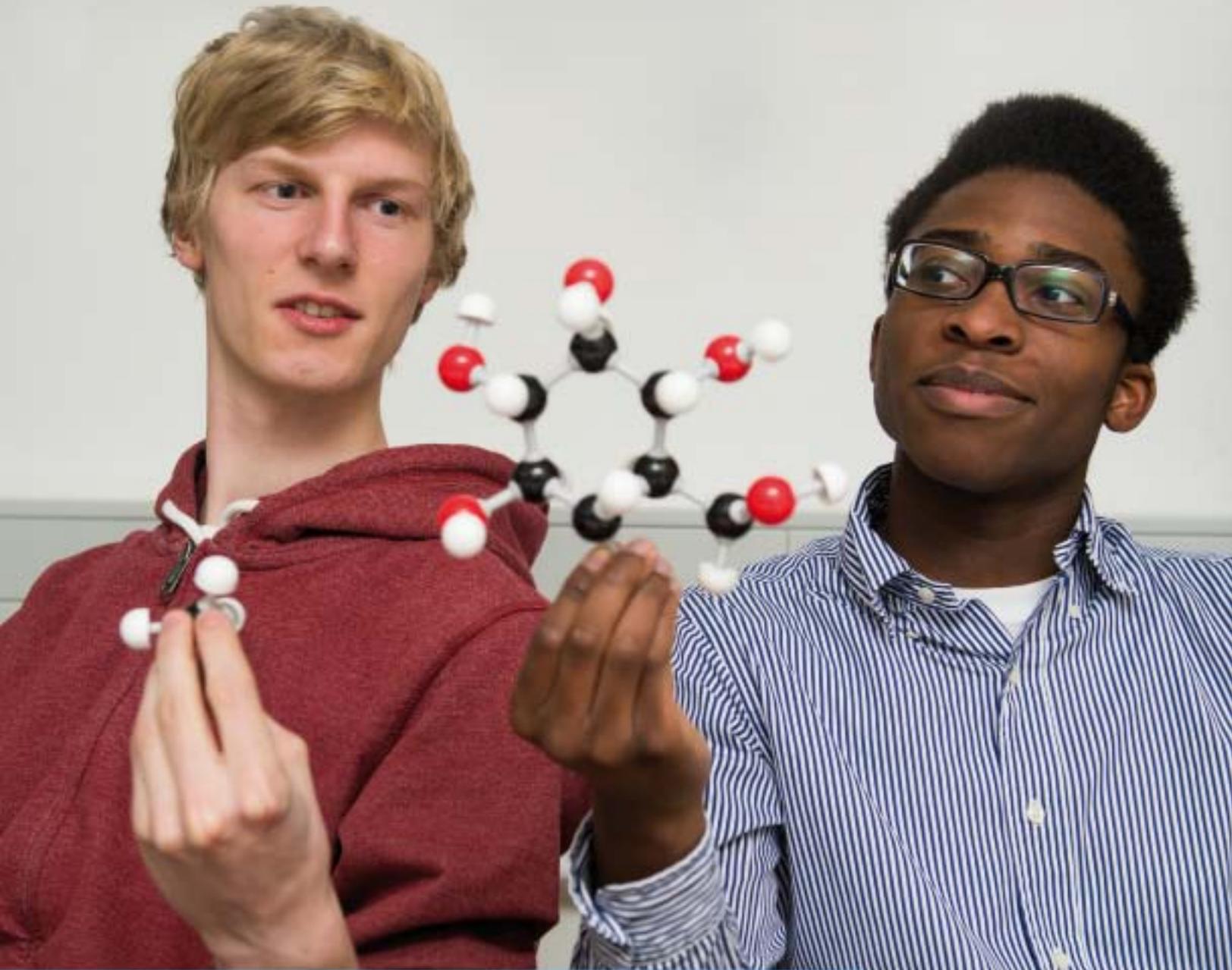


# Germany – a Great Place for Knowledge



Natural Sciences, Mathematics,  
Computer Science

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Germany



Land of Ideas

# Natural sciences, mathematics and computer science in Germany

Research in the natural sciences has a long and significant tradition at German universities. In the fields of chemistry, physics, biology, pharmacy and earth sciences, scientists are seeking solutions to deal with the challenges of our time. To this end they frequently conduct research **in interdisciplinary teams together with national and international research organisations**. The many interdisciplinary degree courses that are emerging are an indication of how cooperation between the natural science disciplines is advancing.

Computer science is the largest field of study in the natural sciences in numerical terms nowadays and is offered by both traditional universities and universities of applied sciences. Like mathematics, it plays a **fundamental role in the natural sciences** and provides important technologies, for example for simulations and for the collection and analysis of data.

A bachelor's degree in one of the natural sciences creates the basis for graduates to extend the skills they have acquired in an **application-oriented or research-oriented master's course**. Via a multitude of master's courses and doctoral programmes the graduates can enter very different and increasingly also interdisciplinary fields of research.

This magazine provides an overview of the natural sciences, mathematics and computer science in Germany for **anyone abroad who is interested in taking a degree or in pursuing academic further training**.

The **higher education landscape** and the disciplines of chemistry and mathematics are presented under the heading "studying natural sciences, mathematics and computer science". Foreign students are also given tips on how to get a place at university and the best way to commence studying.

Another section is dedicated to **master's courses** (taking computer science and earth sciences as an example) and doctoral studies, in particular in **international post-graduate programmes** (reports from the life sciences and physics). These courses guarantee special support for foreign students or doctoral candidates both in issues related to their studies and in general issues.

Finally the **career prospects** of graduates in mathematics, computer science and the natural sciences on the German labour market are examined.

We hope you enjoy reading the magazine!

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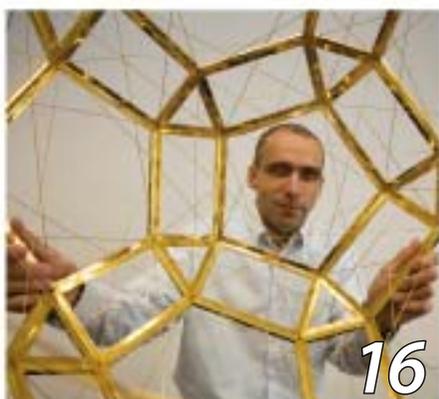
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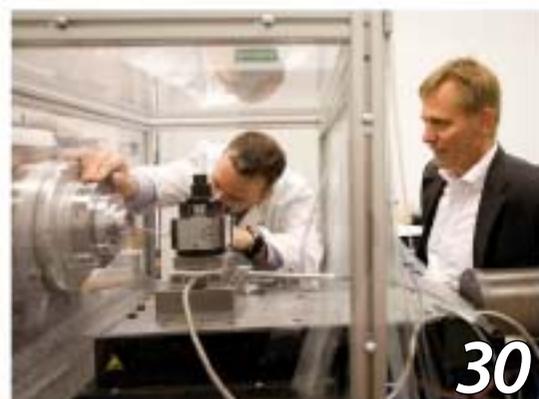
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# Crossing frontiers

Research in the natural sciences has a long and successful tradition at German universities. In order to cross the frontiers of knowledge or to find solutions to urgent problems, natural scientists are increasingly leaving traditional paths and are conducting research together throughout the world and across the boundaries of their disciplines. Mathematics acts as a universally applicable cross-disciplinary science. Computer science takes on in particular the storage, structuring and analysis of the accumulating quantities of data. In this section we present a few examples of cutting-edge research in Germany.



*An especially impressive example of research in science and technology crossing frontiers: the photograph taken by NASA shows the Mars rover Curiosity examining rocks on Mars.*

In 2012 the Mars rover Curiosity landed on the red planet. Over a period of at least two years the curious rover will investigate whether conditions for the emergence and development of life could once have prevailed on Mars. For this purpose there are ten instruments for examining rock, atmosphere and radiation on board the rover. One of them is the Radiation Assessment Detector (RAD). A substantial part of the development work for this was conducted at the Institute of Experimental and Applied Physics at Kiel University over a ten-year period.

Weighing only about one and a half kilos and using less electricity than an energy-saving bulb, the device measures galactic and solar radiation that reaches the surface of Mars. This makes it possible to draw conclusions about the soil depth at which microbial life may have existed or survived the inhospitable radiation environment of Mars. In addition, the measurements provide information about the level of radiation to which astronauts would be exposed during a manned mission to Mars.

## Collaborative research

As is the case with space research, large-scale projects in scientific basic research can generally only be achieved by means of cooperation between universities, research centres, firms and institutions from many different countries. Large instruments, such as telescopes, particle accelerators or neutron sources, are expensive and complex to develop. The concept that makes them feasible is known as collaborative research.

A prominent example of European collaborative research is the Large Hadron Collider (LHC) at the European Organization for Nuclear Research, CERN, in Geneva. With a circumference of almost 27 kilometres, it is the largest particle accelerator in the world. One of the spectacular research results of 2012 was the highly plausible evidence of the Higgs boson. According to existing

theory, this elementary particle endows all other particles with mass. The team in Geneva included German particle physicists from 16 universities, from the Max Planck Institute for Physics in Munich, from the two Research Centres of the Helmholtz Association, Deutsches Elektronen-Synchrotron (DESY) and Karlsruhe Institute of Technology (KIT). The German research centres are also involved in storing and analysing the huge quantities of LHC data.

Major parts of the complicated LHC detectors were developed and constructed in Germany. The Department of Physics and Astronomy at Heidelberg University has specialised in this and is responsible, for example, for the Calorimeter Trigger Pre-Processor, which is a key component of the ATLAS experiment, digitalising and analysing 8,000 analogous measurement channels 40 million times per second. Professor Sandra Klevansky, Administrative Director of the Heidelberg Graduate School of Fundamental Physics HGSPF (see also the report on page 26) points out that Heidelberg scientists also play a large role in three of the four experiments at the LHC: "In the ATLAS experiment they were involved in the search for the Higgs boson, in ALICE (A Large Ion Collider Experiment) it was all about understanding heavy-ion physics, and in LHC-b (Large Hadron Collider beauty) about understanding the 'b-quark particle'."

### Nothing works without mathematics and computer science

Basic research of this magnitude would be absolutely inconceivable without mathematical procedures and the tools of computer science. Mathematics is regarded as a cross-disciplinary science, which is universally applicable in physics, chemistry, biology and earth sciences due to its potential for abstraction. Mathematical modelling, simulation and optimisation are decisive factors for innovations in research and industry.

It is the same with computer science: computer simulations and virtual reality have become indispensable in all scientific disciplines. They enable scientists to take a targeted look into the unknown and the future. For instance, the development and consequences of climate change can only be predicted with the aid of high-performance computers. The climate high-performance computer "blizzard" of the German Climate Computing Centre (Deutsches Klimarechenzentrum – DKRZ) at the Universität Hamburg is a supercomputer with a total of almost 200 TeraFlops on more than 10,000 processor cores. It has storage space for 67,000 magnetic tapes in seven tape libraries with 56 tape robots, and is linked with scientific networks all over the world. Equipped with this capacity, it can simulate the earth's climate system and its complex development using numerical models.

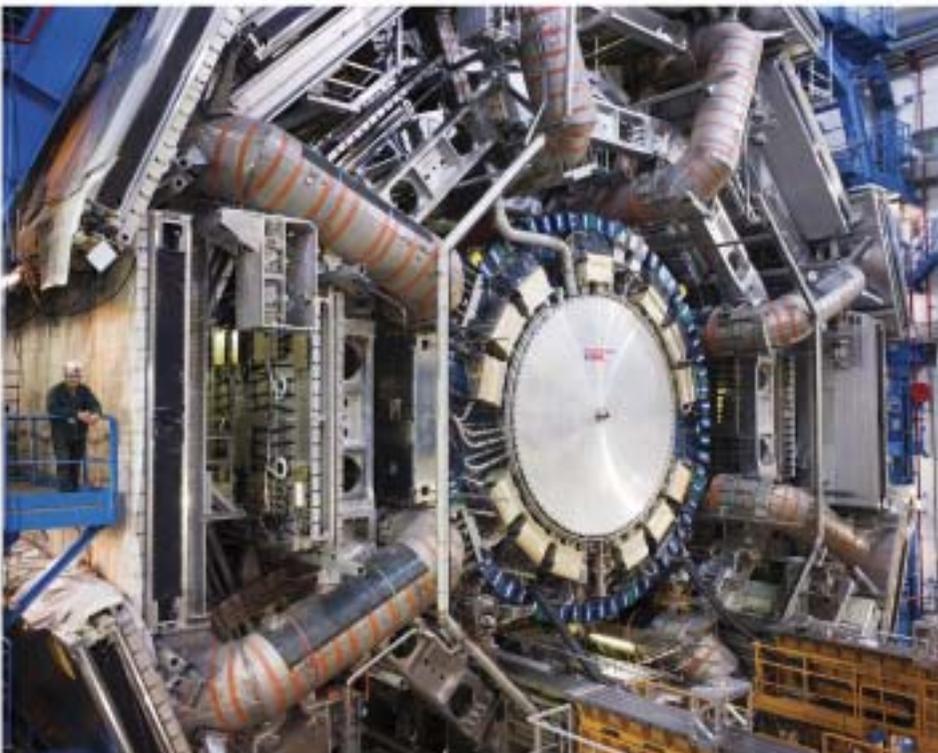


*Kiel University is responsible for the heart of the Radiation Assessment Detector (RAD), the actual detector (RSH – Rad Sensor Head) that measures the cosmic radiation.*

Computers and mathematical models are comparably important for deciphering the genetic make-up of humans. At German universities and research institutes, bioinformatics specialists deal with the storage, structuring and analysis of biological data. They develop algorithms and software for analysing large quantities of sequences and data or, for example, predict structures of proteins.

This groundwork on deciphering the human genome, in turn, opens up a variety of possible applications in research in the life sciences and biomedicine. Systems biology, for example, creates new solutions for individualised medicine by linking approaches in molecular biology with mathematical computer models. The launch of the National Genome Research Network (NGFN) was the start of a large-scale project that is unique in the world. The task of this genome network is to conduct research into diseases that are relatively common in Germany and are of particular importance in terms of health policy.

