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Annual Report 2011

Johann Radon Institute for Computational and Applied Mathematics

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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 2011

2.1. Zusammenfassung des wissenschaftlichen Berichts 2011

Das Institut verfügte 2011 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, Prof. 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
- Transfergruppe, Gruppenleiter: Prof. Dr. Ronny Ramlau
- 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 geometrische und algebraische Mehrgitter-, Multilevel- und Multiskalenverfahren sowie Gebietszerlegungsmethoden zur numerischen Lösung und Simulation großdimensionierter technischer Probleme und Probleme in den Lebenswissenschaften,
- A posteriori Fehlerabschätzungen vom Funktionaltype,
- Isogeometrische Analysis.

Das neuen Forschungsgebiet “Isogeometrische Analysis” wurde mit einem FWF-Forschungsprojektes 2010 begonnen. 2011 wurde ein nationales Forschungsnetzwerk zum Thema „Geometrie + Simulation“ vom FWF bewilligt. Die Gruppe ist mit einem Projekt zur Isogeometrische Analysis an diesem Forschungsnetzwerk beteiligt. Dieses neue Forschungsgebiet hat viele interessante praktische Anwendungen und soll in der Zukunft weiter ausgebaut werden.

Gruppe „Inverse Problems“

Im Berichtzeitraum wurden die Forschungsaktivitäten der Inversen Probleme Arbeitsgruppe im Wesentlichen durch zwei extern finanzierte Projekte bestimmt:

Eines ist das EU-Projekt “DIAdvisor: personal glucose predictive diabetes advisor,” welches am RICAM von S. Pereverzyev geleitet wird.

Das FWF Projekt P22341 “Electromagnetic Scattering by Complex Interfaces” (Nov. 2010 – Oct. 2013) wird von M. Sini geleitet wird.

In beiden Projekten geht es um inverse Fragestellungen, dass EU Projekt zur Diabetes Behandlung ist praxisbezogen ausgelegt, während das FWF Projekt naturgemäß Grundlagenforschungsorientiert ist. In Summe stellen beide Projekte einen gesunden Mix zwischen Theorie und Praxis dar.

Gruppe „Symbolic Computation“

Drei FWF-Projekte beeinflussten die Forschung der Symbolik-Gruppe im Jahr 2012: Im FWF Doktoratskolleg W1214 „Computational Mathematics" konnte die Entwicklung von Algorithmen zur topologischen Analyse von Kurvensingularitäten abgeschlossen werden, und die Doktorandin Madalina Hodorog schloss im Oktober erfolgreich ihr Studium ab. In einem weiteren Projekt, das sich mit Kurven befasst, wurden Parametrisierungen solcher Kurven durch Radikale untersucht. Das gemeinsame Projekt mit der Universität Wien „Lösen von Algebraischen Gleichungen 2" befasst sich mehr mit algebraischen Varietäten höherer Dimension; auch hier ist ein Doktoratsabschluss zu verzeichnen, naemlich der von Niels Lubbes. Ein zusätzlicher Impuls war der Neuzugang von Martin Weimann, der den Hintergrund der algebraischen Theorie von Integraltransformationen wie etwa der Radontransformation oder der Abeltransformation mitbringt.

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.

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 der Herleitung vollständiger Optimalitätssysteme für zeitoptimale Probleme, der struktureller Analyse und numerischen Umsetzung.

Gruppe “Mathematical Imaging”

Ein neu entwickeltes Meßverfahren in der photoakustischen Bildgebung wird betrachtet, welches erstmals erlaubte, gezielt Messungen von einzelnen Querschnitten eines Objekts vorzunehmen. Ausgehend von solchen Meßdaten, werden explizite Rekonstruktionsformeln

für die Absorptionsdichte (den bildgebenden Parameter in der Photoakustik) hergeleitet. Um die Möglichkeiten dieses neuen Verfahrens weiter auszuschöpfen, schlug die Arbeitsgruppe vor, Messungen für alle möglichen Querschnitte eines Objekts durchzuführen. Aus diesem vollständigen Satz von Meßdaten lassen sich nämlich, wie die Mathematical Imaging Gruppe zeigen konnten, explizit die Absorptionsdichte gemeinsam mit der lokal variierenden Schallgeschwindigkeit rekonstruieren. Weiters wurde damit begonnen, kompliziertere physikalische Modelle, die zusätzlich Dämpfungseffekte der Schallwellen berücksichtigen sollen, zu untersuchen. Die Halbzeitevaluierung des NFN-Projekts "Photoacoustic Imaging in Biology and Medicine", geleitet von Otmar Scherzer, verlief erfolgreich und das Projekt wurde im März 2011 um weitere drei Jahre verlängert.

Dr. Daniel Leitner wurde für das Projekt „Root architecture modelling in heterogeneous soils" das APART Stipendium der Österreichischen Akademie der Wissenschaften zuerkannt.

Gruppe „Mathematical Methods in Molecular and Systems Biology“

Die 2009 gegründete Arbeitsgruppe beschäftigt sich mit der Anwendung bestehender und der Entwicklung mathematischer Methoden aus den Gebieten inverser Probleme und partieller Differentialgleichungen zur Lösung von Fragestellungen im Bereich der Molekular- und Systembiologie. Die Forschungsschwerpunkte 2011 lagen dabei auf:

- Modellierung und Simulation des Aktin-Zytoskeletts
- Identifizierung und in-silico Manipulation biochemischer Reaktionsnetzwerke
- Modellierung und Simulation von Transport durch Membranen

Zu den interdisziplinären Kooperationspartnern der Gruppe zählen Vertreter der Forschungseinrichtungen IMP, IMBA (im Rahmen des WWTF-Projektes „Mathematical modeling of actin driven cell migration“), MFPL, der Universität Wien (Institut für Pharmakologie und Toxikologie, Department Molecular Systems Biology) und der Universität Linz (Institut für Biophysik).

Transfergruppe

Die Transfergruppe wurde mit 1. April 2011 eingerichtet. Ziel der Gruppe ist der Transfer von aktuellen mathematischen Forschungsergebnissen in die Industrie. Daher erfolgen die Forschungsarbeiten der Mitarbeiter der Gruppe immer in Kooperation mit Unternehmen oder anderen außeruniversitären Einrichtungen. In den vergangenen 9 Monaten wurden solche Forschungskooperationen mit der Europäischen Südsternwarte ESO (Garching), der AVL List GmbH (Graz), der uni software plus GmbH (Linz), der MathConsult GmbH (Linz) sowie mit der Bachmann GmbH (Feldkirch) durchgeführt. Für die ESO wurden mathematische Algorithmen und Software für die Adaptive Optik – Systeme des derzeit in Planung befindlichen European Extremely Large Telescopes (E-ELT) entwickelt. Mit der AVL werden Methoden zur Modellierung und Simulation von Motorkomponenten entwickelt. Im Rahmen der Kooperation in der Finanzmathematik mit der MathConsult und der uni software plus werden schnelle Löser für stochastische Differentialgleichungen und für spezifische partielle Differentialgleichugnen sowie Methoden zur Identifikation von Parametern in diesen Differentialgleichungen entwickelt. Zusammen mit Bachmann wird derzeit an der Entwicklung von Methoden zur Unwuchtüberwachung in Windenergieanlagen gearbeitet. Die Vielfalt der bearbeiteten Probleme erfordert auch den Einsatz und die Entwicklung unterschiedlichster

mathematischer Techniken. Insbesondere Methoden im Bereich der Inversen Probleme sowie schnelle und stabile Löser für partielle Differentialgleichungen werden erarbeitet.

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 verschiedene Qualitätsmaße für Folgen in Kryptografie, drahtloser Kommunikation und für quasi-Monte Carlo Methoden verglichen und für konkrete viel versprechende Folgen analysiert. Mit fünf Übersichtsartikeln wurde ein wesentlicher Beitrag zum Handbook of Finite Fields geleistet. Außerdem wurden gemischte Folgen studiert, die Vorteile von Monte-Carlo und quasi-Monte Carlo Methoden kombinieren, sowie Folgen und Boolesche Funktionen, die mit Fermat Quotienten und verwandten Abbildungen definiert wurden, in Hinblick auf ihre kryptografische Eignung untersucht.

START Projekt Y432 „Sparse Approximation and Optimization in High Dimensions“

Die Arbeitsgruppe hat sich auf das folgende Thema fokussiert: „sparse“ Optimierung und Anwendungen auf die Dimensionsreduzierung in komplexen Problemen. Die Dimension von den zu verarbeitenden Daten in Problemen unserer modernen Gesellschaft ist mittlerweile sehr groß geworden. Um aus dieser Menge von Daten, die in einer Vielzahl moderner Anwendungen (wie das Internet, physikalische Experimente, medizinische Diagnostik, um nur ein paar zu nennen) gesammelt werden, nur die wesentliche Information zu extrahieren und zu interpretieren, ist die Etablierung eines neuen Fachgebietes der Natur- und Ingenieurwissenschaften vonnöten. Die Durchführung numerischer Simulationen basierend auf diesen Daten (skaliert zu der jeweils geforderten Größenordnung) ist eine der wichtigsten Aufgaben des 21. Jahrhunderts. Kurz gesagt muss man imstande sein, die Komplexität zu verstehen und zu organisieren. Die bemerkenswertesten Vorstöße in diese Richtung in der modernen Datenanalyse und in numerischen Simulationen basieren auf der Erkenntnis, dass in etlichen Situationen, sogar für sehr komplexe Phänomene, nur ein paar wenige führende Komponenten benötigt werden, um die Dynamik des ganzen Problems zu beschreiben. Eine Reduktion der Dimensionalität kann hierbei durch die Forderung, dass das Ergebnis dünn besetzt (englisch "sparse") bzw. komprimierbar ist, erreicht werden. Da die relevanten Freiheitsgrade des Ergebnisses nicht vorgeschrieben sind und von Problem zu Problem variieren können, werden effiziente Optimierungsmethoden benötigt, um das schwierige kombinatorische Problem der entsprechenden Identifizierung zu lösen. Die Gruppe hat sich zuerst mit der Entwicklung effizienter Algorithmen beschäftigt, mit denen es möglich ist, auch in höherdimensionalen Fragestellungen optimale dünn besetzte Ergebnisse zu erhalten. In einem zweiten Schritt sollen die dadurch gewonnenen Werkzeuge für die Lösung partieller Differenzialgleichungen und Variationsproblemen, die auf Gebieten von großem Maßstab gelöst werden sollen, eingesetzt werden. Schliesslich ist das Interesse groß, diese gesamte Maschinerie in interessanten Anwendungen in der Bildverarbeitung, in Problemen mit freien Unstetigkeiten und in freien Randwertproblemen, wie z.B. der Erkennung von

Korrossionsstellen und der Identifizierung von Brüchen, zu verwenden. Außerdem hat sich die Gruppe mit neuen Anwendungen in sehr innovativen Gebieten, wie dem automatisierten Lernen und der optimalen Steuerung von hochdimensionalen dynamischen Systemen, beschäftigt.

2.2. Highlights 2011

Jede Arbeitsgruppe am RICAM hat interessante Highlights erzielt, die es verdient haben, hier extra genannt zu werden. Wir halten uns aber an die Vorgabe, höchstens zwei zu nennen:

- Die numerische Lösung von Optimierungsproblemen mit partiellen Differentialgleichungen als Nebenbedingungen erfordert effiziente Algorithmen. Für deren Entwicklung werden Ergebnisse aus verschiedenen, am RICAM vertretenen Teilgebieten der angewandten Mathematik benötigt: Numerik, Analysis und Optimierung. In einer Zusammenarbeit von Sven Beuchler (Gruppe "Computational Methods for Direct Field Problems") und Daniel Wachsmuth (Gruppe "Optimization and Optimal Control") wird eine neue Klasse von Lösungsmethoden, basierend auf sogenannten hp-FEM Diskretisierungs-verfahren, entwickelt. Die Forschungsarbeiten werden durch ein FWF-Projekt (P23484-N18 "High-order finite element methods for optimal control problems") gefördert. Beide Nachwuchswissenschaftler konnten darüberhinaus weitere Forschungsprojekte einwerben. Sie nutzen die Möglichkeiten des Instituts, um internationale Reputation zu erlangen, und haben im abgelaufenen Jahr Rufe auf Professurenstellen an Universitäten in Deutschland angenommen.

- Das EU-Projekt “DIAdvisor: personal glucose predictive diabetes advisor” beschäftigt sich mit der Verbesserung der Diabetes Therapie durch verbesserte Vorhersage des Blutzuckerspiegels von individuellen Diabetes Patienten. Das RICAM DIAdvisor Team hat ein neues mathematisches Vorhersagemodel entwickelt, welches bestehende state-of-the-art Algorithmen übertrifft, und welches nun auch schon klinische Versuchsstadien erfolgreich absolviert hat. Das neue Model ist die Grundlage einer gemeinsamen Patentanmeldung EP 11163219.6 (April 20,2011) der Österreichischen Akademie der Wissenschaft und des industriellen Partners Novo Nordisk A/S (Dänemark).

Figure 1: Das DIAdvisor Gerät, das den RICAM-Algorithms zur Vorhersage der Blutzuckerkonzentration benutzt.

Key Publications:

Wir nennen hier die **18** wichtigsten Publikationen aus den Forschungsgruppen und den Forschungsprojekten. Darunter sind **5** Publikationen, die wir in AkademIS als Highlights markiert haben:

1. **S. Anzengruber** and **R. Ramlau**. Convergence rates for Morozov's discrepancy principle using variational inequalities. Inverse Problems, 27(10), October 2011.

2. **L. M. Emans**, S. M. Frolov, B. Lidskii, V. Posvyanskii, B. Basara (2011): SIMPLE-H: A finite-volume pressure–enthalpy coupling scheme for flows with variable density, International Journal for Numerical Methods in Fluids, Article first published online : 30 MAR 2011, DOI: 10.1002/fld.2552.

3. Erokhova, A. Horner, **P. Kügler**, P. Pohl, *Monitoring single-channel water permeability in polarized cells*, Journal of Biological Chemistry, v. 286 (2011), No. 46, pp. 39926-32.
4. **M. Fornasier**, **J. Haskovec**, and **J. Vybiral**: Particle systems and kinetic equations modeling interacting agents in high dimension, to appear in SIAM J. Multiscale Modeling and Simulation.

5. **M. Fornasier**, R. March, and **F. Solombrino**: Existence of minimizers of the Mumford and Shah functional with singular operators and unbounded data, to appear in Annali Mat. Pura Appl.

6. **M. Fornasier**, **K. Schnass**, and **J. Vybiral**: Learning Functions of Few Arbitrary Linear Parameters in High Dimensions, to appear in Found. Comput. Math.

7. M.Grasmair, M. Haltmeier, **O. Scherzer**: *Necessary and Sufficient Conditions for Linear Convergence of l1-Regularization*, Comp. Pure Appl. Math., v. 64 (2011) , pp.

161–182.

8. O. Iliev, R. Lazarov, and **J. Willems:** *Variational multiscale finite element method for flows in highly porous media,* SIAM Multiscale Modeling and Simulation, 9 (2011), No. 4, pp. 1350-1372.

9. J. Liu, P. A. Krutitskii, and **M. Sini**: Numerical solution of the scattering problem for acoustic waves by a two-sided crack in 2-dimensional space. J. Comput. Math. 29 (2011), No 2, pp. 141-166.

10. **J. Kraus** and **S. Tomar**: Algebraic multilevel iteration method for lowest-order Raviart-Thomas space and applications. Int. J. Numer. Meth. Engng., v. 86 (2011), No. 10, pp. 1175–1196.

11. **V. Naumova**, **S. V. Pereverzyev** and **S. Sivananthan**: Extrapolation in variable RKHSs with application to the blood glucose reading. Inverse Problems, v. 27 (2011) No. 7, pp. 1-13.

12. **H. Niederreiter**: The independence of two randomness properties of sequences over finite fields. Journal of Complexity, to appear.

13. A. Ostafe, **A. Winterhof**: Some applications of character sums. In: G. Mullen, D. Panario (eds.), Handbook of Finite Fields, to appear.

14. **D. Ölz, C. Schmeiser,** Simulation *of lamellipodial fragments*. Epub 2011, J Math Biol. 2012 Feb; 64(3):513-28.

15. A. Rösch, **D. Wachsmuth**: A-posteriori error estimates for optimal control problems with state and control constraints. Numerische Mathematik, to appear.

16. H. Hauser, **J. Schicho**: Forty Questions on Singularities of Algebraic Varieties. Asian Journal of Mathematics, v. 15, No. 3, pp 417-436 (in press).

17. **R. Schulze**, G. Zangerl, M. Holotta, D. Meyer, F. Handle, R. Nuster, G. Paltauf, **O. Scherzer**: *On the Use of Frequency-Domain Reconstruction Algorithms for Photoacoustic Imaging*, Journal of Biomedical Optics, v. 16 (2011), No. 8, 086002 (1-6).

18. J.R. Sendra, **D. Sevilla**: Radical parametrizations of algebraic curves by adjoint curves. J. Symb. Comp., v. 46, No. 9, pp 1030—1038 (in press).

2.2.1. Personnel Development

It is a principle at RICAM (see Mission Statement in Section 1) to hire PostDocs internationally and in most cases with limited time contracts. In 2011 our PostDocs have been successful in obtaining offers for permanent positions including professorial positions. **Daniel Wachsmuth** received an offer of a professorial position from the University of Würzburg (Germany). **Massimo Fornasier** accepted a call to a full professorship position at the Technical University of Munich (Germany). **Ronny Ramlau** rejected the offer of a professorial position from the University of Würzburg (Germany). **Mourad Sini** rejected offers for professorial positions from King Fahd University of Petroleum and Minerals, Dhahran (Saudi Arabia) and from the Seoul National University (South Korea).

It is on the one hand certainly a great success for people receiving offers for excellent positions worldwide, 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 2011

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
- Transfer Group, group leader: Prof. Dr. Ronny Ramlau
- 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 been focused on the development, analysis and implementation of efficient and robust computational methods for Partial Differential Equations with emphasis on the following topics:

- Robust geometric and algebraic Multigrid-, Multilevel- and Multiscale Methods as well as Domain Decomposition Methods for large-scale technical problems and problems in life sciences,
- Functional-type a posteriori error estimates,
- Isogeometric Analysis.

The new research area „Isogeometric Analysis“ was started with a FWF research project in 2010. In December 2011 the FWF approved a national research network (NFN) on the topic “Geometry + Simulation”. The group participates in this NFN with one research project on Discontinous Galerkin Isogeometric Analysis. This research topic has many interesting practical applications, and will be strengthened in the future.

Group "Inverse Problems"

The group "Inverse Problems" is a leading research center in the regularization theory and in applications of inverse problems to science and engineering. Recent theoretical achievements consist in justification of optimal parameter choice rules for multi-parameter regularization, as well as explaining the dependence of the accuracy of the linear sampling method for inverse scattering problem on the geometry of obstacles.
The group plays leading role in the large-scale integrating project "DIAdvisor: personal glucose predictive diabetes advisor", which is funded by the EU Commission within 7th Framework Programme. Moreover, in 2011 one more stand-alone project funded by FWF has been performed in the group.

Group "Symbolic Computation"

Three FWF projects influenced the research of the symbolic computation group in 2012: in the FWF doctoral college W1214 "Computational Mathematics", the development of the algorithm for topological analysis of curve singularities was completed, and the PhD researcher Madalina Hodorog successfully graduated in October. In another project related to curves, we computed parametrizations of algebraic curves by radicals. The joint project with the University of Vienna "Solving Algebraic Equations 2" was more concerned with algebraic verieties of higher dimension; also this project saw a successfull graduation, namely by Niels Lubbes. An additional incentive was the new entrant Martin Weimann, who has some expertise in the algebraic theory of integral transforms such as the Radon transform or the Abel transform.

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.

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 time optimal control. They aim for obtaining complete optimality systems, investigate their structure and develop efficient numerical schemes for their numerical realization.

Group "Mathematical Imaging"

We mathematically analysed a new focusing measurement concept for photoacoustic imaging which is able to record photoacoustic imaging data along sections of an object. For single sliced measurements we derived explicit reconstruction formulas for the absorption density (the imaging parameter of Photoacoustics). Moreover, we suggested a measurement method based on sectional imaging for which we could find an explicit reconstruction formula for the absorption density and the locally varying speed of sound in parallel. Recently, we also started to evaluate more complicated photoacoustic models takeing into account in addition acoustic attenuation. The midterm evaluation of the NFN "Photoacoustic Imaging in Biology and Medicine" (headed by Otmar Scherzer) was successful and the project was renewed in March 2011. The project prolongates for another three years.

Group "Mathematical Methods in Molecular and Systems Biology"

The group was started in 2009 and works on the application of existing and the development of new mathematical techniques from the areas of inverse problems and partial differential equations to/for the solution of questions in the field of molecular and systems biology. 2011 the research focus was put on:

- modelling and simulation of the actin cyto-sceleton
- identification and in-silico manipulation of biochemical reaction networks
- modelling and simulation of transport through membranes

The interdisciplinary co-operation partners of the group include members of the research institutions IMP, IMBA (as part of the WWTF-project „Mathematical modeling of actin driven cell migration"), MFPL, the University of Vienna (Institute for Pharmacology and Toxicology, Department Molecular Systems Biology) and the University of Linz (Institute of Biophysics).

Transfer Group

The transfer group has been installed in April 2011. Its aim is the transfer of modern mathematical methods to industry. Therefore the research is always done in close cooperation with industrial or other scientific partners. In the past 9 months, we have in particular worked with the European Southern Observatory ESO (Garching), AVL List GmbH (Graz), uni software plus GmbH (Linz), MathConsult GmbH (Linz) and Bachmann GmbH (Feldkirch). For ESO, we develop mathematical algorithms and software of adaptive optics systems for the European Extremely Large Telescope (E-ELT), which is currently planed. With AVL, methods for modeling and simulation of engine components are developed. In Finance, we cooperate with MathConsult and uni software plus in the development of fast numerical solvers for stochastic and specific partial differential equations and methods for the

identification of parameters in these differential equations. The development of methods for condition monitoring of wind power plants is the topic of the cooperation with Bachmann. The variety of the considered applications requires the use of a whole range of different mathematical techniques. In particular, we develop new mathematical methods in Inverse Problems and develop fast and stable numerical solvers for partial differential equations.

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, several quality measures were compared for sequences in cryptography, wireless communication and for quasi-Monte Carlo methods. Five surveys provided an essential contribution to the Handbook of Finite Fields. Moreover, hybrid sequences were studied which combine the advantages of Monte-Carlo and quasi-Monte Carlo methods. Additionally, sequences and Boolean functions derived from Fermat quotients and related mappings were analyzed in view of their cryptographic suitability.

START Projekt Y432 „Sparse Approximation and Optimization in High Dimensions“
The research group focused on the following topic: sparse optimization for dimensionality reduction in complex problems. The dimension scale of problems arising in our modern information society became very large. A new area of science and engineering is now urgently needed in order to extract and interpret significant information from the universe of data collected from a variety of modern sources (Internet, physics experiments, medical diagnostics, etc.). Numerical simulations at the required scale will be one of the great challenges of the 21st century. In short, we need to become capable of organizing and understanding complexity. The most notable recent advances in data analysis and numerical simulation are based on the observation that in several situations, even for very complex phenomena, only a few governing components are required to describe the whole dynamics; a dimensionality reduction can be achieved by demanding that the solution be "sparse" or "compressible". Since the relevant degrees of freedom are not prescribed, and may depend on the particular solution, we need efficient optimization methods for solving the hard combinatorial problem of identifying them. Our group will first address the problem of designing efficient algorithms which allow us to achieve sparse optimization in high-dimensions. Secondly, the tools which we are developing for achieving adaptive dimensionality reductions will subsequently be used as building blocks for solving large-scale partial differential equations or variational problems arising in various contexts. Finally, we will apply the whole machinery to interesting applications in image processing, numerical simulation, and we will explore new applications in innovative fields such as automatic learning of dynamical systems.

2.4. Highlights 2011

Each of these groups has produced very interesting highlights, but we follow the requirement to quote at most two:

- The numerical solution of optimization problems with differential equations as side constraints demands for efficient solution algorithms. In order to develop such methods one needs results from different mathematical disciplines, which are in the expertise of the RICAM institute: numerics, analysis, and optimization. In a cooperation of Sven Beuchler (research group "Computational Methods for Direct Field Problems") and Daniel Wachsmuth (research group "Optimization and Optimal Control") a new class of solution methods is being developed. This research is funded by **FWF research grant P23484** "High-order finite element methods for optimal control problems". Both young researchers could got additional third-party funding. They utilized the research opportunities at the RICAM institute to achieve international reputation, and both accepted calls to professorships at universities in Germany during the last year.

- EU-funded project “**DIAdvisor**: personal glucose predictive diabetes advisor” aims at improving diabetes therapy by means of the prediction of blood glucose evolution of diabetic patients. The RICAM DIAdvisor team has developed a new design for such prediction that has been successfully tested in several clinical trials, where it has outperformed the state-of-the-art algorithms. New design is the subject of the joint patent application EP 11163219.6 (April 20, 2011) of the Austrian Academy of Sciences and the industrial partner Novo Nordisk A/S (Denmark).

Figure 1: DIAdvisor device, where RICAM-algorithm for prediction of the future blood glucose concentration is installed.

Key Publications:

We here quote **18** key publications of our research groups and projects, where **5** of which are highlighted in AkademIs:

1. **S. Anzengruber** and **R. Ramlau**. Convergence rates for Morozov's discrepancy principle using variational inequalities. Inverse Problems, 27(10), October 2011.

2. **L. M. Emans**, S. M. Frolov, B. Lidskii, V. Posvyanskii, B. Basara (2011): SIMPLE-H: A finite-volume pressure–enthalpy coupling scheme for flows with variable density, International Journal for Numerical Methods in Fluids, Article first published online : 30 MAR 2011, DOI: 10.1002/fld.2552.

