Austrian Academy of Sciences

Annual Report 2009

Scientific Aspects

Johann Radon Institute for Computational and Applied Mathematics

REPORTING PERIOD:	1.1.2009 – 31.12.2009
DIRECTOR OF THE REPORTING RESEARCH INSTITUTION:	Prof. Heinz W. Engl
ADDRESS:	Altenbergerstr. 69 A- 4040 Linz

Content

1 Scientific Activity 2009

1.1 Zusammenfassung des wissenschaftlichen Berichts 2009

Das Institut verfügte 2009 über folgende 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 „Stochastic Analysis and Quantitative Finance“, Gruppenleiter: Prof. Dr. Hansjörg Albrecher
- Arbeitsgruppe „Analysis of Partial Differential Equations“, Gruppenleiter: Prof. Dr. Peter Markowich, Doz. Dr. Massimo Fornasier
- Arbeitsgruppe „Optimization and Optimal Control“, Gruppenleiter: Prof. Dr. Karl Kunisch
- Arbeitsgruppe „Mathematical Imaging“, Gruppenleiter: Prof. Dr. Otmar Scherzer
- Arbeitsgruppe „Mathematical Methods in Molecular and Systems Biology”, Gruppenleiter: Prof. Christian Schmeiser und Dr. Philipp Kügler

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 sonstige wissenschaftliche Tätigkeit wie Symposien finden sich im englischsprachigen Teil dieses Berichts.

Gruppe „Computational Methods for Direct Field Problems“ (Ulrich Langer)

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

- Algebraische Mehrgitterverfahren für großdimensionierte technische Probleme und Probleme in den Lebenswissenschaften (dazu ist eine Monographie entstanden),
- HP (high-order) Finite-Elemente-Methoden mit Anwendungen in der Festkörper- und Strömungsmechanik sowie in der Elektrotechnik.

Der letztere Themenbereich fällt teilweise in das START-Projekt „hp-FEM“, das bis Ende 2008 unter der Leitung von Herrn Joachim Schöberl am RICAM gefördert wurde.

Darüber hinaus wurden neue Gebietsdekompositionsmethoden entwickelt. Abbildung 1 zeigt die innerhalb eines Projektes mit dem ACCM Linz durchgeführte Simulation einer elektrischen Maschine mit den neuen Gebietsdekompositionsmethoden.

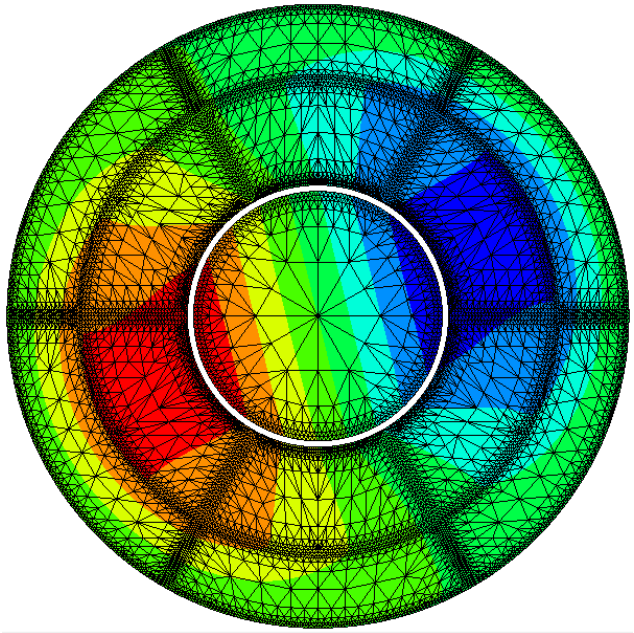


Abb. 1. Simulation elektrischer Maschinen mit DDM.

Gruppe „Inverse Problems“ (Heinz Engl)

Die Arbeitsgruppe beschäftigt sich vor allem mit der weiteren Entwicklung der mathematischen Theorie und Numerik von Regularisierungsverfahren und der Lösung von inversen Problemen aus natur-, ingenieur- und finanzwissenschaftlichen Anwendungen. Aktuelle Fortschritte betreffen die Entwicklung von Regularisierungsverfahren zur stabilen Rekonstruktion dünn besetzter Lösungen samt der zugehörigen Konvergenztheorie, welche wegen der Nicht-Konvexität des Strafterms kompliziert ist. Weitere Fortschritte wurden erzielt bei der Rekonstruktion komplizierter Objekte aus akustischen oder eektromagnetischen Fernfelddaten und bei der theoriebasierten Weiterentwicklung Bayesscher Inversionsmethoden.

Die Gruppe beteiligt sich am EU-Projekt "DIAdvisor". Ziel des Projektes ist eine Verbessurung der Behandlung von Diabetes, und die Gruppe ist der einzige mathematische Partner und entwickelt Prognosemethoden u.a. für die Glukosekonzentration.

Im Oktober 2009 starteten die Arbeiten am Projekt „Mathematical methods and Algorithms for E-ELT Adaptive Optics“ im Auftrag von ESO. Ziel ist die Entwicklung von Algorithmen zur

Rekonstruktion einfallender Wellenfronten und die darauf basierende Bestimmung von Spiegeldeformationen zur Bildkorrektur.

Gruppe „Financial Mathematics“ (Hansjörg Albrecher)

Neue Charakterisierungen für optimale Dividendenzahlungsstrategien in Versicherungsportfolios führten zu einer bemerkenswerten Verallgemeinerung der lösbaren Modelle, auch Transaktionskosten konnten berücksichtigt werden. Erreichzeiten-Identitäten für stochastische Prozesse, die an ihrem Maximum gebeugt werden, konnten auf Levy-Prozesse verallgemeinert werden. Effiziente Kalibrierungen komplexer Finanzmarktmodelle wurden mit Hilfe von Tikhonov-Regularisierungen weiterentwickelt. Mehrere neue theoretische Resultate mit Anwendungen in der Kryptographie, drahtlosen Kommunikation und Kodierungstheorie wurden erzielt, so etwa eine Rechtfertigung der Sicherheit des Doppel-diskreten Logarithmus und ein Resultat, dass sich jede gute quaternäre Folge zwei guten unkorrelierten Binärfolgen zuordnen lässt.
Wegen der Wegberufung von Prof. Albrecher wird die Gruppe mit Ende 2009 zumindest temporär geschlossen.

Gruppe „Symbolic Computation“ (Josef Schicho)

Das Problem der Ausbalancierung von Gelenkmechanismen ist, durch Verteilung der Gewichte auf den beweglichen Teilen zu erreichen, dass die Summe der durch die Bewegung ausgeübten Kräfte gleich Null ist. Solche Mechanismen finden in der Raumfahrt und in der Optik Anwendungen. Mit der symbolischen Methode der torischen Polynomdivision ist es gelungen, algebraische Bedingungen für die Ausbalancierung von Vierstangen-Gelenkmechanismen zu finden und die Lösungen vollständig zu klassifizieren.

Gruppe „Optimization and Optimal Control“ (Karl Kunisch)

Der Fokus der Gruppe lag auf unendlich dimensionalen Optimierungsproblemen mit partiellen Differentialgleichungen als Nebenbedingungen. Die numerische Überprüfung von hinreichenden Optimalitätsbedingungen wurde das erste Mal erfolgreich demonstriert. Weitere Beiträge wurden zu Optimalsteuerungsproblemen von nicht Newtonischen Fluiden mittels Randsteuerung und Zustandsbeschränkungen erzielt. Darüber hinaus wurden ein Optimalsteuerungsproblem für ein Zweiphasenfluid, sowie semi-glatte Newtonverfahren für Optimale Steuerung von elliptischen Systemen mit polygonialen Zustandsbeschränkungen analysiert. Für die Navierstokes’schen Gleichungen mit geeigneter Glättung konnte ein Konvergenzanalyse basierend auf P1 Elementen erzielt werden.

Darüber hinaus wurden zulässige Richtungsmethoden sowie direkte Suchverfahren für mehrstufige nichtlineare Programme untersucht.

Gruppe „Analysis of Partial Differential Equations"(Peter Markowich, Massimo Fornasier)

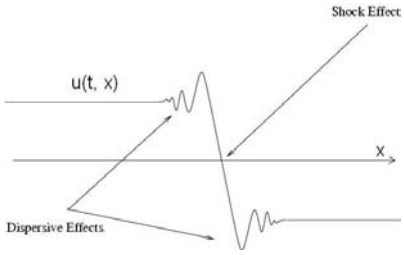
Die Gruppe konzentrierte sich auf die folgenden Themen:

- Variationsmethoden und partielle Differentialgleichungen (PDGen) höherer Ordnung für die Bildverarbeitung.

  Bemerkenswerte Ergebnisse wurden in der mathematischen Restaurierung, im Speziellen in der Einfärbung und Retusche von beschädigten oder zerstörten Fresken, erreicht.

Abbildung. Beispiel für die mathematische Einfärbung eines beschädigten Freskos mit Hilfe der Lösung einer nichtlinearen partiellen Differentialgleichung

- Nichtlineare Flachwasserwellen: Existenztheorie für verallgemeinerte Lösungen und Stabilitätsergebnisse in Anwesenheit eines Schocks im Gradienten der Lösung.



- Kinetische Gleichungen und Modellierung von kollektivem Verhalten:

Analyse der Existenz und Stabilität von Lösungen, Langzeitverhalten, Musterbildung, und numerische Simulation. PDG-Modelle für Schwarmbildung und Aggregationsphänomene von biologischen Zellen.

Im Zeitraum 2008-2009 hat sich die Gruppe mit einem Outstanding Thesis Award, einem START-Preis, und dem Boelpaepe-Preis der Akademie der Wissenschaften in Belgien (die letzten beiden für M. Fornasier) ausgezeichnet.

Gruppe „Mathematical Imaging“ (Otmar Scherzer)

Die Gruppe entwickelte eine allgemeine mathematische Analysis für nicht-lokale Funktionale, die insbesondere seit kurzem auch erfolgreich zur Datenanalyse eingesetzt werden. Eine dieser Methoden beruht auf dem Vergleich unterschiedlicher Bildbereiche und wurde gemeinsam mit INRIA Rennes und dem Institut Curie Paris zum Entrauschen biologischer Bilddaten verwendet. Außerdem wurde über die nicht-konvexe Regularisierung (eines unserer letztjährigen Forschungsthemen) eine Beziehung zwischen dem optischen Fluß und Niveaulinien-Methoden hergestellt.
Beim langfristigen Projekt, praktisch einsetzbare Methoden der photoakustischen Tomographie zu entwickeln, gelang es erstmalig, reale biologische Proben zu analysieren.

Gruppe “Mathematical Methods in Molecular and Systems Biology” (Philipp Kügler, Christian Schmeiser)

Die Anfang des Jahres 2009 gegründete Arbeitsgruppe befindet sich noch in der Aufbauphase, auch gekennzeichnet durch Personalrekrutierung und organisatorische Eingliederung ins Vienna Biocenter. Gespräche über interdisziplinäre Kooperationen wurden mit Vertretern vom IMP, IMBA und der Universtät Wien (Institut für Pharmakologie und Toxikologie, Department Molecular Systems Biology) geführt. Mathematische Methoden aus den Gebieten inverser Probleme und partieller Differentialgleichungen wurden erfolgreich zur Lösung von Fragestellungen in den Bereichen Transport durch Zellmembranen, biochemische Reaktionsnetzwerke, spannungsabhängige Ionenkanäle und Chemotaxis entwickelt und angewendet. Zudem ist die Gruppe mit der Leitung zweier WWTF Projekte zu den Themen Stresshormon-Regulation und Zytoskelettdynamik betraut.