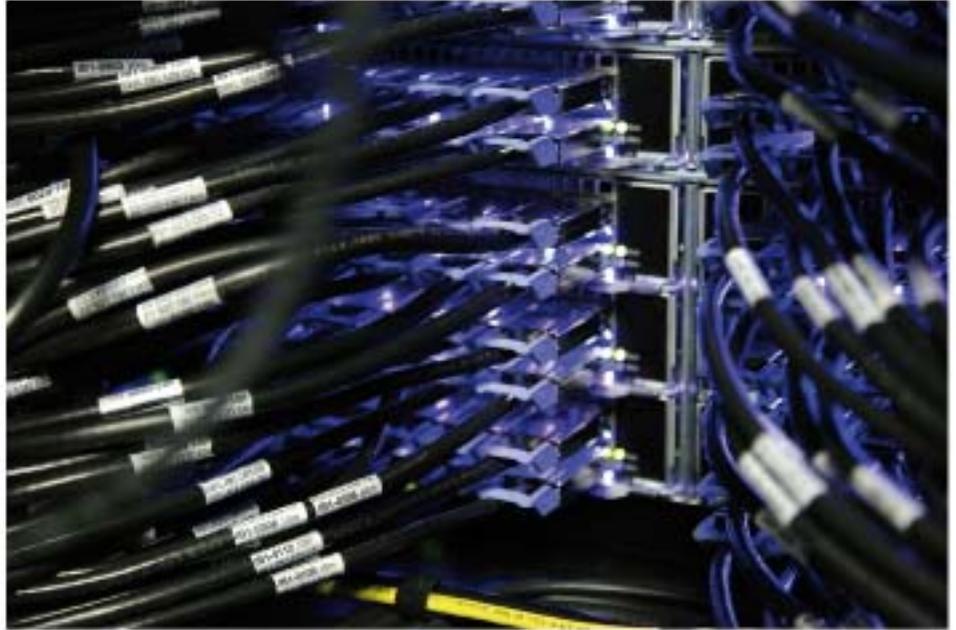
*The ATLAS particle detector at the European Organization for Nuclear Research, CERN, in Geneva is part of the Large Hadron Collider (LHC), the largest particle accelerator in the world, with a circumference of almost 27 kilometres. The ATLAS was used among other things to detect the Higgs boson.*



### Scientists of all disciplines

Just how much Germany's cutting-edge research is organised in the form of interdisciplinary teams is also shown by an example from the field of nanoscience. In the Nanosystems Initiative Munich (NIM), research groups from several universities and non-university research institutes in the Munich area are brought together. The scientists from the disciplines of physics, biophysics, physical chemistry, biochemistry, biology, electrical engineering and medicine aim to gain a fundamental understanding of the properties of nanostructures. They expect to discover a broad range of potential applications, for example, in information technology and biotechnology.

Among other things, NIM deals with so-called nanoscale building blocks, which were designed at molecular level and in some cases are so small – some of them no thicker than an atom – that they are able to utilise quantum effects such as electron spin. How such tiny structures can be integrated into functional computer systems is a key issue addressed by the team of researchers. NIM scientists have also developed multifunctional nanoparticles that work like biopharmaceuticals. The particles are constructed in such a way that they can specifically detect diseased cells, transport the active substances into the cell, thereby successfully attacking and destroying tumour cells, for example.

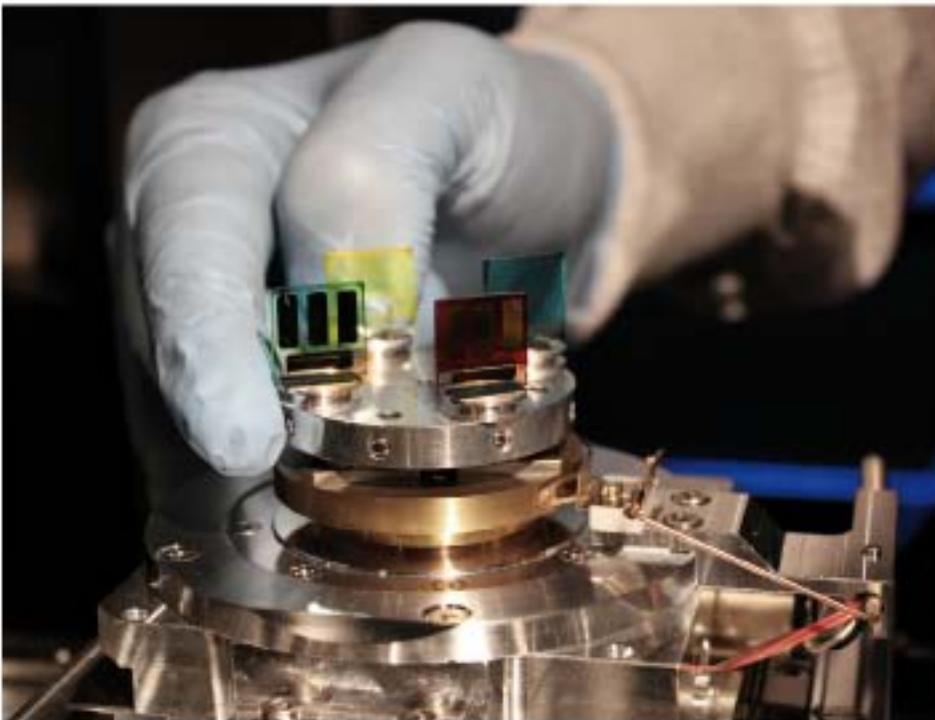


Data cables of the climate high-performance computer "blizzard" at the German Climate Computing Centre (DKRZ), Universität Hamburg, KlimaCampus.

### Innovation and sustainability

2.9 percent of Germany's gross domestic product went into research and development in 2011. Expenditure on this sector has therefore risen to a record high of more than € 74.6 billion. Great importance is attached to scientific basic research, in particular. The Federal Ministry of Education and Research

(Bundesministerium für Bildung und Forschung – BMBF) sees it as the "starting point for technical innovations and for a sustainable development of the economy and society". At German universities, BMBF funding is intended, among other things, to benefit the university education of young scientists.



Nanotechnology and interdisciplinary research are bringing us closer to the development of more efficient organic solar cells.

## INFORMATION

### Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung - BMBF)

Scientific basic research:  
[www.bmbf.de/de/98.php](http://www.bmbf.de/de/98.php)

### Institute of Experimental and Applied Physics at Kiel University

[www.ieap.uni-kiel.de](http://www.ieap.uni-kiel.de)

### Department of Physics and Astronomy at Heidelberg University

[www.physik.uni-heidelberg.de](http://www.physik.uni-heidelberg.de)

### German Climate Computing Centre (Deutsches Klimarechenzentrum – DKRZ)

[www.dkrz.de](http://www.dkrz.de)

### National Genome Research Network (Nationales Genomforschungsnetz – NGFN)

[www.ngfn.de](http://www.ngfn.de)

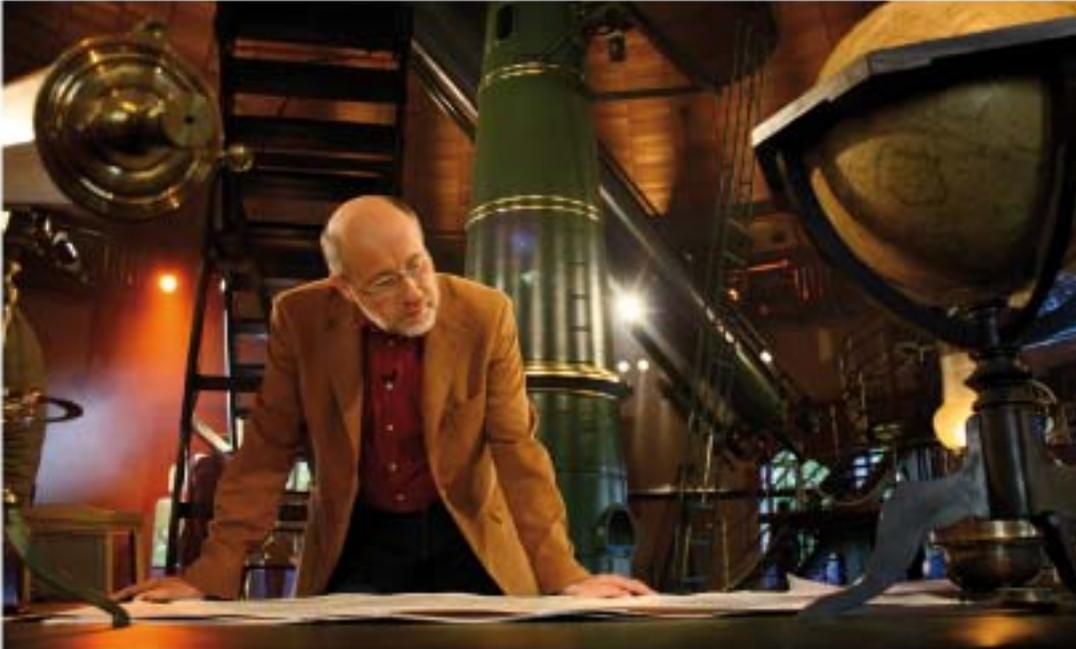
### Nanosystems Initiative Munich (NIM)

[www.nano-initiative-munich.de](http://www.nano-initiative-munich.de)

Interview with Professor Harald Lesch, university lecturer of the year 2012

## Science needs time and leisure

There is hardly anyone who addresses highly theoretical issues as eloquently or explains dark matter as clearly and with as much humour as Professor Harald Lesch. The astrophysicist, who is well-known from German television, praises the tradition and research infrastructure of the natural sciences in Germany. But he knows that students initially need time and leisure to get their bearings in this cosmos of formulae, hypotheses and concepts and to link their islands of knowledge.



*Astrophysicist and television presenter Harald Lesch in his element: against a historical background in "Faszination Universum" on the Zweites Deutsches Fernsehen (ZDF), he looks into one of the most fascinating questions of our existence: what does the world consist of?*

### **As university lecturer of the year 2012 you know the answer: how should the natural sciences be taught?**

The students have to feel that the exact and quantitative natural sciences are alive, which means that they can be practised actively and passionately. I begin every one of my lectures with the question of what is new in the natural sciences. Giving research a topical relevance is immensely important in teaching. And there is an abundance of it in the natural sciences. So we scientists find it easy to motivate our students. The topics of the lectures then just have to be linked cleverly with these issues of topical relevance. In this sense I am an opponent of module handbooks, as there are no closed chapters in our subject matter. Natural scientists should remain mentally active.

### **Nonetheless there is a great deal of subject matter to be tackled ...**

Yes, but it would actually be better to reduce the course contents. We should teach by example, explaining the subject matter on the basis of a few carefully selected examples. That's also the way I know it from my physics degree course at Giessen University.

### **On the television you explain complicated theories about black holes, parallel universes and dark matter clearly and vividly to a broad audience. What does understanding mean in the natural sciences?**

Only if I have understood something can I say it clearly as a lecturer. That helps the students, who initially often have trouble with concepts and not only with mathematical relations. When things are explained and interpreted, when we try together to comprehend what we do not yet

know, then understanding is a matter of language in the natural sciences, too. The objective character of the natural sciences makes communication easier in some cases than in the humanities. However, in scientific publications written in English, the lingua franca of academic life, you often notice that the authors have not been able to exploit their topic fully because they were not writing in their native language. Linguistic competence is therefore also very important in the natural sciences. By the way, that is why I consider it disastrous if students here in Germany don't have good command of the German language.



*Professor Harald Lesch was voted "university lecturer of the year 2012" by the German Association of University Professors and Lecturers (Deutscher Hochschulverband – DHV). He is a professor of theoretical astrophysics at the Institute for Astronomy and Astrophysics of the Ludwig-Maximilians-Universität (LMU) in Munich and a visiting professor of natural philosophy at the Munich School of Philosophy.*

**You also teach natural philosophy. Is it of fundamental importance for scientists to look beyond the boundaries of their discipline?**

The natural sciences have changed our lives considerably. Just think of quantum mechanics, which digital electronics is largely based on. The natural sciences demand that we abstract from ourselves. Their methods are major challenges to our self-conception. They lead us into worlds with which we may experience extreme difficulties. That's why I give my students the following advice: observe science from outside! Pay attention to what you're doing and how you're doing it! It would be very desirable for scientists to receive an adequately philosophical basic training. Humanistic reflection is much closer to the human being, since we can then use our reflected internal perspective to consider the consequences of scientific insights and our role in them.



*Professor Harald Lesch is known from numerous television appearances since the early 1990s, as seen here in the ZDF science magazine programme "Abenteuer Forschung".*

**How would you describe the requirements that a student of natural sciences should fulfil?**

They should be interested in puzzles, possess a high potential for dealing with crises and have plenty of patience, not only for mathematical problems. It takes time for knowledge to sediment, as lots of cross-references have to be established. This can be compared with football today: the urge to achieve a rapid conclusion has to be overcome in order to be successful. The Spanish national team has been proving that impressively for years with its tiki-taka football.

**So that means the first step is the hardest ...**

Yes, difficulties are quite normal at the beginning of a degree course in natural sciences, which is why I'm in favour of not awarding marks in the first part of the bachelor's degree course. The students should have enough time to get their bearings and to deal intensively with the subject. Only in this way can they become personalities who are suitable for responsible tasks in research and development. In my opinion it is also of great advantage if they leave home to do their degree and seek new social structures. That trains their ability to work in teams most effectively, since science is not something that you practise alone, whether it is an examination preparation group or a team of researchers.

**Scientific research is often not necessarily application know-how that is oriented towards the economy. How important is basic research?**

Basic research is like taking an inventory. The researchers ask themselves, "What have we actually got?" – if possible without being influenced by particular purposes. Basic research can therefore not be viewed using

concepts from economics. How should research into the unknown be efficient? You don't know what is awaiting you. After all, universities are not supplier businesses and production plants. If they were, then researchers would only deal with the topics and things that have already been successful. But if they keep their eyes open and look carefully, they might be lucky enough to find something that perhaps nobody was looking for.

Take the Mars rover Curiosity: the data it delivers are not associated with any immediate possibilities for use. The rover was placed in a crater in order to examine soil samples and therefore to investigate the history of the planet. The river gravel found there indicates that water existed there recently and therefore that life may have been present. Everything else is science-fiction.

**What breakthroughs can be expected in basic research in the natural sciences? What trends do you find remarkable?**

It is becoming increasingly difficult to move the boundaries of knowledge forward. Many continents on the planet of knowledge have already been discovered. In contrast to the view depicted in the media (catchword: breakthroughs and sensations), the research activity in the natural sciences seems to me to be more like a long, calm river where breakthroughs are rather seldom. However, the first proof of a theory always has something of the quality of a breakthrough. For example, when it was proven that earthquakes in the Indian Ocean triggered all the other earthquakes on earth. The findings in epigenetics that can explain the ability of organisms to adapt are sensational. The neurosciences are very productive, especially when overly deterministic perspectives are abandoned. And in chemistry and materials science many new materials are yet to be designed. In the field of energy release and energy storage we could really do with a breakthrough!

