Université Grenoble Alpes

International Master and PhD programs on quantum technologies

All you need to know as a BSc or Msc student in physics to join a high level Master program on quantum technologies in an exceptional environment.

Contact: david.ferrand@neel.cnrs.fr

This project is supported by the French National Research Agency (ANR-20-SFRI-0007) under the "Investissements d'avenir" programme.

Can we build machines based on the fundamental laws of quantum mechanics ?

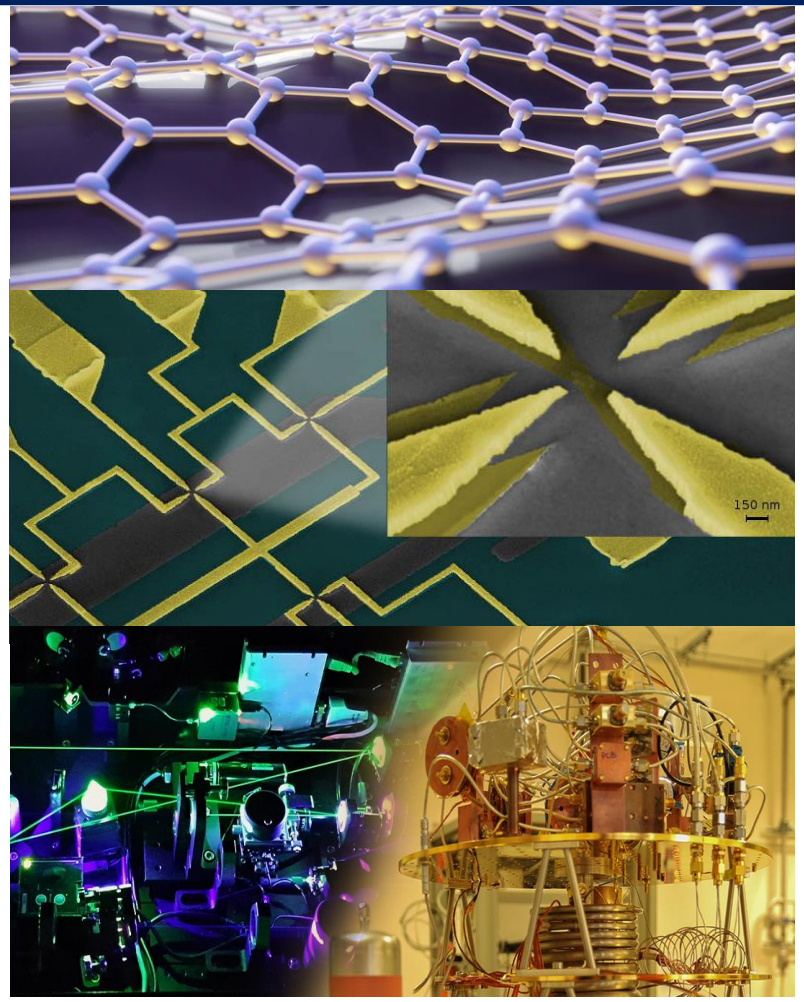
First quantum revolution

1935	EPR paper
1945	ENIAC
1947	Transistor
1960	Laser
1964	Bell's theorem
1982	Violation of Bell's inequalities
	Call for « second quantum revolution »

ENIAC

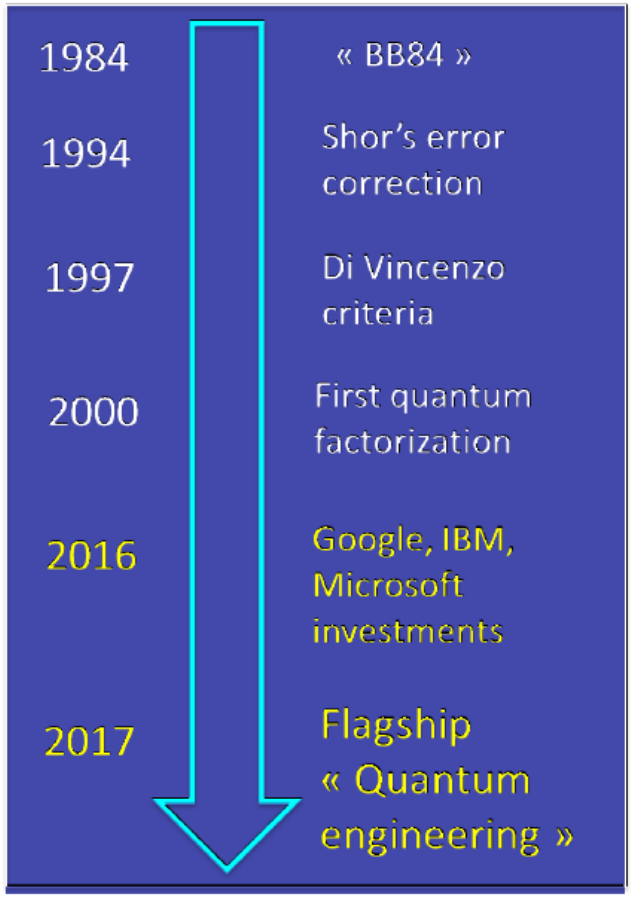
First transistor

Laser



Can we build machines based on the fundamental laws of quantum mechanics ?