1.2 Summary of the scientific report 2009

At the end of 2009, the Institute had the following group structure:

- Computational Methods for Direct Field Problems, group leader: Prof. Dr. Ulrich Langer
- Inverse Problems, group leader: Prof. Dr. Heinz Engl
- Symbolic Computation, group leader: Prof. Dr. Josef Schicho
- Stochastic Analysis and Quantitative Finance, group leader: Prof. Dr. Hansjörg Albrecher
- Analysis of Partial Differential Equations, group leaders: Prof. Dr. Peter Markowich, Doz. Dr. Massimo Fornasier
- Optimization and Optimal Control, group leader: Prof. Dr. Karl Kunisch
- Mathematical Imaging, group leader: Prof. Dr. Otmar Scherzer

- Mathematical Methods in Molecular and Systems Biology, group leaders: Prof. Christian Schmeiser und Dr. Philipp Kügler

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

Group "Computational Methods for Direct Field Problems" (Ulrich Langer)

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

- Algebraic multigrid methods for large-scale technical problems and problems in life sciences (on this topic a monograph has been published recently).
- High-order finite element methods with application to solid and fluid mechanical as well as electrical engineering problems.

The latter topic is partly connected with the START project „hp-FEM" led by Joachim Schöberl. The START project was supported by the Austrian Science Fund under the grant Y192 until 2008.
Furthermore, new Domain Decomposition Methods (DDM) have been developed. Figure 1 shows the simulation of an electrical machine by means of the new DDM within a project with the ACCM in Linz.

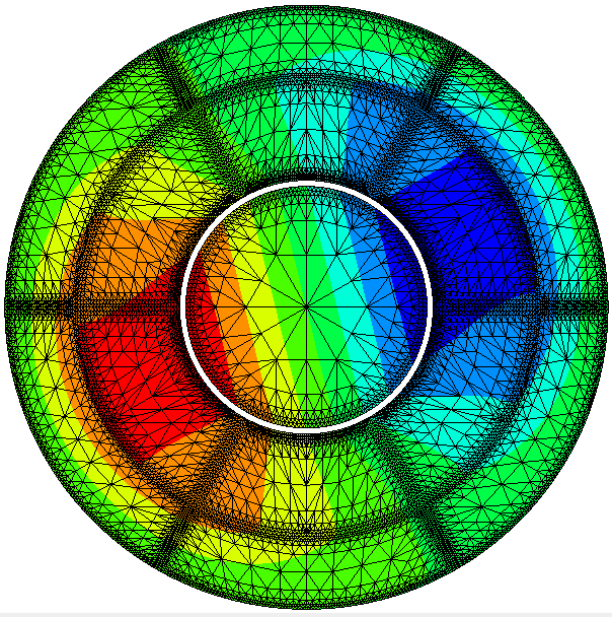


Fig. 1. Simulation of electrical machines with DDM.

Group "Inverse Problems" (Heinz Engl)

The group is active in the mathematical theory and numerics of regularization methods, and in applying inverse problems techniques to science, engineering and finance. Recent achievements concern the development of regularization methods for the stable reconstruction of sparse solutions including a convergence theory, which is complicated due to the non-convexity of the penalty term. Significant progress has been made towards identification of complex objects from measurements of far fields of acoustic and electromagnetic waves and in a theory-based further development of Bayesian inversion methods.

The group is a member of EU-consortium "DIAdvisor" aimed at the improvement of the diabetes therapy and develops, in this context, methods for the prediction of blood glucose levels.

In October 2009, the project „Mathematical methods and Algorithms for E-ELT Adaptive Optics" contracted by ESO has started. Its main aim is the development of algorithms for reconstrucing incoming wavefronts and for determining mirror deformation for image improvement.

Group "Financial Mathematics" (Hansjörg Albrecher)

New characterizations for optimal dividend payout strategies in insurance portfolios led to a remarkable extension of solvable model classes, and transaction costs could be included in the model as well. Hitting time identities for stochastic processes refracted at their running maximum could be extended to a general Levy setup. Efficient calibration of complex finance market models could further be developed by suitable application of Tikhonov regularization. Several new theoretical results with applications in cryptography, wireless communication and coding theory were obtained, including a theoretical justification for the hardness of the double discrete logarithm problem and a result that every good quaternary sequence corresponds to two good uncorrelated binary sequences.

Due to the fact the Prof. Albrecher has left, the group will be closed at least temporarily.

Group "Symbolic Computation" (Josef Schicho)

The balancing problem for linkages is to find distributions of weights on the movable parts such that the sum of the forces exerted by movements vanishes. Such mechanisms are useful in applications in space and in optics. Using the symbolic method of toric polynom division, we found algebraic conditions for the balancing of four bar mechanisms and could give the complete classification of the all solutions.

Group "Optimization and Optimal Control" (Karl Kunisch)

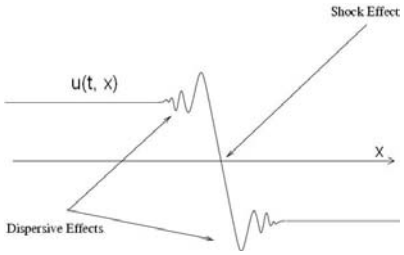
The research focus was put on optimal control with partial differential equations as constraints. We successfully started the numerically verification of optimality conditions for optimal control problems. The investigation of flow control problems was continued for non-Newtonian flow and boundary control with state constraints. An optimal control problem for two phase fluids, and semi-smooth Newton methods for optimal control for elliptic systems with pointwise *polygonial* state constraints were investigated. An error analysis for the P1 nonconform finite element for the penalized Navier-Stokes equations we accomplished.
Moreover, feasible direction and direct search methods were investigated for nonlinear bilevel programming problems.

Group "Analysis of Partial Differential Equations" (Peter Markowich, Massimo Fornasier)

The group focussed on the following topics.

- Variational methods and high-order PDEs for image processing. Significant results have been achieved in the mathematical restoration, recolorization and retouching, of damaged or destroyed frescoes.

- Nonlinear water waves: existence theory of generalized solutions and stability results in presence of shock on the gradient of the solution.



- Kinetic equations and collective behavior modeling: Analysis of existence and stability of solutions, large time behavior, pattern formation, and numerical simulation. PDE models for swarming of animals, and aggregation-motion of biological cells.

In the period 2008-2009 the group has been awarded with an Outstanding Thesis Award, a START-Prize, and the Boelpaepe-Prize of the Academy of Science of Belgium (the last two for M.Fornasier).

Group "Mathematical Imaging" (Otmar Scherzer)

The group developed a general framework for the mathematical analysis of non-local functionals, which in particular have been successfully implemented for data analysis. One of these methods is non-local patch-based filtering. Jointly with INRIA Rennes and the Institute Curie Paris, this method was applied for denoising biological data.
In addition, via non-convex regularization (one of our ongoing research topics), a relationship between the optical flow and level-set methods has been established.
In the long-term project of developing practically useable methods for photo-acoustic tomography, real biological samples were successfully analyzed.

Group "Mathematical Methods in Molecular and Systems Biology "(Philipp Kügler, Christian Schmeiser)

The group was founded at the beginning of 2009 and is currently still in the phase of recruiting and organizational integration into the Vienna BioCenter. Discussions about interdisciplinary co-operation were led with representatives of IMP, IMBA and the University of Vienna (Institute for Pharmacology and Toxicology, Department for Molecular Systems Biology). Mathematical methods from the areas of inverse problems and partial differential equations were developed successfully for answering questions related to transport through cell membranes, biochemical reaction networks, voltage-gated ion channels and chemotaxis. Furthermore, the group is responsible for two WWTF projects on stress hormone regularization and cytoskeleton dynamics.

1.3 Report on scientific acitivity during 2009

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. Sven Beuchler (on leave since October 1, 2009)

Dr. Ivan Georgiev (employed until August 31, 2009)

PD Dr. Johannes Kraus (employed until August 31, 2009)

Dr. Satyendra Tomar

Dr. Astrid Sinwel (employed until February 28, 2009, former START-Project Y-192)

Visiting Scientist funded ÖAW/Upper Austrian government funds

Prof. Dr. Ludmil Zikatanov (3 Oktober 2008 – 30 June 2009)

Researchers funded via FWF

Dipl.-Ing. Erwin Karer

Dipl.-Ing. Martin Purrucker

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 2009:

- J. Kraus successfully completed his habilitation thesis on "Algebraic multilevel methods for solving discretized finite element elliptic equations with symmetric positive definite matrices" at the JKU in July 2009 [8].

- J. Kraus and S. Margenov (IPP, BAS) published the monograph on the topic "Robust algebraic multilevel methods and algorithms" in Radon series of de Gruyter [9].

- A. Sinwel has completed her PhD thesis on "A New Family of Mixed Finite Elements for Elasticity" in February 2009, and received her PhD "sub-auspiciis proaesidentis" from Austrian Federal President Fischer in October 2009. Within the thesis, she designed and analyzed a new mixed formulation of elasticity. The thesis was published by the "Südwestdeutscher Verlag für Hochschulschriften" [14].

- FWF-Research Project P19170-N18 "Algebraic Multigrid and Multilevel Methods for Vector Field Problems" led by J. Kraus (1 PhD position: E. Karer): E. Karer worked on algebraic multigrid (AMG) methods for linear elasticity problems. The approach, which was originally proposed by J. Kraus (in 2007), exploits low-rank matrices (so-called edge matrices) in the construction of the main components of the AMG method. Based on this concept an efficient preconditioner, also for anisotropic problems, was developed. The obtained theoretical and numerical results have been summarized in the article "Algebraic multigrid for finite element elasticity equations: Determination of nodal dependence via edge matrices and two-level convergence", which has been accepted for publication in the *International Journal for Numerical Methods in Engineering* in 2009 [7]. It is well known that piecewise linear continuous finite elements suffer from locking effects when used for discretization of elasticity problems describing the deformation of nearly incompressible materials. One remedy of this shortcoming is to use "reduced integration" techniques. We, E. Karer, J. Kraus, and L. Zikatanov (Penn State University, USA), consider such a nonconforming (low-order) finite element method as a starting point and are currently working on a robust preconditioner for the related discrete problems by means of auxiliary space methods.

- FWF-project P20121-N18 "Fast hp-solvers for elliptic and mixed problems" led by S. Beuchler (1 PhD-position: M. Purrucker): The work is focused on the development of preconditioners for systems of linear algebraic equations based on the discretization of partial differential equations by the hp-version of the FEM. On the one hand, a wavelet based solver is developed for the elliptic problem. This solver is one ingredient of an efficient preconditioner for the Stokes problem. The second ingredient for the design of a fast solver of the Stokes problem is the usage of stable finite elements. This part will be investigated this year.

- FWF-Research Project P21516-N18 "Isogeometric method for numerical solution of partial differential equations" led by S. Tomar (2 PhD positions): This project was approved on 22.06.2009, and has been started from 15.07.2009. S. Tomar visited his international

research partner on this project, Prof. T.J.R. Hughes at ICES, University of Texas, Austin, from 22.07.2009 to 20.08.2009. For this visit, he was also awarded J.T. Oden faculty research fellowship (mixed financing). One of the Ph.D. positions of this project has been filled and the candidate started working from 8th Jan 2010.

- FWF-Research Project I457-N18 “Advanced numerical methods for discretization, iterative solution and error estimation”. This project has been jointly submitted by S. Tomar to FWF (on 03.08.2009) and to Russian Foundation of Basic Research by S. Repin. The decision from FWF is expected in March or May 2010.

