UNIVERSITÉ DE GENÈVE

FACULTY OF SCIENCE

Physics Section

2023 - 2024

The illustration on the cover of this booklet is taken from research carried out in 2021 on Mount Säntis, Switzerland, the main result of which is to have demonstrated that lightning can be guided through the atmosphere using a very high-power laser. The image shows one of the events in which lightning was guided by the laser. These results were published in the journal Nature Photonics and featured on the cover of the May 2023 issue.

This research explained in video
ENG subtitle - 11 min

Message from the President

UNIGE's Physics Section is an extremely dynamic environment not just in terms of its research and teaching activities but also our outreach work in the wider community.

The Section's research focuses on four key areas: theoretical physics, particle physics, quantum materials and quantum applications. The progressive quality of the research here is reflected in the growing number of scientific publications and our very high placing in the majority of international university rankings. Significant levels of federal and international funding are awarded to our staff on a regular basis, especially in new research fields.

As a top-tier university, it goes without saying that UNIGE and the Physics Section are deeply committed to our mission to educate. We are constantly fine-tuning and improving our research methods and teaching so we can measure up to the highest, most innovative standards of the day. It is with this in mind that we have redesigned and remodelled the curriculum of our master's degrees from top to bottom, with a new programme for the start of the 2024 academic year. And yet the Section continues to operate on a very human scale, with a particularly advantageous student-teacher ratio and a teaching team that is always on hand. The Physics Student Association (AEP) is also extremely lively, with a dynamic environment for exchange of all kinds.

Where would fundamental science be if it failed to reach the widest possible audience? In today's increasingly high-tech society, it is vital that science is within everyone's reach. This is especially the case in a country such as Switzerland, where every citizen has the right to his or her say in the nation's political decisions and policy-making. Against this background, the Physics Section created a laboratory-cum-theatre for scientific exploration with the MaNEP National Research Centre in 2007: the PhysiScope. We also recently introduced the Athéna programme, which helps pupils in upper secondary level find out all about student life by attending university courses and getting a head-start in their studies.

In addition, the Physics Section and UNIGE are gearing up for the future by leading the project to build the Centre for Physical and Mathematical Sciences (CSPM), which is scheduled to come online at Quai Ernest-Ansermet by 2031. This ambitious initiative is vital for consolidating scientific excellence in Geneva. As well as ensuring that UNIGE retains the ability to compete with the best in the world, CSPM will also give local residents direct access to the river Arve and the future park.

You will find a great deal of information about UNIGE's Physics Section in this brochure, including our research and teaching activities and our outreach work together with our latest news.

I hope you will enjoy leafing through these few pages so you can find out more about UNIGE's Physics Section!

Jean-Pierre Wolf, Physics Section President.

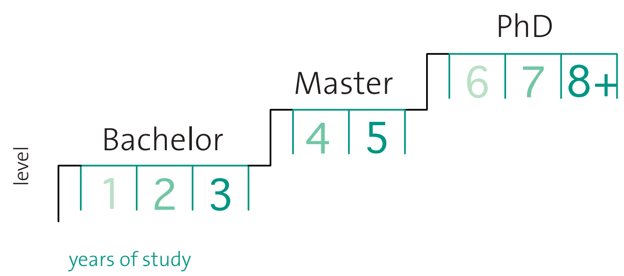
Teaching

The Physics Section is deeply committed to its mission to educate and mentor its students. The teaching staff strive constantly to take their teaching practices to the next level.

The physics curriculum follows the model drawn up in the Bologna Agreement: a three-year bachelor's degree offering 180 ECTS credits, followed by a two-year master's granting 120 ECTS credits, and a doctoral thesis over three to five years.

From the first year of the bachelor's degree onwards, a sizeable chunk of the teaching programme is devoted to experimentation, with the second year of the master's in particular spent in a laboratory research group. In addition, advanced maths and computer science play a prominent role, since they are vital for physics students to progress in their university courses.

University registration takes place before April 30 of the current year (February 28 for students who require a visa). Furthermore, although the University of Geneva is French-speaking, from the master's degree onwards all courses are delivered in English.



Excellent student-teacher ratio

The Physics Section has a unique student-teacher ratio with one teacher for every six students. The teaching team consists of professors, post-doctoral fellows and graduate teaching assistants. Thesis students also supervise other students, for the most part during exercise sessions and practical work.

Comprehensive range of courses

Physics at UNIGE includes a very wide choice of courses. These prepare the ground for a number of pathways and specialisations not just in physics but also in astrophysics and other trans-disciplinary specialist fields.

Oustanding supervision and personal relations

The teaching staff is at the leading edge of teaching and educational methods. But there is also a friendly, family-like atmosphere here. The fact that the teaching team is always close at hand helps our students thrive and flourish.

Ground-breaking research

A university is not just about teaching, it is also about research, and UNIGE's Physics Section is a world leader in its fields. In 2021, the Section was 18th in the Shanghai Ranking of the world's top universities. This has a direct impact on the quality of the qualifications we award.

Wolrdwide recognition

The University of Geneva is a signatory to the Bologna Agreement: degrees awarded at UNIGE are compatible with the vast majority of European universities, which gives our student body great mobility in Europe. Thanks to the quality of the teaching and research in the Physics Section, the degrees awarded here are recognised across the globe.

An international environement

Our strong links to a host of institutions – not to mention our contributions to the largest scientific collaborations worldwide – means that the Physics Section is a forum for international discussion and debate. This facilitates the mobility of our students and boosts recognition of the qualifications awarded here.

Multi-disciplinary

Students touch on many different fields when studying for a degree in physics: not just physics itself – of course! – but also maths and computer science. This wide-ranging approach helps students acquire an open mind and a methodology that helps them adjust to multiple challenges, with many graduates turning to very diverse professional careers.

Bachelor in physics - **3 years**

Mathematics: analysis, algebra
Computing: programming, algorithms, numerical methods
Basic physics: mecanics, electrodynamics, thermodynamics, quantum and statistical physics
Introductory course: particles and nuclei, solids, astrophysics, quantum optics
Elective courses and practical work

Careers
Computer science, finance, science journalism, etc.

Master in physics - **2 years**

Master in physics
Orientations:

- Quantum science and information
  - Quantum optics
  - Quantum materials
- Particle physics
- Physics of complex systems
- Theoretical physics
- Cosmology and astrophysics of particles

Master in astrophysics
Provided by the Department of Astronomy

Personal work in a research group

PhD in physics - **3 to 5 years**

Specialised education
Personal research work
Integration in a research group
Publication of results
Participation in teaching

Careers

Research, education, industry, management, finance, medical applications, meteorology, climatology, energy, environmental applications, etc.

Bachelor’s degree

The bachelor's degree in physics provides a solid basic training in conventional and quantum mechanics, electrodynamics, thermodynamics and statistical mechanics. The bachelor’s also introduces students to solid-state physics, astronomy, astrophysics, applied physics and particle physics. In addition, the course includes the acquisition and development of the mathematical and IT tools used in physics and the natural sciences in general. Obtaining a bachelor's degree gives students access to master's degrees in physics, astrophysics and joint science degrees.

conseiller-etudes-bachelor-physique@unige.ch

Master's degree

The master's in physics gives students an intensive training that includes specialisations in different subject areas: quantum information science (which is split into two streams: quantum optics and quantum materials), theoretical physics, particle physics, physics of complex systems, cosmology and particle astrophysics. This training and the internships give students the opportunity to work very closely with prestigious institutions such as CERN or the Paul Scherrer Institute (PSI). It also provides a solid base in modern physics and in-depth expertise specific to a specialised field. The master's in physics is an ideal entry point for professional and academic careers – such as research, teaching or industry – where the skills of physicists are in great demand. The degree also equips students with a modelling capacity that is highly valued in economics and finance.

conseiller-etudes-master-physique@unige.ch

Doctorate

A thesis is much more than an individual piece of work: it is an adventure that prepares students for research and teaching. In addition to their research, which is always carried out under the auspices of a professor, students take courses, attend conferences, teach and give seminars. The thesis is usually undertaken in a student’s specialist field, chosen in the third year of his or her bachelor's degree or during the master's, and lasts for between three and five years.