Second quantum revolution



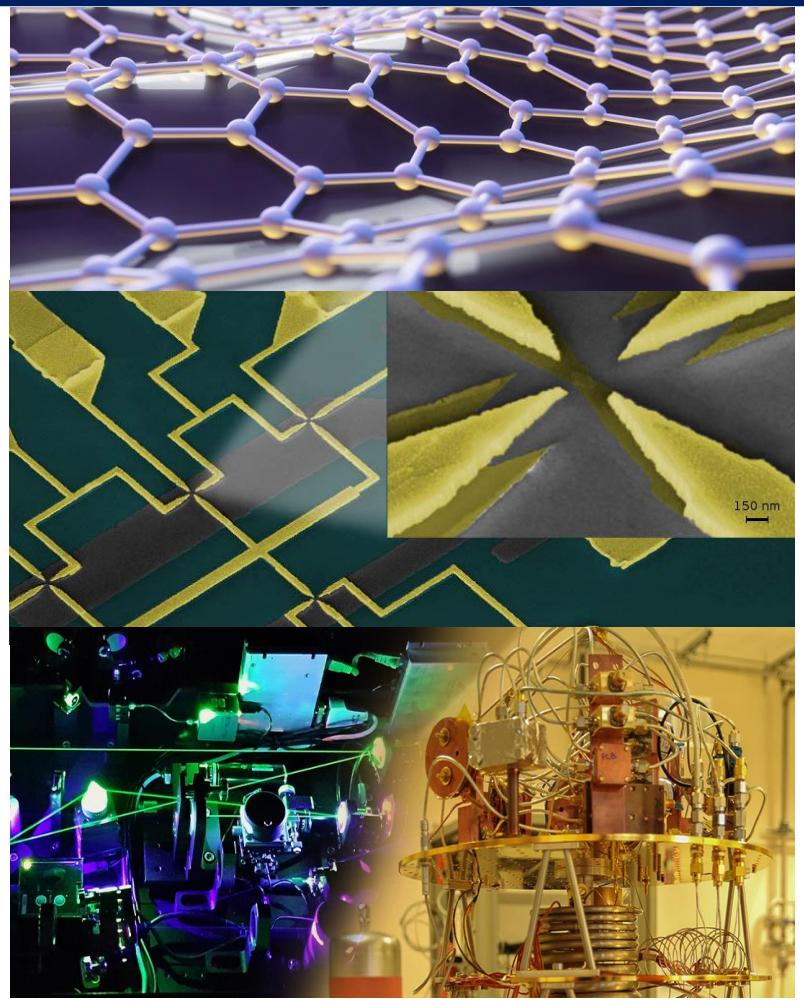
Exploiting coherence and entanglement for information technologies

Superposition principle

$$|\varphi\rangle = 1/\sqrt{2}\ (|1\rangle + |0\rangle)$$

Entanglement

$$|\varphi\rangle = 1/\sqrt{2}\ (|1\rangle|0\rangle + |0\rangle|1\rangle)$$



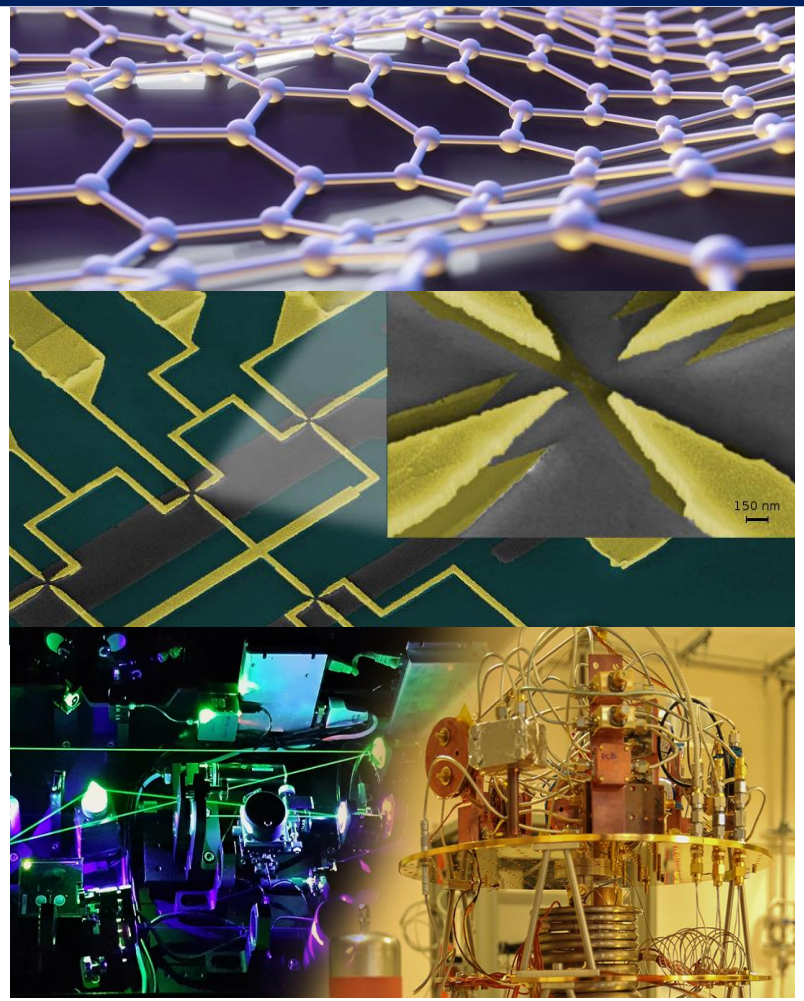
Can we build machines based on the fundamental laws of quantum mechanics ?

Goals

- **Faster computation**: Quantum algorithms (Shor 1994, Grover 1996)
- **Secure communication**: Quantum cryptography