**And astrophysics?**

To date we are acquainted with the visible universe back to the time when it was 380,000 years old. With an assumed age of 13.7 billion years, that's not bad at all. As you know, what we can see out there is already history. And astronomers are actually the people who always read yesterday's newspaper. The older, the better! Of course, we can still build bigger and more expensive telescopes. But what's the use of that given the fact that the visible matter, if calculated generously, only accounts for five percent of the universe, with 22 percent of it consisting of dark matter and 73 percent of dark energy? No consistent explanatory model has yet been found for these discoveries, in some cases they haven't even been fully understood yet. Neither the theory of relativity nor quantum mechanics have helped us here so far. We'll probably be struggling with this problem for some time to come.

**What research topics are you currently working on?**

I'm working on magnetic fields in galaxies, the synthesis of light elements in the early cosmos and the link to particle physics.

**INFORMATION**

**Faculty of Physics of LMU Munich**  
[www.physik.uni-muenchen.de](http://www.physik.uni-muenchen.de)

**University Observatory Munich**  
[www.usm.uni-muenchen.de](http://www.usm.uni-muenchen.de)

**"Leschs Kosmos" on the Zweites Deutsches Fernsehen (ZDF)**  
<http://leschskosmos.zdf.de>

# Logic, theory and experiment

Whether it is the quantum world of atoms, molecular components, mechanisms of life or cosmic structures of the universe – degree courses in mathematics and the natural sciences impart the know-how needed for investigating the phenomena of nature by combining theory and experiment. Anyone with analytical skills, who is able to think in a logical way and is inquisitive, determined and resilient, has the qualities required for understanding the laws of nature and perhaps for uncovering relationships that have so far remained hidden.



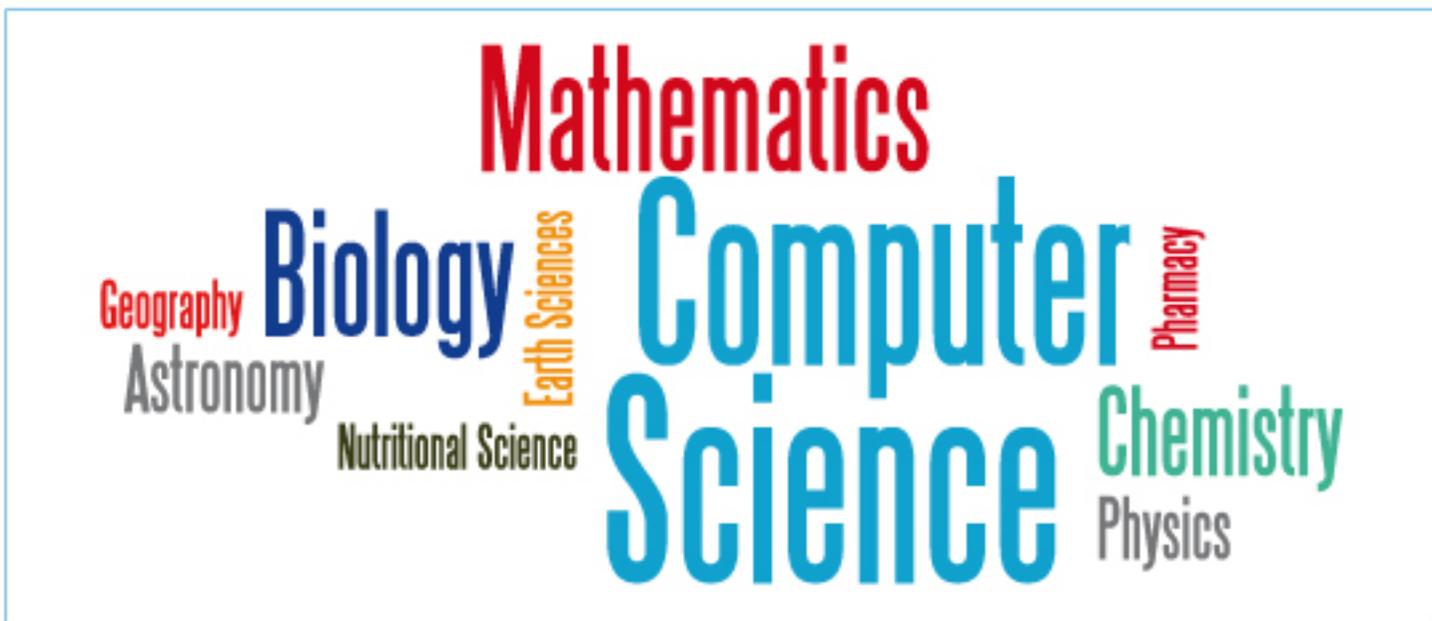
*In degree courses in mathematics and the natural sciences, students very often do internships within the universities.*

According to the German physicist and Nobel Prize winner Werner Karl Heisenberg, nature was made in such a way that it can be understood: "Or perhaps it would be more correct to say that our way of thinking is made in such a way that it can understand nature." Developing such a way of thinking is the aim of the classic natural science subjects, chemistry, earth sciences, physics and biology.

## Conducting experiments right from the start

The degree courses traditionally have a distinct research orientation. There is a considerably stronger focus on research topics in lectures and classes today than was the case ten years ago. Research methods are also an important component of teaching in the natural sciences. So it comes as no surprise when professors often take up current research issues in their lectures and make them the starting point for their remarks.

Working in laboratories with up-to-date equipment is naturally part of everyday student life. Students of physics, chemistry or biology have opportunities to conduct their own small research projects or experiments more often than students of other subjects. In an advanced stage of the degree course, some of the students also have a chance to collaborate actively on larger-scale research projects. Compulsory internships outside of the university, for example in an industrial enterprise, are less frequently scheduled than is the case, for instance, in engineering degree courses.



*Degree courses in mathematics and the natural sciences (a selection)*

### Constant companions: mathematics and computer science

Mathematics is the universal structural and systems science and, as such, is a self-contained discipline that permeates virtually all areas of life and work. Knowledge and innovation in the natural sciences would be inconceivable without mathematical procedures and methods. A corresponding amount of attention is therefore paid to mathematics in all natural science degree courses. Similar applies to computer science, which is closely interwoven with mathematics and can be regarded as a key technology for progress in the natural sciences. In addition to many other applications, it provides the tools for controlling experiments or obtaining information from experimental data.

A degree course in the natural sciences therefore requires the students to have not only an interest in the subject but also a distinct ability to think in a logical way and a good understanding of mathematics. It demands a sound school education, especially in mathematics. The intensive work culture entails relatively high demands as regards performance. To prepare students specifically for their degree courses, a number of universities therefore offer preparatory courses. These courses revise and consolidate the subject matter that was taught at school

before the degree course begins, thereby imparting the knowledge of mathematics and natural sciences that is required in the first year of studies.

### Modern concepts, good support

In assessments regarding the quality of degree courses, the natural science and mathematics courses at German universities occupy a top position, also in the opinion of the students. The intensive specialist training and supervision, the well-structured courses and the support provided by the teaching staff all contribute to this. Modern teaching concepts and the good equipment at the institutes create the conditions for successful studies.

Foreign students are clearly also convinced of the quality of the education: about 18 percent of the students who come to Germany to study at a university or a university of applied sciences enrol for a subject in the field of mathematics, the natural sciences or computer science.

### Mainly at traditional universities

The majority of degree courses in mathematics and the natural sciences are offered at the traditional universities. There the students acquire the foundations of mathematics and the theoretical and experimental know-how for their subsequent work in development,

research or teaching. In the process they gain insights into fields of research at an early stage in a generally international environment. Analytical thinking, determination and the ability to work in a team are fostered, too.

The degree courses offered at the universities of applied sciences place special emphasis on the applications of natural science knowledge. Some examples of such courses are applied chemistry, biotechnology, applied mathematics, biomathematics/technomathematics, or physics-related courses such as engineering physics or building physics. Here the transitions between the natural sciences and engineering are often blurred.

Courses in the field of computer science are represented at the universities of applied sciences just as strongly as at the traditional universities, frequently with specialisations such as bioinformatics, technical computer science or medical computer science.

As knowledge has progressed, new fields of research have arisen that involve more than one discipline and accordingly the range of courses available has become increasingly differentiated. New self-contained degree courses such as biochemistry, molecular life science, bioinformatics and genome research, biomathematics, environmental chemistry, nanoscience or geoinformatics and satellite positioning are just a few examples.

» Degree courses in physics are currently offered by 58 universities and institutes of technology in Germany. Besides courses in pure physics, there is also an increasing number of physics-related degree courses with specific focuses. The Department of Physics of the Karlsruhe Institute of Technology (KIT) covers a broad spectrum of research ranging from particle physics, through solid-state physics and modern optics, to geophysics and meteorology, involving both experiment and theory. Students are closely integrated into the main fields of research of the department. In addition, the department offers an education in graduate schools and centers of excellence. At KIT great importance is attached to the quality of the teaching with regard to didactics and scientific depth. Physics students should have an excellent understanding of logical and mathematical issues and a fair amount of staying power. In return they gain insights into fascinating fields of research and acquire skills in modern experimental techniques. The university environment is generally international in character. «

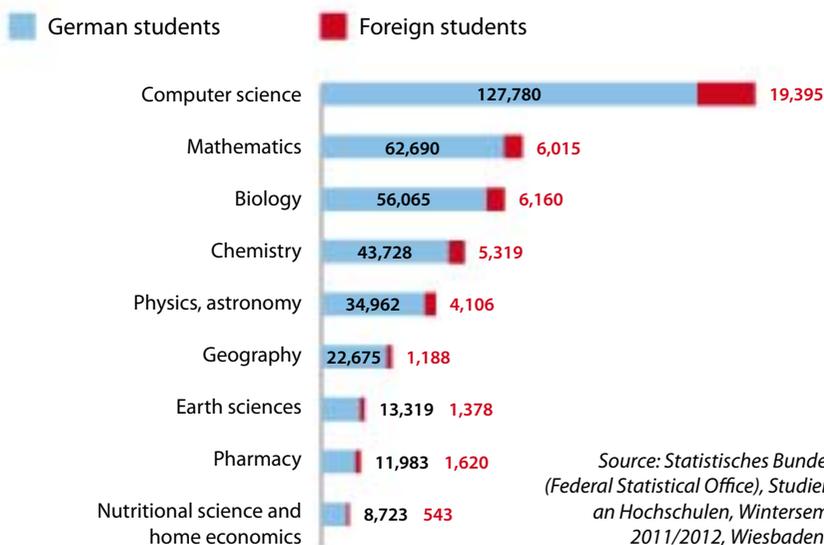


Professor Wulf Wulfhchel is dean of study affairs for physics at the Karlsruhe Institute of Technology (KIT), shown here with a visiting student from Osaka University in Japan.

### Single-subject bachelor's degree is the norm

The bachelor's degree courses in mathematics, the natural sciences and computer science are generally offered as single-subject bachelor's degrees - they therefore concentrate on one single subject. In addition, at some universities it is also possible for students to create academic profiles incorporating several subjects, which may also be a combination of a natural science subject and a subject from the humanities or the social sciences. Anyone wishing to work as a teacher of biology, physics, mathematics, chemistry, computer science or geography in the state school system later on has to study at least two subjects in parallel.

### German and foreign students in the winter semester 2011/12



» When I received the scholarship from "Science without Borders", I opted for the University of Potsdam. It has a good reputation in the field of earth sciences and provides excellent support for foreign students. The professors are helpful all the time. For example, they offered to explain the things I didn't understand in English after the lecture. The staff of the International Office found a place for a research project in one of the university laboratories for me, among other things. In my degree course I'm particularly interested in environmental modelling, environmental protection and sedimentation systems in association with oil production. «

Ana Elisa Ferrari Carvalho comes from Brazil and is in her second semester of a degree course in earth sciences at the University of Potsdam.



*A biology student conducting a radiation experiment on a plant.*

## INFORMATION

### Higher Education Compass of the German Rectors' Conference (Hochschulkompass der Hochschulrektorenkonferenz – HRK)

Information about higher education opportunities, universities and colleges, doctorate opportunities and international cooperations with German higher education institutions  
[www.hochschulkompass.de](http://www.hochschulkompass.de)

### uni-assist

Internet portal of the University Application Service for International Students (Arbeits- und Servicestelle für ausländische Studienbewerber)  
[www.uni-assist.de](http://www.uni-assist.de)

### anabin

Information system of the Central Office for Foreign Education Systems (Zentralstelle für Ausländisches Bildungswesen) for the recognition and evaluation of foreign educational qualifications  
[www.anabin.de](http://www.anabin.de)

### DAAD

This page of the DAAD website provides information about which educational certificates obtained outside Germany are required for admission to higher education in Germany.  
[www.daad.de/admission](http://www.daad.de/admission)

### A place at university in Germany – admission restrictions, application, admission

For just over half of the bachelor's degree courses in the natural sciences there are no **admission** restrictions in terms of student numbers. For the rest of the courses there are local admission restrictions with selection procedures. In the case of combined degree courses (double-subject bachelor's degrees) the admission situation has to be taken into consideration for both of the subjects chosen.

When **selecting applicants** the universities can take into account not only the average mark of the qualifications entitling the applicant to go to university but also other criteria, for example grades in certain subjects, the results of an interview or a selection test. What is also important is the waiting period for a university place.

It is frequently only possible to **begin a degree course** as of the winter semester.

At many universities, **prospective students from outside Germany** who fulfil the basic requirements for entering higher education in Germany can apply directly to the university. They should obtain informa-

tion about the specific admission requirements for the degree course in advance from their preferred university.

For a number of universities, applications have to be submitted via the University Application Service for International Students, **uni-assist**. You can find details about the member universities and detailed information about the application procedure at [www.uni-assist.de](http://www.uni-assist.de).

Anyone interested in a master's programme also applies directly to the university or to uni-assist. Doctoral programmes are often offered by universities in cooperation with research institutes. Where necessary, applications are to be sent directly to these institutes.

In general the **application for admission** must have arrived at the relevant university by 15th July for the winter semester and by 15th January for the summer semester. The application deadlines may differ from this depending on the university, however.

Preparatory course for international applicants

# Pre-Study Fulda

Foreign students do not always have the possibility to acquire the skills required for studying at a German university while still in their home country. Fulda University of Applied Sciences has responded to this: Pre-Study Fulda helps students to build up their background knowledge, to practise methods of academic work and to improve their German language skills.



*Britta Simon, contact person for international applicants, talking to two applicants for a master's degree course.*

With about 6,500 students, Fulda University of Applied Sciences is one of the smaller universities in the state of Hesse. Everything is close at hand, both in the town and at the university, including the International Office. The office provides comprehensive support for the just under 1,000 foreign students. "One of the most important aims of the International Office in cooperation with the faculties is to ensure that the foreign students are successful in their studies. Services aimed at preparing students for taking up a degree course, such as Pre-Study Fulda, play a particularly important role here," explains Winnie Rosatis, head of the International Office.

