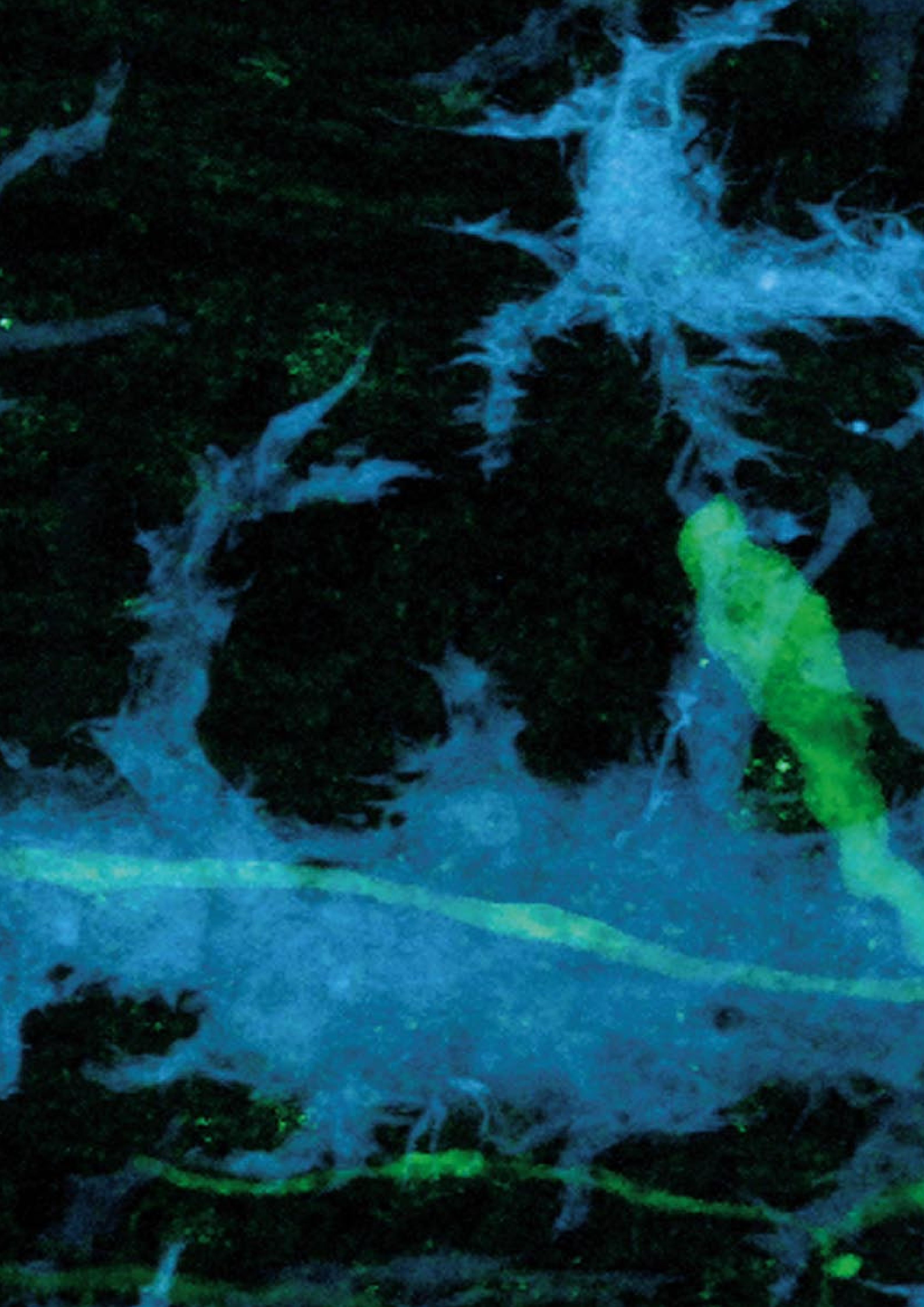
Annual Report

TUM Institute for Advanced Study

2007 | 2008



Annual Report

TUM Institute for Advanced Study

2007 | 2008

Table of Contents

Foreword of TUM President

The “TUM Institute for Advanced Study” (TUM-IAS), founded in 2005, was the centerpiece of the Excellence Initiative proposal, “TUM. The Entrepreneurial University”. Much like the legendary IAS in Princeton, TUM-IAS is based on the assumption that an atmosphere of creativity, inspiration, freedom, and support - without a lot of red tape - for excellent researchers forms the most productive source for outstanding scientific achievements.

The goal of the Institute for Advanced Study is to establish new fields of excellence in research at TUM. The TUM-IAS gives scientists from TUM and from abroad the time and resources to focus on new, cutting-edge research, and is therefore a key to fostering scientific excellence at TUM. Very often our most gifted scientists are burdened by bureaucracy in their daily work. The Institute brings top scientists from TUM and distinguished international scientists together with the most promising young scholars in a community where intellectual creativity can flourish and young creative minds can exchange ideas with established leaders.

Three years after the founding of the TUM-IAS, I am very pleased to see that the Institute is already thriving with 19 Fellows and numerous start-up projects. The size of the fellowship program will be increased in proportion with the programming and support offered to Fellows in order to maximize the think-tank-like environment.

The TUM-IAS strives to bring top scientists from TUM together with top international scientists. So far, six of the first Fellows have come from Harvard, MIT, the University of Bern, and the University of Toronto. In addition, Alexander von Humboldt prizewinners at TUM are also integrated into the Institute programs and many of the research groups of the TUM-IAS. This is a win-win set up as the TUM-IAS Fellows benefit from collaborating with a larger network of prestigious international scientists, and the Humboldt prizewinners have a larger circle for intellectual exchange and are better integrated into the academic community of TUM.

Finally, young scientists are an integral part of the TUM-IAS and its research groups. Many elite institutions focus primarily on their established professors. The TUM-IAS actively promotes the transfer of knowledge between generations.

With the hiring of the Institute's first official Director, Professor Patrick Dewilde, TUM has acquired an outstanding and experienced leader who will help take the TUM-IAS to the next level in innovative research. I wish Professor Patrick Dewilde and his team all the best for the TUM-IAS:
It is our unique challenge to adapt this concept to the specific conditions of a Technical University while creating unprecedented opportunities for young and even more experienced researchers, from inside and outside our University.

Wolfgang A. Herrmann
President

Director's Message

Traditionally one would think of an Institute for Advanced Study as a big building in which a good number of top scientists reside, work, think, and develop new ideas, interact occasionally with each other, and generally behave like monks whose main mission in life is the enrichment of mankind's knowledge base. A Technical University is also devoted to this last ideal, but the technical sciences (or technology, if you will) do not lend themselves to a monkish approach. Ideas are important, but they have to be strongly anchored in technological feasibility and hence require an environment that leads to multidisciplinary experimentation and realization.

The Institute for Advanced Study at TUM has therefore embraced a different model of operation. Surely, its foremost ambition is to support and attract absolutely top-level scientists to engage in new, advanced fields of research. These are our selected Fellows and they form the basis of our Institute. The important difference, however, is that these top scientists are integrated into the active environment of the University so that they have direct access to experimental facilities and can deliver the best possible technological prowess in their fields.

The primary goal of our Institute is what one could call "research innovation". Our first years of existence have been devoted to developing the mechanisms that would ensure the realization of that ideal. We have conceived our fellowship program along the three main dimensions in which technological science evolves. The first dimension is the connection between promising young scientists vying for new concepts and seasoned researchers with an impressive record of excellence - connecting dynamism with experience. The second is the international dimension, between local research groups of top international standing and their counterparts elsewhere - connecting Munich's excellence to the world's. And the third, very important for technological research, is the interdisciplinary dimension and in particular the connection with that segment of industry that is devoted to putting new ideas on the market.

Our Hans Fischer Senior Fellows are top scientists from all over the world who have committed themselves to one of the TUM advanced research programs for extensive periods of intense collaboration. At the other side of the seniority scale we have our Carl von Linde Junior Fellows who are young scientists who have already shown considerable promise at the dawn of their career and want to commit themselves to at least two years of dedication to a new topic of endeavor. Parallel with the Hans Fischer Fellows, our Carl von Linde Senior Fellows are top level TUM scientists who have taken it upon themselves to create and develop a substantial innovative research effort, often playing a leading role in setting the necessary experimental environment for the junior and international Fellows.

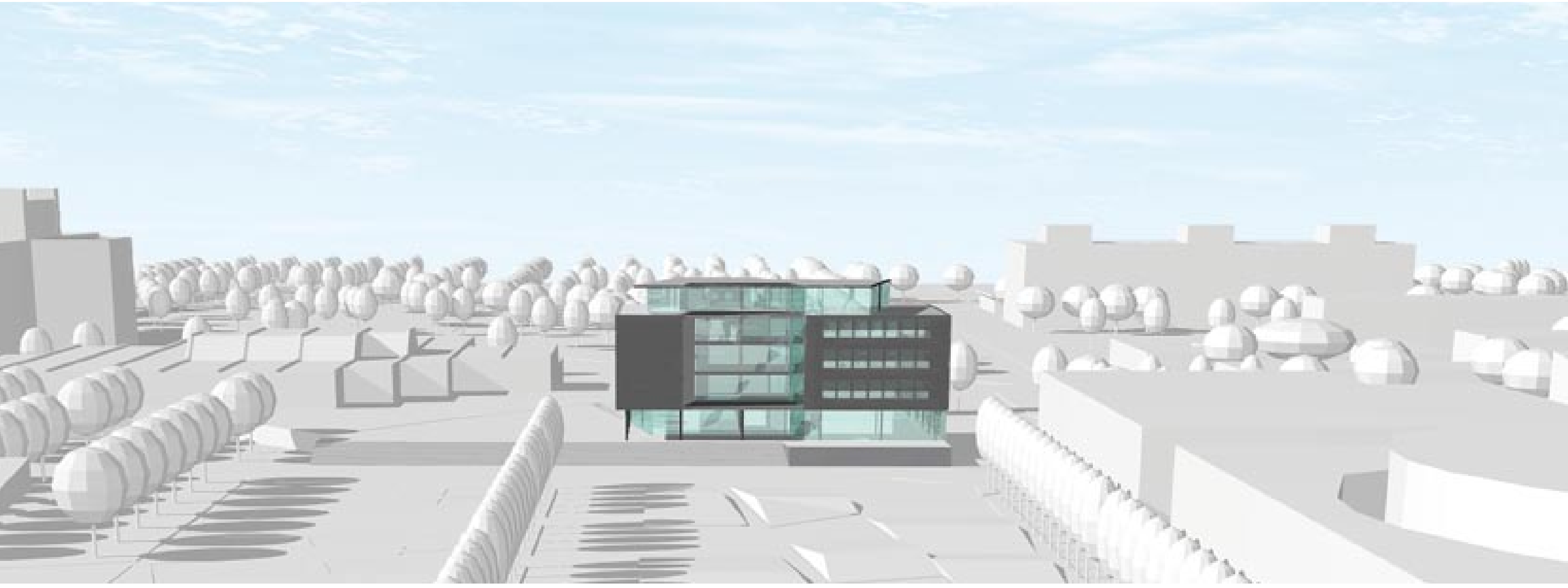
The Hans Fischer Tenure Track Fellows are special members of the TUM-IAS for five years. Their faculty commits to continuing the position after their TUM-IAS term. These fellowships are instrumental in the creation of new professor chairs.

Finally, Rudolf Diesel Industry Fellows are leading researchers from Industry who are tightly connected to on-going research projects at TUM. We are especially keen on developing ties with research-minded companies that aim at making new technology work in the market place.

The laboratories that host our Fellows and their projects play an important role in setting up our "research renewal movement from within" at TUM. We consider these hosts as a constitutive part of our organization. They provide much needed and appreciated scientific leadership and the means to achieve our goals.

The IAS belongs to the TUM and the TUM belongs to the IAS! In this sense we are a “virtual Institute”, but one with very real people and facilities.

And we also have a building! At the moment we have very nice temporary facilities in downtown Munich, Nymphenburgerstrasse 39, where many of the common activities of the Institute take place. We have at our disposal open offices and meeting places where we organize workshops, think



tanks, planning sessions, get-togethers, etc. These facilities are too small to accommodate our ambitions, so a new facility is generously being built for us by BMW group on the Garching campus that will allow us to provide our Fellows and their research units with a well-equipped and spacious anchor. Space is a scarce commodity on campus, and we will be able to provide spatial roominess where needed.

As already stated, our prime focus is on engaging excellent Fellows. Almost equally important, because highly motivational, is their integration in kernels for advanced research. These we call *Focus Groups*. We are open for any excellent proposal coming from the University community, but we ultimately focus our resources on a limited number of key topics. Most of them form a combination of existing excellence with a drive towards novelty. The process that leads to them often happens in the context of some major projects or existing laboratories whose excellence attracts both young people and international interest. The TUM-IAS tries (and succeeds!) to ease the huge demand for advanced knowledge and experience such larger endeavors often require.

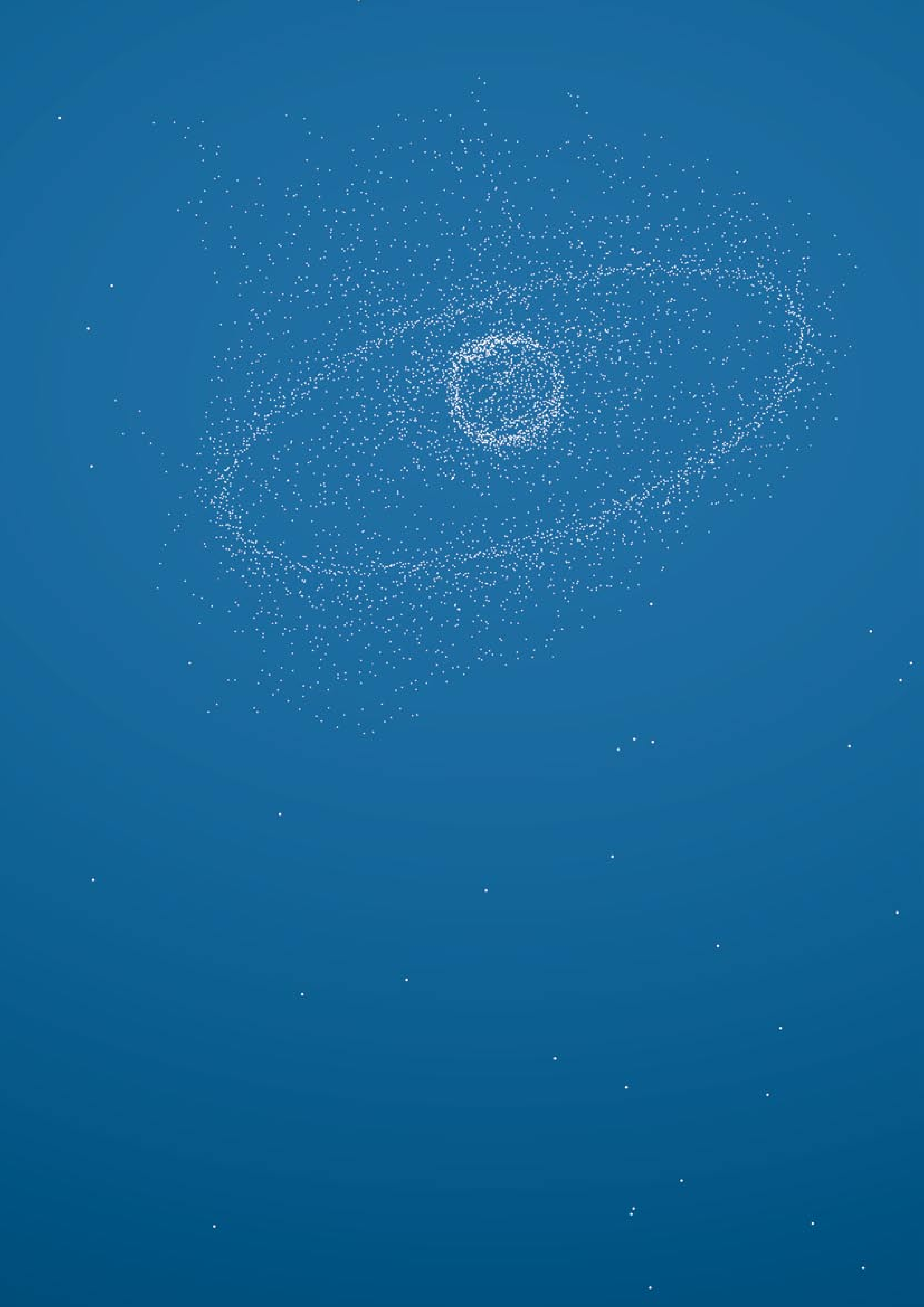
An Institute that is developing, and developing fast, needs to be managed with diligence and professionalism matching the excellence of its Fellows. As new Director (since September 2007) I have been greatly impressed by the achievements of the founders of the Institute, in particular its first director, Prof. Wolfgang A. Herrmann and its first managing director Dr. Günter Schmidt-Gess. To them goes the merit of having defined the basic ideas, setting up the first framework, and engaging the first Fellows.

Soon the staff was enlarged with Margaret Jaeger. Her impressive human and management competences have strongly boosted the scope of the Institute and provided for an environment that is appreciated by our Fellows as both engaging and efficient. Dr. Schmidt-Gess had to leave us in mid-2007 for a new position in Berlin. He was succeeded by Dr. Markus Zanner who brought with him a sturdy experience as a University science manager, in addition to a doctoral degree in Philosophy, which allows him to oversee the proceedings of the Institute in a conceptual fashion. Recently, Rebecca Innerhofer joined us as Institute Secretary, and we were happy to obtain the assistance of a new Program Manager, Stefanie Hofmann, and a Team Assistant, Sigrid Wagner. The very competent and promising new staff situation should allow the Institute to at least double in scope and people in the coming two years, potentially adding a score of new topics and Focus Groups.

The present annual report gives a summary of what we have achieved so far, including the start-up phase and the first Fellows who joined the TUM-IAS in October 2007. It documents how we have been able to attract Fellows in the different categories and the Focus Groups we have been able to set up. It is also organized in that order, our Fellows being our main asset, and they are presented thematically within their Focus Groups.

The success of the Institute should be measured by the research innovation it generates at TUM. Research units are evaluated by their research output, but how can innovation be gauged? High quality technological research is characterized by a combination of a keen sense of relevance and the knack for realizing an idea. The first is the high ideal, often inspired by a combination of technical know-how and societal relevance, the second reflects a strong sense of engineering realism. The success of the TUM-IAS will hopefully be measured by its idea(l)s in combination with its know-how to provide solutions.

Patrick Dewilde
Director



Presentation of TUM-IAS

Values and Ideas

What is Advanced Study?

While incremental scientific progress depends on disciplinary work according to a paradigm – that is, a matrix of set goals and defined methods, agreed upon by a distinct scientific community – revolutionary scientific progress that produces new disciplines, methods, and communities often requires ground-breaking work in the absence of such a paradigm. Advanced Study is scientific activity in novel fields that have not developed a sufficient paradigm to become disciplines. Science Historian Thomas Kuhn, who coined the phrase "scientific revolution", described the nascent state of a science as a "morass" in which the formative structuring of new thoughts can take place. About the study of electricity in the first half of the 18th century, he wrote:

> During [the first half of the eighteenth century] there were almost as many views about the nature of electricity as there were important electrical experimenters. [...] [A]ll were components of real scientific theories [...] drawn in part from experiment and observation. [However, there was general divisiveness, leading to unguided fact gathering, and this] produces a morass.
>
> Thomas Kuhn, The Structures of Scientific Revolutions, 1962

Naturally, progress in Advanced Study cannot be measured by conventional instruments, such as quantity and impact of publications. Rather, the importance of Advanced Study and its formative significance becomes apparent only in hindsight. At the TUM-IAS we encourage our Fellows to spend their time with fundamental considerations and experimentation that will shape their scientific activities in the years or even decades to come. The Institute thus strives to provide an ideal environment for thought experiments, creative scientific work and experimental trials without worries about immediate success and feasibility.
In the same way as the legendary IAS at Princeton University, TUM-IAS is based on the conviction that an atmosphere of creativity and inspiration, freedom and support without red tape for excellent scientists is the most fertile ground for outstanding progress. Endorsing such a policy, the founder of the first IAS at Princeton, Abraham Flexner, summed up his ideas on Advanced Study in an essay entitled "The Usefulness of Useless Knowledge" (1939), in which he described how science for its own sake,

simply in the pursuit of knowledge itself, ultimately has the greatest impact and utility. In an anecdote about a conversation with the industrialist George Eastman, founder of Kodak Company and inventor of the roll film, Flexner also referred to the study of electricity described by Thomas Kuhn in order to make this point. Not the inventors of the early 20th century, but the "useless" theoretical physicists of the 19th century who studied electromagnetism deserved the credit for technological progress:

> Mr. Eastman, a wise and gentle farseeing man, gifted with taste in music and art, had been saying to me that he meant to devote his vast fortune to the promotion of education in useful subjects. I ventured to ask him whom he regarded as the most useful worker in science in the world. He replied instantaneously: "Marconi."
> I surprised him by saying, "Whatever pleasure we derive from the radio or however wireless and the radio may have added to human life, Marconi's share was practically negligible.
>
> I shall not forget his astonishment on this occasion. He asked me to explain.
> I replied to him somewhat as follows:
> "Mr. Eastman, Marconi was inevitable. The real credit for everything that has been done in the field of wireless belongs, as far as such fundamental credit can be definitely assigned to anyone, to Professor Clerk Maxwell, who in 1865 carried out certain abstruse and remote calculations in the field of magnetism and electricity. [...] Finally in 1887 and 1888 the scientific problem still remaining—the detection and demonstration of the electromagnetic waves which are the carriers of wireless signals—was solved by Heinrich Hertz, a [physics professor at Karlsruhe].
> Neither Maxwell nor Hertz had any concern about the utility of their work; no such thought ever entered their minds. They had no practical objective. The inventor in the legal sense was of course Marconi, but what did Marconi invent? Merely the last technical detail, mainly the now obsolete receiving device called coherer, almost universally discarded.
>
> Hertz and Maxwell could invent nothing, but it was their useless theoretical work which was seized upon by a clever technician and which has created new means for communication, utility, and amusement by which men whose merits are relatively slight have obtained fame and earned millions. Who were the useful men?
> Not Marconi, but Clerk Maxwell and Heinrich Hertz. Hertz and Maxwell were geniuses without thought of use.

What is trans-disciplinary?

As scientific disciplines and even entire "sciences" keep evolving, Advanced Study often takes places between established disciplines. Thus, several scientific groups at the TUM-IAS are composed of scholars from different fields. In this context, a differentiation can be made between interdisciplinary and trans-disciplinary work. True inter-disciplinarity implies a close collaboration of scientists from different disciplines

such that their work, rather than being attributed to any of these established disciplines, converges in the formation of a field that develops its own agenda, methodology, and infrastructure. Trans-disciplinary work takes place whenever approaches from one single field are supplemented with the research expertise from entirely different fields for better understanding of the research subject. The development of an interdisciplinary approach and, eventually, a new discipline may be the result of a successful trans-disciplinary approach. Therefore, the TUM-IAS is a "knowledge exchange" among top-class scientists from TUM, industrial R&D labs, and institutions overseas.

"High Risk, High Reward"

"High Risk, High Reward" is in the mission statement of the Institute, whose goal it is to establish new disciplinary fields and strongly shape scientists' careers. On the whole, the TUM-IAS should not only establish room for creative freedom, but should also – within certain parameters – provide room for speculation and venture projects. These should develop areas in which, where possible, decisive scientific breakthroughs will be achieved in the coming years.

Our Work

The TUM-IAS is an “experiment workshop” for top researchers, a type of think tank in which scientists from different subjects work in small teams on issues of the future. The Institute is truly defined by the excellent scientists who carry the title of Fellow. The Fellows of the TUM-IAS include both senior- and early career-level scientists both from within the TUM and around the world, from industry as well as from academia.
As Institute Fellows, they define, establish, and develop new and promising research areas. Together, the IAS Fellows form a special community that leaves the door open for future intellectual and scientific exchange. In order to foster trans-disciplinary work and exchange of ideas, we strongly promote the formation of thematic focus groups of Fellows. Ideally, these teams would furthermore be diverse in terms of disciplines and gender aspects. Needless to say, the TUM-IAS will at all times be open to Fellows outside of such clusters, not least in order to guarantee a certain degree of scientific diversity. We promote an open dialogue with the scientific community beyond the usual disciplinary and departmental structures.