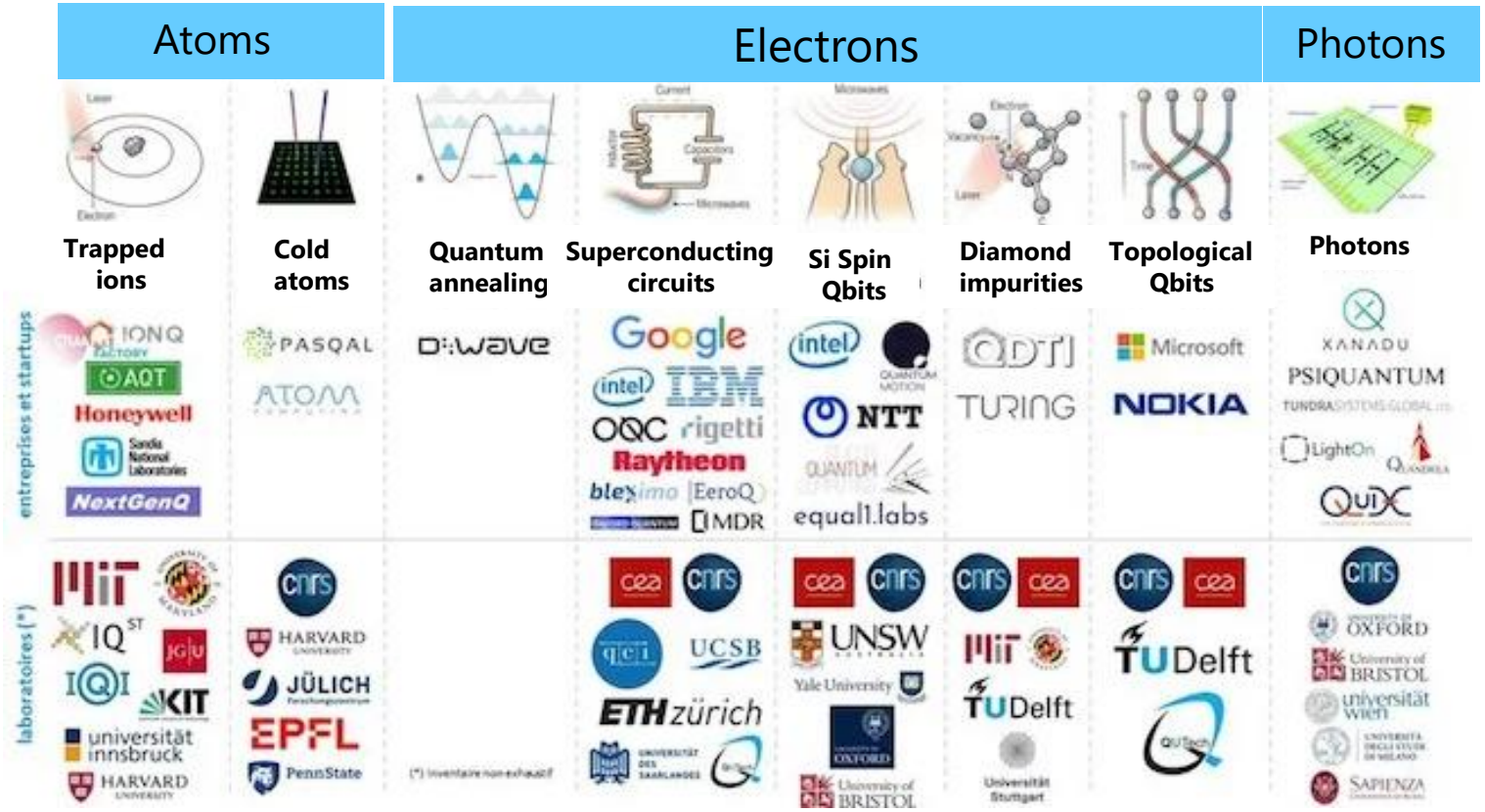
  Nobel prize in physics 2022: A. Aspect, F. Clauser, A. Zeilinger, quantum information science.

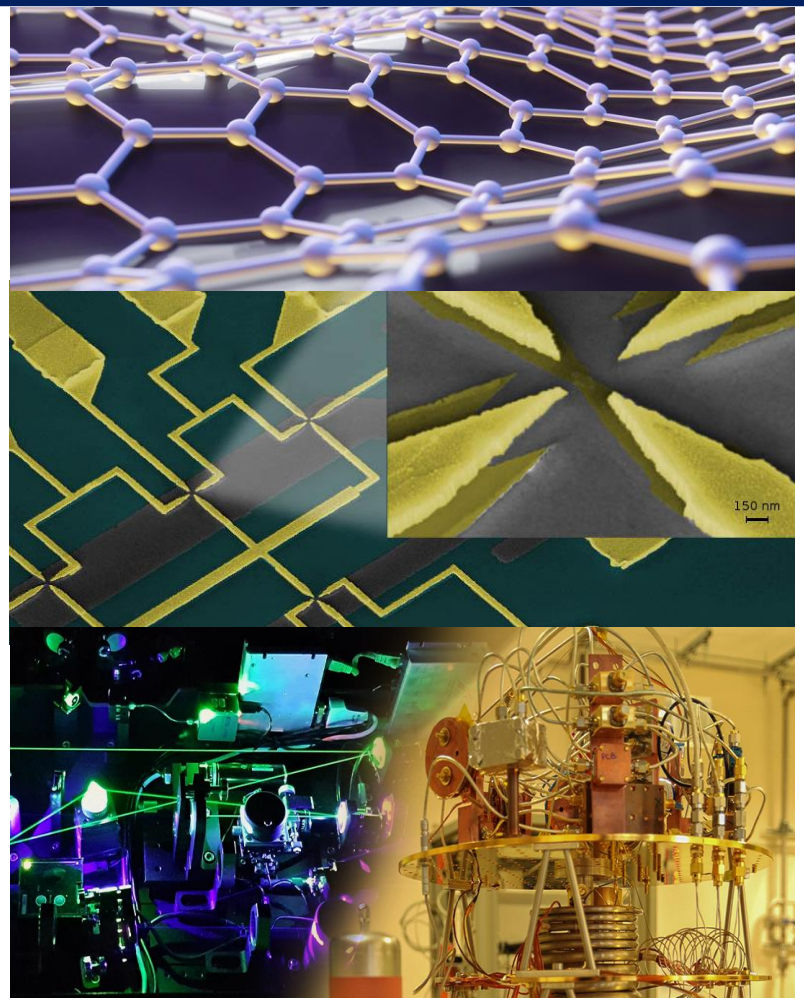
- **Better sensors: gravimeters**, Josephson junction amplifiers,…



Can we build machines based on the fundamental laws of quantum mechanics ?

