-level training in materials science and physics & chemistry of materials and their applications to pharmaceuticals.

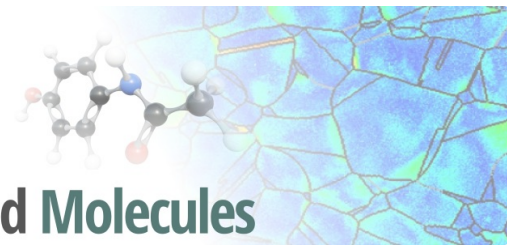
BIOPHAM was built by a consortium of four acknowledged European Universities and benefits from the



~50% of classes in the condensed matter options are shared with **BIOPHAM**

BIOPHAM

- Erasmus Mundus Joint Master Degree
- Training in materials science and physics & chemistry of materials and their applications to pharmaceutical
- Semester 1 and 3 in Lille



3 teaching blocs, spread over 4 semesters

Bloc 1: Develop specialized skills to produce knowledge in fundamental physics

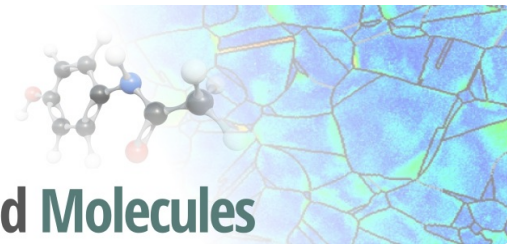
- By implementing advanced and specialized uses of digital tools
- By analyzing data for fundamental physics
- By practicing an experimental approach adapted to a physics problem
- By mobilizing and producing highly specialized knowledge

Bloc 2: Produce and communicate highly specialized knowledge, including in a professional context

- By mobilizing and producing highly specialized knowledge
- By implementing specialized communication for knowledge transfer
- By contributing to transformation in a professional context

Bloc 3: Solving complex problems by applying fundamental physics concepts

- By mobilizing and producing highly specialized knowledge
- By solving complex problems using fundamental concepts of fundamental physics