Perspectives and Goals

The TUM-IAS has the goal of establishing new fields of excellence in research at Technische Universität München. The concept is to allow not only selected guest scientists but also our best faculty members to conduct top-level research, while offering young scientists the chance to develop their talents in the inspiring environment of outstanding senior scientists. Because our Fellows have already displayed exceptional talent in their disciplines, the Institute gives them carte blanche in the development of new focus groups. They generate exceptional ideas and are encouraged to strike new paths off the beaten track of established fields of research. Out of such trail-blazing excursions, new research projects can emerge at any time. The Institute supports this creative process leading to the new and the not-yet-imagined.

TUM-IAS has made a novel contribution to the concept of Advanced Study by seeking to integrate engineering sciences and technology into an IAS. Almost all Institutes for Advanced Study, lacking large research facilities, are based in the theoretical sciences and the humanities. While the majority of Institutes for Advanced Study are solitary institutes, TUM-IAS Fellows have access to the TUM labs and the Garching High Tech Campus. Thus, it is the goal of TUM-IAS to include experimental sciences and engineering. In addition, TUM-IAS is expected to continue TUM's effort to establish humanities on campus with a special focus on their interrelations with science and technology.

History

On June 23, 2005, the German federal and state governments agreed on an initiative to promote top-level research in Germany. The Excellence Initiative aims at strengthening science and research in Germany in the long term, improving its international competitiveness, and raising the profile of the top performers in academia and research. For the first time in the German academic system, with its equally funded state-owned universities, an official identification of the top-level universities took place, based on performance and future planning.

As a result of extensive evaluation by international committees, the German Science Foundation (DFG) and Science Council (WR) granted several large research clusters and funding for a new Graduate School to TUM, which was recognized as one of the first three institutions to be awarded the “elite status” among German universities. The TUM-IAS is the centerpiece of TUM’s institutional strategy – “TUM. The Entrepreneurial University” – in terms of both structure and content. With about 25 million Euros the TUM-IAS constitutes the largest project within the Excellence Initiative and encompasses the entire university.

The TUM-IAS was formally established in 2005 as part of a competitive internal restructuring process called innovaTUM. The Excellence Initiative gave us the opportunity to develop the idea of the TUM-IAS and consider how an interdisciplinary Institute for Advanced Study would be designed under ideal conditions, reflecting the strengths of TUM, including engineering sciences and industry research, and reaching out to the humanities. Rather than distributing means among existing departments and institutes of TUM, the concept of the TUM-IAS is now based on temporary fellowships for internal as well as external researchers who operate under its roof.

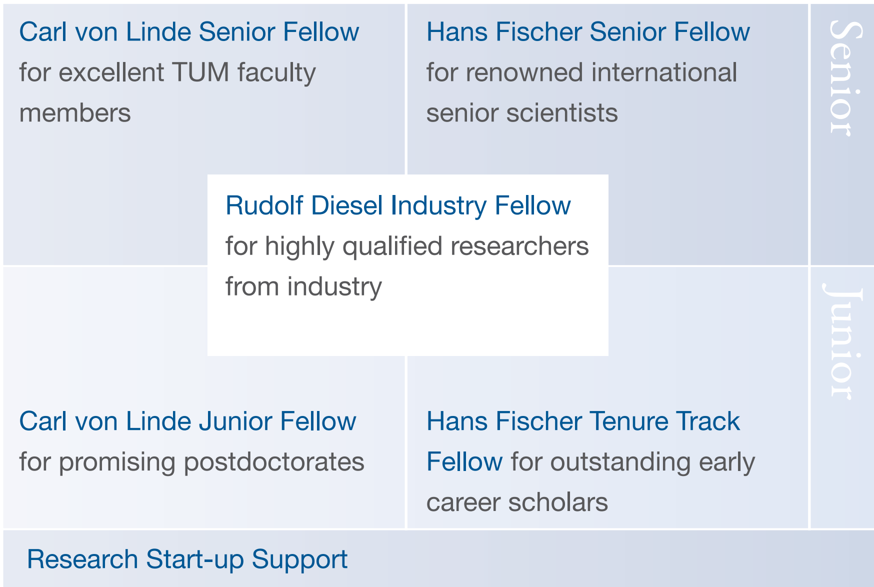
Visits to benchmark institutions, such as the Princeton IAS and the Peter Wall Institute at UBC Vancouver, and the organization of a management office began in fall 2006 with Günter Schmidt-Gess as managing director. Further staff members were recruited in 2007. In January 2007, the strategy and planning were presented to the governing Board of Trustees at their first meeting in Munich. Following recommendations of the Board,

we focused on the search for the first academic director, the planning of the Institute’s building, and the selection of a small, excellent group of Fellows. The first eight Fellows of TUM-IAS started their projects in October 2007. These Fellows gather in thematic focus groups, consisting of scientists from TUM but also including external Fellows.

The TUM-IAS continued its expansion in 2008. In addition to naming a new Director of the Institute and recruiting new employees for the management office, we named eleven outstanding scientists as new Fellows. Highlights throughout the year included several TUM-IAS-organized workshops and symposia, which received significant press coverage. Existing projects were expanded and new ideas were developed in these programs. In 2009 the Institute is developing along the same lines, the basis of which has already been laid at the end of 2008.

Fellowship Program

Five lines of fellowships determine the core of the Institute's activities. Through these programs, the TUM-IAS attracts Fellows from TUM itself (early career and senior level) and from abroad (also on both levels) plus industry Fellows. Qualified candidates for TUM-IAS fellowships must be

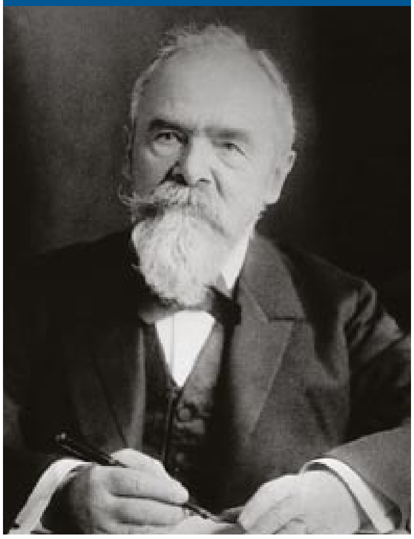


nominated, either by their Department Dean or, in the case of an external candidate, by the Department Dean of the host institute, at which the Fellow will spend his or her extended stay. Eligible for nominating candidates are also all further members of what is known as the Extended Board of Management of TUM, as well as all Members of the Board of Trustees of TUM-IAS. Candidates who are to expand an existing focus group are proposed by the members of the focus group directly to the management of TUM-IAS. The Institute evaluates the fellowship proposals it has received and collects information from experts in the field of the proposers (or neighboring field) so as to obtain an as clear view as possible about the quality of the submitted proposals. The views of these reviewers is assembled anonymously in a protocol together with a possible short response from the proposers. The finalized protocol is submitted to the Advisory Council (Delphi procedure) for ranking with other proposals.

Carl von Linde Senior Fellowship

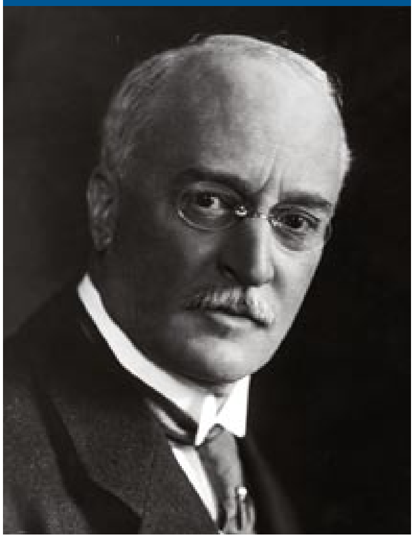
Eligible are TUM faculty members with a distinguished track record in research who intend to explore innovative, high-risk topics in their scientific research areas, if possible within a trans-disciplinary team. This fellowship is named after TUM Professor Carl von Linde (1842-1934) who invented air liquefaction and founded the "Linde's Eismaschinen" company in 1879. For a duration of 1 to 3 years, a work environment without teaching obligations or the bureaucratic burdens which typically are part of the daily routine at a university is created for the Fellows. This enables them to devote their time entirely to research. Financial support for Carl von Linde Senior Researchers consists of a qualified substitute professorship, coupled with one additional staff position (TVL-E13) for research. Additionally, € 50,000 of research related support without bureaucratic red tape is available to each Fellow.

Carl von Linde



Hans Fischer

Rudolf Diesel



Carl von Linde Junior Fellowship

Young postdoctoral researchers are eligible for this fellowship on the basis of excellence, such as an outstanding PhD thesis. Candidates may be former TUM graduate students or qualified young researchers who are integrated into a focus group of the TUM-IAS. Junior Fellows are full members of the scholarly community in TUM-IAS without any form of hierarchy. A significant time of the fellowship may be spent abroad at research institutions of the applicant's choice. The TUM-IAS offers postdoctoral fellowships lasting 3 years with the opportunity to fully devote one's time to research, completely unrestricted by teaching obligations. The fellowship comes with an employment according to the TVL-E14 pay scale. Fellows may interrupt existing positions at TUM and continue with their appointments afterwards. Additionally, € 100,000 of financial support for research related expenses without bureaucratic red tape are available to each Carl von Linde Junior Fellow.

Hans Fischer Senior Fellowship

Outstanding scientists from outside of TUM who intend to explore innovative, high-risk topics in their scientific research areas are eligible for the TUM-IAS Hans Fischer Senior Fellowship. The selection is based on a joint proposal by the nominee and a TUM host institution. This fellowship is named after TUM Professor Hans Fischer (1881-1945) who was awarded the Nobel Prize in Chemistry in 1930 for his pioneering work on haemoglobin and related structures.

The Hans Fischer Senior Fellowships last 3 years with the expectation that the Fellow will begin his/her fellowship with a longer stay at TUM (at least 6 months) and return to Munich for shorter stays frequently thereafter so that a total of at least 1 year will be spent at TUM. In this way, the TUM-IAS intends to further a lasting connection, preferably on an international level.

Support for Hans Fischer Senior researchers consists of a stipend of € 60,000 plus € 100,000 for travel, housing and research related costs. In addition, Hans Fischer Senior Fellows receive support for up to two PhD student stipends.

Hans Fischer Tenure Track Professorship

For selected outstanding early career scholars, the TUM-IAS offers the possibility to be employed as an assistant professor on a tenure-track. Proposals by a host department guarantee that once the candidate has completed his/her assistant professorship at TUM-IAS (typically after 5 years), a tenure position will be available at the host department, which will be offered to the candidate following a strict peer-review in his/her fourth year.

Even though the Hans Fischer Tenure Track Professorship is meant to provide ideal conditions for research and comes without teaching obligation, the Fellows are invited to offer courses and lectures. The young professors benefit considerably from the interaction with the most distinguished senior researchers at TUM-IAS.

Support for a Hans Fischer Tenure Track Professor consists of his/her salary according to the pay scale for assistant professors (W1) for up to five years, the funding of a research assistant, € 15,000 p.a. research support and an initial endowment from the funds of the Excellence Initiative (negotiable).

Rudolf Diesel Industry Fellowship

This fellowship line is experimental in its approach to reintegrate researchers from R&D departments into the academic context. A selected group of highly qualified researchers from industry will become Rudolf Diesel Industry Fellows. The fellowship includes the status as Temporary Affiliated Professor at TUM. The selection is based on a joint proposal by the applicant and a TUM host institution. This fellowship is named after Rudolf Diesel (1858-1913) who was a TUM student with Professor Carl von Linde. In 1897 Diesel invented the combustion principle named after him.

The purpose of the Rudolf Diesel Industry Fellowship is to strengthen collaboration between industry and research groups at TUM. Throughout the affiliation period, the Rudolf Diesel Fellows will offer special courses and lectures in their field of expertise. The fellowship duration is six months to one year, with the expectation that a lasting connection between the host institute and the industry partner will be established. While the TUM-IAS expects the company of the Fellow to support the reconnection of their researcher to academia by continuing his/her employment, up to € 50,000 in remuneration costs will be covered by TUM, supplemented by € 20,000 research funds.

Start-up Funding

The TUM-IAS awards a significant amount of research money (€ 1.5 million p.a. total) in addition to the funding via fellowships as a “start-up” support for high-risk, high-potential research projects.

TUM-IAS provides this initial seed funding for new projects that have potential for ground-breaking scientific success – even if they are high-risk. Outstanding scientific accomplishments are the primary selection criteria for this type of special sponsorship. The Earth Systems Engineering Group, for example, received start-up funding. In this group, scientists from various disciplines research the impact of humans and technology on the geological and ecological systems of Earth and search for new methods to bring technology and ecology into equilibrium.

Workshops and the funding of small research projects are important instruments in the TUM-IAS-strategy of incremental start-up funding of research. The basic idea is that low entry barriers for small-scale funding of kick-off events lead to the development of ideas for large-scale projects and eventually new TUM-IAS focus groups. By granting funding step-by-step without much red tape, quality management can be maintained without the burden of extensive research proposals and reports.

Presentation of Fellows and Focus Groups

Biochemistry

Biomedical Engineering

Biophysics

Fundamental Physics

Haptics and Active Adaptation

Nano Photonics

Neuroscience

Risk Analysis and Stochastic Modeling

Satellite Geodesy

Director’s Vision

Biochemistry
From Basic Research to Drug Development

Prof. Horst Kessler | Carl von Linde Senior Fellow

"Developing a rational way to convert peptides into orally available drugs is one of the most important issues in the pharmaceutical industry."
Horst Kessler

The main topics of our research are the development of cell adhesion molecules for improvement of biomaterials and molecular imaging, as well as NMR work, for understanding the function and interaction of proteins. We collaborate with a number of scientists in biochemistry, biophysics, and medicine, as well as with several industrial partners.

Specific cell adhesion and applications for improvement of biomaterials and for molecular imaging

Our main focus in drug research is on the development of new integrin ligands. Integrins are receptors for cell adhesion that are important in a number of biological processes. Malfunction of cell adhesion causes many diseases such as cancer or thrombosis; thus, integrin receptors are important targets for medical applications. Integrins bind to proteins in the extracellular matrix in a more or less specific way. A number of different integrin subtypes are involved in specific recognition of cellular surroundings. For medicinal applications, it is essential to develop molecules that bind with high affinity and receptor subtype selectivity to specific integrin receptors.

We have developed ligands that bind with super-activity to the $\alpha v\beta 3$ integrin but low affinity to $\alpha IIb\beta 3$. In the last decade these selective peptides have been modified and developed into the anti-cancer drug Cilengitide, into substances for coating of biomaterials, and into markers for molecular imaging of cancer. Currently, we are designing and synthesizing compounds that can also differentially bind members of the αv integrin family, e.g. $\alpha v\beta 3$ and $\alpha 5\beta 1$ receptor subtypes, both of which are involved in angiogenesis (formation of new blood vessels that support cancer metastasis via nutrition). In the last year, we achieved for the first time supreme selectivity for $\alpha 5\beta 1$ with minimal recognition of other integrins. We are continuing our work to discriminate in the opposite way (recognition of $\alpha v\beta 3$, but low affinity for $\alpha 5\beta 1$).

Further modifications have to be done in order to use these new ligands for coating of biomaterials or for molecular imaging. Among the necessary steps are creation of "homology models" of the structurally unknown integrin receptor subtypes, computer modeling of putative ligands, synthesis of the most interesting candidates, and biological verification. In this connection, we are now establishing an in-house bio-testing system because our collaboration partner, Jerini, has been sold and is not able to perform testing for us any more.

Additional ongoing work includes the exploration of different ligands in functional studies, the investigation of the role of the spatial distribution of binding ligands in the formation of focal adhesion clusters and

Horst Kessler
qualified as a professor ("Habilitation") at the Universität Tübingen through his proof of intramolecular motility through NMR spectroscopy. He was Professor in the Department of Organic Chemistry at the J.W. Goethe Universität in Frankfurt/Main and in the Department of Organic Chemistry and Biochemistry at TUM. At TUM, he was also the Faculty Dean for Chemistry, Biology, and Earth Sciences. Since October 2008 Kessler has been a Carl von Linde Senior Fellow at TUM-IAS.

cell mobility (with the biophysics group of Prof. J. Spatz, MPI Stuttgart) and cell signalling (with Dr. U. Reuning, Womens Hospital, Klinikum rechts der Isar, and Dr. B. Geiger, Weizmann Institute, Israel). Coating of surfaces is done in collaboration with Prof. R. Gradinger and Dr. R. Burgkart (Orthopedia, Klinikum rechts der Isar), Prof. D. Wedlich (Karlsruhe) and Prof. C. Sukenik (Bar-Ilan-University, Israel).

It has been shown that cells anchor via multimeric binding with spacing between binding sites smaller than 65 nm and move along concentration gradients of ligands. These observations are important not only from a scientific point of view but provide basic knowledge for the design of improved biomaterials.

Our "^{18}F-Galacto-RGD" ligand, which is used in the Klinikum rechts der Isar for imaging cancer metastasis (with Prof. M. Schwaiger), allows monitoring of the healing process after myocardial infarction via Positron-Emission Tomography (PET). This approach uses the ability of PET to quantify receptor densities in vivo in man.

Oral bioavailability of peptides via multiple N-methylation

A huge number of bioactive peptides have been found in recent decades that might be powerful drugs against a number of diseases. However, the low stability of peptides in the blood serum and the lack of uptake when peptides are given orally prevent many medicinal applications. Hence, developing a rational way to convert peptides into orally available drugs is one of the most important issues in the pharmaceutical industry. We have previously shown that small and cyclic bioactive peptides are stable against enzymatic cleavage.

Recently, we found that multiple N-methylation of peptide bonds not only need not interfere with biological activity but also can make the modified cyclic peptide stable against the most aggressive enzymes in the gut. In one case, uptake from gut into the blood stream was also observed (oral availability). We have now – in particular by the development of improved synthetic methods – paved the way for a systematic application of multiple N-methylation in order to improve pharmaceutical properties of peptides.

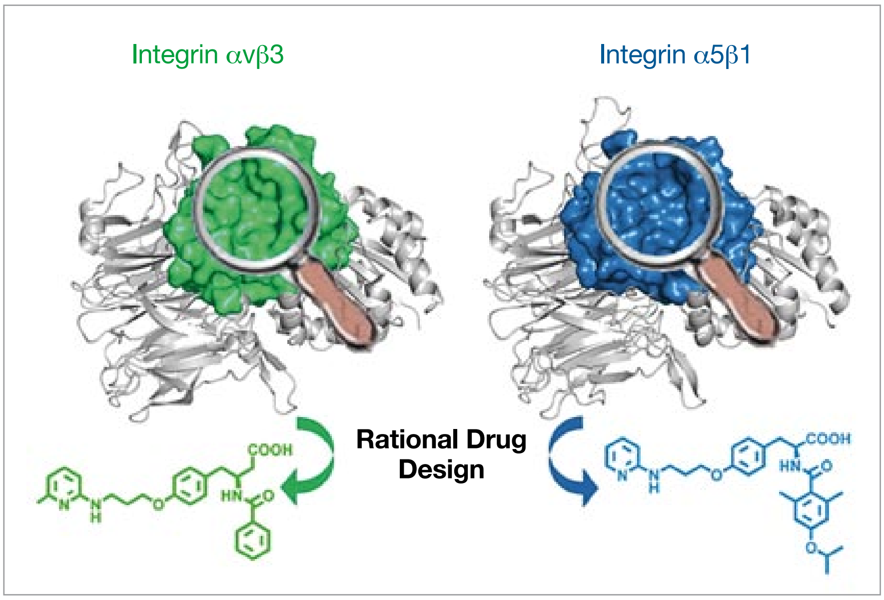
NMR technology and applications in drug research and biochemistry

With the help of sophisticated NMR techniques, screening of a huge number of chemical compounds for affinity to medicinally relevant targets is possible. We recently have used ^{31}P (phosphorous) nuclei for this purpose, a procedure that has many advantages over existing techniques in specific cases.

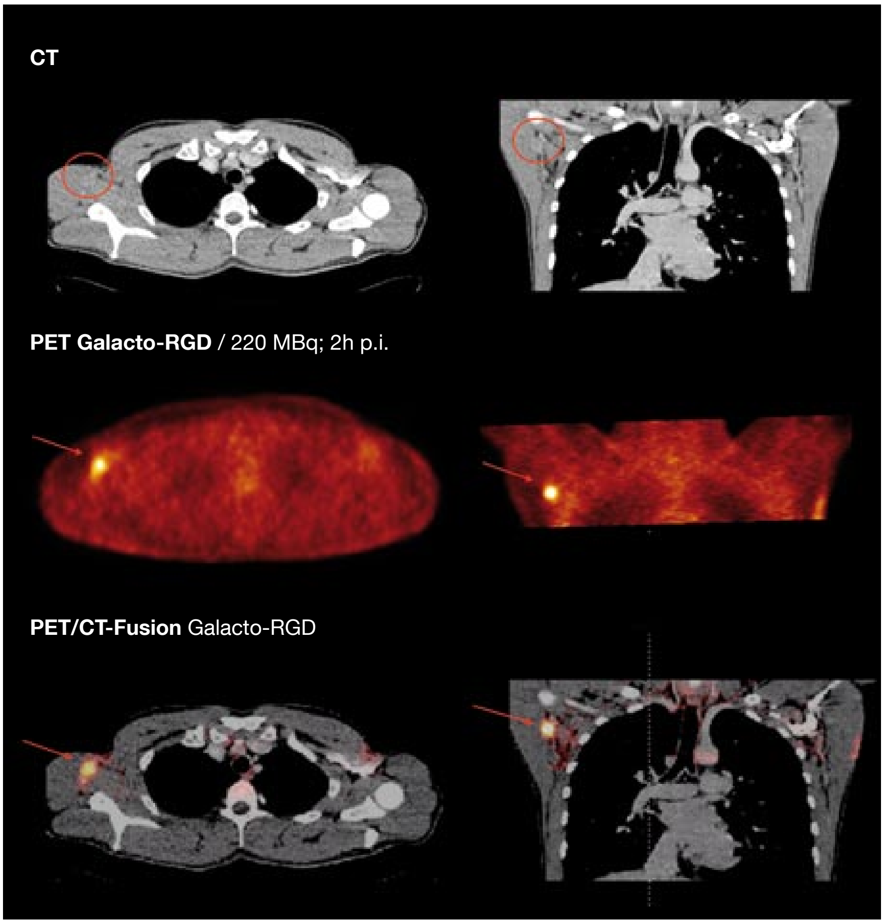
Finally, protein folding intermediates have been structurally elucidated in collaboration with Prof. J. Buchner (TUM) and others to understand differences in proteins of the immunoglobulin family that often form toxic misfolded aggregates (amyloids).

Development of selective integrin ligands

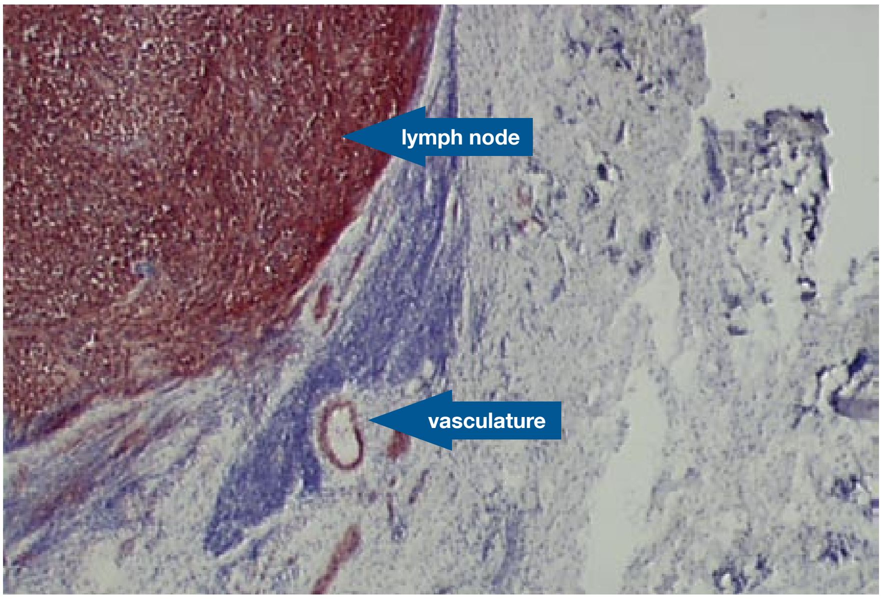
Integrins are a family of cell adhesion receptors which attach cells onto the extracellular matrix and, through the cells, perceive their surroundings. The bonding of their natural ligands is an important deciding factor on whether a cell proliferates, progresses to apoptosis (natural cell death), or emigrates.