3. Erokhova, A. Horner, **P. Kügler**, P. Pohl, *Monitoring single-channel water permeability in polarized cells*, Journal of Biological Chemistry, v. 286 (2011), No. 46, pp. 39926-32.

4. **M. Fornasier**, **J. Haskovec**, and **J. Vybiral**: Particle systems and kinetic equations modeling interacting agents in high dimension, to appear in SIAM J. Multiscale Modeling and Simulation.

5. **M. Fornasier**, R. March, and **F. Solombrino**: Existence of minimizers of the Mumford and Shah functional with singular operators and unbounded data, to appear in Annali Mat. Pura Appl.

6. **M. Fornasier**, **K. Schnass**, and **J. Vybiral**: Learning Functions of Few Arbitrary Linear Parameters in High Dimensions, to appear in Found. Comput. Math.

7. M.Grasmair, M. Haltmeier, **O. Scherzer**: *Necessary and Sufficient Conditions for Linear Convergence of l1-Regularization*, Comp. Pure Appl. Math., v. 64 (2011) , pp. 161–182.

8. O. Iliev, R. Lazarov, and **J. Willems:** *Variational multiscale finite element method for flows in highly porous media,* SIAM Multiscale Modeling and Simulation, 9 (2011), No. 4, pp. 1350-1372.

9. J. Liu, P. A. Krutitskii, and **M. Sini**: Numerical solution of the scattering problem for acoustic waves by a two-sided crack in 2-dimensional space. J. Comput. Math. 29 (2011), No 2, pp. 141-166.

10. **J. Kraus** and **S. Tomar**: Algebraic multilevel iteration method for lowest-order Raviart-Thomas space and applications. Int. J. Numer. Meth. Engng., v. 86 (2011), No. 10, pp. 1175–1196.

11. **V. Naumova**, **S. V. Pereverzyev** and **S. Sivananthan**: Extrapolation in variable RKHSs with application to the blood glucose reading. Inverse Problems, v. 27 (2011) No. 7, pp. 1-13.

12. **H. Niederreiter**: The independence of two randomness properties of sequences over finite fields. Journal of Complexity, to appear.

13. A. Ostafe, **A. Winterhof**: Some applications of character sums. In: G. Mullen, D. Panario (eds.), Handbook of Finite Fields, to appear.

14. **D. Ölz, C. Schmeiser,** Simulation *of lamellipodial fragments*. Epub 2011, J Math Biol. 2012 Feb; 64(3):513-28.

15. A. Rösch, **D. Wachsmuth**: A-posteriori error estimates for optimal control problems

with state and control constraints. Numerische Mathematik, to appear.

16. H. Hauser, **J. Schicho**: Forty Questions on Singularities of Algebraic Varieties. Asian Journal of Mathematics, v. 15, No. 3, pp 417-436 (in press).

17. **R. Schulze**, G. Zangerl, M. Holotta, D. Meyer, F. Handle, R. Nuster, G. Paltauf, **O. Scherzer**: *On the Use of Frequency-Domain Reconstruction Algorithms for Photoacoustic Imaging*, Journal of Biomedical Optics, v. 16 (2011), No. 8, 086002 (1-6).

18. J.R. Sendra, **D. Sevilla**: Radical parametrizations of algebraic curves by adjoint curves. J. Symb. Comp., v. 46, No. 9, pp 1030—1038 (in press).

2.5. Report on the scientific activity during 2011

2.5.1. Group „Computational Methods for Direct Field Problems"

Group Leader:

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

Researchers funded via ÖAW/Upper Austrian government funds:

PD Dr. Johannes Kraus
Dr. Angelos Mantzaflaris (employed from 1 December 2011)
Dr. Satyendra Tomar (employed from 1 April 2011)
Dr. Gerhard Unger (employed until 30 April 2011)
Dr. Jörg Willems
Dr. Huidong Yang

Researchers externally funded:

Dr. Ivan Georgiev
MSc Nadir Bayramov (employed from 1 December 2011)
MSc Krishan Gahalaut
MSc Erwin Karer (employed until 30 October 2011)
Dipl.-Ing. Stefan Kleiss (employed from 1 September 2011)
Dipl. math. tech. Martin Purrucker (employed until 31 March 2011)

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 2011. The most important basic research work was performed in the following 3 FWF projects:

- **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 FWF-project P20121 has successfully been finished in March 2011. M. Purrucker will finish his thesis in Bonn where he got a 2 years position. The PI moved to a professorship position at the University of Bonn in December 2010. In cooperation with V. Pillwein from RISC and the former group members J. Schöberl and S. Zaglmayr , S. Beuchler has developed sparsity optimized high order finite element functions on simplices by means of techniques from symbolic computation [20,21].
- **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 + S. Kleiss):** IsoGeometric Method (IGM), introduced in 2005 by Hughes et al., is a promising concept that establishes a close link between numerical simulation via Finite Element Method (FEM) and Computer Aided Design (CAD). In IGM, the same function spaces, which are used for the geometric representation of the computational domain, are used for the approximation of unknown variables of the problem. Two main advantages of IGM, when compared to classical FEM, are (1) some common geometries arising in engineering and applied sciences, such as circles or ellipses, are represented exactly, and complicated geometries are represented more accurately than traditional polynomial based approaches, and (2) it is a difficult and cumbersome (if not impossible) task to achieve even inter-element continuity of function derivatives in FEM, whereas IGM offers up to p-1 continuity, where p denotes the polynomial order. In IGM, the description of the geometry, taken directly from the CAD system, is incorporated exactly at the coarsest mesh level and fixed. Thereby, the mesh refinement does not

modify the geometry. Our first focus has been on developing fast solvers for the linear system of equations obtained by isogemetric discretization of two-dimensional elliptic problems. With K. Gahalaut, graph theory based preconditioners were first studied, which didn't give promising results. With K. Gahalaut and J. Kraus, the focus was then shifted to multigrid (MG) solvers. The condition number estimates of the stiffness matrix has been studied, and the multigrid solvers (V-, W- and F-cycles) have been shown to be of optimal order complexity. The numerical results support the theoretical estimates.

With S. Kleiss, and our national research partners Dr. C. Pechstein and Prof. B. Juettler, we also studied isogeometric tearing and interconnecting (IETI) method. This is an application of the finite element tearing and interconnecting (FETI) approach to IGM discretization. We considered multi-patch domains, and as a first step focused on matching-interfaces and T-joints (i.e. hanging nodes). This study also proposed some local refinement strategies. The numerical results support the theoeritcal estimates of FETI approach.

- **FWF-Research Project P22989-N18 "*Subspace correction methods for nearly singular and indefinite problems with highly oscillatory coefficients*" (2010 – 2014) led by *J. Kraus* (1 PostDoc position: I. Georgiev, and 1 PhD position: N. Bayramov):** In this project, which started in December 2010, we 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. First results on robust multilevel preconditioners have already been obtained for elliptic problems with highly oscillatory coefficients, see [11, 12, 18], for ansiotropic problems, see [13,17], and for discontinuous Galerkin discretizations of elasticity systems [15,16]. On December 1, 2011, Msc N. Bayramov joined the project team and he will work on subspace correction methods for optimal control problems.

FWF-Research Project P19170-N18 "*Algebraic multigrid and multilevel methods for vector field problems"* (2007-2010) led by *J. Kraus* was successfully completed in October 2010. E. Karer who was supported by this FWF-Project and supervised by J. Kraus successfully defended his PhD thesis on December 19th, 2011 [24]. The results have also been presented at the 20th International Conference on Domain Decomposition Methods, see [14].

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

1. **Robust geometric and algebraic multigrid-, multilevel- and multiscale methods as well as domain decomposition methods for large-scale technical problems and problems in life sciences: *J. Kraus*** works on algebraic and geometric multigrid methods and subspace correction methods based on multilevel and domain decomposition techniques. The objectives partially overlap with the research plan of the **FWF project P22989-N18** "*Subspace correction methods for nearly singular and indefinite problems with highly oscillatory coefficients*". His work mainly focuses on problems that arise from nonconforming and discontinuous Galerkin discretizations, recently also isogeometric analysis, when modeling multiphysics phenomena of heterogeneous media. ***J. Willems*** works on robust two- and multi-level methods for problems arising in the modeling of physical processes in highly heterogeneous media (see Fig. 2 (left)). This research is carried out with collaborators at Texas A&M University. In particular R. Lazarov and J. Willems are supported by the mutual **NSF project DMS-1016525** "Subgrid Discontinuous Galerkin Approximations of Brinkman Equation with Highly Heterogeneous Coefficients*".* ***H. Yang*** works on iterative partitioned solvers for the Fluid-Structure-Interaction problems, in particular, on fast and robust algebraic multigrid solvers for the fluid and the structure sub-problems, as well as preconditioned Krylov subspace solvers for the interface equation of the

coupled problems [2-4]. Similarly, ***U. Langer*** et. al. investigated elastic-plastic problems in [22]. Domain decomposition solvers for frequency-domain Finite Element Equations are constructed and analyzied in [23].

2. **Functional-type a posteriori error estimates:** Together with our international research partner Prof. S. Repin, we extended functional-type a posteriori error estimates to nonconforming time-dependent convection diffusion problems. These techniques will also be studied for multi-patch isogeometric discretization.

3. **Isogeometric Analysis (IGA): *S. Tomar***, together with ***K. Gahalaut*** and ***S. Kleiss***, and in cooperation with B. Jüttler, **J. Kraus**, C. Pechstein and W. Zulehner, has initiated the isogeometric analysis related work in the group [25]. Their first focus has been on developing fast solvers for the isogeometric discretizations. First results in this direction, using IETI and multigrid solvers, have been promising (see Fig. 2 (right)). Another approach based on algebraic multilevel iteration (AMLI) method is also the subject of current investigation. Functional-type a posteriori error estimates for isogeometric discretization are also being studied. Recently, ***A. Mantzaflaris*** was recruited by our group. His background spans symbolic computation and geometric modeling (cf. [5], [6]). His current interest in isogeometric analysis lies in practical as well as theoretical aspects. A particular problem in his focus, which constitutes a computational bottleneck in IGM, is an efficient assembly of the mass and/or stiffness matrices. To this end, exact formulae are investigated for the Gram matrix of uniform B-Splines. The use of such formulae for the approximation of integrals involving NURBS basis functions can lead to robust approximation schemes for their mass/stiffness matrices. ***U. Langer*** and ***S. Tomar*** applied for a project in the National Research Network **NFN S117 "Geometry + Simulation"** that was approved by the FWF in December 2011. Our project is devoted to the construction and analysis of *"Discontinuous Galerkin Domain Decomposition Methods in Iso Geometric Analysis"*. It is planed to start the NFN on 1 March 2012. Thus, the first funding period will cover the time from 1 March 2012 until 29 February 2016. Thus, beside the first research topic, the IGA will certainly be the second main research topic of the group during the next four years.

G. Unger has accepted an offer to an assistant professor position at the TU Graz, and moved to Graz on 1 May 2011. He could continue his research work on the numerical solution of eigenvalue problems for elliptic PDEs by means of boundary element methods. This non-standard approach yields non-linear eigenvalue problems. G. Unger focused on the numerical analysis of iterative refinement methods for algebraic non-linear eigenvalue problems and on their combined use with the contour integral method [7].

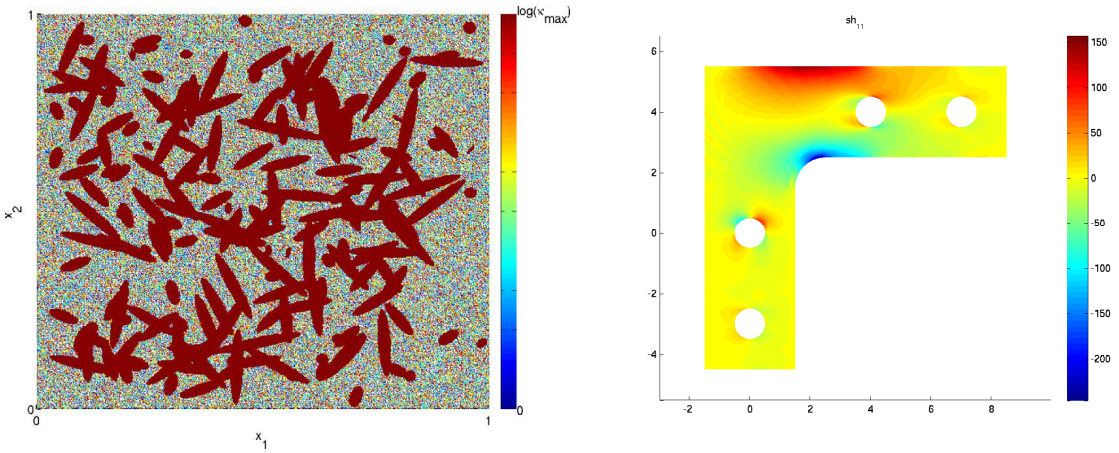

Figure 2: (left) Multiscale Diffusion Problem, (right) Isogeometric Analysis.

Publications 2011:

1. **J. Kraus**, **S. Tomar**, Algebraic multilevel iteration method for lowest-order Raviart-Thomas space and applications. Int. J. Numer. Meth. Engng., v. 86 (2011), No. 10, pp. 1175-1196.

2. **H. Yang**, W. Zulehner, Numerical simulation of fluid–structure interaction problems on hybrid meshes with algebraic multigrid methods. Journal of Computational and Applied Mathematics, v. 235 (2011), No. 18, pp. 5367-5379.

3. **H. Yang**, A Numerical Study on a Preconditioned GMRES Solver with Algebraic Multigrid Accelerations for the Fluid-Structure Interaction Problems on Hybrid Meshes, RICAM-Report 2011-15 (submitted).

4. **H. Yang**, Two finite element methods on hybrid meshes and their applications to the fluid-structure interaction problems, RICAM-Report 2011-24.

5. **A. Mantzaflaris, B. Mourrain, E. Tsigaridas**, On continued fraction expansion of real roots of polynomial systems, complexity and condition numbers, Theoretical Computer Science, v. 412 (2011), No. 22, pp. 212-233.

6. **I.Z. Emiris, A. Mantzaflaris**, Multihomogeneous resultant formulae for systems with scaled support, Journal of Symbolic Computation, Available online 22 December 2011.

7. O. Steinbach, **G. Unger**, Convergence orders of iterative methods for nonlinear eigenvalue problems. RICAM-Report 2011-03 (submitted).

8. Y. Efendiev, J. Galvis, R. Lazarov, and **J. Willems**, Robust Domain Decomposition Preconditioners for Abstract Symmetric Positive Definite Bilinear Forms. Mathematical Modelling and Numerical Analysis, (accepted).

9. O. Iliev, R. Lazarov, and **J. Willems**, Variational multiscale finite element method for flows in highly porous media. SIAM Multiscale Modeling and Simulation, v. 9 (2011), No. 4, pp.1350-1372.

10. Y. Efendiev, J. Galvis, R. Lazarov, and **J. Willems**, Robust Solvers for Symmetric Positive Definite Operators and Weighted Poincaré Inequalities. In I. Lirkov, S. Margenov, and J. Wasniewski, editors, Large-Scale Scientific Computing: 8th International Conference, LSSC 2011, Sozopol, Bulgaria, Lecture Notes in Computer Science, Springer, (accepted).

11. **J. Kraus**, Additive Schur complement approximation and application to multilevel preconditioning. RICAM-Report 2011-22 (submitted).

12. **J. Kraus**, Additive Schur complement approximation for elliptic problems with oscillatory coefficients. In I. Lirkov, S. Margenov, and J. Wasniewski, editors, Large-Scale Scientific Computing: 8th International Conference, LSSC 2011, Sozopol, Bulgaria, Lecture Notes in Computer Science, Springer, 2011 (accepted).

13. **J. Kraus**, M. Lymbery, and S. Margenov, On the robustness of two-level preconditioners for quadratic FE orthotropic elliptic problems. In I. Lirkov, S. Margenov, and J. Wasniewski, editors, Large-Scale Scientific Computing: 8th

International Conference, LSSC 2011, Sozopol, Bulgaria, Lecture Notes in Computer Science, Springer, 2011 (accepted).

14. **E. Karer**, **J. Kraus**, and L. Zikatanov, A subspace correction method for nearly singular linear elasticity problems. In Proceedings of the 20th International Conference on Domain Decomposition Methods, UC San Diego, La Jolla, California, Lecture Notes in Computational Science and Engineering, Springer, 2011 (accepted.)

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18. **I. Georgiev**, **J. Kraus**, and S. Margenov, Two-level preconditioning for DG discretizations of scalar elliptic problems with discontinuous coefficients, AIP Conference Proceedings 1404, Melville, New York, 2011, 389-396, ISSN 0094-243X.

19. P. Boyanova, **I. Georgiev**, S. Margenov, and L. Zikatanov, Multilevel Preconditioning of Graph-Laplacians: Polynomial Approximation of the Pivot Blocks Inverses, Technical Report 2011-030, Department of Information Technologies, Uppsala University, ISSN 1404-3203, and RICAM-Report 2011-30, 2011 (submitted).

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21. **S. Beuchler**, V. Pillwein, S. Zaglmayr: Fast summation techniques for sparse shape functions in tetrahedral hp-FEM, Proceedings of the DD20. Accepted for publication on 16 November 2011.

22. P. Gruber, J. Kienesberger, **U. Langer**, J. Schöberl, J. Valdman: Fast solvers and a posteriori error estimates in elastoplasticity. In: Numerical and Symbolic Scientific Computation: Progress and Prospects, ed. by U. Langer and P. Paule, Texts and Monographs in Symbolic Computation, pp. 45-63, Springer-Verlag, Wien, 2011.

23. D. Copeland, M. Kolmbauer, **U. Langer:** Domain Decomposition Solvers for Frequency-Domain Finite Element Equation, In: Domain Decomposition Methods in Science and Engineering XIX, ed. by Y. Huang, R. Kornhuber, O. Widlund and J. Xu, Lecture Notes in Computational Science and Engineering (LNCSE), v. 78, pp. 301-308, Springer-Verlag, Heidelberg, 2011, ISSN 978-3-642-11303-1.

24. **E. Karer**: Subspace Correction Methods for Linear Elasticity. PhD thesis, Johannes Kepler University, Linz, 2011.

25. **S.K. Kleiss**, B. Jüttler, W. Zulehner: Enhancing Isogeometric Analysis by a Finite Element-Based Local Refinement Strategy. Comput. Methods Appl. Mech. Engrg., v. 213-216 (2012), pp. 168-182. (accepted 2011).

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. Thanh Nguyen
Prof. Dr. Sergei Pereverzyev
Dr. Hanna Katriina Pikkarainen
Dr. Sivananthan Sampath (partially)
Priv. Doz. Dr. Mourad Sini

Researchers externally funded:
DI Stephan Anzengruber (employed until 31 March 2011)
M.Sc. M.Tech. Durga Prasad Challa
Dipl.-Ing. Tapio Helin
M.Sc. Manas Kar
PhD Valeriya Naumova
Dr. Jenny Niebsch
Dr. Sivananthan Sampath (partially)
Dipl.-Ing. Mykhaylo Yudytskiy

At present, the research activity of the group is concentrated mainly around two externally funded projects.
One of them is the EU-funded project "**DIAdvisor**: personal glucose predictive diabetes advisor," which was already highlighted above. This projected is headed by Prof. S. Pereverzyev.
The other one is the FWF-Research Project **P22341-N18** "Electromagnetic Scattering by Complex Interfaces" (Nov. 2010 – Oct. 2013) led by M. Sini. The two PhDs, M. Kar + D.P. Challa, study the following research topics:

- M. Kar studies the interface detection from electromagnetic waves using Complex Geometrical Optics solutions. During his first year (Nov.2010-Dec.2011), he already solved the case of impenetrable obstacles and he made serious progress in the study of the case of penetrable obstacles. The next step is to derive asymptotic formulas to reconstruct, in addition of the interfaces, the surface impedances and the jumps of the coefficients across the interfaces.

- D. P. Challa is studying some inverse elastic problems for detecting interfaces. In the Lame model, we know that every wave is a sum of two fundamental body waves: the pressure wave (P-wave) and the shear wave (S-wave). The objective is to show that only the P parts or the S parts of the elastic waves are enough to reconstruct interfaces. In the first year (Nov.2010-Dec.2011), he already solved the problem in the case of point-like scatterers in the general setting given by the Foldy regime. He also made some progress in studying the case of small scatterers. In this case, the analysis is based on the Foldy algebraic system. This approach is different from the well established method by Ammari-Kang. It has several advantages: (1) it models correctly the multiple scattering since we do not need a condition on the well separation of the scatterers; (2) it allows designing new materials by adding many small scatterers to a given medium, as it is proposed and already tested by A. Ramm in the acoustic waves case. In the last step, Durga will study extended scatterers using only P-waves or S-waves via the sampling methods.

Publications 2011:

1. **V. Naumova**, **S.V. Pereverzyev** and **S. Sivananthan**: Extrapolation in variable RKHSs with application to the blood glucose reading. Inverse Problems, v. 27 (7), 2011, pp.1-13.

2. S. Lu and **S. V. Pereverzyev**: Multi-parameter regularization and its numerical realization. Numerische Mathematik, v. 118, 2011, pp. 1-31.

3. **V. Naumova**, **S.V. Pereverzyev** and **S. Sivananthan**: Reading Blood Glucose from Subcutaneous Electric Current by Means of a Regularization in Variable Reproducing Kernel Hilbert Spaces. Proceedings of the 50th IEEE Conference on Decision and Control and European Control Conference (CDC-ECC), Orlando, FL, USA, December 12-15, 2011, pp. 5158-5163.

4. **S. Sivananthan**, **V. Naumova**, C. Dalla Man, A. Facchinetti, E. Renard, C. Cobelli, and **S. Pereverzyev**: Assessment of Blood Glucose Predictors: The Prediction-Error Grid Analysis. Diabetes Technology & Therapeutics, v. 13 (8), 2011, pp. 787-796.

5. **S. V. Pereverzyev**, S. G. Solodky, and E. A. Volynets: The balancing principle in solving semi-discrete inverse problems in Sobolev scales by Tikhonov method. Applicable Analysis, v. 91(3), 2011, pp. 435-446.

6. N. Honda, G, Nakamura, and **M. Sini:** Analytic extension and reconstruction of obstacles from few measurements for elliptic second order operators. To appear in Mathematische Annalen.

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11. **N. T. Thanh**, H. Sahli, and D. N. Hao: Detection and characterization of buried landmines using infrared thermography. Inverse Prob. Sci. Eng., v. 19 (3), 2011, pp. 281–307.

12. **N. T. Thanh**, D. N. Hao, and H. Sahli: Thermal infrared technique for landmine detection: Mathematical formulation and methods. Acta Mathematica Vietnamica v. 36 (2), 2011, pp. 469–504.

13. **N. T. Thanh**, D. N. Hao, and H. Sahli: Passive infrared technique for buried object detection and classification. In Proceedings of the 8th IEEE Workshop on Object Tracking and Classification beyond Visible Spectrum, Colorado Springs, CO, USA, June 25, 2011.

14. **S. Anzengruber** and R. Ramlau. Convergence rates for Morozov's discrepancy principle using variational inequalities. Inverse Problems, 27(10), October 2011.

15. C. Brandt, **J. Niebsch**, R. Ramlau, P. Maass: Modeling the influence of unbalances for ultra-precision cutting processes, Zeitschrift für Angewandte Mathematik und Mechanik (ZAMM), Bd. 2011, p14.

16. **J. Niebsch**: Determination of Rotor Imbalances, Carriveau, Rupp (Hrsg.), Fundamental and Advanced Topics in Wind Power: InTech.

17. **M. Aichinger**, Binder: A Workout in Computational Finance, Wiley, to appear 2012.

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19. M. Yudytskiy, **T. Helin**, and M. Zhariy. Wavelet-based wavefront reconstruction for SCAO. Technical Report E-TRE-AAO-528-0005 Issue 2, Austrian In-Kind Contribution - AO, 2011.

20. **T. Helin** and **M. Yudytskiy**. Wavelet-based wavefront reconstruction for MCAO. Technical Report E-TRE-AAO-528-0014, Austrian In-Kind Contribution - AO, 2011.

21. **T. Helin**, A. Obereder, R. Ramlau, M. Rosensteiner, and **M. Yudytskiy**. Mid Term Review AO2: MCAO. Technical Report E-TRE-AAO-528-0017, Austrian In-Kind Contribution - AO, 2011.

22. G. Auzinger, A. Obereder, R. Ramlau, M. Rosensteiner, I. Shatokhina**, M. Yudytskiy**, and M. Zhariy. Mid Term Review AO4: SCAO / XAO. Technical Report E-TRE-AAO-528-0016, Austrian In-Kind Contribution - AO, 2011.

23. **Jenny Niebsch**, Ronny Ramlau, and Christina Brandt. Unbalances in ultra-precision cutting machinery and the relation to surface quality. In 9. Internationale tagung Schwingungen in rotierenden Maschinen, Darmstadt, Germany, February 2011.

24. **T. Helin** and M. Lassas, Hierarchical models in statistical inverse problems and the Mumford--Shah functional, Inverse Problems 27 (2011), 015008, 32 pp.

In 2011, the article "Three-dimensional acoustic scattering by complex obstacles: the accuracy issue" by M F Ben Hassen, O Ivanyshyn and M Sini, that appeared in Inverse Problems has been selected as one of the journal's "Highlights 2010".

2.5.3. Group "Symbolic Computation"

Group Leader:
Ao. Univ.-Prof. Dr. Josef Schicho

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Gabor Hegedüs
MSc. Anja Korporal
Dr. David Sevilla Gonzalez
Dr. Martin Weimann (since October 2011)
Researchers externally funded:

MSc. Cevahir Demirkiran (since April 2011)
Dr. Madalina Hodorog
Dr. Niels Lubbes

In the FWF doctoral college W1214 “Computational Mathematics", a joint project with researchers from symbolic computation and numeric computation groups at the University of Linz, we could complete the development of algorithms for topological analysis of curve singularities. This was an interdisciplinary effort, because the completion required techniques in algebraic geometry, knot theory, computational geometry and numerical analysis. The PhD researcher Madalina Hodorog graduated in October and will start as a postdoctoral researcher at the Technical University of Berlin. The second period of the doctoral college has started in October after a hearing organised by FWF; and a new PhD student has joined the group in January 2012.