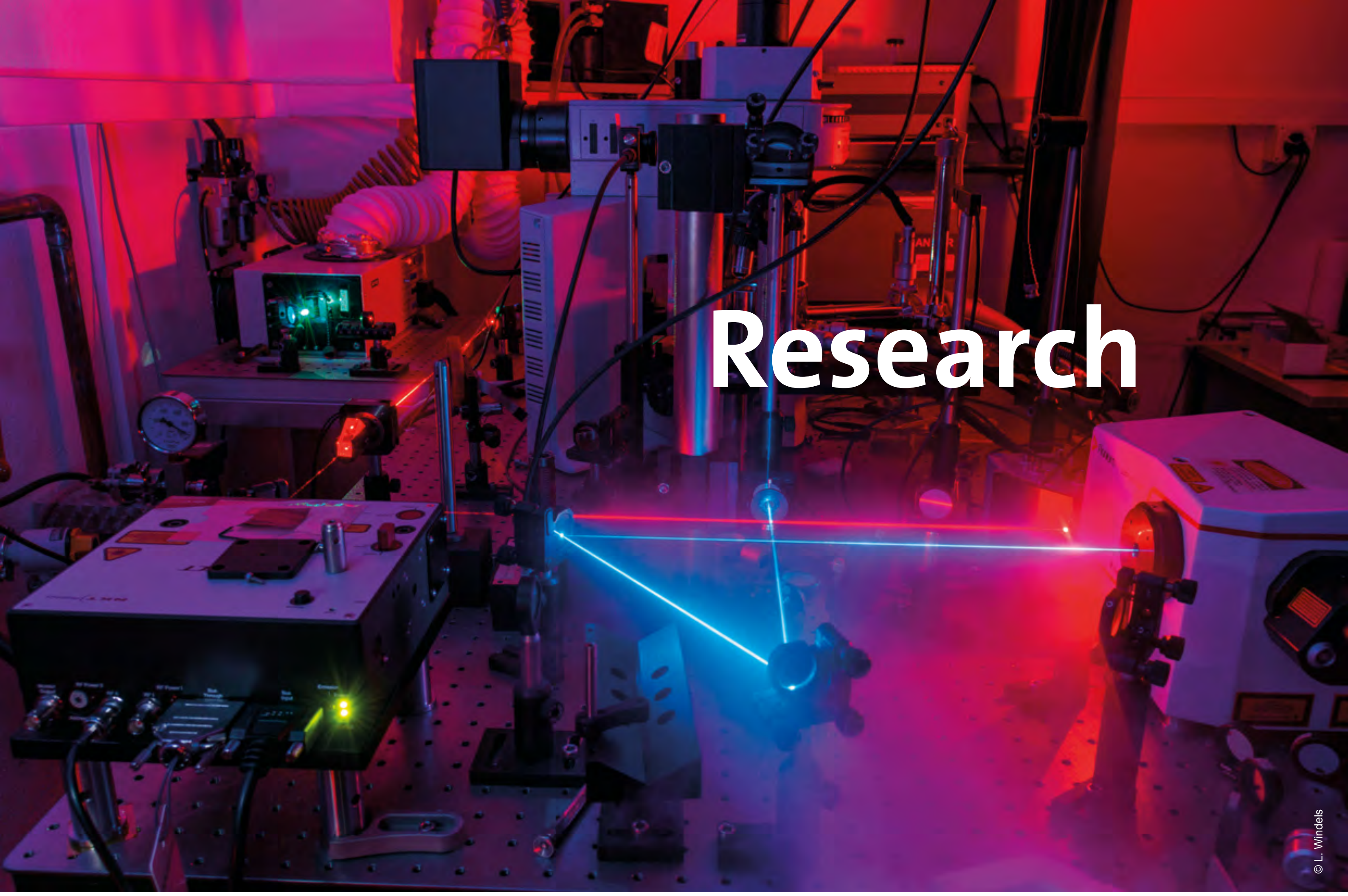
You’re following in their footsteps...

« I did all my studies at the University of Geneva from my first degree to my thesis. I really enjoyed the close relationships you have will all the teaching body, and the fact they’re always available. Our year group was small, and there was a very good team spirit among the students. What’s more, I was able to take part in the Physics and Faculty of Science student associations, and they’re my fondest memories! » Julien, engineering physicist

«Studying at UNIGE is very flexible, and you can organise yourself how you want. You have a lot of contact with the other students. You’re all in the same boat together, which creates very strong bonds. The way you chill out at the university is also really cool, it’s always cheerful and the atmosphere’s very good. It really does feel like one big family!» Florian, Manager in reforestation company

«I was lucky enough on my physics course at UNIGE to have top-quality teaching and to make the most of the different courses on offer and the huge freedom to custom-build my course. What I liked in particular was the study environment provided by this Section, which is on a human scale. It makes it easier to be in contact with the teaching staff and showcases the current research being done here. It also means you’re more likely to bump into people and exchange ideas – and it encourages students to support each other.» Gaëtan, physicist

Research



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The University of Geneva has a strong tradition of excellence, as reflected in the growing number of scientific papers and the Physics Section's very high position in most international rankings. It is the leading Swiss institution in the Shanghai 2023 league table, where it lies in 19th place. Furthermore, the 2019 Nobel Prize in Physics was awarded to two researchers in the Department of Astronomy: Michel Mayor and Didier Queloz – incontrovertible proof of the avant-garde and visionary quality of the research conducted at UNIGE.

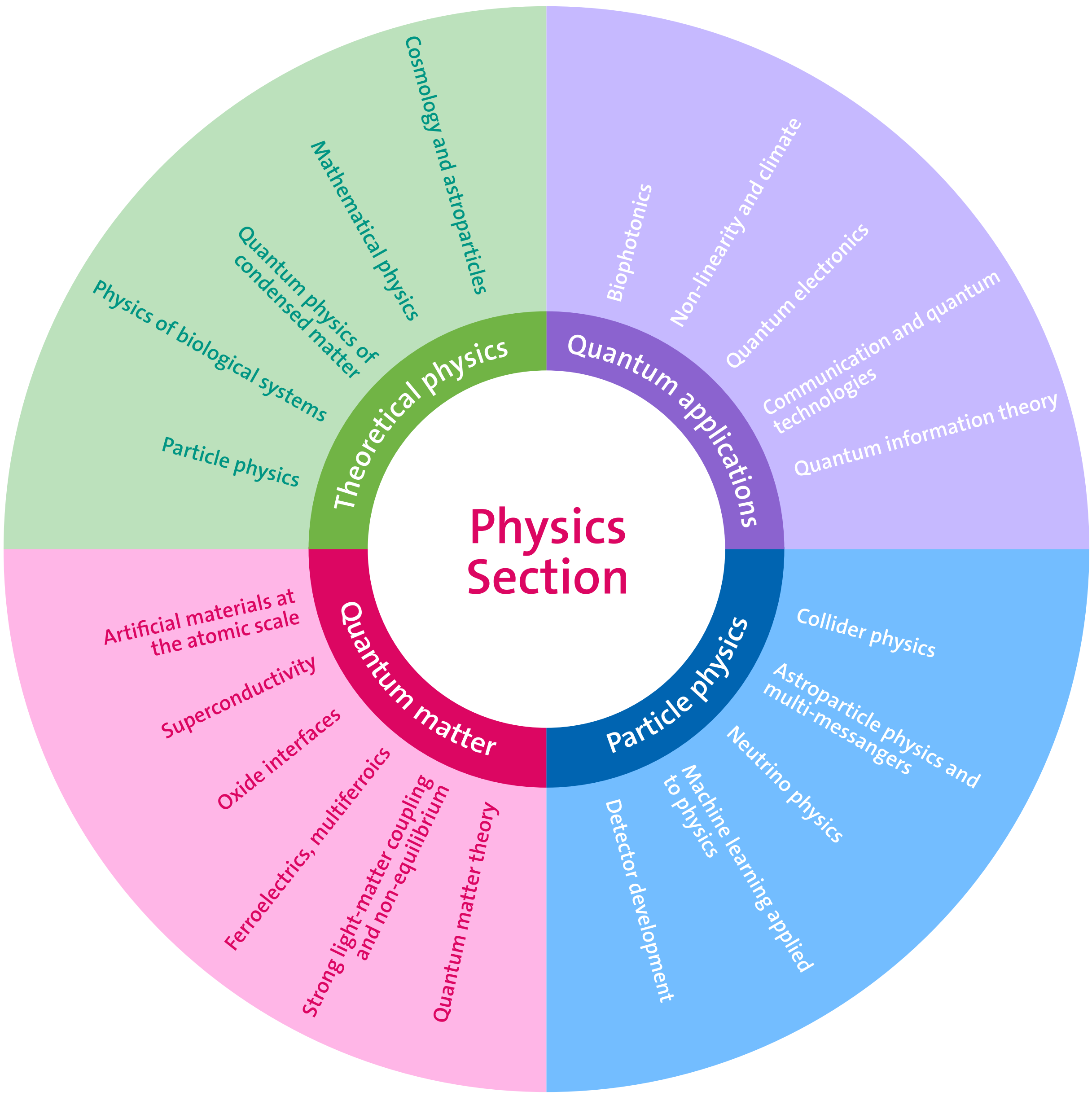
The funding awarded by the Swiss National Science Foundation (FNS), which is bigger every year, and the European Union are further evidence of the vibrancy of the University's research activities.

