Austrian Academy of Sciences

Annual Report 2010

Johann Radon Institute for Computational and Applied Mathematics

REPORTING PERIOD:	1.1.2010 – 31.12.2010
DIRECTOR OF THE REPORTING RESEARCH INSTITUTION:	Prof. Heinz W. Engl
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Content

1. Mission Statement

The current mission statement of the Johann Radon Institute for Computational and Applied Mathematics (RICAM) is as follows:

The Johann Radon Institute for Computational and Applied Mathematics

1. does basic research in computational and applied mathematics according to highest international standards
2. obtains the motivation for its research topics also from challenges in other scientific fields and industry
3. emphasizes interdisciplinary cooperation between its workgroups and with institutions with similar scope and universities world-wide
4. cooperates with other disciplines in the framework of special semesters on topics of major current interest
5. wishes to attract gifted PostDocs from all over the world and to provide an environment preparing them for international careers in academia or industry
6. cooperates with universities by involving PhD-students into its research projects
7. promotes, through its work and reports about it, the role of mathematics in science, industry and society

2. Scientific Activity 2010

2.1. Zusammenfassung des wissenschaftlichen Berichts 2010

Das Institut verfügte 2010 über die folgenden Arbeitsgruppen:

- Arbeitsgruppe „Computational Methods for Direct Field Problems“, Gruppenleiter: Prof. Dr. Ulrich Langer
- Arbeitsgruppe „Inverse Problems“, Gruppenleiter: Prof. Dr. Heinz Engl
- Arbeitsgruppe „Symbolic Computation“, Gruppenleiter: Prof. Dr. Josef Schicho
- Arbeitsgruppe „Analysis for Partial Differential Equations“, Gruppenleiter: Prof. Dr. Peter Markowich, Doz. Dr. Massimo Fornasier
- „Arbeitsgruppe „Optimization and Optimal Control“, Gruppenleiter: Prof. Dr. Karl Kunisch
- Arbeitsgruppe „Mathematical Imaging“, Gruppenleiter: Prof. Dr. Otmar Scherzer
- Arbeitsgruppe „Mathematical Methods in Molecular and Systems Biology“, Gruppenleiter: Prof. Christian Schmeiser, Dr. Philipp Kügler
- Forschungsprojekt „Applied Discrete Mathematics and Cryptography“, Doz. Dr. Arne Winterhof

Im Folgenden wird kurz über die wissenschaftliche Tätigkeit der einzelnen Arbeitsgruppen berichtet; Details und Informationen über die Zusammenarbeit zwischen den einzelnen Gruppen sowie über die sonstigen wissenschaftlichen Tätigkeiten sind dem Punkt 2.5. zu entnehmen.

Gruppe “Computational Methods for Direct Field Problems”

Die Forschungsarbeit dieser Gruppe konzentriert sich auf die Entwicklung, die Analyse sowie die Implementierung effizienter und robuster numerischer Methoden zur Lösung partieller Differentialgleichungen mit folgenden Schwerpunkten:

- Robuste Algebraische Mehrgitter- und Multilevelverfahren für großdimensionierte technische Probleme und Probleme in den Lebenswissenschaften.
- HP (high-order) Finite-Elemente-Methoden mit Anwendungen in der Festkörper- und Strömungsmechanik sowie in der Elektrotechnik.

- A posteriori Fehlerabschätzungen vom Funktionaltype.

Innerhalb eines FWF-Forschungsprojektes wurden Forschungsarbeiten zu dem neuen Forschungsgebiet “Isogeometrische Analysis” begonnen. Dieses Forschungsgebiet hat viele interessante praktische Anwendungen und soll in der Zukunft weiter ausgebaut werden. Die Abbildung 1 zeigt eine FSI-Simulation, wo Gebietsdekompositionsverfahren mit neuen Algebraischen Mehrgittermethoden kombiniert worden sind.

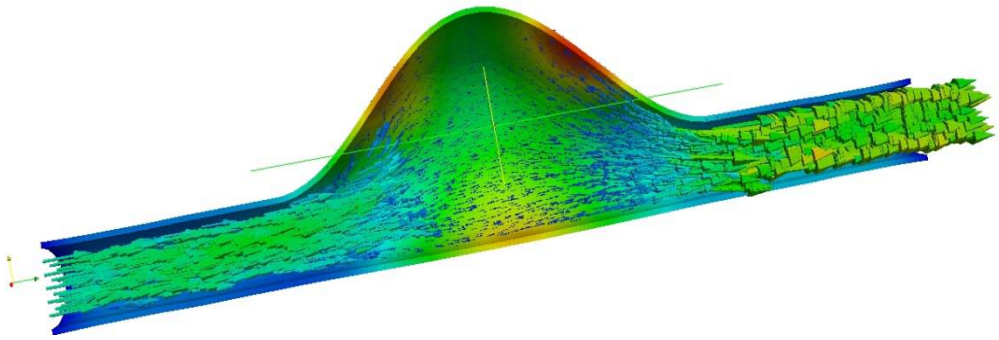


Abbildung 1: Simulation eines Fluid-Structure-Interaction (FSI) Problems

Gruppe „Inverse Problems“

In der Arbeitsgruppe werden theoretische Fragestellungen auf dem Gebiet der Inversen Probleme untersucht und anwendungsorientierte Forschungsprojekte bearbeitet. Aktuelle theoretische Forschungsresultate umfassen Untersuchungen zu optimalen Parameterwahlregeln für die Multi - Parameter Regularisierung und die Ableitung von Konvergenzraten für Regularisierungsverfahren zur Rekonstruktion dünnbesetzter Lösungen mit Hilfe von Variationsungleichungen. Fortschritte wurden auch bei der Analyse der Rekonstruktionsgüte der Linear Sampling Methode zur Lösung von Inversen Streuproblemen erzielt.
Die Arbeitsgruppe ist derzeit an zwei großen Forschungsprojekten beteiligt: Das EU - Projekt “DIAdvisor: personal glucose predictive diabetes advisor” wird über das 7. Rahmenprogramm finanziert, und das Projekt "Mathematical algorithms and software for ELT adaptive optics" ist ein wesentlicher Bestandteil der InKind Beiträge Österreichs zur Europäischen Südsternwarte (ESO). Darüber hinaus wurden in der Gruppe 5 Einzel - Forschungsprojekte durchgeführt, die vom FWF oder der FFG finanziert wurden.

Gruppe „Symbolic Computation“

Für die Berechnung des Geschlechts und die Analyse der Singularitäten einer algebraischen Kurve gibt es seit langem Algorithmen. Für diese ist aber eine exakte Kenntnis und

Darstellung der komplexen Koeffizienten notwendig. Die Gruppe löste diese beiden Probleme für den Fall, dass die Koeffizienten mit numerischen Fehlern behaftet sind. Dabei wurden Ideen aus der Regularisierungstheorie und klassische Sätze der algebraischen Geometrie und der Knotentheorie verwendet (siehe Figur 1). Zu einem ähnlichen Thema, nämlich der Parametrisierung von algebraischen Kurven mit Radikalen, wurde ein Projekt bewilligt; es wird 2011 beginnen.

Ein weiterer Schwerpunkt war die algebraische Theorie von Green'schen Operatoren im Zusammenhang von Randproblemen. Die Gruppe entwickelte Entscheidungsalgorithmen für Gleichungen mit solchen Operatoren. Ein bereits bewilligtes Projekt mit diesem Fokus konnte nicht wie geplant begonnen werden, weil der PI ein Erwin-Schrödinger-Fellowship akzeptiert hat und zu INRIA, Paris übersiedelt ist.

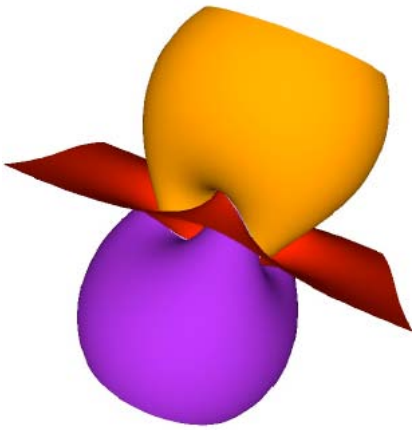


Abbildung 2: Die Milnor-Faserung zu einem gewöhnlichen Tripelpunkt

Gruppe „Analysis for Partial Differential Equations“

Die Arbeitsgruppe fokussiert auf die folgenden Themen: Variationsrechnung und geometrische Masstheorie mit Betonung auf inverse freie Diskontinuitätsprobleme. Existenz von Lösungen und numerische Methoden wurden untersucht. Weiters haben wir Gebietszerlegungsmethoden und Unterraumkorrektionsmethoden für nichtglatte konvexe Minimierung untersucht, mit Anwendungen in der Totalvariationsminimierung für Bildbearbeitung und Analyse. Im Moment untersuchen wir weiters die folgenden partiellen Differentialgleichungsprobleme: Fluidmodelle für Chemotaxis, kinetische Modelle für die Beschreibung von Tierschwärmen und klassische Gleichungen der mathematischen Physik (Bolzmanngleichung, Vlasov-Boltzmanngleichung).

Gruppe „Optimization and Optimal Control“

Das Hauptaugenmerk der Forschung liegt auf der Entwicklung numerischer Verfahren zur Berechnung optimaler Steuerungsprobleme bei partiellen Differentialgleichungen. Ein Teil

der Forschung, welcher auch durch ein FWF-Projekt unterstützt wird, zielt auf die Entwicklung adaptiver Diskretisierungsverfahren ab, welche sich auf a-posteriori Fehlerschätzer stützen, die vollständig numerisch auswertbar sind. In einem weiteren Forschungsfeld beschäftigen wir uns mit Problemen mit nicht glatten Strukturen. Die Entwicklung halbglatter Newtonverfahren wird im Kontext von Optimalsteuerungsproblemen mit polygonalen Beschränkungen an die Zustände und die Kontrollen vorangetrieben. Eine wesentliche Herausforderung stellen zurzeit auch zeitoptimale Probleme bei Problemen, etwa im Hinblick auf die Herleitung geeigneter Transversalitätsbedingungen, dar.

Gruppe “Mathematical Imaging”

Ein interessantes Anwendungsgebiet der photoakustischen Bildgebung ist für mikroskopische Anwendung, um Proben in "tieferen" Bereichen zu analysieren als es mit herkömmlichen Mikroskopen möglich ist. Wir visualisieren die beta-Zell Bildung in der Bauchspeicheldrüse in Zebrafischen, wobei mathematische Algorithmen basierend auf der "nicht gleichmäßig abgetasteten Fourier Transformation" zum Einsatz kommen um eine optimale Auswertung der Daten zu ermöglichen. Das derzeitige Auflösungslimit ist bei Formationen von etwa 1000 Zellen, was in Zukunft weiter reduziert werden soll.

Gruppe „Mathematical Methods in Molecular and Systems Biology“

Die Anfang des Jahres 2009 gegründete Arbeitsgruppe arbeitet an interdisziplinären Projekten, die durch Fragestellungen aus der Zell- und Molekularbiologie angeregt werden. Interdisziplinäre Kooperationen mit Vertretern von IMP, IMBA, MFPL und der Universität Wien (Institut für Pharmakologie und Toxikologie, Department Molecular Systems Biology) sind in verschiedenen Phasen der Realisierung. Zwei davon sind im Rahmen von WWTF-Projekten zu den Themen Stresshormon-Regulation und Zytoskelettdynamik institutionalisiert. Die mathematische Methodenentwicklung und -anwendung konzentriert sich auf die Gebiete inverse Probleme, partielle Differentialgleichungen und Bildverarbeitung. Die derzeitigen biologischen Fragestellungen umfassen die Stressantwort von Pflanzen, die asymmetrische Zellteilung, Chemotaxis, Regulation in Metabolomnetzwerken und die Fortpflanzung des Meereswurm Platynereis dumerilii.

Forschungsprojekt „Applied Discrete Mathematics and Cryptography“

Das Forschungsprojekt hat seinen Schwerpunkt bei den Anwendungen der Diskreten Mathematik bei

- quasi-Monte Carlo Methoden und der Erzeugung von Pseudozufallszahlen,

- Kommunikations- und Kodierungstheorie,
- Kryptografie.

Insbesondere wurden gemischte Folgen analysiert, die die Vorteile von Monte Carlo und quasi-Monte Carlo Methoden verbinden, zwei neue Klassen sehr viel versprechender Pseudozufallszahlengeneratoren studiert und Qualitätsmaße für neue Klassen von Binärfolgen abgeschätzt. Außerdem wurden Fortschritte bei den Problemen der Suche nach guten algebraisch geometrischen Kodes und Permutationen für Prüfziffersysteme wie die internationale Standardbuchnummer (ISBN) erzielt.

2.2. Highlights 2010

- In einem gemeinsamen Projekt mit ESO, der Europäischen Südsternwarte, entwickeln wir Algorithmen zur Bildkorrektur von großen Teleskopen. Um qualitativ hochwertige Bilder, etwa von Galaxien, zu erhalten, müssen die durch atmosphärische Turbulenzen gestörten Bilder mit Hilfe von biegbaren Spiegeln korrigiert werden. Im letzten Jahr wurde ein Algorithmus entwickelt, der die Korrekturen für das geplante Extremely Large Telescope (ELT) in Echtzeit berechnet. Eine erste Evaluierung durch die ESO verlief sehr erfolgreich.
- Im Rahmen des nationalen Forschungsnetzwerkes “Photoacoustic Imaging” haben wir uns gemeinsam mit Prof. Dirk Meyer (Molekularbiologie, Universität Innsbruck) mit der Photoakustischen Visualisierung von beta-Zellen in der Bauchspeicheldrüse (ein Modellorganismus) beschäftigt. Dafür werden ausgefeilte mathematische und computerunterstützte Methoden verwendet, wie etwa eine auf die Photoakustik getrimmte unregelmäßig abgetastete schnelle Fouriertransformation.
- Jede Arbeitsgruppe am RICAM hat selbstverständlich weitere Highlights erzielt, aber wir halten uns an die Vorgabe, höchstens zwei zu nennen.

Key Publications:

Wir nennen zehn anstatt der geforderten fünf Key-Publications:

- B. Buchberger, **G. Regensburger**, **M. Rosenkranz**, L. Tec: An automated confluence proof for an infinite rewrite system parametrized over an integro-

differential algebra. In: Fukuda, K et al (eds), Mathematical Software - Proc. ICMS 2010, Springer, 2010, pp 245--248.

- **R. Duan**, **M. Fornasier** and G. Toscani: A kinetic flocking model with diffusion, Commun. Math. Phys., Vol. 300, no. 1, 2010, pp. 95-145 ://www.ricam.oeaw.ac.at/people/page/fornasier/DFT.pdf
- **R. Duan**, A. Lorz and **P. A. Markowich**: Global Solutions to the coupled chemotaxis-fluid equations, Communications in Partial Differential Equations, Vol. 35, no. 9, 2010, pp. 1635-1673 http://www.math.cuhk.edu.hk/~rjduan/Preprint%20for%20Homepage/DLM-Re03.pdf
- **P. Elbau**, M. Grasmair, F. Lenzen, **O. Scherzer**: Evolution by Non-Convex Functionals, Numerical Functional Analysis and Optimization, Volume 31, Issue 4, April 2010, pages 489-517
- **E. Karer**, **J. Kraus**: Algebraic multigrid for finite element elasticity equations: Determination of nodal dependence via edge matrices and two-level convergence. Int. J. Numer. Meth. Engng., vol. 83 (2010), pp. 642-670.
- **Karl Kunisch**, Kewei Liang and **Xiliang Lu**: Optimal Control for an Elliptic System with Polygonal State Constraints, SIAM J. Control Optim, 48(2010), 5053-5072
- **P. Kügler**: Online parameter identification without Ricatti-type equations in a class of time-dependent partial differential equations: an extended state approach with potential to partial observations, Inverse Problems 26 (2010) 035004 (23pp)
- J. Liu and **M. Sini**: Reconstruction of cracks of different types from far field measurements. Mathematical Methods in the Applied Sciences 33, no. 8, 950-973, 2010
- **D. Ölz**, **C. Schmeiser**: Derivation of a model for symmetric lamellipodia with instantaneous cross-link turnover, Archive Rat. Mech. Anal. 198 (2010), pp. 963-980.

- A. Winterhof: Recent results on recursive nonlinear pseudorandom number generators (invited paper). Recent results on recursive nonlinear pseudorandom number generators (invited paper). In: Carlet, Claude et al.

2.2.1. Personnel Development

It is a principle at RICAM (see part 1) to hire PostDocs internationally and in most cases with limited time contracts. In 2010 our PostDocs have been successful in obtaining offers for permanent (mostly professorial) positions as the following table shows:

Employee	University
Sven Beuchler	University of Bonn
Massimo Fornasier	Technical University of München
Ronny Ramlau	University of Würzburg
Mourad Sini	• King Fahd University of Petroleum and Minerals, Dhahran • Seoul National University

This is on the one hand a success, but also implies that we have to constantly hire new PostDocs. The financial constraints and the financial restrictions of the last two years have made this difficult, and we hope for an improvement in this context in order to remain competitive internationally.

2.3. Summary of the scientific report 2010

At the end of 2010, the Institute had the following group structure:

- Group “Computational Methods for Direct Field Problems”, group leader: Prof. Dr. Ulrich Langer
- Group “Inverse Problems”, group leader: Prof. Dr. Heinz Engl

- Group “Symbolic Computation”, group leader: Prof. Dr. Josef Schicho
- Group “Analysis of Partial Differential Equations”, group leaders: Prof. Dr. Peter Markowich, Doz. Dr. Massimo Fornasier
- Group “Optimization and Optimal Control”, group leader: Prof. Dr. Karl Kunisch
- Group “Mathematical Imaging”, group leader: Prof. Dr. Otmar Scherzer
- Group “Mathematical Methods in Molecular and Systems Biology”, group leaders: Prof. Christian Schmeiser, Dr. Philipp Kügler
- Research Project “Applied Discrete Mathematics and Cryptography“, Doz. Dr. Arne Winterhof

In the following, we present an overview about the scientific activities of these groups. More details and information about their interaction and about further scientific activities follow in later sections.

Group “Computational Methods for Direct Field Problems“

The research of the Group has focused on the development, analysis and implementation of efficient and robust computational methods for Partial Differential Equations with the focus on the following topics:

- Robust Algebraic Multigrid- and Multilevel Methods for large-scale technical problems and problems in life.
- High-order finite element methods with application to solid and fluid mechanical as well as electrical engineering problems.
- Functional-type a posteriori error estimates.

In the framework of a research project supported by the Austrian Science Fund, a new research direction on „Isogemetric Analysis“ has been started and will be strengthened in the future. Figure 1 shows a FSI-Simulation, where domain decomposition methods were combined with new Algebraic Multigridmethods.

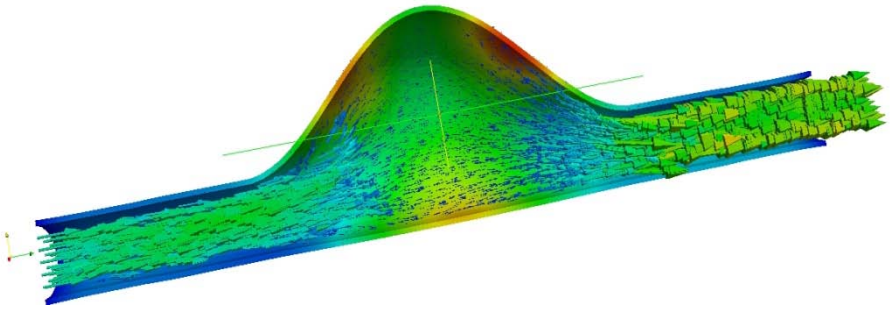


Abbildung 3: Simulation of a Fluid-Structure-Interaction Problem

Group “Inverse Problems”

The group is involved in both basic and application-oriented research in the area of Inverse Problems. Recent theoretical achievements include a justification of optimal parameter choice rules for multi-parameter regularization as well as the derivation of convergence rates for sparsity promoting regularization by means of variational inequalities. Significant progress has been made in analyzing the dependence of the accuracy of the linear sampling method for inverse scattering problem on the geometry of the obstacles. The group plays a major role in two large-scales projects: “DIAdvisor: personal glucose predictive diabetes advisor” is funded by the EU Commission within 7th Framework Program, and the project "Mathematical algorithms and software for ELT adaptive optics", is part of the In-Kind contributions of Austria to the European Southern Observatory (ESO). Additionally, five stand-alone research projects, funded by FWF and FFG, have been performed in the group.

Group “Symbolic Computation”

Genus computation and singularity analysis of a complex plane algebraic curves are well understood in computer algebra. The available algorithms assume that the complex coefficients of the defining equation are known exactly (given by some rational representation of the real and imaginary part). The group solved these problems for coefficients that are only known up to some given accuracy, using ideas from regularization theory and classical theoretical results in algebraic geometry and knot theory (see Figure 1). A new FWF project in a closely related topic was granted, focusing on parametrization of algebraic curves by radicals; it will start in 2011.

Another major activity was focused on the algebraic theory of Green's operators in the context of boundary problems. The group devised a decision algorithm for equalities of such operators. An already granted project on related issues could not start as planned, because the principal investigator accepted an Erwin Schrödinger fellowship and went to INRIA, Paris.

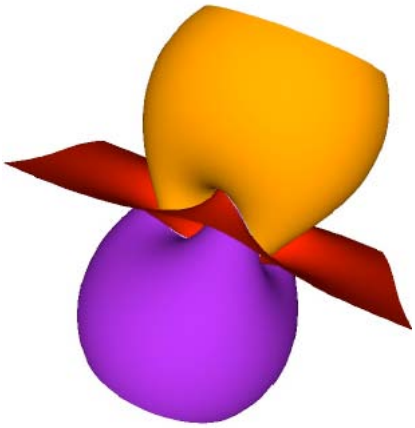


Abbildung 4: The Milnor fibration for an ordinary triple point

Group “Analysis for Partial Differential Equations”

The group focused on the following topics. Variational calculus and geometric measure theory with particular emphasis on inverse free-discontinuity problems. Existence of solutions and numerical methods were investigated. We also addressed domain decomposition and subspace correction methods for nonsmooth convex minimizations, with applications in total variation minimization for image processing. The current research is focused on the following PDE models and theoretical results: fluid dynamic models for chemotaxis, particle-kinetic-fluid dynamics for multiagent interaction phenomena (e.g., swarming and flocking), classical equations of mathematical physics (e.g., Boltzmann equation and Vlasov-Poisson-Boltzmann system) and theoretical results of stability at equilibria and rate of convergence via hypocoercivity and Fourier-energy methods.

Group “Optimization and Optimal Control”

The group focuses on the development of numerical solution strategies for optimal control problems governed by partial differential equations. One part of our research involves adaptive discretization methods based on a-posteriori estimators using fully computable error bounds. This work is also supported by an FWF project. A second research area involves optimal control problems with non-smooth structure. We investigate semi-smooth Newton methods for PDE-constrained optimization problems with polygonal control/state constraints and time-optimal control problems. The proper formulation of transversality constitutes a particular challenge.

Group “Mathematical Imaging”

Among other applications, photoacoustic imaging is developing into a microscopy tool for "deep imaging" of model organisms. We have developed mathematical algorithms based on the non uniform fast Fourier method for accurate photoacoustic visualization of beta-cell formations in the pancreas in the zebrafish. The current resolution limit of about 1000 cells should be further increased by manipulated fish and optimized setups and algorithms.

Group “Mathematical Methods in Molecular and Systems Biology”

The group has been started in 2009 and is working on interdisciplinary projects motivated by questions from cell and molecular biology. Interdisciplinary cooperation with groups from IMP, IMBA, MFPL, and from the University of Vienna (Institute for Pharmacology and Toxicology, Department Molecular Systems Biology) are in different stages of realization. Two of them have been institutionalized in the framework of WWTF (Vienna Science and Technology Fund) funded projects on the regulation of stress hormones and on cytoskeleton dynamics. The development and application of mathematical methods concentrates on the fields of inverse problems, partial differential equations, and image processing. Biological fields under investigation include the stress response of plants, asymmetric cell division, chemotaxis, regulation in metabolomic networks and the reproduction of the marine bristle worm Platynereis dumerilii.

Resarch Project “Applied Discrete Mathematics and Cryptography”

The research project focuses on applications of discrete mathematics to

- quasi-Monte Carlo methods and pseudorandom number generation,
- communication and coding theory,
- cryptography.

In particular, hybrid sequences were analyzed which combine the advantages of Monte Carlo and quasi-Monte Carlo methods, two new classes of very promising pseudorandom number generators were studied, and quality measures for new classes of binary sequences were estimated. Moreover, the progress for the problems of finding good algebraic geometric codes and permutations for check digit systems as the international standard book number (ISBN) were obtained.

2.4. Highlights 2010

- In a large project with ESO, the European Southern Observatory, we develop algorithms for the image correction of large telescopes. In order to obtain high quality pictures of, e.g., galaxies, the image degradation caused by atmospheric turbulences is corrected by deformable mirrors. In the last year an algorithm was developed that computes the corrections for the planned Extremely Large Telescope (ELT) in real time. The first evaluation of our progress by ESO has been very successful.