Curriculum: Semester 1

Bloc 1 Specialized Skills

AI and advanced
computational methods
in physics
3 ECTS

States of Matter
and Materials
Science Primers
3 ECTS

Atomic scale
modeling I
3 ECTS

Bloc 2 Professional Skills

French or English
3 ECTS

Tutored trainings
3 ECTS

Materials science
graduate program
3 ECTS

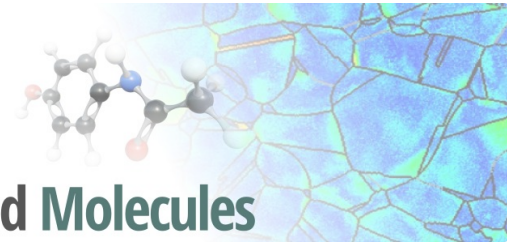
Bloc 3 Fundamental physics

Continuum
mechanics
3 ECTS

Statistical physics and
critical phenomena
3 ECTS

Condensed matter I
Electrons
3 ECTS

Atomic physics
3 ECTS



Curriculum: Semester 2

Bloc 1 Spezialized Skills

Satellites and
remote sensing
3 ECTS

Radiative transfer and
radiation-matter interactions
3 ECTS

Large scale research
infrastructures
3 ECTS

Experimental project
3 ECTS

Bloc 2 Professional Skills

Tutored trainings
3 ECTS

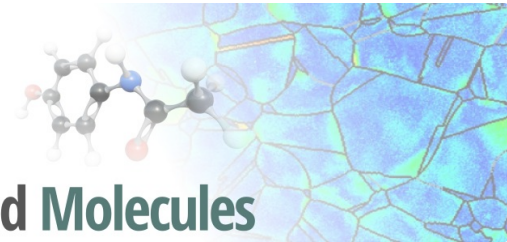
Internship
6 ECTS

Bloc 3 Fundamental physics

Condensed Matter II
Phonons
3 ECTS

Fundamentals of
molecular spectroscopy
3 ECTS

Microstructures and
defects in materials
3 ECTS



Curriculum: Semester 3

Bloc 1 Specialized Skills

Electron microscopy
and diffraction
3 ECTS

Advanced Spectroscopy
of Molecular Systems
3 ECTS

Atomic scale
modeling II
3 ECTS

Bloc 2 Professional Skills

French or English
3 ECTS

Speciality
6 ECTS

3 out of 5
Materials under extreme conditions
Metals and alloys
Polymers
Mathematical crystallography
Instrumentation in spectroscopy

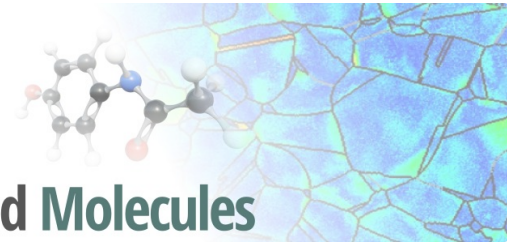
Bloc 3 Fundamental physics

Advanced thermodynamics
and phase transformations
3 ECTS

Molecular mobility and
amorphous state of matter
3 ECTS

From macro to
nanophysics
3 ECTS

Materials plasticity
3 ECTS

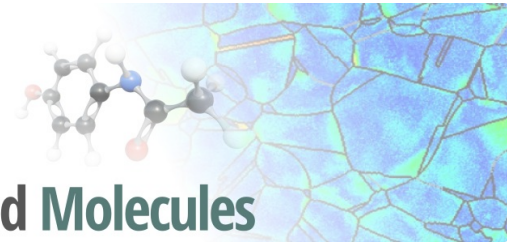


Curriculum: Semester 4

Bloc 2 Professional Skills

Option
or Graduate Program
3 ECTS

Internship
21 ECTS



Offers for internships 2024-2025

LOA

- Aerosol Measurement Over Oceans

PhLAM

- Characterization of Gas-Phase Atmospheric Organic Compounds and their Weakly Bonded Complexes via Rotational Spectroscopy
- Complexation of trivalent actinides by phosphate species
- Linking core spectra features of actinide complexes to their local environment
- Studying Reactivity of Atmospherically Relevant Radicals using Chirped Pulse Fourier Transform Millimeter wave spectroscopy
- Theoretical Investigation of the Surface Activity of Organosulfates on water droplets

Subjects for internships

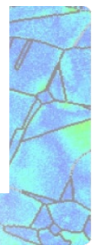
- Can be outside Lille
- change from year to year, depending on students, labs, etc.
- Not so many from LOA this year. Could be different next year

UMET

- High PT experiments for modeling the Earth's inner core
- Machine-learning approaches for nanoparticle simulations
- Modeling of dislocations in perovskite oxides AB₃O₃
- Phase-field modelling of radiation induced segregation application to nickel based alloys
- TEM analysis of a possible natural deep Earth sample