Also Niels Lubbes graduated in October. He contributed to the project “Solving Algebraic Equations 2", a joint project with the University of Vienna. One of the highlights of this project was the organisation of a research program at the Erwin Schrödinger Institute in Vienna, which as a theme contrasted algebraic geometry with analytic geometry. Lubbes will continue his research as a postdoctoral researcher in this project.

In a third project, we computed radical parametrizations of algebraic curves, together with J. R. Sendra (University of Alcala). This extends the class of parametrizable curves considerably, because up to now only rational parametrizations have been studies systematically. Also this project is still in progress, there is still a large class of curves where existence of radical parametrisation is not clear.

The new postdoctoral researcher Martin Weimann has a background in the algebraic theory of integral transforms; his recent research field is factorisation of polynomials, using residues. He could improve the computational complexity for this problem in the sparse case. The method is related to toric geometry and lattice geometry, which is also relevant for the research of other researchers in our group; e.g., members of our group computed formulas for boundary volumes for lattice polytopes, in a cooperation with A. Kasprzyk (Imperial College, London).

In joint cooperation with researchers from the University of Cantabria, we devised algorithms for the parametrisation and construction of Del Pezzo surfaces of degree~5. The degree~5 case was the last in a list of surfaces which are difficult to parametrize, hence this result also is a final point in the larger project of parametrizing algebraic surfaces.

In August, we started a cooperation with H.-P. Schröcker (Univ. Innsbruck) on algebraic methods in kinematics. We discovered a relation between the synthesis problem of linkages with rotational joints and polynomials over a non-commutative domain, which could open a door to construct many new linkages (work in progress).

Figure 3: A linkage with four rotational joints.

Publications 2011:

1. B. Juettler, B. Moore: A Quadratic Clipping Step with Superquadratic Convergence for Bivariate Polynomial Systems. Mathematics in Computer Science, Volume 5, Number 2, pages 223-235.

2. **M. Weimann** (in press): Algebraic Osculation and Factorization of Sparse Polynomials. Foundation of Computational Complexity, to appear.

3. M. Harrison, J. Gonzalez, I. Perez-Diaz, **J. Schicho** (in press): Algorithms for Del Pezzo Surfaces of Degree 5 (Construction, Parametrisation). Journal of Symbolic Computation.

4. **M. Weimann** (in press): Concavity, Abel-transform and the Abel-inverse Theorem in Smooth Complete Toric Varieties. Collectanea Mathematica, to appear.

5. H. Hauser, **J. Schicho** (in press): Forty Questions on Singularities of Algebraic Varieties. Asian Journal of Mathematics, Bd. 15 (3), pages 417-436.

6. **G. Hegedüs**, L. Ronyai (in press): Multivalued Generalizations of the Frankl--Pach Theorem. Journal of Algebra and its Applications, pages 21.

7. J. Sendra, **D. Sevilla**: Radical Parametrizations of Algebraic Curves by Adjoint Curves. Journal of Symbolic Computation, Bd. 0, pages 15.

8. G. Ivanyos, L. Ronyai, **J. Schicho** (in press): Splitting Full Matrix Algebras over Algebraic Number Fields. Journal of Algebra, pages 15.

9. **G. Hegedüs**, A. M. Kasprzyk: The Boundary Volume of a Lattice Polytope. Bulletin of the Australian Mathematical Society, Bd. 85, pages 21.

10. **M. Hodorog**: Symbolic-Numeric Algorithms for Plane Algebraic Curves. Abstract of Doctoral Dissertation, ACM Communications in Computer Algebra: Association for Computing Machinery Special Interest Group on Symbolic and Algebraic Manipulation, to appear.

11. **M. Hodorog**: Symbolic-Numeric Algorithms for Plane Algebraic Curves, PhD Thesis. Doctoral Program "Computational Mathematics", Johannes Kepler University, Linz.

12. **N. Lubbes**: Minimal Families of Curves on Surfaces, PhD Thesis. Johannes Kepler University, Linz.

13. **M. Hodorog**, **J. Schicho** (in press): A Regularization Method for Computing Approximate Invariants of Plane Curves Singularities. Association for Computing Machinery, Proceeding of the 4th International Workshop on Symbolic-Numeric Computation.

14. **M. Hodorog**, B. Mourrain, **J. Schicho**: A Symbolic-Numeric Algorithm for Computing the Alexander Polynomial of a Plane Curve Singularity. Proceeding of the 12th International Symposium on Symbolic and Numeric Algorithms for Scientific Computing, pages 21-28.

15. **M. Hodorog**, B. Mourrain, **J. Schicho**: An Adapted Version of the Bentley-Ottmann Algorithm for Invariants of Plane Curve Singularities. Proceeding of the 11th International Conference on Computational Science and Its Applications, Part III, Session: Computational Geometry and Application. Lecture Notes in Computer Science 6784, pp. 121-131, Springer.

2.5.4. Group "Analysis of Partial Differential Equations"

Group Leader:
O.Univ.-Prof. DI. Dr. Peter Markowich

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Francesco Solombrino

Francesco Solombrino focused in two different research directions: the first one, intened as a continuation of his previous work as a Ph.D Student at SISSA, concerned the study of evolutionary variational models in the theory of elastic-plastic materials, namely the so-called Cam-Clay model.

The second one is the study of some theoretical and applied questions related the study of inverse free-discontinuity problems. From an abstract point of view, it was investigated the question of existence of solutions of the regularization of linear inverse problems in fracture mechanics and image processing by means of the minimization of a functional formed by a term of discrepancy to data and a Mumford-Shah functional term. Depending on the type of the involved operator the resulting variational problem has had several applications: image deblurring, or inverse source problems in the case of convolution operators, and image inpainting in the case of suitable local operators, as well as the modelling of propagation of fracture. Counterexamples were constructed showing that, despite this regularization, the problem is actually in general ill-posed. However, existence results of minimizers in a reasonable class of smooth functions out of piecewise Lipschitz discontinuity sets, were recovered.

From the point of view of numerics, a novel algorithm for performing nonsmooth and nonconvex minimizations with linear constraints has been proposed. This algorithm is actually a natural generalization of well-known non-stationary augmented Lagrangian methods for convex optimization.The relevant features of this approach are its applicability to a large variety of nonsmooth and nonconvex objective functions, its guaranteed global convergence to critical points of the objective energy, and its simplicity of implementation. Although only the application to the minimization of Mumford-Shah type of functionals, mainly for their typical hard features of nonconvexity and nonsmoothness, was explicitly highlighted, in our view the algorithm will have significant further numerical applications in several problems involving nonsmooth and nonconvex energies with additional linear (boundary) conditions.

Publications 2011:

1. G. Dal Maso, A. DeSimone, and **F. Solombrino**: Quasistatic evolution for Cam-Clay plasticity: properties of the viscosity solution, to appear Calc. Var. PDEs.

2. **M. Fornasier**, R. March, and **F. Solombrino**: Existence of minimizers of the Mumford and Shah functional with singular operators and unbounded data, to appear in Annali Mat. Pura Appl.

3. **M. Fornasier** and **F. Solombrino**: Linearly constrained nonsmooth and nonconvex minimization, preprint.

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. Henry Kasumba (from January 1, 2011)
Dr. Axel Kröner (from October 1, 2011)
Dr. Sergio Rodriues (from October 1, 2011)
Dr. Daniel Wachsmuth

Researchers externally funded:
M.Sc. Saheed Ojo Akindeinde

The "Optimization Group" has focused on the development of analytical and numerical techniques for solving PDE-constrained optimal control problems. In the following we present the main scientific activities and the most important achievements and results obtained in 2011. An important part of the scientific work was focused around two FWF-projects:

FWF-research project P21564-N18 "Numerical verification of optimality and optimality conditions for optimal control problems"
(2010-2013) led by Daniel Wachsmuth (1 Phd student: Saheed Akindeinde)
The work on a-posteriori verification of optimality conditions for optimal control problems with finite-dimensional control space was brought to a good end. The novelty of our approach is that error contribution in the computation of the discrete Hessian is taken into account. As a result fully computable error bounds, where all the required conditions can be verified a-posteriori are obtained. This is in contrast to the results existing in the literature, where certain a-priori assumptions are present (sufficient second-order optimality conditions and smallness of remainders) [1].
These findings can be used to in an adaptive mesh refinement process. The adaptive methods built upon verified error bounds have been shown as competetive to full adaptive refinements in [2].

FWF-research project P23484-N18 "High-order finite element methods for optimal control problems" (2011-2014) led by Daniel Wachsmuth in cooperation with Sven Beuchler (2 Phd positions)
We continued our work on high-order finite element methods in a joint project with Sven Beuchler (Bonn), who is a former member of the RICAM group "Computational Methods for Direct Field Problems".

Furthermore, we continued our work on the following topics which are based in part on international collaborations.

Time optimal control: Karl Kunisch and Daniel Wachsmuth continued their research on time-optimal control problems. A first paper was submitted [7], where complete first-order necessary optimality conditions are derived. The novelty of our approach is conditions to check whether strict transversality holds. In addition, a Newton-type algorithm was developed and implemented. The convergence analysis is under current active research. The collaboration with Mrs. Wang, who visited the Radon Institute for several months, has led to two publications [10, 11].

Vortex reduction: Vortex reduction: Furthermore we investigate the use of translation invariant cost functionals for the reduction of vortices in the context of shape optimization (see Fig. 4). The results reported in [12] confirm the importance of such cost functionals for vortex reduction in fluid dynamics. Furthermore, we investigate in [13] the computation of the shape derivative of a general cost functional without the necessity to involve the shape derivative of the state variable. The extension of this approach to second order conditions is under current active research.

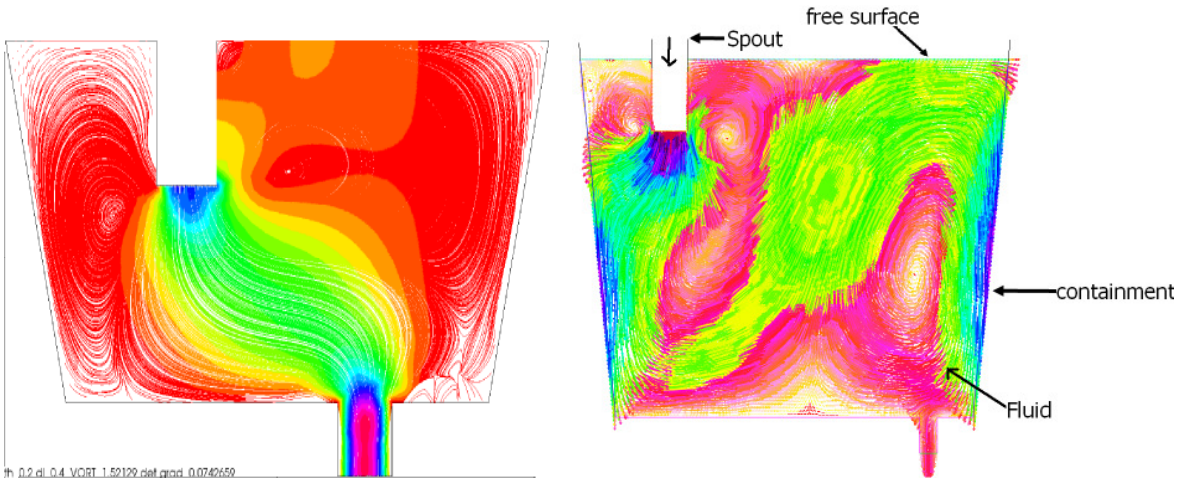

Figure 4: (left) Stream lines of the flow , (right) Vector field of the flow.

Publications 2011:

1. **S. Akindeinde**, **D. Wachsmuth**: A-posteriori verification of optimality conditions for control problems with finite-dimensional control space. To appear in Numerical Functional Analysis and Optimization, 2011.

2. **S. Akindeinde**, **D. Wachsmuth**: Adaptive methods for control problems with finite-dimensional control space, submitted, 2011.

3. A. Rösch, **D. Wachsmuth**: A-posteriori error estimates for optimal control problems with state and control constraints. To appear in Numerische Mathematik, 2011.

4. **K. Kunisch**, **D. Wachsmuth**: Path-following for Optimal Control of Stationary Variational Inequalities. To appear in Computational Optimization and Applications, 2011.

5. G. Wachsmuth, **D. Wachsmuth**: Convergence and regularization results for optimal control problems with sparsity functional. ESAIM: Control, Optimisation and Calculus of Variations 17, 858-886 (2011).

6. A. Rösch, **D. Wachsmuth**: Semi-smooth Newton's Method for an optimal control problem with control and mixed control-state constraints. Optimization Methods and Software 26(2), 169-186 (2011).

7. **K. Kunisch**, **D. Wachsmuth**: Time optimal control of the wave equation, its regularization and numerical realization. RICAM Report 2011-16, submitted.

8. A. Schiela, **D. Wachsmuth**: Convergence analysis of smoothing methods for optimal control of stationary variational inequalities. RICAM Report 2011-09, submitted.

9. G. Wachsmuth, **D. Wachsmuth**: On the regularization of optimization problems with inequality constraints. RICAM Report 2011-01, submitted.

10. **K. Kunisch**, L. Wang: The Bang-bang principle for time optimal controls of the linear Fitzhugh-Nagumo equation with pointwise control constraints, submitted.

11. **K. Kunisch**, L. Wang: Time Optimal Control of the Heat Equation\\ with Pointwise Control Constraints, submitted.

12. **H. Kasumba**, **K. Kunisch**: Vortex control in channel flows using translational invariant cost functionals. Computational Optimization and Applications (2011), doi:10.1007/s10589-011-9434-y

13. **H. Kasumba**, **K. Kunisch**: On shape sensitivity analysis of the cost functional without shape sensitivity of the state variable. RICAM report 2011-07, submitted.

2.5.6. Group "Mathematical Imaging"

Group Leader:

Univ.-Prof. Dr. Otmar Scherzer

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Peter Elbau
Dr. Konstantinos Kalimeris (since October 1, 2011)
Dr. Daniel Leitner (from August 1, 2011 till December 31, 2011)

Researchers externally funded:
Dipl.-Ing. Rainer Schulze

Our physical collaborators in the NFN project "Photoacoustic Imaging in Biology and Medicine", G. Paltauf and R. Nuster, began to work on a new measurement method for photoacoustic imaging, named Photoacoustic Sectional Imaging, which allows for measurements of single slices of a sample. Hereby, the laser pulse, used to excite the object, is (unlike in standard photoacoustic imaging) focused on one plane so that only one slice of the object is illuminated. To improve the measurements, they additionally used focusing detectors to measure the resulting pressure wave. The form of these detectors causes waves originating from points outside the illuminated plane to interfere on the surface of the detector so that their contribution is small compared to the signals coming from this plane.
Correspondingly, we developed mathematical models for this sort of experiment and derived

explicit reconstruction formulas for the absorption density of the material for different placements of the detectors. We did thereby however not model the focusing shape of the detectors, but approximated them with point, integrating line, or integrating plane detectors.

At the University of Innsbruck, Prof. D. Meyer applies these photoacoustic methods to gather informations about endoderm cells in early embryogenesis of a Zebrafish. For the analysis of the resulting images, we contributed mathematical and computational methods.

To be able to additionally account for a varying speed of sound of the pressure waves inside the object, which we expect to improve the reconstruction quality quite a bit, we suggested to make additional measurements so that data for all possible slices of the object are available. These measurement data would enable us to explicitly reconstruct the absorption density together with the speed of sound (at least in first order of the deviation from a constant speed of sound).
Moreover, we made first attempts to include effects caused by the attenuation of the pressure wave in the material. In contrast to most of the actually used models, special care was taken to guarantee that our attenuation model is causal.

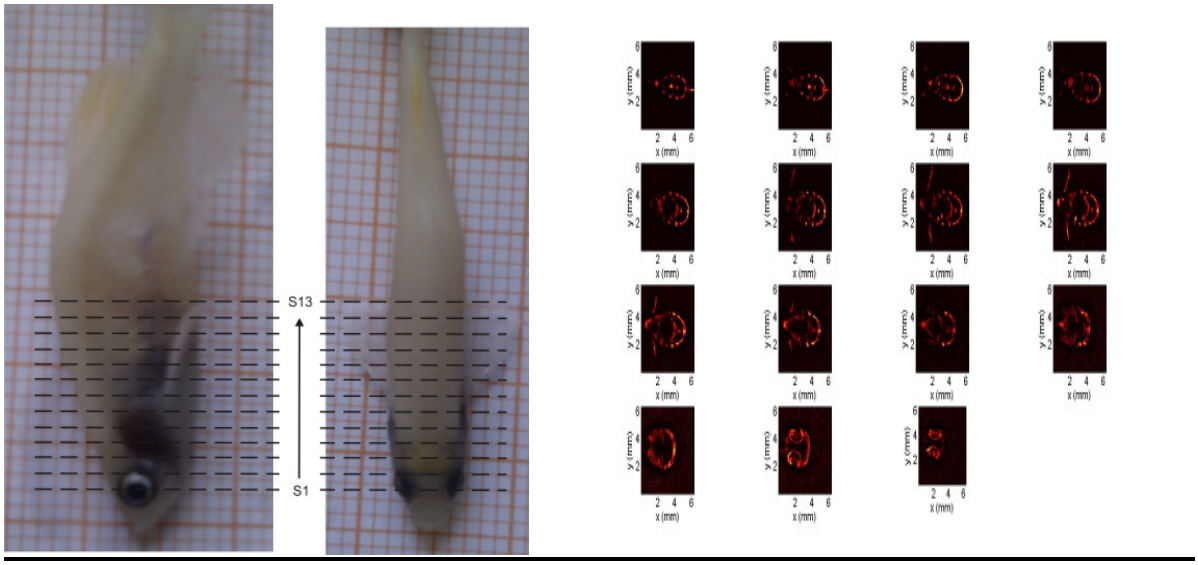

Figure 5: Sectional Imaging of a Zebrafish. Left Image: the sections are superimposed on the Zebrafish and the reconstructions can be seen on the right image.

Publications 2011:

1. M.Grasmair, M. Haltmeier, **O. Scherzer**: Necessary and Sufficient Conditions for Linear Convergence of l1-Regularization, Comp. Pure Appl. Math., v. 64 (2011), pp. 161–182.

2. **R. Schulze**, G. Zangerl, M. Holotta, D. Meyer, F. Handle, R. Nuster, G. Paltauf, **O. Scherzer**: On the Use of Frequency-Domain Reconstruction Algorithms for Photoacoustic Imaging, Journal of Biomedical Optics, v. 16 (2011), No.8, 086002 (1-6).

3. **O. Scherzer**: Handbook of Mathematical Methods in Imaging, Springer (Editor in Chief) (2011).

4. R. Kowar, **O. Scherzer**, X. Bonnefond: Causality analysis of frequency dependent wave attenuation, Math. Meth. Appl. Sci., 34 108–124 (2011), DOI: 10.1002/mma.1344.

5. F. Lenzen, **O. Scherzer**: Partial Differential Equations for Zooming, Deinterlacing and Dejittering, International Journal of Computer Vision 92, 162-176 (2011), DOI: 10.1007/s11263-010-0326-x.

6. M.Grasmair, M. Haltmeier, **O. Scherzer**: The Residual Method for regularizing ill-posed problems, Applied Mathematics and Computation 218, 2693-2710 (2011), doi:10.1016/j.amc.2011.08.009.

7. C. Pöschl, **O. Scherzer**: Distance Measures and Applications to Multi-Modal Imaging, Pp 111 – 138 in Handbook of Mathematical Imaging, O. Scherzer (Ed.), Springer (2011).

8. J. Boulanger, **P.Elbau**, C.Pontow, O.Scherzer: Non-local Integrands. In Fixed-Point Algorithms for Inverse Problems in Science and Engineering, Pp 131 – 154, H.H. Bauschke, R.S. Burachik, P.L. Combettes, V. Elser, D.R. Luke, H. Wolkowicz (Eds.), Springer Optimization and Its Applications 49, DOI 10.1007/978-1-4419-9569-8 8, Springer Science+Business Media, LLC 2011.

9. F. Frühauf, C. Pontow, **O. Scherzer**: Texture Enhancing Based on Variational Image Decomposition. Pp. 141-158 in Mathematical Image Processing, M. Berginoux (Ed). Springer Proceedings in Mathematics 5 (2011).

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. Philipp Kügler
Dr. Dietmar Ölz
Dr. Wei Yang
Msc. Clemens Zarzer

Researchers externally funded:
Mag. Stefanie Hirsch (from March 1st 2011)
Mag. Angelika Manhart (from October 1st 2011)
Msc. Christoph Winkler (from February 2011)

A central role in the activities of the group is played by the WWTF project "Mathematical modeling of actin driven cell migration" with the Small group at the Institute of Molecular Biotechnology IMBA as project partner. The project employs the three PreDocs S. Hirsch, A. Manhart, and C. Winkler. In 2011, a version of the lamellipodium model previously developed has been implemented in a new simulation package based on a finite element discretization. Furthermore, we were concerned with the description of the actin-myosin interaction at the molecular level. The resulting model, in the form of a kinetic transport equation, permits the computation of force-velocity relations [17]. These are used in extended lamellipodium models which then give a theoretical explanation for spontaneous movement of lamellipodial fragments. Another focus has been put on the tracking of actin filaments in electron

tomograms of lamellipodia [18] which also has been related to stochastic simulation models of the growth of actin filaments [19].

In [2] we used our previously developed model for cytoskeleton dynamics and conducted thought experiments in which a lamellipodial fragment is pushed by a pipette such that it changes its shape and position. In two related studies [4], [15] we investigated properties of this model for the special case of a single filament and developed a new set of governing equations which implies convergence to a straight curve equilibrium at an exponential rate. Another analytic study with respect to the cytoskeleton dynamics model involves a system of an integral equation of the Volterra type that describes the trajectories of binding sites and accounts for the remodeling process of linkages in the asymptotic limit [3].

Research conducted independently of the WWTF-project can be summarized as follows:

In collaboration with the Institute of Biophysics, University of Linz, we supported the development of an assay for the estimation of the permeability of single water channels in biological membranes [1]. Part of that assay is the solution of a nonlinear inverse problem for the determination of the water permeability of a monolayer of live epithelial cells from fluorescence correlation spectroscopy measurements of reporter dye concentrations. For the modeling of the latter a system of coupled convection-diffusion and Navier Stokes equations has been chosen.

Another example of our efforts in the analysis of actual experimental data is the co-operation with the Cowan group at the Institute for Molecular Pathology (IMP). In [14] a reaction diffusion model describing the molecular basis of the asymmetric segregation of the germline fate determinant protein PIE-1 in C. elegans has been developed. Simulations have been conducted which are in quantitative agreement with time-lapse images of PIE-1 from knock-out experiments. The key finding of the study is that reciprocal anterior-posterior cytoplasmic gradients of the proteins MEX-1 and MEX-5 control the asymmetric segregation of PIE-1. The mathematical model confirms that differentiated diffusion in combination with competition for binding to a substrate is a prospective mechanism underlying the segregation process. Furthermore, an inverse problems approach has been chosen in order to shed light on the underlying key reaction pathways.

One postulate of systems biology is that disease arises from genetic or environmental perturbations of biochemical reaction networks. Based on a Langevin type modeling approach that takes stochastic fluctuations at the macroscopic level into account we developed an algorithm for the detection of differences in the network Jacobians for wild type and mutation from steady state concentration data [12]. Under idealized assumptions on the unknown Langevin fluctuation terms we proved that not only the location of altered entries in the Jacobian but also the relative errors can be uniquely identified. Based on the premise that damage is confined to separable parts due to network modularity our computational approach utilizes the sparsity enforcing effect of lp-penalization. The potential of this strategy for the analysis of metabolomic data is currently discussed with our partners at the Department for Molecular Systems Biology, University of Vienna and at the Bioinformatics Group, Max-Planck-Institute of Molecular Plant Physiology, Potsdam.

Sparse solutions may also be of relevance when looking for reaction network intervention sites for the manipulation of dysfunctional biological behaviour. In [11] we developed an iterative algorithm for the solution of nonlinear underdetermined systems that computes updates of the current iterates by solving a sparsity promoting linear program. The convergence properties have been analyzed and numerically tested by means of model representing a defective apoptotic signaling cascade with insufficient cell death execution. According to the outcome of the computations both the production of inhibitors of apoptosis and the stimulating effect of Caspase 3 activation has to be reduced in order to facilitate the

triggering of the death program. With respect to the death executor Caspase 3 this result is counter-intuitive such that the potential benefits of the method for identifying drug target candidates are nicely demonstrated. Furthermore, with respect to infinitely dimensional inverse problems sparsity enforcing regularization has also been studied in [16] in which iterative thresholding is combined with a Nemytskii operator that transforms non-convex into convex penalty terms.

Publications 2011:

1. L. Erokhova, A. Horner, **P. Kügler**, P. Pohl, *Monitoring single-channel water permeability in polarized cells*, Journal of Biological Chemistry 2011, 286(46):39926-32.

2. **D. Ölz, C. Schmeiser,** Simulation *of lamellipodial fragments*. Epub 2011, J Math Biol. 2012 Feb; 64(3):513-28.

3. V. Milisic, **D. Ölz,** *On the asymptotic regime of a model for friction mediated by transient elastic linkages*, Journal de Mathematiques Pures et Appliques. Volume 96, Issue 5, November 2011, Pages 484-501.

4. **D. Ölz**, *On the curve straightening flow of inextensible, open, planar curves*, SeMA Journal, no. 54 (2011), 5-24.