Members of the Section have extremely diverse profiles, with backgrounds in physics, IT, electronics, mechanics, administration or even student profiles. These broad skillsets, interests and areas of activities are a major asset for the Section's research in this extremely collaborative, international environment.

The Section undertakes a host of projects with other scientific disciplines, such as biology, chemistry, climatology and maths. The Physics Section has been particularly active in setting up four intra-faculty research centres in five fields: the science of gravitational waves, quantum sciences and technologies, the physics of biology and life in the universe.

> « If we consider a theory perfect and stop verifying it by daily scientific experience, it becomes a doctrine.»
>
> *Claude Bernard, physician (1813 -1878)*

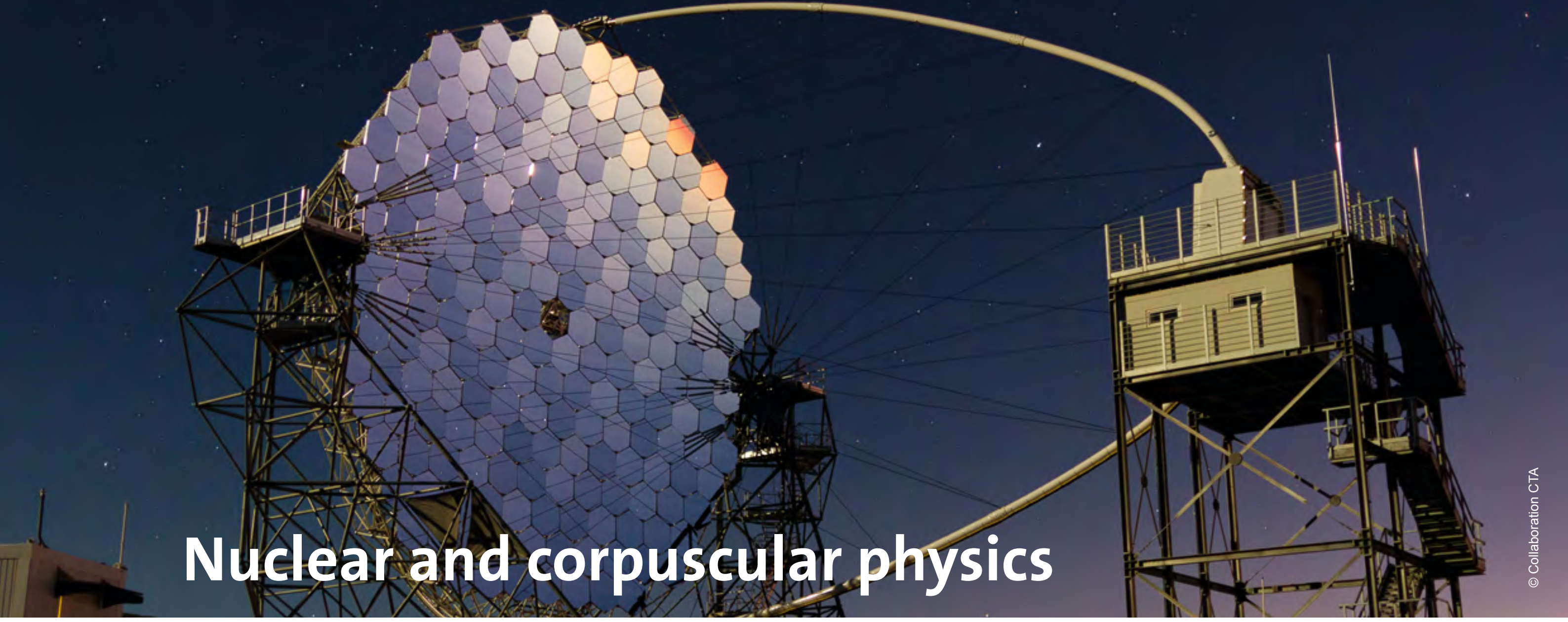
Priority research areas



You’re following in their footsteps...

« Doing a thesis isn’t just a great experience for research or a first job. Depending on the direction you’re thinking of taking, it’s also an opportunity to explore experimental techniques that are more closely connected to the world of industry and fundamental research. It’s the best way to build up your profile so you can make the transition to a professional future as simple as possible, whatever it may be.»
Alexandre, engineering physicist

« You have to be able to come up with a lot of ideas if you want to do research in physics, and demonstrate creative thinking, a passionate interest and dedication. But one of the most important things is communication: for funding requests, where you need to explain the science behind what you want to do and put it in context, or to make the research accessible to everyone. » Xavier, assistant professor



Nuclear and corpuscular physics

The Department of Nuclear and Corpuscular Physics (DPNC) carries out experimental research at the cutting edge of high-energy physics, astrophysics and various fields of applied physics, such as medical imaging.

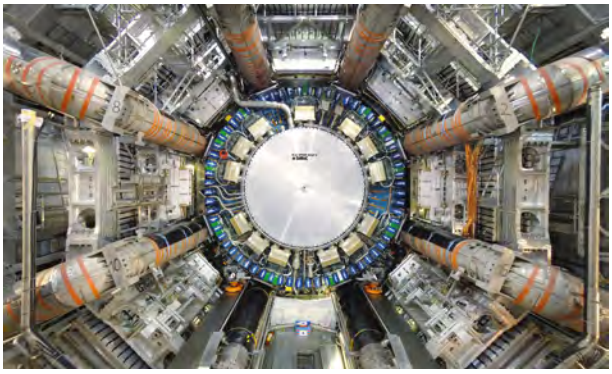
Implementation of an 8" diameter wafer with around 50 microchips, DPNC-designed, on a Cascade Microtech microprobe machine for electrical characterisation tests.

The DPNC's mission is to attempt to understand the fundamental laws of physics that govern interactions between sub-atomic particles, and the physical mechanisms involved in the most violent phenomena in the universe and cosmos. Many mysteries are still to be solved to this day: the fundamental model of particle physics, for example, which remains incomplete; the nature of dark matter; the difference between matter and antimatter; astrophysical magnetic fields; and how particles are accelerated in the universe. The Department adopts a multi-disciplinary approach to investigating these mysteries, ranging from analysing particle collisions in accelerators to research into multi-messenger astrophysics via experiments on earth and in space.

Furthermore, the diverse range of DPNC 's experiments call for a synergy between many different fields in a research environment that is extremely dynamic, creative and international. The Department is a member of the most groundbreaking international partnerships in the field of collider, neutrino and astroparticle physics, with ground tests and space missions. The DPNC is at the leading edge of technology, devising new pixel detectors for high-energy physics; Cherenkov gamma cameras based on silicon photo-detectors; onboard-satellite particle detectors; and large Cherenkov neutrino detectors.

The Department's technical and technological advances have potential applications in medical imaging and treatment, such as PET scanners, proton therapy and radio-guided surgery. Last but not least, over the past few years the DPNC has also developed expertise in applying machine-learning techniques to several areas of particle physics, ranging from astrophysics to collider physics.

In short, the DPNC embraces every aspect of modern research in high-energy physics and astrophysics (technical developments, data analysis, potential applications and machine learning) in a dynamic, fast-moving atmosphere.



View of a section of the ATLAS detector at CERN LHC.

© CERN

Focus on...

Collider neutrinos detected directly for the first time.

In a world first, the Forward Search Experiment (FASER) has detected neutrinos produced by a particle collider. The neutrinos detected by FASER are the highest ever energy neutrinos produced in a laboratory. They have similar energies to the neutrinos found when cosmic rays produce cascades of particles as they interact with our atmosphere. This is one of the first and most recent results from FASER using data derived from collisions at CERN's Large Hadron Collider (LHC).

FASER is a unique particle detector designed and built by an international consortium with major input from the Department of Nuclear and Corpuscular Physics (DPNC). It is very recent: the preliminary results were announced in spring 2023. Compared to other CERN detectors – such as ATLAS, which is more than 20 metres high and weighs 7,000 tonnes – FASER comes in at just one ton and fits perfectly into a small side-tunnel of the LHC. What is more, it took only a few years to design and build using spare parts from other experiments.

The DPNC research groups and technical teams played a key role in constructing the part of the detector that measures the properties of charged particles. They also spearheaded the development and implementation of the electronics and the read-out and trigger software. And they are already working on building the update for one of the FASER sub-detectors to measure the photons more efficiently. This is a direct result of their research in the field of monolithic pixel detectors.