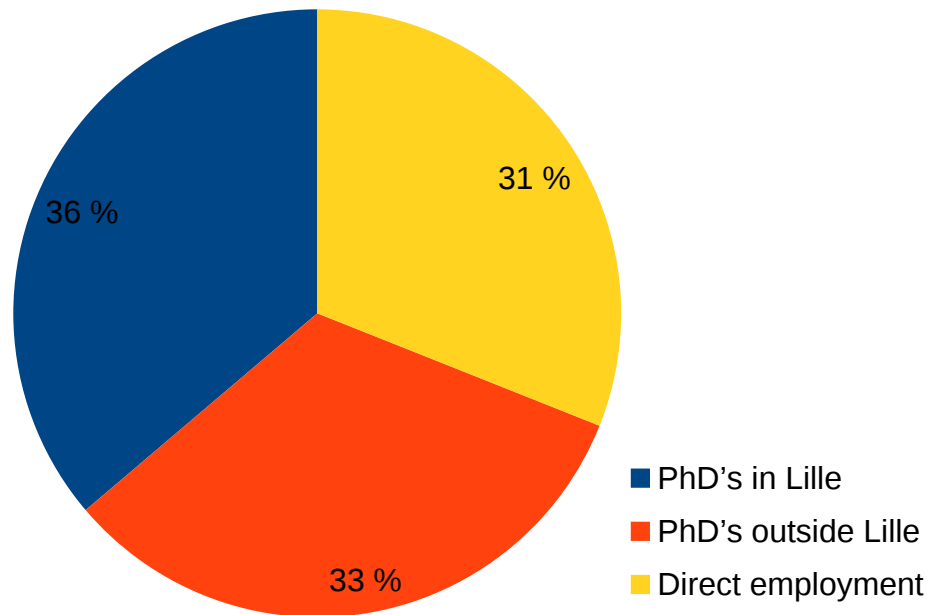
IEMN

- Using strong coupling to detect gas traces in the THz range
- Exploring Proteins quantum dynamics by using strong coupling in the Terahertz range
- Developing Novel THz Spectroscopy Techniques for Biological Sample sensing
- THz-Photonics in Biomolecular Research

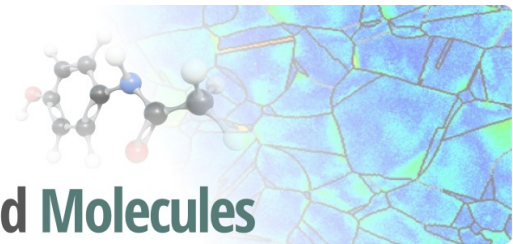
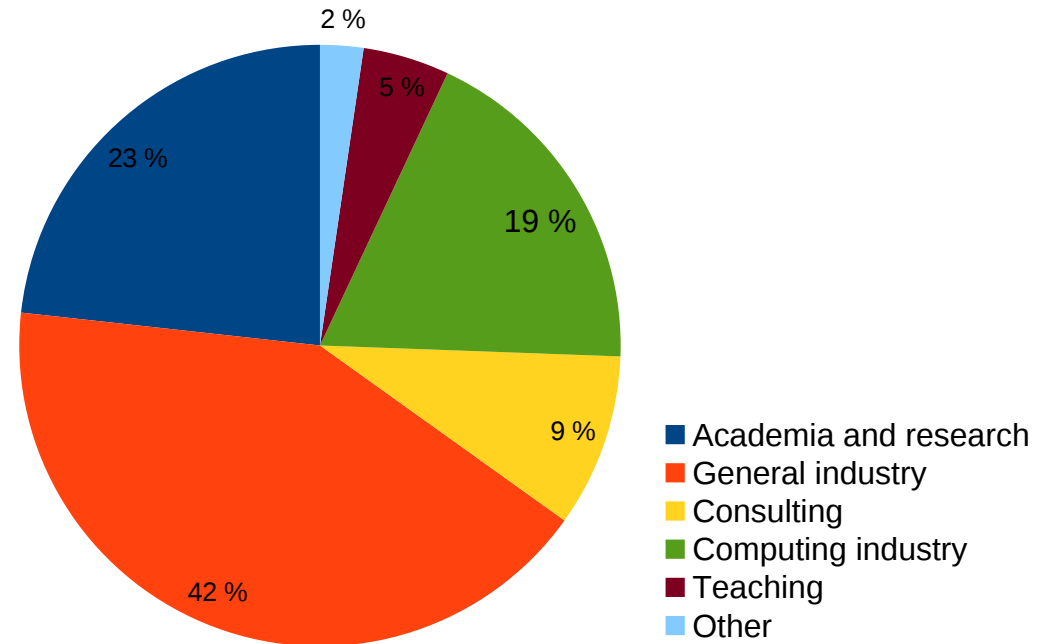


