UNIVERSITY OF FRIBOURG SWITZERLAND

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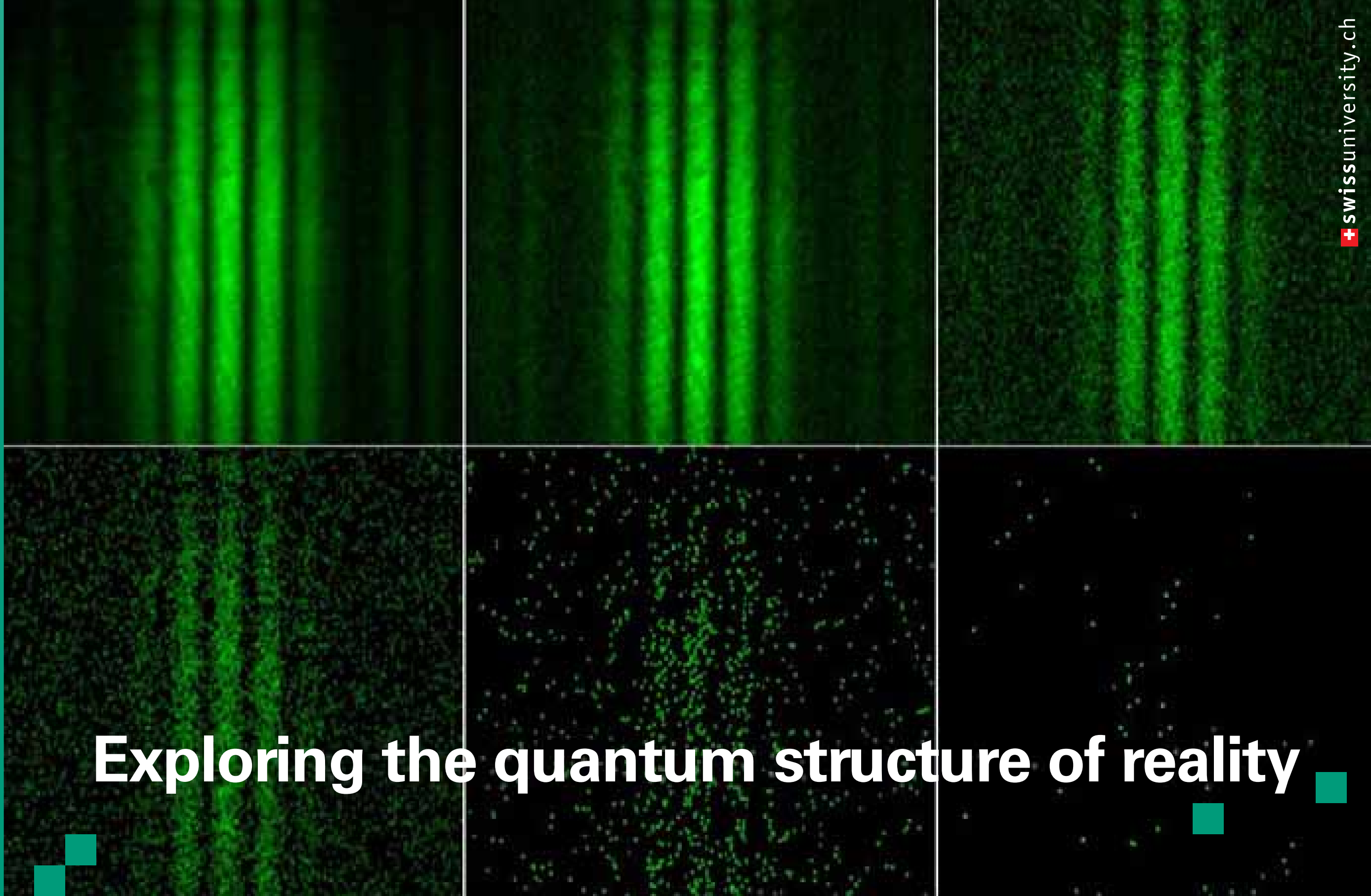