- Within the national research network on “Photoacoustic Imaging”, together with Prof. Dirk Meyer (Molecular Imaging, University Innsbruck), we have performed studies for photoacoustic visualization of beta-cell formation in the pancreas in the zebrafish (as a model organism). For accurate visualization we require sophisticated mathematical and computational tools, such as the non uniform fast Fourier methods adapted to Photoacoustics.

- Of course each of these groups has produced additional highlights, but we follow the requirement to quote at most two.

Key Publications:

We quote 10 (instead of the 5 requested) key publications from the Institute:

1. B. Buchberger, **G. Regensburger**, **M. Rosenkranz**, L. Tec: An automated confluence proof for an infinite rewrite system parametrized over an integro-differential algebra. In: Fukuda, K et al (eds), Mathematical Software - Proc. ICMS 2010, Springer, 2010, pp 245--248.

2. **R. Duan**, **M. Fornasier** and G. Toscani: A kinetic flocking model with diffusion, Commun. Math. Phys., Vol. 300, no. 1, 2010, pp. 95-145 ://www.ricam.oeaw.ac.at/people/page/fornasier/DFT.pdf

3. **R. Duan**, A. Lorz and **P. A. Markowich**: Global Solutions to the coupled chemotaxis-fluid equations, Communications in Partial Differential Equations, Vol. 35, no. 9, 2010, pp. 1635-1673 ://www.math.cuhk.edu.hk/~rjduan/Preprint%20for%20Homepage/DLM-Re03.pdf

4. **P. Elbau**, M. Grasmair, F. Lenzen, **O. Scherzer**: Evolution by Non-Convex Functionals, Numerical Functional Analysis and Optimization, Volume 31, Issue 4, April 2010, pages 489-517

5. **E. Karer**, **J. Kraus**: Algebraic multigrid for finite element elasticity equations: Determination of nodal dependence via edge matrices and two-level convergence. Int. J. Numer. Meth. Engng., vol. 83 (2010), pp. 642-670.

6. **Karl Kunisch**, Kewei Liang and **Xiliang Lu**: Optimal Control for an Elliptic System with Polygonal State Constraints, SIAM J. Control Optim, 48(2010), 5053-5072

7. **P. Kügler**: Online parameter identification without Ricatti-type equations in a class of time-dependent partial differential equations: an extended state approach with potential to partial observations, Inverse Problems 26 (2010) 035004 (23pp)

8. J. Liu and **M. Sini**: Reconstruction of cracks of different types from far field measurements. Mathematical Methods in the Applied Sciences 33, no. 8, 950-973, 2010

9. **D. Ölz**, **C. Schmeiser**: Derivation of a model for symmetric lamellipodia with instantaneous cross-link turnover, Archive Rat. Mech. Anal. 198 (2010), pp. 963-980.

10. **A. Winterhof**: Recent results on recursive nonlinear pseudorandom number generators (invited paper). Recent results on recursive nonlinear pseudorandom number generators (invited paper). In: Carlet, Claude et al.

2.5. Report on the scientific activity during 2010

2.5.1. Group „Computational Methods for Direct Field Problems"

Group Leader:

O.Univ.-Prof. Dipl.-Ing. Dr. Ulrich Langer

funded via ÖAW/Upper Austrian government funds:

PD Dr. Sven Beuchler (on leave from 1 October 2009 until 28 Feb 2010, and from1 October 2010)
PD Dr. Johannes Kraus (employed from 1 March 2010)
Dr. Satyendra Tomar (employed until 30 September 2010)
Dr. Gerhard Unger (employed from 1 May 2010)
Dr. Jörg Willems (employed from 15 July 2010)
Dr. Huidong Yang (employed from 1 April 2010)

Scientist funded via ÖAW/Upper Austrian government funds:

Dr. Ivan Georgiev (8 April 2010 – 2 June 2010, 3 weeks were granted by the Bulgarian NFS Grant)
Prof. Dr. Ludmil Zikatanov (6 - 18 December 2010)

Researchers externally funded:

Dr. Ivan Georgiev (employed from 6 December 2010)
MSc. Krishan Gahalaut
MSc Erwin Karer
Dipl. math. tech. Martin Purrucker

Dr. Beuchler accepted an offer of an associate (W2) professorship position from the University of Bonn (Germany). In the Winter Semesters 2009/10 and 2010/11 he replaced this professorship position. The University of Erlangen offered a replacement of a full (W3) professorship position to Dr. Tomar which was accepted by him for the Winter Semesters 2010/11. Dr. Kraus was visiting Penn State University for the Winter Semesters 2009/10.

The "Computational Mathematics Group" (CMG) has focused on the development, analysis and implementation of novel fast computational methods for Partial Differential Equations (PDEs) or systems of PDEs arising in different fields of applications such as solid and fluid mechanics, electromagnetics, and others. In the following we present the main scientific

activities and the most important achievements and results obtained in 2010. The most important basic research work was performed in the following 4 FWF projects:

- **FWF-Research Project P19170-N18 "*Algebraic multigrid and multilevel methods for vector field problems*" (2007-2010)** led by *J. Kraus* (1 PhD position: E. Karer): This project has been successfully completed end of October, 2010. Some of the most recent research results in the scope of this project deal with the construction and with the analysis of auxiliary space preconditioners for elasticity problems where the main focus is on nearly incompressible materials, and on mixed and pure traction boundary conditions. These results are still to be published (submitted) in early 2011. The PhD candidate E. Karer who has been supported via this project is expected to submit and defend his PhD thesis in spring 2011. The publications [1,2,13] that appeared or have been accepted in 2010 have been supported by this grant.

- **FWF-Research Project P20121-N18 "*Fast hp-solvers for elliptic and mixed problems*" (2008 – 2011)** led by *S. Beuchler* (1 PhD-position: M. Purrucker): The work is focused on the development of preconditioners for systems of linear algebraic equations based on the discretization of partial differential equations by the hp-version of the FEM. On the one hand, a wavelet based solver is developed for the elliptic problem. This solver is one ingredient of an efficient preconditioner for the Stokes problem. The second ingredient for the design of a fast solver of the Stokes problem is the usage of stable finite elements. During the last year, M. Purrucker investigated several element pairings as the Qk-Pk-1 disc element theoretically and numerically. The solution time of the linear system grows quasioptimal with respect to the discretization parameter. The approach is extended to mixed formulations of linear elasticity.

- **FWF-Research Project P21516-N18 "Isogeometric method for numerical solution of partial differential equations" (2009 – 2012)** led by *S. Tomar* (2 PhD positions: K. Gahalaut + Stefan Kleiss): K. Gahalaut is working on developing fast solvers for the linear system of equations obtained by isogemetric discretization of the underlying PDE. The isogeometric analysis (IGA) approach, proposed by Hughes et al. (2005), aims to bridge the gap between finite element analysis (FEA) and computer aided design (CAD). The main idea of IGA is to directly use the geometry provided by CAD using non-uniform rational B-splines (NURBS), and to approximate the unknown solution of the PDE by the same NURBS functions. One

of the main advantages of this approach is that the geometry is exactly represented at the coarse level. For the resulting linear system of equations, we are currently exploring the support graph theory based preconditioners, namely, maximum weight spanning tree and support tree. The second Ph.D. student, DI Stefan Kleiss, is being co-supervised with Prof. B. Juettler (JKU, Linz).
Currently, he is working in the project "Exact Geometry Simulation for Optimized Design of Vehicles and Vessels (EXCITING)" that is a Collaborative Project within the 7th framework programme of the EU (see also http://www.ag.jku.at/home_en.htm).

- **FWF-Research Project P22989-N18 "*Subspace correction methods for nearly singular and indefinite problems with highly oscillatory coefficients*" (2010 – 2013)** led by *J. Kraus* (1 PostDoc position: I. Georgiev, and 1 PhD position: N.N.): In this project, which started on December 6, 2010, we plan to develop and analyze new subspace correction methods for the numerical solution of coupled systems of partial differential equations. We target nearly singular and symmetric positive definite and indefinite problems with a main emphasis on systems with highly oscillatory coefficients. The publication [13] falls in the preparation phase.

Furthermore, we have continued our research on the following 3 topics which are partly connected with the FWF projects but mainly based on national and international cooperations:

1. **Robust Algebraic Multigrid and Multilevel Iteration Methods:** J. Kraus and S. Tomar developed a uniformly convergent multilevel method for problems in the space H(div) where the finite element approximation is in the lowest-order Raviart-Thoma s space [1]. J. Kraus and E. Karer presented a two-level convergence analysis of an algebraic multigrid method for elasticity problems. The method yields a (nearly) optimal preconditioner, also for problems with jumps in Young's modulus of elasticity and orthotropic materials [2]. J. Kraus together with B. Ayuso, I. Georgiev, and L. Zikatanov constructed and analyzed uniform preconditioners for a family of interior penalty discontinuous Galerkin (DG) discretizations of linear elasticity problems using space decomposition and subspace correction techniques Multilevel preconditioning of stiffness matrices arising from the Crouzeix-Raviart finite element discretization of 3D pure displacement elasticity boundary value problems were investigated in [16].

2. **Functional-type a posteriori error estimates:** Together with S. Repin (St. Petersburg), preliminary results have been obtained on a posteriori error estimates for nonconforming approximations of evolutionary convection-diffusion problems [3]. This has further strengthened our collaboration on the topic, and we intend to advance this for wider class of problems. Moreover, the FWF project on “Advanced numerical methods for discretization, iterative solution and error estimation” is being revised and will be re-submitted to FWF soon. J. Kraus and S. Tomar introduced and analyzed a cost-efficient optimal order algebraic multilevel iteration (AMLI) method for the solution of the discrete problems arising from functional-type a posteriori error estimates for DG approximations of elliptic problems [1].

3. **Higher-order Finite Element Solvers:** The research focused on the following three topics:
   - The application of hp-FEM for discretizations of optimal control problems: In collaboration with D. Wachsmuth (Optimal Control Group, RICAM) and C. Pechstein, a joint publications [4] has been accepted; further applications of hp-FEM for optimal control problems are intended to investigate within the applied FWF-project P23484-N18,
   - Basis functions for H(div) and H(curl) for triangular and tetrahedral elements: A report [5] and an survey paper [14] have been finished,
   - hp-FEM-solvers for the Stokes problem within the FWF-project P20121-N18.

The new group members J. Willems and H. Yang are mainly contribute to research topic 1.

J. Willems works on robust iterative solvers for porous and highly porous media flow problems. This work is also carried out in cooperation with R. Lazarov from Texas A&M University and is supported by the mutual **NSF project DMS-1016525** "Subgrid Discontinuous Galerkin Approximations of Brinkman Equation with Highly Heterogeneous Coefficients".

H. Yang works on Fluid-Structure-Interaction problems, in particular, on fast and robust algebraic multigrid solvers for the fluid and the structure subproblems as well as for the coupled problem [8,9].

We are participating in FFG project applications of the RISC Software GmbH on aneurysm simulation, and we have started cooperation with Prof. Fitch (University of Vienna) on the simulation of vocal production mechanisms in vertebrates that is also based on fluid-structure interaction.

The new group member **G. Unger** investigates the solution of eigenvalue problems for elliptic PDEs by means of boundary elements methods. This non-standard approach leads to non-linear eigenvalue problems. G. Unger has mainly contributed to discretization error estimates for the eigenvalues and eigenvectors as well as to fast solution methods [12]. In cooparation with O. Steinbach (TU Graz) we are preparing a joint FWF resarch project application on the topic "Efficient Solvers for Maxwell Eigenvalue Problems by Using Fast Boundary Element Methods".

Key publications 2010:

1. **J. Kraus** and **S. Tomar**: Algebraic multilevel iteration method for lowest-order Raviart-Thomas space and applications. Int. J. Numer. Meth. Engng. (accepted).

2. **E. Karer**, **J. Kraus**: Algebraic multigrid for finite element elasticity equations: Determination of nodal dependence via edge matrices and two-level convergence. Int. J. Numer. Meth. Engng., vol. 83 (2010), pp. 642-670.

3. S.I. Repin, **S. Tomar**: A Posteriori Error Estimates for Nonconforming Approximations of Evolutionary Convection-Diffusion Problems. Journal of Mathematical Sciences, vol. 170 (2010), No. 4, pp. 554-566, 2010.

4. **S. Beuchler**, C. Pechstein, **D. Wachsmuth**: Boundary concentrated finite elements for optimal boundary control problems of elliptic PDEs. RICAM-Report 2010-04 (accepted for publication in Computational Optimization and Applications)

5. **S. Beuchler**, V. Pillwein, S. Zaglmayr: Sparsity optimized high order finite element functions for H(div) on simplices. RICAM-Report 2010-07 and submitted.

6. D.M. Copeland, **U. Langer**: Domain decomposition solvers for nonlinear multiharmonic finite element equations. Journal of Numerical Mathematics, vol. 18 (2010), pp. 157-176.

7. C. Hofreither, **U. Langer**, **S. Tomar**: Boundary Element Simulation of Linear Water Waves in a Model Basin. Proceedings of 7th International Conference on Large Scale Scientific Computations (ed. by I. Lirkov, S. Margenov and J. Wasniewski), Lecture Notes in Computer Science (LNCS), vol. 5910, Springer-Verlag, Berlin, Heidelberg, New York 2010, pp. 132-139.

8. **H. Yang**, W. Zulehner: Numerical Simulation of Fluid-Structure-Interaction Problems on Hybrid Meshes with Algebraic Multigrid Method. Proceedings of 7th

International Conference on Large Scale Scientific Computations (ed. by I. Lirkov, S. Margenov and J. Wasniewski), Lecture Notes in Computer Science (LNCS), vol. 5910, Springer-Verlag, Berlin, Heidelberg, New York 2010, pp. 116-123.

9. **H. Yang**, W. Zulehner: A Newton Based Fluid-Structure Interaction Solver with Algebraic Multigrid Methods on Hybrid Meshes. In Y. Huang, R. Kornhuber, O. Widlund, J. Xu, editors, Domain Decomposition Methods in Science and Engineering XIX, Lecture Notes in Computer Science and Engineering, Springer-Verlag, 2011, pp. 285-292.

10. O. Iliev, R. Lazarov, and **J. Willems**. Fast numerical upscaling of heat equation for fibrous materials. J. Computing and Visualization in Science, vol. 13 (2010), pp. 275-285.

11. C. Hofreither, **U. Langer**, C. Pechstein: Analysis of a non-standard finite element method based on boundary integral operators. Electronic Transactions on Numerical Analysis, vol. 10 (2010), pp. 413-436.

12. O. Steinbach, **G. Unger**: Convergence analysis of a Galerkin boundary element method for the Dirichlet Laplacian eigenvalue problem. RICAM-Report 2010-06 and submitted.

13. B. Ayuso, **I. Georgiev**, **J. Kraus**, and L. Zikatanov: A simple preconditioner for the SIPG discretization of linear elasticity equations. In I. Dimov, S. Dimova, and N. Kolkovska (eds.), NMA 2010, Lecture Notes in Computer Science (LNCS), vol. 6046, Springer-Verlag, Berlin, Heidelberg, New York 2011, pp. 353–360.

14. **S. Beuchler**, V. Pillwein, J. Schöberl and S. Zaglmayr: Sparsity optimized high order finite element functions on simplices. In "Numerical and Symbolic Scientific Computing: Progress and Prospects" (ed. by U. Langer and P. Paule), Springer Verlag Wien, 2011 (to appear).

15. D. Copeland, M. Kolmbauer, **U. Langer**: Domain Decomposition Solvers for Frequency-Domain Finite Element Equation. In Y. Huang, R. Kornhuber, O. Widlund, J. Xu, editors, Domain Decomposition Methods in Science and Engineering XIX, Lecture Notes in Computer Science and Engineering, Springer-Verlag, 2011, pp. 301-308.

16. **I. Georgiev**, **J. Kraus**, and S. Margenov, Multilevel preconditioning of Crouzeix-Raviart 3D pure displacement elasticity problems. In: I. Lirkov, S. Margenov, and J. Waśniewski (eds.) LSSC 2009. Lecture Notes in Computer Science (LNCS), vol. 5910, pp. 100-107, Springer, Heidelberg 2010, pp. 100-107.

2.5.2. Group "Inverse Problems"

Group Leader:

o. Univ.-Prof. DI. Dr. Heinz W. Engl

Researchers funded via ÖAW/Upper Austrian government funds:

DI. Dr. Michael Aichinger

Dr. Hui Cao (employed until 31 July 2010)

Dr. Esther Klann (employed from 01 March until 30 June 2010)

Dr. Thanh Nguyen

Prof. Dr. Sergei Pereverzyev

Dr. Hanna Katriina Pikkarainen (on maternity leave from 17 August 2010 on)

Dr. Sivananthan Sampath (partially)

Priv. Doz. Dr. Mourad Sini

Researchers externally funded:

DI Stephan Anzengruber

M.Sc. M.Tech. Durga Prasad Challa (employed from 01 November 2010)

Dipl.-Ing. Tapio Helin

M.Sc. Manas Kar (employed from 01 November 2010)

Dr. Shuai Lu (employed until 31 July 2010)

PhD Valeriya Naumova (employed from 01 June 2010)

Dr. Jenny Niebsch

Dr. Sivananthan Sampath (partially)

Dipl.-Ing. Mykhaylo Yudytskiy (employed from 01 November 2010 on)

The group does basic and applications-oriented research in the theory, numerics and applications of regularization methods for solving inverse problems. In addition to its members employed via basic funds, it is heavily involved in third-party funded research:

In the project "DIAdvisor", which is funded by the EU Commission within 7th Framework Programme, the group (person in charge: Prof. Pereverzyev) is responsible for the development of the mathematical methodology for the prediction of the future blood glucose concentration from its past measurements with the goal to optimize the therapy of diabetes. A patent together with the project partner NovoNordisk will be applied for.

The project "Mathematical algorithms and software for ELT adaptive optics" (Principal investigator: Prof. Ramlau) is a part of the In-Kind contributions of Austria to the European Southern Observatory (ESO) and aims at the development of mathematical methods for

different types of adaptive optics technology that will be utilized in the world's biggest telescopes on the mount Paranal in Atacama desert.

Moreover, in the group, three stand-alone projects, which were granted by FWF and led by Profs. Pereverzyev and Ramlau, have been successfully completed during 2010, and a new FWF project “Electromagnetic Scattering by Complex Interfaces” led by Doz. Dr. Sini has been started.

In addition, the FFG project “Model based unbalance determination in wind turbines” led by Prof. Ramlau is running in the group until 2012.

A more detailed description of some significant results is given in the following:

In the course of the project “DIAdvisor” (Prof. Pereverzyev, Dr. Sampath, M.Sc. Naumova) a radically new design of a blood glucose predictor has been developed. Mathematically, it is based data-driven selection of reproducing kernel Hilbert spaces, in which predictions are performed by means of adaptive kernel methods. In experiments with data from three clinical trials, several attractive features of this new design have been observed such as a) a portability of the predictor from individual to individual without re-adjustment; b) a possibility to use data with essential gaps in measurements; c) predictors based on the new design outperform the state-of-art methods in the sense of clinical accuracy; d) for some prediction horizons; the new predictors demonstrate the same level of reliability as modern blood glucose monitors (i.e., devices that measure current values of the blood glucose concentration, but are not able to predict its future evolution). A first presentation of the performance of the new predictor has been made in [14].

The project "Mathematical algorithms and software for ELT adaptive optics" (Prof. Ramlau, Dr. Helin, Dipl.Ing. Yudytskiy) is conducted together with the Industrial Mathematics Institute of the University of Linz and the Industrial Mathematics Competence Center (MathConsult GmbH) and overall coordinated by Prof. Ramlau. Major progress has been achieved by developing two candidate algorithms for the reconstruction of incoming wavefronts of a bright star from measurements of a wavefront sensor. The reconstructed wavefront is afterwards used to control a deformable mirror that corrects degraded images. The degradation is due to turbulences in the atmosphere, therefore the reconstructions have to be obtained in real time. It has already been verified that at least one algorithm fulfils the speed and quality

requirements set by ESO. According to the funding contract, ESO does a close monitoring of the progress; the team has passed the first milestones in time (which cannot be said for other Austrian in-kind projects done for ESO).

The reconstruction of asymmetric mass distributions (unbalances) in rotating mechanical systems is the topic of the successfully finished FWF project “Mathematical methods for high-precision balancing of machine tools” and the FFG project “Model based unbalance determination in wind turbines” (Prof. Ronny Ramlau, Dr. Niebsch). Unbalances cause vibrations of the system that in turn can damage the machine, which is, e.g., the case for wind turbines. For ultra precise cutting machines the vibrations caused by unbalances significantly decrease the surface quality of the work piece. The goal of both projects is the development of a model that permits the determination of the influence of a given unbalance distribution on the mechanical system and allows the reconstruction of the unbalance distribution from measurements of the vibrations. Based on the reconstructions the system is balanced, i.e., the vibrations are reduced.

In the course of the completed FWF project “Indirect regularization in non-Hilbert spaces” (Prof. Pereverzyev, Dr. Lu Shuai, Dr. Cao Hui) first results on the convergence rates of multi-parameter regularization have been obtained that can be seen as a step forward towards the development of a general theory for this regularization scheme.

In the course of the FWF project “Inverse Problems with Sparsity Constraints” (Prof. Ramlau, DI. Anzengruber) the regularization properties of Tikhonov regularization with nonlinear operator and sparsity constraints have been analyzed. Using variational inequalities for the nonlinear operator and as source condition, convergence rates in the underlying norm have been established for Tikhonov regularization.

In the course of the preparation for starting FWF project “Electromagnetic Scattering by Complex Interfaces” (Doz. Dr. Sini, Dr. Thanh Nguyen, M.Sc. Manas Kar, M.Sc. Durga Prasad Challa) the accuracy of the linear sampling method for a two-dimensional acoustic inverse obstacle scattering problem with a Dirichlet boundary condition has been investigated with the use of an asymptotic analysis of the so-called indicator function around the boundary of the obstacle. An asymptotic expansion of the limit, as the noise level and the regularization parameter tend to zero, of the indicator function has been obtained. The

theoretical results show the dependence of the blow-up rate of this limit on the geometrical properties of the obstacle. This partly (up to the above limit) explains the dependence of the accuracy of the linear sampling method on the geometry of the obstacle.

In addition to the activity within the framework of the third party funded projects, a research on the identification of model parameters for the evaluation of exotic financial derivatives using Vanilla options were conducted with the aim to reduce the computational time (Dr. Aichinger).

Besides research activities, the group is also active in organizing high-level scientific events on various topics of Inverse Problems. In 2009, a “Mini Special Semester on Inverse Problems” was organized (as reported last year); from June 29 to July 23, 2010, Part II, with about 40 participants from 20 countries and the workshops “Impact of Smoothness on Regularization” and “Inverse Problems in Data Driven Modelling” was conducted.

In addition, several members of the research group serve in editorial boards of international journals, wrote referee reports, book proposals and research grant proposals.

Key publications 2010

1. **M. Aichinger**, S. Janecek, and E. Räsänen: Billiards in magnetic fields: A molecular dynamics approach. Physical Review E 81, no. 1, 6 pp, 2010.
2. **S. W. Anzengruber**, **R. Ramlau**: Morozov discrepancy principle for Tikhonov- type functionals with non-linear operators. Inverse Problems 26, no. 2, 17 pp, 2010.
3. F. Ben Hassen, O. Ivanyshyn and **M. Sini**: The 3D acoustic scattering by complex obstacles. The accuracy issue. Inverse Problems 26, no. 10, 29 pp, 2010.
4. C. Brandt, **J. Niebsch**, P. Maass and **R. Ramlau**: Simulation of Process Machine Interactions for Ultra Precision Turning. Proceedings of the 2nd International Conference on Process Machine Interactions, Vancouver, Canada, 2010.
5. F. Cakoni, G. Nakamura, **M. Sini** and N. Zeev: The identification of a partially coated dielectric from far field measurements. Applicable Analysis 89, no. 1, 67–86, 2010.
6. **H. Cao**, **S.V. Pereverzyev**: Regularization of naturally linearized parameter identification problems and the application of the balancing principle. Chapter in

the book “Optimization and Regularization for Computational Inverse Problems and Applications”, Springer, 2010.

7. E. De Vito, **S.V. Pereverzyev** and L. Rosasco: Adaptive Kernel Methods Using the Balancing Principle. Foundations of Computational Mathematics 10, no. 4, 455–479, 2010.

8. Y. Heng, **S. Lu**, A. Mhamdi and **S.V. Pereverzyev**: Model functions in the modified L-curve method—case study: the heat flux reconstruction in pool boiling. Inverse Problems 26, no. 5, 13–26, 2010

9. J. Liu and **M. Sini**: Reconstruction of cracks of different types from far field measurements. Mathematical Methods in the Applied Sciences 33, no. 8, 950–973, 2010.

10. **S. Lu**, **S.V. Pereverzyev**, Y. Shao and B. Tautenhahn: On the Generalized Discrepancy Principle for Tikhonov Regularization in Hilbert Scales. Journal of Integral Equations and Applications 22, no. 3, 481–515, 2010.

11. **S. Lu**, **S.V. Pereverzyev**: Multiparameter Regularization in Downward Continuation of Satellite Data. Handbook of Geomathematics, Chapter 27, 813–832, 2010.

12. **J. Niebsch**, **R. Ramlau** and **T.T. Nguyen**: Mass and Aerodynamic Imbalance Estimates of Wind Turbines. Energies 3, 696–710, 2010.