Statistics on ~60 students 2008-2024

PhD's

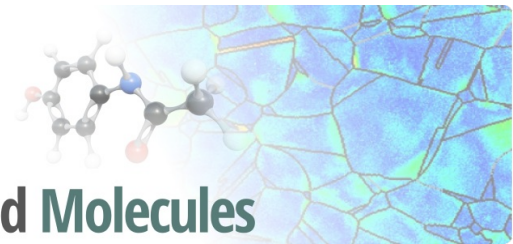
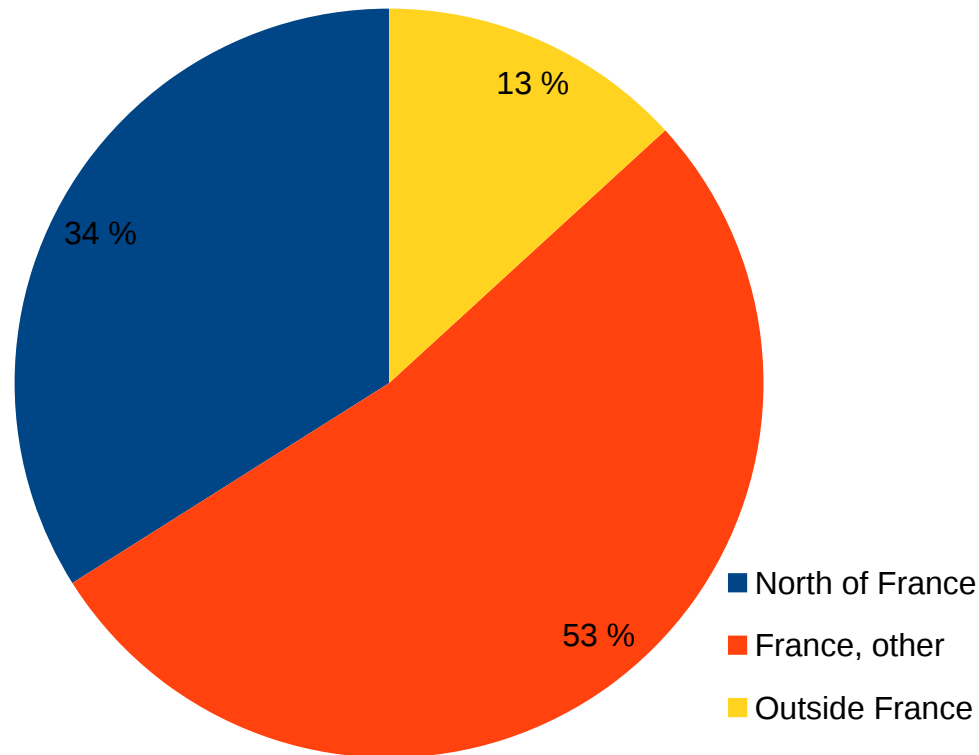


Activity sector (direct of after PhD)



Statistics on ~60 students 2008-2024

Localization (if known)



How to apply?

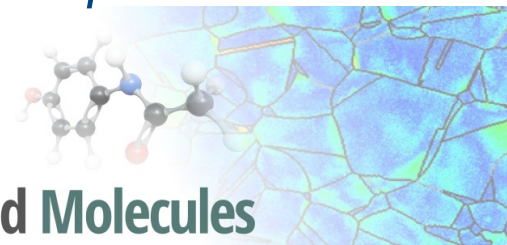
The "Etudes en France" (Studying in France) procedure

- Applies to ~70 countries
- Create an account on the "**Study in France**" platform and apply
- Deadlines: **mid-December**, probably
- Will take care of admission procedures and visas