- Special Collaborative Research Project on “Robust Large-Scale Scientific Computing Methods and Scalable Algorithms” of our RICAM group with the Institute for Parallel Processing (IPP) of the Bulgarian Academy of Sciences (BAS) at Sofia (Bulgaria). This project is based on an agreement between RICAM and the IPP that was renewed on 1 January 2009 for 4 years. There are numerous joint publications co-authored by I. Georgiev, J. Kraus, S. Margenov, and L. Zikatanov, see [List 17], and other joint scientific activities like the organization of special sessions at the 7th International Conference on Large-Scale Scientific Computations held in Sozopol, 4 – 8 June 2009. In particular, J. Kraus and S. Margenov were able to publish the joint monograph titled “Robust Algebraic Multilevel Methods and Algorithms” in Radon Series of the publishing company “Walter de Gruyter” in 2009 [9].

- Functional-type a posteriori error estimates: The new estimates obtained by S. Tomar and S. Repin (St. Petersburg), based on Helmholtz type decomposition of the error, has been accepted for publication in IMA J. Numer. Anal. [12]. S. Tomar has further strengthened his cooperation with S. Repin to advance this work for wider class of problems. See item 7 for their joint research project.

- Domain Decomposition Methods: U. Langer and D. Copeland (Texas A&M University, College Station, USA) have developed efficient domain decomposition preconditioner for the systems arising from the multiharmonic space-time discretization of non-linear parabolic initial-boundary value problems. One paper was finished and submitted to a journal [5].

- S. Beuchler accepted an offer to a replacement of a professorship position at the University of Bonn (1 October 2009 – 28 February 2010). He is teaching a course

"Ingenieurmathematik" at the Institute for Numerical Simulation and starting new cooperations with scientists in Bonn to continue after his return.

- L. Zikatanov, who joined our group from 1 October 2008 until 30 June 2009 as visiting scientist, has collaborated with J. Kraus and I. Georgiev at RICAM and V. Pillwein at the JKU (DK W1214) on the development of new Algebraic Multilevel Iteration methods for general elliptic problems and discontinuous Galerkin discretizations for elliptic PDEs and systems of elliptic PDEs [1,10]. We have also worked on design and development of algebraic multigrid and upscaling techniques with targeted applications in porous media, elasticity and other multiscale models.

Key publications:

1. B. Ayuso, I. Georgiev, J. Kraus, L. Zikatanov: A Subspace Correction Method for Discontinuous Galerkin discretizations of linear elasticity equations. RICAM-Report 2009-16.
2. B. Ayuso, L. Zikatanov: Uniformly convergent iterative methods for discontinuous Galerkin discretizations. *J. Sci. Comput.*, 40(1-3), 4–36, 2009.
3. S. Beuchler: Wavelet solvers for *hp* FEM discretizations in 3D using hexahedral elements. *Comput. Methods Appl. Mech. Engrg.*, 198 (13-14), 1138-1148.
4. P. P. Boyanova, I. Georgiev, S. Margenov, L. Zikatanov: Multilevel Preconditioning of Graph-Laplacians: Polynomial Approximation of the Pivot Blocks Inverses, *Mathematics and Computers in Simulation* (submitted).
5. D. Copeland, U. Langer: Domain Decomposition Solvers for Nonlinear Multiharmonic Finite Element Equations. RICAM-Report 2009-20 (submitted).
6. I. Georgiev, J. Kraus, S. Margenov, J. Schicho: Locally Optimized MIC(0) Preconditioning of Rannacher-Turek FEM Systems, *Applied Numerical Mathematics*, 59, 2402-2415, 2009.
7. E. Karer, J. Kraus: Algebraic multigrid for finite element elasticity equations: Determination of nodal dependence via edge matrices and two-level convergence. *Int. J. Numer. Meth. Engng.*, (accepted 2009).
8. J. Kraus: Algebraic multilevel methods for solving discretized finite element elliptic equations with symmetric positive definite matrices, Habilitation *thesis*, Johannes Kepler University, Linz, 2009.
9. J. Kraus, S. Margenov: Robust algebraic multilevel methods and algorithms. *Radon Series Comp. Appl. Math.,* vol. 5, Walter de Gruyter, Berlin, New York, 2009.

10. J. Kraus, V. Pillwein, L. Zikatanov: Algebraic multilevel iteration methods and the best approximation to 1/x in the uniform norm, RICAM-Report 2009-17.
11. P. Monk, J. Schöberl and A. Sinwel: Hybridizing Raviart-Thomas elements for the Helmholtz equation, *Electromagnetics* (accepted 2009).
12. S.I. Repin and S.K. Tomar: Guaranteed and robust error bounds for nonconforming approximations of elliptic problems. *IMA J. Numerical Analysis* (accepted 2009).
13. J. Schöberl and A. Sinwel: Tangential-Displacement and Normal-Normal-Stress Continuous Mixed Finite Elements for Elasticity (submitted).
14. A. Sinwel, A New Family of Mixed Finite Elements in Elasticity: A Robust Computational Method for Mechanical Problems, Dissertation an der JKU Linz, Suedwestdeutscher Verlag für Hochschulschriften, Juni 2009.

Further publications of the group can be found in Chapter 17 of the Akademis report in section 1.6.

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
Dipl.-Math. Kattrin Arning
Dr. Hui Cao
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
Dipl.-Ing. Tapio Helin
Dr. Shuai Lu
Dr. Jenny Niebsch
Dr. Sivananthan Sampath (partially)

Sergei Pereverzyev, Hui Cao, Shuai Lu, Sivananthan Sampath

FWF Project P 20235-N18:

1) Systematic study of the multi-parameter regularization has been started. As a result, a modified discrepancy principle for choosing multiple regularization parameters has been introduced and theoretically justified. This approach has been successfully implemented in Graph Laplacian Regularized Least Squares for learning from labeled and unlabeled examples (in cooperation with Professor Ulrich Tautenhahn from University of Applied Sciences Zittau/Görlitz (Germany)).

2) The balancing principle as an a posteriori regularization parameter choice strategy has been justified with the use of a Carleman estimate in the quasi-reversibility method for solving the Cauchy problem for parabolic equations (in cooperation with Dr. Hui Cao and Professor Michael Klibanov from University of North Carolina
(USA))

EU-Project EUP0139-20900 “DIAdvisor”:

1) A fully adaptive regularized kernel based learning algorithm has been proposed, where kernels and regularization parameters are adaptively chosen on-line in the course of the regularization. The construction of such an algorithm is motivated by the problem of monitoring and predicting the blood glucose concentration, which is extremely important in diabetes therapy. In experiments with real clinical data it has been demonstrated that the proposed algorithm requires only 2 blood glucose measurements sampled with time interval of 5 minutes to make a prediction with a clinically acceptable accuracy 20 minutes ahead of time. This feature of the algorithm is very promising since potentially it may reduce the burden associated with blood sampling.

Key publications:

1. Mathé, Peter; Pereverzev, Sergei V. The use of higher order finite difference schemes is not dangerous. J. Complexity 25 (2009), no. 1, 3--10.
2. Cao, Hui; Klibanov, Michael V.; Pereverzev, Sergei V. A Carleman estimate and the balancing principle in the quasi-reversibility method for solving the Cauchy problem for the Laplace equation. Inverse Problems 25 (2009), no. 3, 035005, 21 pp.

3. Lu, Shuai, Pereverzev Sergei V., Tautenhahn, Ulrich, Regularized total least squares: computational aspects and error bounds, SIAM Journal on Matrix Analysis and Applications, 31 (2009), 918-941.
4. Lu, Shuai, Pereverzev Sergei V., Sparsity recovery by the standard Tikhonov method, Numerische Mathematik, 112 (2009), 403-424.
5. Pereverzev, Sergei V.; Sampath, Sivananthan Regularized Learning Algorithm for Prediction of Blood Glucose Concentration in ``No Action Period''. 1st International Conference on Computational & Mathematical Biomedical Engineering, 395—398.
6. Heng, Yi, Lu, Shuai, Mhamdi, Adel, Pereverzev Sergei V., Model function approach in the modified L-curve method for the choice of regularization parameter, RICAM report 2009-08, submitted.
7. Lu, Shuai, Pereverzev Sergei V., Multi-parameter regularization and its numerical realization, RICAM report 2009-11, submitted.
8. Lu, Shuai, Pereverzev Sergei V., Shao, Yuanyuan, Tautenhahn, Ulrich, On the generalized discrepancy principle for Tikhonov regularization in Hilbert scales, RICAM report 2009-19, to appear in Journal of Integral Equations and Applications.

Jenny Niebsch

Dr. Niebsch has worked in two externally funded projects led by Prof. Ronny Ramlau in the application of inverse problems in rotor dynamics. In the FWF project P20237-N14 “Mathematical methods for high-precision balancing of machine-tools” the goal is the development of a general model for the description of the attainable construction unit quality as a function of the imbalance state and the structure configuration by the example of ultra precision machining. Here we developed a structural model of an experimental platform describing the vibrations of that platform in the presents of imbalances and forces from the cutting process. Project partners in this project are the Laboratory of Precision Machining (LFM) Bremen and the Center for Industrial Mathematics at the University of Bremen.

The second (FFG funded) project, that started in March 2009, aims at the simultaneous reconstruction of mass and aerodynamic imbalances in wind turbines. Here we cooperate with the industrial partners Deutsche WindGuard Dynamics GmbH (recently DET GmbH), Berlin, Germany, and the My-Sen GmbH, Rudolstadt, Germany. First results for aerodynamic imbalances arising from pitch angle deviations were already achieved in 2009.

Thanh Nguyen

Investigated non-iterative methods for inverse obstacle scattering problems with the main focus devoted to the linear sampling method. The main concentrations were:

1) Analysis of the roles of geometrical and physical properties of an obstacle on the accuracy of the non-iterative methods for reconstructing the shape of the obstacle using the asymptotic behavior of the so-called indicator functions in terms of geometrical and physical properties near the boundary of the obstacle.
2) Implementation of the integral equation method for forward scattering problems.
3) implementation of non-iterative algorithms and interpretation of numerical results for different kinds of obstacle.

Key publication:

1. Nguyen Trung Thanh and Mourad Sini. An analysis of the accuracy of the linear sampling method for an acoustic inverse obstacle scattering problem. Inverse Problems, vol. 26, no. 1, pages 015010 (29pp), 2010.

Hanna Pikkarainen

1) Research on convergence issues for the Bayesian inversion theory has been continued by concentrating on the interplay between regularization and discretization.
2) Bayesian inversion has been used for obtaining information about qualitative properties of an unknown. As an example of a problem where qualitative information is essential root computation of univariate polynomials was studied, following earlier work with J.Schicho (Symbolic Computation Group).
3) Regularization of problems involving Radon measures using the total variation norm has been examined and a numerical algorithm has been developed.
4) A review of the use of regularization methods in calibration of option price models was published.

Key publications:

1. H. K. Pikkarainen, J. Schicho, A Bayesian Model for Root Computation, Mathematics in Computer Science, 2, 567-586, (2009).
2. A. Hofinger and H. K. Pikkarainen. Convergence rates for linear inverse problems in the presence of an additive normal noise. Stochastic Analysis and Applications, 27, 240-257, (2009).

3. S. Kindermann and H. K. Pikkarainen. Regularization of Inverse Problems and its Application to the Calibration of Option Price Models. In H. Albrecher, W. J. Runggaldier and W. Schachermayer, ed., Advanced Financial Modelling, Radon Series on Computational and Applied Mathematics 8, 223-244, Walter de Gruyter, (2009).