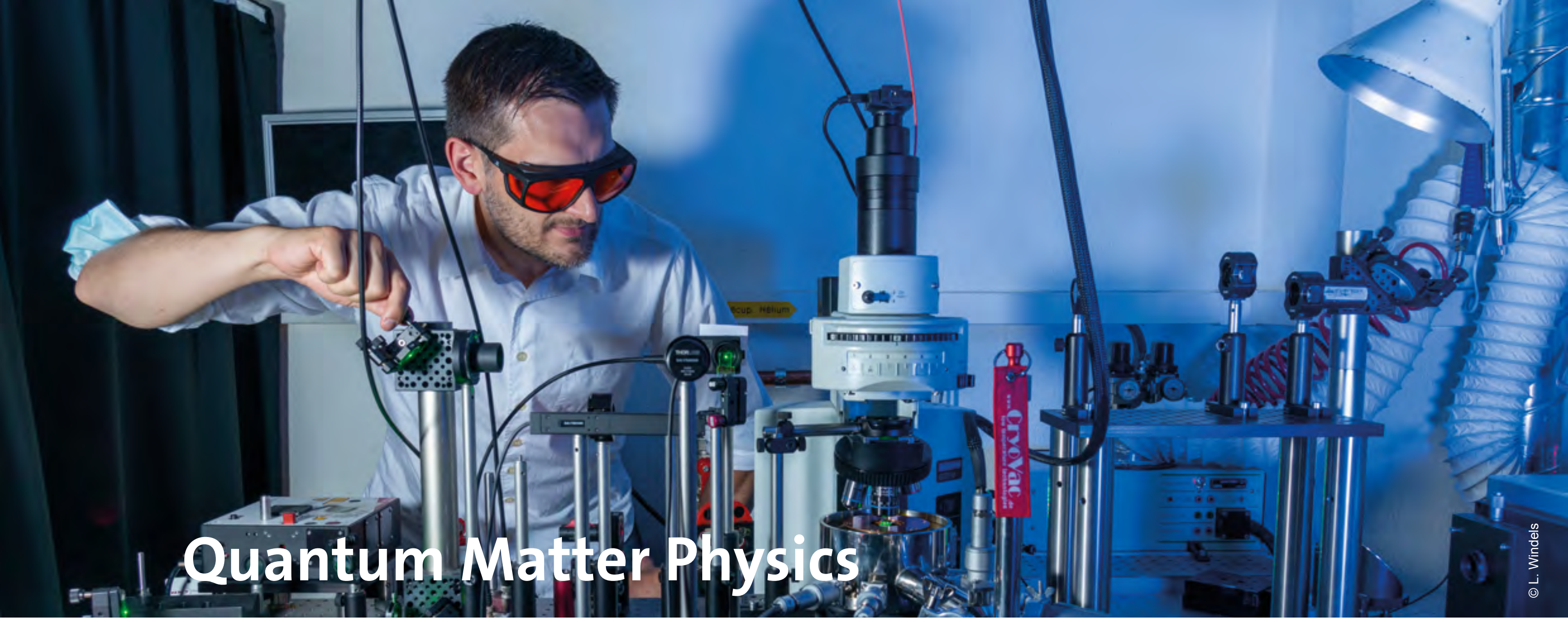
Alongside neutrino physics, one of FASER's key objectives is to help identify the particles that make up dark matter, something that has never been directly observed before now, and which is thought to comprise most of the matter in the universe.

© CERN - FASER

Students conduct tests during the installation of the FASER detector.

These preliminary results set the stage for a better understanding of the cosmic neutrinos that travel huge distances and collide with the earth, providing a window of opportunity to study the most distant reaches of the universe.

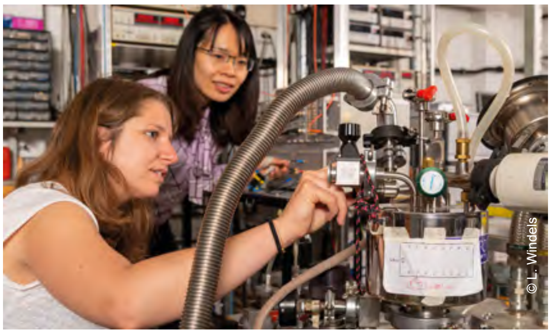
This research explained in video 1'15 minutes



Quantum Matter Physics

The mission of the Department of Quantum Matter Physics (DQMP) is to understand the properties of matter, discover new electronic functionalities, and ascertain the fundamental physics that lie behind them.

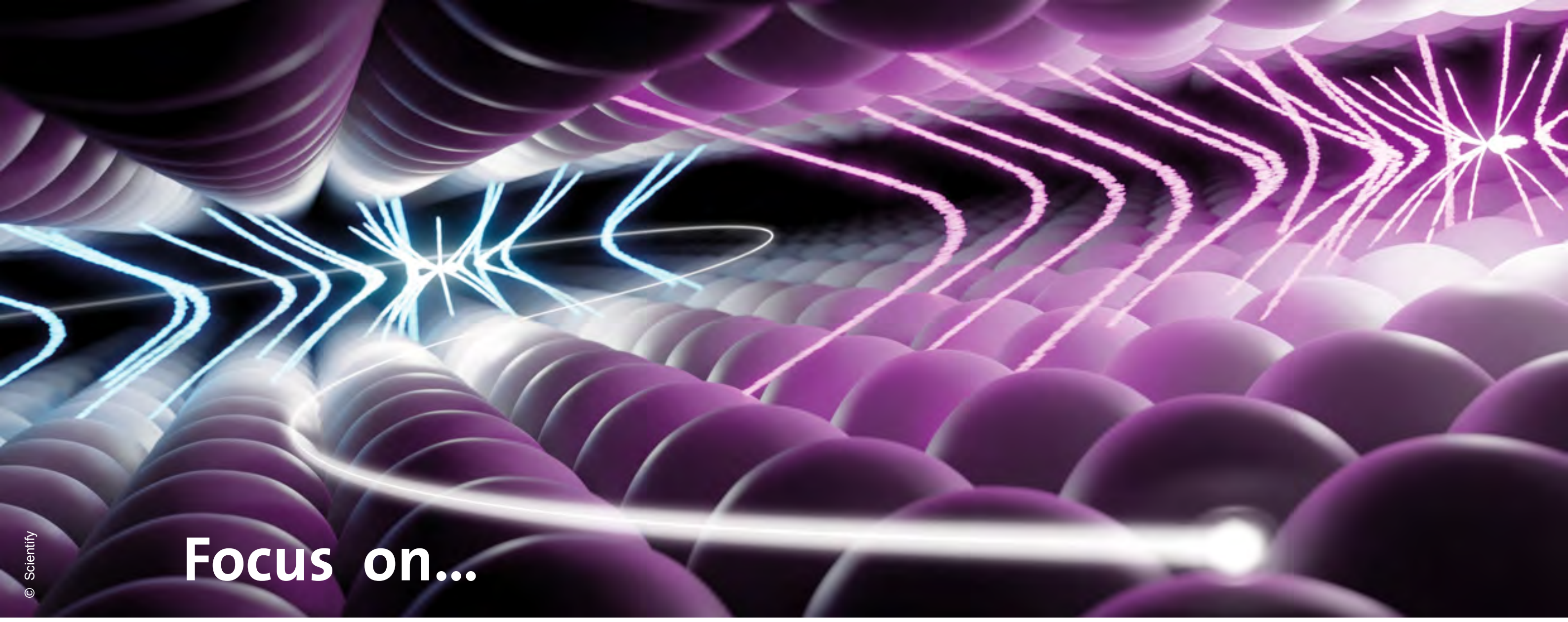
The DQMP undertakes experimental and theoretical research on atomic-scale synthetic quantum materials, such as thin layers and oxide superlattices or van der Waals heterostructures. Our groups devise, design, manufacturate and study the properties of these materials using a series of state-of-the-art methods and techniques. These include scanning tunnelling microscopy; mesoscopic-scale of charge transport in magnetic fields; electron-beam lithography; the latest deposit techniques; photoelectron spectroscopy; and nano-optics and ultra-fast optics.



The DQMP's research also embraces theoretical work on cold atoms and quantum materials with strong electronic correlations. In addition, the research covers studies on cell fronts and work on applied superconductivity, particularly for high-field magnets. The DQMP's explorations into artificial solids has recently been boosted by a major research programme into single crystals with new electronic properties.

The diverse nature of these fields of research and techniques stimulates a wide range of collaborations inside the Department and on the international stage. In addition, the DQMP's researchers work closely with industry to facilitate transferring spin-offs to the market. For example, the development of a new hallmarking technique for the watchmaking, medical and aerospace industries has taken its cue from STM equipment and expertise. Work on superconducting wires has resulted in record values for magnetic fields, which play a vital role in magnetic resonance spectroscopy and particle accelerators.

The DQMP's fields of research lie at the forefront of current knowledge and at the centre of the second quantum revolution, meaning that the Department offers students promising career opportunities that they will not find elsewhere!



Focus on...

