University of Zurich

STUDY PHYSICS AT UZH!

SHOOT FOR THE STARS
STUDY PHYSICS AT UZH!
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Editorial</strong></td>
<td></td>
</tr>
<tr>
<td>We Want You on Board!</td>
<td>6</td>
</tr>
<tr>
<td><strong>Research</strong></td>
<td>9</td>
</tr>
<tr>
<td>Invisible Giants</td>
<td>10</td>
</tr>
<tr>
<td>Big News on the Big Bang</td>
<td>14</td>
</tr>
<tr>
<td>Heavy-Duty Honeycombs</td>
<td>18</td>
</tr>
<tr>
<td>Irresistible Power</td>
<td>22</td>
</tr>
<tr>
<td>Matter Matters</td>
<td>26</td>
</tr>
<tr>
<td>Weird and WIMPY</td>
<td>30</td>
</tr>
<tr>
<td><strong>Research at the Department of Physics</strong></td>
<td>35</td>
</tr>
<tr>
<td><strong>Study</strong></td>
<td>36</td>
</tr>
<tr>
<td><strong>Testimonials</strong></td>
<td></td>
</tr>
<tr>
<td>“Meet the Director” Céline Nauer (23)</td>
<td>38</td>
</tr>
<tr>
<td>“Big Family” Magnus Gienal (24)</td>
<td>40</td>
</tr>
<tr>
<td>“Unusual Minors” Nehir Schmid (23)</td>
<td>42</td>
</tr>
<tr>
<td>“Hands on” Benjamin Tobler (23)</td>
<td>44</td>
</tr>
<tr>
<td><strong>Why Study Physics @ UZH?</strong></td>
<td>46</td>
</tr>
<tr>
<td>Interviews</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>“Taking Advantage of Freedom”</td>
<td></td>
</tr>
<tr>
<td>Susanne Rechsteiner, acoustic and structural physics consultant at Amstein + Walthert AG</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td></td>
</tr>
<tr>
<td>“Getting Involved in Research”</td>
<td></td>
</tr>
<tr>
<td>Christian Elsasser, project manager at Swiss Re</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td></td>
</tr>
<tr>
<td>“Physics Makes Us Innovative”</td>
<td></td>
</tr>
<tr>
<td>Michel Willemin, head of the Swatch Group’s research and development lab</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td></td>
</tr>
</tbody>
</table>

| Careers for Physicists | 60 |
Dear physics enthusiasts – There is something special about being involved in physics. To me, exploring the most fundamental questions of existence is incredibly exciting, fascinating, and intellectually stimulating. Whether they focus on the tiniest particles, the entire cosmos, or specific problems in everyday life, physicists always look at the world from a different angle. But they also help solve the challenges facing people all over the world. After earning their degree, physicists are not confined to working in academic research; thanks to their analytical thinking skills, they are in high demand in business, at banks and insurance companies, as R&D managers and patent lawyers, or in telecommunications and optics.

I am particularly pleased that you share our passion for physics and are thinking about studying at the University of Zurich (UZH). Because our scientists conduct research at the cutting edge of science, they
can offer young students a broad, highly relevant academic education. And thanks to an ideal balance between researchers and students, UZH provides access to real-world research already at the Bachelor’s level, thus giving students the opportunity to get actively involved in this exciting work. The flexible program structure – also geared to part-time study – and the option of choosing one or two minor subjects in addition to your major, means you can put together a course tailored to your interests.

We would be delighted to welcome you on board!

Prof. Ulrich Straumann
Director, Department of Physics
BLACK HOLES, DARK MATTER, AND PUZZLING PARTICLES
Invisible Giants

Supermassive black holes are cosmic power plants that hold entire galaxies together.
Strange Monsters – At the heart of our own Milky Way – indeed at the heart of most galaxies in the universe – there sits a supermassive dark hole. These giants swallow up whole stars and can reach a mass of several million or even billions of suns. Their gravitational pull is so strong that not even light can escape – the reason we can’t see them.

Cosmic Power Plants – Supermassive black holes have played a key role in the development of the universe. They act as huge cosmic power plants that emit incredible amounts of energy and shape galaxies. Physicists believe that our universe would look completely different without supermassive black holes.