## Preparation with an added bonus

Pre-Study Fulda is aimed at international students who wish to prepare for their future specialist studies as well as possible. The programme goes far beyond a German course and a general introduction to academia. For eight bachelor's programmes and six master's programmes, the students may attend academic courses which provide them, for example, with programming skills, the basics of electrical engineering or knowledge of mathematics and physics.

Although Pre-Study Fulda takes place before the regular degree programme begins, the participants are already matriculated students. Furthermore, with the course the students earn between 20 and 30 credit points that can be counted towards the subsequent study programme in a number of degree courses. In addition, successful participants have an added bonus when it comes to admission.

Other modules of the programme are the German language courses comprising 14 to 20 hours per week, and introductory courses on the methods and techniques of academic work and on living and studying in Germany. All in all, up to 400 hours of classes are accumulated in this way. As German is the language of tuition in most of the academic courses, one of the admission requirements is German skills at level B1 (CEFR).

## Tests and feedback

Christina Pitz, coordinator of Pre-Study Fulda, points out that "in Fulda we ensure that the

students attend the seminars regularly. Tests provide the participants with feedback about their learning progress. Only those who pass the final examinations in the German and academic courses at the end of the programme will be granted admission to the regular degree courses." The course fees vary between € 500 and € 750 depending on whether the students complete Pre-Study Fulda with or without the language course. In addition there are living costs and the semester fee.

Is the time and expense involved worthwhile? "Yes, definitely," Gesa Pusch, the officer for integration, says. "Since the preparatory course was set up we have been following the participants' progress in their subsequent studies systematically. It is quite clear that those who took advantage of the opportunities in the preparatory semester as much as possible are also more successful later in their degree courses."



»» *The knowledge and skills that I was able to acquire in "Pre-Study Fulda" really helped me in my degree course. The preparatory course was tailored perfectly to my requirements. It taught me the basics of computer science and working methods. I therefore found programming and understanding database systems much easier in the first semester. As a result of the intensive German course I quickly improved my language skills.* ««

Nurgul Omorova comes from the Kyrgyz Republic (Kyrgyzstan) and is in her fifth semester of a degree course in business informatics at Fulda University of Applied Sciences.

## INFORMATION

**International Office of Fulda University of Applied Sciences**  
www.hs-fulda.de/io

### Language courses and introductory courses

In the DAAD database "International Programmes", prospective students can look for language courses and introductory courses/prep courses.  
www.daad.de/international-programmes

# In the microcosm of molecules

Chemistry plays a key role in the development of new materials, in research into effective forms of treatment and medication, in functional pest control or in the development of environmentally compatible production processes. As a schoolgirl in Poland, Julita Opalach was already fascinated by this science with its numerous facets. Now she is studying chemistry at the University of Rostock.



Laboratory practicals account for a large part of the degree course in chemistry (about 76 hours per semester).

Together with the rest of her Polish class in their last year at school, Julita Opalach visited the University of Rostock in 2009 as part of a partnership programme. "In a workshop at the Institute of Chemistry we isolated the DNA of a banana. I found that very interesting," remembers the 21-year-old, who is now in her fifth semester of a chemistry degree course in the Hanseatic city on the Baltic Sea. The modern buildings and well-equipped laboratories already appealed to her then. On making further enquiries she discovered that the level is very high in Rostock. But not only subject-related reasons were points in favour of Rostock as a place to study: "The town and the university are not too big. You can settle down quickly here. In addition, rents are comparatively low."

## Studying chemistry in all its breadth

In Rostock, the bachelor students acquire both the fundamentals of mathematics and physics as well as knowledge from all

branches of chemistry in six semesters. There are only limited opportunities for specialisation, for example via electives in organic, inorganic and physical chemistry. Is that a disadvantage? Not at all – early specialisation is deliberately avoided. "Here in Rostock we study towards bachelor's and master's degrees in chemistry and not in individual sub-disciplines," explains Professor Christian Vogel, deputy managing director of the Institute of Chemistry who is also responsible for studies and teaching. This broadly based education in Rostock is expected to lead to advantages and freedom for the doctoral study phase, which almost all students of chemistry strive for. "Because important fields, such as analytics, are not neglected in the degree course, our graduates have a large number of options when choosing their doctoral positions," Professor Vogel is convinced.

The main course contents are taught in the lectures. This subject matter is consolidated, supplemented and illustrated using

*Professor Christian Vogel is the deputy managing director of the Institute of Chemistry at the University of Rostock and is also responsible for studies and teaching in his role as chairman of the examination board.*



examples in tutorials, seminars and lab practicals. Julita Opalach confirms that a chemistry degree course involves a lot of hard work and demands endurance: "We have a relatively large number of exams, and you spend almost every day in the library or learning at home during the examination period."

## Preparative skills

Throughout their entire degree course the students work in the laboratory. Right from the start they are introduced to the practical and experimental work of chemists and experience the interaction between theory and experiment. "In the first semesters we deliver the lectures on organic, inorganic and general chemistry in the form of experimental lectures. Numerous experiments are conducted during the lecture with the support of an assistant. That goes down really well with the students," Christian Vogel explains.

There are few fields of study in which craftsmanship and scientific and analytical thinking are so closely linked as in chemistry.

*Julita Opalach comes from Poland and is in her fifth semester of a degree course in chemistry at the University of Rostock.*



With an increasing level of difficulty, the students are introduced to all the important work techniques, right through to solving scientific problems. Professor Vogel puts his finger on the importance of preparative skills: "You may be able to write down lovely chemical equations on paper, but if you can't put it into practise in the laboratory, then it's no use to you at all."

### Good support and safety in the lab

"The laboratory practicals during the semester are very time-consuming. You always have to prepare well and write lab reports," Julita Opalach tells us. She finds the support very competent: "The students are allocated personal mentors for the practical work and they can be asked for advice at any time." At the start of a laboratory practical all the students are given a safety briefing with a test of safety. "When preparing our lab days, we also have to investigate whether the substances that are used are toxic or hazardous and how we have to deal with that," the young student explains.

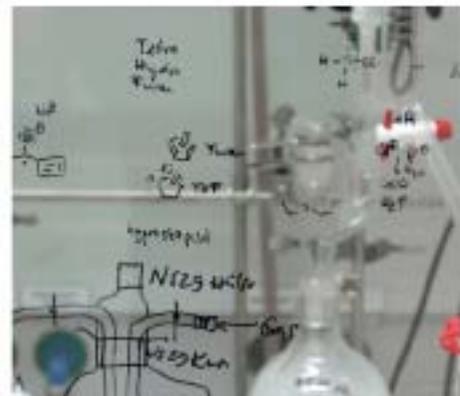
Although the extensive laboratory work makes great demands regarding facilities and equipment, waiting times for places in the laboratory or the introduction of admission restrictions are currently not an issue in Rostock. "Each of us has a workplace, a locker and his or her own glassware. Sometimes there are not enough fume hoods, but we manage to cope with that."

The nine-week period for writing the bachelor's thesis at the end of the sixth semester basically comprises the practical lab work in a study group, chosen by the students themselves, with a focus on research topics.

### Master's degree and doctoral studies are the norm

As for almost all the graduates of the bachelor's course in chemistry, Julita Opalach is also certain that she will study for a master's degree and then go on to do a doctorate. She would like to specialise in the field of biochemistry and organic chemistry: "These areas are more strongly related to everyday life and to medicine. Chemistry can explain, for instance, what happens in the body when caffeine is ingested."

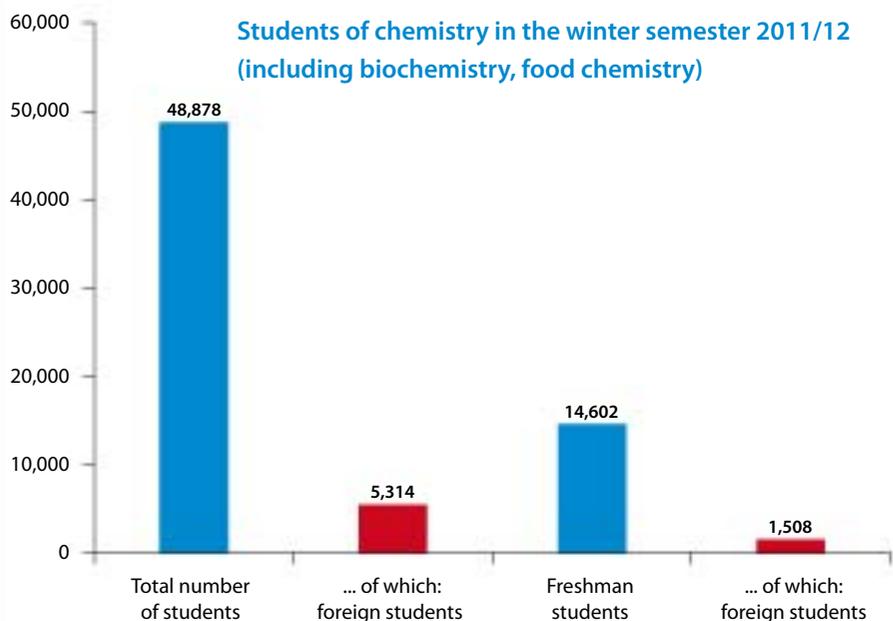
Before starting a master's course, however, she would like to take time to do a subject-related internship in industry for six months first: "The degree course doesn't involve an external internship. I want to get to know chemistry from the other side, too, and see how chemists work and what problems they encounter." She has not yet decided whether to do her master's degree in Rostock, too. Good reasons occur to her straight away, though: "The good support and facilities are points in favour of it. In addition, I know the study groups and professors at the university well now. The atmosphere is quite informal."



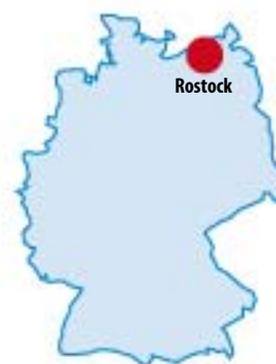
### Catalysis and marine chemistry

Anyone wishing to stay in Rostock to study for their master's degree can also do so in association with the Leibniz Institute for Catalysis (LIKAT) or the Leibniz Institute for Baltic Sea Research, Warnemünde (IOW). They are both closely interlinked with the University of Rostock as regards teaching and research and are represented there with their own lectures and classes on the subjects of catalysis and marine chemistry. "Word has got around that the conditions are excellent at both institutes, and our graduates like to take advantage of this," is Professor Vogel's assessment.

Julita Opalach looks to the future with optimism. As a long-term aim she can well imagine working in an international environment. The opportunities for that are good, as expertise in the field of chemistry is in demand everywhere.



Source: Federal Statistical Office (Statistisches Bundesamt), Studierende an Hochschulen, Wintersemester 2011/2012, Wiesbaden 2012



## INFORMATION

University of Rostock, Institute of Chemistry

[www.chemie.uni-rostock.de](http://www.chemie.uni-rostock.de)

# Abstraction with an international flair

Mathematics at the University of Bonn is well-known throughout the world for its research orientation. Each of the fields of mathematics is represented by several professors. The students on the bachelor programme can therefore combine their classes from a broad spectrum in line with their own interests. The Italian student Tashi Walde praises the freedom of choice and is especially enthusiastic about theories of abstract algebra.



*The students presenting and discussing mathematical topics in a stochastics seminar at the University of Bonn.*

Tashi Walde has been fascinated by mathematics since he was small. "What inspires me most is the precision with which you can talk about things," says the 19-year-old student at the Institute for Applied Mathematics. "There's an immense variety of concepts, and you need creativity to find the right one in order to solve a problem." He grew up in Bruneck in Italy and gained his upper secondary school certificate (Abitur) at a Ger-

*Tashi Walde comes from Italy and is in his third semester of a degree course in mathematics at the University of Bonn, where he holds a scholarship from the DAAD and the German National Academic Foundation (Studienstiftung des deutschen Volkes).*



man school in Rome. In the summer of 2010 he attended a summer course at the German Pupils Academy (Deutsche Schülerakademie - DSA) on the subject of "algebraic topology", which he describes as his "introduction to real mathematics". Two course teachers recommended the University of Bonn to him. The reputation and the quality of the broad range of courses on offer convinced Tashi Walde straight away. Pupils who have not yet decided for sure whether to study mathematics can also test their interests and abilities in mathematics using the Bonn Online Self-Assessment test.

## Trademark research orientation

"Mathematics in Bonn occupies a top position in national and international rankings regarding both research and teaching," the coordinator of the bachelor programme, Dr Antje Kiesel, emphasises. "Moreover, the Hausdorff Center for Mathematics (HCM) in Bonn is a Cluster of Excellence for mathema-

*Dr Antje Kiesel is the coordinator of the bachelor programme in mathematics at the University of Bonn.*

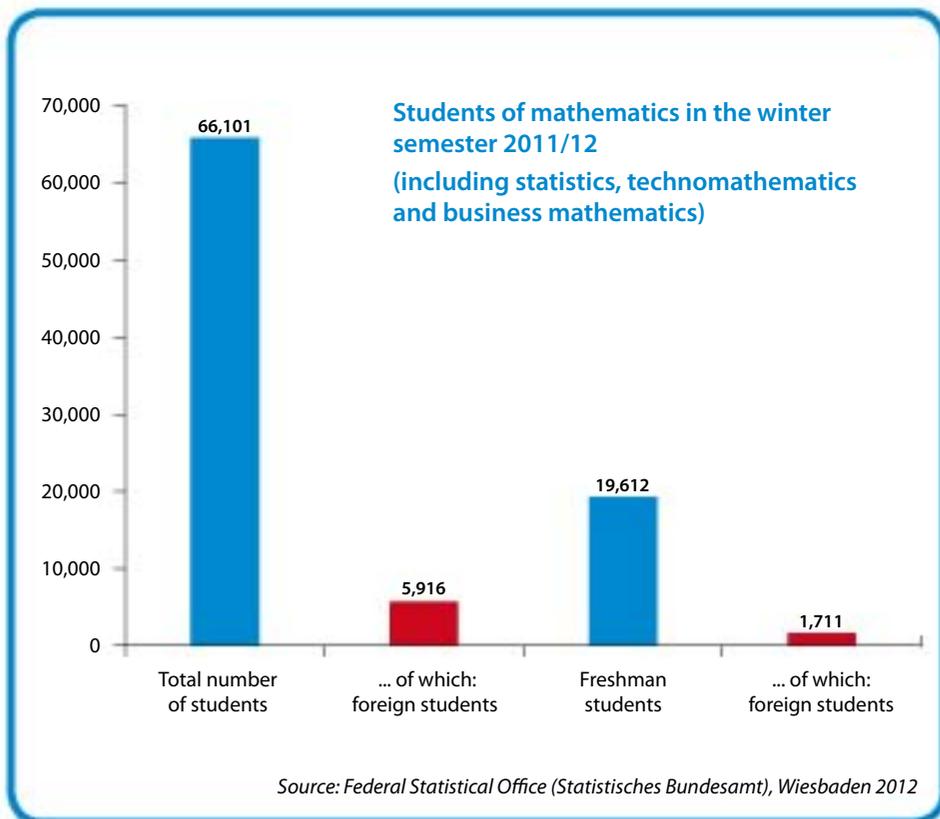


tics." Research orientation therefore plays an especially important role here – and that is already noticeable in the bachelor programme. Even in the teaching of basic principles the course contents are constantly brought into line with current research developments. In addition, the students are able to specialise at an early stage in fields that they find particularly interesting. "From the second year of studies onwards there are no longer any compulsory lecture modules. The students combine the classes themselves," Dr Antje Kiesel explains. The study regulations guarantee that all the key areas are covered for a sound education in mathematics.