13. R. Potthast and **M. Sini**: The No-response Test for the reconstruction of polyhedral objects in electromagnetics. Journal of Computational and Applied Mathematics 234, no. 6, 1739-–1746, 2010.

14. J. U. Poulsen, A. Avogaro, F. Chauchard, C. Cobelli, R. Johansson, L. Nita, M. Pogose, L. del Re, E. Renard, **S. Sivananthan**, F. Saudek, M. Skillen, J. Soendergaard: A Diabetes Management System Empowering Patients to Reach Optimized Glucose Control: From Monitor to Advisor. Invited Paper. 32nd Annual International IEEE EMBS Conference (EMBC2010), Buenos Aires, Argentina, 2010.

15. **N. T. Thanh** and **M. Sini**: An analysis of the accuracy of the linear sampling method for inverse obstacle scattering problems using asymptotic expansion. Inverse Problems 26, no. 12, 29 pp, 2010.

16. **N. T. Thanh** and **M. Sini**: Accuracy of the linear sampling method for inverse obstacle scattering: effect of geometrical and physical parameters. Inverse Problems 26, no. 12, 24 pp, 2010.

17. **S.V. Pereverzyev**, B. Hofmann: Estimation of linear functionals from indirect noisy data without knowledge of the noise level. International Journal on Geomathematics 1, no. 1, 121–131, 2010.

2.5.3. Group "Symbolic Computation"

Group Leader:

Prof. Dr. Josef Schicho

Researchers funded via ÖAW/Upper Austrian government funds:

Dr. Gábor Hegedüs

Dr. Georg Regensburger (until 31 October 2010)

Dr. David Sevilla González

Researchers externally funded:

Dr. Michael Harrison (from 01 November 2010)

M.Sc. Madalina Hodorog

M.Sc. Niels Lubbes

The problem of genus computation and singularity analysis of a complex plane algebraic curve are well understood in computer algebra, when the complex coefficients of the defining equation are known exactly (given by some rational representation of the real and imaginary part). Together with B. Mourrain from INRIA at Sophia Antipolis, France, the group solved these problems for coefficients that are only known up to some given accuracy [1,2]. Both problems are numerically ill-posed, because the answers depend on structural information that abruptly changes under infinitesimally small perturbations. In order to deal with the ill-posedness, concepts from regularization theory were applied. Instead of analyzing the singular point directly, they intersected the given curve by a small sphere centered at the singular point -- the radius of the sphere plays the role of a regularization parameter -- and analyzed the intersection knot using techniques from topology and computational geometry [3]. The method is known to converge for exact data. Numerical experiments give some evidence that the convergency statement for noisy data also holds.

Together with B. Jüttler from the University of Linz, B. Bastl, M. Lavicka, and Z. Sir from the University of West Bohemia, we extended a result on quadratic Bezier curves which is useful for various geometric constructions such as closest point computation to the surface case [4]. The standard quadratic Bezier representation for circular arcs is an arc-length parametrization. The bivariate counterpart holds for certain quadratic triangular Bézier patches on the sphere, for instance those whose three corner points lie at a common distance from the centre of the stereographic projection that defines their parameterization. A complete characterization of the patches which have bivariate arc-length parameterization was given in terms of tripolar coordinates.

Another research activity was concerned with families of rational curves on algebraic surfaces. Any rational surface has infinitely many such families. In [5], the families of minimal degree have been classified. There is an analogy of this question and its answer to the study of discrete directions which minimize the width of a given convex lattice polygon. In [5], this is called the “vineyard problem”: in a minimal direction, the sticks of a vineyard are aligned and sees a minimal number of rows. In the core of this analogy, there is a formula by Fulton for the canonical divisor of a toric variety, relating the adjoint surface to the construction of convex hulls of lattice points. The analogy is a surprisingly close one: the proof of the statement on families on surfaces was modeled as a blueprint of the combinatorial proof of the vineyard problem, and the combinatorics serves as a guideline to understand the algebraic situation.

Lattice polytopes are also related to a conjecture of Golyshev, namely that the roots of the Ehrhart polynomial of any smooth lattice polytope of dimension at most five lie on the characteristic line, i.e. they have real part equal to -1/2. This conjecture was proven in [6], together with A. Kasprzyk from the University of Sydney. Smooth lattice polytopes are simple and reflexive, and these have been classified up to dimension eight, with the help of computer programs. However, the classification tables are so huge that a direct verification of the conjecture appears to be not an option. The proof given in [6] is an elementary one. In the same paper, examples are given that show that the conjecture cannot be extended to dimension six.

A combinatorial relation between the number of intervals in certain lattices has been shown in [7]. As a consequence, one obtains another proof for the Dehn-Sommerville equations for this special case. The main technique is an algebraic one, via the Stanley-Reisner ring of a graph which is constructed from the lattice, and the free resolution of the Hibi ideal which defines this ring.

In cooperation with the group "Optimization and Optimal Control", we solved a problem that arises in numerical optimization schemes [8]. The problem was to integrate the positive part of a quadratic polynomial over a triangle. A symbolic algorithm for the solution was given, and the method has been applied to an optimal control problem.

The algebraic theory of Green's operators in the context of boundary problems has been initiated by the group in the past years. In 2010, the group developed a system of rewrite rules for an algebra with the relevant differential operators which allows unique normal forms and therefore automatic decision of equalities [9, 10], together M. Rosenkranz from Univ. Canterbury and B. Buchberger and L. Tec from Univ. Linz. The system has been

implemented in Maple [11]. The group also organized a special session at the conference "Applications of Computer Algebra", Albania 2010, edited a collection [12] (together with W. Sit, Stony Brook Univ.), and gave a lecture at Univ. Linz on this new topic in symbolic computation.

Key publications 2010

1. M. Hodorog, J. Schicho: A symbolic-numeric algorithm for genus computation. In: Texts and Monographs in Symbolic Computation, to appear.
2. M. Hodorog, B. Mourrain, J. Schicho: A symbolic-numeric algorithm for computing the Alexander polynomial of a plane curve singularity. Proc. SYNASC 2010, IEEE Trans. 2010.
3. M. Hodorog, B. Mourrain, J. Schicho: GENOM3CK -- a library for genus computation of plane algebraic curves using knot theory. ACM Comm. Comp. Alg., 2010.
4. B. Bastl, B. Jüttler, M. Lavicka, J. Schicho, Z. Sir: Spherical quadratic Bezier triangles with chord length parametrization and tripolar coordinates in space.CAGD, accepted.
5. N. Lubbes, J. Schicho: Lattice polygons and families of curves on rational surfaces. J. Alg. Comb., accepted.
6. G. Hegedüs, A. M. Kasprzyk: Roots of Ehrhart polynomials of smooth Fano polytopes. Discrete and Computational Geometry, accepted.
7. G. Hegedüs: Linear equations for the number of intervals which are isomorphic to Boolean lattices and the Dehn-Sommerville equations. Comm. Algebra, accepted.
8. D. Sevilla, D. Wachsmuth: Polynomial integrations on regions defined by a triangle and a conic. Proc ISSAC 2010, ACM Press, 2010.
9. M. Rosenkranz, G. Regensburger, L. Tec, and B. Buchberger, B.: Symbolic analysis for boundary problems: From rewriting to parametrized Gröbner bases (54 pages). In: Texts and Monographs in Symbolic Computation, to appear.

10. M. Rosenkranz, G. Regensburger, L. Tec, and B. Buchberger, B.: An automated confluence proof for an infinite rewrite system parametrized over an integro-differential algebra. In: K. Fukuda et al (eds.) Mathematical Software - Proceedings of ICMS 2010, LNCS, vol. 6327, pp. 245–248. Springer (2010)

11. A. Korporal, G. Regensburger, and M. Rosenkranz: A MAPLE Package for Integro-Differential Operators and Boundary Problems. ACM Comm. Comp. Alg., 2010.

12. M. Rosenkranz, G. Regensburger, W. Sit: Algorithmic Aspects of Differential and Integral Operators, Special Issue of Math. Comp. Sci., to appear in 2011.

2.5.4. Group "Analysis of Partial Differential Equations"

Group Leaders:

Univ.-Doz. Dr. Massimo Fornasier

o.Univ.-Prof. DI. Dr. Peter Markowich

funded via ÖAW/Upper Austrian government funds:

Dr. Renjun Duan (until 31 July 2010)

Dr. Massimo Fonte (until 31 March 2010)

Univ.-Doz. Dr. Massimo Fornasier

Dr. Francesco Vecil (until 30 September 2010)

Dr. Francesco Solombrino (from 01 November 2010)

externally funded:

DI. Andreas Langer

Dr. Jan Haskovec

Dr. Karin Schnass

Dr. Jan Vybiral

Within the scope of our group we focused in 2010 on the following topics, which are involving the active joint cooperation of all the members of the group as it is shown by the related joint publications.

Variational calculus and geometric measure theory with particular emphasis on inverse free-discontinuity problems.

Free-discontinuity problems describe situations where the solution of interest is defined by a function and a lower dimensional set consisting of the discontinuities of the function. In particular, it is of great practical interest to be able to recover functions which are piecewise smooth also from partial information, provided, for instance, by suitable linear measurements via a singular operator, i.e., an operator which is not necessarily boundedly invertible. We search for solutions as minimizers of Mumford-Shah-like functional, measuring the discrepancy to data and imposing additional smoothness to solutions out of discontinuity sets of lower Hausdorff dimension. Unfortunately, we constructed recently counterexamples which exclude the existences of solutions in well-known function spaces for free-discontinuity problems, such as the space of special functions of bounded variation. Our current research is towards giving an appropriate formulation, which will provide well-posedness of the problem. In [14] we show existence of minimizers in a certain class of smooth functions out of piecewise Lipschitz continuous discontinuity sets. In order to obtain existence we resume

compactness/coerciveness by exploiting the special structure of the linear measurements, geometrical and regularity properties of domains, interpolation inequalities, and classical compactness arguments in Sobolev spaces. Together with this theoretical analysis, we are addressing also numerical methods for computing such minimizers [18], and the analysis of the complexity of these algorithms. The results in this direction are a joint work of the group leader Dr. Fornasier with external collaborators.

Domain decomposition and subspace correction methods for nonsmooth convex minimizations.

Domain decomposition and subspace correction methods are known to converge to solutions of PDEs associated to smooth strictly convex energies, and many counterexamples are known for nonsmooth and nonseparable cases. However, we succeeded to achieve the first proof of convergence of these methods [13] in the context of problems related to total variation miminization (known to be nonsmooth and nonseparable). This relevant result comes after several successful investigations [16] on a more general subspace correction algorithm, which has been applied in [12] specifically for image deblurring problems in combination with suitable wavelet space decompositions.

The results in this direction are a joint work of the group leader Dr. Fornasier and the Ph.D. student DI. Andreas Langer, together with external collaborators.

Kinetic transport equations

The current research is focused on the following PDE models and theoretical results: fluid dynamic models for chemotaxis [7,20], particle-kinetic-fluid dynamics for multiagent interaction phenomena (e.g., swarming and flocking) [1-2,6,10,11], classical equations of mathematical physics (e.g., Boltzmann equation and Vlasov-Poisson-Boltzmann system) and theoretical results of stability at equilibria and rate of convergence via hypocoercivity and Fourier-energy methods [4,8-9]. Recent work on multi-dimensional balance laws with non-local dissipation, modeling radiative hydrodynamics is included in [5]. The results in this direction are a joint work of the group leaders Dr. Fornasier and Prof. Markowich with several group members, in particular Dr. Duan, Dr. Haskovec, and Dr. Vecil, together with external collaborators.

Sparse approximation, optimization, and nonlinear PDEs

Since July 2009, the group of “Analysis of Partial Differential Equations” acquired new members, Dr. Jan Haskovec, Dr. Karin Schnass, and Dr. Jan Vybiral, thanks to the funding obtained via the START-Preis project “Sparse Approximation and Optimization in High Dimensions” (://hdsparse.ricam.oeaw.ac.at/). This project is *highly interdisciplinary*, started in

April 2009 and it will work until June 2012. It has the function of connecting the activity of the group of “Analysis of Partial Differential Equations” to the research done within RICAM by other related groups, in particular, “Computational Mathematics for Direct Field Problems”, “Inverse Problems”, “Optimization and Control”, “Mathematical Imaging”, and “Mathematical Methods in Molecular and Systems Biology“.

The project focused on several topics: dimensionality reduction by Johnson-Lindenstrauss embeddings [21,27], new models for random compressible vectors [26], breaking the curse of dimensionality in high-dimensional function approximation [17,24], adaptive augmented Lagrangian methods for linearly constrain convex optimization [25], dictionary learning [19], iterative reweighted least squares [3,15] (for the paper [3] Dr. Fornasier obtained the *Best Paper Award 2010* of the ÖAW on Oct. 15, 2010), and additional topics in functional analysis [22,25]. The project supported the edition of the book [28], which collects the lecture notes of the Sumer School "Theoretical Foundations and Numerical Methods for Sparse Recovery" which was held at RICAM on August 31 - September 4, 2009.

WWTF project “Mathematical Methods for Image Analysis and Processing in the Visual Arts”

This project is a joint cooperation with the University of Vienna as well as the Academy of Fine Arts and the University for Applied Arts. For what concerns our contribution, mathematical models based on nonlinear PDEs and variational calculus are developed specifically for so-called “mathematical inpainting/retouching” of digital images. Also efficient numerical methods for the solution of the devised partial differential equations are addressed [12-14,18,23]. The relevant work in 2010 for this project involved the joint cooperation of Dr. Fornasier, Dr. Haskovec, DI. Langer, together with external colleagues.

Key publications 2010

1. J. A. Carrillo, **M. Fornasier**, J. Rosado, and G. Toscani: Asymptotic flocking dynamics for the kinetic Cucker-Smale model, SIAM. J. Math. Anal., Vol. 42, no. 1, 2010, pp. 218-236.

2. J. A. Carrillo, **M. Fornasier** G. Toscani, and **F. Vecil**: Particle, kinetic, hydrodynamic models of swarming, within the book “Mathematical modeling of collective behavior in socio-economic and life-sciences”, Birkhäuser (in preparation, Eds. Lorenzo Pareschi, Giovanni Naldi, and Giuseppe Toscani), 2010.

3. I. Daubechies, R. DeVore, **M. Fornasier** and C. S. Güntürk: Iteratively re-weighted least squares minimization for sparse recovery, Commun. Pure Appl. Math., Vol. 63, no. 1, 2010, pp. 1-38

4. **R. Duan**: Hypocoercivity of linear degenerately dissipative kinetic equations, submitted preprint (Dec. 3, 2009).

5. **R. Duan**, K. Fellner and C.-J. Zhu: Energy method for multi-dimensional balance laws with non-local dissipation, Journal Mathematiques Pures Appliquees, 93 (2010), no. 6, 572-598

6. **R. Duan**, **M. Fornasier** and G. Toscani: A kinetic flocking model with diffusions, Commun. Math. Phys., Vol. 300, no. 1, 2010, pp. 95-145

7. **R. Duan**, A. Lorz and **P. Markowich**: Global Solutions to the coupled chemotaxis-fluid equations, Communications in Partial Differential Equations, 35 (2010), no. 9, 1635--1673

8. **R. Duan** and R.M. Strain: Optimal time decay of the Vlasov-Poisson-Boltzmann system in R^3, Archive for Rational Mechanics and Analysis, to appear (online first).

9. **R. Duan** T. Yang: Stability of the one-species Vlasov-Poisson-Boltzmann system, SIAM Journal on Mathematical Analysis, 41 (2010), no. 6, 2353-2387.

10. R. Erban and **J. Haskovec**: From individual to collective behaviour of coupled velocity jump processes: a locust example. Preprint, 2010

11. **M. Fornasier**, **J. Haskovec** and G. Toscani: Fluid dynamic description of flocking via Povzner-Boltzmann equation, Physica D (nonlinear phenomena), Vol. 240, no. 1, 2011, pp. 21-31.

12. **M. Fornasier**, Y. Kim, **A. Langer** and C. Schönlieb: Wavelet decomposition method for L2/TV-minimization problems, preprint, 2010

13. **M. Fornasier**, **A. Langer**, C. Schönlieb: A convergent overlapping domain decomposition method for total variation minimization Numer. Math., Vol. 116, no. 4, 2010, pp. 645-685

14. **M. Fornasier** and R. March: Existence of minimizers of the Mumford and Shah functional with singular operators in two space dimensions, preprint, 2009.

15. **M. Fornasier**, H. Rauhut, and R. Ward: Low rank matrix recovery via iteratively reweighted least squares minimization, preprint 2010

16. **M. Fornasier** and C. Schönlieb: Subspace correction methods for total variation and l1-minimization, SIAM J. Numer. Anal., Vol. 47, no. 5, 2009, pp. 3397-3428

17. **M. Fornasier**, **K. Schnass**, and **J. Vybiral**: Learning Functions of Few Arbitrary Linear Parameters in High Dimensions, preprint, 2010

18. **M. Fornasier** and R. Ward: Iterative thresholding meets free-discontinuity problems, Found. Comput. Math., Vol. 10, no. 5, 2010, pp. 527-567

19. R. Gribonval, **K. Schnass**: Dictionary Identification - Sparse Matrix-Factorisation via l1-Minimisation, IEEE Transactions on Information Theory, Vol. 56, No. 7, 2010, pp. 3523-3539

20. **J. Haskovec**, **C. Schmeiser**: Convergence of a stochastic particle approximation for measure solutions of the 2D Keller-Segel system. Communications in Partial Differential Equations, to appear (online first).

21. A. Hinrichs and **J. Vybiral**: Johnson-Lindenstrauss lemma for circulant matrices, Random Structures and Algorithms, to appear

22. A. Hinrichs and **J. Vybiral**: On positive positive-definite functions and Bochner's Theorem, J. Compl., to appear

23. **A. Langer** and **M. Fornasier**: Analysis of the adaptive iterative Bregman algorithm, preprint, 2010.

24. **K. Schnass** and **J. Vybiral**: Compressed Learning of High-Dimensional Sparse Functions, ICASSP, 2011

25. W. Sickel, L. Skrzypczak, and **J. Vybiral**: On the interplay of regularity and decay in case of radial functions I. Inhomogeneous spaces, Commun. Contemp. Math., to appear

26. **J. Vybiral**: Average best m-term approximation, preprint, 2010

27. **J. Vybiral**: A variant of the Johnson-Lindenstrauss lemma for circulant matrices, J. Func. Anal., to appear

28. Theoretical Foundations and Numerical Methods for Sparse Recovery, (**Massimo Fornasier** Ed.) Radon Series on Computational and Applied Mathematics 9, 2010

2.5.5. Group "Optimization and Optimal Control"

Group Leader:

o.Univ.-Prof. DI. Dr. Karl Kunisch

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Xiliang Lu (until 31 July 2010)
Dr. Alyalew Mersha (until 31 August 2010)
Dr. Daniel Wachsmuth

Researchers externally funded:
M.Sc. Saheed Ojo Akindeinde (from 15 January 2010)

The group focused on optimal control of systems governed by partial differential equations, with analytical as well as numerical issues being of equal importance.

Numerical Methods: An important step towards adaptive solution methods for optimal control problems is the development of a-posteriori error estimators to get information about the distribution of the discretization error. In cooperation with Arndt Rösch (University of Duisburg-Essen) we developed an a-posteriori error estimator for optimal control problems with state and control constraints. In contrast to existing literature, our estimator yields is a fully computable error bound [10]. Another contribution of our group to the study of numerical solution methods results from a collaboration with Sven Beuchler (Computation methods group) and Clemens Pechstein (JKU Linz). We studied boundary-concentrated finite element methods for the discretization of boundary control problems. The resulting numerical approximations enjoy convergence rates that are superior to standard finite-element discretization [1]. Together with Sven Beuchler a new proposal for an FWF-project is submitted, with the goal of extending these results to obtain adaptive methods of high efficiency.

The discretization of optimal control problems with higher-order variational discretization was studied by Daniel Wachsmuth and David Sevilla (Symbolic computation group) leading to the joint publication [11]. There they investigated a numerical integration scheme to evaluate integrals of certain non-smooth functions, which have to be computed during the numerical solution procedure.

Daniel Wachsmuth has a long-standing cooperation with researchers in Berlin regarding flow control. Together with Christian John (TU Berlin) they contributed mathematical analysis of boundary control problems in high-lift configurations [4]. In cooperation with Tomaz

Roubiczek (Prague) optimal control problems subject to incompressible non-Newtonian flow were investigated [12]. The analysis relies on novel estimates providing solutions with bounded gradients for the flow equations.

Discretization of higher order optimality conditions: Saheed Akindeinde started his work within the FWF-project P21564-N18 "Numerical verification of optimality and optimality conditions for optimal control problems". Together with Daniel Wachsmuth he investigated control problems with a finite-dimensional control space. They concentrated on a-posteriori verification of positive definiteness of the control Hessian. A publication is in preparation.

Semi-smooth Newton methods: These methods have been investigate earlier with the aim of obtaining super-linearly convergent algorithms in spite of low problem regularity, as for instance in the presence of point wise constraints. In previous work, both within our group and outside, the constraints were simple uni- or bilateral bounds on the control or the state. Xiliang Lu and Karl Kunisch started to investigate the practically relevant case of general convex constraint on state or control variables. Polygonal state constraints were analyzed with respect to Newton differentiability in [5]. Constraints on the point wise norm of the control variables were studied in[6] and polygonal control constraints are treated in [7], which special emphasize on the avoidance of any type of regularization terms. Xiliang Lu also has cooperated work with Dr. Bangti Jin (in Bremen in the first half year of 2010, and in Texas A&M now) on parameter estimation for the evolutionary Robin boundary values problem [8].

Bilvel optimization: In [9] Ayalew Mersha, jointly with S. Dempe obtained necessary and sufficient optimality conditions for bilevel optimization problems in a finite dimensional setting. Current work aims at obtaining necessary optimality conditions for a class of optimal control problems, where the lower level problem is a wave equation with an obstacle.

Optimal control without regular point conditions: Most of the pde-constrained optimal control problems for which higher order numerical methods were developed satisfy the Maurer-Zowe regular point conditions. During 2010 we started to investigate problem classes for which this is not the case. Time optimal control is an important candidate for such problems. Daniel Wachsmuth and Karl Kunisch started to investigate time optimal control problems for the wave equation. In a first step a complete optimality system was derived, in particular, a point-wise transversality condition was obtained. This is an indispensible prerequisite for numerical realization. The development of semi-smooth Newton methods is under preparation. In [3] a rather general framework for the derivation of optimality principles was derived for

nonsmooth, but convex, variational problems in function spaces. The key ingredient is based on Ekeland's variational principle. It is applicable to L^1 and L^\infinity type functionals.

Key publications 2010

1. **S. Beuchler**, C. Pechstein and **D. Wachsmuth**: Boundary concentrated finite elements for optimal boundary control problems of elliptic PDEs. Computational Optimization and Applications, to appear. See also RICAM Report 2010-04.
2. K. Bredies, **K. Kunisch** and T. Pock: Total generalized variation, SIAM Journal on Imaging Sciences 3(2010), 492-526.
3. K. Ito and **K. Kunisch**: Karush Kuhn Tucker Conditions for Non-smooth Mathematical Programming Problems in Function Spaces, submitted.
4. C. John, B. R. Noack, M. Schlegel, F. Tröltzsch and **D. Wachsmuth**: Optimal Boundary Control Problems Related to High-Lift Configurations. In: Active Flow Control II, Notes on Numerical Fluid Mechanics and Multidisciplinary Design Vol. 108, 405-419, Springer (2010).
5. **K. Kunisch**, K. Liang and **X. Lu**: Optimal Control for the Elliptic System with Polygonal State Constraints, SIAM J. Control Optim, 48(2010), 5053-5072 .
6. **K. Kunisch** and **X. Lu**: Optimal control for an elliptic system with pointwise nonlinear control constraints. Submitted.
7. **K. Kunisch** and **X. Lu**: Optimal control for an elliptic system with polygonal control constraints. In preparation.
8. B. Jin and **X. Lu**: Numerical identification of a Robin coefficient in parabolic problems. Submitted.
9. **A. G. Mersha** and S. Dempe: Linear bilevel programming with upper level constraints depending on the lower level solution. Appl. Math. Comput. 180 (2006), no. 1, 247–254.
10. A. Rösch and **D. Wachsmuth**: A-posteriori error estimates for optimal control problems with state and control constraints. RICAM Report 2010-08, submitted.

11. **D. Sevilla**, **D. Wachsmuth**: Polynomial integration on regions defined by a triangle and a conic. Proceedings of the 2010 International Symposium on Symbolic and Algebraic Computation ISSAC 2010, 163-170, ACM (2010).

12. **D. Wachsmuth**, T. Roubiczek: Optimal control of planar flow of incompressible non-Newtonian fluids. Journal for Analysis and its Applications 29(3), 3-376 (2010).