Condensed Gas – But how do these dark giants arise? Opinions among experts are divided. Astrophysicist Lucio Mayer at UZH works on the assumption that black holes formed early on, only a few hundred million years after the Big Bang, when interstellar gas became ultra condensed.
Simulations on Supercomputers – Lucio Mayer is seeking answers not just in real space but in virtual space as well, using powerful supercomputers to simulate cosmic events. These simulations, which sometimes take months of computing, make it possible to test a variety of hypotheses – for example, on the origin of supermassive black holes.

Prof. Lucio Mayer, lmayer@physik.uzh.ch
Big News on the Big Bang

Gravitational waves lead to fresh insights into how the universe developed.
Invisible Giants – Black holes are invisible giants in space. When two of them collide, enormous masses are converted into gravitational energy. This generates gravitational waves, ripples that move through spacetime.

What Einstein Knew – Physics great Albert Einstein predicted the existence of gravitational waves a hundred years ago in his theory of general relativity. But it was only in the fall of 2015 that scientists finally succeeded in measuring them.

Galileo’s Telescope 2.0 – Gravitational waves are messengers from the history of the universe. They tell us about events that took place somewhere in space billions of years ago. “Just as Galileo Galilei’s telescope made it possible to explore the universe optically, gravitational waves enable us to see objects we didn’t know about before,” says astrophysicist Philippe Jetzer. “With a bit of luck, we’ll be able to see right back to the beginning of the universe.”
Satellites in Space – In his research at the University of Zurich, Philippe Jetzer plans to measure gravitational waves in space. To do so, a huge measuring instrument – consisting of three satellites circling the sun, a million kilometers apart from each other – will be launched into orbit. The gravitational waves they measure will bring about new insights into the universe.

Prof. Philippe Jetzer, jetzer@physik.uzh.ch
Heavy-Duty Honeycombs

Carbon-based graphene is a supermaterial with near-miraculous properties – and everything it takes to revolutionize technology.
Flexible Touchscreens – A smartphone on your wrist? It could soon be possible thanks to graphene, a carbon-based supermaterial that has captured the imagination of scientists. Graphene has the potential to revolutionize technology and promises to be key in developing flexible yet robust displays and touchscreens, more powerful computers, and highly sensitive sensors.

Tougher than Steel – Graphene is the thinnest material known. It consists of a single layer of carbon atoms arranged in a honeycomb-like network of hexagons. This structure makes it extremely tough and gives it 125 times the tensile strength of steel. But that’s not all: Graphene is also an incredibly good conductor of electricity. For all these reasons, a great technological future is predicted for the supermaterial.

The Scotch-Tape Method – In 2004, two physicists from the University of Manchester succeeded in producing graphene for the first time – with amazingly simple means requiring only graphite, – the
material used as pencil lead – and plenty of adhesive tape. Graphite basically consists of millions of layers of graphene, one on top of the other. The two researchers used the tape to remove graphite layer by layer, until only one final layer of graphene remained.

**Supermaterial Grown in the Lab** – There’s only one problem: The quality of the graphene produced using the Scotch-tape method cannot be upscaled for large quantities of graphene as needed for innovative technologies. High-quality graphene can, however, be grown in the lab, which is precisely what UZH physicists Jürg Osterwalder and Thomas Greber do. Their work promises to open up a whole new world of technological possibilities.

Prof. Thomas Greber, greber@physik.uzh.ch,
Prof. Jürg Osterwalder, osterwal@physik.uzh.ch
Irresistible Power

Transmitting electrical energy with no resistance is one of the great dreams of physics – one that has become reality.
The Well-Tempered Superconductor – Superconductors are materials that, at a certain transition temperature, conduct electricity without resistance. Ever since K. Alex Müller and J. Georg Bednorz made their groundbreaking discovery in 1986, we have known that, in addition to metals, ceramic compounds such as copper oxides can become superconductive – with the advantage that they develop the property at much higher temperatures than metals.

Global Excitement – K. Alex Müller, at the time professor of solid-state physics at UZH, set off a wave of global excitement with this discovery and, just one year later, he and J. Georg Bednorz were awarded a Nobel Prize for their achievement. The fact that these ceramic superconductors have significantly higher transition temperatures than metals gives them tremendous potential for applications in areas such as power plants, transformers, energy transmission, and microelectronics.
Fleeting Euphoria – By now, however, some of the euphoria has evaporated. Because the transition temperature is still extremely low, complicated and expensive technology is needed to work with the material. On top of this, the question of why copper oxides are even able develop superconductivity has been the subject of intense scientific dispute for decades.