## A bird's-eye view of mathematics

Besides set theory, logic and topology, Tashi Walde's interests are mainly in the field of algebra: "What I find fascinating about algebraic theories is operating with general concepts. The results obtained using them have a large range. I like to get 'a bird's eye view' of mathematical concepts and to recognise major links." Bachelor programme coordinator, Antje Kiesel, can confirm similar motives in the majority of her students: "They enjoy logical thinking, solving problems and proving mathematical issues. Abstract thinking is clearly paramount."

Anyone studying mathematics in Bonn can enjoy not only theoretical flights of fancy but also an environment with excellent facili-



ties. The good conditions for studying make it possible even when the number of new students is rising sharply: "We provide low student-teacher ratios," Antje Kiesel explains. "For example, some lectures in the first semester are flanked by four-hour practical classes, which are conducted in groups of no more than 20 students." In addition, the bachelor-master's office (Bachelor-Master-Büro) is a constant port of call: "The office hours are so extensive that it's possible to clarify all the relevant questions of the total of about 750 bachelor students."

### Mathematics needs practice

The tutorials on offer are also part of the good support. Tashi Walde currently conducts a tutorial on the lecture Analysis I. "I find leading tutorial groups great fun. I like helping the students in their first semester with initial problems in the subject." What takes up a lot of time in this respect is correcting his protégés' exercises. The exercises are an extremely important element of the degree course in mathematics, as Tashi Walde explains: "In every lecture a sheet of exercises is compiled, which has to be completed within a week. In mathematics it just isn't enough to watch other people proving something. Everyone has to do it themselves in order to understand the relationships and concepts."

Tashi Walde has to complete such exercise sheets himself from four lectures. In addition there are two seminars in algebra and logic. He chose chemistry as his minor subject. The common minor subjects in Bonn – and probably the most intensive fields of application of mathematics – are physics, computer science and economics.

### Melting pot of international mathematics

Internationality plays an important role in mathematics in Bonn, which can be seen in numerous international cooperation arrangements and research projects, guest researchers from many countries and, in association with that, an extensive lecture programme. The students benefit even more from the international atmosphere if they continue their studies with the master's programme, for which the bachelor programme specifically prepares the students and which is taught in English. In the master's degree course about a quarter of the students are international students.

The South Tyrolean Tashi Walde already feels quite at home in Bonn and gets on well with the people. In his free time, too, he has a preference for activities that are demanding in logical terms, such as the Asian board game "Go", and likes to organise games evenings.

### Mathematics in practical terms

Even though very few graduates of the Bonn bachelor programme go straight into working life, career preparation is taken seriously. In a colloquium on occupations, representatives of firms provide insights into fields of activity in industry. "Our students have to do an internship in their fourth or fifth semester. In addition to internal programming internships, it is also possible to choose an internship in industry. There the participants are able to experience how mathematics is used in the business world," Antje Kiesel explains.

About two thirds of the bachelor programme graduates opt to do a master's degree in mathematics, too, at the University of Bonn. A large percentage would like to go on to do a doctorate at the Bonn International Graduate School (BIGS) afterwards. Some graduates of the bachelor programme continue studying mathematics at a different university, a smaller proportion follow their bachelor's degree with a master's degree in economics. Tashi Walde envisages following the straight path: "Master's in Bonn, then probably a doctorate and into mathematical research after that."



## INFORMATION

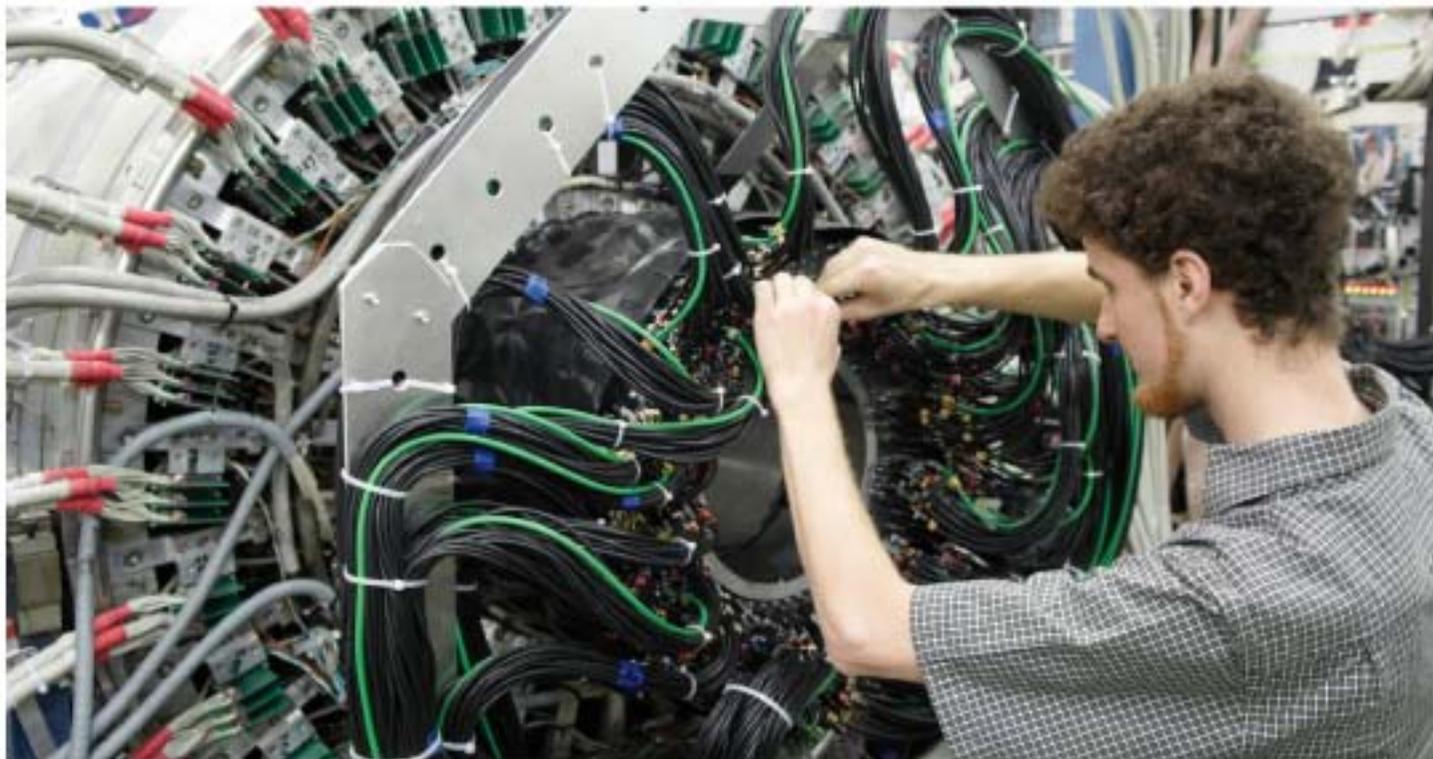
**Mathematics at the University of Bonn**  
[www.mathematics.uni-bonn.de](http://www.mathematics.uni-bonn.de)

**Hausdorff Center for Mathematics (HCM)**

The HCM includes the Bonn International Graduate School (BIGS) and the Hausdorff Research Institute for Mathematics (HIM).  
[www.hausdorff-center.uni-bonn.de](http://www.hausdorff-center.uni-bonn.de)

## Mostly Master's

Straight into an occupation after gaining a bachelor's degree – this career path is also possible in principle for mathematicians, computer scientists and natural scientists, though it is quite rare. The majority of the graduates wish to pursue their theoretical and practical interests in a master's degree course – whether as specific preparation for a subsequent research activity and doctoral studies or in order to acquire the skills required for successful career entry.



*A doctoral student by the Electron Stretcher Accelerator (ELSA) at the Physics Institute of the University of Bonn.*

The number of master's degree courses and their diversity as regards contents are impressive: in recent years the range of degree courses offered by the faculties of mathematics and natural sciences and in computer science has been extended considerably. That does not only apply for master's courses which consolidate and extend the knowledge and skills acquired in a bachelor's degree course in a way that is application-oriented or research-oriented. Numerous new degree courses have also been developed that combine the specialist and methodological skills of different natural science disciplines in an interdisciplinary approach, thereby opening up new fields of knowledge and technology.

### Master's degree – career booster for research and development

Graduates of bachelor's degree courses can choose from some 1,300 master's courses in the field of mathematics, natural sciences or

computer science. The majority of them are at universities. As is the case with bachelor's degree courses, the master's courses offered by universities of applied sciences focus on applied natural sciences and computer science. English is the language of tuition in about 150 master's courses.

A master's degree course need not necessarily be restricted to the specialism of the first degree. It is also possible to choose a related discipline or to tap into a completely new domain. Physicists, for example, can acquire extensive knowledge of medicine in the master's course in medical physics or train as specialists in the future-oriented sector of 'light' in the master's course in optics and photonics.

The specific admission requirements, such as above-average grades in the examinations for the first degree or certain specialist skills and work experience, are laid down by the university.

### Doctoral studies – breaking new ground in science

The doctoral thesis is frequently a student's first independent research achievement. Every doctorate therefore breaks new ground in science. A large proportion of the research in the natural sciences is conducted by doctoral students.

In hardly any other group of subjects is there such great interest in doing a doctorate as in mathematics and the natural sciences. About 43 percent of those graduating in a mathematics or natural science subject embark on doctoral studies. They therefore account for roughly a third of all doctoral students at German universities. One of the reasons for this is that a doctorate is generally a requirement for managerial positions or for research-oriented jobs. However, it is also the wide-ranging spectrum of interesting fields of research, the available funding and the good supervision that induce some 19,000

graduates of master's courses in mathematics or the natural sciences to take up doctoral studies every year. But the strongest motive is academic curiosity and a love of research.

In the field of mathematics and the natural sciences, "internal doctoral studies" continue to be common. These are associated with a paid position in a university department and include tasks at the institute, for example teaching classes. The doctoral students choose and work on the topic of their doctoral thesis largely independently. As a result of their direct connection to the university department, contact with the doctoral supervisor is more regular than is the case with "external doctoral studies". There, although the research project and the doctoral thesis are supervised by a university professor, they are not linked with a paid employment relationship. About three to four years need to be scheduled for working on the doctoral thesis and the subsequent examination.

### Reaching the goal more quickly: structured doctoral studies

Interest in structured doctoral programmes is growing steadily. With a fixed duration of three years, they generally shorten the time required to gain a doctorate. A curriculum to be followed concurrently with the doctoral studies prepares the doctoral candidates for their research tasks. Other advantages are the intensive supervision and regulated funding, whether it is via a scholarship linked with the PhD programme or via a position as a research assistant. Furthermore, English is frequently the language of tuition and the working language in the doctoral programmes.

» *My field of research is the "functional ecology of microbial associations in the plant-soil system", in other words, the role of symbiotic microorganisms, for example in the nutrient uptake of plants. Through the PhD programme of the Freie Universität Berlin, I became a member of a scientific community with brilliant researchers. It gave me access to excellent research infrastructures and cooperation opportunities with other research institutions in Germany and the USA. In addition, I benefit from the experience of those supervising my doctoral studies and from the regular meetings in seminars of the research groups.* «

Marco Cosme, seen here collecting leaf samples, comes from Portugal and is working towards a doctorate at the Institute of Biology – Research Group Functional Biodiversity – of the Freie Universität Berlin.

The graduate colleges and graduate schools, too, provide a structured form of doctoral studies. They include, for example, the graduate schools and Research Training Groups funded by the German Research Foundation (Deutsche Forschungsgemeinschaft – DFG). In the graduate schools, outstanding doctoral candidates are supported and qualified within an excellent research environment. In graduate colleges, doctoral students work as part of a coordinated research programme supported by several university professors. The "International Research Training Groups" of the DFG are coordinated by a German university and a partner abroad.

In the "International Promovieren in Deutschland (IPID)" programme, the DAAD promotes the internationalisation of structured doctoral programmes at German universities out of funds provided by the Federal Ministry of Education and Research (BMBWF). They include 14 programmes from the field of mathematics, the natural sciences and computer science in which young international researchers, in particular, can benefit from good academic supervision.

Furthermore, graduate colleges and graduate schools are also offered by non-university research institutions in cooperation with the universities. These include, for example, the International Max Planck Research Schools, the graduate schools of the Helmholtz Association (Helmholtz-Gemeinschaft), the Leibniz Association (Leibniz-Gemeinschaft) or the Fraunhofer-Gesellschaft. Among other things, these graduate schools and colleges provide access to large-scale instruments and equipment, some of which are globally unique and which the doctoral students can use to conduct their experiments and series of measurements.



## INFORMATION

### DAAD – International Programmes in Germany

On the website of the German Academic Exchange Service (Deutscher Akademischer Austauschdienst), you can search for internationally recognised, accredited bachelor's, master's and doctoral programmes in the natural sciences, mathematics and computer science, most of them taught in English. All the programmes offered in the database ensure special course-related and personal support for students and doctoral candidates from abroad.

[www.daad.de/international-programmes](http://www.daad.de/international-programmes)

### PhDGermany – the platform for doctoral positions and research opportunities in Germany

The DAAD platform for doctoral positions contains offers of doctoral study opportunities aimed specifically at foreign candidates. You can apply directly via the DAAD portal.

[www.phdgermany.de](http://www.phdgermany.de)

### IPID – International Promovieren in Deutschland

The website of the programme provides an overview of the structured doctoral programmes promoted in IPID.