Physical implementations: academic researches and developments in industry



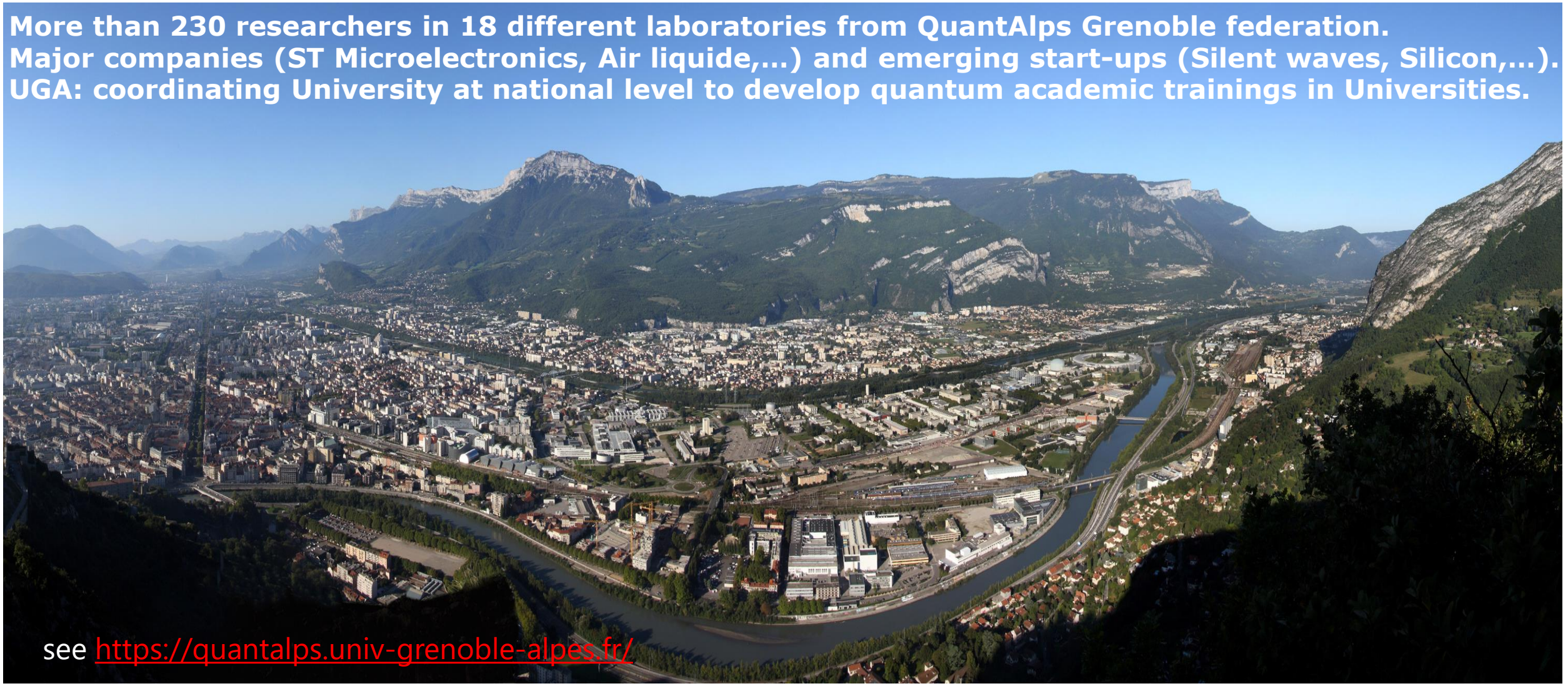


Many issues remain to be solved and will require to hire many talented new young scientists !

Quantum technologies in Grenoble

An outstanding ecosystem for Research, Education and Innovation

More than 230 researchers in 18 different laboratories from QuantAlps Grenoble federation.
Major companies (ST Microelectronics, Air liquide,…) and emerging start-ups (Silent waves, Silicon,…).
UGA: coordinating University at national level to develop quantum academic trainings in Universities.



see https://quantalps.univ-grenoble-alpes.fr/

Quantum technologies in Grenoble

An outstanding ecosystem for Research, Education and Innovation.

Grenoble uses its unique strengths to impact Quantum Technologies.
The exceptional density of expertise present on the site and their synergy also makes it a natural place for the emergence of new ideas and breakthrough innovations, beyond quantum technologies.

More than **230 researchers in 18 different laboratories in QuantAlps,** a Quantum Federation working on different scientific axes :

Quantum Engineering and Hardware :
Coherent manipulation and controlled entanglement of individual quantum objects.

Quantum Matter :
Collective quantum effects and new states of matter.

Quantum Information and Software :
New quantum techniques for the manipulation, processing and transfer of information.

Enabling technologies :
Technologies essential to Quantum Technologies: elaboration, clean rooms, cryogenics, cryo-CMOS, spintronics.

https://quantalps.univ-grenoble-alpes.fr/

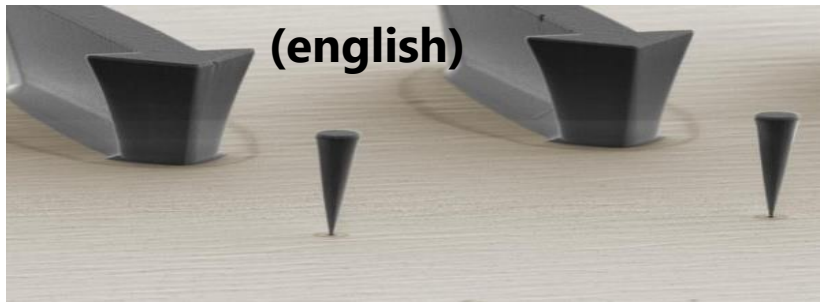
International quantum Master programs taught in English

International Master programs of the quantum thematic programs of UGA graduate Schools

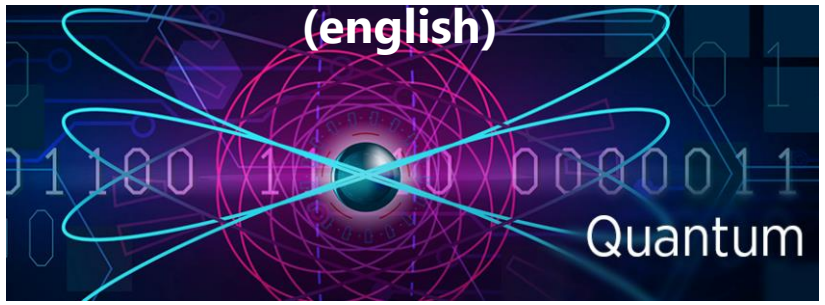
- High-level Master training in **fundamental** physics and its **applications** in nanotechnologies and quantum technologies.
- Open to students with a Bachelor in physics (or equivalent) from **national** and **international** origin.

Year 1: M1 NanoPhysics & Quantum Physics or Engineer School Phelma IPHY-2A
(english) **(french)**

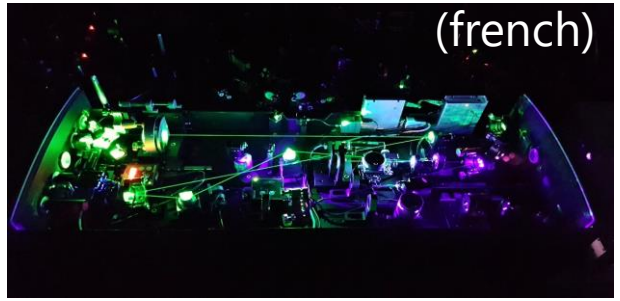
M2 NanoPhysics



M2 Quantum Information & Quantum Engineering



M2 Photonique et semiconducteurs



https://tinyurl.com/PTQuantum

Quantum technologies in Grenoble

An outstanding ecosystem (Research, Education, Innovation)