[18F]Galacto-RGD
Axillary Lymph Note
Metastasis / Melanoma



Immuno-histochemistry of αvβ3-positive lymph node obtained after surgery



Biomedical Engineering

Prof. Walter Kucharczyk | Hans Fischer Senior Fellow

A major research interest of mine is in the field of minimally invasive image-guided therapeutics.

For the past many years at the University of Toronto, I have collaborated with a multidisciplinary team of radiologists, surgeons, radiation oncologists, medical physicists, and engineers in a research program called

Guided Therapeutics or GTx. I was a co-founder of this program. The common theme across all facets of GTx is to develop advanced imaging methods to detect, characterize, and diagnose diseased tissue early in the course of the disease process, so as to maximize the probability of cure. We also seek to treat the disease or "target" we discover wherever it may occur in the body, using very small devices and novel image-guided methods, so as to cause minimal or no damage to surrounding normal tissue. These methods include transcutaneous MR-guided, high-intensity focused ultrasound of breast cancer and bone metastases; trans-perineal interstitial laser ablation of early prostate cancer; and radio-frequency ablation of liver and renal tumors. The reason that imaging is critical to all these procedures is that the targets are deep in the body and can only be seen using methods such as MRI or CT. Conventional surgical treatment would entail considerable damage to normal surrounding tissues as the surgeon must traverse much tissue just to get to the small, deep target.

Prof. Walter Kucharczyk graduated from the University of Toronto's Faculty of Medicine and undertook specialty training in radiology in Toronto, followed by subspecialty training in neuroradiology and magnetic resonance imaging at the University of California. He became the inaugural Director of Magnetic Resonance Imaging (MRI) at what was then the Toronto General Hospital. He has remained Director of MRI ever since. At the University, he became Professor and Chair of the Department of Medical Imaging, a position he still holds today. Since October 2007 Kucharczyk has been a Hans Fischer Senior Fellow at TUM-IAS (Host: Prof. Tim Lüth, Micro Technology and Medical Device Technology, TUM).

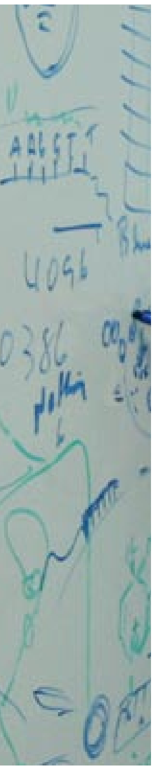
Some doctors have developed great expertise in understanding complex geometries, mentally fusing data from several different imaging sources and using free-hand methods to guide hand-held devices to image-defined targets. But there are many inaccuracies to the procedures, and often many attempts are required to achieve proper targeting. This exposes the patient to increased risk, and the doctor to increased radiation, for example by being beside the patient while multiple CT scans are performed to check the position of a partially inserted treatment device. We seek to develop and use automated image-navigation systems coupled with remotely controlled devices and simple robotics to make these procedures faster, more accurate, and less risky to the patient and the doctor. Professor Lüth at MIMED at TUM shares these same objectives. As a Fellow of the TUM-IAS I worked with Prof. Lüth on these ideas, and we planned a series of staged developments to achieve our objectives.

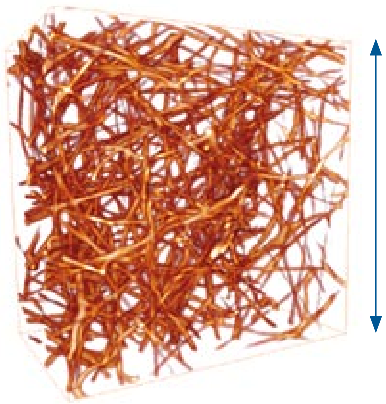
Our first project was to develop new software for fast guidance assistance for CT-guided procedures such as biopsies, for use with a navigation system that Prof. Lüth had developed earlier. With Matthias Markert and other students of Prof. Lüth's, we were successful in developing the software and adapting commercially available associated devices, such as biopsy needles, for the uses we intended. The method was tested and shown to be feasible and accurate with our collaborator Dr. Ralf-Thorsten Hoffmann at Klinikum Grosshadern in Munich. I am now carrying out further tests on the system at my own hospital in Toronto. If these tests are successful, I will seek approval from our Research Ethics Board to test the method on patients. I will continue to collaborate with Prof. Lüth to refine the system and extend the research program to other procedures. Our next steps will be to add remote control to the procedures and to fuse image data from other sources, such as ultrasound and MRI, to enable a broader scope of advanced applications.

One of the most fascinating aspects of my research project at TUM-IAS has been learning once again that despite medical practitioners often having excellent ideas about technical, engineering, and scientific developments that would improve patient care, they lack the knowledge to do all the required research themselves, and they also lack the contacts, collaborators, and time for multidisciplinary collaboration with other scientists and engineers. My fellowship at TUM-IAS reinforced the importance of “time to think” and collaboration with experts in other fields as great enablers for research. TUM-IAS provided me with this time to think, unfettered by other responsibilities, and provided me with excellent opportunities to meet and work with experts in other fields. I am sure that had I been at the TUM-IAS longer, especially once it was firmly established – with regular meetings among Fellows with one another and with each other's students – this cross-fertilization would have been even greater.

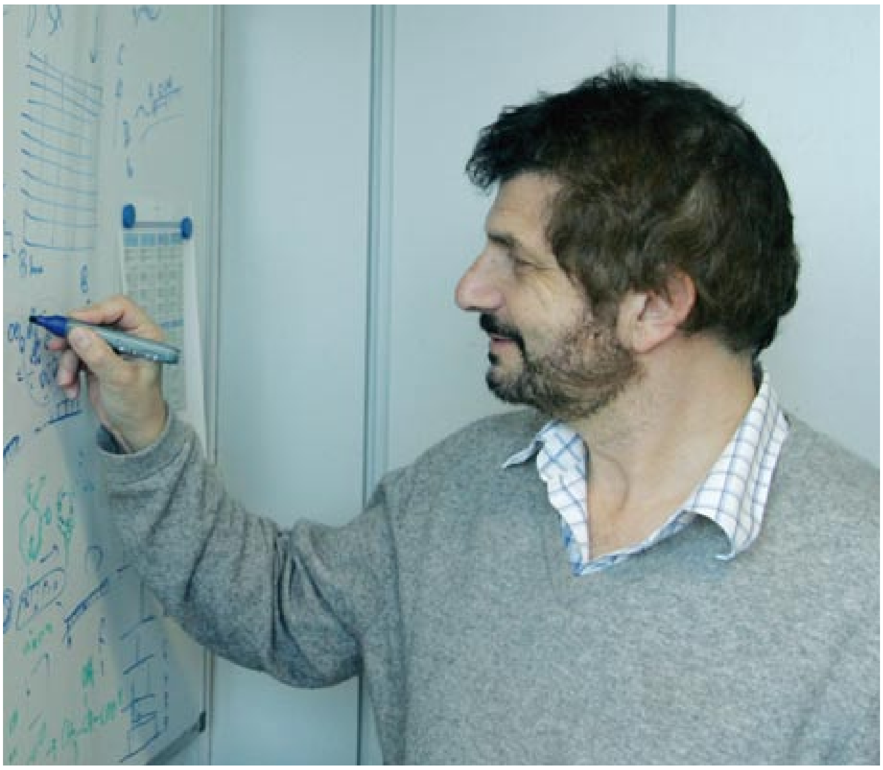
Biophysics

Prof. David A. Weitz | Hans Fischer Senior Fellow





Confocal microscopy image of network similar to those found in cells. A cargo the size of the arrow must be pulled through this network by molecular motors.



I have been working on several inter-related projects. The first is part of an ongoing attempt to decipher the design principles used by nature to construct living matter. Nature has had a very long time to allow evolution to learn and refine design principles that enable living creatures to sustain and control motion, while still being sufficiently elastic to withstand the inevitable forces of gravity and other natural occurrences in life. How does nature do this? What are the design principles that nature has learned? Can we learn from these to design our own materials?

To address these questions, we are attempting to mimic the structure found in living cells and assemble model, reconstituted systems that enable us to test specific designs by reconstructing the same behavior found in nature. Our current focus is on the mechanisms that nature uses to transport materials through living cells. We are building a model system that contains motor proteins that the cell uses for materials transport. We include a model of the highway or track for these proteins. We also include a substructure, found in all cells, that provides some of their mechanical rigidity. We then incorporate small probe beads into the system that play the role of the cargo: The motor protein pulls the cargo along the track.

The important question we wish to address is how the cargo is able to move through the mechanical substructure. It forms a rather tight meshwork that should block the transport of the cargo; however, we know that cargo transport does occur. How? Do the motor proteins exert sufficient force to break the network? Or can they simply push the network aside? Understanding these questions will provide new insight into how nature can achieve a strong, rigid structure that is nonetheless sufficiently flexible to allow the transport of cargo through it.

We have successfully constructed an initial model system where we use reconstituted proteins to form the different structures that we wish to model. Now we are developing methods to make the requisite measurements. As part of this, we intend to construct a new form of optical microscope that uses non-linear optics to dramatically improve resolution. Normally, the resolution of optical microscopy is limited by wavelength of light, which is of the order a micron.

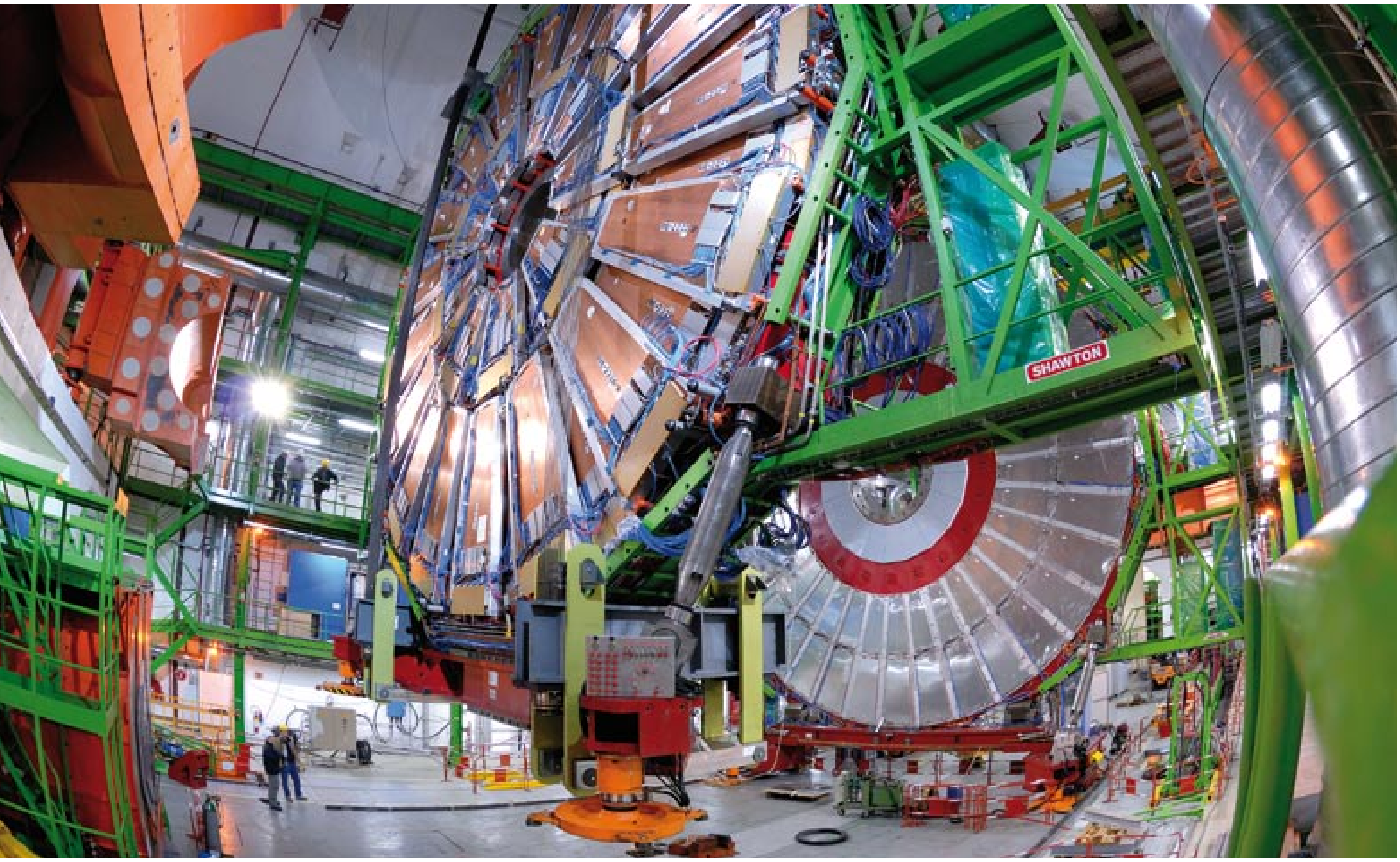
However, new developments using non-linear optics enable the resolution to be dramatically improved, to well within the nanometer range; hence it is truly not microscopy but nanoscopy. Nanometer resolution would be ideal for our experiments: We would be able to directly model the reconfiguration of the network structure as the motors transport cargo through it. We intend to construct a new "nanoscope" which will qualitatively improve our ability to investigate nature's design principles.

The time and resources available to TUM-IAS Fellows have made this work feasible. Moreover, the interdisciplinary character of the Biophysics group at TUM is essential for enabling me to address this class of question.

Prof. David A. Weitz
received his Ph.D. in physics from Harvard University. He worked as Professor of Physics at the University of Pennsylvania and at Harvard University. Today, Weitz is Director of the Harvard Materials Research Science & Engineering Center, in addition, he is Mallinckrodt Professor of Physics & Applied Physics at Harvard University and Professor in the Department of Systems Biology. Since October 2008 Weitz has been a Hans Fischer Senior Fellow at TUM-IAS (Host: Prof. Andreas Bausch, Department of Physics, TUM).

Fundamental Physics

Prof. Andrzej Buras | Carl von Linde Senior Fellow
Dr. Martin Gorbahn | Carl von Linde Junior Fellow



Lowering of the YE+2 end-cap for CMS

The Fundamental Physics focus group at the TUM-IAS explores the limitations of the current Standard Model of particle physics in order to arrive at a more powerful theory.

As the first results of the Large Hadron Collider (LHC) at CERN should soon become available, and several high-precision experiments in Europe and Japan either are in operation or will be active in the coming decade, we expect a number of open questions in physics to be answered, setting the future direction of research in fundamental physics. Our focus group will use the experimental data from both LHC and these high-precision experiments, in conjunction with novel theoretical ideas, to construct and test specific scenarios of new physics beyond the Standard Model at very short distance scales. Indeed, particle physics stands on the threshold of a new and exciting era of discovery and we intend to take part actively in these fascinating new developments.

Elementary Particle Physics as of 2009

The main goal of elementary particle physics is to establish the fundamental laws of nature down to the shortest accessible distances. In the 19th century, well before elementary particle physics was born, it was possible with the help of ordinary microscopes to explore distances down to micrometers, 10^{-6}m. During the 20th century, dramatic progress was made in the exploration of very short distances and the physical laws governing them. With the development of quantum mechanics and subsequently quantum field theories, it became evident, through Heisenberg's uncertainty principle, that in order to probe ultrashort distances it is necessary to perform high-energy collisions – of protons with protons or antiprotons, electrons with protons, electrons with positrons, and so on.

> “ The main goal of elementary particle physics is to establish the fundamental laws of nature down to the shortest accessible distances.”
> *Andrzej Buras*

Alternatively, the study of very rare processes governed by quantum fluctuations, such as certain decays and transitions involving bound states of quarks and antiquarks (K and B mesons), could also be used for this purpose, requiring this time not high energies but very high precision. A given theory of elementary particle physics must be able to accommodate and even predict the outcome of both high-energy collision experiments and very high-precision experiments that involve rare processes. These two routes to very short distances, while being complementary, must reveal the same physical laws.

In the second half of the 20th century, dramatic progress in technology and computers, accompanied by novel ideas of experimental and theoretical particle physicists, made it possible to construct a theory of elementary particles (quarks and leptons; see Table 1) and their interactions mediated by the gauge bosons (electromagnetic, weak and strong; see Table 2) by utilizing the two routes of high-energy and high-precision exploration. This theory, known under the name of the Standard Model of elementary particle physics, is capable of describing most of the observed phenomena down to the scales 10^{-17} to 10^{-18}m.

	quarks		**leptons**	
Generation	up-quarks	down-quarks	neutrinos	electrons
1.	u	d	ν_e	e^-
2.	c	s	ν_μ	μ^-
3.	t	b	ν_τ	τ^-

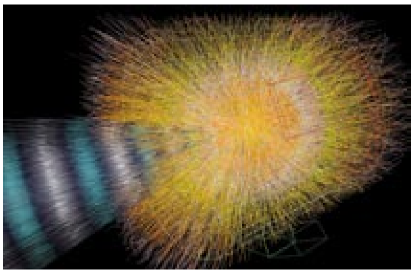
Table 1: Ordinary matter is grouped together into an object called a generation. Each generation contains an up-type quark, a down-type quark, a neutrino-type lepton, and an electron-type lepton. Apart from the mass of its particle, each generation is an exact copy of another generation. The particles are grouped so that the particles in the first generation are lightest and the ones in the third generation are heaviest.

While very successful in describing many phenomena, the Standard Model cannot be the final theory, as a number of facts observed in nature, such as large hierarchies in the masses of elementary particles and their interactions, are put into this model by hand. The violation of certain symmetries in nature can at best be parametrized by this model, but not really explained. Two prominent examples of breakdowns of symmetries that require further explanation are the violation of the so-called electroweak symmetry – related to the "Higgs particle" and to the mass generation – and the violation of the so-called CP symmetry related to the matter-antimatter asymmetry in the universe, which is responsible for our existence. Moreover, "dark matter" present in the universe is absent from this model.

Now, in spite of its deficiencies, the Standard Model is capable of predicting that at even shorter distances than those studied so far (10^{-19} to 10^{-20}m), whose exploration requires even higher energies and even higher precision than have been achieved to date, new phenomena beyond this model will take place that will definitely help to explain some of the most outstanding open questions and to construct a more powerful theory.
It will be possible to explore this new region of short distances with the help of the Large Hadron Collider and several high-precision experiments around the world, leading – we expect – to a revolution in our understanding of nature.

Interaction:	strong	electromagnetic	weak
Gauge bosons:	gluons	photons	$W^{\pm}$-bosons and Z^0-boson

Table 2: The interactions of the Standard Model are mediated by particles (gauge bosons). The massless photons are responsible for the electric and magnetic interactions of everyday life. So-called electroweak symmetry breaking makes the $W^{\pm}$-bosons and Z^0-boson massive, such that the weak interaction acts only at short distances (10^{-17}m).



Strategy

Direct searches at the high-energy frontier and indirect searches at the high-precision frontier will shed light on the more fundamental theory. New particles and new elementary forces present in this theory should help in removing the deficiencies of the present Standard Model. Yet the properties of these new particles and their interactions have to be tested through various quantities in both high-energy collisions and high-precision experiments, and in order to achieve this goal, extensive and often very difficult and innovative calculations have to be performed.

The Fundamental Physics group at TUM-IAS pursues two main goals: to build predictive theoretical models of new physics containing new particles and new fundamental interactions that would solve the aforementioned problems of the Standard Model; and to work out the predictions for high-precision experiments involving quarks and their bound states (K and B mesons) and to correlate them with the findings at the Large Hadron Collider in order to confirm or to falsify different scenarios of new physics. To this end, in addition to the groups of Prof. Andrzej Buras (Carl von Linde Senior Fellow since 2007) and the group of Dr. Martin Gorbahn (Carl von Linde Junior Fellow since 2008), we plan for two Hans Fischer Senior Fellows and two additional Carl von Linde Junior Fellows to take part in these activities.

Present Activities

Prof. Andrzej Buras

The group of Andrzej Buras investigates presently a number of avenues beyond the Standard Model with the main goal of identifying those extensions of this model that, on the one hand would agree with the results of present experiments, and on the other hand would provide solutions to the outstanding problems. In particular, supersymmetric models and models with an additional (4th) space dimension are investigated. Each of these models predicts the existence of new particles, such as new heavy quarks and leptons and new heavy gauge bosons, implying new elementary interactions.

These new interactions in turn have an impact, through quantum fluctuation, on the rates of K-meson and B-meson decays that will be measured with high precision in the coming years. The main result of these intensive studies is the finding that supersymmetric models and models with an additional space dimension imply rather different patterns of deviations from the Standard Model predictions for the decay rates in question. In particular, the predicted rates related to violation of the CP symmetry can deviate from the Standard Model expectations in a spectacular manner. The interplay of these findings with the direct search for new particles at LHC may give a clear direction for new laws in nature that govern very

Model of an LHC superconducting dipole magnet

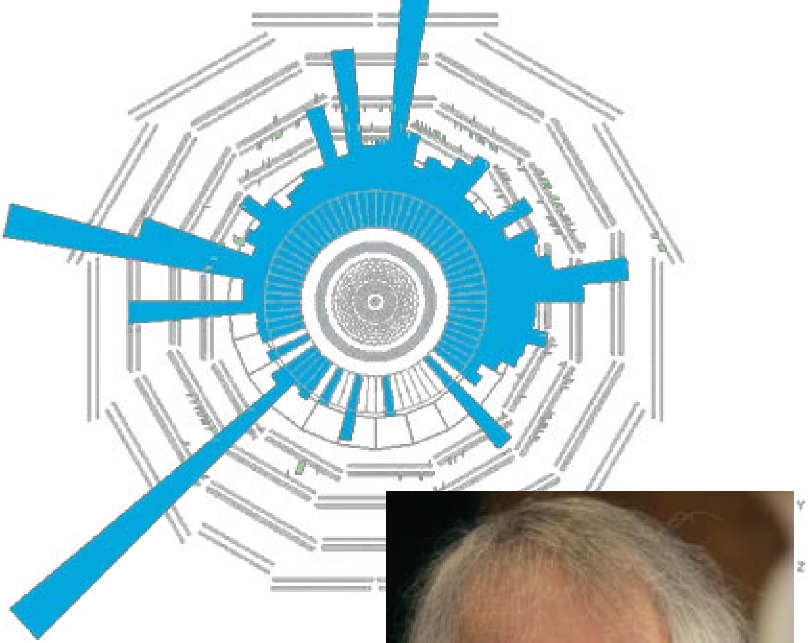
Transport of a magnet from LHC sector 3-4 to the surface in order to be repaired

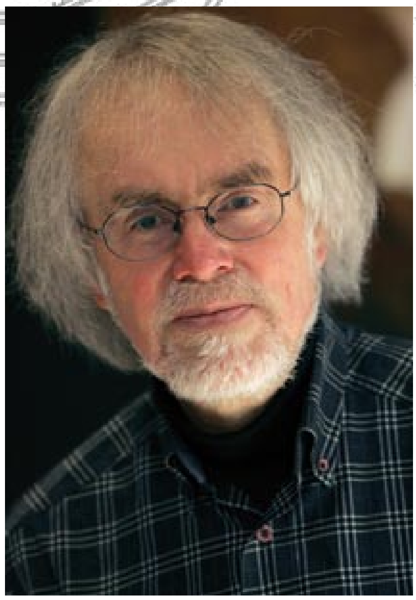
A simulation of a lead ion collision in ALICE short distance scales. These investigations resulted in 11 publications in 2008, and their results have been presented at various international conferences. In the Andrzej Buras group, five postdoctoral researchers and ten Ph.D. students are actively participating in the project.

Dr. Martin Gorbahn

In his first months at TUM-IAS, Martin Gorbahn and his group have been working on a particular extension of the Standard Model: the minimal supersymmetric Standard Model (MSSM), a theory that can explain the dark matter found in the universe and can improve the understanding of the breakdown of the electroweak symmetry. The MSSM predicts many new heavy particles that could be detected at LHC. In particular, there are new Higgs particles, with properties that differ significantly from those of the Higgs particle of the Standard Model. These properties can be best measured in high-precision experiments of rare B meson decays, and their study requires very involved calculations of quantum corrections. The group has computed these corrections and proposed how these results could be efficiently used in conjunction with high-energy collider experiments at LHC.