Exploring the quantum structure of reality

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FACULTY OF SCIENCE

MASTER OF SCIENCE IN PHYSICS

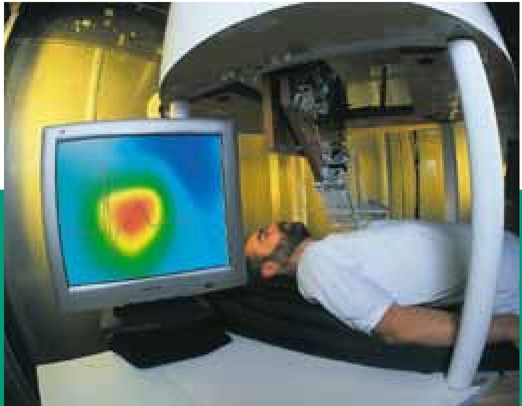
UNIVERSITAS FRIBURGENSIS

PHYSICS TODAY

Physics has been the main motor of the incredible scientific and technological developments of the 20th century and will definitely continue to play a dominant role in this century. Exciting discoveries are expected to be made on all length and time scales, from the universe at large down to the smallest elementary constituents of matter. Physics students, at the Bachelor, Master, or Ph. D. level, have a unique opportunity to explore a wealth of phenomena, which are ultimately governed by simple general laws. This happens in an active process where the student both deepens his understanding of established results and moves towards horizons where there are more open questions than definite answers.

Physics is more than just a well-defined study branch, it remains the basis of natural sciences (chemistry, biology, medicine), it influences the thinking in human sciences (philosophy, psychology, social sciences) and has an increasing impact on modeling in economy and finance. Its role in the development of new technologies cannot be overemphasized; new materials, advanced experimental techniques, and sophisticated algorithms for large-scale simulations are instrumental for the next generation of innovative devices.

Cardiac diagnosis with optical magnetometers



PHYSICS AND ITS SUBFIELDS

Long in the past, a physicist could be well informed and active in all known fields of physics, but since the 20^{th} century physics research has diversified to such a degree that specialization is unavoidable. The well-known subfields are condensed matter, particle and atomic physics, astrophysics and optics, however, a wide variety of original niche studies exist.

Fribourg has a strong focus on condensed-matter physics, where students can acquire a solid foundation for further studies. Specialists in the fields of superconductivity, complex fluids, and collective phenomena of many-body systems teach in those domains. Other modern topics, such as atom-laser interactions and atomic inner-shell processes or econophysics, can also be studied in depth. The proximity of the University of Bern allows easy access to lectures on other topics, in particular on particle and astrophysics.

RESEARCH

The department is composed of several relatively small research groups, each with its own specialty. Students are brought into contact with activities of these groups early in their studies, e.g., through experimental or theoretical projects in the research groups. The Master thesis is usually hosted by a particular research group, but it can also be undertaken at another university.

The combined research within the department covers an important part of modern physics, including solid-state physics, soft condensed matter, atomic physics and optics, many-body theory, and interdisciplinary statistical physics. The experimental research is partly carried out in the in-house labs, and partly at large facilities (PSI in Villigen, ESRF and ILL in Grenoble, FZ Karlsruhe, ISI in Chilton UK, GSI in Darmstadt), where particle beams (neutrons, muons, synchrotron radiation) can be exploited. Both experimental and theoretical groups have extensive collaborations, often in the framework of larger national and international networks. The research quality is internationally recognized and regularly confirmed by bibliometric studies.

EMBL-ESRF-ILL Research site
(Image: Denis Morel)

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ATOMIC PHYSICS

Atoms are fundamental building blocks of matter and our knowledge of their structure is derived from their spectra. 100 years ago the understanding of atomic structure gave birth to quantum mechanics, a revolutionary new theory which constitutes the basis of modern physics.

Two groups perform precision experiments in atomic physics using advanced tools such as tunable lasers, ion beams, and X-ray sources that allow investigations with unprecedented precision and sensitivity. Experiments are performed both in-house and at large-scale facilities. Fundamental research projects include the measurement of the blackbody radiation effect on atomic clocks, magnetic field control in a new search for a permanent electric dipole moment of the neutron, investigations of atoms, molecules, and nanostructures in helium crystals, the study of X-ray resonant Raman scattering, and the investigation of hollow atoms. More applied projects include determinations of ultra low-level impurities on the surface of silicon wafers and measurements of magnetic field maps of the beating human heart.