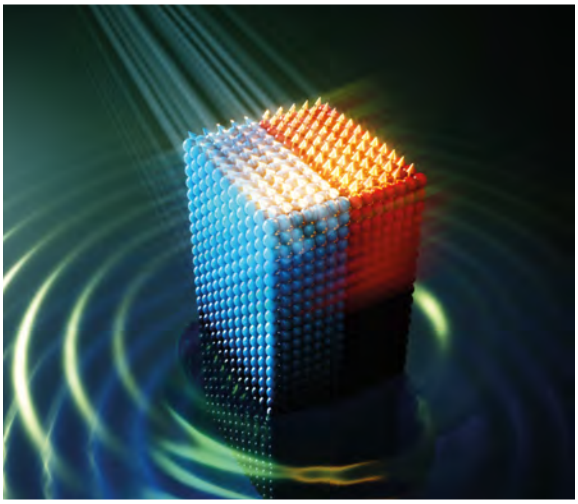
Sculpting quantum materials for the electronics of tomorrow

An international team headed by UNIGE has created a quantum material where the electron dynamics can be controlled by curving the fabric of space they evolve in. This is of major importance for next-generation electronic devices, especially opto-electronics. These need to be capable of processing electromagnetic signals in the picosecond range at ground-breaking speeds – i.e. one-thousandth of a billionth of a second – which is unthinkable with today's semiconductor materials.

One of the most intriguing properties of quantum matter is the fact that the electrons can evolve in a curved space. Due to this distortion of the space inhabited by the electrons, the force fields generate dynamics that are not found in conventional materials. After a preliminary theoretical analysis, the research team designed a material in which the curvature of the space frame can be controlled. This is an interface hosting an extremely thin layer of free electrons and sandwiched between two insulating oxides: strontium titanate and lanthanum aluminate, a combination that can be used to obtain particular geometrical and electronic configurations.

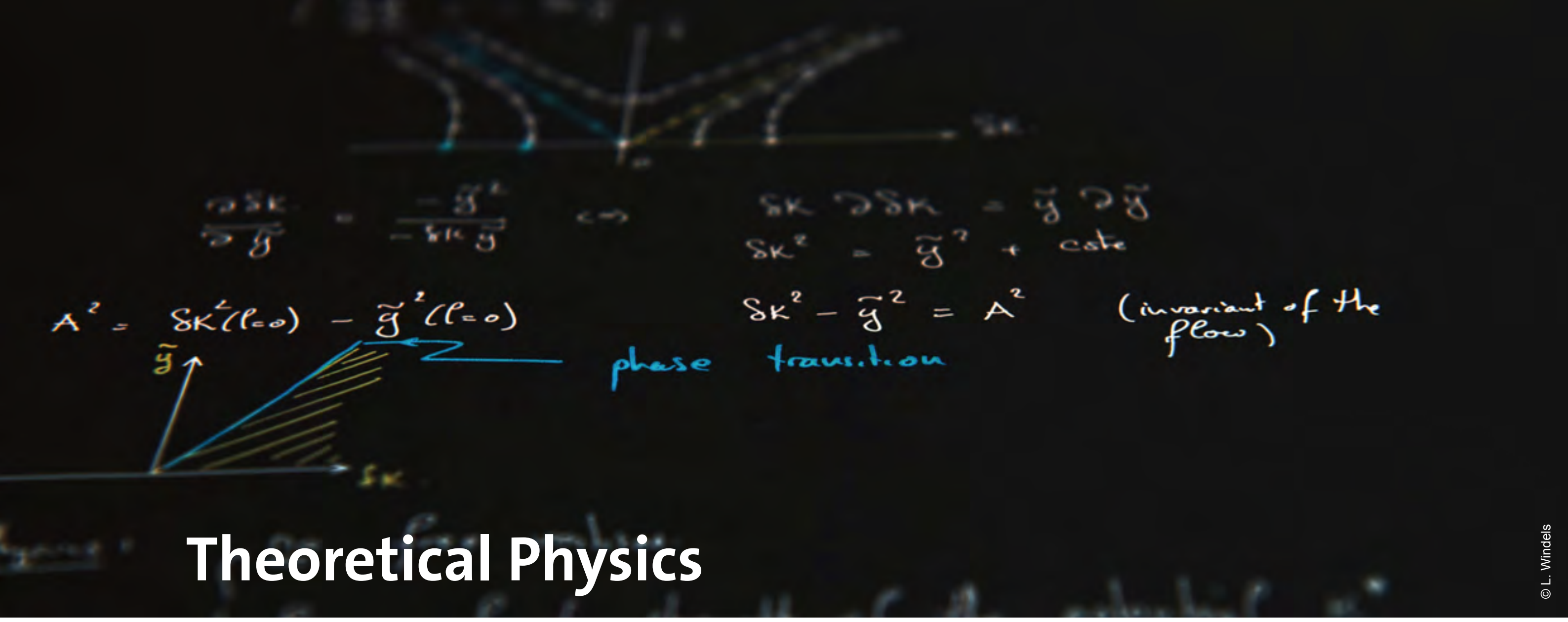
The research team used laser pulses to make this interface, stacking each layer of atoms one after the other. Using this method, the scientists were able to create special combinations of atoms in space that affect the behaviour of the material.

Thanks to their unique properties, these quantum materials could be used to capture, manipulate and transmit information-carrying signals inside new electronic devices. While the prospect of using these new materials in technology is still some way off, they break new ground in the exploration of very high-speed electromagnetic signal manipulation, a largely uncharted field. This should open the way to very high-speed communication systems. These results can also be used to develop new sensors. The next step for the research team will be to observe more closely how the material reacts to high electromagnetic frequencies so they can identify its potential applications with greater precision.



Light control of magnetic interactions in correlated materials. A beam of light is used to stimulate atomic vibrations in a solid, inducing magnetic order.

This research explained in video 2 minutes



Theoretical Physics

The Department of Theoretical Physics (DPT) works very closely with all the other departments in the Physics Section as well as on many first-class international collaborations. The DPT's activities focus largely on five key areas of research.

Cosmology investigates inflation or alternatives to dark matter, primordial black holes, dark energy and modified gravity. Although some of these topics are purely theoretical, the cosmology group works closely with experimental research, such as observations of the cosmic microwave background, the cosmic large-scale structure or the gravitational-wave background, with (for example) the Planck satellite in the past or the Euclid satellite that will be launched in late 2022.

Formal and mathematical research into quantum field theory (QFT) and gravity tackles fundamental problems. In particular the teams look at how to discover the deeply quantum and mechanical information hidden in non-perturbative QFT structures or how to combine QFT with general relativity. This work is supplemented by research into the phenomenology of high-energy physics.

In the field of condensed matter, the department investigates the fundamental properties of collective states of matter in synthetic materials and systems, such as ultracold atoms. There is particular focus on the topological phases of matter capable of accommodating anyon excitations and the analysis of their transport properties. The DPT leads the way in studying the non-equilibrium properties of quantum matter, and has developed new approaches based on models of quantum simulations and calculations.

Today, gravitational waves – discovered by the Virgo and LIGO collaborations – are opening a new window onto the universe. The DPT is heavily involved in studying how to use gravitational waves as cosmology probes in relation to the data from these gravitational-wave detectors. The next generation of detectors, such as the Einstein Telescope in Europe, will observe millions of events a year with unprecedented precision.

The DPT is also positioned at the interface of the biology and physics of active matter. Over the last few years, scientific collaborations with several UNIGE departments – including the GAP – have been developed in this field.

The research team, student body and all departmental members cooperate very closely with their colleagues in the Physics Section and with theoretical scientists and experimenters working on the major international experiments, leading to an enormously constructive scientific rivalry.


© NASA, ESA, CSA, STScI

Focus on...

Einstein and Euler put to the test at the edge of the universe

The cosmos is a laboratory like no other for testing the laws of physics. This is particularly the case with Euler's law on the movements of celestial objects, and Einstein's law describing how these objects distort the universe. Physicists have devised all kinds of experiments to test the equations of these two scientific greats, which have proved successful up to now. Two more recent discoveries, however, are still putting these models to the test: the acceleration of the expansion of the universe and the existence of invisible dark matter, which is believed to account for 85% of all matter in the cosmos. Do these mysterious phenomena still obey Einstein's and Euler's equations?

This is a question that the researchers are not in a position to give an unequivocal answer to. Nevertheless, a team working in UNIGE's Department of Theoretical Physics (DPT) has devised the first effective method for discovering them. It factors in a measurement that has never been used in the past: time distortion. Until this point, scientists only knew how to measure the speed of celestial objects and the sum of time and space distortion. The method devised to access this additional measurement is the product of ten years of research, and it can be used on future missions.