However, the MSSM, for all its merits, suffers from a major drawback. In its most generic form, it suffers from too many new parameters that can be extracted from experiments but cannot be predicted by this theory. The number of new parameters can be drastically reduced by assuming a pattern of unification of the strong and electroweak interactions (the so-called Grand Unification of forces and matter). Extensive studies in this direction are now in progress. Another focus of this group is calculating strong interaction corrections to rare decay processes. Here there is close contact with the Andrzej Buras group. The Martin Gorbahn group, with one postdoctoral researcher and one diploma student at present, is expected to gain up to two more Ph.D. students.

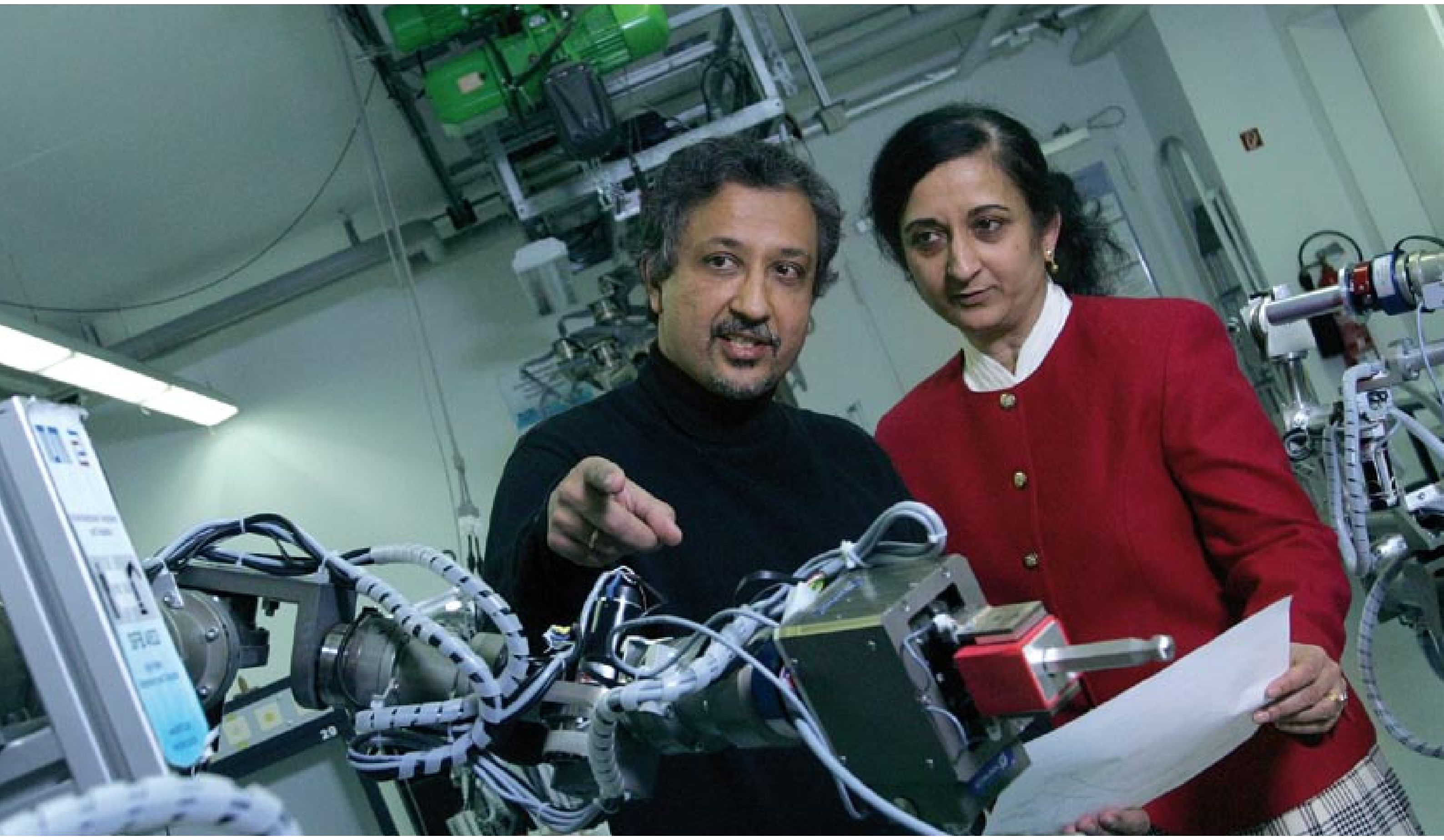




Prof. Andrzej Jerzy Buras
is Professor in the Physics Department at TUM. Since October 2007 he has been a Carl von Linde Senior Fellow and the Leader of the Focus Group “Fundamental Physics” at TUM-IAS. Buras received his Ph.D. degree in High Energy Theoretical Physics from the Niels-Bohr-Institute in Denmark. He worked in the Theory Group at CERN, the Fermilab Theory Group and the SLAC Theory Group. Buras also joined the Max-Planck-Institute of Physics in Munich and received an appointment to the TUM in 1988.

Dr. Martin Gorbahn
was awarded his Ph.D. degree at TUM in 2003. He has worked at the Institute for Particle Physics Phenomenology at the University of Durham as Research Associate and at the Institute for Theoretical Particle Physics at the Universität Karlsruhe. In October 2008 he returned to the TUM Department of Physics as a Carl von Linde Junior Fellow at the TUM-IAS.

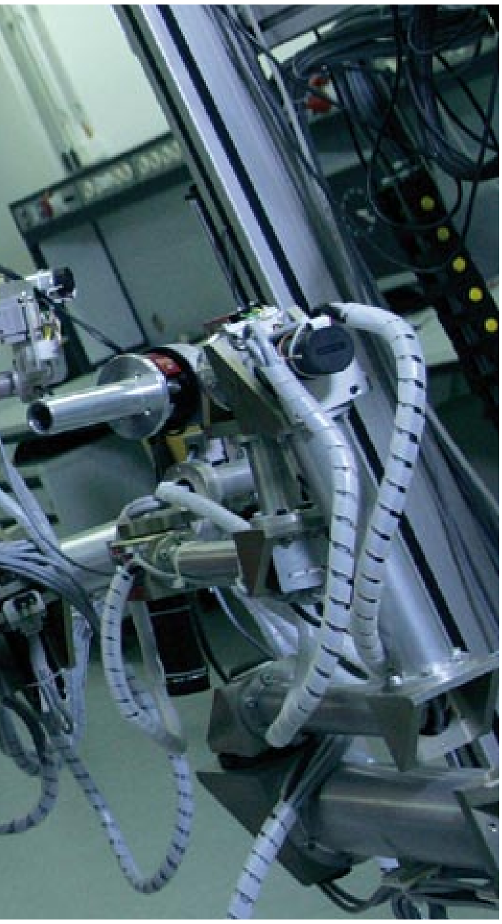
Haptics and Active Adaptation



Telehaptics for Nanoassembly: Reaching into the nano-world

Prof. Mandayam A. Srinivasan | Hans Fischer Senior Fellow

The multidisciplinary research in our project is driven by this basic question: Is it possible to develop a system of computer interfaces through which a user can be immersed in nanoscale environments, so as to touch, manipulate, and assemble nanostructures as easily as we handle objects in our macroscopic world?



Just as the optical microscope extended our vision into the microworld, the system we propose would extend our reach into the nanoworld, to enable "learning by doing" in nanoscale. It should therefore rapidly increase our ability both to understand nanoscale mechanisms and to synthesize novel nanostructures. We can then expect significant impact in a wide variety of fields ranging from materials science to microbiology to nanomedicine.

As we started exploring possible solutions, recent dramatic advances in what superficially appear to be unconnected fields provided inspiration for the design and development of a system. Scanning probe microscopy, as in the atomic force microscopy where a probe tip is in physical contact with an object's surface, can achieve spatial resolution of the order of nanometers during high precision scanning. Telesurgical systems – in which the surgeon operating a "master" robot using human-scale motions controls a "slave" robot that operates on a patient with scaled-down motions – have caused a revolution in certain types of minimally invasive surgeries requiring high precision. Haptic interfaces that enable a user to touch, feel and manipulate virtual objects through force feedback offer a remarkable sense of realism and immersion in virtual worlds. We believe that an optimal combination of such technologies, together with appropriate control software design, would enable us to interact with micro- and nano-scale objects in an unprecedented manner.

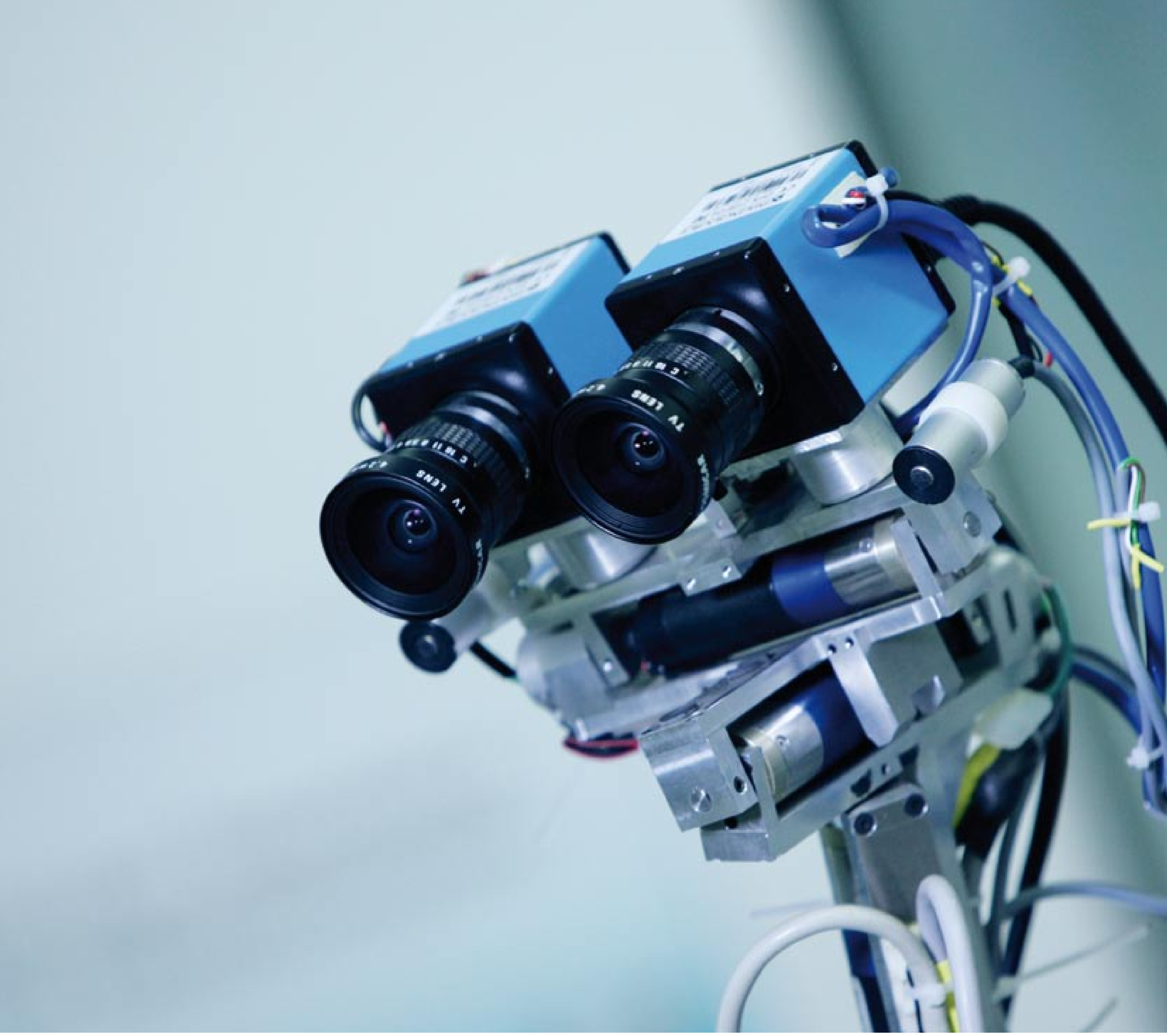
We were able to start our research shortly after proposing the project because of the strong encouragement and financial support provided by TUM-IAS upper administration, through judicious and bold decisions free of bureaucratic delays. From proposal to system design and development, we were able to make rapid progress thanks to the high-quality time for research freed up through the Hans Fischer Senior Fellowship. Equally significant was the uniform support in terms of space, resources, and free access to expert knowledge generously provided by several professors at TUM (Prof. Martin Buss, Prof. Paolo Lugli and Dr. Giuseppe Scarpa) and researchers at Helmholtz Zentrum (Dr. Stefan Thalhammer) as well as personnel at Attocube (Prof. Khaled Karrai, Florian Ponnath), a local nanosystems company. These collaborations engender thought-provoking discussions and rapid learning in new fields. On the basis of decades of research experience, I am convinced that this project would have taken years to get started anywhere else. Here it took only a couple of months because of the special cluster of high-quality institutions in Munich and the adventurous spirit of their people.

Adaptation in Complex Networked Systems: From human beings to "smart grids"

Prof. Anuradha Annaswamy | Hans Fischer Senior Fellow

The hallmark of complex systems that are required to perform well amidst uncertainties is self-governance through judicious use of information. Space probes, autonomous underwater vehicles, aviation systems, and industrial robots have this much in common with human beings. Development of better analytical tools for understanding such systems should lead to more effective synthesis for scientific and technological purposes. My research addresses fundamental principles with an eye toward practical applications, such as the creation of intelligent power grids. Decision-making processes in complex adaptive systems are often characterized by decentralization, hierarchical architecture, and multi-layered information processing, with distinct time-scales and length-scales. Be it in biology, physics, chemistry, or engineering, a blueprint for smart operation in these systems includes many or all of the above features. Creating robust artificial systems of this kind requires the realization of fault tolerance, utilization of information via an intricate network of data, monitoring using appropriate devices, and controllers that process information and suitably direct the system's performance. Analyzing such systems requires the development of suitable theoretical tools, including complexity theory, distributed parameter systems, asynchronicity, graph theory, and hybrid systems.

The research project my group will carry out under the umbrella of TUM-IAS aims to develop fundamental mathematical tools for exploring the role of adaptation in complex systems. While adaptation is well understood in the innermost loops of feedback control for regulation and tracking, no one has even articulated a rigorous description of decision making at all levels using the notion of adaptation. My goal is to explore this concept in hierarchical, network-based, and decentralized dynamic systems. While most of the research activity will focus on fundamental building blocks of complex systems, the research context will be two disparate real-world systems: smart power grids comprising heterogeneous energy sources and the interplay of human perception and action. Two Ph.D. students have been hired as a part of the fellowship to explore the smart-grid problem in greater detail. In relation to the second topic, human perception-action models, we are in discussion with members of the excellence cluster on Cognition for Technical Systems or CoTeSys. Given that a majority of the current research problems in science and engineering are interdisciplinary in nature, the Hans Fischer Senior Fellowship is a unique opportunity to tackle fundamental problems whose resolution can impact a wide range of applications outside one individual's expertise. The fellowship has enabled me to study and explore – and possibly even create – new areas that I would rarely have time to investigate in my laboratory at MIT.



“ Just as the optical microscope extended our vision into the microworld, the system we propose would extend our reach into the nanoworld, to enable ‘learning by doing’ in nanoscale.” *Mandayam A. Srinivasan*

"The hallmark of complex systems that are required to perform well amidst uncertainties is self-governance through judicious use of information. Space probes, autonomous underwater vehicles, aviation systems, and industrial robots have this much in common with human beings."
Anuradha M. Annaswamy

Human Robot Interaction: The haptic "handshake"

Prof. Mandayam A. Srinivasan, Prof. Anuradha M. Annaswamy

Rapid progress in information technology, together with miniaturization of sensors and actuators, has contributed to continuous improvement in the capabilities of robots. While deployment of autonomous robots in factory assembly lines as well as for home vacuuming and entertainment has met with varying degrees of success, the proverbial robot butler has proven elusive. Design and development of "cognitive" robots that can work collaboratively with humans in unstructured environments is being pursued vigorously at TUM-LSR (http://www.lsr.ei.tum.de/) and collaborative institutions within Germany as well as through several large European Union projects.

On the basis of research presentations that we were kindly invited to – either during several days of meetings of all collaborating partners or weekly seminars given by TUM-LSR students funded by the projects – we have identified two common themes relevant to our respective areas of expertise that have the potential to open new research paradigms: the need to develop robust mathematical models of human haptic behavior and the need to incorporate sophisticated adaptation algorithms into robot haptic behavior. Human haptics pertains to information acquisition and object manipulation through touch, primarily through our hand-brain system. Understanding human haptic behavior involves multiple fields such as mechanics, neuroscience, psychophysics, and motor control. A reliable mathematical model of human haptic behavior would serve two purposes: as a tool for predicting human actions so that a robot can react appropriately and as a target for a robot to emulate in order to improve its own performance. Although we know that human behavior, even when limited to haptics, is quite complex, there is growing literature consisting of both experimental data and models for limited sub-domains. Through unification of existing models and further model development based on new, targeted experiments, we hope to improve our ability to understand and predict human haptic behavior.

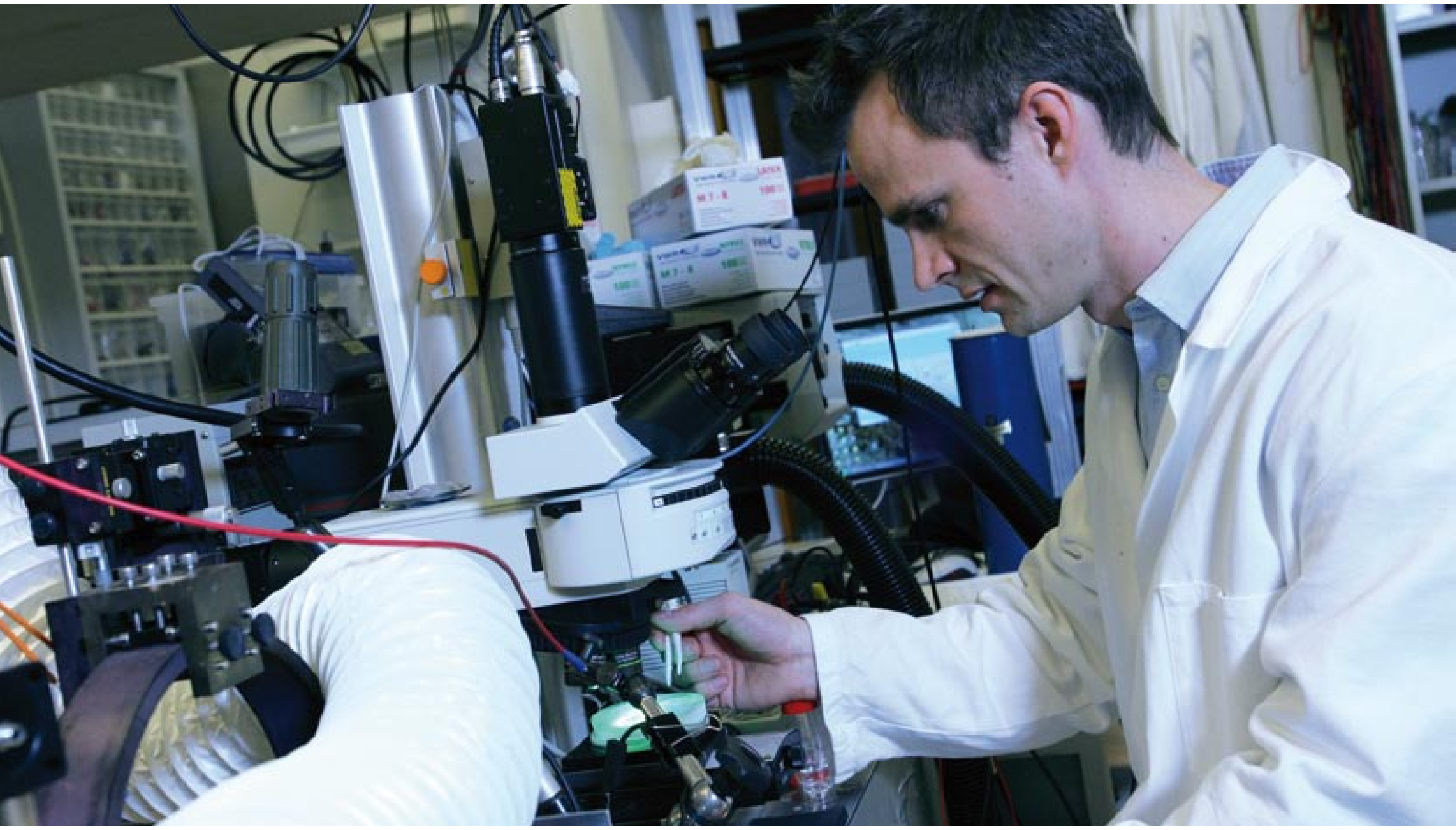
One of the notable characteristics of nature is its ability to improve its own performance via adaptation and learning. In robot haptic tasks, the adaptation of robot behavior via feedback control is expected to yield similar improvements. Often this may be accomplished by utilizing real-time information to adapt the robot actions. Different adaptation algorithms will be explored that attempt to improve robot haptic behavior, using both existing and newly derived models. Various learning models that act on suitable information will be explored. We will investigate how adaptation and learning take place during performance of disparate tasks that involve both contact and non-contact contexts. Using such model-based adaptation and learning algorithms, we expect to obtain increasingly accurate and natural behavior from robots in various haptic tasks, including contact interactions with humans.

Prof. Anuradha M. Annaswamy
received her Ph.D. in electrical engineering from Yale University. She was working as an Assistant Professor in Aerospace and Mechanical Engineering at Boston University. Annaswamy came to the Massachusetts Institute of Technology (MIT) as an Associate Professor. Today, she is a Senior Research Scientist and Director of the Active Adaptive Control Lab at the MIT. Since August 2008 Annaswamy has been a Hans Fischer Senior Fellow at TUM-IAS (Host: Prof. Martin Buss, Institute of Automatic Control Engineering, TUM).

Prof. Mandayam Anandanpillai Srinivasan
received his Ph.D. in mechanical engineering from Yale University. He came to the Massachusetts Institute of Technology (MIT) as a research fellow in the Newman Laboratory, and joined Research Laboratory of Electronics (RLE) as Research Scientist. Srinivasan was promoted to Senior Research Scientist in MIT's Department of Mechanical Engineering. Srinivasan is also the founder and director of RLE's Laboratory for Human and Machine Haptics, known worldwide as the Touch Lab. Since August 2008 he has been a Hans Fischer Senior Fellow at TUM-IAS (Host: Prof. Martin Buss, Institute of Automatic Control Engineering, TUM).

Nano Photonics

Dr. Ulrich Rant | Carl von Linde Junior Fellow



“In our research, we aim to design novel bio-nanostructures consisting of biological macromolecules and solid matter. These hybrid devices will be engineered to feature unprecedented functionalities in order to monitor and manipulate physical, chemical, or biological processes on nanometer-length scales.” *Ulrich Rant*

Hybrid Nanostructures: Nanorganic, actually

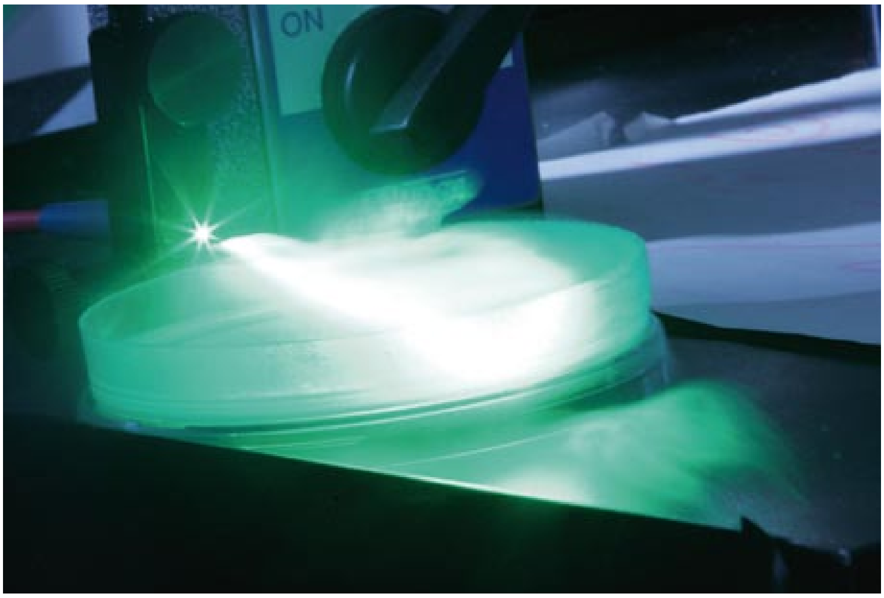
In order to afford life, nature had to become the ultimate nano-composer. She assembles fundamental chemical building blocks such as amino acids, with dimensions of around one nanometer (10^{-9}m), to larger biomolecules – proteins – typically 10 nm or more in size. These nano-scale objects exceed the "basic" chemical properties of their building blocks and adopt advanced functions.