5. F. Cerreti, B. Perthame, **C. Schmeiser**, M. Tang, N. Vauchelet, *Waves for an hyperbolic Keller-Segel model and branching instabilities*, Math. Models and Meth. in Appl. Sci. 21 (2011), pp. 825-842.

6. J. Haskovec, N. Masmoudi, **C. Schmeiser**, M.L. Tayeb, *The spherical harmonics expansion model coupled to the Poisson equation*, Kinetic and Related Models 4 (2011), pp. 1063-1079.

7. J.V. Small, **C. Winkler**, M. Vinzenz, **C. Schmeiser**, *Reply: Visualizing branched actin filaments in lamellipodia by electron tomography*, Nature Cell Biology 13 (2011), pp. 1013-1014.

8. B. Perthame, **C. Schmeiser**, M. Tang, N. Vauchelet, *Traveling plateaus for a hyperbolic Keller-Segel system with attraction and repulsion: existence and branching instabilities*, Nonlinearity 24 (2011), pp. 1253-1270.

9. J. Haskovec, **C. Schmeiser**, *Convergence analysis of a stochastic particle approximation for measure valued solutions of the 2D Keller-Segel system*, Comm. PDE 36 (2011), pp. 940-960.

10. F. Achleitner, S. Hittmeir, **C. Schmeiser**, On nonlinear conservation laws with a nonlocal diffusion term J. Diff. Equ. 250 (2011), pp. 2177-2196.

11. **P. Kügler,** *A sparse update method for solving nonlinear underdetermined systems applied to the manipulation of signalling pathways*, submitted

12. **P. Kügler, W. Yang**, *Identification of altered dependencies in disease perturbed biochemical reaction networks using sparsity enforcing penalization,* submitted.

13. M. G. Puchinger**, C. A. Zarzer**, **P. Kügler**, E. Gaubitzer, G. Köhler, *Ultrasensitive in-vitro detection of Adrenocorticotropic hormone levels by Fluorescence Correlation Spectroscopy Immunoassay*, submitted.

14. A.U. Göppert, Sabina Sanegre Sans, Silke Reiter, **D. Ölz**, C. R. Cowan, *Reciprocal anterior-posterior cytoplasmic gradients control asymmetric segregation of the fate determinant PIE-1 in C. Elegans*, submitted.

15. **D. Ölz**, *Convergence of the penalty method applied to a constrained curve straightening flow*, submitted.

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

17. **A. Manhart, C. Schmeiser,** A kinetic transport model for actin-myosin interaction, submitted.

18. **C. Winkler**, M. Vinzenz, J.V. Small, **C. Schmeiser**, *Actin filament tracking in electron tomograms of negatively stained lamellipodia using the localized Radon transform*, submitted.

19. M. Vinzenz, M. Nemethova, F. Schur, J. Mueller, A. Narita, E. Urban, **C. Winkler**, **C. Schmeiser**, S. Koestler, K. Rottner, G.P. Resch, Y. Maeda, J.V. Small, *Actin branching in the initiation and maintenance of lamellipodia*, submitted.

2.5.8. Transfer Group

Group leader:
Prof. Ronny Ramlau

The funding model of the transfer group differs from the other groups, as all group members are at least partially funded by external cooperation partners.

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Michael Aichinger (75%)
Dr. Maximilian Emans (from 1 April 2011, 50%)
Dipl.-Ing. Johannes Fürst (from 1 April 2011, 50%)
Dipl.-Ing. Josef Haslinger (from 1 April 2011, 50%)
Dr. Roman Heinzle (from 1 April 2011, 50%)
Dipl.-Ing. Christian Kletzmayr (from 1 April 2011, 50%)
Dipl.-Ing. Norbert Lorenz (from 1 April 2011, 50%)
Dr. Stefan Janecek (from 1 November 2011, 62,5%)

Researchers externally funded:
Dr. Tapio Helin
Dr. Jenny Niebsch
Dipl.-Ing. Mykhaylo Yudytskiy

The group focuses on the transfer of mathematical methods and numerical techniques to industrial and other scientific partners and develops algorithms and software prototypes for mathematical problems motivated from specific applications of the partners. The group has been installed in April 2011. More recently, members of the Inverse Problems group have been moved to the Transfer group (Aichinger, Helin, Niebsch, Yudytskiy), as their profile fits better to the Transfer Group and their externally funded projects were led by the leader of the Transfer Group.

Mathematically, the transfer group deals with the following fields:

- Fast and stable methods for (systems of) stochastic or partial differential equations arising from industrial applications.

- Inverse problems and optimisation of systems described by differentital equations

- Model reduction and surrogate models

In 2011, the focus of our work was in particular on applications from Adaptive Optics, Automotive, Finance and Energy.

Mathematical Algorithms and Software for E-ELT Adaptive Optics

The project is carried out in close cooperation between RICAM, the Industrial Mathematics Institute of the Kepler University Linz and MathConsult. At RICAM, the work was carried out by T. Helin, M. Yudytskiy and R. Ramlau. The aim of the project is the development of mathematical reconstruction methods for different types of adaptive optics systems for the European Extremely Large Telescope (E-ELT). The algorithms have to achieve a certain quality of reconstruction and the reconstructions have to be carried out in real time. In October 2011 the project passed the MidTerm Review by the European Southern Observatory with excellent results.

Images from ground based telescopes suffer from atmospheric turbulences, which lead to serious image degradation. Adaptive Optics is a hardware-based technique for the correction of the incoming light. The correction is based on reconstruction of the turbulence in the atmosphere from guide star measurements. Essentially, for each correction step, several inverse problems have to be solved. In 2011, the research has been focused on two AO - Systems: Single Conjugate Adaptive Optics (SCAO) and Multi Conjugate Adaptive Optics (MCAO).

The SCAO system uses the measurements of the wavefront of a bright guide star in order to obtain an optimal shape of a deformable mirror such that, after the wavefront conjugation, a sharp image of the guide star is obtained. Then all astronomical objects of interest in a near vicinity of the guide star appear sharp. As the wavefront sensors usually do not measure the wavefront directly, the reconstruction of the wavefront requires the solution of an inverse problem. Several algorithms have been under the investigation by the Austrian Adaptive Optics (AAO) team. In particular, we have developed the Cumulative Reconstructor with Domain Decomposition (CuReD) and a wavelet-based reconstructor. Both algorithms have been analyzed w.r.t. reconstruction quality, regularization properties and complexity.

Although both algorithms meet the quality specifications and are computationally cheaper than all existing methods for wavefront reconstruction, the CuReD algorithm is incomparably faster than any of the current state of the art algorithms. CuReD sets a new speed benchmark in adaptive optics wavefront reconstruction.

The aim of Multi Conjugate Adaptive Optics (MCAO) is to achieve a uniform image quality over a large field of view, thus allowing the observation of different astronomical objects at the same time. To this end, MCAO system use several guide stars, each assigned to a wavefront sensor, and several deformable mirrors which are optically conjugated to different altitudes. The problem resembles limited angle tomography, as the solution approach requires reconstructing the atmospheric turbulence layers from data measured by the wavefront sensors aimed at the sky in different directions.

The AAO team has developed and analyzed two different algorithms, namely the Kaczmarz reconstructor and a wavelet-based reconstructor.

The Kaczmarz reconstructor is applied in two sequential steps. First, the incoming wavefront measured at each wavefront sensor is reconstructed by using the CuReD algorithm. Then, the Kaczmarz method is applied to reconstruct turbulence layers at high altitudes from the incoming wavefronts. It turns out that the reconstruction can be achieved at a very high speed and does not require any matrix-vector multiplications. An RTC prototype of the algorithms shows that the method allows a computation of the mirror correction in about 750 microseconds, which is well below the available time span of 1 millisecond.

For the wavelet-based reconstructor, the same principles as for SCAO can be applied in MCAO. Both methods meet the quality criteria set by ESO.

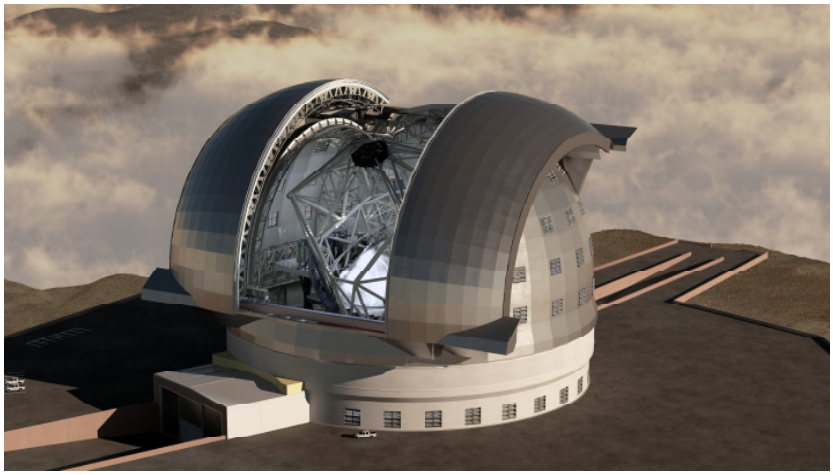

Figure 6. The proposed European Extremely Large Telescope (E-ELT)

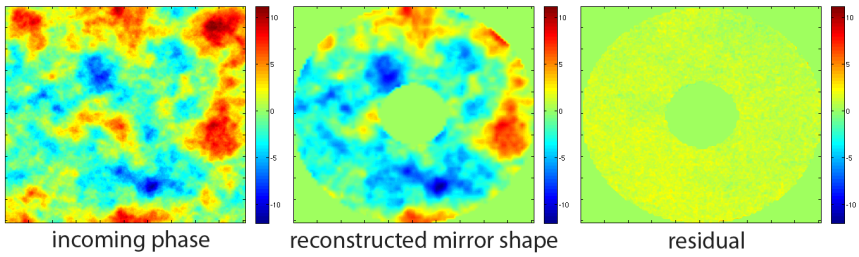

Figure 7. A wavefront reconstruction example for SCAO using the wavelet-based approach

Finance

The research of the computational finance subgroup (C. Kletzmayr and J. Fürst) has been focused on the development, analysis and implementation of fast and stable computational methods for the valuation, calibration and risk management of financial instruments.

The following topics were covered:

- Calibration of advanced volatility models: In order to obtain fatter-tailed distributions of equity prices, a variety of volatility models is proposed in mathematical finance. The parameters of these models have to be calibrated from prices of liquid financial instruments like European options with different exercise prices and different maturities. The transfer group dealt with the so-called Heston, Variance Gamma (VG) and Normal Inverse Gaussian (NIG) models in 2011. For the determination of the model parameters in the sense of (possibly regularized) least squares fit, typically up to 1 million options have to be valuated, i.e., PDEs have to be solved. The Fourier cosine method, introduced by Oosterlee, was refined, parallelized and implemented for GPUs. Compared to the single CPU, a speedup of up to 100 could be obtained, meaning a calibration time in the order of 1 second.

- Monte Carlo (MC) and Quasi Monte Carlo (QMC) methods for advanced volatility models and for complex financial instruments (e.g., barrier, lookback and Asian options) on the GPU: Path dependent financial instruments are typically tackled by (Q)MC methods. The difficulty with VG and NIG lies here in obtaining the (Q)MC points for non-normal distributions in the form of efficient GPU implementations. Again, speedups of up to 100 could be achieved.

- Calibration of short rate and inflation models: When negative interest rates may occur (yields of German bonds, Jan. 2012), special emphasis has to be laid on the stability and robustness of calibration routines for interest rate models. In the case of inflation models, regularization techniques have to be applied.

- Valuation of credit-linked instruments and inflation-linked notes. For credit-linked instruments, efficient numerical methods for Gaussian and Student-T copulas have been studied; inflation instruments are valuated by (Q)MC techniques.

Automotive

M. Emans worked on the implementation of a velocity-pressure coupling algorithm for the CFD software package FIRE. For selected applications this coupled approach is expected to lead to a faster convergence. Although the method has been discussed in the literature, it is challenging to develop it up to a robustness level which allows for the employment of such methods in the industrial practice. In this context it was of particular importance to provide an efficient but still sufficiently robust algebraic multigrid solver: Various benchmarks have shown that Krylov-accelerated methods appear to be best suited.

N. Lorenz worked on the simulation of the temperature distribution in the oil film lubricated contacts in a combustion engine. Therefore a reduced temperature approach was developed from a full 3D energy equation. Additionally, partly filled clearance gaps were considered. The model was reduced by an appropriate transformation of the domain and by neglecting the change of the state variables in the direction of the clearance gap.

Furthermore, new body types were incorporated into the AVL multi body dynamics environment EXCITE PU. For some simpliefied body types (components with limited mobility), the equations of motion were reduced and simpliefied.

J. Haslinger worked on the simulation of valve train dynamics within a multi-body framework. One of the main features in a valve train simulation is that bodies may lose or gain contact. A literature review about the state of the art handling of nonsmooth dynamical multi-body systems was carried out. The gained knowledge is now applied to the simulation of coil clashes within a valve spring. Furthermore a “kinetostatics solver” was developed, which computes a consistent initial state of a flexible multi-body system in order to reduce initial oscillations.

R. Heinzle worked on the real-time engine simulation. A specific part of the engine simulation is the simulation of the cooling and lubrication inside a car. Based on previous work, two major improvements were achieved which improve the stability of the numerical solver. First, the characteristics of the pump are now better interpolated and second, the calculation of the Jacobi-Matrix of the numerical solver has been improved. Both result in a sugnificantly improved stability of the simulations. Another part of the complete engine simulation is the combustion inside the cylinder block. A new approach was developed which splits the cylinder calculation into smaller steps. This leads to a better resolution of physical effects, like pulsations in the reservoirs, and to a more equally distributed calculation time.

FFG-Project *Model based imbalance determination in wind turbines*

In 2011, Dr. Niebsch was employed in the framework of the FFG project, which runs until September 2012. The project focuses on the determination of both mass and aerodynamic imbalances in wind turbines from vibration measurements. Additionally, methods for the non-stationary case (i.e. when the rotating frequency of the turbine is time dependent) are under development. The project is a cooperation with two companies: Bachmann Monitoring GmbH (former My-Sen GmbH), Rudolstadt / Feldkirchen, and BerlinWind GmbH.

Within 2011, the theoretical work focussed on fast reconstruction algorithms for the simultaneous identification of aerodynamic and mass imbalances. Gradient-based methods were developed for the minimization of a Tikhonov-type functional. Additionally, first steps were taken to investigate the non- stationary case, where a first forward model was developed. Our second aim in 2011 was to start the development of a software tool which will be combined with a Condition Monitoring System of our partner Bachmann Monitoring. The realization of the system is planned for 2012.The key ideas of imbalance reconstruction as the solution of an inverse problem were presented at several meetings, in particular to engineers (e.g., SIRM Conference Darmstadt, Workshop “Profi(t) am Wind” Feldkirch, TU Graz).

Computational physics

The experiments of Haug’s group (Hannover) exhibited strong signatures of spin flips in quantum rings exposed to external magnetic fields in the Coulomb blockade regime. The signatures appear as a pattern of lines corresponding to local reduction of conductance, and they cover a large range of magnetic fields and number of electrons. The sequence of lines, as well as other features in the conductance, can be captured by many-electron calculations within density-functional theory. Within this framework huge non-linear hermitian eigensystems have to be solved (eigenfunctions to be determined on up to 512^3 grid points). We combine high order operator splitting techniques with subspace orthogonalization and advanced iteration schemes to solve these systems. Our calculations show that most lines in the pattern correspond to sequential spin flips between filling factors 2 and 1. We believe that the ability to probe individual spin flips provides an important step toward precise spin control in quantum ring devices.

Synergies

Although the application fields are extremely diverse, cross-sectional techniques are employed, e.g., algorithms for GPUs are used in automotive and in finance applications, regularisation techniques have to be applied in adaptive optics and in condition monitoring.

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2.5.9. Research Project "Applied Discrete Mathematics and Cryptography"

Researcher funded via ÖAW/Upper Austrian government funds:

Univ. Doz. Dr. Arne Winterhof

Researcher externally funded:

Prof. Dr. Harald Niederreiter

The Discrete Mathematics (DM) has focused on quasi-Monte Carlo methods and pseudorandom number generation, communication and coding coding theory, and cryptography. More precisely:

Uniform distribution: Several new discrepancy bounds for hybrid sequences were obtained showing that these sequences combine the advantages of Monte-Carlo and quasi-Monte Carlo methods [10,12,13]. We mention in particular sequences involving matrix method vectors. Moreover, some new uniformly distributed sequences using the b-adic method were constructed [6].
Character sums and algorithmic number theory: Bounds on character sums of new nonlinear vector sequences were estimated which imply results on the distribution of powers and primitive elements in such sequences showing that they are suitable in algorithms for finding primitive elements [14].
Additive number theory and codes: The solvability of equations with multivariate Dickson polynomials was studied using new sum-product results. These results are important for the construction of certain covering codes [15].
Measures of pseudorandomness: The correlation measure and linear complexity profile of new binary sequences called Legendre-Sidelnikov and two-prime Sidelnikov sequences were analyzed [18,2]. Moreover, a close relationship between correlation measure and linear complexity profile for m-ary sequences was obtained showing, roughly speaking, that any sequence with a small correlation measure (up to a certain order) must have a high linear complexity profile [3]. Moreover, the independence of two important randomness properties for finite sequences over a finite field was proved, a perfect linear complexity and complete uniform distribution [8].
Applications of Fermat quotients: Fermat quotients and related functions called polynomial quotients were used to construct Boolean functions and sequences with many desirable features in view of cryptographic applications and pseudorandom number generation [1,4,5].
Surveys: DM contributed with five surveys to the Handbook of Finite Fields on (t; m; s)-nets and (t; s)-sequences [11], algebraic geometry codes [9], character sums and applications [16], linear complexity of sequences and multisequences [7], and finite fields in quantum information theory [17]. Moreover, two surveys on measures of pseudorandomness and uniform distribution [19,20] will be published in the CRC Handbook on Sequences, Codes and Applications.
Talks and university courses: DM gave 11 invited talks, 6 contributed talks, 3 university courses and 1 seminar. Two small workshops on pseudorandomness and applications of finite fields were organized by DM in Linz.

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2.5.10. START-Project Y432 „Sparse Approximation and Optimization in High Dimensions“

Group Leader:
Prof. Dr. Massimo Fornasier

Researchers funded via ÖAW/Upper Austrian government funds:
Prof. Dr. Massimo Fornasier

Researchers externally funded:
DI. Andreas Langer (until 01.08.2011) (employed until 1 August 2011)
Dr. Jan Haskovec
Dr. Karin Schnass
Dr. Jan Vybiral

In connection with the state of the art research in the field, we report below also the most recent work of the research team (http://hdsparse.ricam.oeaw.ac.at/index.php/members), formed by Jan Haskovec, Andreas Langer, Karin Schnass, Jan Vybiral, and myself, as its Leader. As in the recent economical crisis, the dimension scale of problems arising in our modern and extremely interconnected society became very large, producing significant challenges in prediction of trends and policy making. New mathematical tools and concepts are now urgently needed in order to extract and interpret significant information from this fast dynamical-in-time flow. Numerical simulations at the required scale will be one of the great challenges of the 21st century. In short, we need to become capable of organizing and understanding complexity. The most notable recent advances in data analysis and numerical simulation are based on the observation that in several situations, even for very complex phenomena, the intrinsic dimensionality is significantly lower than the ambient dimension and, when the number of agents involved is very large, that a “mean field approximation” holds.

Quasi-isometrical embeddings of high-dimensional point clouds in lower dimension and recovery. Remarkable mathematical progresses have been made in theoretical modelling of data compression, processing, and acquisition. We mention, for instance, the use of *diffusion maps* for data clouds and graphs in high dimension in order to define low-dimensional local representations of data with small distance distortion, and meaningful automatic clustering properties. In this setting the embedding of data is performed by a *highly nonlinear* procedure, obtained by computing the eigenfunctions of suitable normalized diffusion kernels, measuring the probability of transition from one data point to another over the graph. Quasi-isometrical *linear* embeddings of high-dimensional point clouds into low-dimensional spaces of parameters are provided by the well-known Johnson-Lindenstrauss Lemma.
This embedding strategy is simpler than the use of diffusion maps, as it is linear and universal (it does not depend on the data), however it is “blind” to the specific geometry and local dimensionality of the data, as the embedding dimension depends exclusively on the number of points in the cloud. In many applications, this is sufficient, as the number of points is supposed to be a power of the dimension. The Johnson-Lindenstrauss Lemma is also at the basis of the possibility of performing optimal compressed and nonadaptive acquisition of high-dimensional data. In *compressed sensing*, theory introduced by Candès, Romberg, and Tao and, independently, by Donoho, a vector is encoded in another low-dimensional vector, by applying a random projection with appropriate distribution, which is modeling a linear acquisition device with random sensors. From the lower dimensional representation it is possible to recover the high dimensional vector by using appropriate *sparse optimization algorithms*
In fact the design of further measurement methods and efficient recovery algorithms for more general data structures is at the core of the latest developments towards applying

compressive sensing for problems in numerical simulation, beyond the sole coding-decoding of compressible digital signals, which has been so far the more “traditional” application.
We contributed significantly to the development of novel theoretical advances and new algorithms, precisely with the intention to “clear through customs” the theory of sparse recovery towards new applications:

- New measurements matrices: the well-known Johnson-Lindenstrauss Lemma of quasi-isometric embedding of point clouds in lower-dimension is at the core of designing measurements matrices for compressed sensing. In the work [11, 20] we showed that random partial circulant matrices satisfy the Johnson-Lindenstrauss Lemma on dimension reduction.

  This approach allows to reduce significantly the computational time of the Johnson-Lindenstrauss embedding to O(d log d), where d is the original dimension and allows a simple implementation.

- New definitions of randomized sparse vectors: in [19] we defined the average best K-term approximation widths, and studied these quantities for both classical and new measures on the unit sphere of the ℓp sequence spaces for p < 1 (ℓp-balls are in fact a good model for compressible vectors). This work combines the geometry of (nonconvex) ℓp spaces together with probabilistic techniques and introduces a new very realistic model of random sparse vectors, which can be used to analyze the average behavior of algorithms performing on sparse vectors.

- New efficient numerical methods: domain decomposition methods [4].

- New concepts of sparsity and corresponding algorithms: iteratively reweighted least squares for low-rank matrix recovery [6].

As an example of new developments of uses of compressive sensing as a powerful tool beyond coding-decoding of digital signals we report, for instance, the efficient approximation of high-dimensional functions, as we will describe below.

Learning functions in high-dimension. In large scale data analysis and learning, several real-life problems can be formulated as capturing or approximating a function defined on high dimensional domains, from relatively few given samples or queries. The usual assumption on the class of functions to be recovered is smoothness.
The more regular a function is, the more accurately and the more efficiently it can be numerically approximated. In the field of *information based complexity* it has been clarified that such a problem is in general *intractable*, i.e., it does not have polynomial complexity, as in the recent work by Novak and Wozniakowski. However, by assuming additional structures which combine both sparsity and smoothness, *tractable* models can be provided. In the ground breaking papers [7, 15] we showed the tractability of certain approximation problems, involving functions depending on few linear parameters, and we provided efficient algorithms with polynomial complexity with respect to the ambient dimension. Our approach uses tools taken from the compressed sensing framework before mentioned, recent Chernoff bounds for sums of positive-semidefinite matrices, and classical stability bounds for invariant subspaces of singular value decompositions.

High-dimensional dynamical systems. Besides these relevant results in compressing and coding-decoding high-dimensional “stationary” data, dimensionality reduction of complex dynamical systems and high-dimensional partial differential equations is a subject of recent intensive research. One of the natural directions, where dimensionality reduction is desirable,

is the simulation of dynamical systems with many particle interactions. In particular, we are interested in studying models for multiagent interactions in social dynamics. Everyone at some point in his life was surprised and astonished by the observation of beautiful swinging movements of certain animals such as birds (starlings, geese, etc.), fishes (tuna, capelin, etc.), insects (locusts, ants, bees, termites, etc.) or certain mammals (wildebeasts, sheep, etc.). These coherent and synchronized structures are ruled by “social forces”, for instance *alignment, attraction, repulsion, aggregation, self-drive*, and apparently produced without the active role of a leader in the grouping, i.e., phenomena denominated *self-organization*. Most of the basic models proposed in the literature are based on discrete particle systems incorporating these “social first principles”. When the number of agents is large, the use of continuum models for the evolution of the density of individuals becomes essential. Some continuum models were derived phenomenologically, directly incorporating “social forces”, in other situations the models are based on hydrodynamic descriptions derived by studying the fluctuations or the mean-field particle limits. The essence of the kinetic or mean field equations is that they connect the microscopic world, expressed in terms of particle models, to the macroscopic one, written in terms of continuum mechanics. In this field we contributed with several advances: we introduced new models of social interactions, analyzed their behavior, and questioned their efficient numerical simulation when they are defined in high-dimension [1, 3, 8, 9, 10].

Figure 8: Image halftoning via variational methods from the paper [1].

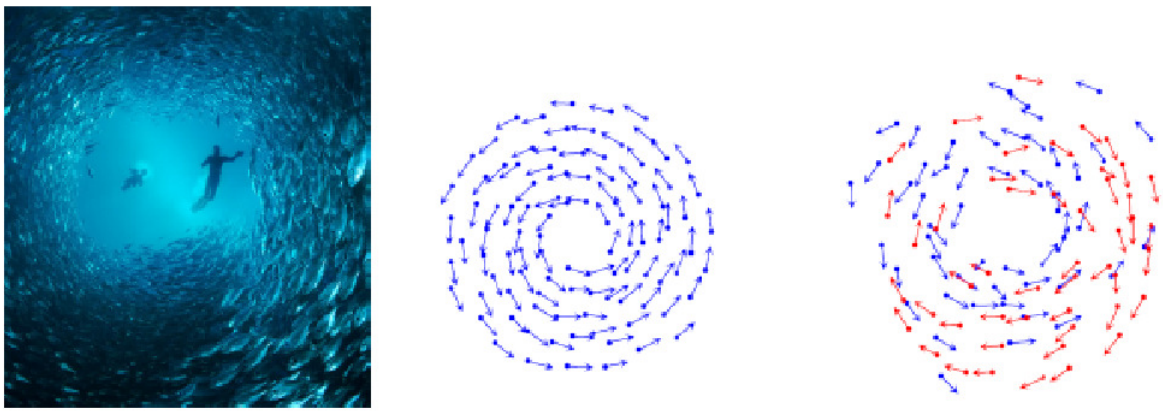

Figure 9: Mills in nature and in our simulations from the paper [3].