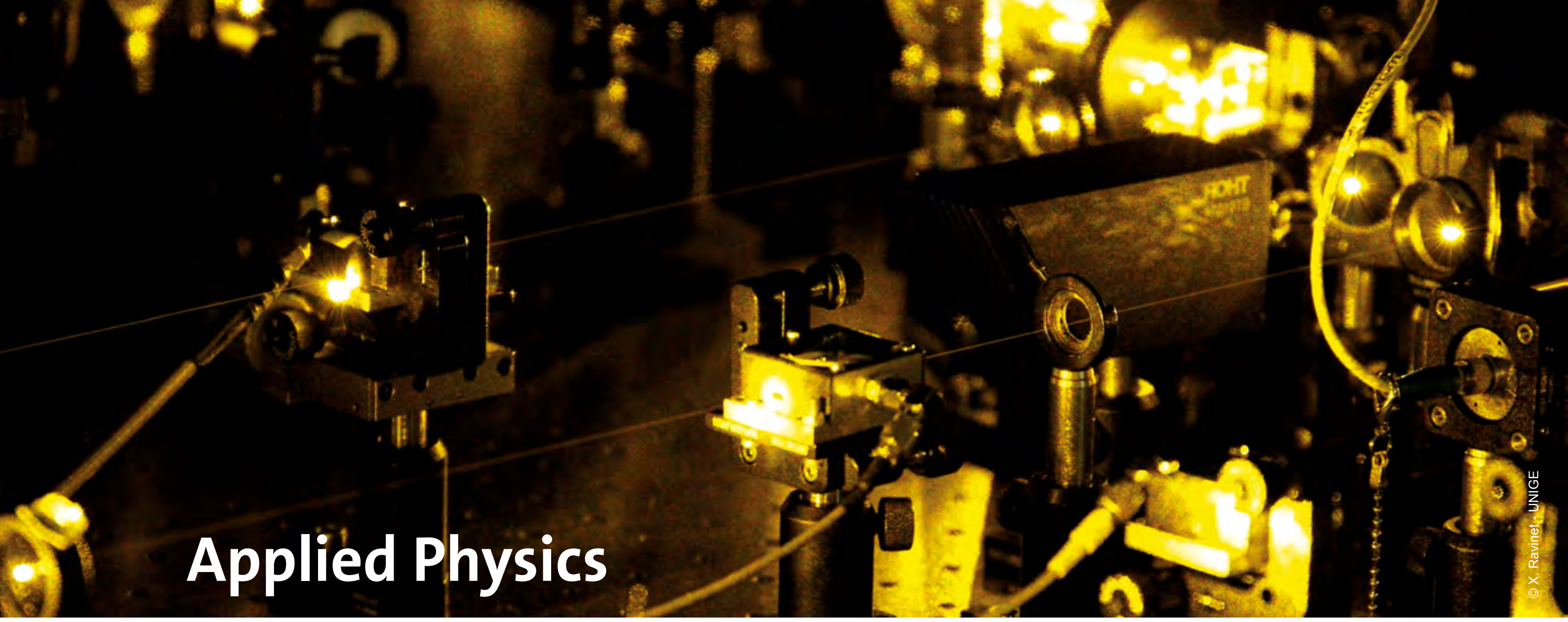
If the time distortion is not equal to the sum of time and space – i.e. the result generated by the theory of general relativity – it means that Einstein's model does not work. If the distortion is not consistent with the speed of the galaxies calculated using Euler's equation, it means that it is not valid. The research team tested their model successfully on synthetic galaxy catalogues. It will now be possible in time to discover whether new forces or materials exist in the universe that violate these two theories.

© ESA

EUCLID is a space telescope launched by the European Space Agency (ESA) in July 2023. The mission's key objective is to give scientists a better understanding of the origins of the accelerating expansion of the universe.

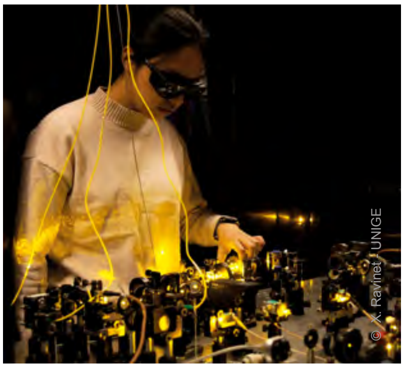
The results will make a vital contribution to a number of missions designed to identify the origins of the accelerating expansion of the universe and the nature of dark matter. These missions include the EUCLID space telescope launched in July 2023 by the European Space Agency (ESA) in collaboration with UNIGE.

This research explained in video 1h30



Applied Physics

Physics aims to do more than simply reveal the secrets of the universe. The discipline plays a far larger role in society, contributing to the economy and the environment via the applications derived from the discoveries it makes. The core mission of the Department of Applied Physics (GAP) is to develop practical applications based on UNIGE's research.



GAP's centres of interest and fields of research are deliberately designed to be wide-ranging in order to boost opportunities for technology transfer.

In the field of biophotonics, GAP's researchers are developing new processes to monitor – and sometimes even control – biological and atmospheric systems. Target applications include identifying bacteria in the ambient air, measuring pollutants, detecting early-stage cancers and monitoring lightning strikes.

The main focus of the group working on quantum communication over optical fibres is quantum cryptography, which is based on the properties of quantum physics that render information transfer tamper-proof. The group also looks at developing tools for quantum optics, such as simple photon detectors and sources. The research team works closely with scientists specialising in the theory of quantum information who explore the fundamental concepts of quantum physics (such as non-locality) and quantum thermodynamics. These scientists are developing applications for information processing and metrology inter alia.

The experts in nonlinear and climate physics look at physical systems, such as the propagation of high-power lasers, oceanic rogue waves, ecosystems, and climate change modelling together with their analogies.

The electronic properties of new materials with the thickness of one (or a handful of) atomic layers are also central to the activities of GAP, which explores the potential of using these materials to make opto-electronic devices with new functionalities.

GAP's research teams and student body tackle research and development issues that combine the fundamental aspects and potential rapid release of their work. It is a very active, prolific and education-focused department for students who are keen to opt for an industrial or academic career.

Two students working on an optical table with a researcher from the Applied Physics Department.

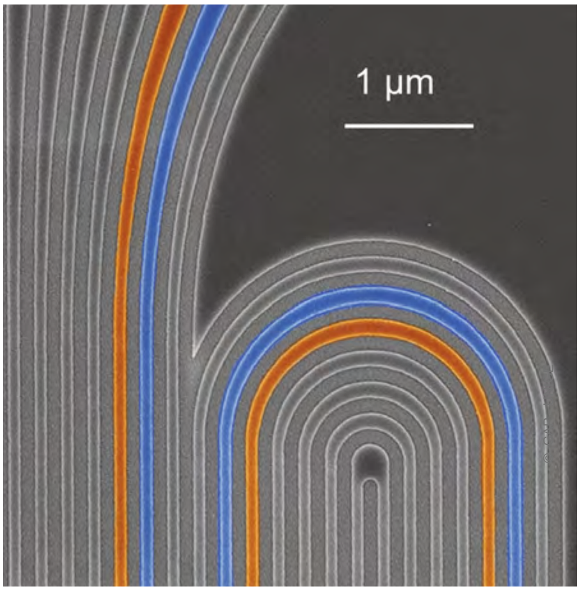
High-performance sensors for data security

The day-to-day transactions carried out on mobile apps are based on payment systems that exchange confidential information between the user and their bank. It is a system, however, that is not fail-safe. The best solution is quantum cryptography, an encryption method that enables two parties to generate shared secret keys and transmit them over fibre optic cables for highly secure communication. This is because the laws of quantum mechanics maintain that a measurement affects the state of the system being measured. If a spy then tries to steal the key by measuring the photons, the information will be altered in an instant and the eavesdropping will be brought to light.

The factor currently limiting the application of this system is the speed of the superconducting nanowire single-photon detectors used to receive the information. This type of device contains a tiny superconducting wire cooled to -272°C: if just one photon hits it, it heats up and stops being superconducting for a brief moment, which then generates an electrical signal that it is possible to detect.

When researchers from UNIGE's Department of Applied Physics embedded 14 nanowires into their sensors, they achieved record detection rates: they can count 20 times faster than a single-wire device. If two photons arrive in these new detectors in a short time frame, they can touch different wires and both be detected, which is not possible with a single wire.

The scientists managed to generate a secret key at a rate of 64 Mb/s over 10 km of fibre optic cable using these sensors, i.e. five times higher than current technology over the same distance. And – the icing on the cake – these new detectors are no more difficult to manufacture than the devices already available on the market, which opens up new possibilities for ultra-secure data transfer.



Scanning electron microscope (SEM) image of part of the 14-nanowire detector array.