ELECTRONS IN SOLIDS

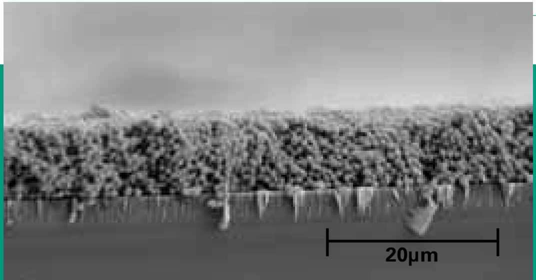
Solids hide a plethora of fascinating phenomena, which often can only be revealed in sophisticated experiments, carried out at very low temperatures. Superconductivity and different kinds of magnetic or charge order are prominent examples. Two groups of the department study such phenomena, using modern experimental techniques. One group investigates new magnetic and superconducting materials showing unconventional properties at low temperatures, for example superconducting pnictides or multi-layers of superconducting cuprates and ferromagnetic manganites. A second group focusses on the spectroscopic signatures of complex electronic phases, in particular on the interplay of charge ordering and structural rearrangements in layered transition metal compounds. Another intriguing phenomenon is the self-assembly of nanostructures on silicon surfaces, which is studied using a low-temperature scanning tunneling microscope.

SOFT MATTER AND PHOTONICS

Soft Matter Physics aims to shed light on the mechanism governing the properties of complex fluids and solids. These interesting materials are made by combining different components – polymers, small particles, soap molecules and droplets. The resulting materials, such as emulsions, dispersion, aerosols, foams and gels, are ubiquitous in everyday life and are used in many technological applications. Their unique properties are determined both by their molecular structure and by the way the different components are assembled. A mixture of three fluids (vinegar, oil and egg) for example can be turned into a soft-solid emulsion (mayonnaise) simply by stirring. Soft materials often appear milky white due to the strong scattering of visible light from small particles or droplets ("colloids"). On the other hand, by tuning the size and structure of colloids, it is possible to manipulate the flow of light. This makes colloids ideal candidates for a successful design of novel photonic devices. A recent prominent example is the colloid-based reflective "e-ink" display developed in the USA and used in the e-books by Amazon and Sony.

INTERDISCIPLINARY PHYSICS FOR FINANCIAL MARKETS AND THE INTERNET

The increasing number of large-scale databases available for research and the ever growing availability of computational power has created a fertile ground for statistical physicists to contribute to real financial and information systems. The interdisciplinary physics group concentrates on statistical analysis and modeling of financial markets, as well as information filtering of web-based systems.
The pattern recognition and correlation analysis of high-frequency financial data uncover some novel phenomena, and have great potential for applications in risk management. In particular, we recently focus on modeling user behaviors and network evolution in large-scale online systems, and on devising efficient algorithms to automatically find out the users' preferences and provide recommendations accordingly. In addition to their theoretical relevance, our interests are closely related to the understanding of financial markets and the design of real online systems, which may yield useful applications in the future.



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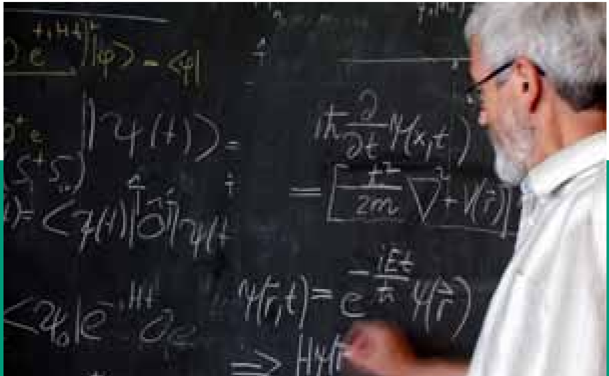
COLLECTIVE QUANTUM PHENOMENA

Every bachelor student learns that the hydrogen atom can only be understood in quantum-mechanical terms. This simple two-body problem – an electron attracted by the proton through the Coulomb force – can be solved exactly. Electrons in metals or in superconductors, or clouds of cold atoms, represent much harder many-body problems which cannot be solved exactly. With modern techniques – analytical, numerical or both – one can make good progress towards reliable results.