Astonishing Phenomena – What is clear is that high-temperature superconductivity (HTS) is accompanied by some astonishing physical phenomena. Solid-state physicist Johan Chang is investigating some of these complex phenomena at UZH. Thanks to his work, this technology could find more practical applications – for example, by finding copper oxide or related compounds able to conduct electricity without resistance at higher temperatures, in ideal cases at room temperature. As such, Chang’s research could prove instrumental in paving the way for a compelling general theory of HTS.

Prof. Johan Chang, johan.chang@physik.uzh.ch
Matter Matters

Why is there anything at all, and not simply nothingness? Particle physicists are looking for answers.
War of the Particles – Why does stable matter exist as we know it? Physics has not yet found a definitive answer to this fundamental question. The Standard Model of particle physics says that, after the Big Bang 13.7 billion years ago, there were equal quantities of particles and antiparticles. Theoretically they should have canceled each other out, and the universe would be a very different place.

A “New” Physics – This asymmetry between matter and antimatter is one of the biggest puzzles that “new” physics is trying to solve. As part of the quest, researchers are trying to identify particles not foreseen in the Standard Model.

Sterile Neutrinos – UZH particle physicist Nicola Serra is one of these “new” physicists. He chases sterile neutrinos, particles that could shed light on the creation of matter and antimatter. It is believed that sterile neutrinos could trigger processes in which particles are converted into antiparticles and vice versa. If one of these processes dominates, more antimatter than matter would be de-
stroyed. But so far, proof of these sterile neutrinos remains elusive.

**A Thousand Trillion Collisions** – Nicola Serra is proposing to use the collider at CERN in Geneva to track down sterile neutrinos: He and his fellow researchers want to make tens of trillions of particles collide every second in order to find out if these elusive particles are created in the collisions. During the five years the experiment is due to run, the team will be able to observe hundreds of millions of trillions of collisions. “If we’re lucky, there will be three events that count,” says Serra. The complex search for sterile neutrinos makes trying to find a needle in a haystack seem like child’s play.

Prof. Nicola Serra, nicola.serra@cern.ch
Weird and WIMPy

A large part of matter in our universe is invisible. Physicists aim to unravel the secrets of this mysterious dark matter.
Dark Secrets – Only a fraction of the matter in our universe is visible, with a much larger part consisting of invisible, or dark matter, whose secrets have thus far eluded physicists.

Galactic Glue – Swiss physicist Fritz Zwicky postulated the existence of dark matter as far back as 1933. While observing a rich cluster of galaxies, he noticed that individual galaxies move very quickly – so quickly, in fact, that the gravitational force of the visible matter alone wouldn’t be sufficient to hold everything together. He concluded an even larger amount of invisible matter must be present to prevent the individual galaxies in the cluster from flying apart.

Small Strangers – Ever since, physicists have been trying to solve the mystery of dark matter. Laura Baudis of UZH is one of them. Her work is based on the assumption that dark matter consists of new, elementary particles, as yet unknown. These interact only very weakly with visible matter and are therefore extremely hard to pin down. Such particles are
aptly named “Weakly Interacting Massive Particles,” or WIMPs.

**Research Deep Inside the Mountains** – Laura Baudis is trying to detect WIMPs using a large detector with a core of liquid xenon. To shield the device from cosmic radiation on the earth’s surface, it is located deep inside the rock in Italy’s Abruzzo region. There, in an underground lab, Baudis and her team hope to finally prove the existence of dark matter particles. If they succeed, astrophysics will be one step closer to solving one of the great mysteries of our universe.

Prof. Laura Baudis, laura baudis@physik.uzh.ch
Research at the Department of Physics

Particle, Astroparticle, and Astrophysics:

- Experimental search for dark matter particles
- Very rare decays of germanium to study the properties of neutrinos
- Physics with the CMS experiment at LHC at CERN
- Study of antimatter – matter asymmetry with the LHCb experiment at CERN
- Theory of general relativity and gravitational waves
- Theory of particle physics
- Theoretical astrophysics, planetary science
- Computational astrophysics
- Theoretical astrophysics and cosmology
Physics of Condensed Matter:

- Quantum matter physics
- Features of surfaces of condensed matter
- Phase transitions and new materials, and their application
- Theory of condensed matter physics
- Soft condensed matter at the nanoscale

Biophysics, Imaging and Medical Physics

- Disordered and biological soft matter
- Imaging methods for single molecules
- Medical physics: Radiotherapy and imaging
- Bioimaging
- Single-molecule biophysics
“STUDYING PHYSICS AT UZH IS HARD FUN.”
“My study advisor was the director of the department. That is really cool!”