2 year international Master program in Quantum@UGA: 120 ECTS

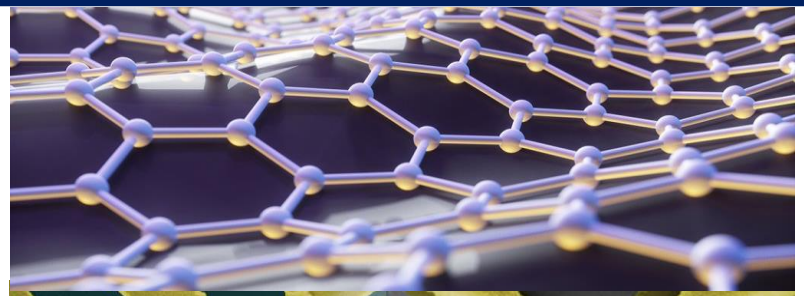
Year 1: NanoPhysics & Quantum Physics (60 ECTS, english)

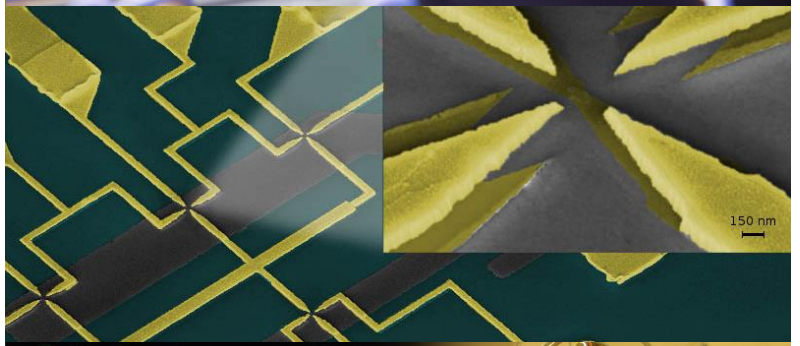
provides a solid knowledge in nanophysics and quantum physics for students willing to pursue a Master 2 and **a PhD in these fields**.

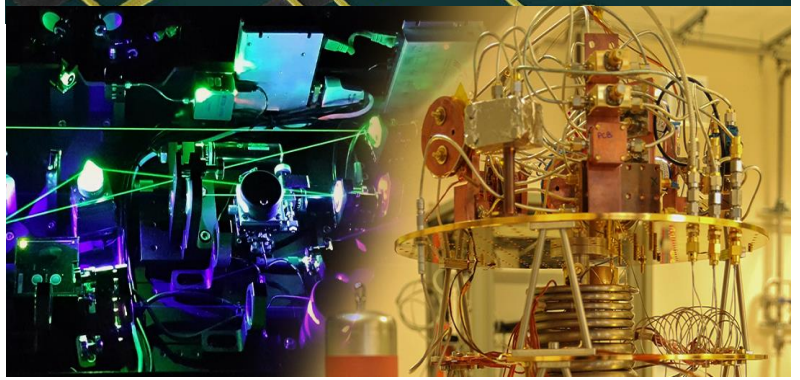
Quantum Physics I and II, Solid State Physics I and II, Semiconductor Physics, Magnetism and Nanosciences, statistical physics, Quantum practicals, + a 2 month research internship.

Year 1: Engineer School Phelma IPHY-2A (60 ECTS french)

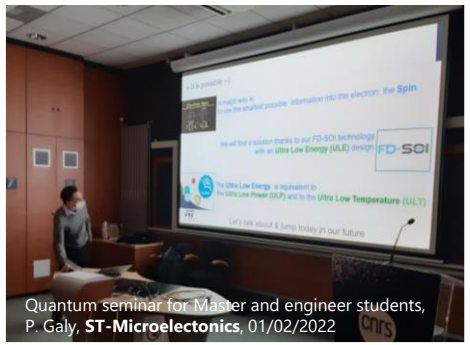
provides pre-requisite courses to attend Master 2 quantum information and quantum engineering or Master 2 photonique et semiconducteurs + 2 month internship.







Direct interactions with scientists and industrials



Quantum seminar for Master and engineer students, P. Galy, **ST-Microelectonics**, 01/02/2022

Quantum Labworks in research Laboratories

Quantum optics, Neel Institute

Quantum transport, CEA-IRIG

https://tinyurl.com/PTQuantum

https://master-nanosciences.univ-grenoble-alpes.fr/academic-program/

Quantum technologies in Grenoble

An outstanding ecosystem (Research, Education, Innovation)

2 year international Master program in Quantum@UGA: 120 ECTS

Year 2 NanoPhysics (60 ECTS, english)

aims to provide fundamental and applied courses on the physical properties, growth, advanced characterization, and applications of nanostructures.

Advanced semiconductor devices, nanophotonics and plasmonics, advanced charaterization technics, nanomaterials and energy, quantum optics, nanomagnetism and spintronics, …
+ a 5 months internship

Year 2 Quantum Information & Quantum Engineering (60 ECTS, english)

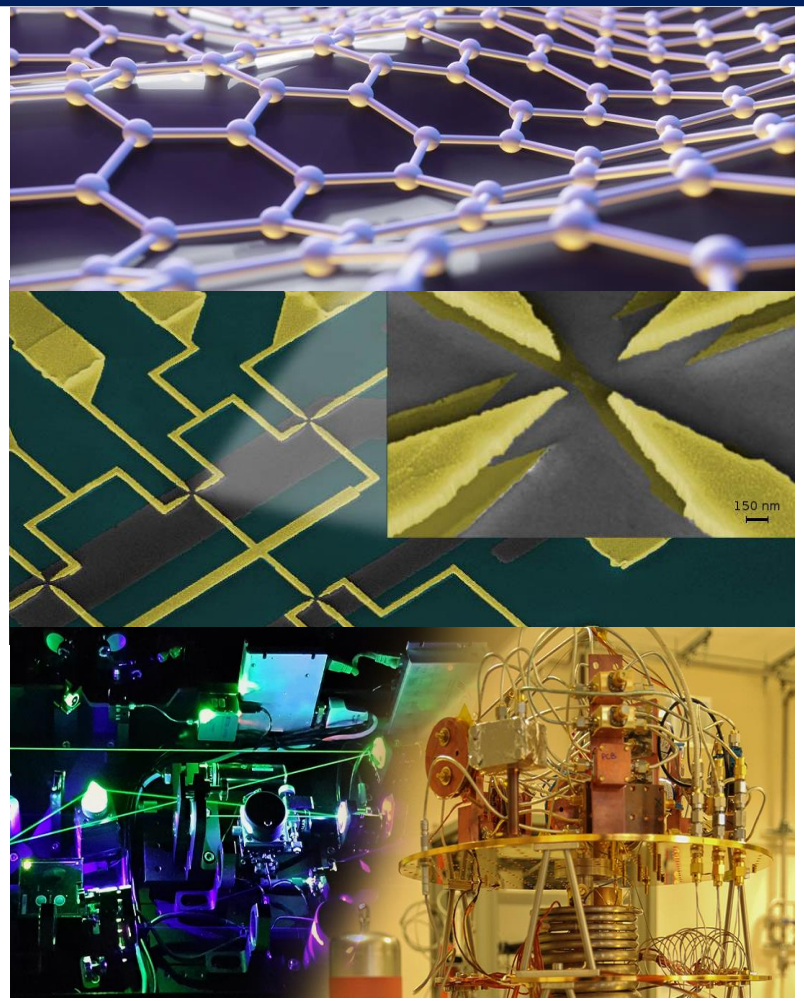
aims to provide a strong education on quantum physics and quantum technologies.