Pairing of electrons is responsible for superconductivity and commonly originates from a glue due to the exchange of vibrational quanta, but is pairing possible if two particles repel each other and if there is no glue? In classical mechanics the answer would be clearly no, but the cooperative effects of quantum many-body dynamics and Fermi statistics can induce such a pairing and thus provide a non-conventional route to superconductivity.

The realization of ultracold atomic gases has opened a new era of many-body theory. In those systems model parameters can be readily manipulated by external fields, allowing the control of phase transitions (e.g., between localized and superfluid states) or inducing other complex system evolutions. Whether such systems may be used for quantum computing is a challenging question.



NANOSCIENCES (NANOMATERIALS)

Nanotechnology is a new field of science and engineering where structures and materials on the nanoscale are investigated, and where researchers manipulate atoms and molecules in order to create new and smart materials. It is multidisciplinary by definition, and promises to revolutionize the scientific and industrial world in a variety of areas that include high performance materials, environmental sciences, health, food, and agricultural products. Research in physics is giving some of the most important contributions to this exciting and rapidly growing field. The Fribourg Center for Nanomaterials (FRIMAT) coordinates the nanoscience research activities in the science faculty and establishes a strong link to the newly established Adolphe Merkle Institute. In 2007 the Fribourgeois entrepreneur Adolphe Merkle established a foundation with 100 million Swiss francs in order to strengthen research and teaching at the University of Fribourg. This private donation, the most important ever in Switzerland to a Swiss University, enabled the creation of this interdisciplinary institute devoted to pure and applied nanosciences.

MASTER STUDIES

The Physics Department offers Bachelor, Master, and Ph.D. curricula. During Bachelor studies, the student will acquire the basic knowledge in physics and mathematics and become acquainted with experimental techniques and computational methods. During master studies, knowledge and techniques are refined, progressing gradually toward a specialization. The master thesis is supervised by an active researcher and initiates the student to the frontiers of research.
At the master level, about half of the courses are compulsory and of general interest, the other half are more specialized elective courses. Specialized lectures may also be taken at other universities, in particular Bern. It is recommended that the student follows the specialized courses in the field of the future master thesis. Other lectures, at the discretion of the student, are necessary to complete the ECTS requirements. The lectures are complemented by seminars on modern research topics and advanced laboratory work.

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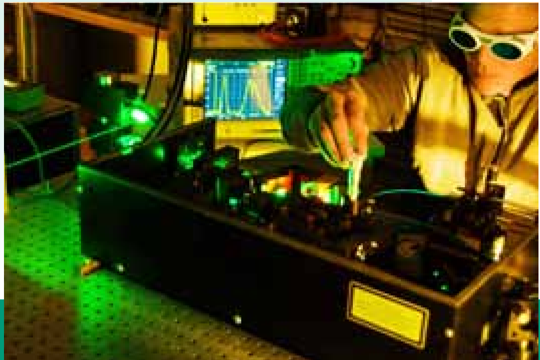
MASTER PROGRAMME

	ECTS
Compulsory courses – *Theoretical physics*: Advanced statistical mechanics, Relativistic quantum mechanics, Field theory, Many-body theory. – *Condensed matter physics*: Structure and dynamics of matter, Magnetism and quantum fluids, Soft condensed matter, Electrons in solids. – *Constituents of matter*: Electrons and photons, Particle physics, Atomic spectroscopy, Modern optics.	**21**
Elective courses – *Specialized courses* (examples): Optics of strongly scattering media, Physics of living matter, Interdisciplinary statistical physics, Advanced materials, Polarized light and polarized atoms, Solid state magnetism, Colloid physics, Solid state spectroscopy, Polymer physics, Symmetries in physics, Atomic collisions, Scattering methods in soft condensed matter, Theories of high temperature superconductors, Physics of information, Critical phenomena, Exotic atomic transitions. – *Other courses*: These courses are at the discretion of the student, such as, for example, a course in Scientific English.	**24**
Seminars, Colloquia, Project in research group	**9**
Master thesis (experimental or theoretical)	**36**

CAREER PROSPECT

The master diploma in physics opens many doors, a natural choice being doctoral studies. A Ph.D. degree is necessary/advantageous for continuing work in academic/industrial research positions. Teaching at the high school level is another obvious choice, it requires an additional graduate certificate in education, which can be obtained within about one year.

