

## Major Results that would not have occurred without TUM-IAS

This is a partial list of major highlights and scientific results achieved by Focus Groups at TUM-IAS.

### Risk Analysis and Stochastic Modelling

- Champions: Klüppelberg, Stelzer, Davis
- Method: modeling of random phenomena changing over time by non-Gaussian stochastic processes and developing statistical inference methods
- Results: new understanding of the behavior of markets, energy production by wind turbines, new methods of risk analysis, control of catastrophes; foundational theoretical work relevant for the use of Lévy based models
- Importance: Finance, Insurance, Signal Processing, Stochastic Turbulence Modelling, Stochastic Control, New Models and Methods for non-Gaussian Space-Time Phenomena

DFG grant „Statistics of Levy-driven Models“ over 2 years ca. 125k€

W3 Professorship at University of Ulm to Robert Stelzer at the age of 30!

Through Prof. Davis development of co-operation Columbia University/TUM/Lamont-Doherty Earth Observatory at Columbia

Successful draft proposal for the Graduate School Risk and Security proposed for the Excellence Initiative II, coordinated by Prof. Klüppelberg. A long term formal cooperation between TUM and MIT on this field is being planned which arose from the contact of Prof. Klüppelberg with Prof. Sanjoy Mitter (TUM-IAS Visiting Fellow).

Establishment of a yearly Workshop at TUM “Statistical Methods and Models” to bring together researchers in different fields using state-of-the-art statistical methods, offering a platform of discussion and collaboration within TUM.

Very close co-operation with DTU on statistical analysis of turbulence with respect to wind energy problems (DTU/RISOE) – Strengthening of the European University Alliance of Science and Engineering.

“Safety Management System zur Verbesserung der Flugsicherheit (SaMSys II)”, participation of Prof. Klüppelberg in this project at the chair of Prof. Holzapfel (contact established via the TUM-IAS) (3.4 Mio.€ for 3 years) 50% financed by Lufthansa, 50% by the Federal Ministry of Economics and Technology. Begin planned for July 2012 upon positive evaluation.

Submission of a ERC Advanced Grant Proposal “Statistical Modelling of Non-Gaussian Complex Dynamic Processes – Finance, Energy and Engineering Risk” in

2011 by Prof. Klüppelberg. (prompted by the success and contact to Prof. Buras, via TUM-IAS)

### **Understanding neurons through in vivo observation**

- Champions: Konnerth, Sakmann, Misgeld
- Methods: development of new approaches for in vivo measurements of functioning neurons
- Results: include first steps toward a cortical wiring diagram in vivo with single synapse resolution and new insights into mechanisms of axonal propagation
- Importance: besides new approaches and major new insights into basic mechanisms of neuronal function, contributions toward the treatment of neurological diseases (MS, ALS, Alzheimer's disease)

Establishment of the EU-financed ERA-Net Neuron consortium '2-photon imaging', ca. 800k€ for 4 years, Prof. Konnerth, Prof. Misgeld, Prof. Yosef Yarom (IAS Visiting Fellow).

Successful evaluation and approval for a second funding period (2011-2015) of the DFG-Graduiertenkolleg 1373 'Brain signaling: from neurons to circuits', Speaker Prof. Konnerth

Co-coordination of the successful cluster draft proposal SyNergy – Munich Cluster for Systems Neurolog by Prof. Misgeld. Funding for TUM 10-15 Mio. € over 5 years (plus overhead).

Additional support from the AvH (400k€) for Prof. Misgeld to match the TUM-IAS funds made available.

Development of intense co-operations with the Marine Biological Laboratory (Woods Hole). Funding obtained from US Foundations (Dana Foundation, Christopher and Dana Reeve Foundation) of ca. 300k€.

Establishment of a cooperation with Prof. Daniel Kerschensteiner (Washington University St. Louis, via a TUM-IAS Visiting Fellowship). This project will receive NIH-R01 funding on the US side soon and is being funded on Prof. Misgeld's group as a part of the SFB596.