Céline Nauer (23) is in her sixth semester at UZH. After high school, she spent a year traveling around the world as a flight attendant with Edelweiss Air. She is proud that she was able to make such a smooth transition from flight attendant to physics student.
“The Department of Physics is like a big family. Contact with assistants and professors is easygoing.

Magnus Gienal (24) is in his eighth semester at UZH. He’s currently working on his Bachelor’s thesis in experimental particle physics. Alongside his studies, he organizes the Out in the Gurin open air festival in Sargans. His goal is to work as a physics teacher and show students just how exciting the subject is.
“The study program is flexible and we can choose unusual minors if we want.”

Nehir Schmid (23), is in her fourth semester studying physics, and is minoring in political science. She wants to know how the world works on a physical and social level. The flexible study system at UZH allows her to combine her two main interests. In the summer she will go to Nepal to rebuild homes destroyed by earthquake.
“Studying physics at UZH is hands-on from the start. I like that.”

Benjamin Tobler (23) has finished his Bachelor’s degree and is now doing an internship at Ruag Space, where he has the opportunity to work on laser technology that can transmit information from space to Earth. Benjamin started star-gazing at age eleven, at the Eschenmosen observatory. He wanted to understand what he saw – a great incentive to study physics.
There are many excellent reasons to study physics at UZH. The low number of physics students at UZH results in good student-to-instructor ratios and ensures high-quality supervision. In addition, a significant part of the study program consists of electives, which allows students to tailor the study program to their interests and encourages them to focus on specific areas of physics. Another advantage to the program is that UZH physics students are free to take courses offered at ETH Zurich as electives.

Professors at UZH care about their students. They are present in lectures and supervise independent research work. At the Department of Physics, students are invited to discuss all kinds of questions directly with their professors; their needs are taken seriously.

The study program at UZH places strong emphasis on practical experience. It demands – and pro-
motes – a high degree of independence to construct, measure, and analyze experiments in the lab. Module exams are conducted individually for each course, allowing students to complete a degree while working part-time.

At UZH, great value is placed on imparting a broad education, which is why students can choose a minor at the Bachelor’s level, and in their Master’s studies from all fields of study offered at UZH and ETHZ.

Learn more about the physics program at: www.physikstudium.uzh.ch
“DEVELOP YOUR SKILLS”
As a physicist, you can find work as a university professor, high school physics teacher, federal chancellor,
“I took advantage of the freedom”

SUSANNE RECHSTEINER (45), acoustic and structural physics consultant at Amstein + Walthert AG in Zurich
Susanne Rechsteiner, what was your motivation to study physics at UZH?

RECHSTEINER: I first became fascinated with physics while studying to be a secondary school teacher. So after earning my teacher’s diploma, I decided to study physics right away.

What part of your studies was particularly positive?

RECHSTEINER: I really liked the challenge of the discipline itself. The small number of people studying physics at UZH is an advantage, as it means there’s a great ratio of instructors to students. The contact with instructors and assistants was also very easygoing. In our advanced studies, after the second intermediate diploma, we had the opportunity to work in research groups doing experiments on real-life problems, which of course was much more exciting than repeating the same old experiments for the hundredth time.

Any other highlights?

RECHSTEINER: I also liked the fact that I had a free choice of second minor alongside the first minor, math. I took advantage of the freedom to combine subjects and chose a minor – biology – outside the mainstream. Since this was my second degree, I already knew my way around the university, and I had the confidence to talk with the professors and go my own way.
How has studying physics benefited your career?

RECHSTEINER: When you study physics, you have to deal with complex, and in some cases, very abstract problems. You get used to not understanding things straight away. That helps a lot at work: I don’t get thrown off balance when I’m confronted with highly complex issues.

What role does physics play in your current job?

RECHSTEINER: My work as an acoustic and structural physics consultant involves physics on a daily basis.

Why would you recommend studying physics at UZH?

RECHSTEINER: The physics department at UZH was – and, I imagine, still is – very down-to-earth and friendly. I liked that a lot. And otherwise, physics is simply incredibly interesting and diverse.
CHRISTIAN ELSASSER (30), project manager at Swiss Re
Christian Elsasser, what was your motivation to study physics at UZH?