Kattrin Arning

Arning finished her PhD with a thesis on modelling gating of ion channels and inverse problems to infer ion channel structure information from measurements (or to design channel structures with desired properties).
PhD Thesis: "Mathematical Modelling and Simulation of Ion Channels", Gutachter: Prof. Martin Burger (Universität Münster, formerly at RICAM), Prof. Christoph Romanin (Biophysics, JKU), 136 pages

Mourad Sini

1) We continued (see the report of 2008) the study of the accuracy issue of reconstructing interfaces from exterior measurements using the so called sampling methods. We showed how the geometry of the interface, the material properties (the coefficients of the PDE) distributed around the interface and the anisotropy influence the quality of the reconstructions.
2) Related to the point 1 is the study of the Green's function for the so-called Interior Transmission Problem. We provided their point-wise estimates. The main difficulty of these non-standard problems is that they are not elliptic.
3) The habilitation thesis has been defended in June 2009 at JKU.

Key publications:

Appeared:

1. J. Liu and M. Sini. On the accuracy of the numerical detection of complex obstacles from far field data using the probe method. Siam J. Sci. Comp V31, N4, 2665-2687. (2009).
2. J. Liu and M. Sini. Reconstruction of complex cracks by far field measurements. Mathematical Methods in the Applied Sciences. Published online: Aug 18 2009. DOI: 10.1002/mma.1203
3. L. He, S. Kindermann and M.Sini. Reconstruction of shapes and surface impedances using few far field measurements. J. Comp. Phys 228, 717-730, (2009).
4. N. T. Thanh and M. Sini. An analysis of the accuracy of the linear sampling method for inverse obstacle scattering problems using asymptotic expansion. Inverse Problems 26 (2010).

Accepted or revised:

1. N. Honda, G. Nakamura and M. Sini. Analytic extension and reconstruction of obstacles from few measurements for elliptic second order operators. Revised.
2. J. Liu, P. Krutitskii and M.Sini. Numerical solution of the scattering problem for acoustic waves by a two-sided crack in 2-dimensional space. Revised.
3. R. Potthast and M.Sini. The No-response Test for the reconstruction of polyhedral objects in electromagnetics. Accepted by J. Comp. Appl. Math.
4. F. Cakoni, G. Nakamura, M. Sini and N. Zeev. The identification of a partially coated dielectric from far field measurements. Accepted by Applicable Analysis.

Tapio Helin

In the framework of Austria's accession to the European Southern Observatory (ESO), the InKind project Mathematical Algorithms and Software for E – ELT Adaptive Optics is carried out partly at RICAM. The goal of the project is the development of algorithms and software for the correction of degraded images from astronomical telescopes. The degradation is caused by atmospheric turbulences. The project is carried out jointly with the Institute for Industrial Mathematics at the University of Linz and the Industrial Mathematics Competence Center. It is funded with 2.225 Mill. Euro by the Austrian Federal Ministry of Science and Research.
Heilio works in this ESO project under the supervision of Prof. Ronny Ramlau, who is currently substituting the Chair for Industrial Mathematics at JKU (replacing Prof. Engl) and is directing the whole ESO project, which is a cooperation between that JKU institute, RICAM, and the Industrial Mathematics Competence Center (IMCC)

Key publications:

1. T. Helin, On infinite-dimensional hierarchical probability models in statistical inverse problems, Inverse probl. imaging 3(4) (2009), pp.567--577.
2. T. Helin, M. Lassas and S. Siltanen, Infinite photography: new mathematical model for high-resolution images, J. Math. Imaging Vision (2009), doi:10.1007/s10851-009-0177-7.

Esther Klann

The runtime of FWF-Project P19029-N18 on 'Mumford-Shah Models for the Inversion of Tomography data' ended September 2009. Together with Prof. Ring from Graz and Prof. Ramlau from JKU we have successfully completed the work on implementing and testing an

algorithm for the simultaneous inversion and segmentation of tomography data from an integrated SPECT/CT scanner. The corresponding theoretical work on the regularization of linear operator equations by perimeter and norm constraints is currently in progress (together with Prof. Ramlau).
During a scientific visit at Tufts University Esther Klann started joint work together with Prof. Todd Quinto on the application of Mumford-Shah type methods to problems from limited tomography.
Together with Prof. LotharReichel from Kent State University and Prof. Ramlau we have analyzed a wavelet-based multilevel method for linear ill-posed problems.
Future Plans: Esther Klann left RICAM end of September 2009 (end of project runtime). She is applying for a grant within the Hertha Firnberg program of FWF. She plans to continue her research on Mumford-Shah models and to qualify for the next step in her scientific career (Habilitation).

Key publication:

1. E. Klann, R. Ramlau and L. Reichel. Wavelet-Based Multilevel Methods for Linear Ill-posed Problems. Submitted to SISC.

Stephan Anzengruber

Under the direction of Ronny Ramlau, Anzengruber works onMorozov's Discrepancy Principle as a parameter choice rule for non-linear Inverse problems in reflexive Banach spaces with Tikhonov regularization using general convex penalty terms.
He showed regularizing properties, convergence and provided convergence rates in the Bregman distance.

Key publication:

1. Anzengruber, Stephan W; Ramlau, Ronny (2010) Morozov's discrepancy principle for Tikhonov-type functionals with non-linear operators. Inverse Problems 26, S. 17pp

With Patricia K Lamm (Michigan State University) and Ronny Ramlau:
Local regularization strategies for Inverse problems arising from Fredholm integral equations of first kind.

Michael Aichinger

Since October 2009, he is employed under a cooperation agreement between RICAM and IMCC in the COMET funding scheme. This is the nucleus of the Transfer Group to be established (see section 1.5. and 2.3.)). He works on inverse problems in finance, especially in connection with stochastic volatility models like Heston-Bates. He also continues earliew work on a molecular dynamics approach to billiards in magnetic fields.

Key publication:

1. Aichinger, M., Janecek, S., Rasanen, E.:"Billiards in magnetic fields: A molecular dynamics approach" has been published in the January 2010 issue of Physical Review E(Vol.81, No.1)

Group "Symbolic Computation"

Group Leader:

Univ. -Prof. DI. Dr. Josef Schicho

Researchers funded via ÖAW/Upper Austrian government funds:

Dr. Gabor Hegedüs

Dr. Georg Regensburger

Dr. Markus Rosenkranz

Prof.Dr. Josef Schicho

Dr. David Sevilla Gonzales

Researchers externally funded:

Msc. Madalina Hodorog

Msc. Niels Lubbes

In April, B. Moore finished his PhD study with distinction; he is now working as a postdoctoral researcher in a robotics lab in Kyoto, Japan. M. Hodorog is part of the Doctoral College "Computational Mathematics", established by FWF at JKU and RICAM. Niels Lubbes is working in the project "Solving Algebraic Equations", a joint project of RICAM and the University of Vienna supported by the FWF.

G. Hegedüs joined the group in May. He graduated 2006 at the Technical University of Budapest and his special area is algebra and combinatorics. He will work together with J. Schicho in combinatorial aspects of algebraic equation solving.

In [1], G. Regensburger and M. Rosenkranz described a setting for treating algebraic properties of linear boundary problems for ordinary and also partial differential equations in a uniform way. In particular, they characterized and constructed all factorization of boundary problem from a given factorization of the differential operators.

In a joint work with B. Buchberger and L. Tec, Regensburger and Rosenkranz described in [4] a symbolic framework for treating linear boundary problems with a generic implementation in the Theorema system. For ordinary differential equations, the operations implemented include computing Green's operators, composing boundary problems and integro-differential operators, and factoring boundary problems. Based on their factorization approach, also some first steps for symbolically computing Green's operators of simple boundary problems for partial differential equations are presented.

The focus of [3] was on algebraic aspects of integro-differential operators over an ordinary integro-differential algebra. By restricting the coefficient functions to polynomials, they defined and investigated the integro-differential Weyl algebra as a natural extension of the classical Weyl algebra in one variable. Fixing the integration constant, one regains the integro-differential operators with polynomial coefficients as a quotient.

In a collaboration with H. Albrecher, C. Constantinescu (former members of the Financial Mathematics group RICAM and now University of Lausanne), and G. Pirsic (JKU), Regensburger and Rosenkranz used their symbolic methods for integro-differential equations and boundary problems in applications in actuarial mathematics, see [2]. There are two on-going projects extending this operator approach to more general models: one including taxes, which leads to boundary problems for partial differential equations, and one on non-constant premiums, resulting in boundary problems for ordinary differential equations with variable coefficients. The latter is a cooperation with Z. Palmowski (University of Wroclaw, Poland).

G. Regensburger and M. Rosenkranz organized also a session on Algebraic and Algorithmic Aspects of Differential and Integral Operators Sessions (AADIOS'09) at ACA (Applications of Computer Algebra). They are editing a special issue http://www.ricam.oeaw.ac.at/conferences/aca09/mcs.html on AADIOS'08 and AADIOS'09 in Mathematics in Computer Science (MCS), which will appear in 2010.

Together with H. K. Pikkarainen from the RICAM group “Inverse problems”, Schicho computed the posterior probabilities of the multiplicity patterns for the roots of a univariate polynomials with noisy coefficients [5]. This is the first time where statistical methods have been systematically used in approximate algebraic computation.
Together with C. Gosselin from the University of Quebec, Schicho and Moore solved the balancing problem for planar [6,7] and for Bennett linkages [8]. The obtained solution for the planar and spherical case are now complete, and in the case of Bennett linkages we can classify all statically balanced linkages, while it is still open whether or not dynamically linked Bennett mechanisms exist.

In cooperation with B. Jüttler and M. Aigner from JKU, and L. Gonzalez-Vega from the University of Cantabria, Schicho computed rational parametrizations for a special class of algebraic surfaces that arises in the context of geometric modeling [9].
Together with S. Margenov from the Bulgarian Academy of Sciences and I. Georgiev and J. Kraus from Prof. Langer’s group, Schicho compared different types of locally optimal constructions of M-matrices for element preconditioning [10], one of which is symbolic/algebraic.

The FWF project “Solving Algebraic Equations II”, which is a joint project together with H. Hauser from the University of Vienna, started in September as a continuation of a project with the same title. In the frame of this project N. Lubbes gave a contructive classification of families of rational curves on rational surfaces. He presented the method in [14].
D. Sevilla González has worked on the problem of parametrizing algebraic curves by roots. An algorithm for the detection and computation of the trigonality character of an algebraic curve has been presented in [11]. A trigonal curve for which a 3:1 map to the line is known can be easily parametrized by radicals (analogously to solving a cubic polynomial in one variable). The result [12] on common factors of resultants modulo p is a joint collaboration within the AMAC research group in the University of Cantabria.
In joint cooperation with A. Roth and I. Juhacs from the University of Miskolc, Hungary, and M. Hoffmann from the University of Eger, Hungary, Schicho developed a variation of Bezier curves based on trigonometric polynomials [13] which is especially suitable for modeling closed curves.