Equipped with particular shapes featuring adapted mechanical properties and suitably placed specific recognition elements, macromolecules such as DNA or proteins can participate in the directed arrangement of biomolecules and form complexes of sophisticated architecture. These "structures of higher order" may then perform functions and activities of great complexity, for instance, playing a piano concert.

Naturally, the fate of macroscopic biostructures (including people) is inherently linked to the activity of processes occurring at the nano-scale, such as the viable interplay of proteins in a cell. In order to exert influence on processes on the nano-scale and use them to our advantage, we need a sound understanding of the interactions between nano-objects as well as the development of methods to monitor and manipulate them. In another field, the realm of anorganic metal and semiconductor materials, the "art" of making artificial nanostructures has been thriving over the last decades, driven and accompanied by significant progress in nanotechnology and nano-science. The time seems right to join man-made anorganic nanostructures with nature's own molecular nano-devices.

In our research, we aim to design novel bio-nanostructures consisting of biological macromolecules and solid matter. These hybrid devices will be engineered to feature unprecedented functionalities in order to monitor and manipulate physical, chemical, or biological processes on nanometer-length scales.

One hybrid device in the making is based on artificial nanopores. Using sharply focused beams of high-energy electrons or ions, a tiny hole only a few nanometers in diameter is drilled into a thin solid membrane on a silicon chip. The chip is then used to separate two liquid compartments, one of which contains molecules of interest (e.g., proteins or DNA). Upon application of a voltage between the two compartments, the molecules are driven from one to the other, thereby crossing the chip membrane through the single pore. This is a crucial moment, because as a molecule traverses the pore, it leaves a characteristic signature in the ionic current that flows through the pore. This footprint may be used to infer information about the molecule's size, shape, or charge, and whether it is currently interacting with other molecules. Artificial nanopores may be used to emulate natural trans-membrane processes, for instance,



transport of biomolecules into and out of cellular compartments. We believe that the possibility to engineer and tailor the properties of artificial nanopores qualifies them to serve as powerful single-molecule devices; thus we set out to immobilize catcher molecules inside artificial pores to observe protein interactions one-on-one.

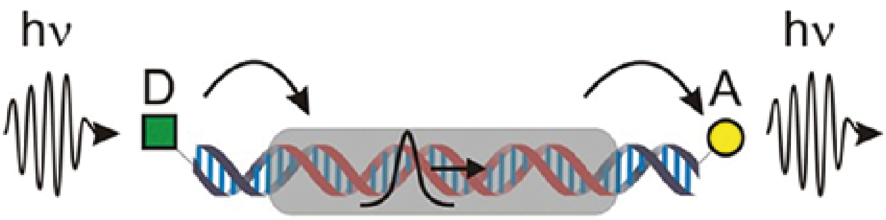
Protein interactions also take the center stage of another topic that we pursue with great enthusiasm. Recently we devised a robust method to electrically manipulate short DNA molecules, which are tethered to a metal surface at one end. We found that switching (wiggling) the molecules in alternating electric fields can serve as a powerful operating principle for otherwise usually passive biosensors. Probe layers of what we call *switchDNA* were successfully used for the highly sensitive detection of diverse target molecules (DNA as well as proteins). Furthermore, the active manipulation and control of molecules on a ~10 nm length scale brought about a new functionality: We were able to show not only that the presence of a target molecule (e.g., an antibody) may be detected, but also that the size of the captured target can be measured by analyzing the dynamics of the electrically driven DNA oscillation.

The idea was simple: Imagine a blindfolded fisherman trying to figure out the size of the fish that has just been caught and is now hanging at the end of the fishing rod. When swinging the fishing rod (DNA) around,

Ulrich Rant
received his Ph.D. degree in physics from TUM. He remained at TUM and became a Post-Doc at the Walter Schottky Institute. Since 2005 he has been the Project Coordinator of the collaboration project “Biosensor” between Fujitsu Laboratories and TUM. As a result, he worked as a visiting researcher at Fujitsu Laboratories Ltd. at the Nanotechnology Research Center in Atsugi, Japan. Rant has been a Carl von Linde Junior Fellow at TUM-IAS since October 2008. (Focus group leader: Prof. Gerhard Abstreiter, Department of Physics, TUM).

a big catch will make it difficult to wiggle the rod quickly. Because of the possibility to detect and analyze biomolecules on the same platform in a parallel fashion, as in a microarray, *switchDNA* sensors seem promising candidates to help tackle the formidable challenges of proteomics, i.e., the attempt to identify all proteins of a given organism and understand the interactions among them.

While one part of our research on *switchDNA* sensors moves toward application-oriented problems, another direction is toward “downsizing”. Here we aim to study individual interactions between DNA and proteins on surfaces by creating a single-molecule protein sensor. Metallic nanoparticles are employed to provide the necessary sensitivity for a robust optical read-out. Thus, we hope to gain insight into the mechanisms (transcription factors) regulating translation of the genetic code from DNA into viable proteins.



We also study new ways of fabricating metal nanoparticles in order to create well defined hybrids of organic molecules and metal nanostructures. Our research focusses on growing metal structures along specially functionalized DNA molecules, which serve as templates for the forming metal nanoparticles. Eventually, we aim to assemble the metalized DNA into larger supramolecular structures with novel optical properties. Our special interest lies in the investigation of plasmonic excitations on these objects, which are coupled oscillations of light and electrons inside the metal. This way, we intend to overcome the diffraction limit of light and realize novel sub 100 nm optical devices for the optics of the future.

Neuroscience
Analyzing and Simulating the Brain

Prof. Bert Sakmann | Hans Fischer Senior Fellow
Prof. Arthur Konnerth | Carl von Linde Senior Fellow
Dr. Thomas Misgeld | Hans Fischer Tenure Track Fellow

The Neuroscience focus group comprises the laboratories of Prof. Bert Sakmann, Prof. Arthur Konnerth, and Dr. Thomas Misgeld, all located in the Institute of Neuroscience at the TUM campus Biederstein. We use advanced microscopy tools to analyze structure, dynamics, and signal processing in the living nervous system. The aim is to provide large-scale analysis of neuronal interconnection and activity patterns in the healthy and diseased nervous system.

> “ Through its regularly occurring workshops, IAS has enabled me to come into contact with a whole number of excellent focus groups from other disciplines – for a newcomer like me this would normally be a formidable challenge!”
>
> *Thomas Misgeld*

In the nervous system, billions of nerve cells communicate through a vast network of connections. Integrity of this network, and proper processing of the signals conveyed in it, underlies mental health. There is an intricate relationship between the nervous system’s structure and its function. This is well illustrated by the cerebral cortex, where higher brain functions reside: The cortex is made up of myriads of so-called cortical columns, small barrel-shaped networks composed of layers of highly interconnected neurons. This miniature functional neuronal circuit integrates sensory signals and drives behavior.

Studying structures such as cortical columns poses a particular challenge for neuroscientists, as reductionist approaches that involve isolating nerve cells in culture can only provide limited insights. Moreover, morphological and physiological methods need to be combined. The recent decade has brought major advances in the area of in vivo techniques that now allow brain cells to be studied deep inside the living brain. For example, a technique known as two-photon microscopy overcomes the “turbidity” of nervous tissue and can provide a window for direct observation of single cells inside the living brain of experimental animals.

By labeling ensembles of nerve cells with probes such as fluorescent proteins or calcium-sensitive dyes, nerve cell dynamics and their activity patterns can be visualized throughout development or as neurological diseases evolve. We call this “opto-physiology.” New light-gated ion channels can be inserted into the genome and used to drive neural activity and even behavior – a capability we call “opto-genetics.” In vivo electrophysiology techniques, such as patch-clamp recordings, allow the physiology of single cells to be studied in detail.

The Neuroscience focus group at TUM-IAS advances the development of such techniques and applies them to address a number of basic problems in neuroscience and neurology. A shared set of core technologies combining genetic cell labeling, in vivo imaging and electrophysiology with large scale post hoc morphological reconstructions form the basis of a network of interactions among the three laboratories of the focus group.

Understanding cortical signal processing

The Sakmann lab addresses the cellular basis of cortical signal processing from multiple angles, with particular focus on the structure and physiology of cortical columns. The group utilizes a wide array of technologies that eventually aim at providing a comprehensive structure-function model of a cortical column that can be used to test specific hypotheses about cortical function. In a first step, the laboratory is characterizing cell classes in cortical layer 5 (L5), which appear to be important integrators of sensory signals and constitute the main output from the cortex (collaboration with Dr. P. Krieger, Karolinska Institute, and Prof. N. Heintz, Rockefeller University). Moreover, the Sakmann group studies the subcortical inputs and targets of L5 neurons by means of long-range anatomy at the level of single nerve cell processes.

As part of the TUM-IAS project and in close coordination with the efforts of the Konnerth group, the lab has developed a method that allows "opto-genetic" modulation of sensory signal processing in anaesthetized transgenic mice, using a light-gated ion channel. This method allows altering the flow of information between cortex and deeper brain structures during perception of signals derived from the animal's whiskers, providing a better understanding of the interplay between the cortex and other brain regions. Future efforts aim at the reverse experiment: silencing specific groups of neurons (such as L5 neurons) using genetically expressed toxins in order to understand their function in sensory-motor behavior.

Visualizing and modulating neuronal activity

Arthur Konnerth's group uses a combination of imaging and physiology tools to study cerebral information processing. The laboratory has developed techniques that allow visualizing neural activity based on observing changes in intracellular calcium concentration, using in vivo two-photon microscopy. Recent efforts expand this opto-physiological tool kit by employing virus-based methods to alter neuronal firing patterns.

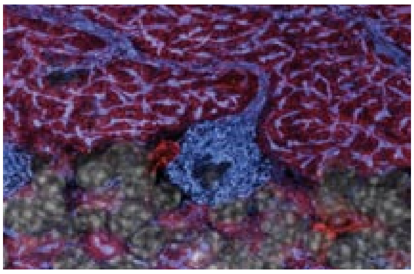
These tools are currently used to better understand brain activity patterns associated with sensory processing and development, cerebellar motor function, and neurodegenerative diseases. For example, the Konnerth group has recently discovered that, contrary to expectation, nerve cells in a mouse model of Alzheimer's disease are not necessarily less active than normal. Clusters of "hyperactive" cells exist, especially near the characteristic foci of Alzheimer's disease. This hyperactivity might be an important aspect of cortical dysfunction in dementia. Future studies will aim at understanding the changes in cortical architecture that underlie the local hyperactivity in Alzheimer's disease.

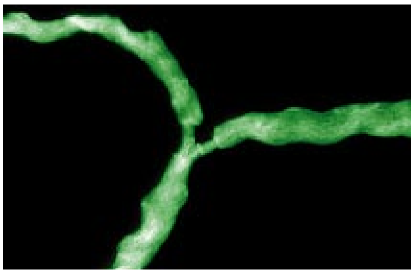
Observing neuronal dynamics

The Misgeld lab studies remodeling of nerve cell processes – the extended structures called axons – in a number of developmental and disease paradigms. The laboratory has a special focus on cellular interactions studied in vivo by labeling of multiple cell types (nerve cells, glia, and immune cells) with genetically encoded fluorescent probes. Currently, the laboratory analyzes the mechanisms of axon degeneration in two important neurological diseases, amyotrophic lateral sclerosis and multiple sclerosis.

Amyotrophic lateral sclerosis is a lethal neurodegenerative disease during which the axons that innervate muscle cells die. By using an in vivo microscopy assay in a mouse model of this disease, the Misgeld laboratory discovered a profound disruption of organelle transport long before neuron cell death sets in. As part of the laboratory's activities in the TUM-IAS, new transgenic mice will be generated to measure functional signals that accompany the reduced turnover of organelles and might initiate axonal degeneration. As many neurodegenerative conditions share final executive pathways of cell damage, similar analyses of subcellular neural changes will become possible in models of Alzheimer's disease, a condition studied in the Konnerth lab using in vivo imaging.

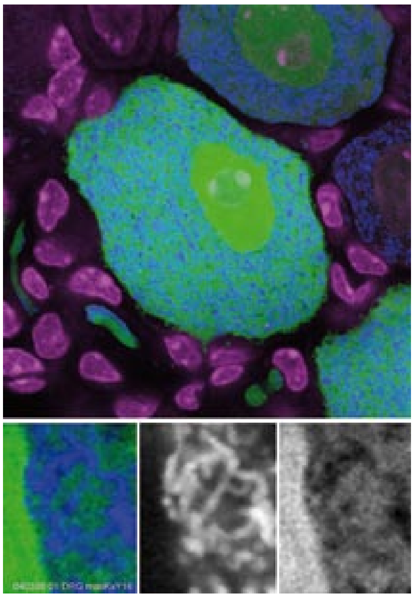
In collaboration with neuroimmunologists at Ludwig-Maximilians University (Prof. M. Kerschensteiner), the Misgeld laboratory has recently also succeeded in visualizing for the first time how axons degenerate in inflammatory lesions of a mouse model of multiple sclerosis. Within the TUM-IAS, Misgeld's group is now aiming at combining such in vivo observations with correlated large-scale electron microscopy to identify the subcellular changes that precede overt axon degeneration. For this, the Misgeld laboratory will be able to take advantage of the tools developed by the Sakmann laboratory to quantitatively analyze large volumes of brain tissue using light and electron microscopy techniques.





1 | Cerebellar Purkinje neuron with synaptic structures labeled red, mitochondria labeled cyan and nuclei labeled using a grayscale.

2 | Branch point of a sensory axon entering the spinal cord labeled with a fluorescent protein in a transgenic mouse.



Sensory cell body (green) with labeled mitochondria (blue) and nuclei (magenta). Insets show subcellular detail in this cell derived from a transgenic mouse with fluorescent neuronal mitochondria.

Core technologies and collaborations

The projects pursued by the three laboratories of the Neuroscience focus group converge on a number of shared core techniques: labeling of neural cells with fluorescent proteins using transgenic and viral techniques, in vivo recording of functional signals using optical reporters, electrophysiological recordings from cells in situ, and large scale reconstructions of neuronal morphology using light and electron microscopy. The first year of TUM-IAS support has seen the expansion of a number of shared facilities that allow the three laboratories to collaborate on the use of these techniques for their specific aims. For example, the facilities for transgenic animal generation and maintenance are being expanded to house new mouse strains with labeled subpopulations of neural cells that are used in shared projects. Also, we are currently setting up core support for histological processing and confocal analysis, to be used by all three laboratories.

Based on these shared resources, the laboratories of the Focus group are pursuing and planning collaborations in a number of fields. For example, the Sakmann and Konnerth groups work together on “opto-genetic” manipulation of sensory processing; the Konnerth and Misgeld groups will join efforts to better understand cerebral dysfunction in neurodegeneration; the Sakmann and Misgeld groups together make use of large-scale confocal image acquisition and analysis. Such future joint efforts will allow pursuing questions relating to the structure and function of the healthy and diseased nervous system in a multi-angled way that would be impossible without the framework provided by TUM-IAS.

Prof. Arthur Konnerth
is a Carl von Linde Senior Fellow since October 2007 and the Leader of the "Neuroscience" Focus Group at TUM-IAS. He conducted research at the Max Planck Institute (MPI) of Psychiatry in Munich and at the MPI of Biophysical Chemistry in Göttingen. Konnerth was Professor of Physiology at the Universität des Saarlandes, the Ludwig Maximilians Universität (LMU) München, and TUM. Today he is Professor of Neuroscience and Director of the Institute of Neuroscience at TUM. In addition, he is Project Leader of the Excellence Cluster CIPS, a collaboration between the LMU and TUM.

Dr. Thomas Misgeld
holds a Hans Fischer Tenure Track position at TUM-IAS since October 2007. He performed research at the Max-Planck-Institute of Neurobiology in Martinsried and at the Institute of Clinical Neuroimmunology at Ludwig Maximilians Universität München. Misgeld joined the Department of Anatomy and Neurobiology at Washington University and the Department of Molecular and Cellular Biology at Harvard University. Since September 2006 he runs his own laboratory, which is located at the TUM Institute of Neuroscience.

Prof. Bert Sakmann
qualified as a professor ("Habilitation") at the Universität Göttingen and conducted research at the Max Planck Institute (MPI) of Biophysical Chemistry in Göttingen. Together with Erwin Neher, he was awarded the Nobel Prize for Physiology or Medicine in 1991. Both scientists received the Prize for the development of patch-clamp technology.
Sakmann is the former Director of the Cell Physiology Department at the MPI of Medical Research in Heidelberg. Since 2008, he has heads up the Emeritus Group "Functional Anatomy of a Cortical Column" at the MPI of Neurobiology in Martinsried and is conducting research as a Hans Fischer Senior Fellow at TUM-IAS since October 2007.

Risk Analysis and Stochastic Modeling

Prof. Claudia Klüppelberg | Carl von Linde Senior Fellow
Dr. Robert Stelzer | Carl von Linde Junior Fellow

In many areas of science – the natural, engineering, and social sciences – one is confronted with phenomena and observations that are of a random nature and thus call for stochastic models. Our models and methods have proven applicable to fields from economics to electrical engineering, and we find that the TUM-IAS fellowships are fostering their extension into new areas.

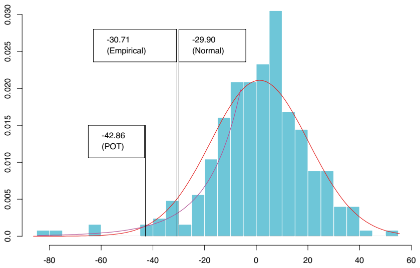
Time off from everyday obligations that normally go along with academic research translates readily into time to think. The TUM-IAS framework encourages high-risk / high-return research and wide-ranging exploration of new fields, in part by creating conditions that favor multidisciplinary collaboration.

“ What is unique about the IAS is the freedom to follow one’s ideas, the encouragement to carry out “high risk – high return“ research and the exchange with very distinguished researchers from various areas.” *Robert Stelzer*

Often one observes some variable of interest over time – e.g. number of animals of a certain species in a specified area, macroeconomic variables such as unemployment or GDP growth rate, prices of financial assets, concentration of pollutants in the air, temperature, or precipitation – and thus has a series of observations over time. An important aim is then to find stochastic models adequately describing the data and capturing its features. Moreover, the models should improve our understanding of the underlying processes, allowing one to infer quantities of interest and to make predictions. Apart from the need to find adequate models for the evolution over time of single variables, one also has to describe, in many concrete situations, the influences of several variables on one another, and thus there is a need for multivariate models. For observations made at equidistant points of time (e.g. for yearly, monthly, daily or hourly data), one uses time series models (e.g. linear models such as autoregressive moving average processes or the Nobel prize-winning nonlinear GARCH processes). If it is more appropriate to specify dynamics in continuous time, stochastic differential equations provide a rich source of models.

Although risk is something mankind has to live with, it is of immense importance to understand and quantify it, as this provides the basis for actively managing (reducing) risk and taking precautions. Usually, risk comes from extreme events; one is confronted with very high or low values that occur only very seldom. In finance, for example the risk is to lose money due to very large movements of prices of financial assets.

Likewise in other domains, the risk comes from the occurrence of extreme events. In insurance that might mean high claims; in engineering safety analysis, catastrophic accidents; in weather, high winds or floods. The mathematical area analyzing extreme events is called extreme value theory. Typical questions addressed in this field are how often extreme events occur, how severe they are, and whether they tend to come alone or in clusters. In this focus group we both develop the needed mathematics behind stochastic models and risk analysis and employ them in concrete situations coming from various applications. Thus the main research topics are linked to time series analysis, stochastic analysis and differential equations, extreme value theory, and statistics of stochastic processes. As in many applications the often used Gaussian models are too tame to be realistic – they underestimate the true risk tremendously and do not cover the features present in the observed data – non-Gaussian distributions and processes are heavily used. Most important here are Lévy processes, because these are very well understood continuous-time stochastic processes whose paths exhibit jumps, enabling one to model the occurrence of very abrupt changes.



DAX daily returns

"I enjoy the opportunity to take a deep breath, and get away from the daily tasks for a given time period, which allows for a new research orientation."
Claudia Klüppelberg

Financial risk analysis

Prof. Claudia Klüppelberg is regarded as one of the leading experts in extreme value theory and very well known for her work on stochastic modeling. Her current projects include financial risk analysis in multivariate models – for example, risk assessment in operational risk, credit risk, and insurance risk models under various dependence structures. Problems in recently deregulated energy markets are also investigated. In all these research areas Markovian models driven by Lévy processes on the one hand, and long-range dependence models like fractional models on the other hand, cover all possible dynamic dependence structures. The specific risk situation determines whether one-dimensional or multivariate models are called for. Finding an appropriate model is always the basic task, and the model should match the most important statistical features of the observations and well known laws of nature. On the other hand, the models used should also be accessible to some probabilistic analysis to allow for a detailed risk assessment. The statistical problems at hand involve the parameter estimation of multivariate models; in a Lévy driven model, this involves statistical estimation of the multivariate jump measure. Since the beginning of the TUM-IAS fellowship, new projects have been set up in the area of wind energy and turbulence modeling, combining laws of nature with some detailed statistical analysis. Another new exciting project is density functional analysis for modeling the structure of molecules.

Modeling of Lévy-driven processes

Dr. Robert Stelzer has been the first to define, analyze, and apply multivariate continuous-time stochastic volatility models driven by Lévy processes in the field of finance. These models for the joint evolution of the prices of several financial assets are able to capture the typical features of financial data very well, which is very important to correctly assess the risk of financial investments. Apart from this, he has considered the general approximation of Lévy-driven stochastic differential equations and studied a very fundamental class of Lévy-driven processes – the multivariate continuous-time autoregressive moving average (CARMA) processes. Furthermore, he has been looking at time series models whose parameters change randomly over time and has contributed to the understanding of their extremal properties.

His current research projects include the improvement of multivariate stochastic volatility models (e.g. inclusion of long memory, pricing of derivatives, introduction and analysis of adequate driving Lévy processes), the estimation of multivariate CARMA processes, extreme value theory for multivariate Lévy-driven models, and improved approximation schemes for stochastic differential equations. Moreover, he intends to use his stochastic modeling techniques in new application, especially in the natural and engineering sciences.

Prof. Claudia Klüppelberg
holds the Chair of Mathematical Statistics at the Center for Mathematical Sciences of TUM. After earning her Ph.D. at the Universität Mannheim, she worked in the Insurance Mathematics group of the Department of Mathematics at ETH Zurich and in the Mathematics Department of the Universität Mainz. In 1997, she accepted an offer from TUM. Since October 2008 Klüppelberg has been a Carl von Linde Senior Fellow and leader of the focus group "Risk Analysis and Stochastic Modeling" at TUM-IAS.

Dr. Robert Stelzer
received his diploma and PhD degree from TUM. In 2007 he became a research assistant for the Chair of Mathematical Statistics at TUM and is currently a postdoctoral researcher at TUM. Since October 2008 Stelzer has been a Carl von Linde Junior Fellow at TUM-IAS.

Satellite Geodesy

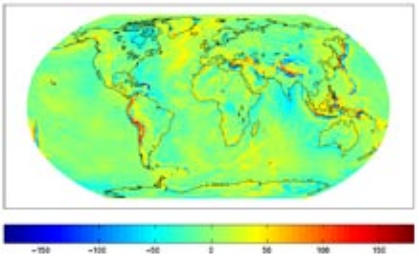
Prof. Reiner Rummel | Carl von Linde Senior Fellow
Prof. Gerhard Beutler | Hans Fischer Senior Fellow
Dr. Adrian Jäggi | Carl von Linde Junior Fellow

GOCE satellite

Geodesy is the science of the Earth's shape. However, the Earth has two shapes, geometric and gravitational. The geometric shape is a flattened sphere with oceans, continents, mountain ranges, hills, valleys, and plains. Gravitationally, Earth has an equally varied (albeit invisible) shape, the geoid, defined as being everywhere horizontal – that is, perpendicular to the local direction of gravity. The differences between the two, though small, are critical in studies of oceans, climate, sea level, mineral deposits, and the physics of the Earth's interior.