2.5.6. Group "Mathematical Imaging"

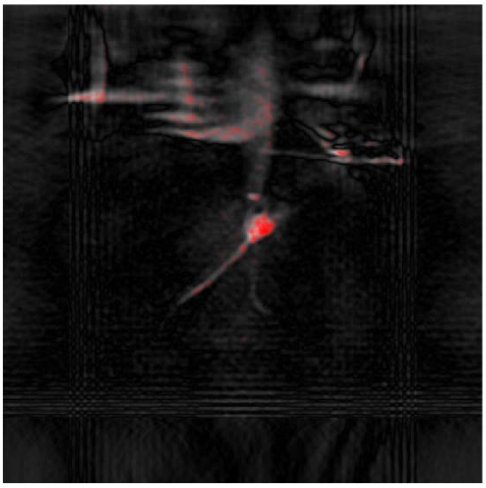
Group Leader:

Univ.-Prof. Dr. Otmar Scherzer

Researchers funded via ÖAW/Upper Austrian government funds:
PhD Jerome Boulanger (until 30 September 2010)
Dr. Peter Elbau

Photoacoustic Imaging is a long term research project funded by the Austrian Science Fund (FWF) within the excellence program "Photoacoustic Imaging in Biology and Medicine". The project has been resubmitted in September 2010 for prolongation, and much of the administrative work has been devoted to the proposal for prolongation. Current work within this project is on experimental studies with the biology group of Prof. Dirk Meyer from the Molecular Imaging group from the University Innsbruck on "deep" imaging of pancreas cells of model organisms like zebra fish. The research is performed by Dipl.-Ing. Rainer Schulze (employed by FWF funding) who is conducting experiments as well as reconstructions. The following image shows preliminary success in imaging accumulations of marked pancreas cells in a zebra fish. The prerequisite biological studies have a high potential for pancreas studies of adult zebra fish, which cannot be performed with the common technology of fluorescence microscopy. This is a research topic for the next years, as well as multi-spectral photoacoustic imaging.

Abbildung 5: imaging of pancreas cells of a zebra fish



Non-Local Functionals. There have been several motivations for considering non-local energy functionals. For instance derivative-free regularization methods, sparsity promoting regularization methods, median priors, and many more others, fall into this category. Although it is a large and expanding area in imaging, the theoretical results, from an inverse problems point of view, are not very well developed. A first step in this direction has been given previously, where we already developed a characterization for weak lower semi-continuity of non-local energy functionals on Lebesgue spaces. Moreover, we already have been starting to analyze some applications in image processing.

- The first application we have been investigating is a derivative-free model for total variation denoising, which has been introduced simultaneously by Aubert and Kornprobst and us. Here the non-local functional arises by replacing the total variation seminorm by a double integral over the corresponding difference quotient. The theoretical foundations for this work have been laid by fundamental work in PDE theory by Brezis et al. Aside from applying the general theory, our work contributes with novel numerical methods for total variation denoising, which actually have been derived with sophisticated computer algebra methods.

- Another application is the non-local energy formulation of neighborhood filters proposed by Kindermann, Osher, and Jones. Using our theoretical results it has also been possible to characterize a class of these non-local functionals where the existence of a minimizer is guaranteed.

- A generalization of the non-local functionals corresponding to neighborhood filters leads to an energy formulation for patch-based filters, e.g. for the non-local means filter. However, the resulting energy functionals are in general more complex than the non-local functionals we had considered so far, and we could only prove the existence of a minimizer in cases, where the functional was convex.

In 2010, we started to use such non-local functionals as regularization terms, which allows direct application to imaging. Since the condition for the regularization functional to be weakly lower semi-continuous does not force the regularization functional to be convex, we have started developing a generalization of the convex regularization theory to non-local, non-convex regularization functionals. Results about stability and convergence of such non-local regularization methods have been established as in the convex case. However, sophisticated results like convergence rates results are still missing.

As an application of our non-local regularization theory, we have been studying regularization functionals which are the product of two prior distances. This is a paradigm of a non-local, non-convex energy functional, which (as our theory shows) is weakly lower semi-continuous. As a concrete example, we are investigating a shape recovery problem for the potential equation. The intention of the regularization term is to recover a shape which is close to one element of a training set. In contrast, existing approaches find approximation to the mean. Currently, first numerical tests are performed.

We furthermore made first steps to extend our result for the weak lower semi-continuity for non-local functionals on Lebesgue spaces to non-local functionals on Sobolev spaces. Hereby, the gradient of the Sobolev function takes the place of the Lebesgue function, therefore shifting the interest from real-valued to vector-valued Lebesgue functions. In the case of vector-valued Lebesgue functions, however, we could show with an explicit example that the (rather implicit) criterion for the weak lower semi-continuity does not simplify to the separate convexity of the integrand of the non-local functional as in the real-valued case.

Dr. Peter Elbau has submitted a research proposal to the Austrian Science Fund on regularization theory for non-local regularization.

2.5.7. Group "Mathematical Methods in Molecular and Systems Biology"

Group leader:

Dr. Philipp Kügler

Prof. Christian Schmeiser

Researchers funded via ÖAW/Upper Austrian government funds:

Dr. Stefan Müller (until 31 October 2010)

Dr. Dietmar Ölz (from 01 August 2010)

Dr. Wei Yang (from 01 October 2010)

Msc. Clemens Zarzer (from 01September 2010)

Researchers externally funded:

Dipl.-Ing. Clemens Zarzer (until 31 August 2010)

Dr. James Lu (until 31 August 2010)

Dr. Nikolaos Sfakianakis (from 31 March 2010)

In 2010, the group was involved in two research projects funded by the Viennese Science and Technology Fund WWTF. While the project "mathematical modeling of actin driven cell migration" (led by C. Schmeiser) started on 01.01.2010, the project "elucidating spatio-temporal coherence of cellular processes by data-driven inverse analysis: redox rhythmicity in yeast and diffusion controlled hormone feedback cycles" (led by P. Kügler and C. Flamm, TBI, University of Vienna) came to an end on 31.08.2010.

The main focus of the project on cytoskeleton dynamics so far was the derivation of a modeling framework for the description of the chemo-mechanics in terms of continuum mechanical models, which can be derived from microscopic (molecular level) descriptions. Principles of the derivation of the model and a first existence analysis of solutions have been published in [6]. Partial aspects of the modeling, such as the derivation of friction effects from the microscopic action of dynamic elastic linkages, the dynamics of flexible beams subject to friction, and polymerization-depolymerization dynamics of actin filaments have been investigated more closely [9], [10], [5]. The mathematical model involved Volterra integral equations, fourth order parabolic systems, and nonlinear hyperbolic conservation laws. First simulations of lamellipodia, based on a variational approach have been carried out [11]. A finite element approach to simulations is well under way. The present formulation of the model is Lagrangian. A Eulerian formulation has recently been derived (partially in a diploma thesis), and its investigation is the subject of a project proposal to FWF by D. Ölz. Two other diploma thesis are concerned with wound healing in lamellipodia and with the dynamics of

lamellipodial fragments, in particular their transition from a rotationally symmetric nonmoving state to a polarized moving state. Finally, three dimensional tomograms produced by the research group of V. Small at the Institute of Molecular Biotechnology (IMBA); on the basis of electron microscope data, are automatically analyzed. The main challenge is the identification and tracking of hundreds of individual actin filaments in each tomogram. Recently, first very satisfactory results have been achieved, which have already been used in conference presentations of V. Small's group.

In the second WWTF project, oscillatory growth dynamics in continuous cultures of yeast have been studied in close cooperation with D. Murray, Institute for Advanced Biosciences, Keio University and R. Machne, TBI, University of Vienna. Metabolic and cell division cycles in yeast are linked in the sense that cells can enter S-phase only in a particular metabolic phase. In order to quantify mechanistic hypotheses about the interactions of respiratory oscillations and the cell division cycle, a multi-scale model has been developed in [4] which covers (in a coarse-grained way) the crucial processes of gene regulation, metabolism, and cell growth and division. In order to compare model predictions with online measurements of O2, CO2 and H2S, a refined model of gas exchange (between the liquid and gas phases) in bioreactors has been built. Another focus has been investigation of negative feedback mechanisms of the hormone cortisol taking place in the pituitary as part of the hypothalamic-pituitary-adrenal (HPA) axis. In co-operation with the biomolecular optical spectroscopy group of G. Köhler at the Max F. Perutz laboratories a physiologically based ODE model for the pituitary cell has been developed in [13] that takes both the genomic slow and a non-genomic fast feedback pathway into account. An FCS-aided immunosorbent assay has been constructed allowing to study the stress response of murine AtT-20 tumour cells and providing time resolved hormone concentration data necessary for the inverse analysis of the model.

Sparsity enforcing regularization methods form a further research interest of the group. When facing underdetermined nonlinear inverse problems, as they may arise in reconstructing biochemical reaction networks from experimental data and in exploring qualitative dynamical biological behaviour such as multistability and oscillation, these methods can be used to determine solutions that reveal key network mechanisms and allow for simple interpretations. In [14] the numerical suitability of a transformation operator, previously used for theoretical studies of non-convex regularization terms, has been demonstrated. Furthermore, we have developed a Newton type iteration procedure that generates sparse corrections by solving a standard linear program in each step. It has been applied to the study of interior apoptotic signaling pathways. Another methodological topic was the online identification of model

parameters in dynamical systems which may find applications in, e.g., real time monitoring of patients or athletes. In [3] an online scheme has been developed that avoids the computationally demanding integration of Ricatti-type operator equations by exploiting monotonicity properties of the underlying PDE operators.

In its second year the group has strengthened its visibility at the Vienna biocenter by seminar presentations and individual approaches of potential research partners. For instance, collaboration with the group of L. Ringrose at IMBA on polycomb proteins has been triggered. They are essential for the epigenetic memory of the transcriptional state of several hundred genes in flies and vertebrates. This memory must be maintained during cell division, however it must also be flexible to allow cell fate transitions. To understand stability and flexibility in the polycomb system, it is essential to consider dynamic aspects of chromatin binding during mitosis and differentiation. Based on quantitative measurements in stem cells and more determined cells, a reaction diffusion model reflecting the interaction of polycomb proteins with chromatin has been developed in [8], which enables exploration of the contribution of key parameters to the different mitotic behaviour of polycomb proteins in stem cells and determined cells.

Another co-operation has been started with the group of C. Cowan at the Institute for Molecular Pathology (IMP) on the asymmetric distribution of certain proteins in *C. elegans* embryo cells just before mitosis, leading to cell differentiation. The distributions of several involved proteins can be measured, but the underlying mechanisms are largely unknown. The goal is to test assumptions on these mechanisms by means of mathematical models of the reaction-diffusion type for the comparison of computational and experimental results.

Further biocenter activities of the group are listed at 2.7.

Key publications 2010

1. F. Cerreti, B. Perthame, **C. Schmeiser**, M. Tang, N. Vauchelet: Waves for an hyperbolic Keller-Segel model and branching instabilities, to appear in Math. Models and Meth. in Appl. Sci.

2. **J. Haskovec**, **C. Schmeiser**: Convergence analysis of a stochastic particle approximation for measure valued solutions of the 2D Keller-Segel system, to appear in Comm. PDE.

3. **P. Kügler**: Online parameter identification without Ricatti type equation in a class of time-dependent partial differential equations: an extended state approach with potential to partial observations, Inverse Problems 26 (2010) 035004

4. R. Machne, **S. Müller**: Spontaneous Synchronization in Continuous Cultures of Yeast - A Coarse-Grained Model for Oscillatory Growth Dynamics, poster at ICSB 2010, Edinburgh.

5. **D. Ölz**: On the curve straightening flow of inextensible, open, planar curves, to appear in Bol. SEMA.

6. **D. Ölz**, **C. Schmeiser**: Derivation of a model for symmetric lamellipodia with instantaneous cross-link turnover, Archive Rat. Mech. Anal. 198 (2010), pp. 963-980.

Since this group is new, we mention also submitted papers to show the current activity.

7. C. Cuesta, S. Hittmeir, **C. Schmeiser**: Traveling waves of a kinetic transport model for the KPP-Fisher equation, submitted.

8. J.P. Fonseca, P. Steffen, **J. Lu**, **S. Müller**, L. Ringrose: Stability and flexibility of polycomb-chromatin interactions upon mitosis and cell fate transition, submitted.

9. H. Freistühler, **C. Schmeiser**, **N. Sfakianakis**: On the length distribution in bundles of polymerizing and depolymerizing actin filaments, submitted.

10. V. Milisic, **D. Ölz**: On the asymptotic regime of a model for friction mediated by transient elastic linkages, submitted.

11. **D. Ölz**, **C. Schmeiser**: Simulation of lamellipodial fragments, submitted.

12. B. Perthame, **C. Schmeiser**, M. Tang, N. Vauchelet: Traveling plateaus for a hyperbolic Keller-Segel system with attraction and repulsion: existence and branching instabilities, submitted.

13. M.G. Puchinger, **C.A. Zarzer**, **P. Kügler**, E. Gaubitzer, G. Köhler: Quantification and mathematical modelling of HPA axis feedback mechanisms in AtT-20 pituitaries by means of FCS-aided immunosorbent assays, submitted.

14. **R. Ramlau**, **C.A. Zarzer**: On the minimization of a Tikhonov functional with a non-convex sparsity constraint, submitted

15. **S. Müller**, R. Machne: A refined model of gas exchange in continuous stirred tank reactors, preprint.

2.5.8. Research Project "Applied Discrete Mathematics and Cryptography (DM)"

In 2010 DM involved two researchers, Professor Harald Niederreiter, who joined RICAM after his retirement from National University of Singapore in July 2009,and Dozent Arne Winterhof, who has a permanent position at RICAM since July2009.

Since October Niederreiter holds a guest professorship at King Fahd University in Saudi Arabia. Winterhof got the advancement award (Förderungspreis) of the Austrian Mathematical Society. In 2010 DM published 23 scientific articles. We mention only the most important new results.

Hybrid Sequences: Monte Carlo methods and quasi-Monte Carlo methods are important techniques for multidimensional numerical integration. Monte Carlo methods have the advantage that they allow statistical error estimation, whereas quasi-Monte Carlo methods have the advantage of faster convergence under mild regularity assumptions on the integrand. It was a proposal of Spanier to combine the advantages of Monte Carlo methods and quasi-Monte Carlo methods by using so-called hybrid sequences. A hybrid sequence is a sequence of points in a (usually highdimensional) unit cube that is obtained by "mixing" a low-discrepancy sequence and a sequence of pseudorandom numbers (or vectors), in the sense that certain coordinates of the points stem from the low-discrepancy sequence and the remaining coordinates stem from the sequence of pseudorandom numbers (or vectors). DM obtained several discrepancy bounds via estimating exponential sums of hybrid sequences.

Nonlinear Pseudorandom Number Generators: Nonlinear methods are attractive alternatives to the linear method for pseudorandom number generation. DM proved bounds on several quality measures (discrepancy, linear complexity, lattice profile) for several subclasses of nonlinear pseudorandom number generators. In particular two new sequences are very promising: sequences derived from triangle polynomial systems and sequences of Fermat quotients.

Binary Sequences: Binary sequences have many applications in cryptography and communication. DM studied quality measures for binary sequences (autocorrelation, well-distribution measure, correlation measure of order k, linear complexity) as for example the two-prime Sidelnikov sequence.

Coding Theory: The main problem of coding theory is to detect and correct errors in (discrete) messages sent over a noisy channel. DM continued the research on two coding

theoretic problems, finding good algebraic geometric codes and estimating the number of permutations of a fixed finite field which can detect certain types of errors in check digit systems. (Examples of check digit systems are the international standard book number (ISBN), the international bank account number (IBAN), and the European article number (EAN or bar-code).)

Additive Number Theory: Sum problems from additive number theory were also studied including Waring's problem in a finite field which has also a coding theoretic application, estimating the covering radii of certain codes.

Surveys: DM published four surveys on quasi-Monte Carlo methods, the asymptotic theory of algebraic-geometry codes, linear complexity and related complexity measures, and nonlinear pseudorandom number generators, respectively.

Talks and University Courses: DM gave 12 invited talks, 4 contributed talks, and three university courses.

Key publications 2010

Appeared 2010:

1. **H. Niederreiter**: A discrepancy bound for hybrid sequences involving digital explicit inversive pseudorandom numbers. Uniform Distribution Theory, Bd. 5, S. 53-63.
2. **H. Niederreiter**: Further discrepancy bounds and an Erdös-Turan-Koksma inequality for hybrid sequences. Monatshefte für Mathematik, Bd. 161,S. 193-222.
3. **H. Niederreiter**: Quasi-Monte Carlo methods. In: Cont, R. (Hrsg.), Encyclopedia of Quantitative Finance: Wiley, S. 1460-1472.
4. **H. Niederreiter**: The asymptotic theory of algebraic-geometry codes. Finite Fields: Theory and Applications (Fq9): American Math. Society, S. 339-348.
5. A. Venkateswarlu, **H. Niederreiter**: Improved results on periodic multisequences with large error linear complexity. Finite Fields and Their Applications, Bd. 16, S. 463-476.
6. M. Su, **A. Winterhof**: Autocorrelation of Legendre-Sidelnikov sequences. IEEE Transactions on Information Theory, Bd. 56 (4), S. 1714-1718.

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2.6. Research program 2011

2.6.1. Group „Computational Methods for Direct Field Problems“

The successful termination of the FWF-Research Project P20121-N18 led by S. Beuchler and the successful work on the FWF-Research Projects P21516-N18 led by S. Tomar and P22989-N18 led by J. Kraus have first priority. In 2011 the research group will focus on the following main research topics:

1. **Robust (Algebraic) Multigrid, Multilevel and Multiscale Methods:** We plan to continue and expand our research on robust iterative methods for problems arising in e.g. porous media flows and elasticity, and to further intensify our international collaborations in this field of research. The activities of the group in this direction will be mainly supported by the FWF project P22989-N18 on “Subspace correction methods for nearly singular and indefinite problems with highly oscillatory coefficients”, led by J. Kraus, which creates two additional full positions (one PhD and one Postdoc for 36 months each), by the Collaborative Research Project with the Bulgarian Academy of Sciences (BAS), and by the "Research Networks in the Mathematical Sciences: Theory, Development and Application of Multilevel Methods" between the Department of Mathematics at the Pennsylvania State University (PSU), the Institute for Scientific Computing (ISC) at Texas A&M University, and the Center for Subsurface Modeling, Institute for Computational Engineering and Sciences at the University of Texas at Austin. Furthermore, this work is carried out in cooperation with our international partners L. Zikatanov (FWF project P22989-N18) and R. Lazarov (NSF project DMS-1016525). We also expect new impulses and cooperation resulting from the Special Semester on Multiscale Simulation and Analysis in Energy and the Environment that will be organized and hosted by RICAM in 2011.

2. **Isogeometric Analysis**: We plan to intensify our research work in isogeometric analysis (IGA). The core of research work is the FWF-project P21516-N18 led by S. Tomar and the cooperation with T.J.R. Hughes (Austin, USA), B. Jüttler (JKU) and W. Zulehner (JKU). Furthermore there is a FWF-application for National Research Network (NFN) on the topic "Geometry + Simulation" registered under the FWF-number B 129-N23. The designated speaker of this NFN is B. Jüttler. One sub-project of this NFN was proposed by U. Langer and S. Tomar. This

subproject is devoted to "Discontinuous Galerkin Domain Decomposition Methods in IGA".

3. The research group is very much involved in the organization of the Special Semester 2011 on "Multiscale Simulation & Analysis in Energy and the Environment". J. Kraus and J. Willems are the local coordinators, and co-organizers of the Workshops 1 and 4, respectively. E.Karer will support the coordinators in their work for the special semester. U. Langer is co-organizer of the Workshops 3 and member of the Program Committee. The research work of the group will certainly heavily benefit from the Special Semester 2011. In particular, we expect new international cooperations.

2.6.2. Group "Inverse Problems"

The above mentioned two large third-party funded projects as well as FWF and FFG projects will continue. Applications for at least two other research grants will be submitted to FWF.

Moreover, participation in various high-level international conferences are expected, such as the 7th International Congress on Industrial and Applied Mathematics, the 4th International Conference on Advanced Technologies and Treatments for Diabetes, the Ninth International Conference on Vibrations in Rotating Machines (SIRM), the International Conference on Simulation Technology 2011, minisymposia organization at the Applied Inverse Problems Conference 2011 in Texas, where the group leader will be an invited speaker.

2.6.3. Group "Symbolic Computation"

It is planned to add two more scientists to the group, one PostDoc and one PhD student. The PhD student (C. Demirkiran) will be funded by a new FWF-funded project, with the goal of constructing parametrizations of algebraic curves in terms of radicals. The question of existence of such parametrizations goes back to Zariski. The motivation for this topic is the well-known fact that parametrization in terms of rational functions are useful for various purposes (geometric modeling, symbolic integration etc.), but they only exist for curves of genus zero. The class of curves that have a radical parametrization is significantly larger, but it is still not known how large it really is.

The first phase of the DK project "Computational Mathematics" will terminate in autumn 2011. As the project was quite successful so far, it can be expected that the current PhD researcher will finish her PhD in time, and a second phase is granted. A project proposal is in preparation; it will again combine symbolic and numerical aspects.

In the funded project "Solving Algebraic Equations", we already have added a PostDoc in autumn 2010. He will work in the project until June 2011. The group plans to work on the adaption of Villamayor's algorithm for resolution of singularities to an algebraic setting, replacing open affine subsets by graded algebras. The motivation is two-fold: first, examples suggest that this approach is faster. Second, the algebraic version may give new ideas for working around the known obstructions in positive characteristic, where the problem is still open.

An already granted project on integro-differential operators was finally not supported by FWF because both project leaders left Austria. Since the proposed research seems promising according to the judgment of referees, the group plans to continue to do research on this topic.

2.6.4. Group "Analysis for Partial Differential Equations"

The following research directions are addressed.

1. Nonlinear kinetic equations with emphasis on models of multiagent interaction phenomena. We investigate the formation of patterns; also numerical methods will be studied in this latter context;

2. variational calculus and geometric measure theory with emphasis on regularity and geometrical properties of the discontinuity set of minimal solutions of inverse free-discontinuity problems; we also address the difficult problem of the degree of identification of discontinuity sets from data provided by linear mappings of the solution; we analyze also the discrete approximation of inverse free-discontinuity problems and numerical methods for computing minimizers; we consider applications in fracture mechanics;

3. we are starting the investigation of the use, for dimensionality reduction of high dimensional dynamical systems and PDEs, of the Johnson-Lindenstrauss Lemma; this classical result allows in many applications to reduce the dimension of the underlying problem essentially and therefore makes numerical calculation easier to handle. It is based on random projections of the problem onto a lower dimensional space and therefore creates a link between deterministic PDEs in high-dimension and stochastic PDE in lower dimension;

2.6.5. Group "Optimization and Optimal Control"

Adaptive numerical methods: In cooperation with Klaus Krumbiegel (WIAS Berlin) we will investigate adaptive methods to solve optimal control problems with state and control constraints. Here the coupling between adaptive mesh refinement and choice of regularization parameter is an important and challenging question. Related considerations will be continued with Anton Schiela (ZIB) for optimal control problems of variational inequalities.

Adaptive parameter choices are also important with respect to regularization of optimal control problems that are not strongly convex with respect to the control. Here, we continue our cooperation with Gerd Wachsmuth (TU Chemnitz) and we a cooperation with Sergei Pereverzyev (Inverse problems group).

Higher order optimality conditions. In the framework of the FWF-project P21564-N18 we will continue to investigate a-posteriori verification of sufficient optimality conditions. Moreover, we will start a-priori error analysis with respect to approximation of eigenvalues of the Hessian of the optimal control problem.

Shape optimization for fluid dynamics: The proper choice of cost functional vortex reduction in fluid flow is a challenging since vortex quantification in itself is an unsettled issue. Clearly an appropriate cost functional must be Galilean invariant. But this is not sufficient, as the example of the curl-operator shows. Different, in part non-differentiable and non-convex functionals will be investigated for flow in confined domains as well as for free surface flow.

Total generalized variation (TGV): This recently developed regularization concept, see [2] has proven to be extremely versatile in the context of multiscale problems. We plan a detailed analysis of L^1-TGV problems, at first without partial differential equations constraints.

2.6.6. Group "Mathematical Imaging"

Non-Local Functionals

Though we have results about convergence and stability for the non-local regularization theory, there is still the open question how source conditions and convergence rates from the convex regularization theory can be generalized to the non-local case. Furthermore, we would like to extend the characterization of weak lower semi-continuity for non-local functionals on Lebesgue spaces to non-local functionals on Sobolev spaces allowing us to consider also non-local regularization theory on Sobolev spaces.

Photoacoustic Imaging

The main focus currently lies on multi spectral photoacoustic imaging and reconstruction methods for that problem.

2.6.7. Group "Mathematical Methods in Molecular and Systems Biology"

The WWTF project on cytoskeleton mechanics will be continued. The predoc Christoph Winkler working on image analysis of electron tomograms will be employed through this grant starting with February. Main goals are simulations of wound healing in lamellipodia, of the dynamics of lamellipodial fragments, and of the lamellipodia of fish keratocytes. For these purposes our models will have to be extended in several directions and new numerical methods will have to be developed and implemented to make computations more efficient.

Further bridges to the Viennese biology community will be built, potential new partners are the group of J. Knoblich at IMBA and the groups of C.-P. Heisenberg and M. Sixt at the Institute of Science and Technology. During 2010, many contacts to biologists that might lead to joint projects have been made. The next step is, in order to focus the resources, to select a few of these projects for further treatment. Criteria for this selection will be mathematical and biological relevance, the degree of interest on the side of the possible project partner, and the potential to both make a contribution to the biological problem and to achieve high-level publications.