## **New clinical Cell Treatments**

- Champions: Busch, Riddell, Stemberger
- Methods: combination of the Riddell/Busch methodology for cell selection and function enhancement with the development of highly selective new cell purification methods in Munich
- Results: new clinical treatments of cancer/infections
- Importance: very promising new technique can revolutionize treatments

A true example of complementary expertise, assembling a group of scientists with the expertise to simultaneously advance the field technically and be capable of evaluating advances in the clinic. Although this focus group is only active since 1 year, the work performed has already garnered international attention and several leading groups are interested to apply this cell purification technology in their research and clinical cell therapy applications. Collaboration with the group of Prof. Misgeld has been established via the IAS.

## **Understanding Emotional Intelligence**

- Champions: Wollherr, Kühnlenz, Buss
- Method: formal understanding and description of “feelings”
- Results: how a robot can understand feelings of people in its environment
- Importance: man-machine interface seen as the most promising robot technique of the future

Joint (Kühnlenz, Wollherr as Principal Investigator) EU FP7 STREP Project „ IURO-Interactive Urban Robot “ coordinated by TUM (1.5 Mio€ for 3 years)  
ERC starting grant (Kühnlenz) “Robot Perception and Control with Camera Skins – ROCCAS” passed selection step 1, in this step, the demonstration of scientific independence and support by the home institution is crucial and Kühnlenz status of independent Carl von Linde Junior Fellow was instrumental for success.

Establishment of a collaboration with the group of Prof. Lugli in visual sensor skins on sensor level (contact established via the IAS).

Organization of the Phi-Bot Workshops 2010, 2011 on Philosophy and Robotics for discussion of future implications and design guidelines of robots entering daily lives of humans. (Together with Prof. Mainzer CvL Academy, contact established via the IAS).

Participation as Principal Investigator (Kühnlenz) in the Munich Bernstein Center of Computational Neuroscience (BCCN) providing a link between BCCN and groups of cognitive sciences, computer science and engineering and particularly the excellence cluster “CoTeSys”.

## **The distribution of mass on Earth**

- Champions: Beutler, Jäggi, Rummel
- Method: the TUM-IAS team is pioneering new concepts of satellite-based geodesy
- Results: major technological results (concept of highly sensitive gravitation measurements in the satellite under very adverse conditions), development of the numerical method for the inverse problem: orbit to global Earth gravitational field.
- Importance: essential data for accurate estimation of the behavior of the Earth.

Bringing together (TUM-IAPG and University of Bern-AIUB) two complementary fields of expertise, which are essential to the best possible gravity field recovery from the new generation of satellites mission.

IAS allowed Rummel to devote his undivided attention to the scientific exploitation of the GOCE mission and providing leadership to the GOCE/HPF (High Level Processing Facility) consortium. High visibility/prestige project for TUM. Joint proposal IAPG/AIUB to DFG/SNF is under preparation (0.6 Mio. €)

DFG Priority program 1257 projects “Sea Surface Topography and Mass transport of the Antarctic Circumpolar Current “ and “Improving Ocean Tides by Constraining the Dynamic HAMTIDE model with altimetry and GRACE data” (ca. 100k€)

“Observation of the System Earth from Space” as part of the R&D program GEOTECHNOLOGIEN of the German Federal Ministry of Education and research (BMBF) (Total volume 5.7 Mio. €)

## **Biochemistry: Drug discovery, spider silk protein investigation**

- Champion: Kessler
- Method: systematic development of new drugs and medicinal devises based on functionalizing peptides and peptidomimetics.
- Application of NMR to biologically relevant problems. NMR investigation of proteins and their interaction partners
- Results: peptides and non-peptides with improved activity, selectivity and bioavailability for cell attachment (biomaterials) and cancer imaging. Elucidation of important mechanisms in spider silk formation and stability
- Importance: a new class of drugs, development of personalized medicine, rational drug design. Contribution for the successful synthesis of spider silk, with threads as strong as steel but as flexible as rubber.