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17. A. Schneider and **J. Vybiral**: Homogeneity property of Besov and Triebel-Lizorkin spaces, preprint.

18. A. Schneider and **J. Vybiral**: Non-smooth atomic decompositions, traces on Lipschitz domains, and pointwise multipliers in function spaces, preprint.

19. **J. Vybiral**: Average best m-term approximation, to appear in Constr. Approx.

20. **J. Vybiral**: A variant of the Johnson-Lindenstrauss lemma for circulant matrices, J. Funct. Anal. 260(4) (2011), 1096-1105,

2.6. Publications/talks/poster presentations 2011

The complete AkademIs report is attached as DVD.

17. Wissenschaftliche Publikationen

	gesamt
A) Bücher / Monographien oder **Editionen**	0
A) Peer-reviewte Beiträge in Fachzeitschriften oder Sammelwerken	101
· davon in indizierten Fachzeitschriften	45
B) Herausgeberschaften	3
B) längere Beiträge ohne Peer-Review in Fachzeitschriften oder Sammelwerken	2
C) Sonstige wissenschaftliche Publikationen	30
Veröffentlichungen von Nachwuchswissenschafter(inne)n/Habilitationen	
(diese Publikationen wurden z.T. bereits in oben angeführten Kennzahlen miterfasst)	
· Diplomarbeiten	0
· Dissertationen	5
· Habilitationen	0
Lexikonartikel	0
Kurze Lexikonbeiträge, summarisch	0

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A) Peer-reviewte Beiträge in Fachzeitschriften oder Sammelwerken

***Fornasier, Massimo; March, Riccardo; Solombrino, Francesco (online :2011) Existence of minimizers of the Mumford-Shah functional with singular operators and unbounded data. Annali di Matematica pura ed applicata, Bd. 191, S. 27.** [Solombrino, Francesco: HauptautorIn]; peer-rev.indiziert lang

***Ramlau, S. Anzengruber and R. (2011) Convergence rates for Morozov's discrepancy principle using variational inequalities. Inverse Problems, Bd. 27 (10), S. 1-1.** [Ramlau, Ronny: KoautorIn]; peer-rev.indiziert lang

***Sendra, J. Rafael; Sevilla, David (2011) Radical parametrizations of algebraic curves by adjoint curves. Journal of Symbolic Computation, Bd. 0, S. 15.** [Sevilla Gonzalez, David: KoautorIn]; peer-rev.indiziert lang

***(2011, online :2011) Variational Multiscale Finite Element Method for Flows in Highly Porous Media., Bd. 9, S. 1350-1372.** [Willems, Jörg: KoautorIn]; peer-rev. lang

A. Ostafe, A. Winterhof (2011) Some applications of character sums. In: G. Mullen, D. Panario (Hrsg.), Handbook of Finite Fields, S. to appear. [Winterhof, Arne: HauptautorIn]; peer-rev.indiziert lang

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Boulanger, Jérôme; Elbau, Peter; Pontow, Carsten; Scherzer, Otmar (2011) Non-Local Functionals for Imaging. In: Bauschke, Heinz; Burachik, Regina; Combettes, Patrick; Elser, Veit; Luke, Russell et al. [..] (Hrsg.), Fixed-Point Algorithms for Inverse Problems in Science and Engineering:

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Burger, Martin; Haskovec, Jan; Wolfram, Marie-Therese (2011) Individual based and mean-field modelling of direct aggregation. Physica D: Nonlinear Phenomena, Bd. Special edition "Emergent behaviour in multi-particle systems with non-local interactions", S. 28. [Haskovec, Jan: KoautorIn; Wolfram, Marie-Therese: KoautorIn]; peer-rev.indiziert lang

C. Brandt, J. Niebsch, R. Ramlau, P. Maass (2011) Modeling the influence of unbalances for ultra-precision cutting processes. Zeitschrift für Angewandte Mathematik und Mechanik (ZAMM), Bd. 2011, S. 14. [Niebsch, Jenny: HauptautorIn; Ramlau, Ronny: KoautorIn]; peer-rev.indiziert lang

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E. Klann, R. Ramlau, W. Ring (2011) A Mumford-Shah level-set approach for the inversion and segmentation of SPECT / CT data. Inverse Problems in Imaging, Bd. 5 (1). [Ramlau, Ronny: KoautorIn]; peer-rev.indiziert lang

E. Räsänen, A. Mühle, M. Aichinger, and R. J. Haug (2011, online :2011) Observation of sequential spin flips in quantum rings. Physical Review B, Bd. 84, S. 165320. [Aichinger, Michael: KoautorIn]; peer-rev.indiziert

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Frühauf, Florian; Pontow, Carsten; Scherzer, Otmar (2011, online :2011) Texture Enhancing Based on Variational Image Decomposition. In: Bergounioux, Maïtine (Hrsg.), Mathematical Image Processing (Mathematics and Image Processing) In Reihe: Springer Proceedings in Mathematics; Berlin Heidelberg: Springer, S. 127-140. [Scherzer, Otmar: KoautorIn]; peer-rev. lang

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Georgiev, I.; Kraus, J.; Margenov, S. (2011, online :2011) Two-level Preconditioning for DG discretizations of Scalar Elliptic Problems with Discontinuous Coefficients. In: Michail D. Todorov, Christo I. Christov (Hrsg.), APPLICATION OF MATHEMATICS IN TECHNICAL AND NATURAL SCIENCES (3rd International Conference—AMiTaNS'11) In Reihe: AIP Conference Proceedings, Volume 1404; Melville, New York: American Institute of Physics, S. 389-396. [Kraus, Johannes: KoautorIn; Georgiev, Ivan: KoautorIn]; peer-rev. lang

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Haskovec, Jan; Masmoudi, Nader; Schmeiser, Christian; Tayeb, Mohammed Lazhar (2011) The Spherical Harmonics Expansion Model Coupled to the Poisson Equation. Kinetic and Related Models, Bd. 4, S. 21. [Haskovec, Jan: KoautorIn; Schmeiser, Christian: KoautorIn]; peer-rev. lang

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Kempka, Henning; Vybiral, Jan (online :2011) Spaces of variable smoothness and integrability: Characterizations by local means and ball means of differences. Journal of Fourier Analysis and Applications. [Vybiral, Jan: KoautorIn]; peer-rev. lang

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Lassas, T. Helin and M. (2011) Hierarchical models in statistical inverse problems and the Mumford–Shah functional. Inverse Problems, Bd. 27 (1), S. 015008. [Helin, Tapio: Koautorln]; peer-rev.indiziert lang

Lenzen, Frank; Scherzer, Otmar (2011) Partial Differential Equations for Zooming, Deinterlacing and Dejittering. International Journal of Computer Vision, Bd. 92 (2), S. 162-176. [Scherzer, Otmar: Koautorln]; peer-rev.indiziert lang

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(2011) On the curve straightening flow of inextensible, open, planar curves., Bd. 54, S. 5ff. [Ölz, Dietmar: AlleinautorIn]; peer-rev. lang

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B) Herausgeberschaften

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C) Sonstige wissenschaftliche Publikationen

Karer, Erwin (2011) Subspace Correction Methods for Linear Elasticity., Johann Radon Institute for Computational and Applied Mathematics, Johannes Kepler University Linz, Linz. [Karer, Erwin: Alleinautorln];

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Kröner, Axel (2011) Numerical methods for control of second order hyperbolic equations., Technische Universität München. [Kröner, Axel: Alleinautorln];

Lorenz, Norbert (2011) RI1DT and RI1DR body type extension for the multi-body dynamic program AVL Excite PowerUnit. Internal Report IMCC-Linz/AVL-Graz. [Lorenz, Norbert: Hauptautorln];

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Hodorog, Madalina (2011) Symbolic-Numeric Algorithms for Plane Algebraic Curves., Doctoral Program "Computational Mathematics",, Johannes Kepler University, Linz. [Hodorog, Madalina: Hauptautorln]; lang

Karer, Erwin (2011) Subspace Correction Methods for Linear Elasticity., Johann Radon Institute for Computational and Applied Mathematics, Johannes Kepler University Linz, Linz. [Karer, Erwin: Alleinautorln];

Kröner, Axel (2011) Numerical methods for control of second order hyperbolic equations., Technische Universität München. [Kröner, Axel:

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Lubbes, Niels (2011) Minimal Families of Curves on Surfaces., Johann Radon Institute for Computational and Applied Mathematics, Johannes Kepler University, Linz. [Lubbes, Niels: HauptautorIn]; lang

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Kröner, Axel (2011) Dual weighted residual method for optimal control of hyperbolic equations of second order. In: Brenn, G.; Holzapfel, G.A.; Schanz, M.; Steinbach, O. (Hrsg.), PAMM, Special Issue: 82nd Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Graz 2011 (82nd Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM)). [Kröner, Axel: AlleinautorIn];

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18. Wissenschaftliche Vorträge und Präsentationen

	gesamt
Eingeladene wissenschaftliche Vorträge	95
· davon auf internationalen Veranstaltungen	84
· davon Internationalität nicht zuordenbar	0
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18. Liste

Eingeladene wissenschaftliche Vorträge

Dietmar, Ölz (28.09.2011) On the asymptotic regime of a model for friction mediated by transient elastic linkages. Vortrag bei: Conference on nonlinear PDEs in Mathematical Biology, Edinburgh/UNITED KINGDOM.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Elbau, Peter (14.01.2011) Non-Local Functionals for Imaging. Vortrag bei: Inverse Problems Seminar, Linz/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Emans, Maximilian (12.09.2011) A fast implementation of v-cycle AMG for symmetric problems. Vortrag bei: PPAM 2011, Torun/POLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Emans, Maximilian (12.09.2011) Parallel coarse-grid treatment in AMG for coupled problems. Vortrag bei: PPAM 2011, Torun/POLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Emans, Maximilian (20.06.2011) Algebraic Multigrid Preconditioning for mixed elliptic-hyperbolic problems. Vortrag bei: COUPLED PROBLEMS 2011, Kos/GREECE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Georgiev, Ivan (09.06.2011) Preconditioner for DG Discretization of Linear Elasticity Equations. Vortrag bei: 8th International Conference on "Large-Scale Scientific Computations" (LSSC'11), Sozopol/BULGARIA .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Georgiev, Ivan (22.11.2011) Generalized hierarchical bases for discontinuous Galerkin discretizations of anisotropic elliptic problems. Vortrag bei: SPOMECH workshop on Reliable solution of nonlinear problems in mechanics, Ostrava/CZECH REPUBLIC.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Haskovec, Jan (19.07.2011) Fluid dynamic description of flocking via Povzner-Boltzmann equation. Vortrag bei: ICIAM 2011, Vancouver/CANADA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Haskovec, Jan (23.11.2011) On two models of biological direct aggregation. Vortrag bei: Transport equations in the life sciences, Wien/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Haskovec, Jan (27.07.2011) From individual to collective behaviour of coupled jump processes: a locust example. Vortrag bei: The 5th G. J. Butler Memorial Conference on Differential Equations and Population Biology, Edmonton/CANADA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Haskovec, Jan (29.06.2011) Modelling agent interactions in high dimension. Vortrag bei: 8th European Conference on Mathematical and Theoretical Biology, Krakow/POLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kasumba, DI Dr. Henry (23.09.2011) On Free Surface PDE constrained Shape Optimization Problems. Vortrag bei: 15th Austrian-French-German Conference On Optimization (AFG scientists), 1, place Emile Blouin - Toulouse/FRANCE .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kraus, J. (16.11.2011) Additive Schur complement approximation and application to multilevel preconditioning. Vortrag bei: Seminar at Scientific Computing Department of Information Technology, Uppsala/SWEDEN.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kraus, J. (28.10.2011) Additive Schur complement approximation and application to multilevel preconditioning. Vortrag bei: Seminar at Fraunhofer Institute for Industrial Mathematics (ITWM), Kaiserslautern/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

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Eingeladene wissenschaftliche Vorträge

Kraus, J.K. (09.06.2011) Additive Schur complement approximation for elliptic problems with oscillatory coefficients. Vortrag bei: 8th International Conference on "Large-Scale Scientific Computations", Sozopol/BULGARIA .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kraus, J.K. (22.07.2011) Additive Schur complement approximation and simultaneous two-grid method. Vortrag bei: ICIAM 2011, July 18 – 22, 2011, Vancouver, BC, Canada, Vancouver/CANADA .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kraus, Johannes (07.02.2011) Subspace Correction Method for Linear Elasticity Equations. Vortrag bei: 20th International Conference on Domain Decomposition Methods, San Diego/UNITED STATES .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kröner, Axel (14.10.2011) Adaptive finite element methods for optimal control of second order hyperbolic equations. Vortrag bei: International Workshop on Control and Optimization of PDEs/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kügler, Philipp (14.09.2011) Applications of Sparsity Enforcing Regularization in Systems Biology. Vortrag bei: CEMM Impromptu Seminar Series (CEMM), Vienna/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kügler, Philipp (22.06.2011) Use of lp-functionals for parameter inference in kinetic biological models. Vortrag bei: Max-Planck-Institute Seminar Series (Max-Planck-Institut für Molekulare Pflanzenphysiologie), Potsdam-Golm/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Kügler, Philipp (23.09.2011) Regularization of Inverse Problems in Molecular Biology. Vortrag bei: Institute Seminar Moscow State University (Department of Mathematics, Physical Faculty, Moscow State University), Moscow/RUSSIAN FEDERATION.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Prof. Dr. Ulrich (02.06.2011) Multiharmonic Finite Element Analysis of Time-Periodic Optimal Control Eddy Current Problems. Vortrag bei: Colloquium on Occasion of Prof. Ronald H.W. Hoppe's 60th Birthday, Augsburg/GERMANY .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Prof. Dr. Ulrich (07.02.2011) Parameter-robust and almost optimal solvers for eddy current problems in the frequency domain. Vortrag bei: 20th International Conference on Domain Decomposition Methods 7-11 February 2011, San Diego in La Jolla, California/UNITED STATES .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Prof. Dr. Ulrich (09.03.2011) The Multiharmonic Finite Element Method for Simulation and Control of Evolution Problems. Vortrag bei: conference on "Computational Methods in Multi-dimensional Applications", Leipzig/GERMANY .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Prof. Dr. Ulrich (22.05.2011) A robust preconditioned MinRes solver for distributed time-periodic eddy current optimal control problems. Vortrag bei: Oberwolfach workshop "Fast Solvers for Partial Differential Equations" 22-28 May 2011, Oberwolfach/GERMANY .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Prof. Dr. Ulrich (28.03.2011) Multiharmonic methods for solving initial-boundary value problems. Vortrag bei: 3rd Spring School on "Analytical and Numerical Aspects of Evolution Equations", Essen/GERMANY .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Maximilian, Emans (05.10.2011) Practical aspects of parallel k-cycle AMG in CFD. Vortrag bei: International PARNUM Workshop 2011, Leibnitz/ AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Maximilian, Emans (20.04.2011) Krylov-accelerated AMG using FGMRES. Vortrag bei: 82th GAMM Annual Meeting, Graz/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Naumova, V. (23.09.2011) Adaptive parameter choice for one-sided finite differerence schemes and its application in Diabetes Technology. Vortrag bei: Chemnitz Symposium on Inverse Problems 2011, Chemnitz/GERMANY .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Naumova, Valeriya (14.12.2011) Reading Blood Glucose from Subcutaneous Electric Current by Means of a Regularization in Variable Reproducing Kernel Hilbert Spaces (I). Vortrag bei: 50th IEEE Conference on Decision and Control and European Control Conference, Orlando/UNITED STATES .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Niebsch, Dr. Jenny (21.02.2011) Unbalances in ultra-precision cutting machinery and the relation to surface quality. Vortrag bei: 9. Internationale Tagung Schwingungen in rotierenden Maschinen, Darmstadt/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Niebsch, Dr. Jenny (30.08.2011) Inverse Imbalance Determination in Rotordynamics and Industrial Applications. Vortrag bei: Industrial Mathematics Seminar (Universität Helsinki)/FINLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Niebsch, Jenny (12.05.2011) Modellbasierte Verfahren zur Bestimmung von Rotorunwuchten. Vortrag bei: Profi(t) am Wind (Bachmann Monitoring GmbH), Feldkirch/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Niebsch, Jenny (13.04.2011) Bestimmung von Unwuchten aus Schwingungsmessungenals Inverses Problem. Vortrag bei: Seminar Institut für Turbomaschinen (Institut für Turbomaschinen, TU Graz), Graz/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

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Eingeladene wissenschaftliche Vorträge

Niederreiter, H. (02.08.2011) Independence of two randomness properties of sequences over finite fields. Vortrag bei: Workshop on Finite Fields and Pseudorandomness, Linz/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Niederreiter, Harald (22.11.2011) Complexity measures for multisequences. Vortrag bei: Workshop on sequences, randomness, and complexity, Istanbul/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Niederreiter, Harald (24.11.2011) Results and problems on randomness and complexity of sequences. Vortrag bei: Workshop on sequences, randomness, and complexity, Istanbul/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Ölz, Dietmar (03.11.2011) Modelling contractility and antiparallel flows in actomyosin bundles. Vortrag bei: Seminar Talk, Mainz/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Ölz, Dietmar (23.03.2011) The asymptotic regime of a model framework for friction mediated by transient elastic linkages. Vortrag bei: Math. Methods and Modeling of Biophysical Phenomena/BRAZIL.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pereverzyev, S. (20.07.2011) A Meta-Learning Approach to the Regularized Learning - Case Study: Blood Glucose Prediction. Vortrag bei: Mathematical and Computational Foundations of Learning Theory, Dagstuhl/GERMANY .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pereverzyev, Sergei V. (15.11.2011) A Meta-Learning Approach to the Regularized Learning - Case Study: Blood Glucose Prediction. Vortrag bei: JIP 11, Annaba/ALGERIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Rodrigues, Sérgio S. (11.10.2011) On the exponential stabilization of a nonstationary solution for Navier-Stokes equations. Vortrag bei: International Workshop on Control and Optimization of PDEs/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Schnass, Karin (06.01.2011) Dictionary Identification - Sparse Matrix-Factorisation via L1-Minimisation. Vortrag bei: SMALL Workshop on Sparse Dictionary Learning, London/UNITED KINGDOM .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (07.01.2011) Reconstruction of interfaces using only the P or S parts of the elastic waves. Vortrag bei: AMS-meeting/UNITED STATES.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (08.03.2011) Inverse scattering by interfaces. Vortrag bei: SNU-Seoul/KOREA, REPUBLIC OF.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (08.03.2011) Reconstruction of interfaces using elastic waves. Vortrag bei: SNU-Seoul/KOREA, REPUBLIC OF.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (15.11.2011) Reconstruction of interfaces using multifrequency acoustic incident waves. Vortrag bei: Annaba-11/ALGERIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (22.02.2011) Reconstruction of interfaces using multifrequency acoustic incident waves. Vortrag bei: CPT-Marseille/FRANCE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (23.03.2011) Inverse scattering by interfaces. Vortrag bei: KUWAIT-2011/KUWAIT.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (24.04.2011) Inverse scattering using elastic waves. Vortrag bei: TAMTAM-11/TUNISIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (25.02.2011) Reconstruction of interfaces using elastic waves. Vortrag bei: LATP-Marseille, Marseille/FRANCE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, M. (30.03.2011) Reconstruction of interfaces using multifrequency acoustic incident waves. Vortrag bei: KUWAIT-2011/KUWAIT.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Thanh, Nguyen Trung (24.11.2011) Inverse obstacle scattering problems using multifrequency measurements. Vortrag bei: Workshop on Wave Propagation and Scattering, Inverse Problems and Applications in Energy and the Environment, RICAM special semester 2011 (RICAM), Linz/ AUSTRIA .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Thanh, Nguyen Trung (25.06.2011) Passive infrared technique for buried object detection and classification. Vortrag bei: The 8th IEEE Workshop on Object Tracking and Classification beyond the Visible Spectrum, Colorado Springs/UNITED STATES.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Tomar, Satyendra (05.09.2011) A posteriori error estimates for nonconforming approximations of evolutionary convection-diffusion problems. Vortrag bei: ENUMATH 2011, Leicester/UNITED KINGDOM .; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Vybiral, Jan (04.07.2011) Dimensionality reduction for dynamical systems. Vortrag bei: Foundations of Computational Mathematics/HUNGARY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Vybiral, Jan (12.10.2011) Function spaces with varying smoothness and integrability. Vortrag bei: Seminar on function spaces, Poznan, Poland/ POLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

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Eingeladene wissenschaftliche Vorträge

Vybiral, Jan (14.10.2011) Various function spaces: their theory and applications. Vortrag bei: Seminar, TU Berlin/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Vybiral, Jan (25.01.2011) Johnson-Lindenstrauss lemma for circulant matrices. Vortrag bei: Seminar on MPI, Leipzig, Leipzig/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Vybiral, Jan (28.01.2011) Average best m-term approximation. Vortrag bei: Seminar on function spaces, FSU Jena, Jena/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (08.07.2011) Einige Anwendungen von Charaktersummen. Vortrag bei: Mathematisches Seminar der Universität Ulm (Universität Ulm), Ulm/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Winterhof, Arne (21.03.2011) Charaktersummen, Kreisteilungsklassen und Anwendungen. Vortrag bei: Mathematisches Seminar (Universität Magdeburg), Magdeburg/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (24.11.2011) On some measures of pseudorandomness. Vortrag bei: Workshop on sequences, randomness, and complexity, Istanbul/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (26.10.2011) Permutations for check digit systems. Vortrag bei: Workshop on rational functions over finite fields and their applications, Istanbul/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (27.04.2011) Polynome über endlichen Körpern und Anwendungen. Vortrag bei: Mathematisches Seminar Uni Klagenfurt (Universität Klagenfurt), Klagenfurt/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Winterhof, Arne (27.10.2011) Interpolation of some cryptographic functions. Vortrag bei: Workshop on rational functions over finite fields and applications, Istanbul/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Eingeladene wissenschaftliche Vorträge: Keynotes and Named Lectures

Christoph, Winkler (17.11.2011) Actin filament tracking and modeling of lamellipodia. Vortrag bei: Collective behavior in active agent systems from experiments to models/FRANCE.; Typ: Named Lecture (internationale Veranstaltung)

Engl, Heinz W. (22.05.2011) Adaptive Optics for ESO. Vortrag bei: Vortrag anlässlich Besuch einer österreichischen Delegation (ESO), Paranal/CHILE.; Typ: Named Lecture (internationale Veranstaltung)

Engl, Heinz W. (24.05.2011) Industrial Mathematics and Inverse Problems. Vortrag bei: Gastvortrag Universidad de Chle (Universidad de Chile), Santiago/CHILE.; Typ: Named Lecture (internationale Veranstaltung)

Kraus, J. (22.11.2011) Algebraic multilevel methods. Vortrag bei: SPOMECH Workshop 2011 (Technical University of Ostrava and Insitute of Geonics of the Czech Academy of Sciences), Ostrava/CZECH REPUBLIC .; Typ: Keynote (internationale Veranstaltung)

Langer, Prof. Dr. Ulrich (05.06.2011) A Non-Standard Finite Element Method based on Boundary Integral Operators. Vortrag bei: 8th International Conference "Large-Scale Scientific Computations" (LSSC'11), Sozopol/BULGARIA.; Typ: Keynote (internationale Veranstaltung)

Langer, Prof. Dr. Ulrich (22.08.2011) The Multiharmonic Finite Element Method for the Simulation and Optimal Control of Parabolic Problems. Vortrag bei: 4th Workshop on Advanced Numerical Methods for Partial Differential Equation Analysis, 22 - 24 August 2011, St. Petersburg/RUSSIAN FEDERATION.; Typ: Keynote (internationale Veranstaltung)

Niederreiter, H. (28.10.2011) Algebra und Kryptographie: eine glückliche Verbindung. Vortrag bei: Festkolloquium zur Emeritierung von Winfried Müller, Klagenfurt/AUSTRIA.; Typ: Keynote

Ramlau, Ronny (05.12.2011) Regularization of Inverse Problems - Methods and Applications. Vortrag bei: Synchrotron Grenoble, Grenoble/FRANCE.; Typ: Named Lecture (internationale Veranstaltung)

Ramlau, Ronny (07.04.2011) Inverse Problems in Adaptive Optics. Vortrag bei: Kolloquium an der Universität Chemnitz (Universität Chemnitz), Universität Chemnitz/GERMANY.; Typ: Keynote (internationale Veranstaltung)

Ramlau, Ronny (10.02.2011) Inverse Problems in Adaptive Optics. Vortrag bei: Vortrag an der Universität Frankfurt (Universität Frankfurt), Frankfurt/GERMANY.; Typ: Named Lecture

Ramlau, Ronny (12.05.2011) Modellbasierte Verfahren zur Bestimmung von Rotorunwuchten. Vortrag bei: Workshop PROFI[T] AM WIND (Bachmann Monitoring GmbH), Feldkirch/AUSTRIA.; Typ: Named Lecture

Ramlau, Ronny (14.07.2011) New Math Methods: Numerical Computation. Vortrag bei: Seminar on Software Application in Tunnelling (Softwarepark Hagenberg), Hagenberg/AUSTRIA.; Typ: Named Lecture