More about this research

Appointments

Following in its long tradition of excellence, the Physics Section is constantly on the lookout for the top scientific talent. It welcomes new professors or promotes them on a regular basis in order to strengthen its teaching and research team and give its students the best possible supervision in terms of teaching and research.

Pr Luigi Bonacina, an associate professor at GAP, works on developing new bioimaging approaches to improve the acquisition speed, penetration depth and selectivity of optical methods by combining nonlinear mixing, nanotechnology, and new laser sources. At present, Professor Bonacina is coordinating an EU inter-disciplinary project on multiphoton microscopy in the SWIR infrared region.

Pr Magdalena Kowalska, a full professor at DPNC, develops spin polarisation techniques in unstable nuclei produced at CERN's ISOLDE facility. She uses them as the basis for ultra-sensitive radiation-detected nuclear magnetic resonance (RD-NMR). Polarised nuclei are used in a broad spectrum of projects ranging from fundamental interactions to biology, medicine and nuclear structures. These projects include research into the unitarity of the CKM quark mixing matrix; the distribution of neutrons in unstable nuclei; the determination of spins and parts of excited nuclear states; NMR imaging on PET isotopes; and a new imaging method using polarised unstable xenon isotopes.

Pr Daniel Pearce, an assistant professor at DPT, is a theoretical physicist who conducts research into active matter, i.e. materials characterised by their ability to induce self-generated motion. Professor Pearce studies the way active materials are organised in an attempt to work out how they can be controlled, the ultimate aim being to design new active materials. He is currently looking at how these materials react to – and influence – their environment. His research attempts to understand morphogenesis in living organisms; the design of bio-inspired microscopic robots; and energy-harvesting devices.

Pr Louk Rademaker, an assistant professor at DQMP, works on new flat materials that are correlated and highly tuneable (using stacking, twist angles and gates). This tunability opens up the possibility of resolving some “strange” condensed matter problems, such as the nature of doped Mott insulators and electronic interaction-driven superconductivity. Professor Rademaker’s research focuses on materials where the heterostructure engineering enhances interaction effects (such as moiré materials), together with the monolayer limit of correlated materials (such as pnictides, cuprates and organics).

Pr. Ajit Srivastava, an associate professor at DQMP, is a specialist in nanostructure optics, with a particular interest in electronic systems based on two-dimensional materials. His research looks at light-matter interactions in these materials, focusing on the quantum, geometric and topological aspects.

Pr Wolfgang Tittel, a full professor at GAP, has undertaken ground-breaking research into quantum communication from the preliminary stages. His experimental work centres on atomic and optical physics, touching on fundamental and applied subjects alike. Professor Tittel's research has helped us understand that quantum communication is not restricted to controlled laboratory environments. He is currently looking at the interaction between photons and rare-earth crystals, particularly for optical quantum memory; sources of quantum light and quantum information processing; nano-photonics; and quantum repeaters.

While the teaching and research staff is constantly changing, some of our professors have recently taken their retirement. The Physics Section would like to thank, and warmly congratulate, Professors Ruth Durrer and Hugo Zbinden for their commendable careers.

Pre Ruth Durrer obtained her doctorate with honours from the University of Zurich in 1988. She continued her research as a post-doctoral fellow at Cambridge and Princeton before returning to Zurich, where she was promoted to the position of assistant professor. Ruth has been a full professor at the University of Geneva in the Department of Theoretical Physics since October 1995. She was head of the Department from 2007 to 2016, and also founded the cosmology group. She has worked on cosmological phase transitions and the formation and evolution of topological defects; the cosmological microwave background; a hypothetical cosmological background of gravitational waves; cosmological magnetic fields; and cosmological large-scale structure and weak lensing. Professor Durrer's work in the field of cosmological large-scale structures has also included studying the effects of general relativity: i.e. the non-Newtonian nature of gravity, which it will be possible to test by observation in the near future. At the same time, between 1997 and 2005, Ruth was coordinator of the Swiss hub of the European TMR network (FRACTALS 1998-2023) (CMBNET 2000-2005) and the Swiss ESF network (COSLAB 1997-2006). She also served as president of the Tomalla Foundation for research in gravitation until 2023. The foundation funds internships for post-doctoral fellows in Switzerland, together with an international prize for gravitation research.

Pr Hugo Zbinden received his doctorate from the Institute of Applied Sciences at the University of Bern in 1991. Following a post-doctoral fellowship at Bern and an MER post at the University of Geneva, Hugo was appointed associate professor in UNIGE's Department of Applied Physics in 2012. The main focus of his research was the application of quantum optics to various fields, in particular quantum communication, involving quantum key distribution (QKD), and quantum random number generation. He worked on the concept of self-diagnostic devices, which provide unparalleled safety, and efficient, low-noise single-photon detector systems. Professor Zbinden's research led to the development of the first practical single-photon detectors for telecom wavelengths, which in 2002 gave rise to the first commercial products made by ID Quantique, a start-up co-founded by Hugo. Professor Zbinden also won the Prix Greinacher in 2016 and the UNIGE Innovation Medal in 2017.

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Services to the wider community

The Physics Section strives to make science more accessible to everyone, creating opportunities to bring it closer to the general public. It promotes science through a range of innovative actions in order to educate and inform people, especially young people, about the fascinating aspects of its cutting-edge research and science.

Physiscope

The PhysiScope, which was created with the MaNEP National Research Centre, aims to give a fun and interactive introduction to science using **discovery workshops**. It is constantly adjusting its curriculum to meet the latest developments and advances in its field. External institutions regularly call on the PhysiScope's expertise in **scientific mediation**, which is recognised at European level, to help them develop their public-facing activities.

Athéna

The Physics and Mathematics Sections have also devised the Athéna **early study programme** as a way of encouraging young people **to embark on scientific careers**. Athéna is intended for college and sixth-form students in their penultimate or last year at school who are keen to find out more about studying at university, and possibly even to get a head start in their studies.

Scientify

As **scientific mediation** and **communication** develop at an increasing pace, the Physics Section has created Scientify: the first scientific media laboratory of its type at UNIGE, Scientify is dedicated to promoting its research activities. Its aim is to produce and create new scientific, **"edutaining" and educational** content that is access-free and rights-free. This content is intended for the media, social networks, general public and scientific community.

Laboratory of Advanced Technology (LTA)

The LTA was set up by the DQMP in collaboration with Geneva HES-SO. Today it is a key platform for the Faculty of Science and **innovation in Geneva**. The LTA gives companies and academic partners easy access to UNIGE's and HES-SO's **leading-edge equipment** and **expertise**, including the Physics Section's.

You're following in their footsteps...

«I was lucky enough to put on scientific activities for schools at the PhysiScope on a wide range of physics topics. I thought it was great because it was really varied, with students from all walks of life, and there were always different questions. It was every Tuesday, and I never knew whether it would be easy or hard, and so I learned a lot about teaching and listening »
Rebecka, post-doc

Student Life

The Physics Student Association (AEP)

The AEP brings together physics students at the University of Geneva, mainly at bachelor's and master's level. Its aim is not just to promote discussion, debate and mutual assistance by connecting physics students of all levels, but also to provide support if a student encounters a problem with his or her course, exams or university administrative procedures.

The AEP has set up weekly rehearsals for its members, with the second and third year student body volunteering to help the first years with their series of exercises. As well as developing a mentoring system for first year students, the AEP also runs a study room reserved for physics students and WhatsApp groups for each year so that information can be disseminated rapidly.

The AEP enjoys excellent relations with the Physics Section and its teaching staff, which facilitates exchanges or better mediation in the event of a conflict.

Last but not least, the AEP works closely with the Association des Étudiants en Sciences (AESc), which is responsible for student life across the science campus and which, over time, has developed good relations with student associations across all sections in the Faculty of Science.

The AEP also boasts a very rich community life outside the classroom, organising a number of events throughout the year (barbecues, parties, and the like)! In short, the association exists because, although studying physics may be stressful, life beyond your studies does not have to be!

A healthy mind in a healthy body

The university boasts an exceptional environment in which it pays special attention to the well-being of its students and staff. It offers a wide range of services to help its members work and study in the best possible conditions.

Everyone can discover at least one supervised physical activity among the very many put on by the university's sports department.

The mental health service is available for members of the university community who want to express themselves freely and access psychological support in complete confidence and with total confidentiality.

In addition, the welfare centre provides support and assistance for resolving any financial problems thanks to its welfare service that give students the tools they need to complete each course in the best living conditions.