Learning scientific rigor, abstract thinking, experimental and mathematical skills, the ability to describe concrete phenomena by theoretical models, the ability to identify relevant variables, are skills of good standing in the search for employment in both the public and private sectors. Branches where physicists are welcome include machine and electronic industries, applied computing, insurance companies, risk management and even financial mathematics. Besides those typical careers, physicists frequently appear in important managerial positions or in politics.



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OPINIONS OF FORMER STUDENTS

«Nach der Matura hatte ich mich entschieden, das Physikstudium in Fribourg aufzunehmen, weil die Stadt sowie die naturwissenschaftliche Fakultät eine übersichtliche Grösse aufweisen und weil die Zweisprachigkeit erlaubt, die Französischkenntnisse zu verbessern. In der Tat habe ich während dem Studium die hervorragenden Betreuungsverhältnisse, aber auch die gute Atmosphäre am Physikdepartement und die Dynamik der Studentenstadt Fribourg sehr geschätzt. Zudem habe ich fast perfekt Französisch gelernt. Heute, als wissenschaftliche Beraterin, profitiere ich täglich von der guten Grundausbildung in Physik sowie von meinen Französischkenntnissen».

Corina Wirth, Juni 2006

«Durant mes études, j'ai eu de nombreuses conversations avec mes professeurs et mes assistants. Ceux-ci étaient toujours disponibles pour répondre à mes questions. Cet encadrement, associé à des cours de haut niveau, m'a permis d'acquérir une solide formation de physicien que je n'aurais certainement pas pu acquérir dans une école plus grande ou plus anonyme. Après le master, durant mon travail de doctorat, j'ai conservé les supports de cours de l'Institut de physique de Fribourg qui sont pour moi encore la meilleure référence».

Philippe Curty, mars 2006

DEGREE OFFERED

Master of Science

LANGUAGE

English

INFORMATION

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http://www.unifr.ch/physics/index.html
http://www.unifr.ch/science/current/pde_ph_bsc_e.php

DEADLINE FOR APPLICATION

30th April / 30th November

SEMESTER TUITION FEE

Swiss students: CHF 655.– per semester
Foreign students: CHF 805.– per semester

ACADEMIC CALENDAR

www.unifr.ch/main/calendrier

PRESENTATION OF THE MASTER PROGRAMMES

www.unifr.ch/master

OVERVIEW OF THE STUDY PROGRAMMES

www.unifr.ch/acadinfo/studies

ADMISSION REQUIREMENTS

Master	Additional programme
Pre-Master Programme	
Bachelor	

Bachelor of Science in Physics or another grade judged as equivalent by the Faculty of Science. Pre-master studies or complements might be requested.

APPLICATION

Students UNIFR:
Automatic access upon accomplishment of the corresponding B Sc

Students from other high schools:
www.unifr.ch/admission

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CONTACTS

❶ Uni-Info
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☎ +41 26 300 70 14
www.unifr.ch/acadinfo

❸ Service des relations internationales (International Relations Office)
✉ Miséricorde 4057, 4058, 4059A
☎ +41 26 300 70 47
www.unifr.ch/international

❹ Service de conseil social et subsides d'études
(Office for Social Counselling and Financial Assistance)
✉ Rue Guillaume-Techtermann 8
☎ +41 26 300 71 60
www.unifr.ch/social

❺ Apartis – Fondation pour le logement des étudiant-e-s
(Apartis – Foundation for Student Accommodation)
✉ Rue de l'Hôpital 4
☎ +41 26 300 73 13
www.apartis.ch

❻ AGEF (Association Générale des Etudiant-e-s de l'Université de Fribourg)
(Student Association of the University of Fribourg)
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