[www.daad.de/ipid](http://www.daad.de/ipid) > Service

### Further links

on the programmes offered for graduates and postgraduates:

[www.hochschulkompass.de](http://www.hochschulkompass.de)

German Rectors' Conference

(Hochschulrektorenkonferenz - HRK)

[www.dfg.de](http://www.dfg.de)

German Research Foundation (Deutsche Forschungsgemeinschaft - DFG)

[www.mpg.de](http://www.mpg.de)

Max Planck Society (Max-Planck-Gesellschaft zur Förderung der Wissenschaften)

[www.fraunhofer.de](http://www.fraunhofer.de)

Fraunhofer-Gesellschaft (Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.)

[www.helmholtz.de](http://www.helmholtz.de)

Helmholtz Association of German Research Centres (Helmholtz-Gemeinschaft Deutscher Forschungszentren)

[www.leibniz-gemeinschaft.de](http://www.leibniz-gemeinschaft.de)

Leibniz Association (Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e.V.)

[www.research-explorer.de](http://www.research-explorer.de)

The Research Explorer of the DAAD and the DFG

# Interaction and networking

With new technical developments, computer science has a huge impact on our everyday lives. The IT structures are becoming increasingly complex, both in companies and in the private sphere. At RheinMain University of Applied Sciences in Wiesbaden the students learn not only how to plan and program user-friendly application software. One of the main emphases is to develop, analyse and evaluate innovative solutions for the entire life cycle of networked systems.



*In seminars, computer science students present the results of programming projects to their fellow students.*

At first it was the Interactive Applications specialisation that particularly interested George Moldovan in the master's programme at RheinMain University of Applied Sciences. The student from Romania had already met some of the professors from RheinMain University of Applied Sciences during his degree course in Computer Science at the Transilvania University of Braşov, when they visited the Romanian partner university in Transylvania several times as part of the ERASMUS Programme. In the process he obtained initial information about the master's programme and established contacts. "After gaining my degree I first worked for a large company in Romania. But that didn't satisfy me because I wanted to learn even more," he tells us.

His destination was therefore Wiesbaden, where RheinMain University of Applied

Sciences has its headquarters. 640 of the approximately 10,400 students come from abroad. Under the umbrella of the Faculty of Design – Computer Science – Media, the Department of Computer Science offers bachelor's programmes in Applied Computer Science and Media Computer Science and the master's programme in Computer Science.

## Freedom of choice in the catalogue of subjects

"Shortly after beginning the course I realised that IT structures in firms and the private sphere, as well as security issues in the communication of components, interest me most. So I changed my degree profile and switched to the second specialisation, Networked Systems," George Moldovan explains.

The fact that this change of specialisa-

tions worked so smoothly is associated with the flexible study options. "With the exception of mathematics, formal modelling and a business seminar, there are hardly any obligatory classes. The students can compile their study plan largely independently from an extensive catalogue of courses," explains Professor Reinhold Kröger, head of the master's programme in Computer Science. "In the middle of the semester we ask the students which of the electives are of interest to them in the following semester and organise our range of courses accordingly. We strive to offer each subject at least once during the course of the master's programme," he adds.

Electives such as Information Processing in the Semantic Web, Parallel and Distributed Algorithms, Complexity Theory or Cryptology are intended for students of both specialisations. In contrast, the courses Application

Professor Reinhold Kröger teaches at the Faculty of Design – Computer Science – Media of RheinMain University of Applied Sciences and manages the distributed systems laboratory there.



George Moldovan comes from Romania and gained a master's degree in Computer Science at RheinMain University of Applied Sciences.



Integration, Home Automation, Management of Distributed Systems or Systems Architecture, for example, are offered specifically for the specialisation chosen by George Moldovan, Networked Systems.

### Employment and part-time studies possible

As George Moldovan already had good German language skills, he managed to get started on his studies in Wiesbaden without much trouble. "Good knowledge of the German language is one of our requirements, although we do also offer individual classes in English, if necessary," says Professor Kröger. For George Moldovan it was definitely helpful that he obtained a paid job as a student assistant in the field of research and development in the faculty where he worked on projects conducted by university professors in cooperation with industrial enterprises. "We endeavour to offer selected students a job as an assistant within our research projects or to employ them as instructors in the bachelor's programme," Professor Kröger explains.

The proportion of the students on the master's programme who work part-time in a relevant field alongside their studies is relatively large. The Rhine-Main area, with Frankfurt as its economic centre, has a considerable demand for well-trained IT specialists, which the students on the master's programme also benefit from. According to Professor Kröger, some of the students accept their degree courses being extended to five or six semesters as a result of working alongside their degree courses. This is no problem, in principle, as the individual courses are independent of each other. So they can be studied in any order, even within a part-time degree course. An obligatory external internship is therefore not scheduled in the master's programme.

### First research experience in master's projects

"Our speciality is the master's project in the third semester. The students are integrated in application-related research projects in which firms are generally also involved. In this way they develop contacts with firms and get to know their problems," explains Professor Kröger. Master's students can participate in these projects in the context of classes or their master's theses or also as paid research assistants.

This semester he himself has begun a project on cloud computing, in which three students are cooperating. The research question: how can freely available cloud computing infrastructures be used, for example, to improve the organisation of internships at the university? "Completely new aspects for the management of distributed infrastructures and applications emerge when the whole issue is examined in a cloud environment," is Professor Kröger's assessment.

In the project "Wiesbaden-Düsseldorfer Ambient Assisted Living Service Platform (WieDAS)", too, students are integrated into the research and development projects of the laboratory for distributed systems. One of the aims of the project is to enable older people to live independent lives in their own homes for as long as possible by means of assistance systems that are suited to their age and sensitive to their situation. For example, to achieve this, the home is equipped with sensors that can recognise dangerous situations, thereby preventing injury or harm, or that assist the residents' activities of daily living by means of comfort functions.

### Career entry or doctoral studies

The majority of the graduates find a job straight after gaining their master's degree. "We know from surveys that our graduates have no trouble seeking work and starting

out in working life. We try to register the current skills requirements in the firms at an early stage and are able to adapt the curriculum in the master's programme at very short notice," Professor Kröger reports.

After completing the master's programme, George Moldovan chose a different career path. He is now working towards a doctorate in the SENSIBLE doctorate programme, which is run jointly by Goethe University Frankfurt am Main and RheinMain University of Applied Sciences. There he is dealing with different approaches aimed at cryptographically secured, wireless communication in sensor networks as they are required for a smart living environment.



## INFORMATION

RheinMain University of Applied Sciences (Hochschule RheinMain)  
www.hs-rm.de

Information about the master's programme in Computer Science  
www.hs-rm.de/dcsm/studiengaenge/informatik-msc

# The earth as an energy reservoir

Clausthal University of Technology is regarded as one of the best places for research and teaching in the fields of energy and raw materials. A particularly large number of students from resource-rich countries have therefore enrolled at the university in the Harz region that is steeped in tradition – among them Muhammad Zain ul Abedin from Pakistan.



*In the North Sea, natural gas deposits are accessed from production platforms, here the drilling platform E.ON Ruhrgas.*

After completing his bachelor's degree in petroleum geology at the University of the Punjab in Pakistan, Muhammad Zain ul Abedin considered together with his family where it might be best for him to continue his academic training. "The high standards of the universities and the flexible conditions for studying in Germany were key factors in my decision," he tells us. His journey first took him to the University of Freiburg, where he enrolled on the master's course in Geosciences.

"I'm very interested in petroleum engineering among other things. That's why Clausthal University of Technology caught my attention." Muhammad Zain ul Abedin applied for two master's programmes there: Petroleum Engineering and Geosciences of

Natural Resources and was offered a place on both courses. In this way he was able to continue the studies in geosciences in Clausthal-Zellerfeld that he had begun in Freiburg.

## Graduates in geosciences act globally

With about 4,000 students, Clausthal University of Technology is the smallest university of technology in Germany, but at the same time also one of the most international ones. "Approximately 30 percent of the students and 20 percent of the academic staff come from abroad. This is certain to have something to do with the fact that the fields of raw materials and energy operate in an international environment," says Professor

Hans-Jürgen Gursky, managing director of the Institute for Geology and Paleontology, explaining the internationality of life on the campus.

The main language of tuition in the master's programme in Geosciences of Natural Resources is German. Some of the classes are already offered in English, as they are held jointly with the master's course in Petroleum Engineering, which is taught in English. "We are currently considering whether we can offer more lectures and classes in English in the future in order to make it easier for foreign students to participate," Professor Gursky tells us, looking ahead.

## Oil, natural gas or mineral resources

The geosciences master's programme offers two specialisations: oil and natural gas, and mineral resources. They involve, in particular, classes in applied geosciences and reservoir engineering. Together with his fellow students from all over Germany and from many other countries, such as Austria, Tunisia or Iran, Muhammad Zain ul Abedin is acquiring specialist skills for the employment sectors in the field of earth sciences that are most in demand. The compulsory modules for all students include subjects such as the geosciences of energy sources and raw materials, hydrogeology, borehole geophysics and applied geographic information systems.



*Muhammad Zain ul Abedin comes from Pakistan and is a student on the master's programme Geosciences of Natural Resources at Clausthal University of Technology.*

Professor Hans-Jürgen Gursky is managing director of the Institute of Geology and Paleontology at Clausthal University of Technology and the academic advisor for the master's programme in Geosciences of Natural Resources.



Muhammad Zain ul Abedin chose the specialisation of oil and natural gas. The intensive study of the geology of reservoirs and petrophysics also provides him with knowledge that is closely related in technical terms to his field of interest, petroleum engineering. "Many of the courses I took during my studies in Freiburg were recognised in Clausthal, so I don't have to attend all the courses in the geosciences master's programme. In addition I'm taking a German course. That makes a total of about 12 to 15 hours of classes per week, not including excursions and project work."

### Module with potential for the future: geothermal energy

In the specialisation of oil and natural gas, the master's programme offers an interesting extension with its module on geothermal energy. There, students learn more about recovering energy from geothermal resources, for example at a depth of 2,000 to 4,000 metres in the Upper Rhine Plain and in the North German Plain. "The exploration is well under way. A great deal of hope is being pinned on this form of energy generation. Geothermal energy has enormous potential for the use of electricity and ground source heat," says Professor Gursky and points out the technical problems that still exist: "As a result of the high salt content in the hot deep water, the piping systems become blocked, for example." What potential for the future is attached to geothermal energy at Clausthal University of Technology can be seen in the fact that there is already a separate professorship for geothermal engineering. "We will continue to promote the subject of geothermal energy strongly in our teaching," he ensures us.

### Out into the field

Contact with the field is very important for geologists. Geosciences field exercises are therefore part of the compulsory programme in the degree programme. In the opinion of Professor Gursky they make a major contribution to methodological competence: "Whenever possible we go out into the field, in other countries, too. In 2012, for instance, there was a field trip to Rwanda. There, the students took part in fieldwork courses aimed at mapping coltan occurrences."

What is also compulsory is an internship in the fourth semester, which the students do at a research institution or, for example, in the oil industry in Germany or abroad. The internships provide important input for the master's thesis.

### Personal university atmosphere

Muhammad Zain ul Abedin sees the fact that he is studying in a comparatively small university town as an advantage: "It's a good and relaxed environment for my degree course. I can concentrate fully on my studies. The atmosphere is very personal and you're always bumping into someone somewhere. I've already made lots of contacts and friends here."

The clear structure of the university also has a positive effect on the contact with the neighbouring institutes. "For instance, a soil sample analysis can be conducted by the neighbouring Institute of Mineral and Waste Processing, Waste Disposal and Geomechanics. If it's a matter of analysing aerial photos using remote sensing, it's no problem for me to phone my colleagues in the surveying technology department and send the students over there to get support," is how Professor Gursky describes the constructive cooperation.

### Graduates in demand in Germany and abroad

Anyone with talent and an interest in research can find access to an academic career in Clausthal, too: "Some master's graduates have stayed here and found doctoral positions, for example in fields of economic geology and salts or disposal research. There is a relatively large amount of funding available there," says Professor Gursky, referring to the Energie-Forschungszentrum Niedersachsen (Energy Research Centre of Niedersachsen)

in the neighbouring town of Goslar. In this centre, Clausthal University of Technology and its partner universities in Lower Saxony have pooled their entire competence in energy research. In an interdisciplinary approach, research is conducted on issues concerning the entire energy-generation and energy-utilisation chain from the raw-material source to disposal.

Professor Gursky knows the potential employment opportunities: "The majority of our graduates work in the extractive industry and go abroad. In addition, the producers of lignite and salt as well as the mining and quarrying sector also provide career opportunities in Germany."

Muhammad Zain ul Abedin would like to keep the research option open, but plans to work in the oil industry for about two years first to gain work experience. "I'll try to find a job with a German company. The Netherlands or Norway are possible alternatives."



## INFORMATION

**Clausthal University of Technology**  
www.tu-clausthal.de

# Of communicating cells and scientists

A total of 150 young scientists of different research disciplines and nationalities are working towards doctorates at the Jena School for Microbial Communication (JSMC), which receives funding under the Excellence Initiative. They all have a common goal: they want to understand how microbes communicate with each other and with their environment. The Irish biologist Seána Duggan is conducting research on interactions between a pathogenic fungus and human immune cells. In the process, she benefits from the exchange of ideas and information in the interdisciplinary network of the JSMC Graduate School.



*Seána Duggan comes from Ireland and is working towards a doctorate at the Jena School for Microbial Communication (JSMC) of the Friedrich Schiller University of Jena.*

Seána Duggan studied biology at the Institute of Technology Tallaght (ITT) in Dublin and gained her master's degree there in 2011. The Irishwoman was looking for a research field with the potential to help people: "That's why I wanted to know as much as possible about pathogenic microorganisms and immunology." Now the 25-year-old is

working at the Centre for Innovation Competence Septomics and is doing a doctorate at the Friedrich Schiller University of Jena. She is supported by the JSMC Graduate School.

Her aim is to create the scientific basis for the treatment of sepsis. Sepsis is an incorrect response of the human immune system to an invasion of pathogens in the bloodstream. The symptoms are additionally aggravated by the misguided immune response. Sepsis frequently ends in death.

Seána Duggan is conducting research on *Candida glabrata*, a fungus that causes infections, especially in patients with weakened immune systems in hospitals, and which is becoming increasingly resistant to conventional treatments. She is interested in how *Candida* interacts with the white blood cells of the human immune system. Normally the immune cells swallow the fungus and release toxic components in order to kill it.



*Professor Axel A. Brakhage is the spokesman of the Jena School for Microbial Communication (JSMC) at the Friedrich Schiller University of Jena.*

The Irish biologist is now trying to find out under what conditions the fungus manages to evade this defence system.

