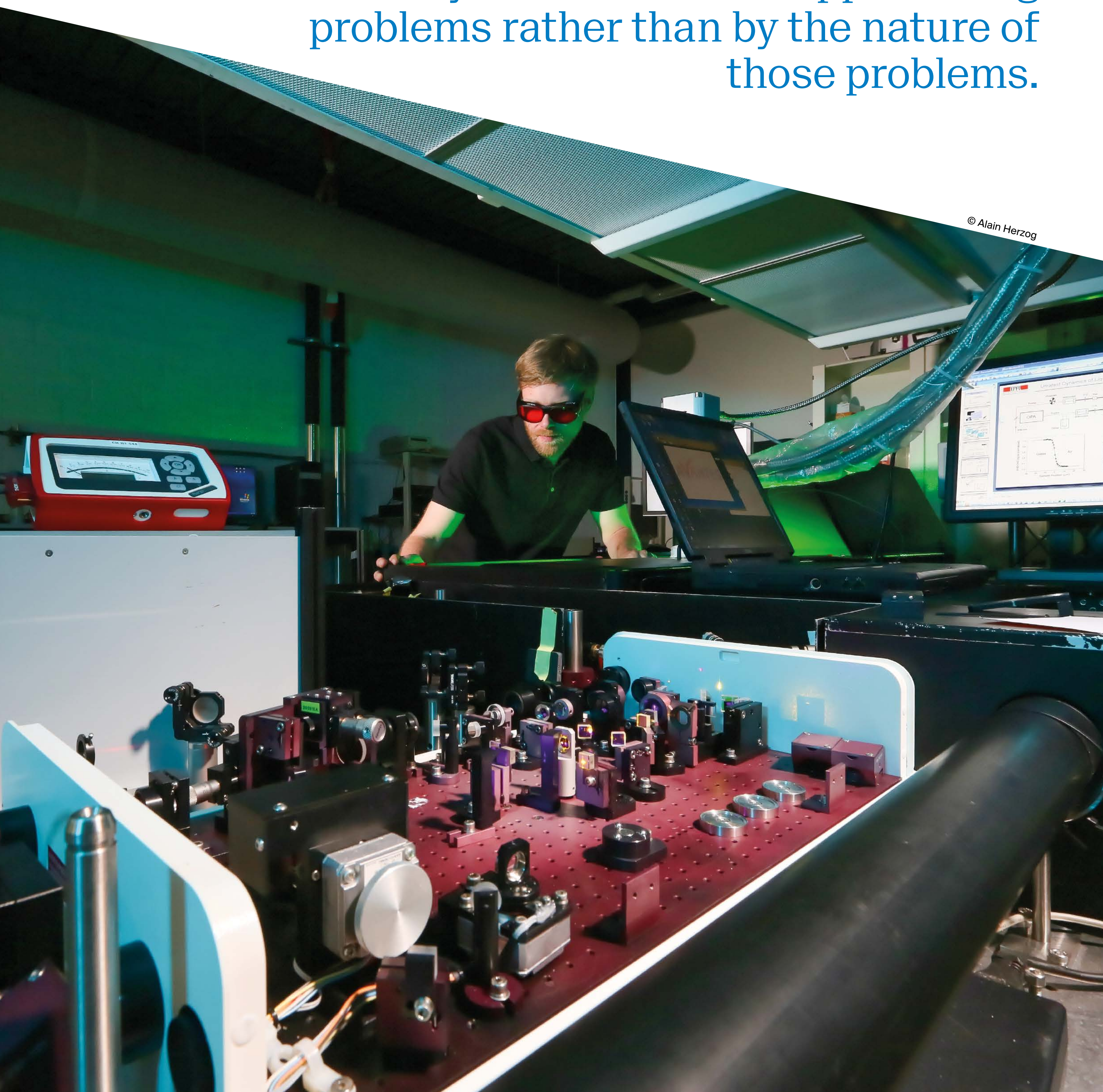
MASTER

PHYSICS AND APPLIED PHYSICS

EPFL

The Master's degrees in Physics and applied physics are envisioned to shape scientific generalists that are able to specialize in many science domains thanks to their pragmatic vision and the set of conceptual tools acquired throughout their education. Gathered around a broad spectrum of topics, the physicists define themselves by their manner of approaching problems rather than by the nature of those problems.