Physics Section

Administration
- Secretary

Services
- Reception
- Auditoriums
- Workshops
- Training labs

Teaching

Bachelor
146 students

Bachelor's advisor
Martin Kunz

Master
59 students

Master's advisor
Patrycja Paruch

PhD
112 students

Outreach

Physiscope
~6000 visitors

Athéna
80 students

Communication

Research

Department of quantum matter physics

ANGLE-RESOLVED PHOTOEMISSION
Pr Felix Baumberger

DESIGNER QUANTUM MATERIALS
Pr Andrea Caviglia

STRONGLY CORRELATED QUANTUM MATERIALS
Pr Antoine Georges

THEORY OF QUANTUM MATTER
Pr Thierry Giamarchi

ELECTRIC POWER NETWORKS
Pr Philippe Jacquod

QUANTUM ELECTRONICS
Pr Alberto Morpurgo

FERROELECTRICS AND MULTIFERROICS
Pr Patrycja Paruch

THEORY OF FLAT AND STRANGE QUANTUM MATTER
Pr Louk Rademaker

SCANNING PROBE MICROSCOPY AND SPECTROSCOPY
Pr Christoph Renner

RESEARCH WITH NEUTRONS AND MUONS
Pr Christian Rüegg

APPLIED SUPERCONDUCTIVITY
Pr Carmine Senatore

QUANTUM LIGHT MATTER
Pr Ajit Srivastava

OXIDE INTERFACE PHYSICS
Pr Jean-Marc Triscone

QUANTUM MATERIALS DISCOVERY
Pr Fabian von Rohr

27 PhD students

Department of nuclear and corpuscular physics

HIGH-ENERGY MULTI-MESSENGER PHYSICS
Pr Domenico Della Volpe

COLLIDER PHYSICS
MACHINE LEARNING
PIXEL DETECTORS
Pr Tobias Golling

COLLIDER PHYSICS
PIXEL DETECTORS
MEDICAL APPLICATIONS
Pr Giuseppe Iacobucci

MEDICAL APPLICATIONS
Pr Magdalena Kowalska

HIGH-ENERGY MULTI-MESSENGER PHYSICS
Pr Teresa Montaruli

COLLIDER PHYSICS
Pr Lorenzo Paolozzi

NEUTRINO PHYSICS
Pr Federico Sanchez Nieto

COLLIDER PHYSICS
Pr Steven Schramm

COLLIDER PHYSICS
Pr Anna Sfyrla

SPACE ASTROPARTICLE PHYSICS
Pr Andrii Tykhonov

SPACE ASTROPARTICLE PHYSICS
Pr Xin Wu

32 PhD students

Department of theoretical physics

COSMOLOGY
Pr Camille Bonvin

GRAVITATIONAL WAVES
Pr Chiara Caprini

COSMOLOGY
Pr Julien Carron

BIOLOGICAL PHYSICS
Pr Karsten Kruse

COSMOLOGY
Pr Martin Kunz

GRAVITATIONAL WAVES
Pr Michele Maggiore

MATHEMATICAL PHYSICS
Pr Marcos Mariño

BIOLOGICAL PHYSICS
Pr Daniel Pearce

COSMOLOGY
ASTROPARTICLES
Pr Antonio Riotto

PARTICLE PHYSICS
Pr Francesco Riva

STRING THEORY
HOLOGRAPHY
Pr Julian Sonner

MESOSCOPIC SYSTEMS
Pr Eugene Sukhorukov

MATHEMATICAL PHYSICS
Pr Vincent Vargas

28 PhD students

Department of applied physics

QUANTUM INFORMATION THEORY
Pr Nicolas Brunner

NONLINEAR BIOIMAGING
Pr Luigi Bonacina

QUANTUM THERMODYNAMICS
Pr Géraldine Haack

NONLINEARITY AND CLIMATE
Pr Jérôme Kasparian

QUANTUM ELECTRONICS
Pr Alberto Morpurgo

QUANTUM COMMUNICATION
Pr Wolfgang Tittel

BIOPHOTONICS
Pr Jean-Pierre Wolf

25 PhD students

UNIVERSITÉ DE GENÈVE
FACULTY OF SCIENCE
Physics Section

Practical Information

UNIGE: a European, global university

Geneva is the westernmost city in Switzerland, located in a canton on a human scale that is close to the Alps and France. It is the country's diplomatic capital, host to most international organisations (UN, WTO, WHO, CERN, etc.), boasting an ideal location in the heart of Europe. Geneva is a very cosmopolitan city, home to a great number of people from all walks of life and all sorts of geographical and cultural backgrounds. In other words, it is the ideal place to grow your personal and professional network!

Europe on the doorstep

The Physics Section and UNIGE are blessed with an ideal location in the centre of international Geneva. They are close to the Cornavin and Eaux-Vives train stations, giving easy access to France and most major cities and foreign capitals in a matter of hours. Although Geneva is not the biggest of cities, it is home to an international airport with good connections, which makes it easier to develop and grow our international activities.

Surrounded by lakes and mountains

Switzerland ranks in fourth place in the list of the "happiest" countries worldwide, and Geneva is a highly liveable city. Ideally located at the crossroads of Lake Geneva, the Jura and the Alps, it gives access to endless cultural, sporting and outdoor activities. Geneva is a very dynamic city on a human scale with many and varied attractions, cultural centres and places of entertainment to suit everyone's tastes, no matter what they are looking for!

A university at the heart of the city

Spread over a number of different sites, the University of Geneva lies at the heart of the city. You can find the Physics Section, which is part of the Faculty of Science, on the banks of the river Arve in the Quartier des Bains, a short walk from the Plaine de Plainpalais (the esplanade made famous by Mary Shelley's Frankenstein), the Promenade des Bastions and the old town of Geneva.

Science meets culture in Geneva

The Quartier des Bains is one of Geneva's most dynamic districts, home to a number of art galleries, museums, theatres and concert venues. It is an extremely lively area, both during the day and in the evening. The nightlife makes it a very popular area for students, due to its numerous restaurants and bars.

Address and telephone

24, quai Ernest-Ansermet
CH-1211 Genève 4

Administration: + 41 22 379 6383
secretariat-physics@unige.ch

UNIGE website: https://www.unige.ch/en

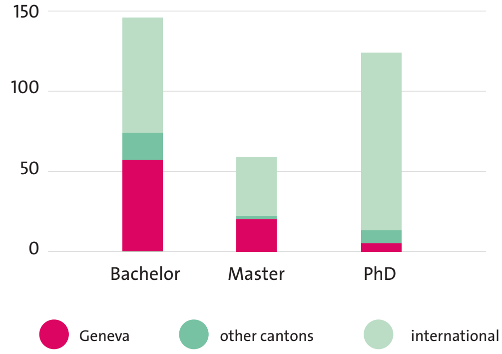
registration

Physics Section in figures

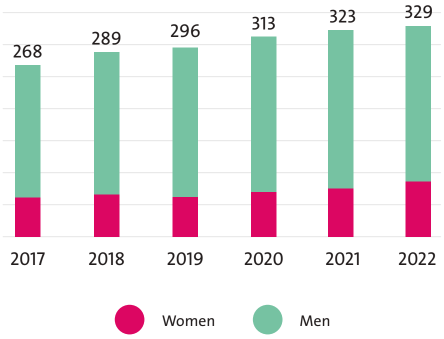
Origin of students 2022

Provenance des étudiant-es 2022

per level



Evolution of the number of students



Student teacher ratio

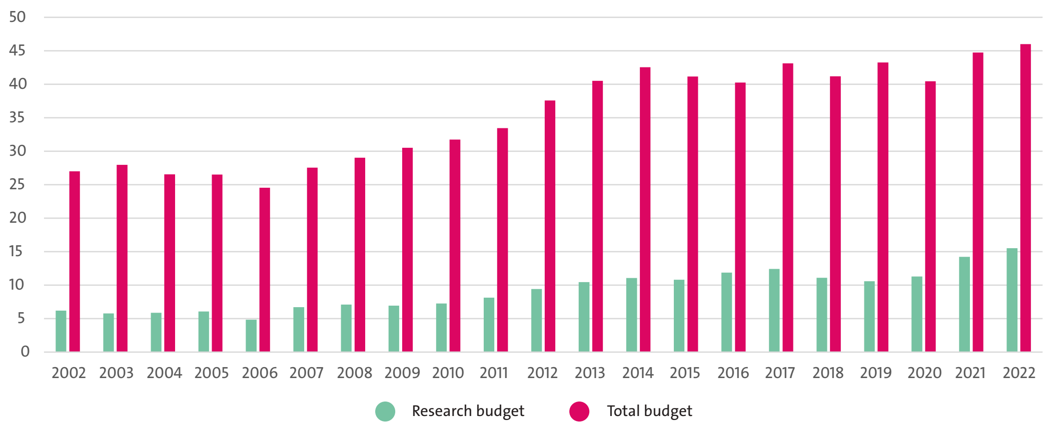
1 Professor for 6 students

Funding of the Section

Excluding ERC (in million CHF)

Funding of the Section

Excluding ERC (in million CHF)



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