## From cell to cell, from subject to subject

The exchange of signals between fungus and human cell occurring in this process is an example of "microbial communication" and therefore fits perfectly into the programme of the Jena School for Microbial Communication, which Seána Duggan applied to two years ago. "Under the umbrella of the JSMC, a common scientific aim is being pursued: a holistic examination of microbial communication. We're interested in the signalling processes that take place between microorganisms. We want to understand all aspects of the interactions between bacteria and fungi and their environment," the spokesman of the Graduate School, Professor Axel A. Brakhage, emphasises.

"With their interdisciplinary doctoral projects and cooperation arrangements, our doctoral researchers strengthen the JSMC network and fill it with life," says the professor of microbiology, describing the approach of the graduate programme. He adds that if, for example, they are looking at microbial communication in the environment, teams composed of microbiologists, ecologists, chemists and earth scientists are formed. In connection with pathological processes and drugs, biologists, doctors, chemists and pharmacists are needed. "If new analytical methods or equipment have to be developed, physicists and our partners in industry become involved. In the case of computer-assisted model calculations, a well-coordinated collaboration with bioinformatics experts is needed," Axel Brakhage explains, emphasising that "the JSMC and its interdisciplinary events make it considerably easier to develop contacts for cooperation across the boundaries of scientific disciplines."

### 30 to 40 fellowships per year

Seána Duggan discovered the JSMC via the Internet. The good supervision in this programme and the prospects of exchanging ideas and information with international scientists were the decisive factors for her application. "The application procedure is tough and involves several stages," the Irishwoman remembers. "After submitting the written application, the topic of a potential doctoral thesis within the advertised research project is discussed during a telephone interview. Finally, I was invited to Jena for a two-day recruitment meeting, where I presented my master's thesis and defended it before a large committee."

The JSMC advertises 30 to 40 fellowships per year. The majority of the several thousand applications come from abroad, many of them from Asia, Africa and South America. "For us, the only selection criterion is academic suitability," JSMC manager Dr Carsten Thoms emphasises, "which, in our opinion, consists of intellectual potential, commitment, independence and communication skills."

### Good laboratory practice and community of fellows

A great deal of Seána Duggan's daily work takes place in the laboratory. There, she extracts immune cells from human blood – sometimes from blood donated by her colleagues. She grows *Candida* fungus cultures and then allows the two types of cells to interact with one another. In addition, the biologist is learning German and taking part in courses on research techniques in immunobiology, scientific writing skills and good laboratory practice. "The courses on offer at the JSMC range from methodology courses in state-of-the-art research technologies to 'transferable skills,'" Carsten Thoms tells us.



Dr Carsten Thoms is the manager of the Jena School for Microbial Communication (JSMC) at the Friedrich Schiller University of Jena.



The organising team of the MiCom2012 – the "MiCom" is an international conference on the subject of microbial communication, which is organised by the JSMC doctoral researchers every year and attracts participants from all over the world to Jena.

For international doctoral researchers, there are not only language courses but also a mentoring service run by the Jena Graduate Academy, and the JSMC Office as the main contact point, providing support in all matters. The active community of JSMC fellows also plays an important role in the integration of the young international researchers. "By means of collective activities and the joint organisation of events, such as the international doctoral student conference MiCom and the MiCo-Colloquium lecture series, it's very easy to get involved and therefore also to become integrated," says Seána Duggan.

### Career network for biotechnology

In its doctoral training programme the JSMC places emphasis on various career options: "We deliberately train for careers both in academia and in industry," Professor Brakhage explains. "In order to provide for contacts in private enterprise at an early stage, we maintain close partnerships with several regional biotechnology companies, which are actively involved in the JSMC training programme." Moreover, establishing an international network early is very important for a successful research career. For that reason, positions at renowned research institutions abroad are found for those who have gained a doctorate from the Graduate School, via so-called JSMC Career Orientation Grants.

Seána Duggan has not yet decided whether she wants to continue her academic career as a postdoctoral research fellow or work in industry. But thanks to her high-ranking training and the numerous contacts that she has already made through the JSMC network, she is well-equipped for both career paths.

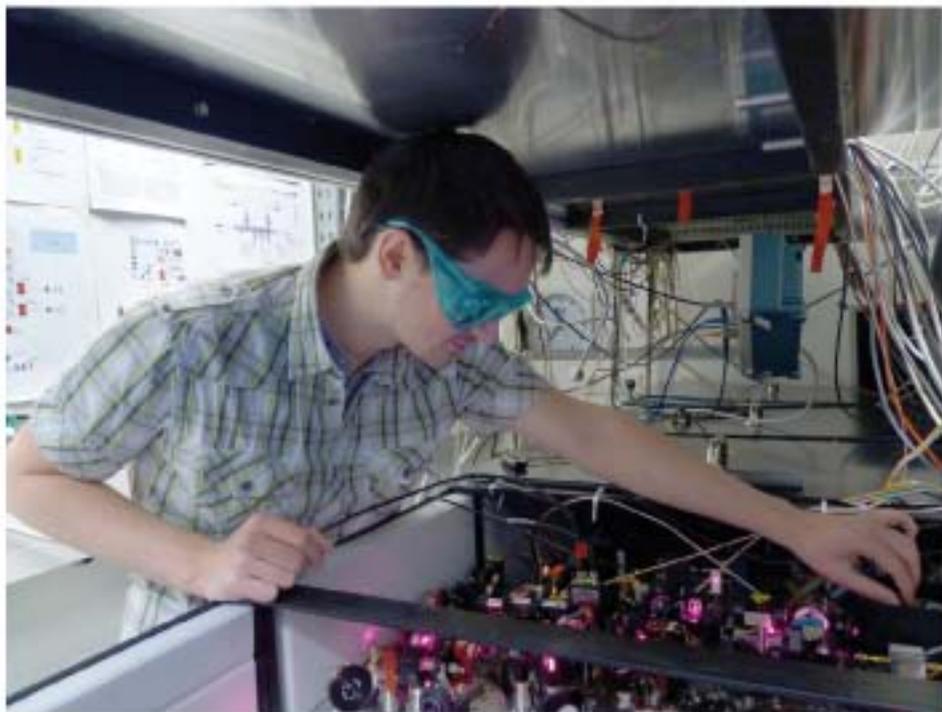


## INFORMATION

**Jena School for Microbial Communication (JSMC)**  
www.jsmc.uni-jena.de

# Physics on all scales

The research programme of the Heidelberg Graduate School of Fundamental Physics (HGSFP) is broad and exciting: whether quantum physics, neutrino physics, astrophysics, biophysics or environmental physics – virtually all fields of the subject are covered, true to the motto of “physics on all scales”. 100 doctoral students gain places at the Heidelberg Graduate School every year. Approximately 20 percent of them are from abroad, like Yuris Ulmanis from Lithuania.



*In modern quantum optics laboratories at the Kirchoff Institute of Physics and the Physikalisches Institut at Heidelberg University, laser light is used to manipulate atoms at ultracold temperatures. That is what Yuris Ulmanis is working on.*

“I’ve been interested in quantum physics since I was at school,” Yuris Ulmanis tells us. The Lithuanian gained his bachelor’s and master’s degrees in physics from the University of Latvia in Riga. In Heidelberg the 26-year-old found the research area in which he wanted to do his doctoral studies. He was convinced by the way the international students are funded and supported at the HGSFP. “The positive feedback from doctoral students at the HGSFP made the decision easy for me in the end.”

## Flexible research programme

As is the case with Yuris Ulmanis, there is almost always a match between the interests of the institutions involved and those of the doctoral candidates at the HGSFP, since the research programme is broad and exciting. “At Heidelberg we keep up the tradition of interdisciplinary discussion and are therefore

able to act very flexibly,” explains Professor Sandra Klevansky, Administrative Director of the HGSFP and the Dean’s Office. There are research opportunities for the students at the Department of Physics and Astronomy, the Max Planck Institutes for Astronomy and for Nuclear Physics, the Heidelberg Institute for Theoretical Studies (HITS) and at the nearby facilities of the GSI Helmholtz Centre for Heavy Ion Physics.

“We are interested in innovative science, and for that we need excellent doctoral students. Their country of origin isn’t important.” With this, Sandra Klevansky means students who achieved a grade of B+ (the German grade of 2.0) or better in their master’s degree. The candidates should have a sound knowledge of experimental and theoretical physics, have received practical training and already have conducted a research project during their master’s degree course. “In the

case of international candidates, we generally clarify whether they match one of our research projects during an interview. Usually the candidate specifies the research field in close agreement with the advisor.”

## New phases of matter

Yuris Ulmanis works at the Centre for Quantum Dynamics of Atomic and Molecular Systems. His research project “polar quantum gas of ultracold lithium-caesium (LiCs) molecules” deals with fundamental questions about matter and interactions between atoms, electrons and molecules. For this he immerses himself fully in the micro- and nano-world that can be described by quantum physics. “In everyday life we are used to “big” things that we can see and touch,” the Lithuanian doctoral student explains. “As they get smaller and smaller, we not only need special devices and techniques to study them, but completely different laws of physics prevail.”

One of the most recent scientific achievements of this working group is the creation of a molecular quantum gas from lithium-caesium molecules. Research is being conducted there into degenerate Fermi gases and Bose-Einstein condensates. The latter are a phase of matter that was theoretically predicted to exist in the 1920s, but only created for the first time in a laboratory at the end of the twentieth century. To do this, the atoms and molecules are “trapped”: they are frozen in a specific quantum state at a temperature near absolute zero. In this state their behaviour can be studied and manipulated. The pro-



*Professor Sandra Klevansky is Administrative Director of the Heidelberg Graduate School of Fundamental Physics (HGSFP) at Heidelberg University.*

Yuris Ulmanis comes from Lithuania and is working towards a doctorate at the Heidelberg Graduate School of Fundamental Physics (HGSFP) at Heidelberg University.



cesses that take place are dominated entirely by the quantum properties of the matter. The results are to be used, for example, to produce special materials that conduct electrons without any resistance.

### Close link between particles and astrophysics

"Besides ultracold and synthetic quantum physics, another area in which exciting new results are expected is that of particle physics," says Sandra Klevansky, emphasizing another highlight of physics at Heidelberg. "Particle physics today is closely connected with astrophysics and cosmology. At the HGSFP almost a third of the doctoral students work in this field." Heidelberg scientists are involved in a number of international astronomy projects, among them the Gaia, Planck and Euclid satellites and the Pan-STARRS telescope system. Research topics include the search for exoplanets in the uni-

verse, the genesis of stars and planets, galaxy formation and the structure of the universe.

"Physics on all scales is the defining motto of physics at Heidelberg," Professor Klevansky stresses. In the future, biophysics, mathematical physics and environmental physics will also be represented at the HGSFP. In biophysics, for example, physical models of neural circuits are created which are more fault tolerant than existing computational designs.

### Graduate Days and Winter School

Wherever possible, networking and collaboration between the students at the HGSFP and the exchange of ideas and information in science are fostered. The Winter School, which is organised by the doctoral students themselves, is the best example of that. "They are able to organise their own seminars and determine for themselves which lecturers or lectures they want to have," Sandra Klevansky explains. "We also like our students to do some teaching. That's an important part of their own learning and education process." The doctoral students at the HGSFP are supported financially by means of scholarships or project funding.

"I benefited in particular from the biannual Heidelberg Physics Graduate Days," says Yuris Ulmanis. Scientists from all over the world provide the doctoral students with insights into cutting-edge research for a whole week. "Representatives from industry also give lectures during our Graduate Days,"

Professor Klevansky adds. "In addition to that, we hold regular regional exchange meetings with industrial companies that are related to physics. This enables our doctoral students to sound out where physics is in demand in industry."

### Best opportunities in research and industry

Sandra Klevansky is convinced of the good opportunities available to the graduates: a large proportion of them have gained positions as post-doctoral researchers in other European countries or in the USA, she tells us. However, most of them could also take up top jobs in various industries after gaining their doctorates. "One of our graduates already holds a junior professorship, others are group leaders in research institutions. I recently received news from one of our international graduates in India, saying that he was working as a research engineer in the Semiconductor R&D Center at IBM India."

Yuris Ulmanis is in Germany for the second time now and feels very welcome. "In the future I would like to continue working in an open-minded and intellectually challenging atmosphere like that in my project in Heidelberg."



## INFORMATION

Heidelberg Graduate School of Fundamental Physics (HGSFP) at Heidelberg University  
[www.fundamental-physics.uni-hd.de](http://www.fundamental-physics.uni-hd.de)

# Young researchers in demand

What can be said in general about the labour markets for graduates in natural sciences, mathematics and computer science? "Good, with occasional difficulties in certain areas at most," says Kolja Briedis from the HIS-Institute for Research on Higher Education (HIS-Institut für Hochschulforschung – HIS-HF). With this he refers to the diversity of the mentioned labour markets on the one hand and the growing demand in the entire sector in Germany on the other.



*The labour market for natural scientists is research-intensive, they frequently work in the laboratory.*

The labour market for graduates in natural sciences, mathematics and computer science is growing and offers good opportunities for employment and earnings. According to the labour market report of the Federal Employment Agency (Bundesagentur für Arbeit – BA), the number of people employed in occupations in mathematics and the natural sciences has risen by 56 percent over the past decade.

The work culture has changed in all sections of the labour market, as Kolja Briedis from the HIS-HF, project centre "Studies on Graduates and Lifelong Learning", has discovered: "Today the demand is for more than the pure specialised scientist. Graduates in the natural sciences have to be able to work in interdisciplinary teams and generally to think in complex structures," says Kolja Briedis. This means here that work processes no longer remain restricted to individual scientific disciplines and that the scientists are being integrated more strongly in economic

issues: "For example, they have to take into account customers' wishes or deadlines and cost factors."

It can be seen from the studies on graduates conducted by the HIS-HF that graduates in the natural sciences rarely start their careers straight after gaining their bachelor's degree. 91 percent of the biologists, chemists and physicists interviewed went on to gain further academic qualifications, most of them even doctorates.

## Computer scientists – rapid career entry

Computer scientists, too, very often choose to do a master's degree nowadays, even though they are highly sought-after on the labour market at the moment. According to information from the Federal Employment Agency (BA), in 2011 95 percent of computer scientists were in regular employment twelve months after graduating – a top figure compared with other graduate groups.

The Federal Association for Information Technology, Telecommunications and New Media, BITKOM, considers the employment prospects of graduates in computer science in Germany to be very good. It currently sees about 38,000 vacancies for IT specialists. In 2012 jobs were created particularly in the fields of software and services. In 2011 the biggest increases in registered vacancies for IT specialists in percentage terms were recorded by the BA in the sectors 'manufacture of machinery and equipment' and 'manufacture of fabricated metal products'.