Solid State Qubits, Quantum algorithm, Quantum condensed matter, Quantum optics, Open Quantum systems, microwaves and cryoelectronics, practicals on IBM-Q, …
+ a 5 months internship

Year 2 Photonique et semiconducteurs (60 ECTS, french)

focused on the fabrication, physics and modeling of devices for photonics electronics and optoelectronics.
+ a 5 months internship

→ **2 common courses for the 3 tracks (Quantum optics and Quantum condensed mattter)**



https://tinyurl.com/PTQuantum

https://master-nanosciences.univ-grenoble-alpes.fr/academic-program/

After the Master: prepare a Phd in a research laborarory of Quantalps federation

Grenoble uses its unique strengths to impact Quantum Technologies.

More than **230 permanent researchers in 18 different laboratories in QuantAlps,** a Quantum Federation working on different scientific axes:

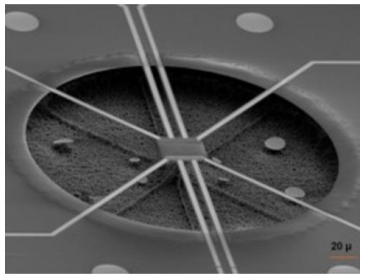
An exceptional PhD funding program ~50 new PhD/year

(Doctoral School, Research Contracts, QuanG Marie-Sklodowska-Curie Action COFUND program of the European Union, QuanTEdu-France, CIFRE, …)

An exceptional scholarships Master program

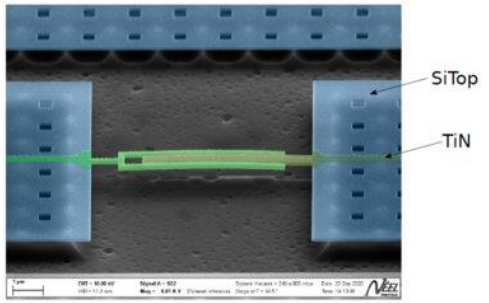
(Graduate School Quantum, QuanTEdu-France, Idex)

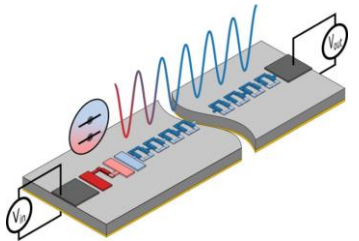
Two calls per year are organized by Quantalps (Spring and Fall calls: See **https://quantalps.univ-grenoble-alpes.fr/ (join us)**



PhD research project like :

Two qubit logic gates in a standard silicon platform
Silicon-enhanced CMOS quantum bits
Coherent manipulation of spin qubits in silicon by applying local magnetic fields
Non-destructive quantum measurement of a superconducting qubit
The G-center: an artificial atom for integrated quantum photonics on silicon
Quantum aspects of magnetic fragmentation in spin ice
Study of topological phases in graphene in the quantum Hall effect regime
Quantum metrology with superconducting quantum circuits
Dynamics of entanglement in quantum computers
Superconducting single photon detectors on silicon for quantum information.
…



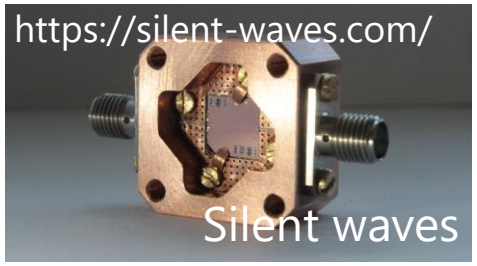


After a Master and/or a PhD : join a quantum technology company in Grenoble

Industries and R&D laboratories in Grenoble: ST Micro-electronics, SOITEC, Leti, Air Liquide, …

Emerging Startups :

- Silent Waves (2021) that aims to provide Josephson TWPAs to the quantum computing community.
- A startup working on Silicon based Quantum computer (2023).
- ….



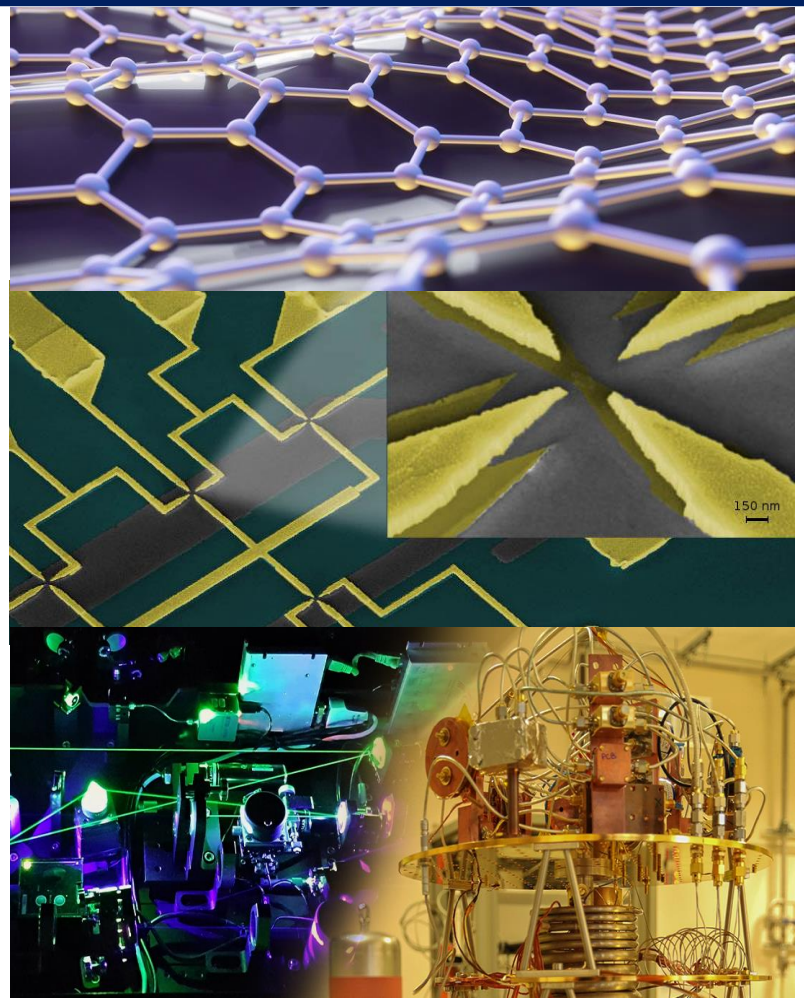
How to join us ?
Quantum master scholarships.