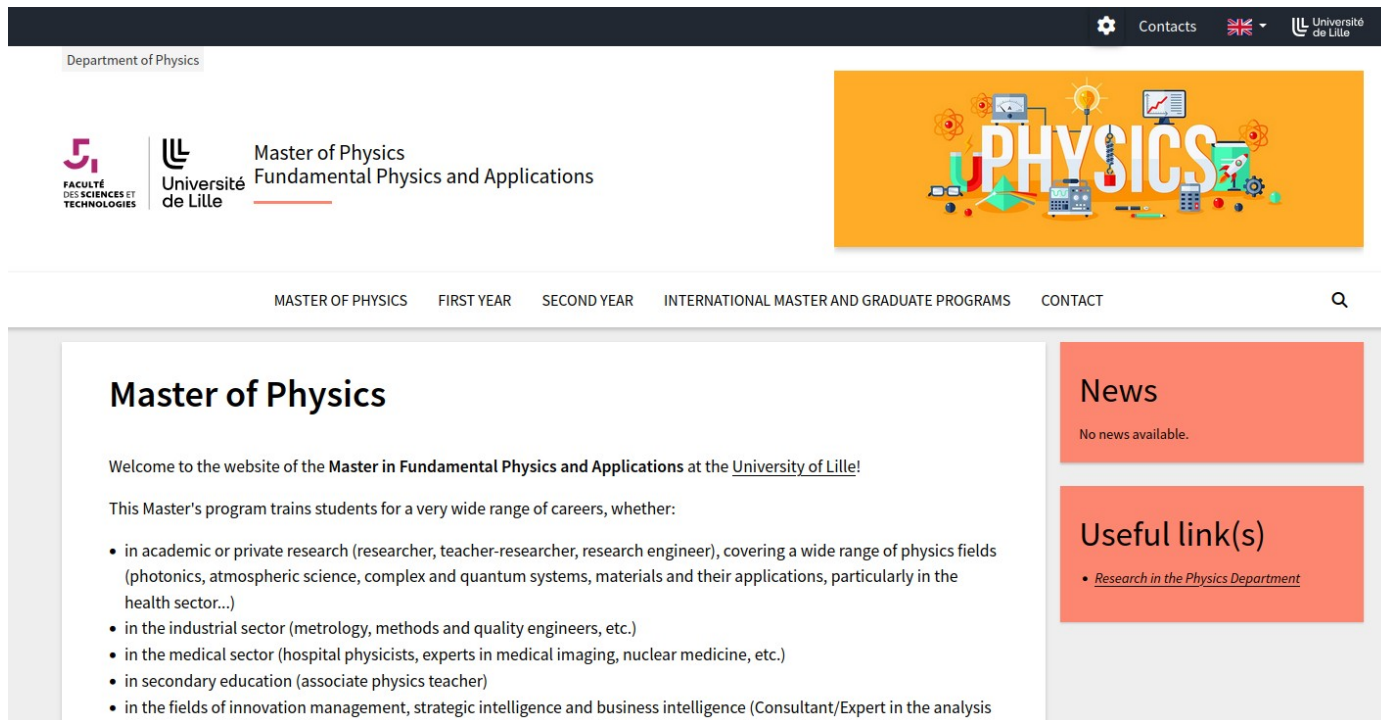
Students with no procedures on "Etudes en France"

- 1st year: use **monmaster.gouv.fr** internet platform, the French national platform for information and applications for a national Master's degree. Applies to
 - International students residing in France;
 - Students who are citizens of or reside in a country in the European Economic Area;
 - International students who reside in a country that is not covered by the "Etudes en France" procedure.
- 2nd year: apply directly to the University, on a platform called **e-candidat** (same conditions as above)
- Deadline: **spring 2026**.

"Etudes en France" is mandatory if you do not meet the conditions above. Do not try to apply directly. We can not accept applications that do not follow the procedure.



Updates and information



Physics masters degree website
Requires an update to new curriculum
<https://master-physique.univ-lille.fr/en/>
Coming up fall 2025