## Chemists – researchers with doctorates

In 2011 a good quarter of all chemists were working in the chemical industry. Most of them are employed in the manufacture of basic chemicals. According to VCI, the Association of the Chemical Industry (Verband der Chemischen Industrie), one in ten chemists works in research and development. "A doctorate is the ticket to an unproblematic labour market there," says Kolja Briedis.

## Mathematicians – finance and information technology

"What is important for mathematicians is whether they opt for theoretical or applied mathematics," Kolja Briedis explains, adding that the former is an option for only relatively few of them. The majority choose fields of application such as insurance mathematics (see also the interview on page 30), software development, management consultancy, business management or company auditing. Approximately 43 percent of mathematics graduates were working in office, admin-



*Kolja Briedis from the HIS-Institute for Research on Higher Education, project centre Studies on Graduates and Lifelong Learning*

istrative or organisational occupations in 2011. A large number of the mathematicians were employed in research and teaching at universities.

**Physicists – problem solvers with vision**

Owing to their specialist knowledge, physics graduates are just as sought-after in finance and management consultancy as they are in the electronics and IT sectors. There are job opportunities wherever complex problems have to be structured and analysed. In industry it is often physicists that bring new principles into existing technologies. For instance, many optical measurement techniques were developed by physicists.

**Geoscientists – opportunities in the resources sector**

The labour market for geoscientists and geophysicists has been undergoing a positive development since 2001. One of the main reasons for this is the newly created career opportunities in the resources sector. Climate-friendly ways to produce energy will continue to gain in importance, for example when assessing locations for wind turbines or researching CO2 storage.

**Biologists – medicine, bioeconomics and bionics**

Dr Carsten Roller, who is responsible for training and careers at the German Life

Sciences Association (Verband Biologie, Biowissenschaften und Biomedizin - VBIO), regards the labour market for biology graduates as exceptionally dynamic and fairly independent of the economic situation so far. "Demand for know-how in the life sciences will remain high," of that he is sure and refers to positive trends in basic medical research, in the field of clinical research, in bioeconomics (bio-based raw materials or also white biotechnology) and in bionics.

Carsten Roller therefore does not only consider knowledge of molecular and systems biology to be important but also knowledge of engineering, computer science and statistical methods. With broad-based education and training, biology graduates prove to be very flexible on the labour market. In job advertisements, however, it is mainly specialists that are sought. Career entry is thus the biggest hurdle. "New entrants to the labour market should therefore contact employers at an early stage and not be disappointed if it doesn't work out with the industry leader straight away," Carsten Roller advises.

The spectrum of specialisations that are in demand is broad in all the labour markets described. For this reason Kolja Briedis recommends that students of mathematics and the natural sciences focus on a particular field, in the master's thesis at the latest, but preferably during the last third of the degree course. This makes their skills more visible to potential employers.

*Dr Carsten Roller is responsible for training and careers at the German Life Sciences Association (Verband Biologie, Biowissenschaften und Biomedizin - VBIO).*



**INFORMATION**

**Federal Employment Agency (Bundesagentur für Arbeit – BA)**

Brochure "Naturwissenschaften/Informatik" from the series "Der Arbeitsmarkt für Akademikerinnen und Akademiker in Deutschland" (only available in German) [www.arbeitsagentur.de/karrieremachen](http://www.arbeitsagentur.de/karrieremachen) > Arbeitsmarkt > Arbeitsmarkt für Akademiker <http://statistik.arbeitsagentur.de>

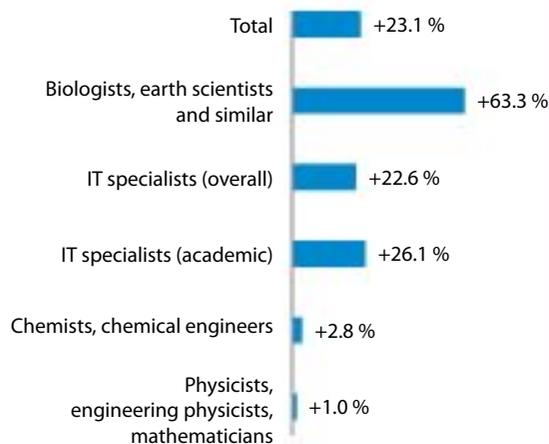
**Higher Education Information System (HIS Hochschul-Informations-System GmbH)**

HIS-Institute for Research on Higher Education (HIS-Institut für Hochschulforschung) [www.his-hf.de](http://www.his-hf.de)

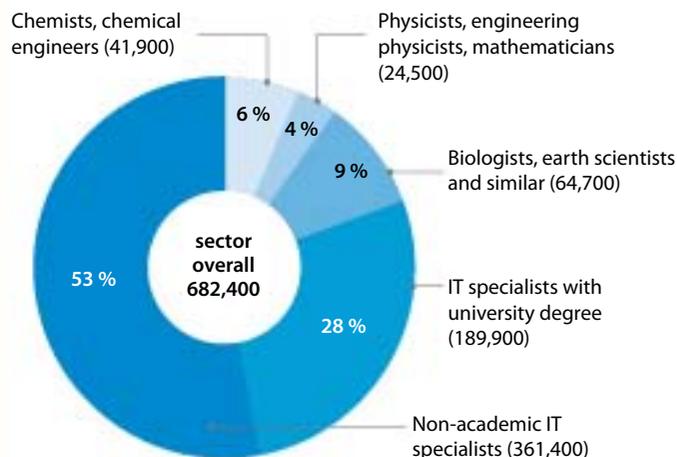
**Employees covered by social security in the natural sciences**

Stock and proportions of employees covered by social security in the natural sciences as of 31.03.2001, change on 31.03.2001, Germany

**Employment in 2011 compared with 2001**



**Occupational groups in 2011**



Source: Statistics department of the Federal Employment Agency (Bundesagentur für Arbeit)

## Mathematicians in the insurance industry

# Keeping an eye on risk

Allianz Deutschland AG recruits 500 university graduates every year. A significant proportion of them are graduates with a background in mathematics. The human resources advisor Markus Kimpel is especially familiar with their recruitment. He knows their distinct analytical and abstractive abilities, without which medium- or long-term risk assessments in the insurance industry would hardly be possible.



Markus Kimpel is a human resources advisor at Allianz Deutschland AG in Stuttgart and is especially familiar with the recruitment of mathematics graduates.

### In which departments do mathematics graduates work at Allianz?

Primarily in product development, in risk management and in the actuarial department, but also, for example, in accounts and in retail and commercial business. Mathematics graduates in these fields generally train as actuaries alongside their work.

### Actuaries? What are they?

An insurance company has to be able to respond to the constant changes and challenges of the market. The actuary's task is to deliver convincing models and well-founded assessments of uncertain developments and risks so that the management has at its disposal an appropriate basis for decision-making. The German Actuarial Association (Die Deutsche Aktuarvereinigung e.V. – DAV), as a professional body, provides the training for actuaries. Allianz bears the costs of this further training for our staff.

### What do mathematicians or actuaries contribute to product development?

They create concepts for new products and evaluate them with the aid of mathematical methods and models. For example, when evaluating life insurance contracts, they have to make assumptions about future mortality trends. Developing current and future insurance products does not only require that the actuaries make creative use of mathematical methods, however: they work between the conflicting poles of the latest economic forecasts and legal framework conditions at national and international level.

### And how does that differ from risk management?

Risk management has less to do with products than with the company itself. The "risk guards" working there check, for example, whether there is sufficient capital cover available or investigate how an insurance company can forearm itself against market-specific dangers. In doing this, they always look at the company as a whole. Their analyses are frequently the basis for decisions at strategic level.

### Can you describe a task in this field that a mathematics graduate could already take on shortly after joining Allianz?

In order to check whether the internal control systems are functioning properly or whether the relevant risks are being identified and taken into account, for example, the risk management department conducts so-called "shock tests" on a quarterly basis. A possible task could be to answer the question of what must be done if the share price, the interest rate level and the company's rating fall. Would the company's own financial resources be sufficient to offset this? Mathematicians, or actuaries, then approach this task using various stochastic instruments. To this end they run through all the more or less likely scenarios in order to obtain a valid result. They also take insurance-relevant risks, such as natural disasters, into consideration.

### Sounds pretty complicated. What skills do mathematics graduates need to be able to solve such problems? What do you value particularly in them?

We value their distinct abstractive abilities and their analytical minds. These skills are necessary if they are to draw the right conclusions from the results obtained using different instruments and simulations. An understanding of business contexts rounds off this competency profile.

### What other recruitment criteria does Allianz have? Who fits into the corporate culture?

We are convinced by personalities who want to make a difference and achieve something, but are also able to work as part of a team. Our employees are used to acting independently and are willing to assume responsibility. In addition, we pay attention to good or excellent academic achievements.

### What chances do recent graduates from other countries have?

They have the same chances as German applicants, whether they gained their degree in Germany or elsewhere. Cultural diversity is highly appreciated at Allianz. However, German language skills are required on the German market.

### Are there any special graduate training schemes at Allianz?

There are graduate schemes for specific fields, for example our management assistant scheme. The majority of those participating in this scheme are lawyers, economists and mathematicians. There is an IT graduate training scheme for computer scientists, in which the participants run through the entire spectrum of tasks, from the development of IT solutions to the maintenance and development of IT systems. In addition, there are also graduate schemes in insurance management as well as in sales and marketing.

### What other career options and career development opportunities are there for mathematics graduates?

Basically there are two possibilities: the leadership career path is open to all graduate groups equally and concerns individuals that we regard as having the potential for it. In the specialist career of an actuary, mathematics graduates can progress, after completing their actuarial training, from consultants to specialists and then on to experts. The demands, personal responsibility and opportunities for helping to shape corporate development increase with each level of competence. As the highest level of competence, senior experts work very closely with the company management.

## INFORMATION

**Allianz Deutschland**  
[www.perspektiven.allianz.de](http://www.perspektiven.allianz.de)

**Deutsche Aktuarvereinigung e.V. (DAV) (German Actuarial Association)**  
<http://aktuar.de>

# Important links at a glance

## Preparation and overview of degree courses

### [www.study-in.de](http://www.study-in.de)

First information about living and studying in Germany, with videos, chat forums, reports from foreign students, city portraits and a database of all degree courses

### [www.daad.de](http://www.daad.de)

Website of the German Academic Exchange Service (Deutscher Akademischer Austauschdienst – DAAD): more detailed information regarding first degree courses and doctoral studies in Germany

### [www.daad.de/international-programmes](http://www.daad.de/international-programmes)

Database with bachelor's, master's and doctoral programmes, most of them taught in English, as well as language and short courses and preparatory programmes

### [www.hochschulkompass.de](http://www.hochschulkompass.de)

Information portal of the German Rectors' Conference (Hochschulrektorenkonferenz – HRK) with information on German higher education institutions, their courses and opportunities for doctoral studies, as well as international cooperations

### [www.hochschulkompass.de/forschungslandkarte](http://www.hochschulkompass.de/forschungslandkarte)

Interactive research map provided by the German Rectors' Conference (Hochschulrektorenkonferenz – HRK) showing the 'institutional research priorities' of German universities

## Support and service

### [www.internationale-studierende.de](http://www.internationale-studierende.de)

Information portal of the 58 student unions (Studentenwerke) in Germany with information about economic, social, health and cultural support for international students at German universities

### [www.daad.de/aaa](http://www.daad.de/aaa)

Addresses of the International Offices (Akademische Auslandsämter – AAA) at the German universities

## Application, admission

### [www.daad.de/admission](http://www.daad.de/admission)

This page provides information about which educational certificates obtained outside Germany are required for admission to higher education in Germany.

### [www.anabin.de](http://www.anabin.de)

Information system for the recognition of foreign educational qualifications run by the Central Office for Foreign Education Systems (Zentralstelle für Ausländisches Bildungswesen – ZAB)

### [www.uni-assist.de](http://www.uni-assist.de)

Internet portal of the University Application Service for International Students (Arbeits- und Servicestelle für ausländische Studienbewerber)

## Scientific organisations, networks

### [www.dfg.de](http://www.dfg.de)

German Research Foundation (Deutsche Forschungsgemeinschaft – DFG)

### [www.research-explorer.de](http://www.research-explorer.de)

Research explorer of the DAAD and the DFG

### [www.fraunhofer.de](http://www.fraunhofer.de)

Fraunhofer-Gesellschaft (Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.)

### [www.helmholtz.de](http://www.helmholtz.de)

Helmholtz Association (Helmholtz-Gemeinschaft)

### [www.mpg.de](http://www.mpg.de)

Max Planck Society (Max-Planck-Gesellschaft)

### [www.tu9.de](http://www.tu9.de)

Alliance of the leading institutes of technology in Germany (TU9)

### [www.wgl.de](http://www.wgl.de)

Leibniz-Gemeinschaft, Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e.V.

## Funding

### [www.funding-guide.de](http://www.funding-guide.de)

Database of scholarships offered by the DAAD and other funding organisations

## Associations, organisations, information portals

### [dmv.mathematik.de](http://dmv.mathematik.de)

German Association of Mathematicians (Deutsche Mathematiker-Vereinigung – DMV)

### [www.dgg.de](http://www.dgg.de)

German Society for Earth Sciences (Deutsche Gesellschaft für Geowissenschaften – DGG)

### [www.dpg-physik.de](http://www.dpg-physik.de)

German Physics Society (Deutsche Physikalische Gesellschaft – DPG)

### [www.einstieg-informatik.de](http://www.einstieg-informatik.de)

Einstieg Informatik, Internet portal for young people interested in computer science

### [www.gbm-online.de](http://www.gbm-online.de)

Society for Biochemistry and Molecular Biology (Gesellschaft für Biochemie und Molekularbiologie – GBM)

### [www.gdch.de](http://www.gdch.de), [www.chemie-im-fokus.de](http://www.chemie-im-fokus.de)

Society of German Chemists (Gesellschaft Deutscher Chemiker – GDCH) and its website with information about degree courses and careers in chemistry

### [www.geographie.de](http://www.geographie.de)

German Society for Geography (Deutsche Gesellschaft für Geographie e.V. – DGfG)

### [www.gi.de](http://www.gi.de)

German Informatics Society (Gesellschaft für Informatik – GI)

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This brochure is also available in German.



## [www.vbio.de](http://www.vbio.de), [www.master-bio.de](http://www.master-bio.de)

German Life Sciences Association (Verband Biologie, Biowissenschaften und Biomedizin in Deutschland – VBIO) and its online database of master's courses in the life sciences, "Master in den Biowissenschaften"

"I'm ambitious about chemistry, so studying in Germany was a natural reaction."

Sally Collins, graduate in chemistry from Imperial College London, is currently a PhD student at the Technische Universität München.

Picture taken in a lecture hall at the Technische Universität München

[www.study-in.de](http://www.study-in.de)

Study in  
Germany



Land of Ideas