Ramlau, Ronny (26.05.2011) In-verse Prob-lems in Astronomy. Vortrag bei: Applied Inverse Problems Conference, Texas/UNITED STATES.; Typ: Named Lecture (internationale Veranstaltung)

Ramlau, Ronny (26.09.2011) A Kaczmarz type iterative reconstructor for Multi Conjugate Adaptive Optics. Vortrag bei: Conference "Adaptive Optics for Extremely Large Telescopes - AO for ELT 2" (University of Victoria), Victoria/CANADA.; Typ: Named Lecture (internationale Veranstaltung)

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Eingeladene wissenschaftliche Vorträge: Keynotes and Named Lectures

Ramlau, Ronny (30.08.2011) Inverse Problems in Adaptive Optics. Vortrag bei: Forschungsaufenthalt bei Prof. Samuli Siltanen (Department of Mathematics and Statistics of University of Helsinki), Helsinki/FINLAND.; Typ: Named Lecture (internationale Veranstaltung)

Vybiral, Jan (20.09.2011) Besov and Triebel-Lizorkin spaces of variable smoothness and integrability. Vortrag bei: Function Spaces, Differential Operators, Nonlinear Analysis (FSDONA-2011)/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (12.09.2011) Regularization methods for optimization problems. Vortrag bei: IFIP TC7, Berlin/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (13.10.2011) Time-optimal control of the wave equation. Vortrag bei: International Workshop on Control and Optimization of PDEs, Graz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (15.03.2011) Regularization methods for optimization problems. Vortrag bei: OCIP 2011, Muenchen/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (17.03.2011) Adaptive Methoden zur numerischen Loesung von Optimalsteuerungsproblemen. Vortrag bei: Institutskolloquium (Uni Wuerzburg), Wuerzburg/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (18.05.2011) Convergence and path-following for regularization of optimal control problems subject to an elliptic variational inequality. Vortrag bei: SIOPT 2011, Darmstadt/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (19.04.2011) Time-optimal control of the wave equation. Vortrag bei: GAMM 2011, Graz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (23.05.2011) Time-optimal control of the wave equation. Vortrag bei: Bayreuth Kolloquium, Bayreuth/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (28.10.2011) Regularization error estimates and discrepancy principle for optimal control problems with inequality constraints. Vortrag bei: Large-Scale Inverse Problems and Applications in the Earth Sciences, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (30.11.2011) Regularization methods for optimization problems. Vortrag bei: Optimal Control of Partial Differential Equations, Klaffenbach/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Winterhof, Arne (27.09.2011) Some applications of character sums. Vortrag bei: Conference of the Austrian Mathematical Society 2011, Krems/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Yang, Huidong (06.05.2011) A preconditioned GMRES solver with algebraic multigrid accelerations for the coupled systems of fluid-structure interaction problems. Vortrag bei: 7th Austrian Numerical Analysis Day/AUSTRIA.; Typ: Named Lecture

Yang, Huidong (15.10.2011) Two finite element methods on hybrid meshes and their applications to the fluid-structure interaction problems. Vortrag bei: Söllerhaus Workshop on Domain Decomposition Methods/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Yang, Huidong (29.09.2011) A Numerical Study on a Preconditioned GMRES Solver with Algebraic Multigrid Accelerations for the Fluid-Structure Interaction Problems on Hybrid Meshes. Vortrag bei: 24th Chemnitz FEM Symposium/GERMANY.; Typ: Named Lecture

Sonstige wissenschaftliche Vorträge

Aichinger, Michael (21.10.2011) Blazingly Fast and Insightful Risk Analysis. Vortrag bei: Wolfram technology conference 2011/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Aichinger, Michael (28.04.2011) Fast and stable algoritms for advanced equity model calibration. Vortrag bei: 8th International Conference on Computational Management Science/SWITZERLAND.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Binder, Andreas (06.06.2011) Efficient Valuation of Complex Derivatives on the GPU. Vortrag bei: Computational Finance Tour 2011, London/UNITED KINGDOM.; Typ: Sonstiger Veranstaltungsbeitrag

Christoph, Winkler (20.10.2011) Actin filament tracking in lamellipodia. Vortrag bei: Mitarbeiterseminar/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Fürst, Johannes (07.11.2011) Influence fo underlying copula model on the prices of basket credit derivatives. Vortrag bei: RICAM Group Seminar - Transfer Group, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Fürst, Johannes (26.09.2011) Comparison of different methods for the calibration of one and two factor Hull White models. Vortrag bei: RICAM Group Seminar - Transfer Group, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Georgiev, Ivan (08.09.2011) Two-Level Method for discontinuous Galerkin Discretizations of Linear Elasticity Equations. Vortrag bei: European Numerical Mathematics and Advanced Applications (ENUMATH 2011), Leicester/UNITED KINGDOM .; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Georgiev, Ivan (12.10.2011) Preconditioning elasticity problems with discontinuous material properties. Vortrag bei: Special Semester on Multiscale

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Sonstige wissenschaftliche Vorträge

Simulation & Analysis in Energy and the Environment - Research Kitchen, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Georgiev, Ivan (23.06.2011) Two Level Method for Discontinuous Galerkin Discretizations of Elliptic Problems with Highly Varying Coefficients. Vortrag bei: Third Conference of the Euro-American Consortium for Promoting the Application of Mathematics in Technical and Natural Sciences (AMiTaNS'11), Albena/BULGARIA .; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Haslinger, Josef (14.09.2011) State of the art review on simulation of nonsmooth dynamical multi body systems. Vortrag bei: RICAM Group Seminar - Transfer Group, Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Haslinger, Josef (24.11.2011) Projektstatus EXCITE. Vortrag bei: IMCC Status Meeting (RICAM und AVL Graz), Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hegedues, Gabor (01.03.2011) Betti numbers of Stanley--Reisner rings with pure resolutions. Vortrag bei: RICAM Group Seminar: Symbolic Computation/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hegedues, Gabor (05.12.2011) The closed 5R linkages. Vortrag bei: Linz Algebra Research Day Christmas edition 2011/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hegedues, Gabor (07.06.2011) The boundary volume of lattice polytopes and smooth polytopes. Vortrag bei: Toric geomety and its applications, Leuven/BELGIUM.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (14.11.2011) Bond theory and closed 5R linkages. Vortrag bei: RICAM Group Seminar - Symbolic Computation - Bond theory and closed 5R linkages, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (21.06.2011) The Minkowskian planar 4R mechanism. Vortrag bei: Conference on Geometry - Theory and Applications Vorau 2011, Vorau/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (24.05.2011) An Upper Bound Theorem concerning lattice polytopes. Vortrag bei: RICAM Group Seminar: Symbolic Computation/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hegedues, Gabor (26.05.2011) Riemannian polytopes. Vortrag bei: Linz Algebra Research Day 2011/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hegedues, Gabor (29.10.2011) Smooth polytopes and Golybshev conjecture. Vortrag bei: CCAAG, Messina/ITALY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (30.08.2011) Multivalued generalizations of the Frankl--Pach Theorem. Vortrag bei: EUROCOMB 11, Budapest/HUNGARY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Heinzle, Roman (12.10.2011) Projektstatus. Vortrag bei: Projekttreffen (AVL Graz), Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Heinzle, Roman (24.11.2011) Projektstatus. Vortrag bei: Projekttreffen (RICAM und AVL Graz), Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hodorog, Madalina (02.08.2011) Approximate Algorithms for Plane Curves Singularities. Vortrag bei: Discrete Optimization Group Seminar, Ecole Polythechnique Federale de Lausanne, Ecole Polythechnique Federale de Lausanne, Lausanne/SWITZERLAND.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (05.12.2011) Singularities and Knot Theory. Vortrag bei: Linz Algebra Research Day LARD (2011, Christmas), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hodorog, Madalina (06.10.2011) Symbolic-numeric algorithms and homotopy methods of plane curves singularities. Vortrag bei: DK Status Seminar, Strobl/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (07.06.2011) A Regularization Method for Computing Approximate Invariants of Plane Curves Singularities. Vortrag bei: 4th International Workshop on Symbolic-Numeric Computation, San Jose, California/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (20.06.2011) An Adapted Version of the Bentley-Ottmann Algorithm for Invariants of Plane Curve Singularities. Vortrag bei: 11th International Conference on Computational Science and Its Applications, Session: Computational Geometry and Applications, Santander/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (23.05.2011) Symbolic-Numeric Algorithms for Invariants of Plane Curves Singularities. Vortrag bei: Hearing of the Doctoral Program "Computational Mathematics" from Linz, Austria, Vienna/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (24.08.2011) Symbolic-Numeric Algorithms for Invariants of Plane Algebraic Curves. Vortrag bei: Numerical Algebraic Geometry Lab, Department of Mathematics, Colorado State University, Colorado State University, Fort Collins/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Karer, Erwin (06.05.2011) Subspace correction method for a locking-free finite element approximation of the linear elasticity equations. Vortrag bei:

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Sonstige wissenschaftliche Vorträge

7th Austrian Numerical Analysis Day (Alpen-Adria-Universität Klagenfurt, Institute of Mathematics and Insitute of Applied Mechatronics), Klagenfurt/AUSTRIA .; Typ: Sonstiger Veranstaltungsbeitrag

Karer, Erwin (19.04.2011) Subspace correction method for a locking-free finite element approximation of the linear elasticity equations. Vortrag bei: 82nd Annual Meeting of the GAMM (TU Graz), Graz/AUSTRIA .; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Kleiss, Stefan (21.06.2011) Enhancing Isogeometric Analysis by a Finite Element-Based Local Refinement Strategy. Vortrag bei: Conference on Geometry - Theory and Application/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Kletzmayr, Christian (14.12.2011) GPU Computing: An Overview. Vortrag bei: RICAM Group Seminar - Transfer Group, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Korporal, Anja (05.04.2011) Generalized LODE Boundary Problems and Green's Operators. Vortrag bei: Research Seminar INRIA Saclay, Project DISCO, Gif-sur-Yvette Cedex/FRANCE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Korporal, Anja (07.10.2011) Symbolic Algorithms for Regular and Singular Boundary Problems. Vortrag bei: DK Status Seminar, Strobl/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Korporal, Anja (08.09.2011) Regular and Singular Boundary Problems in MAPLE. Vortrag bei: CASC 2011 Workshop on Computer Algebra in Scientific Computing (Universität Kassel), Kassel/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (14.03.2011) Domain Decomposition Methods for Total Variation Minimization. Vortrag bei: Workshop on Numerical Methods for Optimal Control and Inverse Problems, Garching bei München/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (21.04.2011) The Adaptive Iterative Bregman Algorithm. Vortrag bei: GAMM 2011, Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (28.01.2011) Analysis of the Adaptive Iterative Bregman Algorithm. Vortrag bei: Applied and Computational Analysis Graduate Seminar, Cambridge/UNITED KINGDOM.; Typ: Sonstiger Veranstaltungsbeitrag

Langer, Prof. Dr. Ulrich (28.11.2011) A Robust Preconditioned-MinRes-Solver for Distributed Time-Periodic Eddy Current Optimal Control Problems. Vortrag bei: workshop on "Optimal Control of Partial Differential Equations" November 28 - December 2, 2011, Klaffenbach/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Lorenz, Norbert (24.11.2011) Projektstatus EXCITE. Vortrag bei: Projekttreffen, Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Niederreiter, H. (11.07.2011) Probabilistic results on the joint linear complexity of multisequences. Vortrag bei: Finite Fields and Their Applications, Ghent/BELGIUM.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Ölz, Dietmar (29.06.2011) Modelling contractility and antiparallel flows in actomyosin bundles. Vortrag bei: ESMTB-Konferenz/POLAND.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Pereverzyev, S. (21.09.2011) Multiparameter Regularization in Geodetic Data Processing. Vortrag bei: Die Jahrestagung der Deutschen Mathematiker-Vereinigung, Minisymposium Geomathematik, Köln/GERMANY .; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Pereverzyev, Sergiy V. (29.11.2011) Some of the DIAdvisor Methods and Results with Perspective for IIT. Vortrag bei: DIAdvisor follow-up, Improved Insulin Therapy, Paris/FRANCE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Schicho, Josef (01.04.2011) Bennett Linkages and Dual Quaternions. Vortrag bei: Seminar Kinematics, Innsbruck/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Schicho, Josef (07.04.2011) Blowing up in numerical mathematics. Vortrag bei: Workshop Resolution of Singularities, Cumca/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (05.12.2011) Tschirnhaus-Weierstrass curves. Vortrag bei: Linz Algebra Research Day LARD (2011, Christmas), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Sevilla, David (17.06.2011) Decidir constructivamente la trigonalidad de una curva algebraica. Vortrag bei: Local group seminar, Universidad Politécnica de Valencia (Valencia)/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag

Sevilla, David (26.05.2011) Attempt at the Casas-Alvero conjecture at degree 12. Vortrag bei: Linz Algebra Research Day 2011/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Thanh, Nguyen Trung (25.07.2011) Reconstruction of acoustic obstacles using multifrequency scattering data. Vortrag bei: The 10th International Conference on Mathematical and Numerical Aspects of Waves, Vancouver/CANADA .; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Unger, Gerhard (19.04.2011) Convergence orders of iterative methods for nonlinear eigenvalue problems. Vortrag bei: 82nd Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM) (Gesellschaft für Angewandte Mathematik und Mechanik (GAMM)), Graz/AUSTRIA .; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

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Sonstige wissenschaftliche Vorträge

Vybiral, Jan (05.05.2011) Generating Random Signals and Sparse and Compressible Vectors. Vortrag bei: Sampling Theory and Applications (SampTA 2011), Nanyang Technological University/SINGAPORE.; Typ: Sonstiger Veranstaltungsbeitrag

Vybiral, Jan (05.05.2011) Learning Functions of Few Arbitrary Linear Parameters in High Dimensions. Vortrag bei: Sampling Theory and Applications (SampTA 2011), Nanyang Technological University/SINGAPORE.; Typ: Sonstiger Veranstaltungsbeitrag

Vybiral, Jan (08.03.2011) Learning Functions of Few Arbitrary Linear Parameters in High Dimensions. Vortrag bei: Workshop "Sparse and Low Rank Approximation", BIRS, Banff/CANADA.; Typ: Sonstiger Veranstaltungsbeitrag

Weimann, M. (15.11.2011) Factoring bivariate polynomials using singularities. Vortrag bei: Journées Nationales du Calcul Formel, CIRM, Marseilles/FRANCE .; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Willems, Joerg (06.05.2011) Robust Two- and Multi-Level Preconditioners for High-Contrast Problems. Vortrag bei: 7th Austrian Numerical Analysis Day, Klagenfurt/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Willems, Jörg (09.02.2011) Robust Additive Schwarz Preconditioners for Abstract Positive Definite Operators. Vortrag bei: 20th International Conference on Domain Decomposition Methods, San Diego, CA/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Willems, Jörg (09.06.2011) Robust Preconditioners for General SPD Operators. Vortrag bei: 8th International Conference on Large-Scale Scientific Computations, Sozopol/BULGARIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Willems, Jörg (19.04.2011) Robust Iterative Solvers for General Symmetric Positive Definite Operators. Vortrag bei: 82nd Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM), Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (02.08.2011) Some problems related to finite fields. Vortrag bei: Mini-Workshop on finite fields and pseudorandomness (RICAM), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (05.12.2011) Check digit systems and orthomorphisms. Vortrag bei: Linz Algebra Research Day LARD (2011, Christmas), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Winterhof, Arne (11.07.2011) Polynomial quotients. Vortrag bei: Finite fields and applications Fq10, Ghent/BELGIUM.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (26.05.2011) Waring problem over finite fields with polynomials. Vortrag bei: LARD 2011, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Winterhof, Arne (26.08.2011) Some applications of Redei functions. Vortrag bei: Turan memorial conference, Budapest/HUNGARY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Wissenschaftliche Posterpräsentationen

Georgiev, Ivan (03.10.2011) Preconditioning of Non-Conforming FEM Systems. Posterpräsentation bei: Workshop on Simulation of Flow in Porous Media and Applications in Waste Management and CO2 Sequestration, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sampath, Sergei Pereverzyev and Sivananthan (02.12.2011) Some of the DIAdvisorTM Methods and Results with Perspective to Prediction of Blood Glucose for Diabetes Patients in India. Posterpräsentation bei: EU-INDIA S&T COOPERATION DAYS 2011, Vienna/AUSTRIA .; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Willems, Joerg (03.10.2011) Robust Preconditioners for General SPD Operators. Posterpräsentation bei: Workshop on Simulation of Flow in Porous Media and Applications in Waste Management and CO2 Sequestration/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Yang, Huidong (06.10.2011) A Numerical Study on a Preconditioned GMRES Solver for the Fluid-Structure Interaction Problems. Posterpräsentation bei: International Workshop on Parallel Numerics 2011/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Yang, Wei (02.03.2011) Inferring Biochemical Perturbation Sites from Metabolomics Covariance Data - A Mathematical Framework. Posterpräsentation bei: FEBS-SystemsX-SysBio2011:From Molecules to Function, Innsbruck/AUSTRIA .; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Zarzer, Clemens (02.03.2011) Qualitative and Quantitative Inverse Analysis of the Hypothalamus-Pituitary-Adrenals Axis. Posterpräsentation bei: FEBS-SystemsX-SysBio2011:From Molecules to Function, Innsbruck/AUSTRIA.; Typ: Named Lecture (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

2.7. Scientific Events 2011

2.7.1. Special Semester on "Multiscale Simulation & Analysis in Energy and the Environment", October 3rd - December 16th, 2011

Program Committee: P. Bastian, M. Cullen, H. Engl, M. Freitag, I.G. Graham, U. Langer, M. Melenk, R. Scheichl, M.F. Wheeler

Technological advances have greatly improved our quality of life. However, they bring with them a huge surge in energy requirement which in turn puts at risk our entire bio-sphere. It is of paramount importance to predict these risks and to develop better solutions for the future. One of the central tasks is the accurate simulation of multiphase flow above and under ground. The key features that make it extremely hard to produce reliable predictions are the multiple time and length scales that arise, as well as the lack of and uncertainty in data. While there is a fairly long history of empirically successful robust computational techniques for many such multiscale problems, the rigorous (numerical) analysis of these methods is of extremely high current interest.

The special semester provided a stimulating environment for research on cutting edge problems in numerical analysis and scientific computing of multiscale (direct and inverse) problems, and stimulated collaboration between mathematicians, engineers, hydrologists, meteorologists and other environmental scientists on problems in risk assessment and in the robust computation of atmospheric and subsurface flow and wave propagation.

Further information: www.ricam.oeaw.ac.at/specsem/specsem2011

Workshop 1: "Simulation of flow in porous media and applications in waste management and CO2 sequestration" (October 3rd-7th, 2011)

Organizers: P. Bastian, J. Kraus, R. Scheichl, M.F. Wheeler

Subsurface flow problems are inherently multiscale in space and time due to the large variability of material properties and the coupling of many different physical processes, such as advection, diffusion, reaction and phase exchange, as well as coupling to surface flow models. Moreover, parameters of the models are difficult to access and often uncertain. The workshop brought together key numerical mathematicians whose interest is in the analysis and computation of multiscale subsurface flow and practitioners whose interest is in the application of these core problems in energy and the environment, such as deep geological disposal of radioactive waste or carbon capture and storage.

Invited Speakers (include):P. Bastian (IWR Heidelberg), J. Becker (ITWM Kaiserslautern), A. Bourgeat (Lyon), A. Cliffe (Nottingham), H. Dahle (Bergen), M. Discacciati (Barcelona), Y. Efendiev (Texas A&M), J. Erhel (INRIA Rennes), A. Ern (Paris), J. Fuhrmann (WIAS Berlin), L. Halpern (Paris), R. Kornhuber (FU Berlin), R. Marschallinger (GIScience Salzburg), A. Michel (IFP Paris), A. Mikelic (Lyon), J. Nordbotten (Bergen), C. Pechstein (Linz), M. Vohralik (Paris), M. Wheeler (UT Austin), B. Wohlmuth (TU Munich), I. Yotov (Pittsburgh)

Further information: www.ricam.oeaw.ac.at/specsem/specsem2011/workshop1

Workshop 2: "Large-scale inverse problems in the earth sciences" (October 24th-28th, 2011)

Organizers: M. Cullen, M. Freitag, S. Kindermann

Practical problems in the earth sciences have a very large number of degrees of freedom, however the measurements are limited and noisy. They are usually ill-posed, and occur in data assimilation and many other inverse problems in geophysics. The use of computer models to allow the observations to be exploited is essential. This workshop examined the challenges that arise in doing this successfully.

Invited Speakers: U. Asher (UBC), M. Burger (Muenster), O. Cirpka (Tuebingen), M. Cullen (UK Met Office), M. Dashti (Warwick), M. Fisher (ECMWF), M. Freitag (Bath), S. Gratton (CERFACS Toulouse), E. Haber (UBC), T. Helin (Linz), B. Kaltenbacher (Graz/Klagenfurt), S. Kindermann (Linz), A. Lawless (Reading), A. Leitao (Santa Catarina), N. Nichols (Reading), T. Payne (UK Met Office), R. Potthast (DWD), S. Reich (Potsdam), O. Talagrand (ENS Paris), D. Wachsmuth (RICAM Linz), A. Weaver (CERFACS Toulouse)

Further information: www.ricam.oeaw.ac.at/specsem/specsem2011/workshop2

Workshop 3: "Wave propagation and scattering, inverse problems and applications in energy and the environment" (November 21st-25th, 2011)

Organizers: I.G. Graham, U. Langer, M. Melenk, M. Sini

The efficient computation of wave propagation and scattering is a core problem in numerical mathematics and arises in many applications in energy and the environment - for example forward wave propagation in heterogeneous media (climate modelling) and seismic inversion for subsurface imaging (oil exploration, earthquake prediction). The workshop brought together key numerical mathematicians whose interest is in the analysis and computation of wave propagation and scattering problems, and in inverse problems, together with practitioners whose interest is in the applications of these core problems.

Invited Speakers: H. Ammari (ENS Paris), T. Betcke (UCL), S. Chandler-Wilde (Reading), P. Childs (Schlumberger Cambridge), M. Gander (Geneva), M. Grote (Basel), R. Hiptmair (ETH Zuerich), G. Hu (WIAS), M. Kaltenbacher (University Klagenfurt), I. Livschits (Ball State University), S. Minkoff (Maryland), L. Nannen (TU Vienna), F. Nataf (Paris), T. Nguyen (RICAM Linz), R. Potthast (Reading/Goettingen), R. Ramlau (RICAM Linz), J. Schoeberl (TU Vienna), E. Spence (University of Bath), O. Steinbach (TU Graz), C. Stolk (Amsterdam), R. Tezaur (Stanford), J. Toivanen (Jyvaeskylae)

Further information: www.ricam.oeaw.ac.at/specsem/specsem2011/workshop3

Workshop 4: "Numerical Analysis of Multiscale Problems & Stochastic Modelling" (December 12th-16th, 2011)

Organizers: I.G. Graham, M. Melenk, R. Scheichl, J. Willems

The workshop focused on effective computational tools for multiscale problems, uncertainty quantification, and adaptive modeling error control. Topics included homogenization, upscaling techniques and multiscale approximation, as well as Monte-Carlo, Quasi-Monte-Carlo, stochastic Galerkin/collocation methods, and adaptive techniques for high-dimensional problems. Particular emphasis was on applications related to flow and wave propagation in porous and heterogeneous media.

Invited Speakers: A. Abdulle (EPFL Lausanne), G. Allaire (Ecole Polytechnique Paris), S. Boyaval (Paris), E. Buckwar (Linz), G. Dagan (Tel Aviv), S. Dahlke (Marburg), B. Engquist (UT Austin), O. Ernst (TU Bergakademie Freiberg), A. Fiori (Universita di Roma Tre), M. Fornasier (TU Munich), V. Ha Hoang (NTU Singapore), R. Hilfer (Stuttgart), X. Hu (Penn State), O. Iliev (ITWM Kaiserslautern), B. Khoromskij (MPI MIS), R. Lazarov (Texas A&M), O. Le Maitre (Paris), S. Margenov (Sofia), H. Matthies (Braunschweig), F. Nobile (Milan), M. Ohlberger (Muenster), G. Samaey (Leuven), M. Sarkis (WPI), C. Schwab (ETH Zuerich), R. Stevenson (Amsterdam), D. Tartakovsky (UC San Diego), L. Zikatanov (Penn State)

Further information: www.ricam.oeaw.ac.at/specsem/specsem2011/workshop4

Beside the workshops there were other **special events** organized by the long term guests, guest lecturer, and local people:

- Special Lecture Series on "Multilevel Methods for Multiscale Problems": http://www.ricam.oeaw.ac.at/specsem/specsem2011/activities/lecture_series/

- Special Graduate Seminar on "Multiscale Discretisation Techniques": http://www.ricam.oeaw.ac.at/specsem/specsem2011/activities/graduate_seminar/

- Wednesday Research Kitchen: http://www.ricam.oeaw.ac.at/specsem/specsem2011/activities/research_kitchen/

- Public Lecture on "Tsunami Früh-Warnung: Mathematik und Wissenschaftliches Rechnen im Dienste der Sicherheit": http://www.ricam.oeaw.ac.at/specsem/specsem2011/activities/public_lecture/

We expect that several publications will appear as a direct output of this special semester. In particular, thee book projects proposed by participants of the special semester have been submitted to the Radon Series on Computational and Applied Mathematics published by De Gruyter.

2.7.2. Other Scientific Events

The complete AkademIs report is attached as DVD, other scientific events are shown in chapter **2.8.11 Seminars**.

2.8. Scientific cooperation 2011

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:

Internal cooperation:

- **J. Kraus** and **S. Tomar** are cooperating on algebraic multilevel iteration (AMLI) preconditioning methods and together with **K. Gahalaut** on geometric multigrid methods for problems arising from isogeometric analysis (IGA).

- **J. Kraus** cooperates with **I. Georgiev** on robust multilevel methods for discontinuous Galerkin discretizations of scalar elliptic and vector-field problems with jumps in the coefficients.