Key publications:

1. Regensburger, G. and Rosenkranz, M. (2009) An Algebraic Foundation for Factoring Linear Boundary Problems. Ann. Mat. Pura Appl. (4), 188 (1), 123-151

2. Albrecher, H., Constantinescu, C., Pirsic, G., Regensburger, G., and Rosenkranz, M. (2009) An algebraic operator approach to the analysis of Gerber–Shiu functions. Insurance: Mathematics and Economics, DOI:10.1016/j.insmatheco.2009.02.002
3. Regensburger, G., Rosenkranz, M., and Middeke, J. (2009) A Skew Polynomial Approach to Integro-Differential Operators. In: Proceedings of ISSAC '09; New York: ACM, 287-294
4. Rosenkranz, M., Regensburger, G., Tec, L., and Buchberger, B. (2009) A Symbolic Framework for Operations on Linear Boundary Problems. In: Proceedings of CASC'09, LNCS 5743; Berlin: Springer, 269-283.
5. H. K. Pikkarainen and J. Schicho. A Bayesian model for root computation. Math. in Comp. Sci., 2:567-586, 2009.
6. C. Gosselin, B. Moore, and J. Schicho. Dynamic balancing of planar mechanisms using toric ge- ometry. J. Symb. Comp., 44:1346-1358, 2009a.
7. C. Gosselin, B. Moore, and J. Schicho. Determination of the complete set of shaking force and shaking moment balanced planar four-bar linkages. Mech. Mach. Theory, 44:1338-1347, 2009b.
8. B. Moore and J. Schicho, Two methods for force balancing of Bennett linkages, Computational Kinematics, Springer, 2009
9. M. Aigner, B. Juettler, L. Gonzalez-Vega, and J. Schicho. Parametrizing surfaces with certain special support functions, including offsets of quadrics and rationally supported surfaces. J. Symb. Comp., 44:180-191, 2009.
10. I. Georgiev, J. Kraus, S. Margenov, and J. Schicho. Locally optimized MIC(0) precon- ditioning of Rannacher-Turek FEM systems. Appl. Num. Math., 59, 2009. 2402-2415.
11. J. Schicho, D. Sevilla, Deciding trigonality of algebraic curves , talk at MEGA, Barcelona 2009
12. D. Gomez, J. Gutierrez, A. Ibeas, D. Sevilla. Common factors of resultants modulo p. Bulletin of the Australian Mathematical Society. 2009
13. J. Schicho A. Roth, I. Juhacs and M. Hoffman. A cyclic base for closed curve and surface modeling. CAGD, 26:528-546, 2009.
14. Niels Lubbes. Families of curves on Del Pezzo surfaces. Talk at OEMG/DMV, Graz, Austria 2009.
15. Albrecher, H., Constantinescu, C., Pirsic, G., Regensburger, G., and Rosenkranz, M. (2009) An algebraic operator approach to the analysis of Gerber–Shiu functions. Insurance: Mathematics and Economics, DOI:10.1016/j.insmatheco.2009.02.002

16. H. K. Pikkarainen and J. Schicho. A Bayesian model for root computation. Math. in Comp. Sci., 2:567-586, 2009.
17. I. Georgiev, J. Kraus, S. Margenov, and J. Schicho. Locally optimized MIC(0) preconditioning of Rannacher-Turek FEM systems. Appl. Num. Math., 59, 2009. 2402-2415.

Group "Financial Mathematics""

Group Leader:

Univ. -Prof. Dr. Hansjörg Albrecher

Researchers funded via ÖAW/Upper Austrian government funds:

Dr. Corina Constantinescu (until December 2009)
Dr. Markus Hahn (until August 2009)
Dr. Ronnie Loeffen (until September 2009)
Prof. Harald Niederreiter (since July 2009)
Dr. Stefan Thonhauser (until January 2009)
Univ.-Doz. Dr. Arne Winterhof

Researchers externally funded:

Dr Alvar Ibeas
Dr Domingo Gomez
Dr. Dominik Kortschak (until January 2009)
Mag. Radwa Marouk
DI Philip Ngare
Mag. Rasha Shaheen
Prof. Ming Su

Since Prof. Albrecher accepted a Chair in Actuarial Science at the University of Lausanne and left RICAM, and the plan to hire Prof. Friz (formerly Cambridge) as his successor as group leader did eventually not materialize, since Prof. Friz accepted a Chair of Financial Mathematics at the Technical University Berlin, it was decided to concentrate the future research activities of the group to the field of Applied Discrete Mathematics and Cryptography, which has always been a strong component of the research group through the work of Doz. Winterhof and received additional impetus by the arrival of Prof. Neiderreiter, who joined RICAM as senior scientist after his retirement from the National University of Singapore. This will be done outside a formal group; the group itself will at least temporarily be closed. Thus, the structure of this

report is a bit different: Scientific work and cooperation are integrated into one text, and (naturally) no plans for further work will be reported.

In 2009, the research activities of the group on the development, calibration and analysis of stochastic models as well as optimal stochastic control for insurance and finance were continued and extended. In the field of Discrete Mathematics and Cryptography, there have been various neew results have been derived, in particular on constructions of sequences with good measures of pseudorandomness.
In the following, more details on the research activities and key publications will be given.

Prof. Hansjörg Albrecher

In the beginning of 2009, Prof. Albrecher finished an introductory textbook on Mathematical Finance for the “Mathematik kompakt Series” of Birkhäuser (together with Dr. A. Binder, IMCC, and Dr. P. Mayer). This book is already in use at several universities, e.g., at the University of Vienna in a bachelors’ seminar guided by Prof. Walter Schachermayer.
In collaboration with Prof. W: Runggaldier and Prof. W. Schachermayer he also finished an edited volume for the Radon Series at deGruyter entitled “Advanced Financial Modeling” which comprises state-of-the art surveys on various topics of Mathematical Finance and is a result of activities during the “Special Semester on Stochastics with Emphasis on Finance” that they organized at RICAM during the fall of 2008. In addition he continued his research in the field of finance and insurance with the group members, with the Symbolic Computation group and with external researchers.

Key publications:

The following is a list of publications that are still related to Prof. Albrecher’s research activities at RICAM (the joint publications with RICAM employees are given later at their respective places).

1. Einführung in die Finanzmathematik (with A. BINDER and P. MAYER) Mathematik Kompakt, Birkhäuser Verlag Basel, 2009. 163 pp. ISBN 978-3764387839.
2. Hochwasser und dessen Versicherung in Österreich (with F. PRETTENTHALER (Eds.)) Studien zum Klimawandel in Österreich, Verlag der Österreichischen Akademie der Wissenschaften, Wien, 2009. 161 pp. ISBN 978-3-7001-6753-2.
3. Advanced Financial Modelling (with W. RUNGGALDIER and W. SCHACHERMAYER (Eds.)) Radon Series of Computational and Applied Mathematics, de Gruyter, Berlin, 2009. 453 pp. ISBN 978-3-11-021313-3.

4. Asymptotics of the Sample Coefficient of Variation and the Sample Dispersion (with S.A. LADOUCETTE and J.L. TEUGELS) Journal of Statistical Planning and Inference 140, No. 2 (2010), 358-368.
5. Impact of underwriting cycles on the solvency of an insurance company (with M. DENUIT and J. TRUFIN) North American Actuarial Journal 13, No.3 (2009), 385-403.
6. A combinatorial identity for a problem in asymptotic statistics (with K. SCHEICHER and J.L. TEUGELS) Applicable Analysis and Discrete Mathematics 3, No.1 (2009), 64-68.
7. The tax identity in risk theory - a simple proof and an extension (with S. BORST, O. BOXMA and J. RESING) Insurance: Mathematics & Economics 44 (2009), 304-306.
8. Reinsurance in: *Encyclopedia of Quantitative Finance*, Wiley, Chichester, to appear.
9. Semi-static hedging strategies for exotic options (with P. MAYER) in: *Alternative Investments and Strategies* (R. Kiesel et al., Eds.), World Scientific, to appear.
10. Properties of a risk measure derived from ruin theory (with M. DENUIT and J. TRUFIN) submitted.
11. Ruin problems under IBNR Dynamics (with M. DENUIT and J. TRUFIN) submitted.

Dr. Corina Constantinescu

In 2009, Dr. Constantinescu has continued the cooperation with Dr. Rosenkranz and Dr. Regensburger from the the Symbolic Computation group. In addition to the analysis of Gerber-Shiu functions in renewal risk models by their algebraic operator approach [1], they have three other on-going projects.

In cooperation with Prof. Albrecher they analyze the Gerber-Shiu functions for renewal models with taxes by an algebraic operator approach involving partial-differential equations. The special structure of these equations involving partial derivatives and the experience learned from the ordinary differential equations case makes this kind of analysis possible and quite transparent [3].

In cooperation with Prof. Palmowski (University of Wroclaw, Poland) there are two promising topics of research. One is the analysis of functionals of a renewal risk process with reserve-dependent premium rate and the second is on the analysis of the penalty function in a two-dimensional (renewal) risk process. When considering non-constant premiums in a renewal model, the ordinary differential equations obtained have variable coefficients, challenging the Green's operator approach introduced in [1]. However, a non-commutative factorization of the

underlying differential operator is possible once the solutions of the ODE are known. This allows then to further factor the boundary value problem [4].

The two-dimensional risk models investigation relies (again) on a quite challenging analysis of some partial integro-differential equations, by means of boundary value problems factorization [7].

In her on-going cooperation with Prof. Thomann (Oregon State University, USA), they managed to formulate an analytical method for identifying martingales for the class of so called renewal jump-diffusion processes - a jump-diffusion process with jumps at renewal times [6]. This relation allows the use of probabilistic methods in the analysis of the resulting equations and conversely, the use of analytical and numerical methods in the analysis of Markov processes. She also continued the research on identifying new methods of investigating the asymptotic behavior of functionals of a renewal risk process with investments [5].

Together with Prof. Albrecher and Prof. Garrido (Concordia University, Canada), Dr. Constantinescu acted as guest editor of a special issue of the journal Insurance: Mathematics & Economics on Gerber-Shiu functions. This volume was initiated during the successful conference on this topic that she organized jointly with Prof. Albrecher at RICAM in August 2008.

Key publications:

1. H. Albrecher, C. Constantinescu, G. Pirsic, G. Regensburger, M. Rosenkranz. An Algebraic Operator Approach to the Analysis of Gerber-Shiu Functions, Insurance: Mathematics & Economics 46, No.1 (2010), 42-51.
2. H. Albrecher, C. Constantinescu, J. Garrido. Editorial for the Special Issue on Gerber-Shiu functions, Insurance: Mathematics & Economics (46), 2010.
3. H. Albrecher, C. Constantinescu, G. Pirsic, G. Regensburger, M. Rosenkranz. Gerber-Shiu functions in a renewal risk model with tax. Preprint.
4. H. Albrecher, C. Constantinescu, Z. Palmowski, G. Regensburger, M. Rosenkranz. Renewal risk processes with reserve-dependent premiums. Preprint.
5. H. Albrecher, C. Constantinescu, E. Thomann. Asymptotic Analysis in Renewal Risk Models with Risky Investments. Preprint.
6. C. Constantinescu, E.Thomann. Martingales in renewal jump-diffusion processes. Preprint.
7. H. Albrecher, C. Constantinescu, Z. Palmowski, G. Regensburger, M. Rosenkranz. A PDE approach of a two-dimensional risk process . Preprint.

8. H. Albrecher, F. Avram, C. Constantinescu. On the Tax Identity for Renewal Risk Models. Preprint.

Dr. Markus Hahn

Dr. Hahn continued his research activities on calibration of continuous-time stock models; previous work on models with Markov regime switching was extended to multivariate models with semi-Markov switching. In contrast to the Markovian case, the exponential waiting times between regime switches can be replaced with arbitrary distributions. This allows to make the model much more flexible; however, parameter estimation gets more involved. Together with J. Hunt, Markov chain Monte Carlo methods for parameter estimation, for the choice of the order of the model and for the choice of the distribution of the waiting times were developed for the continuous-time semi-Markov model.

In cooperation with J. Hunt, the problem of option pricing for semi-Markov stock models was considered using Monte Carlo methods. While it is possible to perform parameter estimation and option pricing in seperate steps, an approach for combining Bayesian parameter estimation and pricing (by using the output of the above-mentioned Markov chain Monte Carlo sampler for the Monte Carlo simulation of the option payoffs) was presented, which allows to incorporate the parameter uncertainty into the option price.

Joint with S. Frühwirth-Schnatter and J. Sass, research about parameter estimation in a general class of models based on Markov jump processes, where a number of independent observation series (instead of one long coherent observation series) are available, has been finished by giving some results on the asymptotics of the proposed correction method. Dr. Hahn also undertook research on the use of quasi-Monte Carlo methods for efficient pricing of credit risk derivatives and fast compution of optimal portfolios (in cooperation with the finance group at JKU Linz).