Applications to Master and engineer school programs

- Master 1 and Master 2 applications : look first at the program web pages listed in **tinyurl.com/PTQuantum** and then apply via
  - **EU student application portal:** *apply from **January to June 2023**:* **ecandidat.univ-grenoble-alpes.fr**
  - **PEF countries (non UE) application portal**: Apply from **October 1st to December 15th 2022**. **tinyurl.com/ETUDES-EN-FRANCE**

    Master 1: a 3 year BSc is requested.
    Master 2: a 4 year BSc, or 3 year BSc + 1 year Master are requested.

- Second year engineer school track: follow the information on the web-page: **https://tinyurl.com/enginuga23**

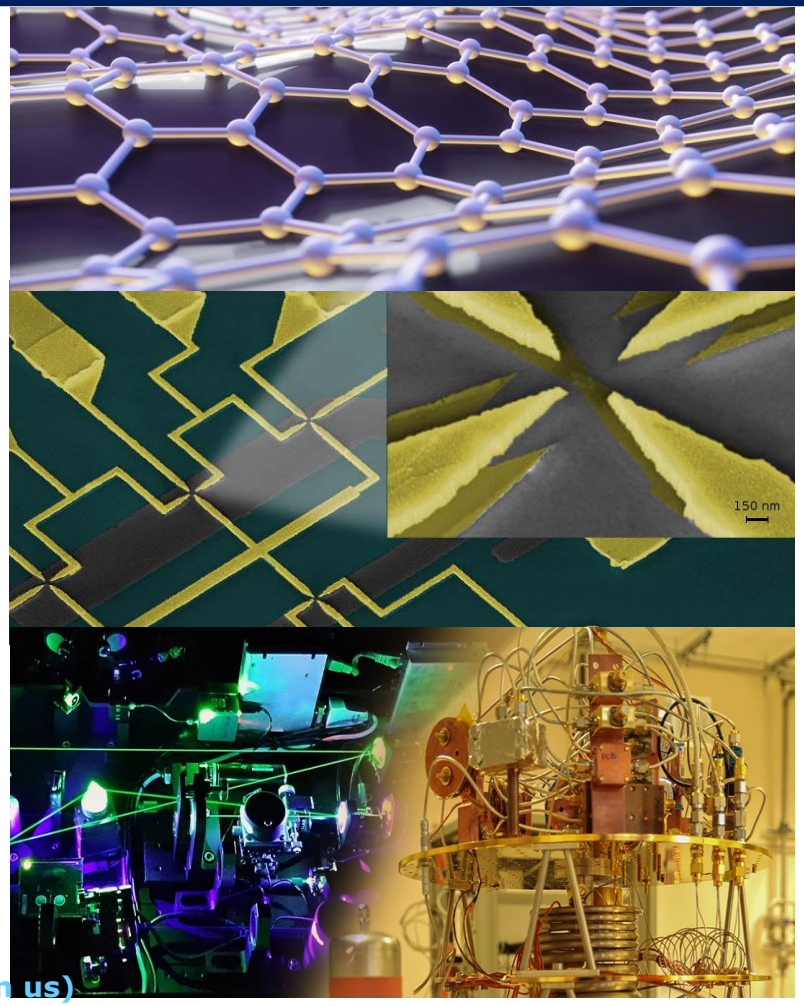


https://tinyurl.com/PTQuantum

How to join us ?
Quantum master scholarships for year 1 and year 2.

Quantum master scholarships

- UGA graduate school quantum master scholarships
  - **Scholarships necessary for 2 years (apply to year 1 programs)**
  - **Apply directly for the Scholarships (independently to your application to year 1 master or engineer tracks.**
  - **16kEuros for 2 years (year 1 + year 2),** your **high school diploma** (baccalaureat) has to be obtained **outside France** to be eligible. To get the scholarship, **you will have to be admitted to Master Nanophysics-quantum physics or 2-year IPHY Phelma engineer School lately in May 2023.**
    - Look at the information web page: **https://tinyurl.com/PTQuantum** and then contact dir@pt-quantum-uga.fr
    - The call will open in Fall 2022 (look at the web-page listed above)



https://tinyurl.com/PTQuantum

Regular PhD calls see https://quantalps.univ-grenoble-alpes.fr/ (join us)

Summary: download our Quantum thematic program pdf Flyer

Attached pdf Flyer with active hyperlinks

UGA Université Grenoble Alpes

QUANTUM Thematic Program

UGA Graduate School

The QUANTUM thematic program offers **specific high-level training on the quantum properties of device, matter and light** shared by several Master or engineer school programs. It will offer also mobility grants open to international students and promote their integration in leading research laboratories in Grenoble or in France via full time Master internships.The research topics covered by the program range from **quantum information devices**, **quantum calculation and metrology**, **quantum sensors** to **quantum materials** or **complex systems and hardware developments for quantum information processing**.

The program is a two-year program open only to students who will be admitted in the following Master or engineer school programs.