- **NFN S 117** (see below)

External cooperation:

- There is a special Collaborative Research Project on ***"Robust Large-Scale Scientific Computing Methods and Scalable Algorithms***" (2009 - 2012) of RICAM with the Institute of Information and Communication Technologies (IICT) of the Bulgarian Academy of Sciences (BAS) at Sofia (Bulgaria). This cooperation has resulted in numerous joint publications. **J. Kraus** cooperates with S. Margenov on robust algebraic multilevel methods.

- **U. Langer** and **S. Tomar** are participating in a consortium that successfully applied for a ***National Research Network*** on ***"Geometry and Simulation"*** (NFN S 117-N23). In this NFN we directly cooperate with B. Jüttler (JKU Linz), M. Rumpf

(University of Bonn) O. Scherzer (University of Vienna and RICAM), and W. Zulehner (JKU Linz) who are project partners in the NFN. Beside the intensive cooperation within the NFN the NFN will establish an international netwotk of cooperation partners.

- **S. Tomar** cooperates with B. Jüttler (JKU Linz) on isogeometric methods for numerical solution of partial differential equations, within the framework of FWF project P21516-N18. They are both supervising the PhD student Stefan Kleiss who moved from Jüttler's group to our group in September 2011.

- **J. Willems** cooperates with R. Lazarov (Texas A&M University) on the development of efficient and robust methods for heterogeneous, highly porous flow problems. This work is supported by the mutual **NSF project DMS-1016525** "Subgrid Discontinuous Galerkin Approximations of Brinkman Equation with Highly Heterogeneous Coefficients".

- **J. Kraus** cooperates with L. Zikatanov (Penn State University) on the design and analysis of optimal subspace correction and auxiliary space methods for elasticity problems and on (algebraic) multigrid methods.

- **J. Kraus** cooperates with S. Margenov and M. Lymbery (Bulgarian Academy of Sciences) on uniform preconditioning methods for anisotropic elliptic problems.

- **H. Yang** visited W. Fitch (University of Vienna) and C. Elemans (University of Southern Denmark), and started a collaboration on the fluid-structure-interaction for the biological simulations.

- ***SFB preproposal "MAXWELL++":*** **J. Kraus** and **U. Langer** are participating in a consortium that has submitted a preproposal for a Special Research Programme (SFB) on the mathematical and numerical analysis of multiphysics and multiscale problems in electrical engineering (***"MAXWELL++"***). The subproject of J. Kraus and U. Langer is on "Subspace correction methods for discontinuous Galerkin space-time discretizations of Maxwells equations". The proposed SFB consists of 3 subprojects on Algorithmic Numerics, 5 subprojects on Numerical Analysis, and 3 subprojects on Applications. The designated host institutions are the Alps-Adriatic University of Klagenfurt, the University of Applied Sciences St.Pölten, the Johannes Kepler University Linz, the Johann Radon Institute for Computational and Applied Mathematics, Linz, the Technical University of Graz, the Vienna University of Technology, and the University of Vienna.

Of course, there is a close cooperation within our group leading to numerous joint publications in the past. But there is also a close cooperation of the RICAM group with the Institute for Computational Mathematics at the JKU. The same is true for the FWF DK W1214 on *"Computational Mathematics"* that was evaluated and prolongated for further three years by the FWF in 2011. 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.

We also refer to Section 2.4 where the cooperation between D. Wachsmuth (Optimal Control Group) and S. Beuchler (Computational Mathematics group) is presented as one of our highlights in 2011.

2.8.2. Group "Inverse Problems"

Internal cooperation:

- S. Pereverzyev with transfer group on optimal regularization methods
- O. Scherzer with transfer group on the Kaczmarz method and data preprocessing

External Cooperation:

- with Novo Nordisk A/S (Denmark) on the DIAdvisor project and the patent application filed jointly with the Austrian Academy of Sciences;
- with Department of Information Engineering, University of Padova (Italy) on the assessment metric for blood glucose predictors;
- with Willi Freeden, University of Kaiserslautern (Germany), Volker Michel, University of Siegen (Germany), and Yanfei Wang, Institute of Geology and Geophysics, Chinese Academy of Sciences (China) on the organization of the conference "New Trends in Regularization theory and methods for Geomathematical problems" within the framework of the initiative Mathematics of Planet Earth 2013";
- with Prof. Gen Nakamura (Hokkaido, Japan) on the Interior Transmission Problems;
- with Prof. Amin Boumenir (West Georgia, USA) on inverse spectral problems;
- with Dr. Guanghui Hu (WIAS, Germany) on elastic inverse problems.

2.8.3. Group "Symbolic Computation"

Internal cooperation:

- With Arne Winterhof from the Research Project ``Applied Discrete Mathematics and Cryptogtaphy'', we worked on algorithms for curves over finite fields and related topics where symbolic computation may be relavant and which have applications in cryptography or coding theory.
- Ronnie Ramlau and Jenny Niebsch from the Transfer Group helped us to use regularisation theory for an ill-posed problem that arose in a geometric context, namely the determination of the topological type of a curve singularity.
- with Ronnie Ramlau from the Transfer Group and Sergei Pereverzyev from the "Inverse Problems'' Group, we started to combine techniques from regularisation theory and complexity theory for analyzing symbolic-numetric algorithms..

External cooperation:

- An ongoing joint seminar with Bert Ju"ttler (University of Linz) -- we also have a

common doctoral college, where also members from the “Direct Field Group" are participating -- brought one joint publication on a clipping method for solving bivariate polynomial systems.

- Together with Irene Polo-Blanco and Jon Gonzalez (University of Cantabria), we devised algorithms for constructing and parametrising Del Pezzo surfaces.

- With Herwig Hauser (University of Vienna), we have a joint FWF project, which in this year lead to one joint publication on singularities of algebraic varieties.

- Bernard Mourrain (INRIA at Sophia Antipolis) was and is a frequent research partner in our project of computing the topological type of curve singularities.

- Georg Regensburger (Inria at Paris) and Markus Rosenkranz (University of Kent) advise the PhD thesis of Anja Korporal on symbolic methods for boundary problems.

- With Alexander Kasprzyk (Imperial College London), we obtained a formula for the boundary volume of a lattice polytope.

- With Juan Rafael Sendra (University of Alcala), we cooperated in the field of radical parametrizations of algebraic curve.

- Lajos Ronyai (Technical University of Budapest) cooperated with several members of the group, on different topics. Together with him, we generalized a theorem of Frankl and Pach, and we gave an algorithm for splitting algebras. The second cooperation was also joined by Gabor Ivanyos (Technical University of Budapest).

- With Hans-Peter Schröcker (University of Innsbruck), we just started a cooperation on algebraic method in kinematics.

2.8.4. Group “Analysis of Partial Differential Equations”

Internal cooperation:

- Massimo Fornasier, START Project

External cooperation:

- Gianni Dal Maso, SISSA, Trieste

- Antonio DeSimone, SISSA, Trieste

- Riccardo March, Consiglio Nazionale delle Ricerche, Roma

2.8.5. Group “Optimization and Optimal Control”

Internal cooperation:

- R. Ramlau and D. Wachsmuth were cooperating on Adaptive Optics.

- K. Kunisch cooperated with D. Wachsmuth (on time optimal control) and H.Kasumba (on optimal vortex reduction).

External cooperation:

- D. Wachsmuth cooperated with A. Schiela (ZIB, Berlin) on regularization methods for optimal control of variational inequalities. In particular, precise convergence estimates are investigated.

- D. Wachsmuth has a long-standing cooperation with A. Roesch (Duisburg). Here, progress was made on a-posteriori error estimators for state-constrained optimal control problems.

- D. Wachsmuth cooperates with G. Wachsmuth (Chemnitz) on the subject of regularization methods for inequality constrained optimal control problems.

- K.Kunisch cooporated with L.Wang (Wuhan) on time optimal control and bang-bang principles.

- K.Kunisch cooperated with K.Ito (North Carolina State University) on sparsity functional in image analysis (l^1 and l^0) and on minimal effort control.

We also refer to Section 2.4 where the cooperation between D. Wachsmuth (Optimal Control Group) and S. Beuchler (Computational Mathematics group) is presented as one of our highlights in 2011.

2.8.6. Group "Mathematical Imaging"

Internal cooperation:

- B. Jüttler, Institute for Applied Geometry, University of Linz, and RICAM (NFN S 117)
- U. Langer, RICAM, (NFN S 117)

External cooperation:

- E. Resmerita, Industrial Mathematics Institute, University of Linz.
- Within the NFN Project "Photoacoustic Imaging in Biology and Medicine", we cooperate with Computational Science Center at the University of Vienna, G. Paltauf and R. Nuster (University of Graz), and D. Meyer (University of Innsbruck).
- H. Ammari, École Normale Supérieure, Paris

O. Scherzer is participating in a consortium that successfully applied for a ***National Research Network*** on ***"Geometry and Simulation"*** (NFN S 117-N23). In this NFN we directly cooperate with B. Jüttler (JKU Linz), U. Langer (RICAM), M. Rumpf (University of Bonn), and W. Zulehner (JKU Linz) who are project partners in the NFN. Beside the intensive cooperation within the network, the NFN will establish an international netwotk of cooperation partners.

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

Internal cooperation:

- **C.A. Zarzer** with R. Ramlau on *sparsity enforcing regularization methods for nonlinear inverse problems*
- **D. Ölz** with J. Haskovec on *discontinuous nonlinear diffusion models*

External cooperation:

- **P. Kügler** with P. Pohl, Institute for Biophysics, University of Linz on *monitoring of single-channel water permeability in polarized cells*
- **P. Kügler** with S. Hering, Institute for Pharmacology and Toxicology, University of Vienna, on *modeling of voltage gated ion channels*
- **D. Ölz** with C. Cowan, Institute for Molecular Pathology on *asymmetric cell segregation in C. elegans*
- **P. Kügler, W. Yang** with W. Weckwerth, Department for Molecular Systems Biology, University of Vienna and Dirk Walther, Bioinformatics Group, Max-Planck-Institute of Molecular Plant Physiology, Potsdam on *identification of perturbation sites in metabolomic reaction networks*
- **C.A. Zarzer, P. Kügler** with G. Köhler, Max F. Perutz Lab, Vienna on *analysis of hormone regulation in the hypothalamic pituitary adrenal axis*
- **D. Ölz, A. Manhart** with N. Sfakianakis, Institute for Mathematics, University of Mainz on *finite element discretizations for lamellipodium model simulations*
- **D.Ölz** with V. Milisic, Laboratoire Analyse, Geometrie et Applications, University of Paris XIII on *modeling and simulation of the mechanic behaviour of polysaccharide hydrogel matrices*
- **D. Ölz** with K. Fellner, Institute for Mathematics and Scientific Computing, University of Graz on *asymtotic regimes of PIE-1 concentration modeling*

2.8.8. Transfer Group

Internal cooperation:

- with S. Pereverzyev, on optimal regularization methods
- with O. Scherzer, on the Kaczmarz method and data preprocessing
- with D. Wachsmuth, on optimal control in Adaptive Optics
- with U. Langer and C. Pechstein, on numerical methods for solving pde's on atmospheric layers
- with J. Schicho, on regularization methods for Symbolic Computation
- within the transfer group: cooperation between M. Emans, C. Kletzmayr and M. Aichinger on numerical methods on the GPU

External cooperation:

- AVL List GmbH, Graz, modeling and simulation of automotive components

- Siemens VAI, on simulation of chemical processes in iron production
- Christian Doppler Laboratory for Model Based Calibration Methodologies, on surrogate models and calibration methods for automotive components
- Virtual Vehicle Competence Center, on air condition modelling for automotive industry
- uni software plus GmbH, Linz, on computational finance
- MathConsult, Linz: G. Auzinger, A. Obereder, M. Rosensteiner, on Adaptive Optics
- Industrial Mathematics Institute, Kepler University Linz: I. Shatokhina, A. Neubauer, S. Kindermann, S. Pereverzyev Jun., M. Zhariy, E. Klann, cooperations in Adaptive Optics and medical imaging
- European Southern Observatory: R. Clare, E. Fedrigo, M. Le Louarn, M. Kasper, on Adaptive Optics
- C. Béchet, Université Claude Bernard Lyon 1, , on Adaptive Optics
- C. Vogel, The Optical Science Company, on Adaptive Optics
- T. Quinto, Tufts University, medical imaging and tomography
- L. Reichel, Kent State University, on multilevel wavelet methods
- B. Hofmann, TU Chemnitz, on regularization theory in Banach spaces
- G. Teschke, Hochschule Neubrandenburg, on sparse regularization
- W. Ring, University of Graz, on shape optimization and medical imaging
- P. Maaß and Christina Brandt, University of Bremen, balancing of ultra precision cutting machines
- Andreas Krause, Laboratory for Precision Machining, University of Bremen, Germany, balancing of ultra precision cutting machines
- Holger Fritsch, Ullrich Oertel from Bachmann Monitoring GmbH Rudolstadt/Feldkirch, Germany/Austria, on mathematical methods for monitoring of wind power plants
- Michael Melsheimer from BerlinWind GmbH Berlin, Germany, on mathematical methods for monitoring of wind power plants

2.8.9. Research Project "Applied Discrete Mathematics and Cryptography"

Internal cooperation:

- Symbolic Computation about possible joint work related to curves and their applications to cryptography and coding theory

External cooperation:

- H. Aly (Cairo University) about Boolean functions
- Z. Chen (Putian University) about sequences for cryptography and quasi-Monte-Carlo methods
- P. Hellekalek (Salzburg University) about uniformly distributed sequences
- W. Meidl, A. Topuzoglu (Sabanci University Istanbul) about finite fields, linear complexity, exponential sums and uniform distribution
- Ostafe, I. Shparlinski (Macquarie University Sydney) about character sums, Waring's problem and applications
- D. Panario and D. Thompson (Carleton University Ottawa) about sequence design and additive number theory
- G. Pirsic (JKU Linz) about cryptographic sequences
- M. Rötteler (NEC Laboratories America) about finite fields and quantum computing
- M. Su (Nankai University) about linear complexity and cryptographic sequences

2.8.10. START-Project Y432 „ Sparse Approximation and Optimization in High Dimensions “

Internal Cooperations:

- Christian Schmeiser, Mathematical Methods in Molecular and Systems Biology
- Francesco Solombrino, Analysis of Partial Differential Equations

External Cooperations:

- Ingrid Daubechies, Duke University
- Radek Erban, University of Oxford
- Aicke Hinrichs, Friedrich-Schiller Universität Jena
- Henning Kempka, Friedrich-Schiller Universität Jena
- Yunho Kim, University of Califorina Irvine
- Riccardo March, Consiglio Nazionale delle Ricerche, Roma
- Mauro Maggioni, Duke University
- Nader Masmoudi, New York University
- Holger Rauhut, Universität Bonn

- Leszek Skrzypczak, Adama Mickiewicz University
- Winfried Sickel, Friedrich-Schiller Universität Jena
- Cornelia Schneider, Universität Erlangen-Nürnberg
- Carola-Bibiane Schönlieb, University of Cambridge
- Gabriele Steidl, Technische Universität Kaiserslautern
- Giuseppe Toscani, Università di Pavia
- Rachel Ward, University of Texas - Austin

2.8.11. 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 2011, the following talks were given in these three categories mentioned above:

RADON COLLOQUIA
Prof. Martin J. Gander University of Geneva, Italy November 22, 2011, 17:15 Johannes Kepler University, SP2 416
Title: From Euler, Schwarz, Ritz and Galerkin to Modern Computing
Abstract: The origins of modern computing are dispersed over centuries, often in the work of pure mathematicians, who invented methods in order to understand mathematical objects and prove theorems. A typical example is the famous Schwarz method for parallel computing, whose origins lie in a problem in Riemann's audacious proof of the Riemann mapping theorem. Another example is the finite element method, which has its origins in the variational calculus of Euler-Lagrange and in the thesis of Walther Ritz, who died just over 100 years ago at the age of 31 from tuberculosis. We will see in this talk that the path leading to modern computational methods and theory was a long struggle over three centuries requiring the efforts of many great mathematicians.
Prof. Dr. Jörn Behrens University of Hamburg

October 27, 2011, 17:15
Johannes Kepler University, Lecture Hall 10

Title: Tsunami Früh-Warnung: Mathematik und Wissenschaftliches Rechnen im Dienste der Sicherheit

Abstract: Die Bilder der verheerenden Katastrophen sind noch frisch und gleichen sich: graue Wassermassen, die in Straßen dringen, alles mit sich reißen bis nur noch nackte Erde übrig ist. Indonesien-Thailand-Sri Lanka 2004, Chile 2010, Japan 2011. Aber was hat das alles mit Mathematik zu tun?
Als Indonesien im Dezember 2004 von einem Jahrhundert-Erdbeben der Magnitude 9,2 heimgesucht wurde, traf der Tsunami die Menschen vollkommen unvorbereitet. Das Ergebnis: Allein in der Region um Banda Aceh kamen mehr als 100.000 Menschen ums Leben. Als im März 2011 die viel dichter besiedelte japanische Hauptinsel Honshu ein für unmöglich gehaltenes Erdbeben der Magnitude 9,0 mit teilweise noch massiverem anschließenden Tsunami erlebte, starben auch Tausende. Die Opferzahl blieb aber deutlich unter der in Indonesien, denn die Menschen waren vorbereitet und es gab ein Warnsystem für Tsunamis.
Ein solches Warnsystem basiert in großen Teilen auf modernen Methoden der Mathematik und des wissenschaftlichen Rechnens. Vor allem dort, wo Tsunamis nahe vor der Küste ausgelöst werden, ist die Unsicherheit darüber, ob ein Erdbeben, tatsächlich auch einen Tsunami ausgelöst hat, sehr groß. Die Mathematik spielt hier in der Warn-Entscheidung eine wichtige Rolle. Auch in der Vorbereitung auf den Katastrophenfall werden mit mathematischen Modellen wichtige Daten geliefert. Wenn alles dann auch noch gut aufbereitet den betroffenen Menschen vermittelt wird, rettet die Mathematik wirklich Leben. Der Vortragende war von 2006 bis 2009 verantwortlich für die Entwicklung der Simulations-Komponente des Deutsch-Indonesischen Frühwarnsystems (GITEWS), das seit November 2008 in Jakarta/Indonesien im Einsatz ist. Er erläutert die Ideen und mathematischen Grundlagen hinter dem modernsten Tsunami-Frühwarnsystem der Welt, beschreibt einzelne Entwicklungen, und berichtet über seine Erfahrungen vor Ort bei der Vermittlung der Ergebnisse.

RADON GROUP SEMINARS

Computational Methods for Direct Field Problems

Prof. Zohar Yosibash
Ben-Gurion University of the Negev, Beer-Sheva, Israel
January 14, 2011, 14:30
Johannes Kepler University, K 153 C

Title: Simulating the mechanical response of artery walls by high order finite elements

Abstract: The healthy human artery wall is a complex biological structure whose mechanical response is of major interest and attracted a significant amount of research, mainly related to its passive response. Herein we present a high-order FE method for the treatment of the compressible hyper-elastic constitutive model for the passive response based on a transversely isotropic strain-energy-density-function (SEDF). More specifically, we first address two variants of the SEDF and augment it by a volumetric part which is neglected in

most studies. Numerical ex-amples are provided to demonstrate the efficiency of the high-order methods compared to classical h-FEMs, and thereafter the influence of the slight compressibility on the results.
Although the active response (when smooth muscle cells are activated) has a significant influ-ence of the overall mechanical response of the artery wall, it has been scarcely investigated because of the difficulty of representing such an influence in a constitutive model and lack of experimental evidence that can validate such models. This active response is strongly coupled with the passive response because of the mutual interaction (smooth muscle cells react as a function of the mechanical response). In this presentation, we provide experimental evidence of the strong influence of the active response and propose different approaches for its imple-mentation using high-order FE methods.

Olli Mali
University of Jyväskylä, Finland
May 18, 2011, 10:30
Johannes Kepler University, HF 136

Title: Analysis of errors caused by incomplete knowledge of material data in mathematical models of elastic media

Abstract: We study the effects that incompletely known data introduces to problems in continuum mechanics. In particular, we are interested in the case when parameters of the media in constitutive laws are not completely known. Our analysis is based on deviation estimates, which are functionals that allow us to study the distance between an arbitrary function from the energy space and the exact solution of the problem. For the Kirchhoff--Love arch model, deviation estimates are derived for the first time. Since the data is not unique, we have a set of solutions instead of a single function. For a certain class of problems, we present estimates for the radius of the solution set, where estimates depend on the problem data and accuracy by which the data is known. For linear isotropic elasticity problem, we show that for certain type of boundary conditions the elastic energy becomes very sensitive with respect to small variations in Poisson ratio at the incompressibility limit. This phenomena may be significant enough to render quantitative analysis meaningless even relatively far from the limit.

Dr. Huidong Yang
RICAM
June 21, 2011, 15:30
Johannes Kepler University, Lecture Hall 14

Title: preconditioned GMRES solver with algebraic multigrid accelerations for the fluid-structure interaction problems

Abstracts: In this talk, we present a preconditioned GMRES method for solving a Schur complement equation of the coupled fluid-structure interaction system, with respect to the displacement unknowns only on the interface. The preconditioning for the interface equation requires approximate solutions of the structure and the fluid sub-problems, with respectively prescribed Robin boundary conditions on the interface for each sub-problem. The solutions of both sub-problems are approximated by very few W-cycles of special algebraic multigrid methods applied to a symmetric and positive definite system and a saddle point system from the discretized structure and the fluid sub-problems, respectively. Both sub-problems are discretized by the finite element method on hybrid meshes. The application of these W-cycles enhances the performance of solving the interface equation.

Dr. Gerhard Unger
TU Graz
June 30, 2011, 16:30
Johannes Kepler University, HF 136

Title: Boundary element methods for Laplacian eigenvalue problems

Abstract: For the numerical solution of Laplacian eigenvalue problems we propose a boundary element method. While the standard approach for the solution of Laplacian eigenvalue problems is the finite element method, the use of boundary element methods

seems to be a competitive alternative in particular when considering problems in unbounded domains, and for rather complicated geometries. The formulation of Laplacian eigenvalue problems in terms of boundary integral equations results in boundary integral operator eigenvalue problems which are nonlinear in the eigenvalue. 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 domain which is enclosed by the contour. Numerical examples demonstrate the reliability of this method for the solution of discretized boundary integral eigenvalue problems.

Dr. Tatiana S. Samrowski
University of Zürich, Switzerland
July 01, 2011, 10:00
Johannes Kepler University, HF 136

Title: Estimates of Modeling Errors for Linear Elliptic Problems

Abstract: We consider dimension reduction and geometry simplifying models for linear elliptic problems. For the corresponding modeling errors, we derive guaranteed bounds of functional type and present a new combined modelingdiscretization strategy, which provides an economical way of getting an approximate solution with an a priori given accuracy based upon balancing modeling and discretization errors.

Prof. Olaf Steinbach
TU, Graz
July 01, 2011, 9:00
Johannes Kepler University, HF 136

Title: Variational inequalities and boundary element methods

Abstract: In this talk we analyse boundary element methods for the approximation of variational inequalities in Sobolev spaces of fractional order, and we describe appropriate iterative solution strategies.

Dr. Angelos Mantzaflaris
RICAM
September 01, 2011, 10:00
Johannes Kepler University, SP2 416

Title: Geometric algorithms and modeling with algebraic primitives

Abstract: We present examples of effective use of applied algebra in geometric modeling. First, the approximation of planar semi-algebraic sets, commonly occurring in constraint geometric solving. We present a method that identifies connected components and, for a given precision, computes a polygonal and isotopic approximation of a planar semi-algebraic set. We focus on the special case of arrangements of algebraic curves. Second, we present an algebraic framework to compute generalized Voronoi diagrams, that is applicable to diagrams where the distance from a site is expressed by a bi-variate polynomial function (anisotropic, power diagram etc) or by a tri-variate implicit equation (eg. Apollonius diagram, diagram of ellipses and so on). A common need behind these algorithms is efficient polynomial system solving. To this end, we introduce new subdivision methods, i.e. branch and bound techniques that compute real solutions both fast and accurately. We discuss difficulties posed by singular solutions as well as local methods for their treatment.

Marcus Sarkis
Worcester Polytechnic Institute/IMPA
November 23, 2011, 13:45
Johannes Kepler University, SP2 416

Title: Robust parameter/mesh-free preconditioner for a boundary control elliptic problem.

Abstract: We discuss the following problem: Given a target function $u^* \in L^2(\Omega)$, what is

the Neumann data λ*so that its harmonic extension u* into is the closest function to u* in the $L^2(\Omega)$-norm. For convex polygonal domain, we show that regularization is not needed in case the control space for the Neumann data is chosen properly. In the second part of the talk we discuss robust solvers for the discrete Hessian system on $\partial\Omega$.

Prof. Dr. Sergey Repin
V.A. Steklov Institute of Mathematics, St. Petersburg, Russia
November 29, 2011, 15:30
Johannes Kepler University, SP2 416

Title: Estimates of deviations from exact solutions of some nonlinear problems in continuum mechanics

Abstract: In the talk, we discuss estimates measuring the difference between exact solutions of boundary value problems and arbitrary functions from the corresponding (energy) space. The estimates must be computable, consistent and possess necessary continuity properties. In the context of PDE theory, deriving such type estimates present one of the general problems, which unlike, e.g., regularity theory is focused on studying neighborhoods of exact solutions. Being applied to numerical approximations these estimates imply a unified way of a posteriori error estimation. They can be also used for the analysis of modeling errors and errors caused by incomplete knowledge on the problem data. The talk contains a short introduction devoted to historical background, overview of the results obtained in the last decade for elliptic variational inequalities, modeling errors of dimension reduction models, and some very recent results related to models with linear growth energy (as, e.g., Hencky plasticity). Literature: S. Repin. A posteriori error estimates for PDE's, deGruyter, Berlin, 2008. M. Fuchs and S. Repin. A Posteriori Error Estimates for the Approximations of the Stresses in the Hencky Plasticity Problem, Numer. Funct. Analysis and Optimization, 32(2011), 6, 610-640. S. Repin and S. Sauter. Estimates of the modeling error for the Kirchhoff-Love plate model. C. R. Math. Acad. Sci. Paris 348 (2010), no. 17-18, 1039–1043.