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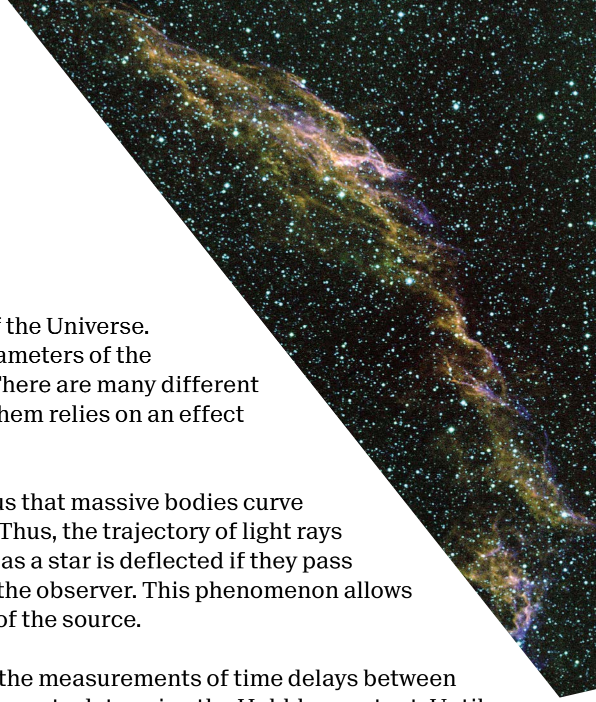


Determining the expansion rate of the Universe

Elodie Savary

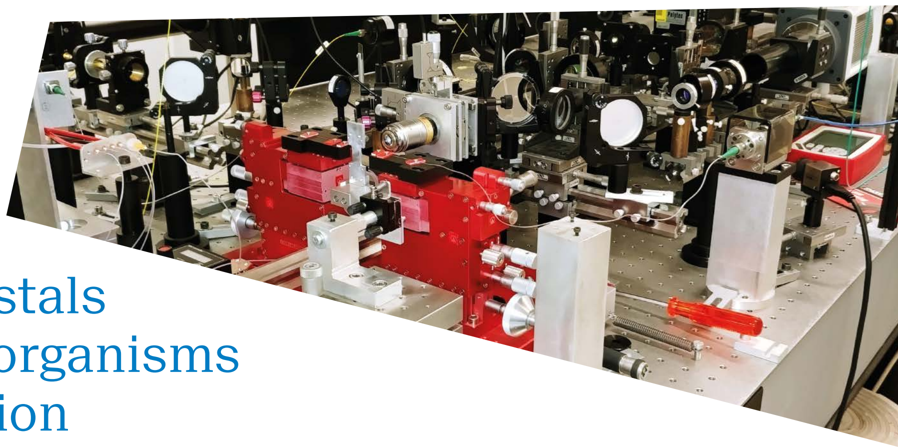
The Hubble constant reveals the actual expansion rate of the Universe. Determining its value is essential to determine the parameters of the cosmological model used to describe the Universe. There are many different methods to measure the Hubble constant. One of them relies on an effect called gravitational lensing.

The equations of the General Relativity tell us that massive bodies curve the structure of the space-time manifold. Thus, the trajectory of light rays coming from a background source such as a star is deflected if they pass near a massive body before reaching the observer. This phenomenon allows the observer to see several images of the source.

Elodie Savary:
“The master gives the opportunity to apply the knowledge and skills accumulated through the previous years on cutting-edge science projects.”

Time-delay cosmography uses the measurements of time delays between the multiple images of the source to determine the Hubble constant. Until now, this type of measurement has been made using quasars as source. However, type Ia supernovae may have many advantages over quasars. Previous estimations of the error on time and path length of the light that passes around supernovae have been done using a 2D disk model. The aim of my project is to study the impact of the 3D geometry of supernovae on the measurement of the Hubble constant.

This kind of project represents an opportunity for the students to extend both their knowledge in cosmology and in computer science.



Photonic crystals for microorganisms detection

Gabriele d’Aversa:
“At EPFL, I touched on both experimental and theoretical aspects of scientific research, contributing to tackle real life problems from day one. Moreover, I took full advantage of the EPFL industry network to test my learnings and strengthen my skills outside academia.”

Gabriele d’Aversa, Master’s thesis published in Science Magazine

Photonic crystals consist of periodic arrangements of materials characterized by different refractive indices. Optical waves, which are intrinsically periodic, interact with periodic media in a unique way, particularly when the scale of the periodicity is of the same order of magnitude as that of the wavelength. One of the main properties deriving from these patterns is the prevention of specific wavelength of radiation from propagating in the crystal, along one, two or three dimensions. A continuous range of forbidden wavelengths is called photonic bandgap.

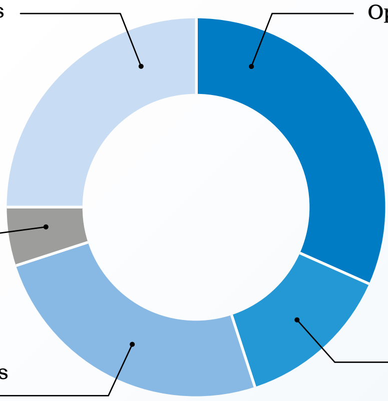
In recent years, photonic crystals have found multiple research applications, including use as filters, waveguides and resonators. Nowadays, research on photonic crystal materials is strongly driven by the field of integrated photonics, as a response to the increasing need of compact and miniaturized technology.