ELSASSER: I decided to study at UZH because of the wide choice of minor subjects available. It was definitely the right decision: My minor degree in economics broadened my horizons. In general, the physics program at UZH offers students a lot of flexibility. Of course that means taking responsibility for your own progress, but it also helps you develop the necessary discipline and self-reliance.

What part of your studies was particularly important?

ELSASSER: The opportunity to be involved in a CERN research group during my Bachelor’s studies. I went on to earn my Master’s and PhD in the same team. Overall, students have the opportunity to be actively involved in research projects at an early stage.

How has studying physics benefited your career?

ELSASSER: The great thing about studying physics was that I also learned a lot about informatics, math, data analysis, statistics, and electronics. In my present job, good skills in data analysis and informatics are essential. Studying physics also enabled me to gain valuable experience in project management.

Successful research – even the simplest student experiment – has to be planned and carefully managed. Another advantage of a physics degree is that...
working in an international environment improves your English skills.

What role does physics play in your current job?

ELSASSER: As a project manager for data analysis projects, I’m frequently confronted with modeling physical phenomena. Without a good knowledge of physics, it would be impossible to develop new ideas or to manage projects efficiently. Also, a grasp of physical phenomena is vital in solving the sort of technical problems that arise in my work. For example, my knowledge of electromagnetism helps me understand the technical possibilities of satellite imaging.

Why would you recommend studying physics at UZH?

ELSASSER: Physics is incredibly exciting. The way it’s structured at UZH – with minor subjects, internships, and early involvement in research – means you can develop your skills in many different areas. Businesses and research institutions are always on the lookout for people with a broad educational background who are able to quickly connect the dots.

biomedical engineer, radiology specialist, radiation oncology specialist, nuclear medicine specialist, robotics
“Physics makes us innovative”

MICHEL WILLEMIN (47), head of the Swatch Group’s research and development lab.
Michel Willemin, what was your motivation for earning your PhD in physics at UZH?

WILLEMIN: After earning my diploma in physics at the University of Neuchâtel, I chose UZH for my doctoral thesis because I wanted to learn another language and broaden my horizons. UZH has the advantage of being a comprehensive university with the entire range of disciplines, including medicine. Working on my thesis gave me the an opportunity to do pioneering work – and to combine academic research with practical applications in industry.

Can you give an example?

WILLEMIN: I conducted research on superconductors and developed a measurement method with special sensors. The work involved close collaboration with IBM’s research lab in Rüschlikon.

How has studying physics benefited your career?

WILLEMIN: Physics helps me in my job every day. For one thing, it enables me to understand developments in research. But it also helps when it comes to discussing complex matters with my team or challenging my colleagues with intriguing new findings.

What role does physics play in your current job?
WILLEMIN: I am head of the Swatch Group’s central R&D lab. Everything we do involves physics – from mechanics, Microsystems, and microtechnology, on to optical and electronic systems, communications, and materials. Without physics, R&D in the watch industry wouldn’t be very innovative.

**Why would you recommend studying physics at UZH?**

WILLEMIN: The academic diversity at UZH gives students and researchers a lot of freedom to develop. UZH also has a good network of academic and industrial partners, which makes it possible to conduct both basic and applied research.
Careers for Physicists

Education and Research

- University professor (research and teaching)
- Secondary school physics teacher

*International Research Institutions like CERN, DESY, PSI or EMPA*
- Leader of research group

Private Sector

*Industrial research*

*Information Technology Industry like IBM Rüschlikon:*
- Storage media developer

*Biotechnology and pharmaceutical companies such as Novartis:*
- Process manager

*Airline Industry:*
- Materials developer
IT companies such as Google, Tesla:
· Computer programmer

Medical technology:
· Materials developer

Service Industry

Finance companies, banking:
· Financial analyst
· Investment banker
· Manager

Insurance and reinsurance companies:
· Risk analysts

Corporate consulting:
· Consultant

Media:
· Science journalist

Public Sector/Non-Profit Organizations

Institute of Intellectual Property:
· Patent examiner

Meteorology institutes:
· Atmospheric physicist

Police:
· Forensic scientist

NGOs such as Myclimate:
· CO2 balance specialist

International organizations such as the UN:
· Head of department

Transport companies such as Swiss Post:
· Logistics Specialist

Best of luck finding the right career!