Inverse Problems

Dr. Elena Kartashova
JKU
February 01, 2011, 13:30
Johannes Kepler University, HF136

Title: Introduction to Nonlinear Resonance Analysis

Abstract: Nonlinear Resonance Analysis (NRA) is a natural next step after Fourier analysis developed for linear PDEs. The main subject of NRA is evolutionary nonlinear PDEs, possessing resonant solutions. Importance of NRA is due to its wide application area -- from climate predictability to cancer diagnostic to breaking of the wing of an aircraft. In my talk I plan to give a brief overview of the methods and results available in NRA, [1], and illustrate it with some examples from fluid mechanics. In particular, it will be shown how 1) to use a general method of q-class decomposition for computing resonant modes for a variety of physically relevant dispersion functions; 2) to construct NR-reduced models for numerical simulations basing on the resonance clustering; theoretical comparision with Galerkin-like models will be made and illustrated by the results of some numerical simulations with nonlinear PDE. 3) to employ NR-reduced models for interpreting of real-life phenomena (in the Earth`s atmosphere) and results of laboratory experiments with water tanks. [1] E. Kartashova. "Nonlinear Resonance Analysis: Theory, Computation, Applications" (Cambridge University Press, 2010)

Martin Burger
WWU Münster, Germany
February 17, 2011, 14:00
Johannes Kepler University, HF 136

Title: Nonlinear Variational Problems in Dynamic Biomedical Imaging

Abstract: This talk will discuss the mathematical modelling of prior knowledge in dynamic molecular and cellular imaging, which leads to nonlinear variational problems and thus

interesting theoretical and computational problems. Applications to be discussed include - Functional imaging of cardiovascular structures, using optimal transport type approaches - Quantitative PET reconstruction, using PDE models and sparsity approaches - Cell tracking from phase constrast microscopy, using geometric variational approaches Besides modeling and medical application, the talk will also highlight basic issues in the analysis and computation, including challenging open questions.

Dr. Christian Clason
Karl-Franzens-University, Graz
February 18, 2011, 10:00
Johannes Kepler University, HF 136

Title: A semi-smooth Newton method for nonlinear inverse problems with L^1 data fitting

Abstract: This talk is concerned with L^1 data fitting for nonlinear inverse problems, which is advantageous if the data is corrupted by impulsive noise. However, it is not differentiable, which makes its efficient solution challenging. By a suitable regularization together with a path-following strategy, a semi-smooth Newton method becomes applicable. These methods show superlinear convergence, and are introduced in the first part of the talk. In addition, a strategy for selecting the regularization parameter based on a balancing principle is suggested. The efficiency of the method is illustrated on several benchmark inverse problems of recovering coefficients in elliptic differential equations, for which one- and two-dimensional numerical examples are presented.

Symbolic Computation

Dr. Angelos Mantzaflaris
INRIA
February 21, 2011, 11:30
Johannes Kepler University, AS 50

Title: Dual bases of isolated singularities and applications

Abstract: We present refined algorithms for computing the local structure (i. e. the dual local space) around a singular isolated root of a polynomial system. This is done by means of linear algebra methods, which can be carried out numerically, notably in the case of approximate inputs. One can use the local structure in application such as: deflation of the multiplicity of the root, identification of a unique singular root in a small enough domain, computation of the topological degree and the number of half-branches attached to a real algebraic curve singularity.

Dr. Gabor Hegedüs
RICAM
March 01, 2011, 10:30
Johannes Kepler University, AS 50

Title: Betti numbers of Stanley-Reisner rings with pure resolutions

Abstract: Let be simplicial complex and let k[ ] denote the Stanley{Reisner ring corresponding to . Suppose that k[ ] has a pure free resolution. Then we describe the Betti numbers and the Hilbert{Samuel multiplicity of k[ ] in terms of the h{vector of . As an application, we derive a linear equation system and some inequalities for the components of the h{vector of the clique complex of an arbitrary chordal graph. As an other application, we derive a linear equation system and some inequalities for the components of the h{vector of Cohen{Macaulay simplicial complexes.

Dr. Clemens Pechstein
JKU
May 10, 2011, 14:00
Johannes Kepler University, AS 50

Title: Poincare's inequality - geometric and analytic connections

Abstract: Poincare's inequality allows to estimate the L2 norm of a function over a domain by a constant factor times the L2 norm of its gradient, provided that the function has a vanishing mean value. The constant factor is related to the second eigenvalue of the Laplace operator on the domain and it is difficult to be determined. In this talk, I will review

results by Maz'ya and John which relate the Poincare constant to geometric quantities associtated to the domain. Also, I would like to present results by Rob Scheichl and myself that allow to estimate the Poincare constant of domains built from finite element meshes.

Michael Harrison
RICAM
May 17, 2011, 14:00
Johannes Kepler University, AS 50

Title: Explicit Solution By Radicals of Algebraic Curves of Genus 5 or 6

Abstract: I will describe explicit computational algorithms to construct minimal degree (always less than 5) ramified covers of P1 for algebraic curves of genus 5 and 6. This completes the work of Schicho and Sevilla (who dealt with the genus < 5 case) on constructing radical parametrisations of arbitrary genus g curves. Zariski showed that this is impossible for the general curve of genus at least 7. The method is based on using the minimal free resolution of the canonical ideal of the curve to construct certain rational scrolls containing the curve.

Wouter Castryck
University of Leuven, Belgium
May 17, 2011, 10:30
Johannes Kepler University, AS 50

Title: Newton polygons and curve gonalities

Abstract: It is well-known that an irreducible bivariate polynomial f in C[x,y] generically defines a curve whose genus equals the number of Z2-valued points that are contained in the interior of the Newton polygon NP(f). The central question of this talk is: does there exist a similar combinatorial interpretation for the gonality of the curve defined by f, i.e. the minimal degree of a rational map to the projective line?

Dr. Gabor Hegedüs
RICAM
May 24, 2011, 14:00
Johannes Kepler University, AS 50

Title: An Upper Bound Theorem concerning lattice polytopes

Abstract: P. Stanley proved the Upper Bound Conjecture in 1975. We imitate his proof for the Ehrhart rings. We give some upper bounds for the volume of integrally closed lattice polytopes. We derive some inequalities for the delta-vector of integrally closed lattice polytopes. Finally we apply our results for re exive integrally closed and order polytopes.

Anja Korporal
RICAM
May 31, 2011, 14:00
Johannes Kepler University, AS 50

Title: Symbolic Functional Analysis in the Context of Boundary Problems

Abstract: In this talk we will give an introduction to some aspects of symbolic functional analysis. We investigate properties of linear operators independently of specific function spaces; that means especially without any topology. What remains is symbolic linear algebra for infinite dimensional vector spaces. We consider subspaces of finite codimension and show how to represent them by switching to the dual space. As an application, we consider the algebraic representation of boundary value problems for differential equations where we express a subspace of functions by the boundary conditions they fulfill.

Madalina Hodorog
RICAM
June 01, 2011, 14:30
Johannes Kepler University, AS 50

Title: A Regularization Method for Computing Approximate Invariants of Plane Curves Singularities

Abstract: We approach the algebraic problem of computing topological invariants for the singularities of a plane complex algebraic curve defined by a squarefree poly-nomial with

inexactly-known coefficients. Consequently, we deal with an ill-posed problem in the sense that, tiny changes in the input data lead to dramatic modifications in the output solution. We present a regularization method for handling the ill-posedness of the problem. For this purpose, we first design symbolic-numeric algorithms to extract structural information on the plane complex algebraic curve: (i) we compute the link of each singularity by numerical equation solving; (ii) we compute the Alexander polynomial of each link by using algorithms from computational geometry and combinatorial objects from knot theory; (iii) we derive a formula for the delta-invariant and the genus. We then prove the convergence for inexact data of the symbolic-numeric algorithms by using concepts from algebraic geometry and topology. Moreover we perform several numerical experiments, which support the validity for the convergence statement.

Prof. Günter Pilz
Johannes Kepler University
June 28, 2011, 14:30
Johannes Kepler University, HF 136

Title: Unbelievable Facts in Math

Abstract: * How big can an n-dimensional sphere grow? Answer: Too big.
* At tests, men always do better than women. Overall, can women be better? Answer: Yes.
* A new additional highway is opened. Can this increase the average travel time? Answer. Yes.
* What is the best strategy to select a wife? Answer: Wait for the first 37% and decide later.
* What does the "No Exam Paradox" explain? Answer: Goedel´s Incompleteness Theorems.

Dr. Gottlieb Pirsic
JKU
June 30, 2011, 14:00
Johannes Kepler University, AS 50

Title: Algebra methods for quasi-Monte Carlo point sets

Abstract: Digital (t,m,s)-nets are point sets in the s-dimensional unit cube [0,1)^s. They satisfy strong conditions on their distribution, which makes them interesting as combinatorial objects (there are, e.g., close connections to ordered orthogonal arrays and linear codes). More commonly, they find application in quasi-Monte Carlo methods, e.g., high-dimensional numerical integration. In this talk, the speaker is going to present a short overview about current algebraic methods used to construct such point sets of high quality and give a preview of his current project, with the aim to find points for collaboration with similarly algebraic/combinatoric/number-theoretic minded researchers in Linz. The talk is an extended version of that given at the LARD 2011.

Prof. Dr. Josef Schicho (on joint work with G. Hegedues and H.-P. Schroecker)
RICAM
August 09, 2011, 10:00
Johannes Kepler University, AS 50

Title: Polynomials over the Quaternions and Motions in 3D

Abstract: In an attempt to solve the problem of synthesizing a linkage enforcing a 3d motion described by a quadric curve in the Study model of the group of Euclidean displacements, we were lead to the classical question of factorising quadratic left polynomials over the quaternions. To our pleasant surprise, the connection between linkage synthesis and factorisations of left polynomials turned to be much more general, opening many possibilities for the creative researcher.

Prof. Lajos Ronyai
MTA SZTAKI, Hungary
August 24, 2011, 10:00
Johannes Kepler University, SP2 416

Title: Splitting simple algebras over number fields

Abstract: Let K be an algebraic number field of degree d and discriminant D over Q. Let A be an associative algebra over K given by structure constants such that A is sio-morphic to the

algebra M_n(K) of n by n matrices over K for some positive integer n. Suppose that d, n and D are bounded. Then an isomorphism of A with M_n(K) can be constructed by a polynomial time ff-algorithm. (An ff-algorithm is a deterministic procedure which is allowed to call oracles for factoring integers and factoring univariate polynomials over finite fields.) As a consequence, we obtain a polynomial time ff-algorithm to compute isomorphisms of central simple algebras of bounded degree over K.

Dr. Martin Weimann
RICAM
November 07, 2011, 14:00
Johannes Kepler University, SP2 416

Title: Factorization of bivariate polynomials and singularities of plane curves

Abstract: I will discuss the relations between singularities and absolute factoriza-tion of rational bivariate polynomials. The main result asserts that, giv-en the univariate factorization of F(x; y) modulo (x) and given a basis for the vector space of degree d-2 adjoint polynomials of F computed mod (x), one can compute very fast both the rational and absolute factorization of F. The proof relies on cohomological considerations and on residue theory.

Dr. Gábor Hegedüs
RICAM
November 14, 2011, 14:00
Johannes Kepler University, SP2 416

Title: Bond theory and closed 5R linkages

Abstract: We define algebraic and combinatorial bonds and as an application we classify closed 5R linkages.

Dr. Madalina Hodorog
RICAM
November 21, 2011, 14:00
Johannes Kepler University, SP2 416

Title: Symbolic-numeric algorithms for computing topological invariants of plane complex algebraic curves

Abstract: In this talk, we approach the algebraic problem of computing topological inva-riants (i.e. delta-invariant, genus) of a plane complex algebraic curve defined by a polynomial with both exact and inexact data. We deal with an ill-posed problem in the sense that, tiny changes in the input data lead to huge modifications in the output solution. We present a regularization method for handling the ill-posedness of the problem. We first design symbolic-numeric algorithms to extract structural infor-mation on the plane complex algebraic curve. We then prove the convergence for inexact data of the algorithms. We implement the algorithms in the Axel algebraic geometric modeler and in the Mathemagix computer algebra system. For our purpose, both of these systems provide algebraic and geometric tools for manipulating both exact and inexact input data.

Dr. Milan Stehlik
JKU
November 28, 2011, 14:00
Johannes Kepler University, SP2 416

Title: Algebra in Statistics and Statistics in Algebra

Abstract: During talk we will address several important interplays between algebra and statistics. To illustrate algebra in statistics, we will discuss Testing Algebraic hypotheses (Drton et al. 2009), Algebraic-geometric foundations of statistical information (Amari 1987), algebraic structures in optimal design (Pistone et al. 2009) and regression (see P´azman 1993, Potock´y and Stehl´ık 2010). We will also introduce problem of Category Theory in Statistical Learning. We also discuss topological-algebraical aspects of correlated fields (Stehl´ık, 2008).
To illustrate statistics in algebra, we will introduce relatively uniform convergence of weighted sums of random elements taking values in a _-complete Banach lattice with the _-

property (see Potock´y, 2002). We have several options for sampling from distributive lattices see e.g. Propp (1997). Thus several hypothesis may be constructed and empirical statistics evaluated. The applications of the given structures will be presented.

Analysis of Partial Differential Equations

Klemens Fellner
Konarka Austria Forschungs und Entwicklungs GmbH, Linz
January 19, 2011, 16:00
Johannes Kepler University, HF 136

Title: Analysis of Partial Differential Equations

Abstract: We present some recent results and ongoing work on drift-diffusion-reaction systems modelling organic photovoltaic devices. While classical semiconductors show recombination typically throughout the whole device feature organic photovoltaic devices significant charge generation only in the very proximity of an interface between two different organic polymers. We discuss basic questions of modelling, existence and stationary states

Transfer Group

Chao Chen
Institute of Science and Technology, Klosterneuburg
May 04, 2011, 10:00
Johannes Kepler University, HF 9905

Title: Time harmonic eddy current problems solved by the geometric multigrid method

Maximilian Emans
RICAM / MathConsult
May 04, 2011, 10:45
Johannes Kepler University, HF 9905

Title: Krylov-accelerated multigrid in computational fluid dynamics

Abstract: An important part of the kernel of industrial fluid flow simulation software is the linear solver. Krylov-accelerated aggregation algebraic multigrid methods ("k-cycle", Y. Notay, ETNA 37, pp. 123-146, 2010) are, from a practical point of view, very efficient preconditioners in this context. While for positive definite systems the suggested method, using flexible conjugate gradients as Krylov-method, is robust and reliable, the proposed method for nonsymmetric problems is not sufficiently robust. Our approach is to substitute the proposed GCR in this method by flexible GMRES to remedy this problem. We present benchmarks from various fluid flow simulations where linear systems with different properties are solved by k-cycle and by common fixed-cycle AMG algorithms.

Optimization and Optimal Control

Dipl.-Ing. Rajesh Kumar
University of Magdeburg
January 31, 2011, 11:00
Johannes Kepler University, HF 136

Title: Convergence analysis of finite volume scheme for solving non-linear aggregation-breakage equations

Abstract: In this talk stability and convergence analysis of a finite volume scheme, for solving simultaneous aggregation-breakage population balance equations, are presented. The proof is based on the basic existing theorems and definitions from the book of Hundsdorfer and Verwer [1] and the paper of Linz [2]. It is shown that the finite volume scheme is second order convergent independently of the meshes for pure breakage problem. For pure aggregation and coupled problem we determine that the scheme is second order convergent only on uniform and non-uniform smooth meshes. Furthermore, it gives only first order convergence on non-uniform random grids for such problems. The mathematical results of convergence analysis are also validated numerically for two test problems. References [1] W. Hundsdorfer and J.G. Verwer. Numerical solution of time-dependent advectiondiffusion-reaction equations. Springer-Verlag New York, USA, 1st edition, 2003. [2] P. Linz. Convergence of a discretization method for integro-differential equations. Numer. Math., 25:103–107, 1975.

Dr. Lijuan Wang
RICAM
February 16, 2011, 10:00
Johannes Kepler University, HF 136

Title: Time optimal control of differential equation

Abstract: In this talk, we begin with an elevator lift problem. By discussing this problem, we will formulate time optimal control of differential equations, and point out the mathematical difficulties. Finally, we shall study a certain time optimal control problem governed by the internal controlled heat equation and with a closed ball centered at 0 as the target set. We derive, by making use of Pontryagin's maximum principle and a special kind of unique continuation property for solutions of the heat equation, the bang-bang property for the optimal control of the problem.

Tamás Kurics
ELTE University Budapest, Hungary
April 05, 2011, 14:15
Johannes Kepler University, HF 136

Title: Operator preconditioning for elliptic problem

Abstract: The numerical solution of linear elliptic PDEs consists of two main steps: discretization and iteration, where generally some iterative method (e.g. a conjugate gradient method) is used for solving the finite element discretization of the problem. However, when for elliptic problems the discretization parameter tends to zero, the required number of iterations for a prescribed tolerance tends to infinity. The remedy is suitable preconditioning, which can rely on Hilbert space theory. Operator preconditioning means that the preconditioning process takes place on the operator level, that is, we look for a suitable preconditioning operator for the operator equation – based on the theory of equivalent operators – and then we use its discretization as a preconditioner for the discrete system. The preconditioned conjugate gradient method with equivalent preconditioners provide mesh independent linear convergence estimate, i.e. the number of iterations does not depend on the size of the mesh. The notion of operator equivalence can be refined, leading to the concept of compact-equivalence, which yields superlinear mesh independent convergence. The results can also be applied for nonlinear elliptic and (leastways partially for) time-dependent problems.

Saheed Akindeinde
RICAM
April 12, 2011, 10:00
Johannes Kepler University, HF 136

Title: A-posteriori verification of optimality conditions for control problems with finite-dimensional control space

When dealing with optimal control problems subject to non-linear partial differential equations, one realizes that the necessary first-order optimality conditions (FOC) which produce candidates for optimal solution, are no longer sufficient for optimality. In addition to the FOC, the optimal control has to fulfill the second order sufficient optimality conditions (SSC). The SSC condition is equivalent to the positive definiteness of the Hessian matrix H of the underlying problem. But neither the entries of H nor its eigenvalues are computable since they depend on the solutions of a pde. It is therefore difficult to check positivity of all the eigenvalues of the Hessian matrix. However, by dicretizing the pde and through aposteriori representation of the error in the entries, we compute the approximation H_h of the Hessian and the error matrix E respectively. Finally using a result from matrix perturbation theory, we derive an error bound for the eigenvalues which allows us to determine the positive definiteness or equivalently, the fulfillment of SSC at the optimal solution.

Dr. Sergio Rodrigues
RICAM
May 10, 2011, 10:00

Johannes Kepler University, HF 136

Title: ON THE CONTROLLABILITY OF THE NAVIER–STOKES EQUATIONS: 1) Finite dimensional forcing; 2) Stabilization of a non-stationary solution

Abstract: In 1) we study controllability issues for the equations on a bounded domain. We consider classical no-slip and Navier boundary conditions. Methods of Geometric/ Lie Algebraic Control Theory are used to find sufficient conditions for $L2$-approximate controllability. Some examples "domain/space of controls" are given. In 2) we consider a time-dependent global solution of the equations on a given domain and an open subset of that domain. Then we look for a finite-dimensional feedback control that is supported by the fixed subset of the domain and stabilizes locally the Navier–Stokes system. In a few words this is done using linearization of the equations, a truncated observability inequality and some standard techniques of the optimal control theory.

Prof. Dr. Karl Kunisch
RICAM
May 31, 2011, 10:00
Johannes Kepler University, HF 136

Title: Optimal Control of the Bidomain Equation (Optimal Defibrillation)

Abstract: The bidomain equation system involving different ionic models is the genuinly accepted model for the electrophysiolgical description of the heart. Optimal control problems are formulated with the extracellular applied current as the control mechanism to influence arrthymia. Optimality conditions are derives and numerical examples illustrate, for the two dimensional case, the feasibility of dampening excitation waves and controlling reentry phenomena.

Jan-Eric Wurst
University of Bayreuth
July 15, 2011, 09:15
Johannes Kepler University HF 136

Title: Optimierungsmethoden in Banachräumen

Martin Naß
Universität Duisburg-Essen
July 19, 2011, 10:00
Johannes Kepler University HF 136

Title: Error estimates of nonlinear optimization problems with pointwise state constraints

Abstract: Nonlinear optimal control problems with pointwise state constraints are studied. The existence of a local minimizer for a discrete counterpart of the original problem is shown. We are interested in the discretization error in terms of the discretization parameter h. The derivation of such an estimate is based on a coercivity condition for the discrete solution. The general theory is applied to an example.

Michael Frey
Universität Bayreuth
September 19, 2011, 10:00
Johannes Kepler University SP2 416

Title: New Necessary Conditions for State-constrained Elliptic Optimal Control Problems and Solving Them Based on Shape Calculus

Abstract: We transfer ideas from the theory of state-constrained optimal control problems governed by ordinary dierential equations to optimal control problems for elliptic partial dierential equa-tions with distributed controls. Replacing state constraints by equivalent terms leads to a new formulation for distributed elliptic optimal control problems, which gives access to new neces-sary conditions. These new neccessary conditions reveal some striking advantages: Higher regularity of the multiplier associated with the state constraint and, in consequence, the ability to apply numerical solvers which do not need any regularization background in order to deal with the multpliers. Since the unknown interface inbetween active and inactive sets are a variable of the new nec-cessary conditions, we use Shape-Calculus to formulate a "Shape-Newton-Scheme" in function space in order to solve

the optimality system. A FE discretized version of this scheme shows encouraging results like a low number of iterations and high accuracy in detection of the active sets. Moreover the numerical results indicate grid independency of this method.

Konstantin Pieper
TU München
November 21, 2011, 10:00
Johannes Kepler University SP2 416

Title: Time-optimal control of parabolic equations with pointwise constraints on the control

Abstract:

In the talk we consider the parabolic time-optimal control problem given in the following form: Minimize the transfer time

$$T = \int_0^T dt$$

of the state u subject to a semilinear parabolic equation. The state has to be driven from the initial state u_0 into a ball around the desired terminal state u_d by means of the control q, i. e., the constraints are given by

$$\begin{aligned} \partial_t u(t) + Au(t) + \varphi(u(t)) &= Bq(t) \text{ in } \Omega \text{ for } t \in (0,T), \\ u(0) &= u_0, \\ \|u(T) - u_d\|_{L^2(\Omega)} &\leq \delta. \end{aligned}$$

Here $A + \varphi$ is a semilinear elliptic spacial differential operator of second order and the spacial control operator $B\colon L^\infty(\omega) \to L^\infty(\Omega)$ describes the influence of the control q, which has to be admissible with respect to the pointwise constraints $q_a \leq q(t) \leq q_b$ in ω for all $t \in (0,T)$. We shortly discuss the differences of exact and approximate controllability and the implications for parabolic time-optimal control problems and the associated optimality conditions.

To derive an efficient numerical algorithm for the time-optimal problem, we also consider an L^2-regularized version by adding the term $\frac{\alpha}{2}\|q\|_2^2$ to the objective functional. We shortly discuss the influence of the regularization parameter α on the optimal solutions. Finally we describe a solution scheme for the regularized problem as an extension of the semismooth Newton method, which is well known for the (semi-)linear quadratic case. The important aspect here is to compute the optimal time T_α directly together with the optimal control q_α by considering (q,T) as the combined optimization variable. When incorporating the pointwise control constraints into the Newton method, we have to be careful to retain the symmetry and positive definiteness (second order optimality conditions) of the linear system. We conclude with some numerical examples to illustrate several aspects of the talk.

Mathematical Imaging

Konstantinos Kalimeris
Paris
May 02, 2011, 14:00
Johannes Kepler University, HF136

Title: Layer Potential Approach for the Narrow Escape Problem

Mathematical Methods in Molecular and Systems Biology

Stefan Müller
Vienna Biocenter, RICAM
March 11, 2011, 09:20
VBC, RICAM Office

Title: A refined model of mass transfer between gas and liquid phases in continuous bioreactors

Abstract: Continuous stirred tank reactors (CSTR) are widely used in a variety of bioprocesses. Gases (such as oxygen and carbon dioxide) are key substrates of many bioprocesses and are continuously supplied via bubbling systems. The gas- liquid mass transfer is determined by the hydrodynamic conditions in the reactor (which in turn depend on stirrer speed, gas flow rate, and geometry) and the physico-chemical properties of the culture. In the simple two film model, the mass transfer rate is proportional to the difference between the equilibrium concentration and the actual concentration in the liquid phase. The crucial mass transfer coefficient (kLa) depends on local diffusion constants and the bubble surface area, and is typically unknown. Traditionally, the dynamics of mass transfer is modeled by ODEs. However, this approach utilizes a single effective gas concentration in the bubbles, whereas in reality the concentration in a bubble changes during its residence

time in the liquid. Hence, we assume a distribution of bubble concentrations and obtain a partial integro-differential equation (PIDE) model for the mass transfer dynamics. We study the steady states of the refined model and transform it into an ordinary integro-differential equation (OIDE) model by eliminating the immeasurable bubble concentration. Our results are applied to the problem of identifying kLa from steady-state data (with uptake/excretion by the cells) and time-series data (without cells). Depending on the characteristic parameters of the bioreactor, the predictions of the traditional and the refined model can differ considerably. Finally, we provide a method for the determination of the current uptake/excretion rate from the history of the dissolved gas concentration.

3. Attachment: Data report from AkademIS (CD-ROM)