In our work, we studied the interaction of light with different types of bacteria, aiming to infer the presence of specific species of microorganisms in aqueous solutions. Photonic crystals came in handy in this contest. We demonstrated that 2-dimensional photonic crystal silicon membranes, together with properly designed periodicity-breaker defects, could lead to the creation of working resonators for nanometer-sized bacteria. In particular, localized defects could create sharp transmission peaks for light at specific frequencies. The frequency of these localized optical resonances was in turn sensitive to refractive index changes within the optical cavity, with changes that could be induced by the presence (or the absence) of the analyzed microorganisms. Bacteria identification within photonic crystals has been demonstrated, opening doors for high-speed and compact sensors for the analysis of biological samples.

Master of Science in

PHYSICS AND APPLIED PHYSICS

2-year program - 120 ECTS



Research training, industrial internship or further courses

Students pursuing a Physics degree must complete a research training semester whereas students enrolled in an Applied Physics curriculum must undertake a 4 to 6-month internship in industry. All students may instead choose to follow further courses to deepen their knowledge in preferred domains (30 ECTS, included in the 120 ECTS). In this case, students enrolled in the Applied Physics Master's degree must complete their Master's thesis in industry (6 months).

Optional courses

Students following the Master in Physics choose:

- at least 20 ECTS in list A
- at most 18 ECTS can be chosen among an approved list of options in other programs

Students following the Master in Applied Physics choose:

- at least 19 ECTS in list B - Engineering
- at most 19 ECTS in list C - Physics

Minor

Instead of the research training semester, the internship in industry or the further courses, students may choose a 30 ECTS minor included in the 120 ECTS. In this case, students enrolled in the Applied Physics Master's degree must complete their Master's thesis in industry. Recommended minors with this program:

- Biomedical technologies
- Energy
- Engineering for sustainability
- Management, technology and entrepreneurship
- Space technologies

School of Basic Sciences
go.epfl.ch/master-physics
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				Credits
Optional courses	**A**	**B**	**C**	**38**
Astrophysics III: stellar and galactic dynamics	A		C	4
Astrophysics IV: observational cosmology	A		C	4
Biophysics: physics of biological systems	A		C	4
Computational quantum physics	A	B		4
Computer simulation of physical systems	A	B		4
Electron microscopy: advanced methods	A	B		3
Experimental methods in physics	A	B		3
Frontiers in nanosciences	A	B		3
Fundamentals of biomedical imaging	A	B		4
Interacting quantum matter	A		C	4
Introduction to astroparticle physics	A		C	4
Introduction to particle accelerators	A	B		4
Lasers: theory and modern applications	A	B		4
Machine learning for physicists	A	B		4
Magnetism in materials	A		C	4
Modeling and design of experiments	A	B		4
Neutron scattering - theory and applications	A		C	4
Nonlinear dynamics, chaos and complex systems	A	B		6
Nonlinear optics for quantum technologies	A	B		4
Nuclear fusion and plasma physics	A	B		4
Nuclear interaction: from reactors to stars	A	B		4
Particle detection	A	B		4
Particle physics I	A		C	4
Particle physics II	A		C	4
Physics of life	A	B		4
Physics of materials	A	B		4
Physics of photonic semiconductor devices	A	B		4
Plasmas I	A		C	6
Plasmas II	A	B		6
Quantum electrodynamics and quantum optics	A		C	6
Quantum field theory I	A		C	6
Quantum field theory II	A		C	6
Quantum information and quantum computing	A		C	4
Quantum optics and quantum information	A	B		6
Quantum physics III	A		C	6
Quantum physics IV	A		C	6
Quantum transport in mesoscopic systems	A	B		4
Radiation biology, protection and applications	A	B		4
Radiation detection	A	B		3
Relativity and cosmology I	A		C	6
Relativity and cosmology II	A		C	6
Selected topics in nuclear and particle physics	A	B		4
Semiconductor physics and light-matter interaction	A	B		4
Solid state physics III	A		C	6
Solid state physics IV	A		C	4
Solid state systems for quantum information	A	B		4
Statistical physics III	A		C	6
Statistical physics IV	A		C	6
Statistical physics of biomacromolecules	A		C	4
Statistical physics of computation	A		C	4
Topics in biophysics and physical biology	A	B		3

Two projects in the following fields:	**16**
Astrophysics, particles, high energy physics	
Condensed matter physics	
Physics of biological and complex systems	
Plasma physics and energy	
Quantum science and technology	