Key publications:

1. M. Hahn, J. Sass: “Parameter estimation in continuous time Markov switching models – a semi-continuous Markov chain Monte Carlo approach”, Bayesian Analysis 4, 63-84, 2009.
2. M. Hahn, S. Frühwirth-Schnatter, J. Sass: “Estimating models based on Markov jump processes given fragmented observation series”, Advances in Statistical Analysis, to appear.

3. M. Hahn, S. Frühwirth-Schnatter, J. Sass: “Markov chain Monte Carlo methods for parameter estimation in multidimensional continuous time Markov switching models”, Journal of Financial Econometrics, to appear.
4. M. Hahn, J. Hunt: “Estimation of semi-Markov models”, preprint
5. J. Hunt, M. Hahn: “Option pricing in semi-Markov models”, in preparation

Dr. Dominik Kortschak

The efficient evaluation of ruin probabilities in the Cramér-Lundberg model was investigated, a classical topic of risk theory that still lacks a complete treatment up to now. Completely monotone claim size distributions were considered. It was shown that a complex path transformation of the standard inversion formula of the Laplace transform of the ruin probability leads to highly accurate and fast approximations for the ruin probability.

Key publications:

1. J. Hartinger and D. Kortschak. On the efficiency of the Asmussen-Kroese-estimators and its application to stop-loss transforms Blätter DGVFM 30(2):363--377, 2009
2. D.Kortschak, L. Lautscham, C. Habsburg-Lothringen and F. Prettenthaler: Hochwasser-Risikoabschätzung für Österreich unter Verwendung einer Nachbarschaftsrelations-Methode. In “Hochwasserrisiko und dessen Versicherung in Österreich", Verlag der österr. Akademie der Wissenschaften, 2009
3. J. Hartinger and D. Kortschak. Quasi-Monte Carlo Techniques and Rare Event Sampling, submitted.
4. D. Kortschak and H. Albrecher. Asymptotic results for the sum of dependent non-identically distributed random variables. Methodology and Computing in Applied Probability 11, No.3 (2009), 279-306.
5. H. Albrecher , F. Avram, D. Kortschak. On the efficient evaluation of ruin probabilities for completely monotone claim size distributions. Journal of Computational and Applied Mathematics 233, No.10 (2010), 2724-2736.
6. H. Albrecher , D. Kortschak. On ruin probability and aggregate claim representations for Pareto claim size distributions. Insurance: Mathematics and Economics 45, No.3 (2009), 362-373.
7. H. Albrecher , D. Kortschak. Quantitativer Nachvollzug des NATKAT-Modells fuer Oesterreich. In: Hochwasser und dessen Versicherung in Oesterreich, Verlag der Oesterreichischen Akademie der Wissenschaften, 2009.

8. D. Kortschak, H. Albrecher ,F. Prtettenthaler. Anreiztheoretische Analyse des NATKAT-Modells fuer Oesterreich. In: Hochwasser und dessen Versicherung in Oesterreich, Verlag der Oesterreichischen Akademie der Wissenschaften, 2009.
9. H. Albrecher , C. Hipp, D. Kortschak. Higher-order expansions for compound distributions and ruin probabilities with subexponential claims. Scandinavian Actuarial Journal, to appear.

Dr. Ronnie Loeffen

Dr. Loeffen continued his research on variations of de Finetti's dividends problem in a Levy insurance risk model. In [2] this dividends problem is studied with the inclusion of transaction costs and it is shown that a certain simple impulse strategy is the optimal dividend strategy if the jump measure of the underlying Levy process has a log-convex density.
Together with J. Renaud, in [3] it is assumed that the value function depends on the severity of ruin in an affine way. It was possible to show that (with a small exception) a barrier strategy forms the optimal strategy under the assumption that the Levy measure has a log-convex tail. This result extends and improves previously known theorems on the original de Finetti's problem. In particular, it generalizes the results of [1], which deals with the case of a constant penalty function and a completely monotone Levy density.

Key publications:

1. An optimal dividends problem with a terminal value for spectrally negative Levy processes with a completely monotone jump density. Journal of Applied Probability 2009, Vol. 46, No. 1, 85-98.
2. An optimal dividends problem with transaction costs for spectrally negative L\'evy processes. Insurance: Mathematics and Economics 2009, Vol. 45, No. 1, 41-48.
3. De Finetti's optimal dividends problem with an affine penalty function at ruin.With J.-F. Renaud. Insurance: Mathematics and Economics 2010, Vol. 46, No.1, 98-108.
4. Refracted Levy processes. (with A.E. Kyprianou). Annales de l'Institut Henri Poincare, to appear.

DI Philip Ngare

The research of DI Ngare focused on the quantitative development of a disaster funding strategy as a method in pre-disaster risk management, including the pricing of weather derivatives for hedging against 'close to mean' weather fluctuations for a given region. In [1] a Markov Chain model for precipitation is proposed and calibrated to real data. Further uility

indifference pricing and Monte-Carlo techniques are applied to investigate the effects of correlation and seasonality.
In [2] utility indifference pricing is applied to catastrophe bonds in a situation where the insurer can adjust his portfolio by choosing the risk loading which in turn determines the demand and increases the efficiency of the insurance activity.

Key publications:

1. G. Leobacher and P. Ngare. On modelling and pricing rainfall derivatives with seasonality (2009), submitted.
2. Utility pricing of CAT bond for insurance facing finite demands (2009), submitted.

Dr. Stefan Thonhauser

Before leaving RICAM by end of January 2009, Dr. Thonhauser finished an overview article on results of optimal control applied to dividend (or consumption) problems for insurance related stochastic processes in collaboration with Prof. Albrecher. This was the main field of research of Dr. Thonhauser when working at RICAM. The article gives an overview on results on these problems, presents a possible solution approach via Hamilton-Jacobi-Bellman equations and points out technical difficulties which may arise for different modeling assumptions. Another topic was the development of a policy iteration algorithm for numerical solutions of impulse control problems. Such problems appear in a risk theoretic environment when incorporating transaction costs in dividend problems for making them more realistic. The characterization of the specific value function by means of a fixed point of an associated optimal stopping operator or by some variational inequalities hardly allows an explicit solution and makes the usage of numerical methods necessary.

Key publications:

1. H. Albrecher, S. Thonhauser. Optimality Results for Dividend Problems in Insurance. RACSAM Rev. R. Acad. Cien. Serie A. Mat. 103, No.2 (2009), 295-320.
2. S. Thonhauser, H. Albrecher. Optimal dividend strategies for a compound Poisson risk process under transaction costs and power utility, submitted.

Univ.-Doz. Dr. Arne Winterhof

After a very positive evaluation Dr Winterhof got a permanent position at RICAM.
Dr Winterhof was leader of an FWF project (Pseudorandom sequences (2006-2009), employees: Dr Ibeas, Mag. Marouk, Mag. Shaheen). He also led two projects for six months

each of the Austrian Exchange Service (ÖAD, Dr Ming Su) and the Spanish Science Fund (Dr Gomez).

His work focused on sequence constructions with good measures of pseudorandomness measures introduced by Mauduit and Sarközy called well-distribution measure and correlation measure of order k and related measures as autocorrelation, linear complexity, discrepancy and lattice structure [1,2,4,6-9,11,13]. In particular, he contributed to the handbook on Selected Topics in Information and Coding Theory with a survey article on Linear Complexity and Related Complexity Measures [12].

Moreover, in [9] is shown that each 'good' quaternary sequence corresponds to two 'good' binary sequences which are 'uncorrelated'. Binary and quaternary sequences are the most important sequences in view ofmany practical applications as wireless communication and cryptography.

He also worked on problems from additive number theory [3,5,14]. In particular, in joint work with Dr Shparlinski (Sydney) he improved essentially earlier bounds on the number of Lehmer numbers developing additionally a much simpler proof method.

In [10] the number of certain permutations over a finite field was studied which can be used in digit check systems as IBAN, European Article Number or ID numbers.

Key publications:

1. A. Sarközy, A. Winterhof (2009) Measures of pseudorandomness for binary sequences constructed using finite fields. Discrete Mathematics, Bd.309, S. 1327-1333.
2. A.Ibeas, A. Winterhof (2009) Noisy interpolation of multivariate sparse polynomials in finite fields. Lecture Notes in Computer Science, Bd. 5527, S.169-178.
3. C. van de Woestijne, A. Winterhof (2009) Exact solutions to Waring's problem for finite fields. Acta Arithmetica, to appear.
4. G. Pirsic, A. Winterhof (2009) On the Structure of Digital Explicit Nonlinear and Inversive Pseudorandom Number Generators. Journal of Complexity, to appear.
5. I. Shparlinski, A. Winterhof (2009) Partitions into Two Lehmer Numbers. Monatshefte für Mathematik, to appear.
6. Ming Su, A. Winterhof (2009) Autocorrelation of Legendre-Sidelnikov sequences. IEEE Transactions on Information Theory, to appear.
7. N. Brandstätter, A. Winterhof (2009) k-error linear complexity over F_p of subsequences of Sidelnikov sequences of period (p^r-1)/3. Journal of Mathematical Cryptography, to appear.

8. N. Brandstätter, G. Pirsic, A. Winterhof (15.06.2009) Two-prime Sidelnikov sequences., Workshop on Coding and Cryptography, S. 389-398.
9. Radwa Marouk, Arne Winterhof (2009) On the pseudorandomness of binary and quaternary sequences linked by the Gray mapping. Periodica Mathematica Hungarica, to appear.
10. Rasha Shaheen, Arne Winterhof (2009) Permutations of finite fields for check digit systems. Designs, Codes and Cryptography, to appear.
11. S. Balasuriya, I. Shparlinski, A. Winterhof (2009) An average bound for character sums with some counter-dependent recurrence sequences. Rocky Mountain Journal of Mathematics, Bd. 39, S. 1403-1410.
12. Winterhof, A. (2009) Linear complexity and related complexity measures. In: Woungang, I. (Hrsg.), Selected Topics in Information and Coding Theory, to appear.
13. Z. Chen, D. Gomez, A. Winterhof (15.06.2009) Distribution of digital explicit inversive pseudorandom numbers and their binary threshold sequence., MC2QMC 2008, to appear.
14. D. Gomez, A. Winterhof: Waring's problem with Dickson polynomials. In Proceedings Fq9, to appear.

Dr Alvar Ibeas

Dr Ibeas spent five months at RICAM employed in Dr Winterhof's FWF project. He was on leave from the University of Cantabria.

Besides two articles on pseudorandom sequences [1, 3] he solved an open question of Konyagin and Shparlinski on the multiplicity of a prime as a factor of a resultant in joint work with Dr Gomez (DM) and Dr Sevilla (Symbolic Computation).

Key publications:

1. Domingo Gomez, Jaime Gutierrez, and Alvar Ibeas: "Cryptographic aspects of some pseudorandom sequences". In "Nuevos Avances en Criptografia y Codificacion de la Informacion". Eds: Policarpo Abascal et al. February 2009, pp. 77-85.
2. Domingo Gomez, Jaime Gutierrez, Alvar Ibeas and David Sevilla: "Common factors of resultants modulo p". Bulletin of the Australian Mathematical Society 79(2). April 2009, pp. 304-307.
3. Alvar Ibeas and Arne Winterhof: "Noisy interpolation of multivariate sparse polynomials in finite fields". In "AAECC 2009". Eds: M. Bras-Amoros and Tom Hoholdt. LNCS 5527, pp. 169-178.