2.6.8. Research Project "Applied Discrete Mathematics and Cryptography (DM)"

In 2011 Professor Ming Su (Nankai University, China) and Professor Domingo Gomez (University of Cantabria, Spain) will join DM each for six months financed by third party grants of the Chinese and the Spanish Science Fund, respectively.

Niederreiter and Winterhof want to prepare a book project on applications of number theory. The successful research areas of DM (analysis of pseudorandom number generators, coding theory, cryptography) shall be continued. In particular, several sequences of extensions of Fermat quotients and combinations of triangle polynomial systems combined with other particularly attractive nonlinear generators as the inversive generators seem to have excellent features where theoretical support has to be found. Also several other attractive hybrid sequences shall be analyzed carefully.

Moreover, a new direction is suggested: From each binary sequence one can derive a Boolean function for cryptographic applications. Several quality measures for both binary

sequences and Boolean functions are well-studied. However, very little is known about the relations between these two types of quality measures and a rigorous analysis is desirable.

2.7. Publications/talks/poster presentations 2010

The complete AkademIs report is attached as DVD.

17. Wissenschaftliche Publikationen	gesamt
A) Bücher / Monographien oder **Editionen**	2
A) Peer-reviewte Beiträge in Fachzeitschriften oder Sammelwerken	105
· davon in indizierten Fachzeitschriften	38
B) Herausgeberschaften	2
B) längere Beiträge ohne Peer-Review in Fachzeitschriften oder Sammelwerken	1
C) Sonstige wissenschaftliche Publikationen	20
Veröffentlichungen von Nachwuchswissenschafter(inne)n/Habilitationen	
(diese Publikationen wurden z.T. bereits in oben angeführten Kennzahlen miterfasst)	
· Diplomarbeiten	0
· Dissertationen	0
· Habilitationen	0
Lexikonartikel	0
Kurze Lexikonbeiträge, summarisch	0

17. Liste

A) Bücher / Monographien oder Editionen

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18. Wissenschaftliche Vorträge und Präsentationen

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Eingeladene wissenschaftliche Vorträge

, SINI (02.06.2010) On the detection of interface using elastic waves. Vortrag: IPCA10/FRANCE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

, Sini (27.05.2010) On the detection of interface using elastic waves. Vortrag: International conference: Modeling and Simulation,/FRANCE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

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Anzengruber, Stephan W. (01.06.2010) Morozov's Discrepancy Principle for Tikhonov-type functionals with non-linear operators. Vortrag: Conference: Inverse Problems, Computation, and Applications (Centre International de Recontres Mathematiques (CIRM)), Luminy/FRANCE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Boulanger, Jérôme (12.04.2010) Patch-based Fluorescence Video-microscopy Image Restoration. Vortrag: SIAM IS 2010 (SIAM), Chicago,IL/ UNITED STATES <http://www.siam.org/meetings/is10/>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Elbau, Peter (13.04.2010) Lower Semi-Continuity of Non-Local Functionals. Vortrag: SIAM Conference on Imaging Science 2010, Chicago/UNITED STATES <http://www.siam.org/meetings/is10/>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

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Fornasier, Massimo (09.11.2010) Particle systems and kinetic equations modelling interacting agents in high-dimension. Vortrag: PDEs in kinetic theories: kinetic description of biological models, Edinburgh/UNITED KINGDOM.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Fornasier, Massimo (12.04.2010) Compressed numerical methods for well-posed and degenerate elliptic PDEs. Vortrag: Seminar for Applied Mathematics, Zürich/SWITZERLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

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Fornasier, Massimo (20.05.2010) Compressed numerical methods for well-posed and degenerate elliptic PDEs. Vortrag: Department of Mathematics, Munich/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Fornasier, Massimo (26.05.2010) Mathematic Enters the Picture (The restoration of the Mantegna's frescoes in Padua). Vortrag: Kunsthistorische Gesellschaft, Vienna/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

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John, Christian (26.05.2010) Optimal Boundary Control Problems Related to High-Lift Configurations. Vortrag: Active Flow Control II/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

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Klann, E. (26.05.2010) Regularization results for a Mumford-Shah like method with application to tomography data. Vortrag: The Fifth International Conference; Inverse Problems: Modeling and Simulation ("Inverse Problems", "Inverse and Ill-Posed Problems" and "Inverse Problems in Science and Engineering"), Antalya/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

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Klann, Esther (13.04.2010) A Mumford-Shah level-set approach for tomography data. Vortrag: Workshop Mathematics and Algorithms in Tomography (Mathematisches Forschungsinstitut Oberwolfach), Oberwolfach/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kraus, J. (01.06.2010) Auxiliary Space Method for Linear Elasticity Equations. Vortrag: SIAM Meeting on Emerging Topics in Dynamical Systems and Partial Differential Equations, Barcelona/SPAIN <http://www.siam.org/meetings/dspdes/index.php>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kügler, Philipp (03.11.2010) In Silico Manipulation of Qualitative Biological Behaviour using Sparsity Enforcing Regularization. Vortrag: Inverse Problems: Theory and Applications 2010 (MSRI Berkeley), Berkeley/UNITED STATES.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Kügler, Philipp (16.12.2010) In Silico Manipulation of Qualitative Biological Behaviour using Sparsity Enforcing Regularization. Vortrag: International Conference on Inverse Problems (City University of Hong Kong), Hong Kong/CHINA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Kügler, Philipp (27.03.2010) Parameter Identification Problems in Systems Biology. Vortrag: 1st IFIP International Conference on Bioinformatics (S. V. National Institute of Technology), Surat/INDIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Kügler, Philipp (29.04.2010) Applications of sparsity enforcing regularization in systems biology. Vortrag: International Conference on Inverse Problems (University of Wuhan), Wuhan/CHINA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Kunisch, Karl (10.03.2010) Optimal Bilinear Control arising in the Schrödinger Equation. Vortrag: DMV Tagung, München/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kunisch, Karl (24.04.2010) Identification and Control of Variational Inequalities. Vortrag: International Workshop on Inverse Problems, Hong Kong/CHINA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Niebsch, Jenny (17.03.2010) Bestimmung von Unwuchten aus Schwingungsmessungen als Inverses Problem. Vortrag: Seminar Research and Education in Advanced Dynamics and Model Based Control of Structures (ACCM), Linz/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Niederreiter, H. (05.07.2010) A generalized Erdös-Turan-Koksam inequality and its applications. Vortrag: 2nd International Conference on Uniform Distribution Theory, Strobl/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Niederreiter, H. (07.03.2010) The asymptotic theory of error-correcting codes. Vortrag: Seminar, Dhahran/SAUDI ARABIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Niederreiter, H. (07.04.2010) Hybrid sequences. Vortrag: Seminar, Beijing/CHINA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Niederreiter, H. (09.03.2010) Quasi-Monte Carlo methods. Vortrag: Seminar, Dhahran/SAUDI ARABIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Niederreiter, H. (12.04.2010) The Gowers norm of binary sequences. Vortrag: Seminar, Tianjin/CHINA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Ölz, Dietmar (25.08.2010) Modelling of friction effects caused by protein linkages. Vortrag: Mechanics of Cell Motion/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (03.06.2010) Inverse problems with Radon measure. Vortrag: Inverse Problems, Computation, and Applications 2010, Luminy/FRANCE <http://www-lmpa.univ-littoral.fr/IPCA2010/index.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (08.04.2010) Bayes formula: how to use it in computational mathematics. Vortrag: Ricam Group Seminar - Symbolic Computation, Linz/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Pikkarainen, Hanna Katriina (26.05.2010) Inverse problems in the space of Radon measures. Vortrag: International Conference "Inverse Problems:

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Eingeladene wissenschaftliche Vorträge

Modeling and Simulation, Antalya/TURKEY <http://www.ipms-conference.org/index.htm>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Ramlau, Ronny (07.05.2010) Regularisierung von Inversen Problemen: Analysis und Anwendungen. Vortrag: Vortrag an der Helmut-Schmidt-Universität (Helmut-Schmidt-Universität), Hamburg/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Ramlau, Ronny (17.03.2010) Bestimmung von Unwuchten aus Schwingungsmessungen als Inverses Problem. Vortrag: Research and Education in Advanced Dynamics and Model Based Control of Structures and Machines (Mechanics and Model Based Control of the Austrian Center of Competence in Mechatronics (ACCM).), Linz/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Ramlau, Ronny (21.04.2010) Regularisierungsverfahren zur Lösung Inverser Probleme: Analysis und Anwendungen. Vortrag: Vortrag an der Universität Würzburg (Universität Würzburg), Würzburg/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Ramlau, Ronny (23.09.2010) An SVD based wavefront reconstruction for adaptive optics. Vortrag: 8th International Conference of Numerical Analysis and Applied Mathematics 2010, Rhodos/GREECE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Regensburger, G. (19.03.2010) Boundary Problems and the Gerber-Shiu Function. Vortrag: 45e Journée de séminaires actuarials L2, Lausanne/SWITZERLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Regensburger, G. (29.10.2010) Integro-Differential Algebras, Operators, and Polynomials. Vortrag: Differential Algebra and Related Topics (DART IV), Bejing/CHINA <http://mmrc.iss.ac.cn/~dart4/>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sampath, Sivananthan (13.08.2010) Multi-parameter regularization in learning theory - extrapolation. Vortrag: SEMINAR, Indian Institute of Technology Madras/INDIA <http://mat.iitm.ac.in/seminar.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Scherzer, Otmar (13.04.2010) Photoacoustic Imaging taking into account Attenuation. Vortrag: Mathematics and Algorithms in Tomography, Oberwolfach/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Scherzer, Otmar (15.11.2010) Variational Methods for the Solution of Inverse Problems. Vortrag: MSRI Inverse Problems and Applications Seminar, Berkeley/UNITED STATES <http://math.washington.edu/~tzhou/MSRI_IPSeminar.htm>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Scherzer, Otmar (18.05.2010) Photoacoustic Imaging taking into account Attenuation. Vortrag: Transport Theory and Tomography, Banff/CANADA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, Mourad (15.12.2010) Reconstruction of interfaces using one type of elastic scattering waves. Vortrag: ICIP2010, Hong Kong/CHINA <http://www6.cityu.edu.hk/ma/icip2010/prog.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Vybiral, J. (02.06.2010) N-widths of embeddings of function spaces. Vortrag: NuHAG Seminar (NuHAG Group, University of Vienna), Vienna/AUSTRIA <http://www.univie.ac.at/nuhag-php/home/index.php>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Vybiral, Jan (14.04.2010) Dimensionality reduction: Johnson-Lindenstrauss lemma for circulant matrices. Vortrag: Colloquium Vortrag (Helmholtz Zentrum, München, Deutschland), Munich/GERMANY <http://www.helmholtz-muenchen.de/en/ibb/events/index.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Willems, Joerg (02.11.2010) Robust DD Preconditioners - Framework and Applications. Vortrag: Fraunhofer ITWM Seminar (Fraunhoferinstitut fuer Techno- und Wirtschaftsmathematik (ITWM)), Kaiserslautern/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Winterhof, Arne (05.10.2010) Constructions of pseudorandom sequences. Vortrag: Number theory and applications, Debrecen/HUNGARY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (14.09.2010) Recent results on recursive nonlinear pseudorandom number generators. Vortrag: SETA 2010, Paris/FRANCE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (20.07.2010) Pseudorandom Sequences I: Linear complexity and related complexity measures. Vortrag: Fields Institute-Carleton Finite Fields Workshop, Ottawa/CANADA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (21.05.2010) Two new classes of nonlinear pseudorandom number generators. Vortrag: Antalya Algebra Days XII, Antalya/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (21.07.2010) Pseudorandom sequences II: Exponential sums and uniform distribution. Vortrag: Fields Institute-Carleton Finite Fields Workshop, Ottawa/CANADA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (22.07.2010) Pseudorandom sequences III: Measures of pseudorandomness. Vortrag: Fields Institute-Carleton Finite Fields

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Eingeladene wissenschaftliche Vorträge

Workshop, Ottawa/CANADA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (29.01.2010) Nonlinear pseudorandom number generators. Vortrag: Workshop on Dynamical Systems and Uniform Distribution (Igor Shparlinski, Robert Tichy, Arne Winterhof), TU Graz/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Eingeladene wissenschaftliche Vorträge: Keynotes and Named Lectures

Aichinger, Michael (04.11.2010) Can you see the Risk ?. Vortrag: Mathematica Finance Day/UNITED KINGDOM.; Typ: Named Lecture (internationale Veranstaltung)

Aichinger, Michael (15.10.2010) Thaming the Machine Infernal. Vortrag: WDC 2010/UNITED STATES.; Typ: Named Lecture (internationale Veranstaltung)

Aichinger, Michael (30.08.2010) A fast and stable Heston Model Algorithm on the GPU. Vortrag: EUROPAR 2010/ITALY.; Typ: Named Lecture (internationale Veranstaltung)

Engl, Heinz W. (07.09.2010) Industrial Mathematics and Inverse Problems. Vortrag: Fudan University (Fudan University), Shanghai/CHINA.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (02.06.2010) Inverse free-discontinuity problems and iterative thresholding algorithms. Vortrag: Emerging Topics in Dynamical Systems and Partial Differential Equations - DSPDE's, Barcelona/SPAIN.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (15.10.2010) Mathematic Enters the Picture - The restoration of the Mantegna's frescoes in Padua. Vortrag: Klassensitzung der math.-nat. Klasse der ÖAW, Vienna/AUSTRIA.; Typ: Keynote (internationale Veranstaltung)

Heinz, Engl (27.04.2010) Inverse Problems in Systems Biology. Vortrag: International Conference on Inverse Problems (Wuhan University), Wuhan/CHINA.; Typ: Named Lecture (internationale Veranstaltung)

Kunisch, Karl (19.08.2010) Novel Concepts for Nonsmooth Optimization and their Impact on Science and Technology. Vortrag: ICM, Hyderabad/INDIA.; Typ: Named Lecture (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Massimo Fonte, Francesco Vecil (13.01.2010) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (20.01.2010) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (27.01.2010) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Ramlau, Ronny (03.11.2010) Inverse Problems in Adaptive Optics. Vortrag: ESO In-Kind Statusseminar, Schloss Weinberg/AUSTRIA.; Typ: Named Lecture

Scherzer, Otmar (03.05.2010) Variational Regularization in Banach Spaces. Vortrag: Inverse Problems and Applications, Norköpping/SWEDEN.; Typ: Keynote (internationale Veranstaltung)

Scherzer, Otmar (30.03.2010) Derivative Free Functionals for Imaging. Vortrag: Second conference "Mathematics and Image processing", Orléans/FRANCE.; Typ: Keynote (internationale Veranstaltung)

Schnass, Karin (17.11.2010) Learning Functions of Few Arbitrary Parameters in High Dimensions. Vortrag: Oberseminar Numerische Mathematik (Institut fuer Numerische Mathematik, Universitaet Jena), Jena/GERMANY.; Typ: Named Lecture (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Wachsmuth, Daniel (01.07.2010) Optimale Steuerung von partiellen Differentialgleichungen: Neue a-posteriori Fehlerschaetzer. Vortrag: Institutskolloquium (Universitaet Hamburg), Hamburg/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (06.07.2010) Optimale Steuerung von partiellen Differentialgleichungen: Neue a-posteriori Fehlerschaetzer. Vortrag: Institutskolloquium (TU Dortmund), Dortmund/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (10.12.2010) Adaptive Techniken zur numerischen Loesung von Optimierungsproblemen mit partiellen Differentialgleichungen als Nebenbedingungen. Vortrag: Institutskolloquium (BTU Cottbus), Cottbus/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (11.05.2010) Optimale Steuerung von partiellen Differentialgleichungen: Neue a-posteriori Fehlerschaetzer. Vortrag: Institutskolloquium (Universitaet Muenster), Muenster/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

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Eingeladene wissenschaftliche Vorträge: Keynotes and Named Lectures

Wachsmuth, Daniel (12.10.2010) Optimal control problems and the maximum principle. Vortrag: EMS School on Industrial Mathematics, Bedlewo/POLAND.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (17.08.2010) Variational discretization of optimal control problems by quadratic polynomials. Vortrag: Numerik Seminar/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Zarzer, Clemens (19.02.2010) Inverse Problems in Systems Biology. Vortrag: 25th TBI Winterseminar - Computational Mathematics and Theoretical Biology, Bled/SLOVENIA.; Typ: Named Lecture

Sonstige wissenschaftliche Vorträge

, Sini (29.10.2010) Reconstruction of interfaces using complex geometrical optics solutions. Vortrag: Inverse Problems seminar/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Anzengruber, Stephan W. (08.10.2010) Variational Inequalities and Morozov's Discrepancy Principle. Vortrag: DK Statusseminar (DK Computational Mathematics), Strobl/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Anzengruber, Stephan W. (09.04.2010) Morozov's Discrepancy Principle for Tikhonov-type regularization. Vortrag: Sparsity and Modern Mathematical Methods for High Dimensional Data (Vrije Universiteit Brussel), Brussels/BELGIUM <http://www.sparsity.be/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Anzengruber, Stephan W. (12.01.2010) Morozov's Discrepancy Principle for Inverse Problems. Vortrag: CIMPA Summer School on Inverse Problems, Santiago/CHILE <http://indico.cmm.uchile.cl/conferenceDisplay.py?confId=4>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Anzengruber, Stephan W. (24.09.2010) Variational Inequalities and Morozov's Discrepancy Principle. Vortrag: Workshop on Compressed Sensing, Sparsity and Inverse Problems (Technische Universität Braunschweig), Braunschweig/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Beuchler, Sven (29.09.2010) Boundary concentrated finite elements for optimal boundary control problems of elliptic PDEs. Vortrag: Chemnitz FEM-Symposium/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Erwin, Karer (07.05.2010) Auxiliary space preconditioner for a locking-free finite element approximation of the linear elasticity equations. Vortrag: 6th Austrian Numerical Analysis Day, Salzburg/AUSTRIA <http://www.users.sbg.ac.at/~erica/anaday10_index.html>.; Typ: Sonstiger Veranstaltungsbeitrag

Erwin, Karer (22.09.2010) Auxiliary space preconditioner for a locking-free finite element approximation of the linear elasticity equations. Vortrag: 10th European Mutli-grid conference (EMG'10), Isola d'Ischia/ITALY <http://emg2010.cats-host.cerebra.at>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Fornasier, Massimo (16.02.2010) Preliminary results on inverse free-discontinuity problems. Vortrag: RICAM Group Seminar - START Project and PDE, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Harrison, Michael (06.12.2010) Some basic facts about p-adic Galois representations. Vortrag: RICAM Group Seminar - Symbolic Computation - "Some basic facts about p-adic Galois representations"/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Harrison, Michael (20.12.2010) Galois Representations II. Vortrag: RICAM Group Seminar - Symbolic Computation - "Galois Representations II"/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Harrison, Michael (22.11.2010) Wiles' Proof of the Taniyama-Shimura-Weil Conjecture I. Vortrag: RICAM Group Seminar - Symbolic Computation - " Wiles' Proof of the Taniyama-Shimura-Weil Conjecture I"/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Harrison, Michael (27.11.2010) A new automorphism of X_0(108). Vortrag: Workshop Linz-Wien in Krems/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Haskovec, Jan (07.04.2010) Mathematical methods for spectral image reconstruction. Vortrag: Sparsity and Modern Mathematical Methods for High Dimensional Data (Vrije Universiteit Brussel), Brussels/BELGIUM <http://www.sparsity.be/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Haskovec, Jan (08.11.2010) From individual to collective behaviour of coupled velocity jump processes: a locust example. Vortrag: Statistical Physics and Biology of Collective Motion (Max Planck Institut), Dresden/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Haskovec, Jan (13.04.2010) A velocity jump process modelling 1D collective motion of locusts. Vortrag: RICAM Group Seminar - START Project and PDE, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

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Sonstige wissenschaftliche Vorträge

Haskovec, Jan (16.12.2010) From individual to collective behaviour of coupled velocity jump processes: a locust example. Vortrag: PDE Models of Biological Processes, Taiwan/TAIWAN <http://math.cts.nthu.edu.tw/Mathematics/20101213-17.htm>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Haskovec, Jan (31.05.2010) Fluid dynamic description of flocking via Povzner-Boltzmann equation. Vortrag: Emerging Topics in Dynamical Systems and Partial Differential Equations, Barcelona/SPAIN <http://www.siam.org/meetings/dspdes/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (04.06.2010) The boundary volume of lattice polytopes. Vortrag: Linz Algebra Day 10/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hegedues, Gabor (08.01.2010) Pick's Theorem. Vortrag: Algebraic Geometry Workshop Wien--Linz in Rastenfeld, Rastenfeld/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (25.03.2010) The boundary volume of a lattice polytope. Vortrag: RICAM Group Seminar: Symbolic Computation/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (26.11.2010) The Minkowskian 4R planar mechanism. Vortrag: Workshop Vienna-Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (28.09.2010) The Minkowskian 4R planar robot. Vortrag: RICAM Symbolic Computation Group Seminar/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Helin, Dr. Tapio (20.09.2010) On the stability of MAP estimation with hierarchical prior distributions. Vortrag: 8th International Conference of Numerical Analysis and Applied Mathematics, Rhodos/GREECE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Helin, Tapio (29.06.2010) Discretization and data segmentation in Bayesian inverse problems. Vortrag: Seminar, Westfälische Wilhelms-Universität Münster, Münster/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag

Hodorog, Madalina (02.02.2010) Advanced Knot Theory. Vortrag: RICAM Group Seminar - Symbolic Computation: Advanced Knot Theory, RICAM, Altenbergerstrasse 50, 4040 Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hodorog, Madalina (02.03.2010) Advanced Topics in Knot Theory (Skein Relations). Vortrag: RICAM Group Seminar - Symbolic Computation: Advanced Topics in Knot Theory (Skein Relations), RICAM, Altenbergerstrasse 50, 4040 Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hodorog, Madalina (06.10.2010) Symbolic-numeric algorithms for invariants of plane curve singularities. Vortrag: DK Status Seminar, Strobl/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (08.01.2010) Symbolic numeric algorithms for genus computation based on knot theory. Vortrag: Algebraic Geometry Workshop Linz-Wien in Rastenfeld, Rastenfeld/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (17.03.2010) The genus computation problem: symbolic-numeric solutions and beyond. Vortrag: Workshop of the SAGA (Shapes, Geometry and Algebra) International Project, Auron/FRANCE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (19.01.2010) Basic Knot Theory. Vortrag: RICAM Group Seminar - Symbolic Computation:Basic Knot Theory, RICAM, Altenbergerstrasse 50, 4040 Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hodorog, Madalina (23.09.2010) A symbolic-numeric algorithm for computing the Alexander polynomial of a plane curve singularity. Vortrag: 12th International Symposium on Symbolic and Numeric Algorithms for Scientific Computing, Timisoara/ROMANIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (24.06.2010) Topology analysis of complex curves singularities using knot theory. Vortrag: 7th International Conference on Curves and Surfaces, Avignon/FRANCE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (26.07.2010) GENOM3CK-A library for genus computation of plane complex algebraic curves using knot theory. Vortrag: 35th International Symposium on Symbolic and Algebraic Computation, Muenich/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (27.11.2010) Hybrid Symbolic-Numeric Methods in Polynomial Algebra. Vortrag: Workshop Linz-Wien, Krems/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Jenny, Niebsch (27.05.2010) Inverse imbalance reconstruction in rotating machinery. Vortrag: 5th International Converence Inverse Problems: Modeling and Simulation, Antalya/TURKEY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Kraus, Johannes (07.05.2010) A Subspace Correction Method for Discontinuous Galerkin Discretizations of Linear Elasticity Equations. Vortrag: 6th Austrian Numerical Analysis Day, University of Salzburg/AUSTRIA <http://www.users.sbg.ac.at/~erica/anaday10_index.html>.; Typ: Sonstiger

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Sonstige wissenschaftliche Vorträge

Veranstaltungsbeitrag

Kraus, Johannes (21.08.2010) Auxiliary Space Preconditioner for a Locking-free Finite Element Approximation of the Linear Elasticity Problem. Vortrag: Seventh International Conference on Numerical Methods and Applications, Borovets/BULGARIA <http://www.math.bas.bg/~nummeth/nma10/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Kraus, Johannes (22.09.2010) Subspace correction method for discontinuous Galerkin discretizations of linear elasticity equations. Vortrag: European Multi-Grid Conference 2010, Isola d'Ischia/ITALY <http://emg2010.cats-host.cerebra.at/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Kügler, Philipp (02.05.2010) Applications of Sparsity Enforcing Penalization in Systems Biology. Vortrag: Seminarvortrag Fudan University (Fudan University), Shanghai/CHINA.; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Kügler, Philipp (12.02.2010) Inverse Bifurcation Analysis of Apoptosis Signaling Pathways. Vortrag: Computational Cell Biology 2010 (Cold Spring Harbor Laboratory / Wellcome Trust), Hinxton/UNITED KINGDOM.; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Langer, Andreas (02.02.2010) Domain Decomposition Methods for Local and Nonlocal Total Variation Minimization. Vortrag: RICAM Group Seminar - START Project and PDE, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Langer, Andreas (04.06.2010) Domain decomposition methods for total variation minimization. Vortrag: Söllerhaus Workshop on Domain Decomposition Solvers for Heterogeneous Field Problems, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (12.04.2010) Subspace correction methods for l1-norm and total variation minimization. Vortrag: SIAM conference on Imaging Science, Chicago/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (25.06.2010) Subspace correction algorithms for l1-norm and total variation minimization. Vortrag: SIMAI Congress 2010, Cagliari/ITALY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Lubbes, Niels (08.01.2010) Derived categories. Vortrag: Algebraic Geometry Workshop Linz-Wien in Rastenfeld, Rastenfeld/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Niederreiter, H. (16.08.2010) The discrepancy of hybrid sequences. Vortrag: 9th International Conference on Monte Carlo and Quasi-Monte Carlo Methodds in Scientific Computing, Warsaw/POLAND.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (01.07.2010) Inverse problems with Radon measures. Vortrag: Seminar, Westfälische Wilhelms-Universität Münster, Münster/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag

Pikkarainen, Hanna Katriina (05.01.2010) A Bayesian model for root computation. Vortrag: Finnish Mathematical Days 2010, Jyväskylä/FINLAND <https://www.jyu.fi/science/laitokset/maths/mp2010/en/etusivu>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (11.06.2010) Ky Fanin metriikka. Vortrag: Demonstration lesson, University of Helsinki, Helsinki/FINLAND.; Typ: Sonstiger Veranstaltungsbeitrag

Pikkarainen, Hanna Katriina (14.06.2010) Regularization of ill-posed problems: what and why?. Vortrag: Inverse problems seminar, University of Helsinki, Helsinki/FINLAND <http://wiki.helsinki.fi/display/inverseproblems/IP+seminar>.; Typ: Sonstiger Veranstaltungsbeitrag

Pikkarainen, Hanna Katriina (28.04.2010) Inverse problems in the space of Radon measures. Vortrag: Seminar, Politecnico di Milano, Milan/ITALY.; Typ: Sonstiger Veranstaltungsbeitrag

Pikkarainen, Hanna Katriina (29.04.2010) Bayesian statistics and inverse problem. Vortrag: Seminar, Universita degli Studi di Milano, Milan/ITALY.; Typ: Sonstiger Veranstaltungsbeitrag

Pikkarainen, Hanna Katriina (29.06.2010) Convergence results for Bayesian inversion. Vortrag: Seminar, Westfälische Wilhelms-Universität Münster, Münster/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag

Purrucker, Martin (07.05.2010) Fast hp-FEM-solvers for the Stokes problem. Vortrag: 6th Austrian Numerical Analysis Day/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Ramlau, Ronny (01.07.2010) AN SVD based Wavefront Reconstruction for Adaptive Optics. Vortrag: Mini Special Semester on Inverse Problems, Part II (RICAM), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Ramlau, Ronny (02.06.2010) An SVD based wavefront reconstruction for adaptive optics. Vortrag: Conference: Inverse Problems, Computation, and Applications (Centre International de Recontres Mathematiques (CIRM)), Marseille/FRANCE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

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Sonstige wissenschaftliche Vorträge

Ronny, Ramlau (26.05.2010) Fast iterative multilevel methods for inverse problems. Vortrag: 5th International Converence Inverse Problems: Modeling and Simulation, Antalya/TURKEY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Ronny, Ramlau (27.05.2010) Inverse Problems in Industry. Vortrag: 5th International Converence Inverse Problems: Modeling and Simulation, Antalya/TURKEY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Schicho, Josef (08.01.2010) On a poem by G. Trakl. Vortrag: Algebraic Geometry Workshop Linz-Wien in Rastenfeld, Rastenfeld/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Schicho, Josef (18.05.2010) The Resolution of Singularities Game. Vortrag: Conference "Real Geometry, Computer Algebra and Math Education, Castro Urdiales/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Schicho, Josef (25.01.2010) Choice-Free Resolution in Characteristic Zero. Vortrag: Workshop "Resolution of Singularities", Cuenca/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Schnass, Karin (04.05.2010) Classification via Incoherent Subspaces. Vortrag: Seminar Acoustic Research Lab, Vienna/AUSTRIA <http://people.ricam.oeaw.ac.at/k.schnass/talks/10_classification_ari.pdf>.; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Schnass, Karin (05.05.2010) Basis Identification from Random Sparse Samples. Vortrag: NuHAG Seminar, Vienna/AUSTRIA <http://people.ricam.oeaw.ac.at/k.schnass/talks/10_dicolearn_nuhag.pdf>.; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Schnass, Karin (10.06.2010) Dictionary Identification. Vortrag: Workshop Sparsity and Computation, Bonn/GERMANY <http://people.ricam.oeaw.ac.at/k.schnass/talks/10_dicolearn_bonn.pdf>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Schnass, Karin (19.01.2010) Basis Identification from Random Sparse Samples. Vortrag: Group Seminar - START Project "Sparse Approximation and Optimization in High Dimensions", Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Schnass, Karin (25.06.2010) Dictionary Identification. Vortrag: 7th International Conference on Curves and Surfaces, Avignon/FRANCE <http://people.ricam.oeaw.ac.at/k.schnass/talks/10_dicolearn_av.pdf>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (04.06.2010) The Casas-Alvero conjecture. Vortrag: Linz Algebra Day 2010, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Sevilla, David (08.01.2010) Integration of the positive part of a quadratic function on a triangle. Vortrag: Algebraic Geometry Workshop Linz-Wien in Rastenfeld, Rastenfeld/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (18.05.2010) Polynomial integration on regions defined by a triangle and a conic. Vortrag: Real Geometry, Computer Algebra and Math Education, Castro Urdiales/SPAIN <http://www.trecio60th.unican.es/sites/default/files/slides/RecioFest-Sevilla-2010-slides.pdf>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (26.11.2010) The four color theorem. Vortrag: Workshop Linz-Wien in Krems/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (27.07.2010) Polynomial integration on regions defined by a triangle and a conic. Vortrag: ISSAC 2010, Münich/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Thanh, Nguyen Trung (03.12.2010) A multifrequency reconstruction method for inverse obstacle scattering problems. Vortrag: Inverse Problems Group seminar, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Thanh, Nguyen Trung (09.04.2010) On the accuracy of the linear sampling method for inverse acoustic obstacle scattering problems. Vortrag: Fifth international conference on Inverse Problems, Control and Shape Optimization (Universidad Politécnica de Cartagena), Cartagena/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Tomar, Satyendra (03.03.2010) Numerical Methods in Continuum Mechanics 1. Vortrag: Tutorial, Linz/AUSTRIA <http://www.numa.uni-linz.ac.at/Teaching/LVA/2010s/NumMC1/>.; Typ: Sonstiger Veranstaltungsbeitrag

Unger, Gerhard (27.09.2010) Convergence analysis of iterative methods for algebraic nonlinear eigenvalue problems. Vortrag: 23rd Chemnitz FEM Symposium 2010, Lichtenwalde/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Unger, Gerhard (30.09.2010) A boundary element method for Laplacian eigenvalue problems. Vortrag: 8th Workshop on Fast Boundary Element Methods in Industrial Applications, Kleinwalsertal/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Vybiral, Jan (12.01.2010) "Johnson-Lindenstrauss Lemma and circulant matrices". Vortrag: Group Seminar - START Project "Sparse Approximation and Optimization in High Dimensions", Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

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Sonstige wissenschaftliche Vorträge

Wachsmuth, Daniel (10.03.2010) A-posteriori Fehlerschaetzer fuer Optimalsteuerungsprobleme mit Zustands- und Steuerungsbeschrbeschraenkungen. Vortrag: Chemnitzer Seminar../AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Wachsmuth, Daniel (24.03.2010) A-posteriori error estimates for optimal control problems with state and control constraints. Vortrag: Gamm 2010/ GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Wachsmuth, Daniel (25.03.2010) Optimal Dirichlet boundary control of stationary Navier-Stokes equations with state constraint. Vortrag: Gamm 2010/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Wachsmuth, Daniel (30.06.2010) Error analysis for eigenvalues of Hessians for optimal control problems. Vortrag: IWASEP 8, Berlin/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Willems, Joerg (07.12.2010) Robust Additive Schwarz Preconditioners for Abstract Symmetric Positive Definite Operators. Vortrag: Radon Seminar (RICAM), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Willems, Jörg (21.09.2010) A two-scale iterative method for computing flows in highly porous media. Vortrag: European Multi-Grid Conference (EMG 2010), Isola d'Ischia/ITALY <http://emg2010.cats-host.cerebra.at/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (04.06.2010) Fermat quotients modulo p. Vortrag: Linz Algebra Research Day 2010, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Winterhof, Arne (06.07.2010) Fermat quotients and pseudorandomness. Vortrag: Uniform Distribution Theory, Strobl/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (28.06.2010) Structure of pseudorandom numbers derived from Fermat quotients. Vortrag: WAIFI 2010, Istanbul/TURKEY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Wissenschaftliche Posterpräsentationen

Haskovec, Jan (22.06.2010) From individual to collective behaviour of coupled velocity jump processes: a locust example. Posterpräsentation: Modelling at different scales in biology, Oxford/UNITED KINGDOM <http://www.maths.ox.ac.uk/groups/occam/forthcoming-events/occam-conference-modelling-different-scales-biology>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Korporal, Anja; Regensburger, Georg; Rosenkranz, Markus (25.07.2010) A MAPLE Package for Integro-Differential Operators and Boundary Problems. Posterpräsentation: International Symposium on Symbolic and Algebraic Computation (ISSAC) 2010, Munich/GERMANY <http://www.issac-conference.org/2010/>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Korporal, Anja; Regensburger, Georg (17.07.2010) Implementing Integro-differential Operators via Normal Forms. Posterpräsentation: Sage Days 24, Hagen/AUSTRIA <http://wiki.sagemath.org/days24>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Müller, Stefan (12.10.2010) Spontaneous Synchronization in Continuous Cultures of Yeast - A Coarse-Grained Model for Oscillatory Growth Dynamics. Posterpräsentation: The Eleventh International Conference on Systems Biology, Edinburgh/UNITED KINGDOM <http://www.icsb2010.org.uk/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Purrucker, Martin (25.06.2010) Fast hp-solvers for tensor product elements. Posterpräsentation: A short course on hp-adaptive Finite Elements Methods/POLAND.; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

2.8. Scientific cooperation 2010

2.8.1. Group "Computational Methods for Direct Field Problems"

We here mention only the most important scientific cooperation leading to joint publications or research projects with other RICAM groups and with other groups or scientists in Austria and worldwide:

Cooperation within RICAM:

1. *S. Beuchler* with C. Pechstein (NuMa, JKU) and *D. Wachsmuth* (Optimal Control Group) on boundary concentrated FEM for optimal control problems: 1 journal publication [4] and submission of a FWF-project (P23484-N18).

2. *J. Kraus* with *S. Tomar* on multilevel methods for problems in the space H(div): Approximations in higher order Raviart-Thomas spaces and applications to a posteriori error estimates.

3. *J. Kraus* with *H. Yang* on fast Krylov space methods for the coupled Darcy/Stokes system.

4. *J. Kraus* with *I. Georgiev* on subspace correction methods for discontinuous Galerkin methods for elasticity equations.

5. *J. Kraus* with *I. Georgiev* and *E. Karer* on uniform preconditioners for highly heterogeneous elasticity problems.

National Cooperation:

1. *J. Kraus* and *S. Beuchler* with T. Renger, P. Pohl and G. Schütz (Institute for Biophysics, JKU Linz) on numerical simulation of the proton transfer along lipid bilayer membranes: FWF project application within the BioDK.

2. *J. Kraus* with V. Pillwein on closed forms and recurrence relations for certain polynomials of best approximation (publication in preparation).

3. *J. Kraus* with *E. Karer* on auxiliary space and subspace correction methods for finite element elasticity systems arising from reduced integration (publication in preparation).

4. *S. Beuchler* with V. Pillwein (RISC+MathDK W1214, JKU Linz) and S. Zaglmayr (TU Graz) on sparse shape functions for H(div) and H(curl): 1 joint paper about the H(div)-case was published as RICAM-Report [5], a second publication concerning the H(curl)-case is in preparation. A survey paper is already published, [14], together with J. Schöberl (TU Vienna).

5. S. *Tomar* with B. Jüttler on isogeometric method for numerical solution of partial differential equations, within the framework of FWF project P21516-N18.

6. *U. Langer* and *S. Tomar* cooperated with C. Hofreither (DK W1214) on the topic "Boundary Element Simulation of Linear Water Waves in a Model Basis" resulting in a paper that was published in the LSSC proceedings [7].

7. *H. Yang* with W. Zulehner (NuMa, JKU) on a joint paper: Numerical Simulation of Fluid-Structure-Interaction Problems on Hybrid Meshes with Algebraic Multigrid Method (in preparation)

8. *G. Unger* with O. Steinbach (TU Graz): On the solution of eigenvalue problems for elliptic PDEs by means of boundary element methods. One paper was published as RICAM-Report [12], a second publication is in preparation.

International Cooperation:

1. There is a special Collaborative Research Project on "***Robust Large-Scale Scientific Computing Methods and Scalable Algorithms***" (2009 - 2012) of RICAM with the Institute for Parallel Processing (IPP) of the Bulgarian Academy of Sciences (BAS) at Sofia (Bulgaria). This cooperation has resulted in numerous joint publications, see [Section 2.7, List 17].

2. *U. Langer* cooperated with D. Copeland (Texas A&M University, College Station, USA, former member of the RICAM group) on the multiharmonic approach to non-linear parabolic initial-boundary value problems. One paper was published in the *Journal of Numerical Mathematics* [6]. The second paper appeared in the DD19 proceedings [15].

3. *S. Tomar* with T.J.R. Hughes (Austin, USA): On isogeometric method for numerical solution of partial differential equations, within the framework of FWF project P21516-N18, and J.T. Oden Faculty research fellowship.

4. *S. Tomar* cooperates with S.I. Repin (St. Petersburg, Russia) on functional-type a posteriori error estimates [3].

5. J. Willems with R. Lazarov (Texas A&M University, College Station, USA): NSF project DMS-1016525 "Subgrid Discontinuous Galerkin Approximations of Brinkman Equation with Highly Heterogeneous Coefficients".

6. *J. Kraus* with B. Ayuso (University of Barcelona, Spain) and L. Zikatanov (Penn State University (PSU), USA) on space decomposition and subspace correction methods for discontinuous Galerkin methods for elasticity equations (publication in preparation); collaboration within Project P22989-N18.

7. *J. Kraus* with P. Vassilevski (Lawrence Liveremore National Laboratory, USA) and L. Zikatanov (PSU, USA) on the use of polynomials of best approximation in the uniform norm in (algebraic) multilevel methods (first publication in preparation); collaboration within Project P22989-N18.

8. *J. Kraus* with J. Brannick (PSU, USA), Y. Chen (PSU, USA), and L. Zikatanov (PSU, USA) on multilevel preconditioning of (weighted) graph Laplacians based on matching of graphs (publication in preparation).

9. *J. Kraus* with L. Zikatanov (PSU, USA) on subspace correction methods for stable discretizations of elasticity problems with nearly incompressible materials and extensions to the Stokes problem; collaboration within Project P22989-N18.

Of course, there is a close cooperation within our group leading to numerous joint publications. But there is also a close cooperation of the RICAM group with the Institute for Computational Mathematics at the JKU. The same was true for the FWF DK W1214 on Computational Mathematics. We have a weekly joint seminar that is attended by the RICAM group members and the people working at the Institute for Computational Mathematics and in DK projects related to the Institute for Computational Mathematics as well as by members of other RICAM groups.

2.8.2. Group "Inverse Problems"

The Research Group "Inverse problems" has developed extensive international collaboration within joint scientific projects resulting in publications [1], [3] – [5], [7] – [10], [12] – [14], [17]. A more detailed description of the scientific cooperation is listed below:

1. with Prof. Bernd Hoffmann (Fakultät für Mathematik, TU Chemnitz, Germany): on regularization of ill-posed problems under general smoothness assumptions, and on organisation of the Mini Special Semester on Inverse Problems;

2. with Dr Lorenzo Rosasco (Massachusetts Institute of Technology, Cambridge, MA, USA): on regularization algorithms in learning theory;

3. with Prof. Ulrich Tautenhahn (Hochschule Zittau, FH Görlitz, Germany): on multi-parameter regularization of ill-posed problems;

4. with Prof. Gen Nakamura (Hokkaido University, Sapporo, Japan) on the study of Green functions associated to interior transmission problems of the scattering theory.

5. with Ass. Prof. Drossos Gintides (TU of Athens, Greece): on the detection of interfaces using elastic waves;

6. with Kazuki Yoshida (Hokkaido university, Sapporo, Japan): on the use of complex geometrical optics solutions for interface detection;

7. with Dr. Faouzi Triki (University of J. Fourier, Grenoble, France): on the use of multi-frequency data for interface detection;

8. with Dr. Stefan Janecek (Institut de Ciència de Materials de Barcelona) and Esa Räsänen (Nanoscience Center, Department of Physics, University of Jyväskylä): on the development of a computational scheme based on classical molecular dynamics to study chaotic billiards in static external magnetic fields;

9. with DI. Johannes Fürst and Christian Kletzmayr (MathConsult, Linz, Austria): on development a fast and stable Heston model calibration algorithms in mathematical finance that run on the GPU;

10. with Prof. Patricia Lamm (Michigan State University): on local regularization of ill-posed integral equations

Moreover, within the framework of the FWF project “Mathematical methods for high-precision balancing of machine tools” a close cooperation with the Center for Industrial Mathematics (ZeTeM) and the Laboratory for Micro Machining (LfM), both at the University of Bremen, Germany has been developed via several visits and joint publications. In the course of the FFG project, cooperation with two companies in Germany, BerlinWind GmbH, Berlin, and My-Sen GmbH, Rudolstadt, as well as with MathConsult GmbH in Linz has been established.

2.8.3. Group "Symbolic Computation"

Internal cooperation:

1. with "Optimization and Optimal Control": in an optimization problem, integration of a polynomial function over a planar domain deliminated by curves of degree 2 arose. By symbolic techniques, a solution formula was given.

External cooperation:

1. with B. Mourrain, INRIA, Sophia Antipolis: Mourrain had developed a program for certified analysis of the topology of intersections. In a cooperation with him, the program was extended to provide a symbolic-numeric algorithm for genus computation.

2. A. Kasprzyk, Univ. Sydney: in cooperation with him, an open conjecture on Ehrhart polynomials of convex polytopes could be proven.

3. with H. Hauser, Univ. Wien, and his group: two joint workshops. Cooperation on the problem of resolution of singularities (a paper is in preparation).

4. with B. Jüttler, Univ. Linz, and B. Bastl, M. Lavicka, Z. Sir from Univ. Plzen: new geometric properties and formulae for quadratic surface patches have been found.

5. with M. Rosenkranz, Univ. Canterbury: continued intensive research cooperation on integral and differential operators. Together with him and other researchers (B. Buchberger and L. Tec from RISC, W. Sit, Stony Brook Univ.), the group organized a session at a conference, edited a collection, wrote two papers, and gave three talks and a lecture at Univ. Linz on that topic.

2.8.4. Group "Analysis of Partial Differential Equations"

Renjun Duan had ongoing internal cooperation with P. Markowich and M. Fornasier, and an external cooperation with A. Lorz (Univ. of Cambridge, where R. Duan also visited), leading to the publications [6,7]. He has cooperation with R. M. Strain (Princeton University) [8] K. Fellner (University of Cambridge) [5], and T. Yang (City University of Hong Kong) [9]. He started new cooperation with J. A. Carrillo (University of Barcelona).

Massimo Fonte had an ongoing internal cooperation with P. Markowich and external cooperation with A. Bressan (PennState University, USA, where M. Fonte also visited), K. Fellner (DAMTP, University of Cambridge, UK), and F. S. Priuli (SISSA, Italy).

Andreas Langer obviously works with his advisor M. Fornasier and they have an ongoing external cooperation with Carola-Bibiane Schönlieb (DAMTP, Univeristy of Cambridge, UK) which led to the publications [12-13,23]. This research direction established also a new cooperation with the group of Direct Fields Problems led by Professor Ulrich Langer. Andreas Langer also visited the Department of Mathematics of the University of California in Los Angeles (Sept.-Dec. 2009) and he activated new ongoing cooperation with Yunho Kim, Stanley Osher, and Luminita Vese.

M. Fornasier's research visits in 2010 include the Hausdorff Center of Mathematics and the Institute for Numerical Simulation (University of Bonn, Germany), the Mathematical Institute (groups of Numerical Analysis and of nonlinear PDE, University of Oxford, UK), Department of Mathematics (Univ. Marburg), the Department of Mathematics (Technical University of Munich), the Seminar in Applied Mathematics (ETH-Zürich). His external cooperation resulting in publications include those with J. Carrillo, J. Rosado (Univ. Barcelona) and G. Toscani (Univ. Pavia) [1-2,6,11], with I. Daubechies (Univ. Princeton) and R. DeVore (Texas A&M University) [5], R. Ward (Courant Institute, New York University) and Holger Rauhut (University of Bonn) [15,18], R. March (IAC-CNR Rome) [14]. Dr. Fornasier co-organized with Holger Rauhut and Ronald DeVore the international conference Sparsity and Computation at the Hausdorff Center for Mathematics Bonn, June 7-11, 2010. He has ongoing cooperation on new projects related to free-discontinuity problems with Francesco Solombrino, Sergio Conti (University of Bonn, Germany), Endre Süli (University of Oxford, UK). He led several internal cooperation with all the group members.

Jan Haskovec had joint internal cooperation with M. Fornasier and G. Toscani [11] and C. Schmeiser [20]. He has also ongoing cooperation with Radek Erban (University of Oxford, UK) with whom he concluded the work [10].

Yunho Kim visited our group in July-Sept. 2009, initiating cooperation with Andreas Langer who later exchanged the visit, going to California in the period Sept.-Dec. 2009 in order to continue the ongoing cooperation which resulted in the paper [12].

Karin Schnass cooperated with M. Fornasier and J. Vybiral [17,24], and with Remi Gribonval (INRIA-Rennes, France) [19].

Francesco Vecil contributed to the work [2] which involved the internal cooperation with M. Fornasier.

Jan Vybiral has ongoing cooperation with M. Fornasier, K. Schnass [17,24], and Jan Haskovec, and with several colleagues, Aicke Hinrichs and Winfried Sickel, at the University of Jena, Germany [21-22,25]

More references see chapter 2.7.

2.8.5. Group "Optimization and Optimal Control"

Internal cooperation:

Dr. Sven Beuchler (Numerics group), Dr. Clemens Pechstein (JKU Linz): boundary concentrated finite elements for optimal boundary control problems; joint proposal for FWF-project.

Dr. David Sevilla (Symbolic group): integration of polynomials on regions defined by a triangle and a conic with application to variational discretization of optimal control problems.

External cooperation:

Prof. Dr. Arnd Roesch (Uni Duisburg-Essen): development of a-posteriori error estimates for optimal control problems with state and control constraints.

Dr. Klaus Krumbiegel (WIAS Berlin): adaptive regularization of optimal control problems with state and control constraints.

Dipl-math Gerd Wachsmuth (TU Chemnitz): regularization error estimates for optimal control problems with pointwise constraints.

Dr. Anton Schiela: convergence estimates for regularization of optimal control problems for variational inequalities.

Dr. Bangti Jin (Texax A&M, College Station) on optimization and iverse problem, an organization of a minisymposium in ICIAM 2011.

Prof. Kewei Liang (University of ZheJiang Uni. China) on optimization and scientific computation.

Prof. K. Ito (North Carolina State University) on numerical realisation of time optimal control.

2.8.6. Group "Mathematical Imaging"

We collaborated with Charles Kervrann and Patrick Perez (Inria Rennes), with Jean Salamero, Alexandre Gidon, and Anatole Chessel (Institute Curie in Paris), with Jean-Baptiste Sibarita (University of Bordeaux), and with John Sedat (University of San Francisco) on patch-based methods for image denoising and event detection.

We continued our cooperation with Jorge Zubelli (IMPA) which has been initiated during the Special Semester on Finance Analyzed by Stochastic Methods in 2008, which was organized by RICAM, Austrian Academy of Sciences.

We also pursued our collaboration with Elena Resmerita on finite dimensional approximations in Banach spaces.

Moreover, we were working with Michael Collins (Calgary University) on radar imaging and with Andreas Kirsch (Karlsruhe Institute of Technology) on a relation between scattering and photoacoustic imaging.