Scope of the project

In the IAS Satellite Geodesy project we focus on the determination of the Earth's gravity field using the vast amount of scientific data generated by the satellite missions CHAMP (CHAllenging Minisatellite Payload, launched in the year 2000), GRACE (Gravity Recovery And Climate Experiment, launched in 2002) and GOCE (Gravity field and steady-state Ocean Circulation Explorer, launched on March 17, 2009). The satellites of the three missions are in so-called Low Earth Orbits, between 250 km and 500 km above the Earth's surface. All of them have Global Positioning System (GPS) receivers on board, allowing their geocentric trajectories to be determined with the accuracy of few centimeters. As the satellites of the missions are, in essence, in free fall in the Earth's gravity field, their trajectories alone, established through GPS, make it possible to determine the field with a resolution, consistency, and accuracy much superior to what was achieved in the 20th century using dedicated passive geodetic satellites. (These were equipped with reflectors; measurements were based on the round-trip travel times for short pulses of laser light transmitted from ground-based observatories.) Gravity field determination with the CHAMP mission is relying on GPS only. The GRACE mission measures in addition the distance between its twin satellites, with an accuracy of a few micrometers (so-called K-Band between-satellite measurements). GOCE, the first mission of the European Space Agency's new Earth science program, will combine two measurement principles for gravimetry.



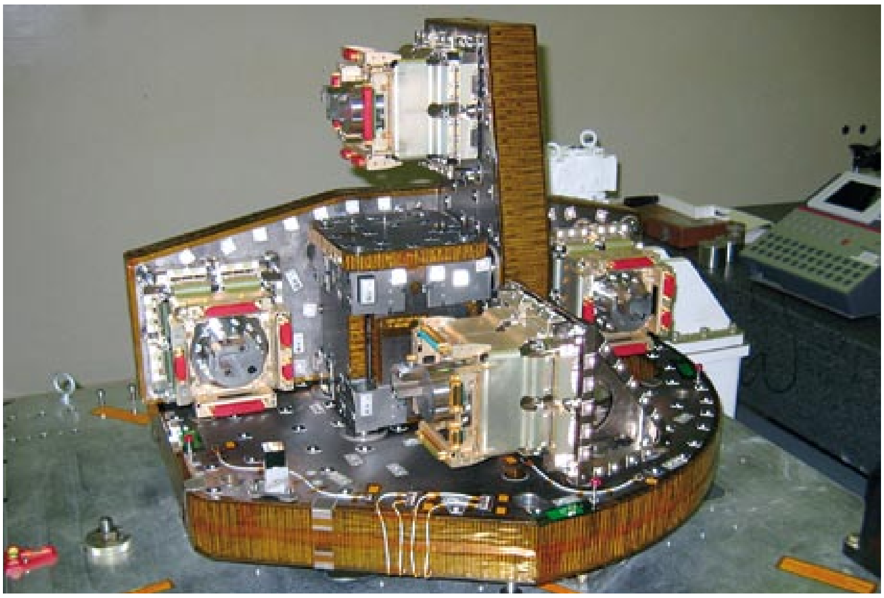
Anomalies in the Earth gravitational acceleration (in units of 10^{-5} m/s^2) as determined from the analysis of one year of GRACE data. Their close relationship to geophysical phenomena such as subduction zones, ocean ridges, or post-glacial mass adjustment is clearly visible.

GOCE gravity – it makes a difference

The Earth science community needs to know gravity globally to a degree more accurate than 1 part per million of "g," the famous 9.8 m/s^2 acceleration that keeps our feet on the ground. Only at this level – as if seen through a microscope – do the tiny geophysical and oceanographic effects that attract scientific interest become visible. Free-fall experiments in the laboratory are incredibly accurate nowadays, but it would take decades to attain global coverage. Satellites need only a few months to cover the Earth, but at satellite altitude the gravitational signal is greatly attenuated. This is where the title of this report comes into play: Whenever signal to noise ratio is very low, take the difference! Therefore we proposed to apply the principle of gravitational gradiometry in a satellite.

The GOCE satellite is novel in several ways, but the first thing to note is that it carries the first gravitational gradiometer, with three perpendicular pairs of ultra-sensitive accelerometers. As the satellite passes over the Earth, this gradiometer will measure the gravitational attraction of mountains, valleys, subduction zones, ocean ridges, and other features.
The observations are derived from acceleration differences, which are measured with an unprecedented accuracy of about $1^{-2} \cdot 10^{-12}$ m/s^2.
The gradiometer will sense gravimetric signals as tiny as a millionth of a

millionth of “g.” Taken in various combinations, the tiny differences between the measured accelerations will result in a detailed global map of the undulations of the Earth’s gravity field. GOCE also carries a second core instrument, a new GPS receiver developed in Europe. The first science satellite designed for an altitude as low as 250 km, GOCE is equipped with ion thrusters to maintain its orbit. Star trackers, together with angular rates measured by the gradiometer, allow smooth navigation



Three-axis gravitational gradiometer; each gradiometer axis consists of two accelerometers at a distance of 50 cm

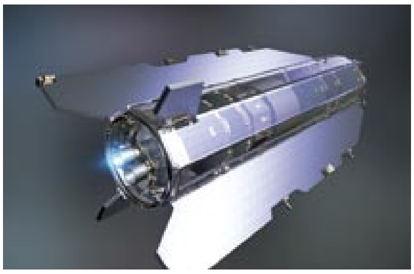
“The project deals with an extremely challenging new branch in our field: Our knowledge of the Earth’s gravity field and its variations grew dramatically in the previous decade. There was, however, not too much time and leisure to think about the methods applied. We view our project as an attempt to reduce the gap between the potential offered by the data and the methods available to analyze them.”
Satellite Geodesy Group

of the spacecraft around the Earth. All these sensor parts act together as one gravimetric system. The use of carbon material and extremely tight thermal control exclude gravimetric disturbances from the satellite itself.

While the small-scale features of the gravitational field are measured by the gradiometer, its long-wavelength part will be extracted from the spacecraft orbit. A satellite’s orbital trajectory can be regarded as a continuous free fall of a heavy test mass in the Earth’s gravitational field. This is particularly true for GOCE, since any non-gravitational force acting on the satellite – such as drag due to residual atmospheric density or solar radiation – will be counteracted by ion thrusters. However, only celestial mechanics at its very best will be capable of modeling orbits with the required precision. This is where the expertise of the astronomers from the University of Bern meets that of the geodesists from the Technische Universität München.
In preparation for GOCE, the Institute of Astronomical and Physical Geodesy (IAPG) at TUM is coordinating the joint work of an international consortium with scientists from eleven institutions in seven European countries. Its purpose is to carry out the scientific data analysis and ultimately the provision of gravimetric data products for user groups from all over the world working on applications in oceanography, geophysics, glaciology, geodesy and sea level research. The work is done under the umbrella of the European Space Agency. After ten years of preparation, a very exciting period of research lies ahead.

Status of the project

The IAS Satellite Geodesy project has been combined with a project of the Swiss National Science Foundation called "Gravity Field Determination using Positions of Low Earth Orbiters established with the Global Positioning System." In this project it is our ambition to develop the methods to generate the "best possible" gravity fields with the individual data sources and with their combinations. What we mean by "best possible" needs explanation. Every analyst knows that in science there is always room for improvement after completion of an experiment, but our ambition is to make our analysis tools sufficiently general to cope with possible improvements without redesigning essential parts.



The GOCE satellite (planned orbital height 270 km)

The CHAMP satellite (current orbital height 320 km)

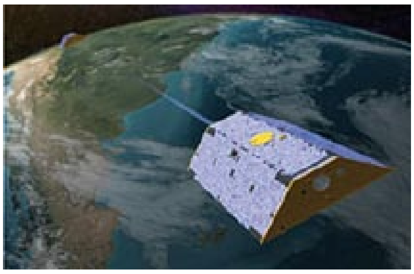
We call our method to deal with all data types from gravity space missions the Celestial Mechanics Method. The method views gravity field determination as a generalized precise orbit determination (POD). Its establishment is an essential goal, if not the essential goal of our IAS project. The method should be called more precisely the method to generate ensembles of gravity field solutions fully exploiting the degrees of freedom of Celestial Mechanics and using the power of applied mathematics to generate these precise solutions in an efficient way. As this description is of the lengthy kind, we stick to the short label, the Celestial Mechanics Method.

Let us highlight a few aspects of the studies performed so far in the context of the IAS since fall 2007:

In 2007 there was a method in place in Bern that was capable of analyzing the CHAMP GPS data to generate gravity field solutions. Today, mainly thanks to the work of Lars Prange, Ph.D. candidate of the Swiss National Science Foundation in Bern, we are close to achieving this first goal using all available CHAMP data 2002-2008.

The IAS has enabled us to study delicate, but very important aspects of POD with the GPS: Using GRACE GPS data, Jäggi et al. (2009b) proved that an accurate modeling of the GPS antenna's near field (accounting for so-called phase center variations and other effects, such as multipath signal propagation) is not only extremely important for POD, but also has a significant impact on a particular subset of the determined field parameters. This important result is an excellent example of the type of research enabled by an IAS project (it also underlines that combining the IAS and SNF projects was a wise move). Such subtle studies need a certain distance from operational or other day-to-day activities and stress. Needless to say (which is why we say it anyway), these results will have a significant impact on virtually all subsequent studies related to global space-based gravity field determination.

It took more than one year to develop the software instruments necessary to model the between-satellite distances of the GRACE mission and to implement them properly into a package to analyze K-Band between-satellite and GPS data. Within our project we now have a program system at hand that allows modeling of the K-Band observables (range and range-rate) with state-of-the-art accuracy and, in combination with the GPS, can determine precise orbits of a constellation of satellites representing all observations within their accuracies.



The twin satellites GRACE-A and GRACE-B orbiting the Earth in the same orbit, separated by about 220 km (current orbital height 470 km)

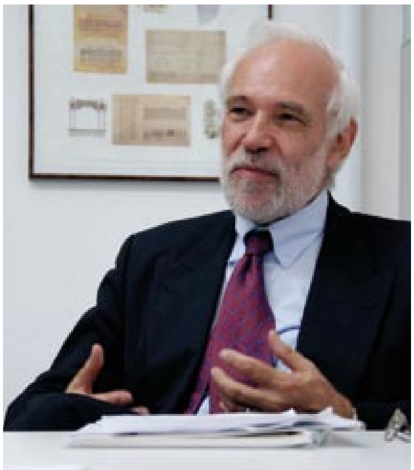
Because the Celestial Mechanics Method views gravity field determination as a generalized POD (in the context of GRACE for constellations), the step from POD to gravity field determination is small, but accompanied by many subtleties attributable to the intricacies of the between-satellite measurements and their combination with GPS. We are now in a position to produce, as planned, ensembles of state-of-the art gravity fields furthering the understanding of gravity field determination and its time variations using the Celestial Mechanics Method.

We expect to harvest over the next two to three years the fruits of our developments by publishing the method itself and analyses based on the method. We also plan to extend our method to the GOCE mission, using GPS as well as gradiometer data.

Prof. Gerhard Beutler
qualified as a professor (Habilitation) at the University of Bern. He spent one year at the University of New Brunswick, Canada, before joining the University of Bern as Head of the GPS Research Team. Since 1991, Beutler has been the Director of the Astronomical Institute of the University of Bern, where the “Bernese GPS Software” was developed. In addition, he is the President of the International Association of Geodesy (IAG). Beutler has worked since October 2007 as a Hans Fischer Senior Fellow of TUM-IAS.

Prof. Reiner Rummel
is the head of TUM’s Institute for Astronomical and Physical Geodesy. He was working at the Department of Geodetic Science at Ohio State University, at the German Geodetic Research Institute in Munich, and the Bavarian Committee for International Geodesy at the Bavarian Academy of Science. Rummel was also Professor and Chair of Physical Geodesy at the Delft University of Technology and Dean of Faculty of Civil and Geodetic Engineering at TUM. Since October 2007 he has been a Carl von Linde Senior Fellow at TUM-IAS.

Dr. Adrian Jäggi
received his Ph.D. in astronomy in 2006 from the University of Bern. Today, he is a Lecturer and Research Assistant at the Astronomical Institute at the University of Bern. Jäggi has been continuing his work in Munich as a Carl von Linde Junior Fellow since October 2007.



Director's Vision

To be instrumental in the development of innovative research and new research areas is the primary goal of the TUM-IAS. We want to combine excellence and innovation in our main field of endeavor, technology. This is not a top-down management assignment; quite on the contrary, it is an intellectual task of the first order, to which the best of our abilities and resources have to be dedicated.

As an Institute, we go first and foremost for excellence, trying to connect the best possible minds from within TUM with their direct counterparts elsewhere in the world. That forms the foundation of our fellowship program. Having this intellectual power on board, we are ready for the discussion on "innovation in technology". Innovation cannot be planned, we must be open to new ideas as they come, but we must also be aware of the fact that good "technology as a science" requires careful consideration and the creation of the means necessary to reach the goals. We need vision, drive, and planning, in that order!

There is evident inspiration for new research topics that we can derive from observing where worldwide innovation in technology is moving. For example, the development of precision in measurements and the mastery of devices have reached nanometer scale dimensions that open up one side of the space dimension. There are also great advances in the time dimension; various new frequency domains are being developed technologically, thereby greatly enhancing our capabilities to measure and see. Microelectronics is reaching into the sub-Terahertz domain; imaging systems are being developed in the submicron-to-nanometer range. Even at the scale of the earth system, much more accurate measurements of all the parameters that characterize it, such as position and gravity, are being developed. We have great excellence in all these fields at TUM, which the TUM-IAS is keen to help develop. We aim at improving our technological abilities at the cutting edge of what is possible.

“ Seeing. One could say that the whole of life lies in seeing - if not ultimately, at least essentially. To try to see more and to see better is not just a fantasy, curiosity, or a luxury. See or perish.”

Pierre Teilhard de Chardin - Le Phénomène Humain

But there is much more that we can and want to go for! To see where we can go, it helps to approach the issue from two opposite viewpoints: technology push on the one hand and societal demand (or “demand pull”) on the other. Both play an essential role in the dialectics of technological innovation. Besides increases in precision, the foremost factor in the technology push is the drive towards higher complexity. Let me mention a few important cases without trying to be exhaustive. We are witnessing an enormous leap forward in our abilities to understand, manipulate and even synthesize complex molecules, bio-molecular systems and proteins, going all the way to influence and manipulate cellular processes. In another direction of complexity, we are trying to build a new generation of robots, e.g. autonomous humanoid robots or intelligent car control systems. Making these artificial contraptions “intelligent” and adaptive to situations appears to be incredibly difficult but possible. And then there are our efforts to try to understand how human intelligence works, how the neo-cortex is capable of astounding pattern recognition abilities, how it abstracts information, how it learns and how the human neural system achieves its myriad control functions. The demands on modeling such complex systems are astronomical. Our modeling capabilities require massive improvements. We are only at the very beginning of our abilities to handle large dynamic systems and the relevant statistical models - the classical linear and Gaussian approaches having reached their capabilities.

From the *application pull* side the demands are no less staggering! It is necessary for the TUM-IAS to concentrate on a few well-chosen application areas; let me mention our two most prominent ones. The first is what I would call the *instrumentation side*, perhaps with an emphasis on instrumentation in the medical context. For example, the combination of advanced imaging techniques with robot-assisted surgery. One case would be to combine NMR with operational robots within the field of imaging. Another case is special micro- (or even nano-) robots manipulating cells. More generally, many of the device-oriented efforts may be turned into new types of high performance measurement and sensing equipment. The second large application we are very interested in is *Earth system engineering*: the demand for new methods in environmental engineering (water, atmosphere), sustainable energy sources, and understanding and modeling the earth as a system.

What is a good Institute strategy for the future? We work with and through people, our excellent Fellows. Nothing can replace their intuitions and creative thinking. We foster the dialogue between the desirable and the possible through problem formulation married to a keen sense of applications and societal demands. One of my professors, a top scientist whom I admired very much (Prof. Ralph Phillips at Stanford University), once told me that “excellent research is characterized by the correct balance between the new and the possible”. To make that choice is precisely the dynamic task our Institute stands for. I cannot predict what we will choose in the near future, but I can guarantee, together with our Fellows, Advisory Council, and Board of Trustees that our choice will be the result of a careful process of evaluating possibilities and their relevance not only for the advancement of technology but also for contributing towards the solution of major societal and environmental problems.

Experience Report

Experience Report

Prof. Walter Kucharczyk

First and foremost I want you to know that I feel very privileged and honored to have been selected as a TUM-IAS Fellow. I thank the TUM and the IAS very much! I think the fundamental ideas and concepts behind the founding of the IAS and the International Graduate School are outstanding and absolutely the correct way to promote and encourage scholarly activity on an internationally significant scale. I think the TUM will experience tremendous returns on the investment that it is putting into the IAS. My experience at the IAS was a great professional, scholarly, and personal experience. With my background as a medical doctor specializing in radiology, I think my integration into the IAS program in the Engineering Department was unlike that of the other Fellows this past year, most of whom had specialties more closely related to that of their hosts. Nevertheless, I found a great deal of synergy between my academic interests and that of my host, Professor Tim Lüth. His department is renowned for its innovation in image-guided navigation and medical robotics, which are exactly my interests, but mine are from a medical viewpoint, whereas his are from the engineering perspective. Our skill sets and vision for the future turned out to be very complementary to one another. Since I was the first to take such a position, it took a while to build up some academic momentum, but in the latter half of my stay in Munich I felt the momentum became sustained. That is why the idea of continuing the fellowship beyond the time that the Fellow is actually living in Munich is so important – so as not to end the momentum just as it gets established.

While in Munich, I would very much have welcomed regular meetings with the other IAS Fellows, even if their work and backgrounds were different than mine. However I am not troubled by the fact that during my time these meetings were limited to a few dinners. I recognize that I came to the IAS before it was fully established. I think your efforts to establish regular dialogue between the Fellows, and perhaps their students, is exactly the right approach. I would strongly support a sustained effort to build a cohort of scholars over a number of years that have active dialogue with one another and each others' students. I think it is inevitable that some of these dialogues will lead to excellent multidisciplinary international collaborations, beneficial to the TUM as well as to the Fellows' home institutions. The administrative arrangements that were made for me were excellent, and, in fact, almost flawless. The IAS found an excellent place for us to live, and provided a superb relocation facilitator in the person of Rosaline Schreiber. Rosaline took care of all our German paperwork (immigration, banking, health papers, etc.) with minimal effort from us. There were minor delays with things such as setting up telephones and internet service, which we learned can take several weeks in Germany, but these were very minor points.

Within TUM, Margaret Jaeger took care of all my administrative and financial issues. She was able to answer every question I directed her way, even if on some occasions she had to consult with someone else. She set up my research account at TUM, and looked after invoices and my research expenses. She facilitated my networking with other Fellows. Furthermore, I found her to be full of ideas and a good strategic thinker with respect to the future of the IAS. Most importantly for me, on a day-to-day basis, whenever I did not know where to find an answer to anything related to TUM or Munich, I turned to Margaret. She became my single point of contact for everything I needed to know. I strongly recommend that the IAS always have someone like Margaret Jaeger in its employ.

Most of the suggestions and ideas that I think important for the IAS are already in place. Nevertheless, I will repeat some of them here. The IAS "rules" stipulate that an applicant for the Fellow position should be sponsored by a TUM faculty member. This is entirely appropriate and, in my opinion, essential. IAS Fellows should at least have had preliminary discussions with the host TUM faculty member prior to arriving in Munich, or even better, should have already established a research partnership with the host TUM professor. This would minimize the inefficient use of the Fellow's time upon arrival in Munich. Along a similar line of thinking, it would be advisable for the IAS Fellows to have jointly developed a plan with their hosts as to how to integrate their graduate students into their research program. This plan should include ideas for specific research projects, timelines, funding, and supervision of students, not only while the Fellow is at the IAS in Munich, but for the years afterward too. Ideally, these plans would describe how to make the research sustainable over several years. I think it would be desirable to develop mechanisms for information exchange between Fellows and their students. With this in mind, consideration should be given to having a symposium of all the Fellows, their hosts, and their students every year or two, where each others' work could be presented, and ideas for the future developed. While it is unlikely that every past and present Fellow could come to every symposium, I believe enough Fellows could attend to achieve a very informative and scientifically valuable meeting. A newsletter would also be helpful to serve the same purpose, not only from a scientific perspective but also from a social and networking perspective.

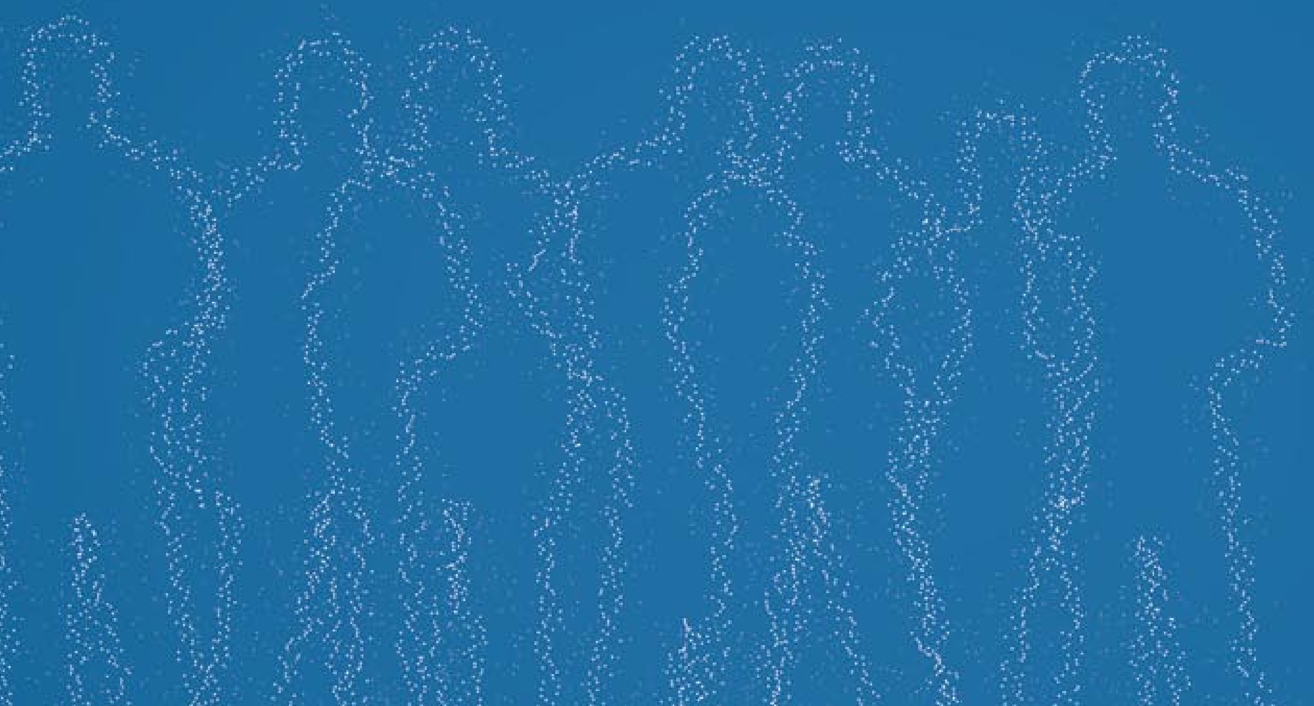
My personal experiences at IAS were valuable in many ways. I developed links to several excellent research collaborators and their students that would have been impossible for me to do elsewhere. I learned about several advanced technologies, and developed new skills, which was made possible by my being in a department (Engineering) outside of my own discipline (Medicine and Radiology). By being in the same place for a relatively long time (9 months), I came to feel at home at TUM, with access to TUM people and TUM resources. This would have been impossible without the IAS initiative, or if I had stayed in Munich for only 1-2 months.