Dr Domingo Gomez

Dr Gomez spent six months at RICAM employed via a project of the Spanish Science Fund. He was on leave from University of Cantabria.

His research focused on the analysis of pseudorandom numbers [1,2] and additive number theory [3]. In particular, he studied with Dr Winterhof Waring's problem in finite fields with Dickson polynomials. Their results can be applied to estimate covering radii of certain codes.

Key publications:

1. Edwin~D. El-Mahassni and Domingo Gomez. On the distribution of nonlinear congruential pseudorandom numbers of higher orders in residue rings. In Bras-Amoros and Hoholdt , 195--203.
2. Arne Winterhof, Zhixiong Chen, and Domingo Gomez. Distribution of digital explicit inversive pseudorando numbers and their binary threshold sequence. In L'Ecuyer and Owen, 249--258.
3. D. Gomez, A. Winterhof: Waring's Problem with Dickson Polynomials. In Proceedings Fq9, to appear.

Prof. Harald Niederreiter

After he had retired from National University of Singapore, Prof. Niederreiter joined RICAM as senior scientist in July.

His research at RICAM focuses on sequence analysis. In particular, he analysed the relation between a measure of pseudorandomness introduced by fields medallist Timothy Gowers and the measures introduced by Mauduit and Sarközy [2]. Moreover, he studied the cryptographic suitability of multi- or vector sequences in terms of their joint linear complexity [3]. In [1] he developed a new duality theory for digital sequences.

Key publications:

1. Dick, J.; Niederreiter, Harald (2009) Duality for digital sequences. Journal of Complexity (25), S. 406-414.
2. H. Niederreiter (2009) On the Gowers norm of pseudorandom binary sequences. (79), S. 259-271.
3. Fu, F.-W.; Niederreiter, Harald; Özbudak, F. (2009) Joint linear complexity of multisequences consisting of linear recurring sequences. Cryptography and Communications, Bd. 1 (1), S. 3-29.

Prof. Ming Su

Professor Su spent six months at RICAM with a grant of the Austrian Exchange Service.
He focused on algorithmic aspects of sequence design. In particular, he developed difficult algorithms for determining the k-error linear complexity of sequences.

Key publications:

1. Ming Su, “Decomposing Approach for Error Vectors of k Error Linear Complexity of 2^n-Periodic Binary Sequences”, WCC(Workshop on Coding and Cryptography) 2009, Ullensevang, Norway, pp. 399-415, May. 2009.
2. Ming Su, “Decomposing Approach for Error Vectors of k-Error Linear Complexity of 2^n-Periodic Binary Sequences”, WCC(Workshop on Coding and Cryptography) 2009, Ullensevang, Norway, pp. 399-415, May. 2009.
3. Ming Su, Arne Winterhof, “Autocorrelation of Legendre-Sidelnikov Sequences”, IEEE Transactions on Information Theory, to appear, 2009.

Rasha Shaheen and Radwa Marouk

Rasha Shaheen and Radwa Marouk spent each two months at RICAM employed via Dr Winterhof’s FWF grant. They have been PhD students of Professor H. Aly on leave from Cairo University.
For their publications see Winterhof [9] and [10].

Group “Analysis of Partial Differential Equations””

Group Leaders:

o. Univ.-Prof. DI. Dr. Peter Markowich
Doz. Dr. Massimo Fornasier

Researchers funded via ÖAW/Upper Austrian government funds:

Dr. Renjun Duan
Dr. Massimo Fonte
Univ.-Doz. Dr. Massimo Fornasier
Dr. Francesco Vecil

Researchers externally funded:

DI. Andreas Langer
Dr. Jan Haskovec

Dr. Yunho Kim (July-September 2009)
Dr. Karin Schnass (since January 2010)
Dr. Jan Vybiral

Within the scope of our group we focused in 2009 on the following topics, which are involving the active joint cooperation of all the members of the group as it is shown by the related joint publications.

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

Free-discontinuity problems describe situations where the solution of interest is defined by a function and a lower dimensional set consisting of the discontinuities of the function. In particular, it is of great practical interest to be able to recover functions which are piecewise smooth also from partial information, provided, for instance, by suitable linear measurements via a singular operator, i.e., an operator which is not necessarily boundedly invertible. We search for solutions as minimizers of Mumford-Shah-like functionals in a certain class of smooth functions out of piecewise Lipschitz continuous discontinuity sets. In order to obtain existence we resume compactness/coerciveness by exploiting the special structure of the linear measurements, geometrical and regularity properties of domains, interpolation inequalities, and classical compactness arguments in Sobolev spaces [17]. Together with this theoretical analysis, we are addressing also numerical methods for computing such minimizers [20], and the analysis of the complexity of these algorithms. The results in this direction are a joint work of the group leader Dr. Fornasier with external collaborators.

Domain decomposition and subspace correction methods for nonsmooth convex minimizations.

Domain decomposition and subspace correction methods are known to converge to solutions of PDEs associated to smooth strictly convex energies, and many counterexamples are known for nonsmooth and nonseparable cases. However, we succeeded to achieve the first proof of convergence of these methods [16] in the context of problems related to total variation miminization (known to be nonsmooth and nonseparable). This relevant result comes after several successful investigations [19] in related topics. We started an active cooperation with the group of Computational Methods for Direct Fields Problems led by Professor Ulrich Langer, for the implementation of our domain decomposition methods coupled with Discontinuous Galerkin methods and adaptive refinement strategies. The results in this direction are a joint

work of the group leader Dr. Fornasier and the Ph.D. student DI. Andreas Langer, together with external collaborators.

Kinetic transport equations

The current research is focused on the following PDE models and theoretical results: fluid dynamic models for chemotaxis [11,21], particle-kinetic-fluid dynamics for multiagent interaction phenomena (e.g., swarming and flocking) [4-5,10,15], classical equations of mathematical physics (e.g., Boltzmann equation and Vlasov-Poisson-Boltzmann system) and theoretical results of stability at equilibria and rate of convergence via hypocoercivity and Fourier-energy methods [7-13]. The results in this direction are a joint work of the group leaders Dr. Fornasier and Prof. Markowich with several group members, in particular Dr. Duan, Dr. Haskovec, and Dr. Vecil, together with external collaborators.

Nonlinear hyperbolic PDEs and numerical methods

We addressed nonlinear models arising from mathematical physics and, in particular, for dispersive equations, like Korteweg - de Vries equation, a continuous semi-group of solutions is constructed [14] by the analysis of the interaction between stationary states and their evolution in time. Lipschitz continuity in time for the solutions is proved by the careful construction of a metric in a space of measures. Following the same idea a general result of stability in presence of shocks for both the solution and its gradient has been proved for the Burgers-Poisson equation. The key point is to define a weighted L^1 norm that controls the behavior of the non-local term, and then study the equation as a smooth perturbation of the Burgers' equation. A second research direction addresses the problem of discontinuous fluxes for Traffic Flow on Networks. Admissible, entropic solutions for the Riemann Problem have been constructed, without any assumption on convexity/concavity of the fluxes, as already done in the literature.
Also numerical methods for the solution of hyperbolic equations have been addressed for specific technology problems, in particular the simulation of nanoscaled devices (DG-MOSFET) [3]. These devices are of great interest in the development of new technologies, but the numerical simulations was yet lacking a precise solver. This first work set the numerical basis for the simulation, proving that the adopted strategy is successful. The results in this direction are a joint work Dr. Fonte and Dr. Vecil together with external collaborators.

Sparse approximation, optimization, and nonlinear PDEs

Since July 2009, the group of “Analysis of Partial Differential Equations” acquired new members, Dr. Jan Haskovec, Dr. Yunho Kim (only as a visiting scholar in the period July-

September 2009, now Professor at the University of California Irvine) Dr. Karin Schnass, and Dr. Jan Vybiral, thanks to the funding obtained via the START-Preis project "Sparse Approximation and Optimization in High Dimensions" (http://hdsparse.ricam.oeaw.ac.at/). This project is *highly interdisciplinary*, started in April 2009 and it will work until March 2015. It has the function of connecting the activity of the group of "Analysis of Partial Differential Equations" to the research done within RICAM by other related groups, in particular, "Computational Mathematics for Direct Field Problems", "Inverse Problems", "Optimization and Control", "Mathematical Imaging", and "Mathematical Methods in Molecular and Systems Biology". We give below a short description of the general intents of the project. The main results of the START project are collected in the papers [1,6,16-20].

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

This project is a joint cooperation with the University of Vienna as well as the Academy of Fine Arts and the University for Applied Arts. For what concerns our contribution, mathematical models based on nonlinear PDEs and variational calculus are developed specifically for so-called "mathematical inpainting/retouching" of digital images. Also efficient numerical methods for the solution of the devised partial differential equations are addressed. The relevant publications in 2009 of this project are [1-2,16-20] and involve the joint cooperation of Dr. Fornasier, Dr. Haskovec, DI. Langer, together with external colleagues.

Key publications:

1. W. Baatz, M. Fornasier, J. Haskovec: Mathematical methods for spectral image reconstruction, Proceedings of the workshop Scientific Computing for Cultural Heritage, Heidelberg Germany, November 2009.
2. W. Baatz, M. Fornasier, P. Markowich, and C.-B. Schönlieb: Binary based fresco restoration, Proceedings of the conference Bridge 2009: Mathematics, Music, Art, Architecture, Culture, 337-338 pp.
3. N. Ben Abdallah, M.J. Caceres, J.A. Carrillo, F. Vecil, A deterministic solver for a hybrid quantum-classical transport model in nanoMOSFETs, Journal of Computational Physics (2009)
4. J. A. Carrillo, M. Fornasier, J. Rosado, and G. Toscani: Asymptotic flocking dynamics for the kinetic Cucker-Smale model, to appear in SIAM. J. Math. Anal., 2010
5. J. A. Carrillo, M. Fornasier G. Toscani, and F. Vecil: Particle, kinetic, hydrodynamic models of swarming, within the book "Mathematical modeling of collective behavior in

socio-economic and life-sciences", Birkhäuser (in preparation, Eds. Lorenzo Pareschi, Giovanni Naldi, and Giuseppe Toscani), 2010.

6. I. Daubechies, R. DeVore, M. Fornasier and C. S. Güntürk: Iteratively re-weighted least squares minimization for sparse recovery, Commun. Pure Appl. Math., Vol. 63, no. 1, 2010, pp. 1-38
7. R. Duan: Stability of the Boltzmann equation with potential forces on torus, Physica D: Nonlinear Phenomena 238 (2009), 1808-1820.
8. R. Duan Hypocoercivity of linear degenerately dissipative kinetic equations, submitted preprint (Dec. 3, 2009).
9. R. Duan, K. Fellner and C.-J. Zhu: Energy method for multi-dimensional balance laws with non-local dissipation, to appear in Journal Mathematiques Pures Appliquees (2009).
10. R. Duan, M. Fornasier and G. Toscani: A kinetic flocking model with diffusions, submitted preprint (Sep. 10, 2009)
11. R. Duan, A. Lorz and P. Markowich: Global Solutions to the coupled chemotaxis-fluid equations, submitted preprint (May 4, 2009).
12. R. Duan and R.M. Strain: Optimal time decay of the Vlasov-Poisson-Boltzmann system in $\mathbb{R}^3$, accepted by Archive for Rational Mechanics and Analysis (Jan. 18, 2010).
13. R. Duan T. Yang: Stability of the one-species Vlasov-Poisson-Boltzmann system, SIAM Journal on Mathematical Analysis, 41 (2010), no. 6, 2353-2387.
14. M. Fonte: An Optimal Transportation Metric for Two Nonlinear PDEs. FURTHER PROGRESS IN ANALYSIS Proceedings of the 6th International ISAAC Congress, pp. 434-443, 2009.
15. M. Fornasier, J. Haskovec and G. Toscani: Fluid dynamic description of flocking via Povzner-Boltzmann equation, sumitted to Physica D (nonlinear phenomena) 2009.[18]
16. M. Fornasier, A. Langer, C. Schönlieb: A convergent overlapping domain decomposition method for total variation minimization, submitted to Numer. Math., May 2009, 35 pp.
17. M. Fornasier and R. March: Existence of minimizers of the Mumford and Shah functional with singular operators in two space dimensions, preprint, 2009.
18. M. Fornasier, R. Ramlau and G. Teschke: A comparison of joint sparsity and total variation minimization algorithms in a real-life art restoration problem, Adv. Comput. Math., Vol. 31, Nos 1-3, 2009, pp. 301-329
19. M. Fornasier and C. Schönlieb: Subspace correction methods for total variation and l1-minimization, SIAM J. Numer. Anal., Vol. 47, no. 5, 2009, pp. 3397-3428
20. M. Fornasier and R. Ward: Iterative thresholding meets free-discontinuity problems, to appear in Found. Comput. Math., 2010, 46 pp.