2.8.7. Group "Mathematical Methods in Molecular and Systems Biology"

1. with Leonie Ringrose, Institute of Molecular Biotechnology, on polycomb proteins for cell memory (status: joint paper submission)
2. with Carry Cowan, Institute for Molecular Pathology, on cell differentiation in C.elegans (status: first modelling and simulation results)
3. with Gottfried Köhler, Max F. Perutz Laboratories, on hormone feedback mechanisms in pituitary cells (status: joint paper submission)
4. with Vic Small, Institute of Molecular Biotechnology, on mechanisms underlying cell motility (status: joint WWTF-project)
5. with Kristin Tessmar, Max F. Perutz Laboratories, on the influence of lunar rhythmicity on the marine bristle worm Platynereis dumerilii (status: joint statistical preprocessing of experimental data)
6. with Claudia Jonak, Gregor Mendel Institute, on stress response of Arabidopsis (status: joint literature exploration)

7. with Wolfram Weckwerth, Molecular Systems Biology, University of Vienna, on inferring biochemical regulation sites from metabolomics covariance data (status: joint algorithm development and co-author invitation)

8. with Steffen Hering, Department of Pharmacology and Toxicology, University of Vienna, on the gating behaviour of voltage sensor ion channel mutations (status: joint publication)

2.8.8. Research Project "Applied Discrete Mathematics and Cryptography (DM)"

Guests:

1. Alina Ostafe (University of Zürich), 11.01.2010-16.10.2010, External Funding

2. Alvar Ibeas (University of Cantabria and University of Vienna), 14.10.2010-15.10.2010, Mixed Funding

3. Domingo Gomez (University of Cantabria), 07.05.2010-13.05.2010, External Funding

4. Hassan Aly (Cairo University), 01.04.2010-28.05.2010, Own Funding of the Research Institution

Conference Participations and Research Stays:

Niederreiter:

1. 05.03.2010-11.03.2010 Research Visit King Fahd University

2. 05.04.2010-11.04.2011 Research Visit Tsinghua University

3. 04.07.2010-09.07.2010 Uniform Distribution Theory (Strobl)

4. 15.08.2010-20.08.2010 MCQMC 2010 (Warszaw)

Winterhof:

1. 03.10.2010-09.10.2010 Number Theory and Applications (Debrecen)

2. 04.07.2010-09.07.2010 Uniform Distribution Theory (Strobl)

3. 12.09.2010-18.09.2010 Sequences and Their Applications (Paris)

4. 14.12.2010-15.12.2010 Minicolloquium on analytic number theory and combinatorics (Vienna)
5. 18.05.2010-23.05.2010 Antalya Algebra Days
6. 18.07.2010-07.08.2010 Research visit at Carleton University
7. 25.02.2010-02.03.2010 Research visit at University of Zürich
8. 27.01.2010-29.01.2010 Workshop on dynamical systems and uniform distribution (Graz)
9. 27.06.2010-01.07.2010Workshop on Arithmetics in Finite Fields (Istanbul)

2.8.9. Seminars

As in the previous years, the seminar series has been structured into three groups:

Radon Colloquia:
In these talks, prominent external scientists should present overviews over important fields dedicated also to non-specialists. All RICAM employees are expected to attend there colloquia.

Radon Seminars:
These are a bit more specialized talks, both by our own scientists and by external visitors. They should not strictly focus on a specialized topic but have connections to work of at least two groups in RICAM and should therefore be attended by all RICAM scientists. One purpose is to initiate internal cooperation; all new PostDocs should give talks in this series.

Group Seminar:
These are specialized talks by internal and external scientists intended mostly for members of the organizing group(s), although, of course, members of other groups are also welcome.

In 2010, the following talks were given in these three categories mentioned above:

RADON COLLOQUIA
Norio Takahashi Okayama University, Japan September 14, 2010, 10:00 Johannes Kepler University, MZ 003A
Title: Optimal Design and Modeling of Magnetic Devices and Related Topics

Abstract: The magnetic field analysis is widely used in order to design a miniature and highly efficient electrical machines and electronic equipments. However, there are sometimes discrepancies between the calculation and measurement. This may be due to the insufficient modeling of magnetic characteristics, by ignoring, for example the effect of stress, temperature dependence of magnetic properties. In this lecture, recent development of modeling of magnetic characteristics including newly measured results is discussed, and the necessity of the consideration of real working conditions of magnetic properties for the precise analysis of magnetic devices is illustrated. Moreover, a topology optimization method called as ON/OFF method is explained and some attractive applications are shown. 1. Real working conditions of magnetic material (1) Stress (compressive stress, cutting stain, shrink fitting) (2) Temperature 2. Modeling of magnetic devices (1) Iron loss of motor (2) Analysis of IH considering temperature dependence of magnetic properties 3. Optimal design of magnetic device using ON/OFF method

Prof. W. Tecumseh Fitch

University of Vienna, ERC Advanced Grant Winner

October 04, 2010, 15:00

Johannes Kepler University, HF136

Title: Vocal Production Mechanisms in Vertebrates: Modeling the Voice

Abstract: Vocal production in vertebrates (animals with a spine, including frogs, alligators, birds and mammals) is based upon a two-component system of source (air generated by vibrating tissue) and filter (via resonances of air contained in the vocal tract). I will describe advances in our understanding of vertebrate communication made possible by a recent focus on the physics and physiology of the filter component; while this component was once thought to be used by humans almost exclusively, it is now clear that it plays an important role in vocal communication in many species. The physical basis of vocal tract filtering is rather simple; far more challenging in the coming years will be an understanding of the voice source. Most research till now has focused on the human larynx (more generally, the mammalian vocal folds), but the source in birds is quite different: vibrating membranes within the syrinx (a specialized organ possessed only by birds). We hope to combine anatomical measurements, physiological observations and computational models to understand the great range of variation in the avian syrinx, and so to isolate the main determinants of acoustic variability in bird songs.

Douglas Murray

Keio University

May 12, 2010, 10:00

VBC

Title: Ultradian Rhythms - Transcriptome, Proteome and Metabolome Studies

Abstract: When continuously grown aerobic yeast cultures reach a critical cell density they synchronise their pysiology. The main manifestation of this synchrony are large amplitude robust respiratory oscillation cycles (period 40 min - 8h) that gate DNA replication. Respiration cycles between phases of high oxygen uptake (oxidative phase) and low oxygen uptake (reductive phase). Transcriptomic, Metabolomic and Proteomic studies have revealed that these dynamics percolate throughout every omic level and that almost every chemical species have an exact time when concentration is at its maximum with respect to respiration. Therefore the respiratory oscillation and its perturbation provide an unrivalled tool for the dissection of the temporal structure of the cell. Our recent studies indicate the many feedback loops involved in regulating oscillatory behaviour correspond with reaction network hubs. In particular amino acid, sulphur, 2-carbon and ATP metabolism. Where the oscillation appears to temporally separate anabolic and catabolic processes. Chromatin immuno precipitation data indicates that here is large-scale chromatin remodelling occurring every oscillation cycle indicating ATP directly feeds back onto chromatin structure. In addition amino acid availability causes a cycle of tRNA charging. These data have led to the basis of a simplified mathematical model for testing how oscillatory sub-networks integrate to produce oscillatory behaviour and how more complex multi-oscillatory dynamics can occur.

RADON SEMINARS

Computational Methods for Direct Field Problems

Dr. Gerhard Unger

RICAM

October 02, 2010, 15:30

Johannes Kepler University, P004

Title: A boundary element method for Laplacian eigenvalue problems.

Abstract: For the solution of Laplacian eigenvalue problems we propose a boundary element method which is used to solve equivalent nonlinear eigenvalue problems for related boundary integral operators. The concept of eigenvalue problems for holomorphic Fredholm operator functions is used to establish a convergence and error analysis for a Galerkin boundary element discretization. The discretization of the boundary integral operator eigenvalue problems leads to algebraic nonlinear eigenvalue problems. We use the recently proposed contour integral method which reduces the algebraic nonlinear eigenvalue problems to linear ones. This method is based on a contour integral representation of the resolvent operator and it is suitable for the extraction of all eigenvalues in a predefined

interval which is enclosed by the contour. The dimension of the resulting linear eigenvalue problem corresponds to the number of eigenvalues which lie inside the contour. The main numerical effort consists in the evaluation of the resolvent operator for the contour integral which requires the solution of several linear systems. Compared with other methods for nonlinear eigenvalue problems no initial approximations of the eigenvalues and eigenvectors are needed. Numerical examples demonstrate the reliability of the method.

Dr. Jörg Willems

RICAM

December 07, 2010, 15:30

Johannes Kepler University, P004

Title: Robust Additive Schwarz Preconditioners for Abstract Symmetric Positive Definite Operators

Title: A framework for constructing robust additive Schwarz preconditioners for general symmetric positive definite (SPD) problems is presented. The term "robust" refers to the property of the condition numbers of the preconditioned systems being independent of mesh parameters and problem parameters. Important instances of such problem parameters are e.g. (highly varying) conductivities and permeabilities. The core of this method is the construction of the coarse space based on the solution of local generalized eigenvalue problems. The framework only requires assumptions which are naturally satisfied by SPD operators corresponding to partial differential equations and is thus applicable to a wide range of problems. To address a broader audience we provide some general background information on domain decomposition methods and discuss the application of our framework to the scalar elliptic equation with jumping coefficients.

RADON GROUP SEMINARS

Computational Methods for Direct Field Problems

Dr. Jörg Willems

Texas A&M University

January 08, 2010, 10:00

Johannes Kepler University, HF136

Title: An Iterative Subgrid Method for Computing Flows in Highly Porous Media

Abstract: A two-scale finite element method for solving Brinkman’s equations is presented. This system of equations models fluid flows in highly porous media. Motivated by industrial applications we focus on the case of these media having a complicated internal structure represented by a heterogeneous permeability field. The method uses a recently proposed discontinuous Galerkin FEM for Stokes equations by Wang and Ye and the concept of

subgrid approximation developed by Arbogast for Darcy's equations. In order to reduce boundary layer errors and to ensure convergence to the global fine solution, the algorithm is put in the framework of alternating Schwarz iterations using subdomains around the coarse-grid boundaries. Several numerical examples are presented to demonstrate the performance of this iterative procedure.

M.Sc. Krishan Gahalaut

RICAM

January 26, 2010, 15:30

Johannes Kepler University, P215

Title: Exploiting sparsity in Jacobian computation using graph coloring

Abstract: The computation of the derivative information is fundamental to many numerical algorithms. For example, in general, the minimization of a function requires the gradient and/or Hessian of the function, or, the solution of a system of nonlinear equations requires the Jacobian matrix. Based on the sparsity exploiting techniques, this work deals with efficient computation of large Jacobian. We will discuss how to take advantage of the sparsity using graph coloring.

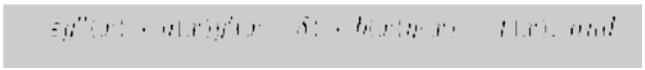
Aditya Kaushik

January 26, 2010, 16:15

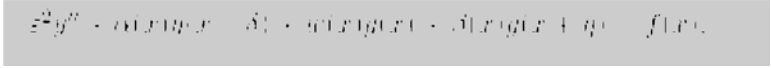
Johannes Kepler University, P215

Title: Uniformly convergent difference schemes for singularly perturbed differential equations

Abstract: We consider the difference schemes for singularly perturbed ordinary differential equations (SPODE). When the perturbation parameter is very small, the solution of the problem exhibits boundary layer behaviour. In the boundary layer region the solution changes rapidly, while away from this region the change in the solution is moderate. This simultaneous presence of two different scales phenomena makes the problem stiff. In this talk we present parameter uniform difference schemes for SPODE of two types, namely: Convection Reaction Diffusion:



And Reaction Diffusion:



The main emphasis will be on the development of parameter uniform error estimates on piecewise mesh. Although the analysis is restricted to the ordinary differential equations, the proposed technique is found useful in assessing the merits of numerical solution of other nonlinear models, as well as partial differential equations.

Wolfgang Wendland

University Stuttgart

February 25, 2010, 10:00

Johannes Kepler University, T111

Title: On Levi Functions

Abstracts: Fundamental solutions to elliptic partial differential operators are explicitly known only in particular cases whereas Levi functions can always be constructed. In this lecture, the simple case of a second order operator with variable coeffients will be considered and with Levi Functions a system of domain– boundary integral equations for the Dirichlet problem will be obtained. The mapping properties of the corresponding operators will provide the opportunity of employing efficient solution techniques.

Peter Bastian

Heidelberg University

March 26, 2010, 09:00

Johannes Kepler University, BA9908

Title: Generic implementation of finite element methods in the Distributed and Unified Numerics Environment (DUNE)

Abstract: In this talk we describe PDELab, an extensible C++ template library for finite element methods based on the Distributed and Unified Numerics Einvironment (DUNE). PDELab considerably simplifies the implementation of discretization schemes for systems of partial differential equations by setting up global functions and operators from a simple element-local description. A general concept for incorporation of constraints eases the implementation of essential boundary conditions, hanging nodes and varying polynomial degree. The underlying DUNE software framework provides parallelization, dimension-independence and adaptive local mesh refinement. The flexibility and efficiency of the approach will be demonstrated with various applications from porous media flow.

Naresh Chadha

National University of Galway, Ireland

April 13, 2010, 15:30

Johannes Kepler University, HS13

Title: Adaptive mesh construction for a class of singularly perturbed differential equations

Abstract: Singularly perturbed differential equations arise in many practical applica- tions, such as flow in porous media, semiconductor device modeling, ion transport across biological membranes. In general, these type of problems exhibit a layer behavior; and commonly used numerical methods may fail to resolve these layers. To solve such problems numerically in a reliable and effcient way, one has to use locally refined meshes. In this talk, we will discuss the convergence analysis of a r-adaptive method based on equidistribution

principle. The problems considered are singularly perturbed one-dimensional convection-diffusion and reaction-diffusion prob- lems. It is proved that starting from a uniform mesh, the algorithm used provides a layer-adapted mesh on which the computed solution is suffciently accurate. The issues related to extending equidistribution principle to higher dimensions will also be discussed. 1. N. Kopteva & M. Stynes, A robust adaptive method for a quasilinear one- dimensional convection-diffusion problem, SIAM J. Numer. Anal., 39 (2001), no. 4, 1446-1467. 2. N. M. Chadha & N. Kopteva, A robust grid equidistribution method for a one-dimensional singularly perturbed semilinear reaction-diffusion problem, IMA J. Numer. Anal., (2009).

Dr. Jörg Willems
RICAM
July 26, 2010, 13:00
Johannes Kepler University, HF 136

Title: A Robust Domain Decomposition Method for General Symmetric Positive Definite Operators

Abstract: We consider the preconditioning of symmetric positive definite operators. These operators for example arise in the discretization of PDEs modeling porous media flow, heat conduction, and many other processes. For preconditioning we apply a two-level additive Schwarz preconditioner, whose coarse space is constructed by eigenfunctions solving sets of suitably chosen (local) generalized eigenproblems. Due to this special choice of the coarse space the condition number of the preconditioned system is robust with respect to the mesh parameters and problem parameters such as variations in the permeability field in porous media flow.

Dr. Johannes Kraus
RICAM
November 23, 2010, 15:30
Johannes Kepler University, P004

Title: Algebraic multilevel preconditioner for the graph Laplacian based on matching of graphs

Abstract: We introduce an algebraic multilevel method for the Graph Laplacian based on matching of graphs. We show that the resulting piecewise constant coarse spaces and an appropriately chosen Algebraic Multilevel Iteration (or AMLI) yield a (nearly) optimal order method.

Krishan Gahalaut

NuMa

December 10, 2010, 15:30

Johannes Kepler University, HS13

Title: Graph theory based preconditioners in isogeometric analysis

Abstract: Conjugate gradient method (CGM), and it's preconditioned version, are one of the most promising techniques for the solution of symmetric and positive de- nite linear system of equations. The number of iterations of the CGM depend on the ratio of largest to smallest eigenvalues. Support graph theory, introduced by Vaidya [1], is a methodology for bounding condition numbers of preconditioned systems. Specically, the extremal eigenvalues can be bounded with support graph techniques. Vaidya analyzed maximum weight spanning tree precondi- tioners, and Miller and Gremban [2], extended this work by using support tree preconditioners. Isogeometric analysis, introduced by Hughes et al. [3,4], is a novel approach to bridge the gap between geometry and numerical simulation. Broadly speak- ing, it replaces the polynomial based approximation in a nite element method by those functions which are used to represent the geometry (e.g., NURBS, a well established methodology in computer aided design (CAD) community). In this talk we discuss the methodology of graph theory based precondition- ers for isogeometric analysis.

Inverse Problems

Arunachalam Kana

Fachhochschule Wels

February 09, 2010, 10:30

Johannes Kepler University, HF136

Title: Fibre extraction and quantitative characterisation from reinforced polymers in CT data

Abstract: X – ray computed tomography (XCT) is an efficient non – destructive testing method for the characterisation of fibres in reinforced polymer composites. The XCT images of glass fibre reinforced polymers consist of gray values which represent polymer matrix, glass fibres and noise. The glass fibres are to be divided into free fibres and clusters. Free fibres are fibres which does not touch other fibres, while a cluster is a group of fibres touching each other. An increase in the fibre content increases the formation of cluster in the polymer matrix. This method is an attempt to solve the problem of extraction of individual fibre and their characteristics from a polymer matrix. Initially the image noise is removed using anisotropic diffusion filtering and Otsu method is used for the segmentation of fibres. A fibre skeleton is a line representing a fibre and is obtained by binary thinning, which is a morphological operator used to extract the skeleton of an object. To obtain the

characteristics of a fibre, it is necessary to extract each fibre separately from the image. For free fibres, a fibre is extracted by tracing on a fibre skeleton to its start and end point. In the case of clusters, each fibre skeleton is connected to each other at a point called cluster point, which makes it difficult to extract an individual fibre. Initially the cluster point is identified and then each fibre segment at a cluster point is extracted. We highlight the difficulties caused due to binary thinning to extract a single fibre from a cluster and some techniques to solve it. The extracted fibres are visualised as lines drawn from its start to end point. Each line is colour coded based on the orientation of the fibre. The length and orientation of each fibre is calculated and evaluated. Our method is tested on polymer specimens with 1%, 5%, 10% and 20% glass fibre content. The result is evaluated based on empirical determination of the individual fibres. The number of fibres identified by the software is evaluated in reference to manual fibre counting.

Caroline Boess

The University of Reading, UK

March 12, 2010, 10:00

Johannes Kepler University, HF136

Title: State Estimation using model order reduction for unstable systems

Abstract: In this talk the state estimation problem as it occurs within data assimilation is discussed. The main target of data assimilation for numerical weather prediction is to find the best estimate of the true state of the atmosphere by using measured observations. This is an ill-posed inverse problem caused by the fact that the number of available observations is at least two orders of magnitude smaller than the dimension of the state vector. The focus of this talk is on the well-known and approved method of four-dimensional variational data assimilation. It can be interpreted as a Tikhonov regularization of the ill-posed data assimilation problem. The methodrequires the minimization of a series of simplified cost functions. These simplified functions are usually derived from a spatial or spectral truncation of the full system being approximated. In this talk a new method for deriving these simplified problems is proposed, based on control theoretic model reduction methods. The models used for numerical weather prediction often possess inherent instabilities. But most standard model reduction methods are designed for asymptotically stable systems only. A new approach for model reduction of unstable systems is proposed. It is shown that this performs well within the state estimation problem. To illustrate the theoretical results numerical experiments are performed using a two dimensional Eady model - a simple model of baroclinic instability, which is the dominant mechanism for the growth of storms at mid-latitudes. It is a suitable test model to show the benefit that may be obtained by using model reduction techniques to approximate the unstable systems within the state estimation

problem.

Kristian Bredies

University of Graz

July 07, 2010, 14:00

Johannes Kepler University, HF 136

Title: Total Generalized Variation

Abstract: The novel concept of total generalized variation of a function is introduced and some of its essential properties are discussed. Differently from the bounded variation semi-norm, the new concept involves higher order derivatives. Numerical examples illustrate the high quality of this functional as a regularization term for mathematical imaging problems. In particular this functional selectively regularizes on different regularity levels and does not lead to a staircasing effect.

Dr. Faouzi Triki

Laboratoire Jean Kuntzmann, Université Joseph Fourier, France

August 26, 2010, 14:00

Johannes Kepler University, HF 136

Title: Recovering electromagnetic parameters from measurement of interior data

Abstract: In this talk we consider the problem of recovering electromagnetic parameters of an object from the knowledge of a finite number of energy densities. We show that the interior data determines uniquely these parameters and we derive a local Lipschitz stability estimate of the reconstruction. These results are in contrast with the classical inverse problem using boundary data, where the ill-posdness is severe and the stability is logarithmic (dimension 3).

Houcine Meftahi

Lille University, France

November 12, 2010, 10:10

Johannes Kepler University, HF136

Title: Some new results on interface and parameter detections in Elasticity

Abstract: The talk will be around the following points: 1. Identification of a crack by rational and meromorphic approximation in the complex plane 2. Estimates of the area of a cavity from boundary measurements 3. Identifications of inclusions by means of the topological and shape gradient 4. Identification of Lamé parameters in linear elasticity from boundary measurements

Symbolic Computation
M.Sc. Madalina Hodorog RICAM January 19, 2010, 10:00 Johannes Kepler University, AS50
Title: Basic Knot Theory
Abstract: Knot theory is an uncommon field. Most of the subject is familiar to everyone. Still, the most basic questions in knot theory require rigorous mathematical methods for modeling them. We describe some of the methods of knot theory (i.e. combinatorial, geometrical and algebraic methods) and some relationships among them. We illustrate some application of these methods to a variety of problems. We thus intend to give a formal mathematical description of knot theory.
M.Sc. Madalina Hodorog RICAM February 02, 2010, 10:00 Johannes Kepler University, AS50
Title: Advanced Knot Theory
Abstract: Knot theory is an uncommon field. Most of the subject is familiar to everyone. Still, the most basic questions in knot theory require rigorous mathematical methods for modeling them. This talk is a continuation of the "Basic Knot Theory" talk, in which the fundamentals of Knot Theory were presented (i.e. knots and equivalence of knots, diagrams of knots, types of knots). The ultimate question in knot theory is to distinguish between different equivalences classes of knots with the help of knots invariants. We continue with reporting on particular combinatorial and algebraic methods used for deriving invariants of knots. The combinatorial methods refer to the Reidemeister moves, while the algebraic ones to the fundamental group of a knot complement. These methods have proved to be successful in introducing important invariants such as the numeric invariants (colorability, unknotting number, crossing number) or polynomial invariants (Alexander, Conway, Jones, HOMFLY polynomials). Even if some of these invariants distinguish between certain types of knots, nonetheless the discovery of a complete invariant for knots is an open problem in knot theory.
Prof. Dr. Josef Schicho RICAM February 16, 2010, 10:00 Johannes Kepler University, AS50
Title: The Alexander Polynomial for Groups

Abstract: The aim of this talk is to give definitions of the Alexander polynomial of a knot from a group theoretic point of view. It is a continuation of the talks by M. Hodorog in the previous group seminars.

Dr. Gábor Hegedüs

RICAM

March 25, 2010, 14:00

Johannes Kepler University, AS50

Title: The boundary volume of a lattice polytope

Abstract: For a d-dimensional convex lattice polytope P, a formula for the boundary volume vol@P is derived in terms of the number of boundary lattice points on the first ⌊d/2⌋ dilations of P. As an application we give a necessary and sufficient condition for a polytope to be reflexive. We also derive formulae for the ±-vector of a reflexive polytope in dimensions 4 and 5, and for the f-vector of a smooth polytope in dimensions 3, 4, and 5.

Dr. Hanna Katriina Pikkarainen

RICAM

April 08, 2010, 14:00

Johannes Kepler University, AS50

Title: Bayes formula: how to use it in computational mathematics

Abstract: An introductory talk on Bayesian staticstics. The main emphasis is on explaining how Bayes formulae can be used to solve problems in computational mathematics.

Dr. Gabor Hegedüs

RICAM

April 29, 2010, 14:00

Johannes Kepler University, AS50

Title: Ehrhart Polynomial of Smooth Fano Polytopes

Abstract: V. Golyshev conjectured that for any smooth polytope P with dimP · 5 the roots z 2 C of the Ehrhart polynomial for P have real part equal to −1/2. An elementary proof is given, and in each dimension the roots are described explicitly. We also present examples which demonstrate that this result cannot be extended to dimension six.

Shaowei Lin

UC Berkeley

August 23, 2010, 10:00

Johannes Kepler University, AS50

Title: Asymptotic Approximation of Marginal Likelihood Integrals

Abstract: The accurate asymptotic evaluation of marginal likelihood integrals is a

fundamental problem in Bayesian statistics. Following the approach introduced by Watanabe, we translate this into a problem of computational algebraic geometry, namely, to determine the real log canonical threshold of a polynomial ideal, and we present effective methods for solving this problem. Our results are based on resolution of singularities, and they apply to all statistical models for discrete data that admit a parametrization by real analytic functions.

Dr. Gabor Hegedüs

RICAM

September 28, 2010, 10:30

Johannes Kepler University, AS50

Title: The Minkowskian 4R planar robot

Abstract: The usual model of geometric designs are working in the Euclidean space. In this article we would like to characterize and classify completely the planar 4R closed chain working on the Minkowskian plane. This work would open a new research direction in the theory of geometric designs: the classification and characterization of the geometric design of linkages working in non Euclidean spaces.

Anja Korporal

RISC

October 18, 2010, 09:30

Johannes Kepler University, AS50

Title: Symbolic Algorithms for Solving Boundary Problems in Maple

Abstract: In this talk we present a Maple package for solving and manipulating linear boundary problems for ordinary differential equations. We first introduce an appropriate algebraic framework, the integro-differential operators, in which we can also express the solution operator - an integral operator called Green's operator. We show how to compute the Green's operator, provided that we know a fundamental system for the underlying homogenous differential equation, and how to factor a boundary problem along a given factorization of the differential operator.

Dr. Michael Harrison

Sydney University

October 25, 2010, 09:30

Johannes Kepler University, AS50

Title: Twisted 2-dimensional Tori and the Parametrization of Degree 6 Del Pezzo Surfaces

Abstract: Combining Josef Schicho's Lie algebra method with the classification of 2-dimensional tori, we describe a practical computational algorithm for producing explicit parametrizations of anticanonically-embedded degree 6 Del Pezzo surfaces.