Fisrt year (2022-2023):

- *Nanophysics-quantum physics* Master 1 or 2A-IPHY *Photonics and Microelectronics* second year Engineer School

Second year (2023-2024):

- *Quantum Information-Quantum Engineering* Master 2
- *Nanophysics* Master 2
- 3A-IPHY *Photonics and semiconductors* Master 2

HOW TO APPLY

Quantum thematic program informations:
- tinyurl.com/PTQuantum

Master scholarships: *apply from october 2022 to may 2023*
- tinyurl.com/PTQuantum

Master programs: *informations before applying*
- tinyurl.com/ugamaster23

Engineer tracks: *informations before applying*
- tinyurl.com/enginuga23

EU student application portal: *apply from January to June 2023*
- ecandidat.univ-grenoble-alpes.fr

PEF countries (non UE) application portal: *apply from october 1st to December 15th 2022*
- tinyurl.com/ETUDES-EN-FRANCE

M1 NANOPHYSICS & QUANTUM PHYSICS

Year 1

Master 1 program accessible to students having a background in physics or engineering. It provides the appropriate background to pursue a second year in the M2 Nanophysics or the M2 Quantum Information Quantum Engineering (QIQE).

SEMESTER 7

Core courses
- *Professional insertion or French foreign language*
- *Quantum physics I*
- *Solid state physics I*
- *Semiconductors physics*
- *Optics*
- *Magnetism & nanosciences*

Elective courses
- *Statistical physics*
- *Mechanics at the micro & nano-scale*
- *Surface and interface*
- *Image and signal processing*
- *Electrochemistry*

SEMESTER 8

Core courses
- *Quantum Labworks**
- *Quantum statistics & interactions**
- *Solid state physics II*
- *Nanophysics with local probes*
- *Modeling and numerical simulations*
- *Nanosciences I*

Elective courses
- *Physics of 2D materials*
- *Molecular electronics & magnetism*
- *Molecular photophysics*
- *Ray-matter interaction*
- *Thin films*
- *Materials science*

* labelling course

+ 2 months minimum internship

Contact : hermann.sellier@neel.cnrs.fr
- tinyurl.com/M1NPQUGA

2A PHOTONICS & MICROELECTRONICS ENGINEER SCHOOL PHELMA-IPHY

Year 1

This second-year engineer track accessible to students already enrolled in the first-year of the engineer school or admitted in second year (admission by title). It provides the appropriate background to pursue a second year in the *Photonique et semiconducteurs* (PhSem) or the M2 Quantum Information Quantum Engineering (QIQE) via a double degree registration (3A engineer and Master 2).

SEMESTER 7

- *Quantum physics I*
- *Statistical physics*
- *Electromagnetism*
- *Physics of lasers*
- *Quantum physics II*
- *Physics and optics labworks*
- *Physic of semiconductors*
- *Solid State Physics*
- *Microelectronics Technologies*
- *English/Sport/ Worker training evaluation*
- *Financial Management-Marketing and Strategy*

SEMESTER 8

- *Quantum Labworks**
- *Quantum statistics & interactions**
- *Nanophysics*
- *Physics of semiconductor devices*
- *Electrical characterization labwork*
- *UE Engineering sciences*
- *Magnetism/Dielectric Physics*
- *Materials Synthesis / Symmetry and physical properties*
- *Business creation course*
- *Optical Engineering.*

* labelling course

+ 10 weeks minimum internship

Contact : celine.ternon@grenoble-inp.fr
- tinyurl.com/2AIPHYUGA

This project is supported by the French National Research Agency (ANR-20-SFRI-0007) under the "Investissements d'avenir" programme.

Summary: download our Quantum thematic program pdf Flyer

UGA Université Grenoble Alpes

M2 NANOPHYSICS

Year 2

This Master 2 program offers fundamental and applied courses on the physical properties (growth, nanofabrication and advanced characterization of nanostructures. It covers topics from crystal growth, quantum transport, photonics, nanomagnetism, spintronics and nanofabrication techniques. The program combines high level courses and trainings on top-equipments of research laboratories and clean rooms facilities of the Grenoble area.

Core courses
- *Advanced characterization techniques for nanostructures*
- *Elaboration of nanostructures / Physics of 2D materials*
- *From Nanofabrication in research labs to VLSI*

Applications
- *Advanced semiconductor devices*
- *Nanomagnetism and spintronics*
- *Nanomaterials and energy*
- *Nanophotonics-Plasmonics*

Specializing courses (quantum thematic program)
- *Quantum condensed matter*
- *Quantum optics*

Thematic and interdisciplinary projects
- *Modeling in Nanoscience, seminars, project*

+ a 5 months minimum Master thesis

Contact : helene.bea@cea.fr
tinyurl.com/M2NPUGA22

M2 QUANTUM INFORMATION & QUANTUM ENGINEERING

Year 2

This Master 2 program offers an ambitious program of lectures covering the whole spectrum from fundamental quantum physics to experimental implementations, new paradigms in computer science, and enabling technologies. The master is open students willing to work on fundamental quantum problems, and simultaneously contribute to the emergence of quantum technologies.

Fundamentals
- *Open Quantum systems*
- *Quantum optics**
- *Quantum Condensed Matter**

Implementations
- *Solid state qubits*
- *Nanomagnetism and spintronics*
- *Quantum algorithms*

Advanced instrumentations
- *Microwave and cryoelectronics*
- *From nanofabrication in research labs to VLSI*

Thematic and interdisciplinary projects
- *Seminars, Practicals (IBM-Q Experience)*

* *Labelling course*

+ a 5 months minimum Master thesis

Contact : franck.balestro@neel.cnrs.fr
tinyurl.com/M2QIQE22

M2 PHOTONICS & SEMICONDUCTORS

Year 2

This Master 2 program is a joint program between UGA's "Physics" Master's program and the Grenoble INP - UGA Phelma engineer school. Its program is focused on the fabrication, physics and modeling of devices for photonics, electronics and optoelectronics. These devices (transistors, lasers, CMOS imagers, photovoltaic cells, frequency converters, etc.) are the subject of intensive research in both academic and industrial environments, because of their importance in many sectors, such as information technology.

Elaboration and characterization of materials
- *Photolithography*
- *Physics of technological processes*
- *Material characterization techniques*

Photonics
- *Nonlinear optics*
- *Guided optics*
- *Optical signal processing*
- *Quantum optics **
- *optoelectronics devices*
- *THz optoelectronics*

Semiconductors
- *Physics of advanced MOS components*
- *Reliability of components and circuits*
- *Quantum condensed matter **

* *Labelling course*

+ a 5 months minimum Master thesis

Contacts : benoit.boulanger@neel.cnrs.fr
lionel.bastard@grenoble-inp.fr
tinyurl.com/M2PhSem22