With respect to specific outcomes, Prof Lüth, his students, and I were able to develop a prototype image navigation system which has immediate application to minimally invasive CT guided procedures, and which can be further expanded to a wide range of advanced medical applications that will benefit patient care. I am currently taking steps in Toronto to implement this navigation system into my clinical research. I will use the outcomes of this research to further develop my collaborative research with Professor Lüth. I plan to continue the same research in Toronto. To support these efforts I have arranged to have Professor Lüth appointed as a Visiting Professor at the University of Toronto. I have also reserved lab space for Professor Lüth, one of his junior faculty members, and one of his graduate students. I have already had one of his graduate students visit me in Toronto (Mario Strauss) for four weeks in September, as a guest in my home, and at my hospital. Mario and I developed concrete plans for a research program should he relocate to Toronto as a junior faculty member upon completion of his PhD, ideally accompanied by a graduate student from the Graduate School in TUM. To further cement the research relationship, I plan to visit TUM at least once, and preferably twice, per year.

I think the most significant obstacle to success of an ongoing collaborative research program will be manpower issues. While in Munich, I came to learn that there is a severe shortage of engineers in Germany. It became apparent to me with such a large number of vacant engineering positions available in industry in Germany, it will be difficult to recruit and retain academic engineers and graduate students to stay within TUM. Unless academic engineers and graduate students stay at TUM in sufficient numbers, it will be difficult to have such individuals spend part

of their careers with me in Toronto. Both Professor Lüth and I have sufficient space and money at TUM and the University of Toronto to support key scientists, engineers, and students, but there appears to be a manpower shortage for the foreseeable future that is currently the weak link in attaining a successful collaborative research program.

In summary, I think the IAS is an excellent initiative. I am very grateful, proud, and appreciative for the opportunity to have been part of it, and I will do my very best to continue to support the IAS as a IAS Fellow.



Events

Satellite Geodesy – Initial Status, Plans, and First Developments

Beckmann Symposia
Gender and Diversity in the Technical Culture
Gender in Medicine

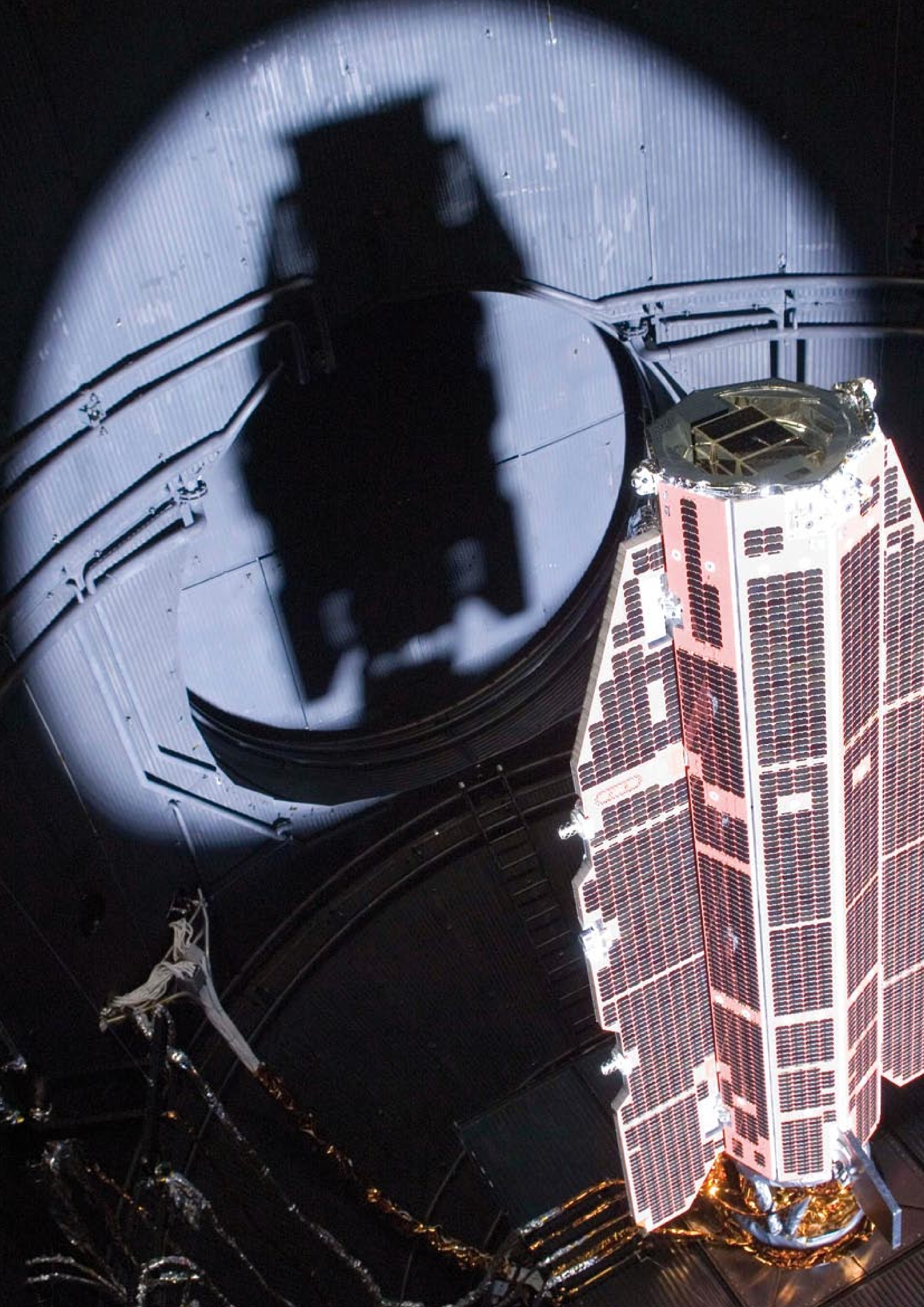
Accessibility – Measurement, Modeling and Evaluation

Tracing the New Mobilities Regimes

Risk Modeling and High Frequency Data

Earth System Engineering – The Art of Dealing Wisely with the Planet Earth

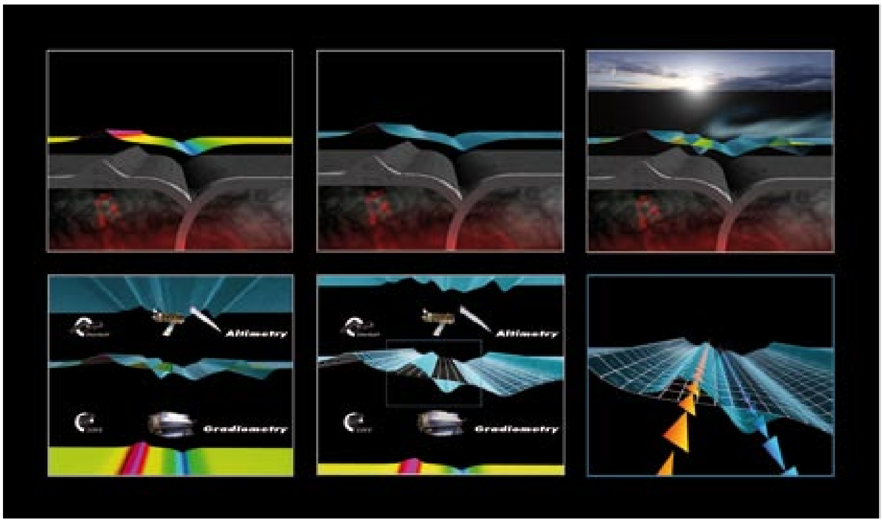
Board of Trustees Meetings
January 2007
November 2007
July 2008



Satellite Geodesy – Initial Status, Plans, and First Developments

Seminar

Density variations in the Earth's crust are an important factor in shaping the geoid. External forces, such as the wind, cause the actual sea surface to deviate from the geoid. The combination of sea-surface height mapped by altimeters and the knowledge of the precise ocean geoid will improve our understanding of surface currents.



The seminar on November 6, 2007, gave an overview of the project plans, and the first developments performed in Munich since the start of the TUM-IAS project on Satellite Geodesy. The Project (led by Prof. Reiner Rummel and Prof. Gerhard Beutler) was established in September, 2007. It is the scientific goal of the project to make the best possible use of GPS and accelerometry/ gradiometry measurements of the satellites CHAMP, GRACE, and GOCE for gravity field determination, which in time can be used to extract important aspects of the mass transport in the Earth's system (between solid Earth, oceans, and atmosphere).

GOCE in the Large Space Simulator at ESA's Test Centre in Noordwijk, the Netherlands.

Beckmann Symposia

President Wolfgang A. Herrmann opened the first Liesel Beckmann Symposium.

TUM has set itself the goal of becoming Germany's most attractive technical university for female students and scientists. TUM-IAS wants to help achieve this goal as quickly as possible and therefore has developed its own platform: the Liesel Beckmann Symposia, named after the first female Professor of the TH München (as the TUM was then called).

Liesel Beckmann

Having studied at the University of Bonn, Liesel Beckmann gained a diploma in Political Economics in 1937 and completed her doctoral thesis on “The Purpose, Development, Nature, and Changes in the Promotion of Skilled Trades” in 1939 under the aegis of Karl Rössle. Rössle took Beckmann with him and made her his assistant when the TH München appointed him to the Chair of Business Economics in 1938.

She earned a postdoctoral degree in1941 for her paper on “The Position of Skilled Trade in Economics”. In 1941 she was the first woman given permission to teach at THM and, ultimately, in 1946 was, as an exception to the rules at that time, nominated as professor for trade business administration.

Every year, experts from different areas of expertise who are developing new concepts in the area of Gender and Diversity are invited to Munich. Together they search for ways to attract women - with their special talents, needs, and interests - to science. The compatibility of a career and a family is just one of the many issues addressed.

Gender and Diversity in the Technical Culture

Prof. Londa Schiebinger (Stanford University), Prof. Martina Schraudner (Fraunhofer Gesellschaft), Dr. Hannemor Keidel (Vice President TUM), Ursula Schwarzenbart (Direct Global Diversity Office, Daimler AG), Petra Diroll (Bayerischer Rundfunk)

The first Liesel Beckmann Symposium, organized by TUM-IAS, was held on November 29 and 30, 2007. The Symposium entitled "Gender and Diversity in the Technical Culture" marked the beginning of a series of events revolving around the topics of Gender and Diversity, to be organized by Technische Universität München every year. During two days approximately 100 participants had intensive discussions with well-known guests from Germany and abroad.

Prof. Wolfgang A. Herrmann, President of TUM, opened the symposium. The American Sociologist, *Prof. Londa Schiebinger* of Stanford University, who has spent years researching the role of women in science, was invited as an international guest speaker. She proceeded to illustrate how the inclusion of women has changed the face of science and outlined to what extent gender aspects need to be integrated into the various scientific disciplines, particularly emphasizing the importance of gender-awareness training.

The speakers also included *Ursula Schwarzenbart*, who is Director of the Global Diversity Office of Daimler AG. She gave an insight into Daimler's strategy of implementing diversity and presented diverse measures employed by the corporation, ranging from mentoring programs and awareness training for executives to the obligatory reports on gender distribution when seeking to fill job vacancies.

Prof. Martina Schraudner, who is in charge of the "Discover Gender" project embarked on by the Fraunhofer Association, provided information on integrating Gender and Diversity in technology and product development. In particular, she stressed the importance of including the various customer groups in the development procedure right at the start of any innovation process to ensure that the finished product ultimately serves a practical purpose. A panel discussion and a reception in the TUM Institute for Advanced Studies concluded the first day.

On the Symposium's second day three workshops were offered:

- ➔ **Gendered Innovations in Science and Engineering**
  with *Prof. Londa Schiebinger*
- ➔ **Gender and Diversity in Technical Research**
  with *Solveig Wehking*
- ➔ **Human Resource Development from the Standpoint of Gender**
  with *Ursula Schwarzenbart*

During these workshops, the speakers delved into their respective topics in greater depth while also providing the participating students, scientists, and representatives from industry with an opportunity to enter into conversation with one another and to ask questions about the papers presented on the first day. The Symposium ended with an interactive exchange of ideas and views in the form of a world café. The related bilingual 50-page brochure: "Women at Technische Universität München" was published by TUM-IAS.

Gender in Medicine

For the second time, on November 27 and 28, 2008, the TUM-IAS hosted the Liesel-Beckmann-Symposium. The conference, focusing on gender-specific differentiation in medicine, took place at the German Heart Center in Munich, an institute of the TUM Medical School.

On podium: Prof. Jörg Rüdiger Siewert, Prof. Vera Regitz-Zagrosek, Dr. Sabine Behrenbeck, Prof. Wolfgang A. Herrmann, Prof. Renate Oberhoffer.

For a long time, considerations of gender-related perspectives from a biological or psychosocial point of view were unaccounted for. Current research in gender medicine shows impressively that gender indeed plays an important part in diagnosing and treating sicknesses. The most familiar current examples are probably gender-specific diagnosis, therapies and survival rates of heart attacks - to the disadvantage of women. Much less known however, is the fact that there are also differences in the effectiveness of aspirin, that gender plays a role in metabolism, nutrition, intensive care, and psychiatry, as well as in the customization of prostheses. For public health the integration of gender-based questions is important in the achievement of adequate health care in the coming years and decades. Educating doctors about gender-based standpoints is also important, given the lack of representation of women in higher positions. Finally, the engagement with the historic-sociological field of the history of the body is a good way of putting the new research results in context with the social construction of gender and its changes.

TUM President *Prof. Wolfgang A. Herrmann* opened the 2008 Symposium. *Prof. John Hess*, Director of the German Heart Center in Munich and symposium host, welcomed the participants and noted the great medical importance of the subject.

The first lecture was given by *Prof. Barbara Duden* of the Leibniz-University in Hannover. She approached the subject from a humanities point of view. Prof. Duden was significantly involved in making the body a legitimate object of the humanities. In her contribution, she addressed the issue of the change in modern medicine to now approach sicknesses and health especially from a statistical analysis point of view, and which effects the emphasis that probabilities has on the perception of the body, especially for women.

Prof. Catherine Whiteside, Dean of the Medical School and Vice President of the University of Toronto, was invited as an international guest speaker. Prof. Whiteside has invested a lot of time and excellent medical research into improving the medical education of doctors and medial researchers. Her lecture showed, through the example of the University of Toronto, which measures were most successful in that area.

Prof. Vera Regiz-Zagrosek, the most well-known German gender-physician, was the third speaker at the Symposium: she currently researches at the Charité in Berlin on gender-specific attributes of heart diseases. Her lecture discussed the differences of cardiovascular illnesses of men and women, which not only express themselves in different perceived symptoms, but also in the differences of diagnosis and therapy.

On the Symposium's second day, three workshops were offered:

→ **Medical education, Careers and Leadership**
with *Prof. Catharine Whiteside*
→ **Historical Aspects of Gender in Medicine**
with *Prof. Barbara Duden*
→ **Female-specific Medicine**
with *Prof. Vera Regitz-Zagrosek*

During these workshops, the participants had the opportunity to discuss the topics with the speakers again and in greater depth, and to contribute to the question of ways to reduce the gender-induced disadvantage of women in medicine, including how the subject can be further developed in medical practice and research.

Accessibility – Measurement, Modeling and Evaluation

Workshop

The TUM-IAS, in cooperation with the Institute of Transportation, represented by *Prof. Gebhard Wulfhorst* and *Dr. Andreas Rau*, organized an expert workshop on accessibility – measurement, modeling and evaluation.

They decided to organize a conference and an expert workshop on accessibility to increase international cooperation and exchange on necessary research questions. The workshop took place April 10–11, 2008. 20 internationally renowned experts on accessibility measurement were invited to come to Munich.

Key questions were: How can accessibility indicators be used for identifying improvements of transportation systems and changes in urban structure? How can accessibility indicators be integrated into transport and land use planning models for implementing long-term strategic mobility decision making? How can we evaluate if the travel requirements of people are met by the existing transportation system?

The benefits of the transportation systems are mostly measured by using travel time savings due to a lack of sophisticated alternatives. The experts discussed possibilities to improve this situation by using accessibility indicators. Further research needs for using accessibility indicators for urban and transportation planning models were defined. Innovative approaches, tools, and solutions to the challenging questions of accessibility definitions, visualization, modeling, policy design, and planning were discussed. The possibilities for setting up a research network and further research activities within the TUM-IAS were explored.

Tracing the New Mobilities Regimes

Conference

The Cosmobilities Network, the Munich Academy of Fine Arts and mobil.TUM at the TUM Transportation Centre, represented by *Dr. Sven Kesselring*, organized a conference supported by the TUM-IAS. The event, “Tracing the new mobilities regimes”, took place October 16–17, 2008.

The conference focused on the analysis and interpretation of the “new mobilities regimes” as they occur in respect to border regimes and migration, the consequences of mobile work and the increasing pressure on the work force to be mobile and to travel, the new technological environments enabling people and global economies to be mobile. Scientists from all disciplines dealing with mobility (sociology, ethnology, anthropology, history, art history) and artists gave presentations on different aspects of mobility, arts, and modern life.

Risk Modeling and High Frequency Data

Workshop

The first workshop of the TUM-IAS focus group “Risk Analysis and Stochastic Modeling” was held June 12–13, 2008, at the Leibniz-Rechenzentrum. Organizers were *Prof. Claudia Klüppelberg*, *Dr. Robert Stelzer*, and *Prof. Jean Jacod*.

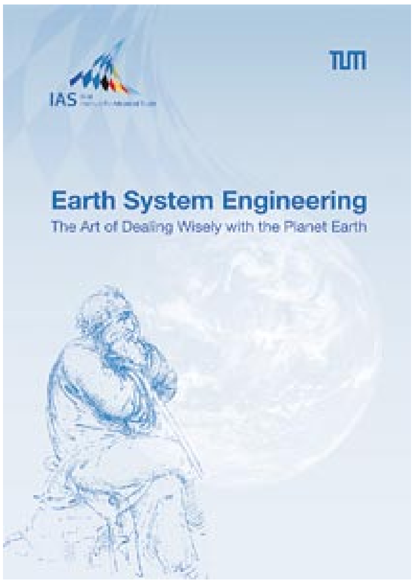
The workshop focused on new developments for modeling financial risk emphasizing on time series models for high-frequency data. The intention was to bring together experts from various scientific fields – econometrics, financial mathematics, statistics, and stochastic processes – that present important recent advances in research related to “Advances in Stochastic Modeling”, “Risk Management” and “Statistical Methods for High-frequency Data”. The event was also in recognition of a Humboldt Research Prize awarded to Prof. Jean Jacod from Pierre & Marie Curie University Paris. Jean Jacod gave a lecture on “Testing Finite Activity versus Infinite Activity for Jumps”.

Earth System Engineering – The Art of Dealing Wisely with the Planet Earth

Workshop

The participants of the workshop in Wildbad Kreuth.

Rising world population, increasing urbanization, advances in technology and medicine, changes in lifestyles even in developing and emerging countries – all these characterize the world we live in today. The consequences: an ever-growing exploitation, often an overexploitation, of natural resources and the pollution of water, soil, and the atmosphere. Planet Earth is responding with global warming and climate change. Are these perhaps the precursors of the progressive erosion of Earth's life-sustaining systems?



From September 23 to 26, 2008, in Wildbad Kreuth, Bavaria, 44 internationally renowned scientists from Europe, the United States, and Asia discussed how the Earth's system can be kept in balance. During this conference, the topic of discussion was to what extent the Earth's system can be managed, in order to continue to provide a life-sustaining environment for humans in the future. "However," according to Prof. Peter Wilderer, the organizer of the conference, "our actions must be planned with careful consideration and farsightedness. With the current state of development, we cannot allow ourselves to make mistakes. Each mistake that is made by science today could trigger irreversible events to our disadvantage."

These are haunting words from the Emeritus of Water Quality and Waste Management at Technische Universität München. Engineer Prof. Peter Wilderer devoted himself to the subject of the environmentally-sensitive usage of water and the implementation and conservation of a "healthy" water cycle. In 2003, he was awarded the "Stockholm Water Prize" for his lifetime scholarly achievements. To date, he is the only German scientist to be awarded the "Water Nobel Prize", highly coveted among experts. Today Professor Wilderer is a member of the TUM-IAS Board of Trustees. Together with the Club of Rome and UNESCO, he initiated the conference in Wildbad Kreuth.

"Technology is the engineer's response to overcoming problems," says Peter Wilderer, convinced that his profession could solve the imminent problem of global warming and the resulting climate change with innovation and ingenuity. Unfortunately, however, it is not that simple. "After a critical evaluation of engineering achievements, we must admit that while solving an urgent problem with technical solutions, we have in many cases uncovered or created new problems," Wilderer acknowledges. As long as the long-term impact of a not entirely thought-out solution remains regional, the consequences can be minimized by even better technology. However, what happens if a well-intentioned but wrong decision impacts the entire Earth and turns the system in a wrong direction regarding the survival of the human race?

Those types of decisions by the human race are evident in many parts of the Earth. The clearing of forests and the desiccation of wetlands have resulted in a loss of species diversity and the self-regulating abilities of the Earth's system. "The rain forest, the wetlands, and the oceans are all ecosystems that decisively contribute to the preservation of the human habitat," warns the Emeritus, because these ecosystems play an important role in the production of oxygen, the compounding of carbon dioxide, and the retention of water. Just as important for the Earth's climate are the diversity of species and the variety of interlinked metabolic reactions, which scientists know today are the precondition for maintaining flexibility in coping with outside influences.

Institute of Advanced Studies on Sustainability

THE CLUB OF ROME
Brussels-EU Chapter

EESP
International Expert Group on Earth System Preservation

The conference "Earth System Engineering – the Art of Dealing Wisely with the Planet Earth" in Wildbad Kreuth set itself two major objectives. Firstly, outstanding scientists from Europe, North America, Asia, and Australia discussed which measures must take place in order to deal wisely with Planet Earth. To achieve this, scientists must work in an interdisciplinary manner, so that a problem that gets resolved in one place does not reappear in another place. Therefore, water experts, physicists, atmosphere researchers, chemists, sociologists, and economists collectively discussed how we can cautiously intervene in the fragile earth system in order to keep the planet liveable.

The second objective of this conference was to transcend a scientific discussion. "Decision-makers in politics and business must also understand that the self-regulating and self-healing powers of an ecosystem cannot be replaced by technology, no matter how sophisticated it is." states Wilderer. "We must all learn that the human being in not the measure of all things." We are only a part of the bigger picture and must modestly fit ourselves into the global, regional, and local ecological networks. Only by doing so will it be possible to secure the survival of the human race."

After the three day conference, the scientists drafted a declaration that was ratified and signed by all participating scientists on Friday, September 26, at the "Schneefernerhaus" on Zugspitze mountain.

The event brought together many prestigious experts and Professors for a discussion leading to a better understanding of the complex nature of the earth system, its physical, chemical and biological dimension as well as its social, cultural and economic dimension.


Hanns
Seidel
Stiftung

Board of Trustees Meetings

A friendly atmosphere in historical surroundings: a tour of Freising rounded out the Trustees meeting.

January 2007

The first Board of Trustees meeting was held on Monday, January 22, 2007 in TUM's Senatssaal. Following a short introduction of the participants, President Herrmann gave a presentation on the profile of TUM, the Excellence Initiative and the current planning concerning TUM-IAS. The first focus of the discussion concerned the architectural challenges: The location and architecture of the institute building on the Garching campus, the location of guest housing and the integration of the planned study center at Raitenhaslach. Prof. Arnulf Melzer presented the fund-raising strategy of TUM-IAS and the difficulties of the situation in Germany. The next item on the agenda was the discussion of the fellowship program and the initial program of TUM-IAS in its first phase. Finding a director who combines impeccable academic standing with a high motivation to build up the institute was considered as a very high priority.

November 2007

On Sunday, November 18, 2007, the members of the international TUM-IAS Board of Trustees had a private tour of the Deutsches Museum. The Board of Trustees meeting was held on Monday, November 19, 2007 in TUM's Senatssaal. Following welcoming remarks and introductions of participants, President Herrmann gave a presentation of the current state of TUM-IAS and its future plans. The first focus of the discussion concerned the search for a new TUM-IAS Director. The result of this discussion was the invitation of Prof. Patrick Dewilde to become the new Director of the TUM-IAS. At this meeting, the first eight TUM-IAS Fellows were also presented. Two of them, Prof. Gerhard Beutler and Prof. Arthur Konnerth, presented some of the initial plans of their focus groups.
The next items on the agenda were the TUM-IAS buildings. Next to the TUM-IAS main building on the Garching campus, the rental of a Villa on Nymphenburgerstraße provides space for conferences, the management office, and an office for the future TUM-IAS Director.