The Carl von Linde Senior Fellowship has allowed Kessler to continue doing research after 2008. Since beginning of his Fellowship, he has published over 49 scientific papers (in Journals such as Nature, Angew. Chem. , Mol. Cell, PNAS, EMBO Reports, C. Eur. J, Chem. Comm., JACS etc), having a h-factor of 71. Member of the Excellence Cluster CIPS

### **Novel methods of Bone Modeling**

- Champions: Yosibash, Rank
- Method: numerical simulation of (human) bones, based on a multilayer model, new numerical techniques and experimental verification. Development of a new numerical technique, the “Finite Cell Method”.
- Results: massive improvement in bone strength prediction accuracy
- Importance: essential components in treatment of bone diseases by allowing surgeons to accurate gauge treatment effect

Multidisciplinary research (Mathematics, Engineering, Clinical). A DFG proposal is in an advanced state of preparation involving statistics and uncertainty quantification (Prof. Ankerst, Prof. Straub, TUM), clinical relevance and experimentation (Dr. Burgkart, Prof. Keyak UC Davis) and computation (Prof. Rank TUM, Prof. Yosibash TUM/BGU). ‘Validated patient-specific bone simulation with uncertainty quantification for specific clinical applications (working title)

Strong interaction with the IGSSE via the project: “Computational Steering for orthopaedics”

DFG Proposal ‘Electro-thermo-mechanical modeling of Field Assisted Sintering Technology using high-order finite elements validated by experiments’. Participants: Prof. Hartmann, Universität Clausthal, Prof. Düster, TUHH, Prof. Rank, TUM, Prof. Frage, BGU, Prof. Yosibash, BGU. Funding for 2 years ca. 800k€.

### **New quantum field theory models for fundamental Interactions of Quarks and Leptons**

- Champions: Buras, Gorbahn, Isidori, Pokorski
- Method: development of new methods for physics at shortest distance scales
- Results: identification of special characteristics of a multitude of extensions of the standard model in flavour violating processes.
- Importance: these results and methods are basic for the development of the theory of flavour and its tests in high energy and high precision experiments in the coming years

4<sup>th</sup> most cited particle theorist in Europe and most cited flavour physicist world-wide. ERC Advanced Grant “Towards the construction of the Theory of Flavour”, 1.6 Mio.€ 2011-2016 (Buras).

High publishing activity, more than 100 citations we collected by four papers in less than a year, a very high score in fundamental physics.

### **New semiconductor lasers and nanophotonic devices**

- Champions: Abstreiter, Arakawa
- Method: enhanced light emission from silicon using two dimensional photonic crystals with point-defect photonic nano cavities or III-V nanowires on silicon
- Goal: Silicon based lasers paving the way towards CMOS-compatible optical signal transmission
- Importance: pioneering a new way of ultra high speed signal processing on chips

Arakawa is world leading expert in artificial quantum dot lasers. The project is combining Munich expertise in integrated photonics fabrication with laser design expertise from Tokyo. Establishment of strong collaborations with the Center of Excellence “NanoQuine” in Japan

Strong project in the NIM cluster. The Carl von Linde Senior Fellowship allows Prof. Abstreiter to set up the newly created Center for Nanotechnology and Nanomaterials (WSI-ZNN) fully operational and to develop it with its state-of-the-art shared technology and nanoanalytics facilities to an important institution within TUM and making it very attractive for researchers from all over the world to spend some time in this stimulating environment.

### **Biosensors based on nanophotonics**

- Champions: Rant, Abstreiter
- Method: grafting short DNA molecules on microelectrodes on a chip, and actuating them dynamically by electric fields. Sensing the molecular switching motion to analyze the binding and properties of target proteins, e.g. antibodies.
- Results: a high-information-content bio-sensor platform.
- Importance: bio sensing is vital to understand the interactions of molecules such as for instance medically relevant proteins and pharmaceutical drugs.