Elias Tsigaridas

Aarhus University

November 08, 2010, 09:30

Johannes Kepler University, AS50

Title: On the topology of planar algebraic curves

Abstract: We consider the problem of computing the topology and geometry of a real algebraic plane curve. Even though the topology is of prime interest for geometric computations, the positions of singular and critical points are also of great importance. We will present an algorithm based on Groebner basis computations, univariate real isolation, and rational univariate representations, that avoids costly symbolic operations like sub-resultant sequences and computations with polynomials with algebraic coefficients, even in case where the curve is not in generic position. The algorithm isolates critical points in boxes and computes a decomposition of the plane by rectangular boxes. This decomposition also induces a new approach for computing an arrangement of polylines isotopic to the input curve. If time permits we will also sketch the complexity analysis of the algorithm, and record complexity bounds for the problem.

Elias Tsigaridas

Aarhus University

November 12, 2010, 10:30

Johannes Kepler University, AS50

Title: The DMM bound: Multivariate (aggregate) separation bounds

Abstract: We present new and close to optimal separation bounds, that is bounds on the minimum distance between any two isolated roots of a polynomial system. We call them DMM after Davenport, Mahler and Mignotte. These are the first bounds applicable to arbitrary positive dimensional systems. For the construction we exploit the structure of the system and the height of the sparse resultant by means of mixed volume, as well as recent advances on aggregate root bounds for univariate polynomials. DMM allows us to compute improved bounds for the number of steps that a subdivision algorithm performs in any dimension.

Dr. Gábor Hegedüs

RICAM

November 15, 2010, 09:30

Johannes Kepler University, AS50

Title: The Minkowskian planar 4R mechanism

Abstract: The usual models of geometric designs are working in the Euclidean space. In this article we would like to characterize and classify completely the planar 4R closed chain

working on the Minkowskian plane. This work would open a new research direction in the theory of geometric designs: the classification and characterization of the geometric design of linkages working in non-Euclidean spaces.

Dr. Michael Harrison

RICAM

November 22, 2010, 09:30

Johannes Kepler University, AS50

Title: Wiles' Proof of the Taniyama-Shimura-Weil Conjecture I

Abstract: First in a series of talks with the aim of providing an introductory account of the basic concepts involved in the TSW conjecture on the modularity of elliptic curves and its connection to Fermat's Last Theorem, and also to provide a semi-technical overview of Wiles' famous proof of TSW in the semistable case.

Analysis of Partial Differential Equations

Dr. Jan Vybiral

RICAM

January 12, 2010, 13:30

Johannes Kepler University, HF136

Title: Johnson-Lindenstrauss Lemma and circulant matrices

Abstract: We shall discuss the famous Johnson-Lindenstrauss Lemma, its original form, several improvements and the possibility of using circulant matrices in this topic. We shall also give some connections to the area of compressed sensing and RIP matrices.

Dr. Renjun Duan

RICAM

January 15, 2010, 10:45

Johannes Kepler University, HF136

Title: A Korn-type inequality and its application

Abstract: Korn's inequality shows the control of the L^2 norm of the gradient of a vector field by the L^2 norm of only the symmetric part of this gradient, under some conditions. It has general applications in elasticity, hydrodynamics or kinetic theory. In this talk, we prove a Korn-type inequality with probability measure for a vector field over the whole space, provide an example to show its application in the study of time-decay of solutions to some PDEs and finally mention a related open problem.

Dr. Karin Schnass

RICAM

January 19, 2010, 13:30

Johannes Kepler University, HF136

Title: Basis Identification from Random Sparse Samples

Abstract: I'll talk about the problem of learning a dictionary providing sparse representations for a given signal class, via l_1-minimisation. The problem is to identify a dictionary *dico* from a set of training samples Y knowing that $Y = dico\ X$ for some coefficient matrix X. Using a characterization of coefficient matrices X that allow to recover any basis as a local minimum of an l_1-minimisation problem, it is shown that certain types of sparse random coefficient matrices will ensure local identifiability of the basis with high probability. The necessary number of training samples grows up to a logarithmic factor linearly with the signal dimension.

Dr. Francesco Solombrino

International School for Advanced Studies of Trieste, Italy

January 27, 2010, 10:45

Johannes Kepler University, HF136

Title: Quasistatic evolution problems for cam-clay nonassociative plasticity

Abstract: Cam-Clay nonassociative plasticity exhibits both hardening and softening behavior, depending on the loading. The analysis of the spatially homogeneous case, where we can give an iterative procedure to construct a viscous solution, shows that for many initial data the classical formulation of the quasistatic evolution problem has no smooth solution. We then propose a notion of generalized solution, based on a viscoplastic approximation. To study the limit of the viscoplastic evolutions we rescale time, in such a way that the plastic strain is uniformly Lipschitz with respect to the rescaled time. The limit of these rescaled solutions, as the viscosity parameter tends to zero, is characterized through an energy- dissipation balance, that can be written in a natural way using the rescaled time. It turns out that the proposed solution may be discontinuous with respect to the original time, and our formulation allows to compute the amount of viscous dissipation occurring instantaneously at each discontinuity time.

Dipl.-Ing. Andreas Langer

RICAM

February 02, 2010, 13:30

Johannes Kepler University, HF136

Title: Domain Decomposition Methods for Local and Nonlocal Total Variation Minimization

Abstract: Nonlocal methods became recently important in image processing due to the fact that they preserve fine structure, texture and details of images. As an introduction into nonlocal methods we recall the nonlocal means filter by Buades et al. and present the

nonlocal total variation minimization. In the last years efficient methods for performing nonlocal total variation minimization for image processing problems of small or medium size have been presented in the literature. Unfortunately the minimization of nonlocal total variation is connected with high computational cost. Hence these methods are not able to solve in real-time large problems. For such problems we need to address methods which allow us to reduce the problem to a finite sequence of subproblems of a more manageable size. With this aim we present domain decomposition methods for both total variation minimization and nonlocal total variation minimization. We will analyze their convergence properties. In particular we are able to present a sketch of their convergence proofs.

Dr. Massimo Fornasier
RICAM
February 10, 2010, 10:45
Johannes Kepler University, HF136

Title: Preliminary results on inverse free-discontinuity problems

Abstract: Free-discontinuity problems describe situations where the solution of interest is defined by a function and a lower dimensional set consisting of the discontinuities of the function. Hence, the derivative of the solution is assumed to be a "small function" almost everywhere except on sets where it concentrates as a singular measure. This is the case, for instance, in certain digital image segmentation problems. 1) In presence of an inverse problem, no existence results were available so far. First of all we show new preliminary results on the existence of minimal solutions by assuming such minimizers in a reasonable class of smooth functions out of piecewise Lipschitz discontinuity sets. The compactness arguments we developed to derive the existence results stem from geometrical and regularity properties of domains, interpolation inequalities, and classical compactness arguments in Sobolev spaces. 2) If we discretize such situations for numerical purposes, the inverse free-discontinuity problem in the discrete setting can be re-formulated as that of finding a derivative vector with small components at all but a few entries that exceed a certain threshold. This problem is similar to those encountered in the field of "sparse recovery", where vectors with a small number of dominating components in absolute value are recovered from a few given linear measurements via the minimization of related energy functionals. As a second result, we show that the computation of global minimizers in the discrete setting is a NP-hard problem. 3) With the aim of formulating efficient computational approaches in such a complicated situation, we address iterative thresholding algorithms that intertwine gradient-type iterations with thresholding steps which were designed to recover sparse solutions. It is natural to wonder how such algorithms can be used towards solving discrete free-discontinuity problems. This talk explores also this connection, and, by

establishing an iterative thresholding algorithm for discrete inverse free-discontinuity problems, provides new insights on properties of minimizing solutions.

Dr. Massimo Fornasier

RICAM

February 16, 2010, 13:30

Johannes Kepler University, HF136

Title: Preliminary results on inverse free-discontinuity problems II

Abstract: Free-discontinuity problems describe situations where the solution of interest is defined by a function and a lower dimensional set consisting of the discontinuities of the function. Hence, the derivative of the solution is assumed to be a "small function" almost everywhere except on sets where it concentrates as a singular measure. This is the case, for instance, in certain digital image segmentation problems. Last week we presented new theoretical results of existence of minimizers of functionals with quadratic fidelity terms to data provided by singular mea-surements and a Mumford-Shah-like regularization term. In this talk we address the discrete counterpart and numerical methods. If we discretize such situations for numerical purposes, the inverse free-discontinuity problem in the discrete setting can be re-formulated as that of finding a derivative vector with small components at all but a few entries that exceed a certain threshold. This problem is similar to those encountered in the field of "sparse recovery", where vectors with a small number of dominating components in absolute value are recovered from a few given linear measurements via the minimization of related energy functionals. As a first result, we show that the computation of global minimizers in the discrete setting is a NP-hard problem. With the aim of formulating efficient computational approaches in such a complicated situation, we address iterative thresholding algorithms that intertwine gradient- type iterations with thresholding steps which were designed to recover sparse solutions. It is natural to wonder how such algorithms can be used towards solving discrete free-discontinuity problems. This talk explores also this connection, and, by establishing an iterative thresholding algorithm for discrete inverse free-discontinuity problems, provides new insights on properties of minimizing solutions.

Giovanni Naldi

Universit degli studi di Milano

February 24, 2010, 10:45

Johannes Kepler University, HF136

Title:Modelling single cell motion: signal transduction, polarization and movement

Abstract: Cell migrations are one of the most important aspects of cell biology. It is a complex process that requires the coordinated regulation of the cytoskeleton and cell

adhesion. In many cases, concentration gradients of small molecules act as extracellular cues to guide and direct movement in space and time (chemotaxis). Cell movements give shape and form to developing embryos and bring about the many connections and interactions between the cells of our nervous system during development. Later in life, cell movements are required for tissue maintenance and repair, whereas cells of our immune system migrate from the blood stream toward sites of infection. In addition to its roles in normal physiology, inappropriate migration is the basis for several pathological conditions, including metastasis and chronic inflammatory diseases. In this talk we present a phenomenological model aimed at understanding key sub-processes of eukaryotic chemotaxis. We couple gradient perception process, cell polarization, and the cell mechanical movement driven by viscoelastic forces. The numerical simulations reproduces qualitatively some in vitro experiments for Dictyostelium discoideum cells. Our preliminary results provide a model of a single cell migration as an integrated process. Different subsystems, biochemical and mechanical, and different effects, as cellular deformations, actin dynamics, cell adhesion, have been incorporated into the numerical simulations. This is a joint work with G. Aletti, M. Semplice, E. DiBenedetto, H. Hamm, and G. J. Scott.

Stephan Dahlke
Marburg University
March 17, 2010, 13:30
Johannes Kepler University, HF136

Title: Adaptive Wavelet Methods for Elliptic Operator Equations: Theoretical Analysis and Practical Realization

Abstract: In this talk, we will provide an overview on recent developments concern- ing the analysis and the design of adaptive wavelet methods. In the first part of the talk, we will perform a theoretical analysis of adaptive schemes, i.e., we want to answer the question: When does adaptivity pay? It turns out that the order of approximation that can be achieved by adaptive and other non- linear approximation methods depends on the regularity of the (unknown) solution u in the specific scale $B^s_\tau(L_\tau(\Omega)),\ 1/\tau = s/d + 1/p$, of Besov spaces, whereas the approximation order of nonadaptive schemes is determined by the Sobolev regularity of u. Therefore, we will examine the smoothness of the solutions of elliptic operator equations and discuss some fundamental results. In the second part of the talk, we will discuss the concrete design of adaptive wavelet schemes. Based on wavelet expansions, we derive a posteriori error estimators that are both reliable and efficient. These error estimators lead to adaptive strategies that are guaranteed to converge in a wide range of cases, including operators of negative order. In the third part of the talk, we will discuss the generalizations of these concepts to the case of (wavelet) frames. In particular, we will

investigate how the frame approach can be combined with domain decomposition techniques such as additive and multiplicative Schwarz schemes.

Aicke Hinrichs

Universität Jena

March 30, 2010, 13:30

Johannes Kepler University, HF136

Title: Importance Sampling for the Approximation of Integrals

Abstract: We investigate the optimal performance of importance sampling for the approximation of integrals $I(f) = \int_D f(x)\, \varrho(x)\, dx$ of functions f in a Hilbert space $H \subset L_1(\varrho)$ where ϱ is a given probability density on $D \subset \mathbb{R}^d$. We show that whenever the embedding of H into $L_1(\varrho)$ is a bounded operator then there exists another density ω such that the worst case error of importance sampling with density function ω is of order $n^{-1/2}$. This applies in particular to reproducing kernel Hilbert spaces with a nonnegative kernel. As a result, for multivariate problems generated from nonnegative kernels we prove strong polynomial tractability of the integration problem in the randomized setting. The density function ω is obtained from the application of change of density results used in the geometry of Banach spaces in connection with a theorem of Grothendieck about 2-summing operators.

Dr. Jan Haskovec and Radek Erban

April 27, 2010, 13:30

Johannes Kepler University, HF 136

Title: A velocity jump process modelling 1D collective motion of locusts

Abstract: We consider a model describing an experimental setting, in which locusts run in a ring-shaped arena. With intermediate spatial density of the individuals, coherent motion is observed, interrupted by sudden changes of direction (”switching”). Contrary to the known model of Czirok and Vic-sek, our model assumes runs of the individuals in either positive or nega- tive direction with the same speed, that are subject to random switches. As supported by experimental evidence, the individual switching frequency increases in response to a local or global loss of group alignment, which con- stitutes a mechanism to increase the coherence of the group. We show that our model, although phenomenologically very simple, exhibits nontrivial dynamics, and, in particular, recovers the observed group directional switch- ing behaviour. Passing to the corresponding Fokker-Planck equation, we are able to give estimates of the expected switching times in terms of number of individuals and values of the model coefficients. Moreover, based on numer- ical simulations, we describe the connection between the models with global and local interactions. Finally, we pass to the kinetic description, which is valid for large numbers of individuals, and perform a mathematical analysis of the resulting system of equations.

Prof. Matteo Novaga

University of Padova

May 05, 2010, 10:45

Johannes Kepler University, HF 136

Title: Variational evolutions in image analysis

Abstract: I will focus on two well-known variational models in image analysis: the total variation based denoising model (ROF) and the Perona-Malik equation. I will present the main mathematical features of these models and discuss some open questions, from a theoretical point of view.

Rob Stevenson

University of Amsterdam

May 17, 2010, 15:00

Johannes Kepler University, HF 136

Title: Adaptive wavelet methods for solving operator equations: An overview and recent results

Abstract: We discuss the state of the art in the field of adaptive wavelet methods for solving operator equations that were introduced by Cohen, Dahmen and DeVore in 2000 and 2002. With an operator equation, we mean an equation of the form $Bu=f$, where B is a (linear) boundedly invertible mapping between X and Y with X and Y being some Hilbert spaces. By equipping X and Y with Riesz bases, an equivalent formulation of the problem is given by a bi-infinite matrix vector equation $Bu=f$. Examples include well-posed boundary value problems, integral equations or parabolic initial boundary value problems. Constructing these Riesz bases as wavelet bases, for a large class of problems the matrix B can be well approximated by sparse matrices. This allowed the design of adaptive schemes for solving the bi-infinite matrix vector equation that converge with the best possible rate in linear complexity. In particular, we will discuss the application of these schemes when tensor product wavelet bases are applied. In that case, the schemes have the unique feature that this best possible rate does not deteriorate as function of the space dimension. One promising application that we will discuss is that to the simultaneous space-time varia-tional formulation of parabolic evolution equations, where, due to the tensor product structure, the additional time dimension does not increase the order of complexity to solve the system.

Vaclav Kucera
Faculty of Mathematics and Physics, Charles University, Prague
May 25, 2010, 14:30
Johannes Kepler University, HF 136

Title: Applications of the discontinuous Galerkin method to compressible fluid dynamics

Abstract: The discontinuous Galerkin (DG) method has gained much attention as a promising numerical method for the solution of conservation laws. As a natural combination of the finite element and finite volume methods, its main advantages are robustness and arbitrarily high order of accuracy. This talk will deal with the application of DG techniques to the solution of compressible viscous and inviscid flows. Specifically, we shall combine DG space semi-discretization along with a semi-implicit time discretization. In such a way we obtain an efficient numerical scheme robust with respect to the Mach and Reynolds numbers. An overview of the DG method will be presented along with numerical experiments and theoretical results on convergence to the exact solution.

Riccardo March
Istituto per le Applicazioni del Calcolo "Mauro Picone" - CNR, Rome, Italy
June 16, 2010, 13:00
Johannes Kepler University, HF 136

Title: Existence and regularity of minimizers of a functional for image segmentation

Abstract: We consider a functional for image segmentation which has been proposed by Sandberg, Kang and Chan. The functional is a modified version of the Mumford and Shah functional for the partition problem. In the new functional the length term of the Mumford and Shah functional is multiplied by the sum of the ratios perimeter/area of the sets of the partition. We prove the existence of minimizers for a weak version of the functional defined on the class of sets with finite perimeter. Then we study the regularity of boundaries of sets which constitute a weak minimizer. Technical tools used in the proofs are adapted from the analysis of the Mumford and Shah functional in the piecewise constant case. Joint work with S.H. Kang (Georgia Tech., Atlanta).

Dr. Jan Haskovec
RICAM
August 24, 2010, 14:00
Johannes Kepler University, HF 136

Title: A stochastic individual velocity jump process modelling the collective motion of locusts

Abstract: We consider a model describing an experimental setting, in which locusts run in a ring-shaped arena. With intermediate spatial density of the individuals, coherent motion is observed, interrupted by sudden changes of direction ("switching"). Contrary to the known

model of Czirok and Vicsek, our model assumes runs of the individuals in either positive or negative direction of the 1D arena with the same speed, that are subject to random switches. As supported by experimental evidence, the individual switching frequency increases in response to a local or global loss of group alignment, which constitutes a mechanism to increase the coherence of the group. We show that our individual based model, although phenomenologically very simple, exhibits nontrivial dynamics with a "phase change" behaviour, and, in particular, recovers the observed group directional switching. Passing to the corresponding Fokker-Planck equation, we are able to give estimates of the expected switching times in terms of number of individuals and values of the model coefficients. Then we pass to the kinetic description, recovering a system of two kinetic equations with nonlocal and nonlinear right hand sides, which is valid when the number of individuals tends to infinity. We perform a mathematical analysis of the system, show some numerical results and point out several interesting open problems.

Optimization and Optimal Control

Nicolae Cindea

Institut Elie Cartan de Nancy

February 09, 2010, 11:00

Johannes Kepler University, HF136

Title: An approximation method for exact controls of vibrating systems

Abstract: We propose a new method for the approximation of exact controls of a second order infinite dimensional system with bounded input operator. The algorithm combines Russell's ‘’stabilizability implies controllability" principle with the Galerkin's method. The main new feature brought in by this work consists in giving precise error estimates. In order to test the efficiency of the method, we consider two illustrative examples (with the finite element approximations of the wave and the beam equations) and we describe the corresponding simulations.

Türker Özsari

University of Virginia

April 12, 2010, 14:00

Johannes Kepler University, HF 136

Title: Stabilization of Weakly Damped Defocusing Semilinear Schrödinger Equation with Inhomogeneous Dirichlet Boundary Control

Abstract: In this talk, we present the stabilization as well as the existence and regularity of solutions of the semilinear Schrödinger equation with an inhomogeneous Dirichlet boundary control. We prove the global existence and the stabilization of weak solutions at the H^1-

energy level in one shot. It is deduced how the decay rate of the boundary data controls the decay rate of the solutions up to an exponential rate. Secondly, we prove some regularity and stabilization results for the smooth solutions in H^2-sense. We introduce the method of smooth extension of traces, and then use the direct multiplier method combined with monotonicity and compactness techniques to get our results. The result for the weak solutions is strong in the sense that it is independent of the dimension of the domain, the power of the non-linearity, and the smallness of the initial data. However, the regularity and stabilization of smooth solutions are obtained only in low dimensions with small initial and boundary data. Then, we present some numerical results obtained by Crank-Nicholson method on the regularized solutions. Finally, we'll discuss about our ongoing research and the related open problems in this field.

Klaus Krumbiegel

WIAS Berlin

May 18, 2010, 14:00

Johannes Kepler University, HF 136

Title: On the convergence and second order sufficient optimality conditions of the virtual control concept for semilinear state constrained optimal control problems

Abstract: We consider a semilinear optimal control problem with pointwise state constraints and control constraints. Problems of this type were discussed extensively in the recent past because of specific difficulties since the Lagrange multipliers associated with the state constraints are in general only regular Borel measures. Therefore, different regularization concepts are developed in the last years, e.g. a Moreau-Yosida type regularization or a Lavrentiev type method. Using the control for the Lavrentiev regularization concept can yield numerical difficulties, if the different constraints are active simultaneously. This leads to a nonuniqueness of the dual variables. Thus, we apply the virtual control concept, where an additional distributed control is introduced. This control acts in the cost functional and the semilinear state equation, and it is used for regularization of the state constraints. Hence, a separation for the active sets can be avoided. We study the convergence of locally optimal controls for the regularized problem for a regularization parameter tending to zero. We place special emphasis on the discussion of sufficient optimality conditions, and show that second-order-sufficient conditions for the original problem carry over to the regularized problems. Moreover, by means of equivalence of a specific setting of the virtual control concept to the Moreau-Yosida regularization, we can formulate the second-order sufficient optimality conditions, obtained for the virtual control concept, in terms of the Moreau-Yosida approximation.

Arnd Roesch

Universität Duisburg

September 07, 2010, 14:00

Johannes Kepler University, HF 136

Title: Identification of an Unknown Parameter in the Main Part of an Elliptic PDE

Abstract: We are interested in identifying an unknown material parameter $a(x)$ in the main part of an elliptic partial differential equation $-div\,(a(x)\,grad\,y(x)) = g(x)$ *in* Ω with corresponding boundary conditions. We discuss a Tichonov regularization

$$\min_a J(y,a) = \|y - y_d\|^2_{L^2(\Omega)} + \alpha\|a\|^2_{H^s(\Omega)}$$

with $s > 0$. Moreover, we require the following constraints for the unknown parameter $0 < a_{min} \le a\,(x) \le a_{max}$. The talk starts with results on existence of solutions and necessary optimality conditions. The main part of the talk will be devoted to sufficient optimality conditions.

Henry Kasumba

Graz University

November 08, 2010, 14:30

Johannes Kepler University, HF136

Title: Optimal Shape design using Translation Invariant cost Functionals

Abstract: We shall investigate the use of translation invariant cost functionals for the reduction of vortices in the context of shape optimization of fluid flow. A case that involves the stationary incompressible Navier-Stokes equations in a bounded domain will be investigated. Analytical expressions for the shape design sensitivity involving different cost functionals are derived rigorously in a generalized framework. Channel flow problems with a bump as a moving boundary and with an obstacle are taken as test examples. Numerical results are provided in various graphical forms for relatively low Reynolds numbers. Striking differences are found for the optimal shapes corresponding to the three different cost functionals, which constitute different quantifications of vorticity. Lastly, we also give a preview on our work on shape optimization of fluid with free surface.

Mathematical Imaging

Dr. Christiane Pöschl

Universität Wien

December 20, 2010, 11:00

Johannes Kepler University, HF136

Title: TV denoising and evolution of sets

Abstract: Let $S \subset \mathbb{R}^2$ be the union of two convex sets with smooth boundary. We connect the

levelsets of the minimizers u_λ of (ROF) $\frac{1}{2}\|u-\chi_S\|_{L^2}^2+\lambda\|u\|_{TV}$ to the minimizers of a (simpler) set-minimization problem in order to obtain a geometrical characterization of the levelsets of u_λ. Moreover, we calculate explicit minimizers of (ROF), when S is the union of two nonintersecting circles, using simple morphological operators. We also show how to construct the solutions for the more general case when S is the union of to nonintersecting convex sets.

Mathematical Methods in Molecular and Systems Biology

Andreas Groh

University of Saarbrücken

January 25, 2010,16:00

VBC, HS A (Biocenter Vienna)

Title: Stochastic Modelling of Biased Cell Migration

Abstract: The migration of eukaryotic cells is a frequently observable phenomenon. In this talk, I will present two models which describe these occurrences mathematically. Both approaches are stochastic in nature, but they operate on different scales. The first part addresses motion on the cell and tissue level where single cells are considered to be point objects. Besides the description of biased migration, where chemotaxis and contact guidance are taken into account, the focus lies on an appropriate modelling of the desmoplastic stromal reaction (DSR). The DSR is a special process in tumour progression where migrating fibroblasts play a key role. This phathogenetic reaction is considered in a so called “hybrid model” which mixes discrete and continuum variables. Fortunately, this framework allows a visualisation which can be interpreted by medics without a mathematical background. The second part puts emphasis on migration on the molecular and cellular level. Based on the physical model of rigid body motion, equations for the translational and rotational velocities are deduced. These equations depend on the distribution of bound and free receptors in the cell membrane. Assuming an analogy between receptor distribution and chemical reactions, we deduce a chemical master equation. Subsequently, further reductions lead to a vectorial stochastic differential equation for the receptor dynamics. Finally, some illustrations show the results of the numerical simulations.