July 2008

The TUM-IAS international Board of Trustees met on July 7, 2008, for the annual Board meeting in the Asam Hall on the Weihenstephaner Nährberg. The IAS Fellows Prof. Claudia Klüppelberg and Prof. Reiner Rummel presented their research projects. Prof. Theodor Hugues explained the architectural concept for the new TUM-IAS building being built in Garching by the BMW Group. The Board also discussed new research groups and the future development of the TUM-IAS. Finally, the Board approved the appointment of Prof. Patrick Dewilde as new Director of the TUM-IAS. A historical guided tour of the city of Freising completed the Board meeting.

New Building and Concept

Resources and Data

Organization

Board of Trustees

Advisory Council

Director

Management Office

Outside view showing the raised basement

The Excellence Initiative funds allow quite a lot of flexibility in use for research and overhead expenditures. However, the funding strictly excludes buildings. The TUM-IAS is extremely grateful to the BMW Group for the 10 Million Euro commitment, which covers design, construction, and the complete project management for the building of the Institute's new home. The new building will be centrally located in the midst of all faculties on the Garching campus of TUM.

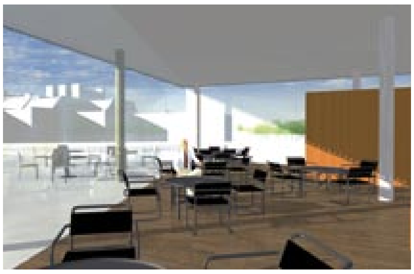
View from the underground station with surrounding buildings

The first part of the planning process involved visiting other Institutes for Advanced Study internationally, including the Princeton IAS and the Peter Wall Institute for Advanced Study at UBC Vancouver. As member of the TUM-IAS Board of Trustees, the directors of both of these Institutes have also been very helpful advisors in the planning process. In addition to the visits, a comprehensive user analysis was conducted, including a committee of professors, administrators, and students. The consensus from the group was that spaces should be designed which encourage the casual interaction of Fellows and foster the cross-pollination of ideas. The list of important attributes included a faculty club in the style of the American universities.

The selection of the architect to design the building involved a competition in which six architects were invited to submit proposals and preliminary designs. The jury of the competition based its decision on consideration of which design most closely observed the facility requirements of the user proposal, while staying within the budget, and, of course, having an attractive design. Fritsch and Tschaidse Architekten GmbH won the competition unanimously with their open and transparent building design.

The planning phase immediately followed, including weekly meetings to discuss the step-by-step process of the actual design of the building. In addition to the architects and project managers at BMW, members of the TUM Real-Estate Department, as well as the Managing Director of the TUM-IAS, were present at all of these meetings to ensure that the final product would be a building that truly meets the needs of the TUM-IAS. Architect and TUM Emeritus Professor Theodor Hugues has also been an official consultant in the design and planning process.

The building design reflects the vision of the TUM-IAS to bring scientists from around the world together in a place of inspiration and communication. The Fellow offices all open onto a circular corridor so that Fellows will come into contact with one another just through normal movement. There are a mixture of single and group offices, to flexibly accommodate the different needs of research groups. A café is planned on the ground floor where all Fellows will be able to get a high-quality coffee beverage. Since there will not be separate kitchens on the office floors, Fellows will naturally meet at the café. The offices for the TUM-IAS administration are not separated from the Fellows so that the needs of the Fellows can be

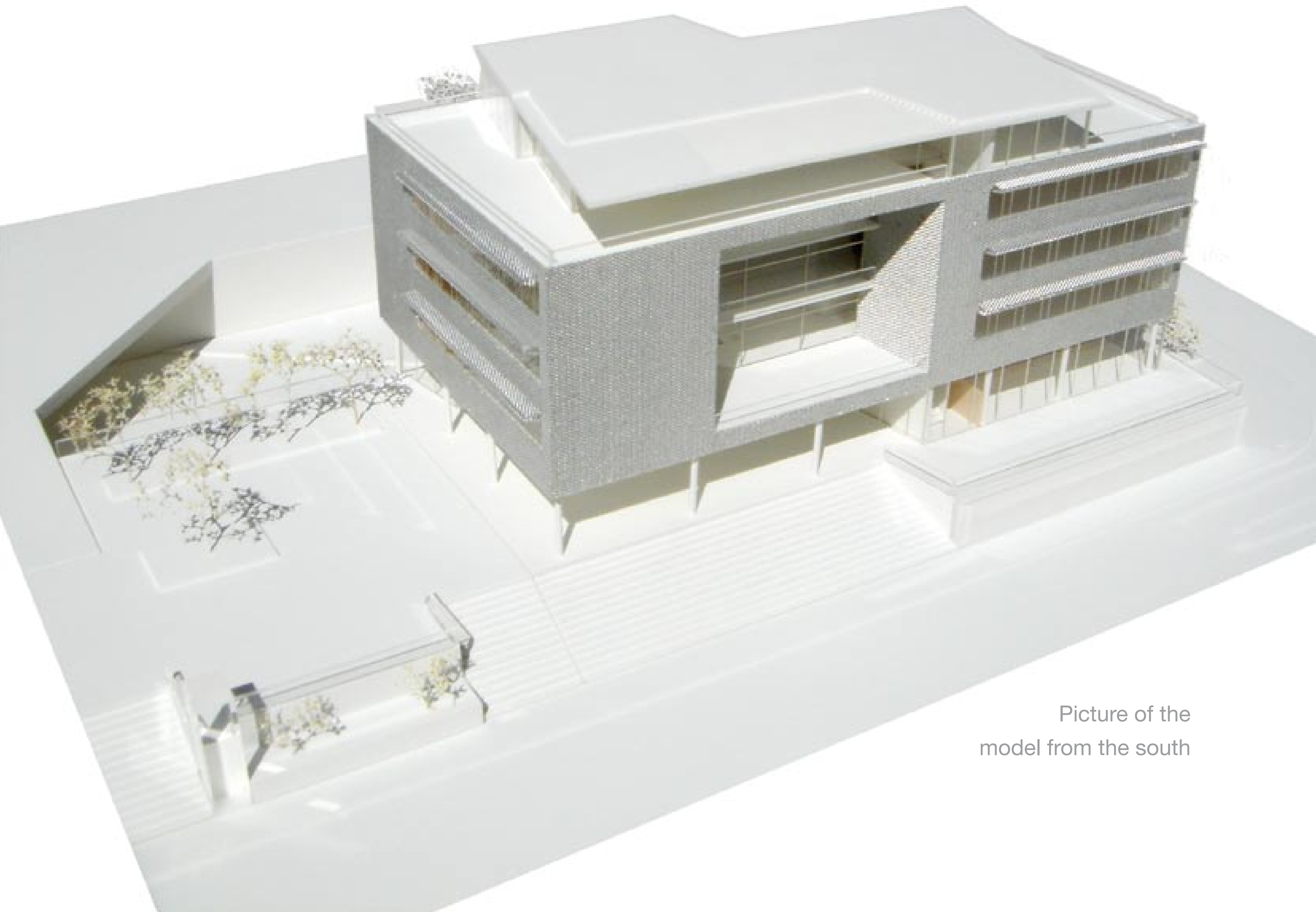


1 | View from the café on the ground floor over the terrace to the cafeteria

2 | Open space over a lounge area Conference room with semitransparent walls

quickly and informally addressed. The building will also have three conference rooms fully equipped with videoconference equipment for smaller meetings and an auditorium for larger symposia. Finally, the building has a faculty club on the top floor, including an outdoor terrace, and a lounge with a fireplace.

The building will be ready for use in the fall semester of 2010.



Picture of the
model from the south

Resources and Data

TUM-IAS will grow incrementally during its initial years until its targeted size of about 50 Fellows, who are present at the Institute at the same time, is reached in 2011.

Due to flexible lengths of the fellowships up to five years, a precise estimate of the size of TUM-IAS's body is difficult. The graph (figure 1) illustrates the existing number of Fellows through 2008 with projections through 2011. Until the Institute building on the Garching campus is available in 2010, operations of the TUM-IAS will have a start-up character.

Total Number of TUM-IAS Fellows

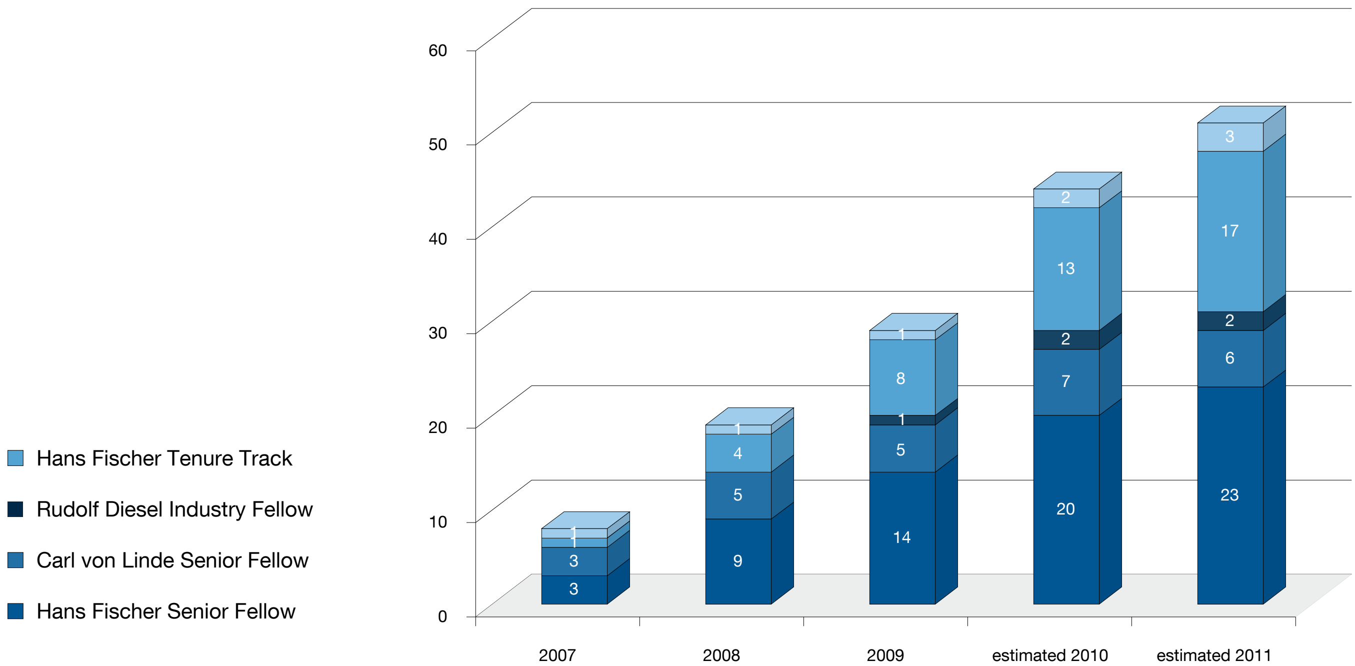


Figure 1

Funding for the TUM-IAS comes from the Excellence Initiative by the German federal and state governments. The Excellence Initiative runs until October 31, 2011. Based on this award, the TUM-IAS has an average budget of 4.5 Million Euros per year for the fellowship program and the start-up fund. Fellowship awards include a research fund, which can be used flexibly to cover costs including travel, relocation, and basic research expenses. 1.5 Million Euros per year are available in the form of start-up or project funding for Fellows and their host institutes to cover special laboratory equipment, conferences, and other extra expenditures. As IAS Fellows are also integrated in the faculties of TUM, the funds actually impact the entire university.

The IAS is a key instrument in the TUM strategy to develop new research topics, and to support the interdisciplinary and innovative ideas of top scientists from within TUM as well as externally. The TUM-IAS is not an instrument to balance out the under-funded fields. Instead, the IAS supports promising ideas, be it part of a small research team in the IGSSE graduate school or a large Excellence Cluster. This is reflected in the graph of the funds distributed in the various faculties in 2007 and 2008 (figure 2). Examples of this approach include two cases where the TUM-IAS has played a crucial role in providing key start-up funding for research projects, which ultimately enabled successful patchwork-funding packages, in combination with Humboldt Foundation Professorships, for two new faculty appointments at TUM.

Expenditures of TUM-IAS

Total: 3.062.113 €

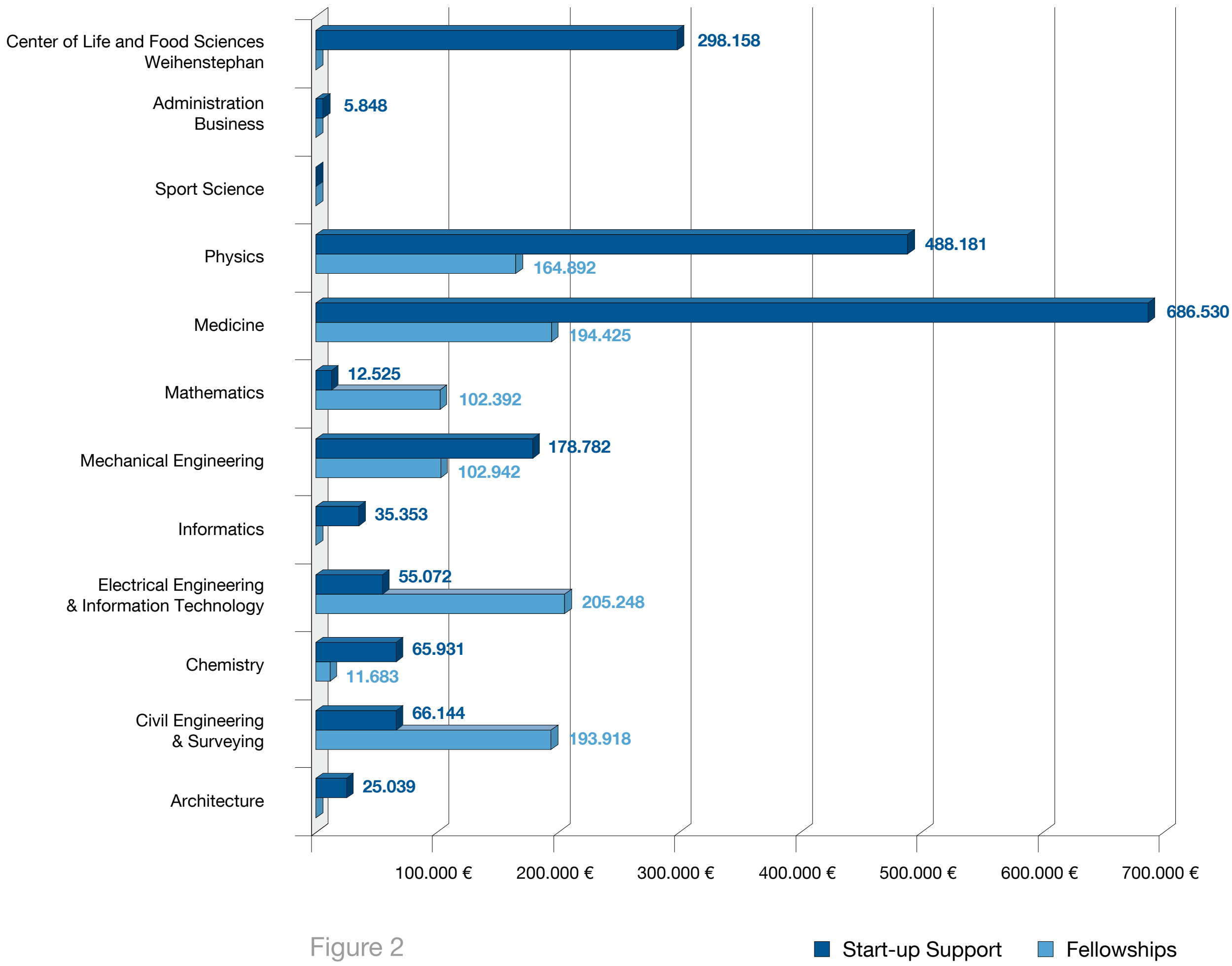


Figure 2

Organization

Members of the Board of Trustees on a guided tour of the Deutsches Museum.

The TUM-IAS has a lean organization. It relies on the experience that excellent and responsible people elect individuals on their own level of performance.

Board of Trustees

The Board of Trustees is formed by a group of international advisors from academia, research support organizations and from industry. The International Board of Trustees advises the Director on general scientific, organizational and technical issues. The Board also defines the general strategy and standards of the Institute.

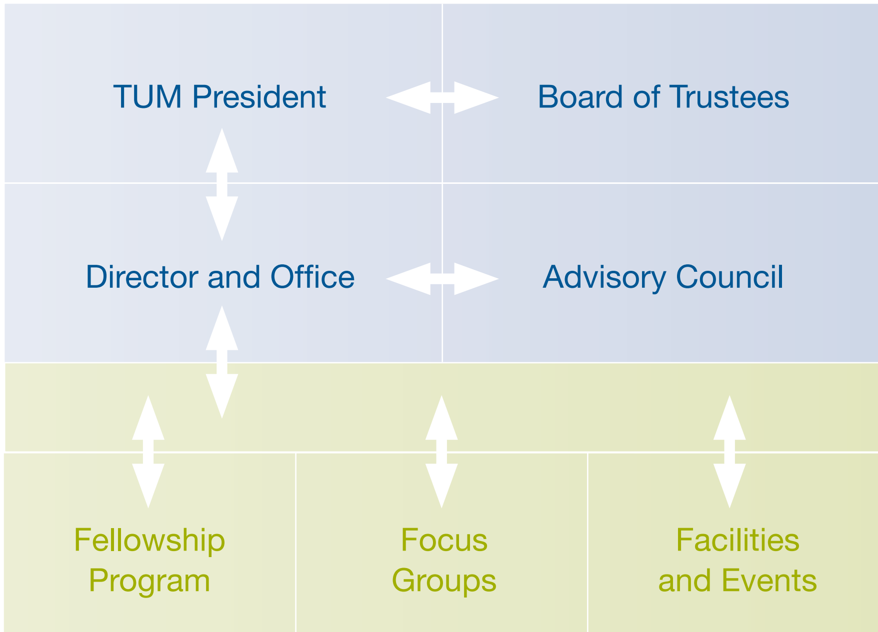
Members

Advisory Council

The Director is advised by the Advisory Council with regard to recruiting new Fellows and setting the research agenda of the Institute. This body is constituted of members of TUM. The leaders of the TUM-IAS Focus Groups, and the leaders of related bodies in the excellence initiative as well as advisers closely connected with the Institute make up this Council.

Members

Prof. Gerhard Abstreiter Experimental Semiconductor Physics 1
Prof. Andrzej Buras Institute for Theoretical Elementary Particle Physics
Prof. Martin Buss Institute of Automation and Autonomous Systems
Prof. Klaus Diepold Department of Data Processing
Prof. Joachim Hagenauer Emeritus Chair of Telecommunications Engineering
Prof. Claudia Klüppelberg Center for Mathematical Sciences
Prof. Arthur Konnerth Institute of Neuroscience
Prof. Klaus Mainzer Philosophy and Philosophy of Science, Director of the Carl von Linde Academy
Prof. Ernst Rank Civil Engineering – Computational Mechanics, Director of the IGSSE
Prof. Reiner Rummel Department of astronomical & Physical Geodesy
Prof. Peter Wilderer Emeritus Chair of Water Quality Control and Waste Management


TUM President
Board of Trustees
Director and Office
Advisory Council
Fellowship Program
Focus Groups
Facilities and Events

Director

Top Scientist for the Think Tank

Patrick Dewilde as Strategic Head of the TUM Think Tank "Institute for Advanced Study"

After approval from the Board of Trustees in July 2008, President Prof. Wolfgang A. Herrmann appointed the internationally reknown engineer Prof. Patrick Dewilde from the University of Delft as the Director of the TUM Institute for Advanced Study (TUM-IAS). Professor Dewilde, who is Belgian, began in his position at the Institute in September 2008. He graduated as an electrical engineer from the Catholic University of Leuven and earned a doctoral degree at Stanford University. After his dissertation, he became an ONR Fellow at the University of California, Berkeley, and thereafter became a lecturer at the University of Lagos.
He was subsequently Professor for Numerical Analysis and Network Theory in Belgium at the Catholic University of Leuven and since 1977 in the Netherlands at the Delft University of Technology. In 1993 Dewilde was appointed Director of the Institute of Microelectronics and Submicroelectronics (DIMES) at the University of Delft. He was also Chairman of the Dutch Technology Foundation STW until 2004.

Dewilde has been an IEEE Fellow since 1981 and a full member of the Royal Dutch Academy of Sciences since 1993. Three years ago he was apponited a "Knight of the Order of the Dutch Lion" by the Dutch queen Beatrix. The new TUM-IAS Director is one of the world's leading engineers in the areas of system and network theory. He enhanced his international network through numerous guest professorships, for example at Stanford University and at the Weizmann Institute. In the process he also came to TUM in 2003 as awardee of the Alexander von Humboldt Foundation prize. TUM President Herrmann praised the appointment: "With Prof. Dewilde we have gained a highly experienced engineer with a worldwide reputation, who thinks interdisciplinarily and who is able to evaluate scholarly quality."

Dewilde fulfills his new role with great pleasure. “I am myself a devoted researcher, and see as my role primarily to be a driving force in the support of top research at TUM.” As Director of TUM-IAS, Dewilde is responsible for the nomination of Fellows, the future development of the Institute, and the establishment of new projects and fields of research. The Professor has ambitious plans for the future. In particular, establishing an attractive ambiance at the Institute is important to him, so that researchers can feel at home and thereby a good foundation can be laid for excellent research. A further objective is focussing on research areas without, however, excluding a priori new, creative ideas. The integration of TUM-IAS into the University is particularly close to Dewilde’s heart. “The Institute should play a decisive role in TUM as a think tank, and I will personally give my best to enable that.”

Management Office

The staff of TUM-IAS supports the Fellows and coordinates the development of the Institute. They offer event organization (conferences, talks), translation services, and editing of foreign-language texts. They assist in such matters relating to relocation to Munich.

The staff also tries to liberate scientists as much as possible from the burden of administration.

Dr. Markus Zanner

is **Managing Director** of the TUM-IAS and coordinator for TUM's institutional strategy "TUM. The Entrepreneurial University." His prior position was as Project Manager for the External Supervisory Board ("Hochschulrat") and the Academic Senate of TUM. From 2000 to 2004 he was a Project Manager at the Faculty of Medicine at TUM. He studied history, philosophy, and romance languages in Regensburg and Posadas (Argentine).

Margaret Jaeger

is a **Program Manager** for the TUM-IAS. Her responsibilities include the management of the Institute operations, the coordination of events and symposia, and general support for the TUM-IAS Fellows and research groups. She has a professional background in fundraising for non-profit organizations, including the Boston Museum of Science. Margaret Jaeger completed her Bachelor's degree in Anthropology at Princeton University.

Stefanie Hofmann

is a **Program Manager** for the TUM-IAS. Her responsibilities include the coordination of the annual report, public relations for the TUM-IAS, and general support for the TUM-IAS Fellows and research groups. She studied political science, sociology, and communication science in Augsburg and Maynooth (Ireland) and was awarded the degree of Master of Administrative Sciences at the German University of Administrative Sciences Speyer.

Sigrid Wagner

is a **Team Assistant** for the TUM-IAS. Her responsibilities include the coordination of events and symposia, and general support for the TUM-IAS fellowship program and research groups.

Rebecca Innerhofer

is the **Foreign Language Secretary** for German, English, French, and Spanish for the TUM-IAS. Her responsibilities include office management, support of the coordination of events and symposia, and general support for the TUM-IAS research groups. She has a broad professional background in office management and customer services. Rebecca Innerhofer completed her apprenticeship as an Insurance Manager in Lucerne, Switzerland.

Melanie Hüttinger

is the TUM-IAS **Accounting Assistant.**

Imprint

Editor
Stefanie Hofmann
Margaret Jaeger

Designer
Christian Klette

Photographer
faces by frank

Translater
Manuela Black

Publisher
Institute for Advanced Study*
Technische Universität München
Arcisstraße 21
80333 München
Phone: 089/289-29076
Fax: 089/289-25245
Email: info@tum-ias.de
Web: www.tum-ias.de

Photo Credits
Page 21: Astrid Eckert
Page 23: Carl von Linde – Carrier Kältetechnik
Hans Fischer – Historisches Archiv TUM, Müller-Hilsdorf
Page 38/41: CERN
Page 64–68, Page 82–83: ESA
Page 84: Rainer Lehmann
Page 87: Historisches Archiv, TUM

as of December 2008
*sponsered by Excellence Initiative by the federal and state governments

TUM Institute for Advanced Study
Arcisstraße 21 · 80333 München
Phone: 0 89/2 89-2 90 76
E-Mail: info@tum-ias.de
Web: www.tum-ias.de