Efforts have successfully been made to create a spin-off company, aiming to commercialize a novel type of biosensor platform to detect and analyze biomolecular interactions on a chip (switchSENSE system).

This had the support of Fujitsu Laboratories Ltd., EXIST Forschungstransfer (BMW) with 380 k€ (July 2009-April 2011), TUM-IGSSE, and will be supported with 2.3 Mio€ (July 2011-June 2013) start-up funding from BMBF within the program GO-Bio under the title “Gründungsvorhaben zur Kommerzialisierung der switchSENSE Technologie, einer Chip-basierten Plattform zur effizienten Analyse von Proteinen”.

Further, a cooperation with the group of Prof. Dietz was established via the IAS, combining the expertise on organic nanostructures (DNA origami, Dietz) and inorganic nanostructures (artificial nanopores, Rant).

### **Here are examples of a few more unique co-operations made possible by TUM-IAS:**

#### **A new combined NMR – tele-surgery tool and treatment**

- Champions: Kucharczyk, Lüth
- Method: a robot that combines an MRI scanner with an ultra sound (tele-) ablation tool, allowing the ablation of a prostate cancer directly under MRI supervision
- Result: a fundamentally new surgical treatment for some prostate cancers, and possibly other cancers too
- Importance: the treatment greatly reduces operational risks, patient morbidity and discomfort.

The stay at TUM-IAS allowed Kucharczyk to develop the new ideas on which the instrument is based. Presently the project continues with the exploration of combined MRI-PET imaging machines.

#### **Nanoimprint and Nanotransfer**

- Champions: Lugli, Karrai, Porod
- Method: nanotransfer printing (ntP) and nanoimprint lithography (NIL)
- Result: a series of novel fabrication and patterning techniques for the realization of innovative devices at the nanoscale
- Importance: economical production of novel nanoscale devices

New activities in the field of infrared, chemical and biological sensors as well as in photocatalysis that would not have been possible without the formation of this group with its complementary expertise and the support of the IAS (Hans Fischer Fellows, PhD students and instrumentation). An additional start-up funding has allowed an innovative work on Carbon nanotube (CNT) Networks . Students of

Electrical Engineering and Physics have had the possibility to carry out experiments using CNT networks and accessing the instrumentation in a series of Lab offers at the Institute for Nanoelectronics.

Submission of a Marie Curie Initial Training Network on “Organic Biosensors”. The TUM contribution is fully based on biosensors utilizing CNT networks. (Total volume 4.2 Mio € for 4 years, TUM share 1.2 Mio€). The results will be known in Mai 2011. DFG project “Elektrokatalytische Aktivität definierter Nanostrukturen, die mittels Nanoimprint Lithographie hergestellt werden”, together with the IAS Carl von Linde Senior Fellow Prof. Stimming.

DARPA project „NanoMagnet Logic“ (Headed by Hans Fischer Senior Fellow Prof. Porod, partners TUM, UC Berkeley, IBM, Grandis) together with the Institute for Technical Electronics (Prof. Schmitt Landsiedel, recipient of IAS start-up funding for the development of a Magnetic Force Microscope for direct observation of magnetic switching events).

SFB short proposal submitted “Charge and energy transfer at material interfaces”, in May will be known if a full proposal should be submitted.

DFG project in cooperation with Prof. Stimming “Elektrokatalytische Aktivität definierter Nanostrukturen, die mittels Nanoimprint Lithographie hergestellt werden“, this is a direct outcome of the IAS focus group, which will extend the focus to the critical field of energy.

Teaching by Prof. Porod within the courses of “Nanotechnology” and “Nanoelectronics” in 2010 and 2011. Several TUM students were offered the possibility to complete their Master or Diploma work in the University of Notre Dame (Porod) or Attocube (the company of the Rudolf Diesel Fellow Karrai). Development and testing of a novel miniature nanoimprint machine which is made available to the excellence cluster NIM.