21. J. Haskovec, C. Schmeiser: Stochastic particle approximation for measure valued solutions of the 2D Keller-Segel system, J. Stat. Phys. 135 (2009), pp. 133-151.

Further publications of the group can be found in section 1.6., chapter 17 of the Akademis report.

Group "Optimization and Optimal Control""

Group Leader:

o. Univ. –Prof. DI. Dr. Karl Kunisch

Researchers funded via ÖAW/Upper Austrian government funds:

Dr. Xiliang Lu, since August 07

Dr. Alyalew Mersha, since July 09

Dr. Daniel Wachsmuth, since August 08

The work of the group focused on optimal control governed by partial differential equations. Problems which involve non-smooth phenomena as well as second order optimality conditions were of central importance.

The work on optimal control of variational inequalities was continued by Dr. Wachsmuth. Such problems are challenging to solve numerically due to lack of differentiability. We analyzed a smoothing technique and investigated an efficient path-following algorithm [1]. The analysis of its speed of convergence will be continued with Anton Schiela (ZIB Berlin).

The availability of fast solution methods for non-convex optimal control problems depends on the validity of certain sufficient optimality conditions. In cooperation with Arnd Roesch (Duisburg) we described a general technique to verify a-posteriori that such a condition is satisfied. This work will be continued within the
FWF-project P21564-N18 "Numerical verification of optimality and optimality conditions for optimal control problems" (1 Phd-position: S. Akindeinde, start January 2010)

Optimal control problems without control cost term are known to be unstable with respect to perturbations. Moreover, the resulting optimality
conditions are difficult to solve numerically. Such problems are typically regularized by adding a regularization term of Tichonov type. In

cooperation with Gerd Wachsmuth (Chemnitz), Daniel Wachsmuth established convergence estimates with respect to the regularization parameter. This estimate is then combined with a-posteriori finite element error estimators to obtain an efficient algorithm to solve the original problem [3].

The work on semi-smooth Newton methods was also continued with the aim of establishing efficient superlinearly convergent algorithms for nonsmooth optimization problems. Together with Dr. Mersha, who only recently joined the group, K. Kunisch started to investigate optimal control related to the damped, respectively undamped, wave equations, where constraints on the state are taken into consideration. Dr. Merha further worked on non linear bilevel programming problems developping direct search and feasibile direction algorithms [4,5]

Investigations on optimal control for the elliptic system with point-wise polygonal state constraints were contiuned by Dr. Lu . Since the first order optimality system is not differentiable and the Lagrange multiplier is only a measure, a regularized problem is studied and a semi-smooth Newton method for the regularized problem is provided. Due to the polygonal structure of the constraints, the Lagrange multiplier is coupled. A decomposition technique is introduced to prove the uniqueness of Lagrange multiplier and the super-linear convergence of the semi-smooth Newton algorithm in [6].

Optimal control for an elliptic system with point-wise Euclidean norm constraints on the control variables were investigated. First order optimality conditions are derived in a manner that is amenable for numerical realization. An efficient semi-smooth Newton algorithm is proposed based on this optimality system. Numerical examples are given to validate the super-linear convergence of the semi-smooth Newton algorithm in [7].

Key publications:

1. K. Kunisch, D. Wachsmuth: Path-following for Optimal Control of Stationary Variational Inequalities, 2009, submitted.
2. A. Roesch, D. Wachsmuth: How to check numerically the sufficient optimality conditions for infinite-dimensional optimization problems. In: Optimal Control of Coupled Systems of Partial Differential Equations. ISNM Vol. 158. Kunisch, Leugering, Sprekels, Tröltzsch (Eds.), 297-317. Birkhäuser (2009).
3. G. Wachsmuth, D. Wachsmuth: Convergence and regularization results for optimal control problems with sparsity functional. RICAM Report 2009-07, submitted.

4. A. Mersha and S. Dempe: Direct search algorithm for bilevel programming problems, to appear in Computational Optimization and Applications
5. A. Mersha and S. Dempe: Feasible direction method for bilevel programming, submitted to Optimization
6. K. Kunisch, K. Liang and X. Lu, Optimal control for an elliptic system with polygonal state constraints, submitted.
7. K. Kunisch and X. Lu, Optimal control for an elliptic system with pointwise nonlinear control constraints, submitted.

Group "Mathematical Imaging""

Group Leader:

Univ. –Prof. Dr. Otmar Scherzer

Researchers funded via ÖAW/Upper Austrian government funds:

PhD Jerome Boulanger

Dr. Peter Elbau

In 2009, the Mathematical Imaging Group was mainly concerned with the following topics:

Non-local patch-based regularization

A paper in IEEE Transaction on Medial Imaging has been accepted. We have presented a non-parametric regression method for denoising fluorescence video-microscopy volume sequences. The designed method aims at using the 3D+t information in order to restore acquired data contaminated by Poisson and Gaussian noise. We propose to use a variance stabilization transform to deal with the combination of Poisson and Gaussian noise. This approach requires the knowledge of parameters related to the acquisition system. Accordingly, we propose a method for the estimation of these parameters. Furthermore, fluorescence video-microscopy usually contains small moving spots with high velocity prescribing unreliable motion estimation. Consequently, we propose an adaptive patch-based framework able to preserve space-time discontinuities and reduce significantly noise level using the 3D+t space-time context. Our method relies on a patch-based energy minimization. A fixed-point solution provides an estimator which can be viewed as a linear combination of atoms lying in a local dictionary. In order to determine the optimal size of this dictionary, we propose to analyze the performance of this estimator. This approach leads to an algorithm whose parameters are calibrated and then

ready for intensive use. The performance of the proposed method is then demonstrated on both synthetic and real image sequences using quantitative as well as visual criteria.
In collaboration with the Department of Biophysics of the University of San Francisco we have shown the interest of the proposed approach for enhancing the sensitivity of video-microscopes. A paper has been recently submitted to Nature Methods.

Event detections

In collaboration with INRIA Rennes, we studied the problem of sudden event detections and proposed two approaches. One has been presented at the conference on Machine Learning and Signal Processing in Grenoble. We used the conditional random Markov to model the interaction between patches and obtained a regularized energy that was minimized using a graph-cut approach. This approach has been applied to the detection of occlusions in video sequences in order to support tracking algorithms. We have also proposed an approach based on the statistical extreme value theory for the detection of these sudden events. We have considered two statistical controls (false discovery rate and family wise error rate) in order to take into account the multi-hypothesis testing context. This last approach has been applied to the automatic detection and characterization of molecular behaviors in large data sets obtained by fast imaging in advanced light microscopy. In collaboration with the Curie Institute we have then selected a molecular model related to membrane trafficking and considered real image sequences obtained in cells stably expressing an endocytic-recycling trans-membrane protein, the Langerin-YFP, for validation. With this model we targeted the efficient detection of fast and transient local fluorescence concentration arising in image sequences from a data base provided by two different microscopy modalities, wide field video microscopy and total internal reflection fluorescence microscopy. Finally, the proposed detection method has been used to statistically explore the effect of several perturbations on the rate of transient events detected on the pilot biological model. A paper written in collaboration with members of the Curie Institute, has been accepted for presentation to the IEEE International Symposium on Biological Imaging. Finally, a more detailed paper is in preparation for PLOS Computational Biology.

Existence of Minimizers of Non-Local Functionals

A standard way in image analysis to regularize a given (noisy) image is to define for all images an energy functional which compromises the similarity to the original image with the regularity of the image. The regularized image is then considered to be the minimizer of this energy functional. A typical choice for the energy functional is to write it as the integral of an energy density which only depends on the image values at one point of the image domain.

But such energy functionals are not suitable to model filtering techniques that take into account multiple structures in an image. In this case, we need to compare (usually similar) intensity values at different points of the image. This idea gave rise to neighborhood filters, as introduced by Yaroslavsky in 1985, and in particular to patch-based filters as for instance the non-local mean filter recently invented by Buades, Coll, and Morel.

Writing these filters in the form of an energy minimization problem, we end up with non-local energy functionals, i.e. with functionals where the energy density depends on the intensity values at two different image points. In the case of patch-based filters, we even have to consider densities depending on the image values at all points in the neighborhood of two different image points.

In the last year, we started to analyse the existence of minimizer for such non-local functionals defined on Lebesgue spaces. In particular, we gave a criterion for well-posedness and strong sequential lower semi-continuity and provided a characterization for the weak sequential lower semi-continuity of these functionals in terms of the energy density only.

Recently, there seems to be an increasing interest in such non-local functionals, especially in those which appear by replacing in classical local regularisation functionals (as e.g. the TV-functional) the gradient by a difference quotient (see e.g. Pontow and Scherzer, Aubert and Kornprobst, or Lou, Zhang, Osher, and Bertozzi, all in 2009).

Photoacoustic Imaging

In our experiments we evaluate the applicability of ex-vivo photoacoustic imaging (PAI) in organs of small animals. We use photoacoustic tomography (PAT) to visualize infarcted areas within mouse hearts and compare it to other imaging techniques (MRI and µCT).

In order to induce ischemia an in-vivo ligation of the Ramus interventricularis anterior (RIVA, left anterior descending, LAD) is performed on nine wild type C41 mice. After varying survival periods the mice are sacrificed. The hearts are excised and immediately transferred into a formaldehyde solution for conservation.

Various wavelengths in the visible and near infrared region (500 nm – 1000 nm) are tested to find the best representation of the ischemic regions. Samples are illuminated with nanosecond laser pulses delivered by an Nd:YAG pumped optical parametric oscillator. Ultrasound detection is achieved by an optical Mach-Zehnder interferometer working as an integrating line detector. For acoustic coupling the samples are located inside a water tank. The voxel data are computed from the measurement data by a Fourier-domain based reconstruction algorithm, followed by a sequence of inverse Radon transforms.

The results show the capability of PAI to detect pathological tissue and the possibility to produce three-dimensional images with resolutions well below 100 µm. Different wavelengths allow the representation of structure inside an organ or on the surface even without contrast enhancing tracers.

Aside from the collaborative work with the medical and biological research groups we have done research in inversion techniques in photoacoustics and transfer of the expertise to other imaging fields, such as radar imaging. In particular we refer to the invited survey article "Sparsity in Inverse Geophysical Problems" (M. Grasmair, M. Haltmeier and O. Scherzer) to appear in the "Handbook of Geomathematics".

A challenge in photoacoustic imaging is to take into account attenuation which refers to the physical fact that high frequency components of a wave are damped more rapidly over time. In the photoacoustics community this topic has been addressed (almost exclusively) in the physics and engineering literature. We performed an axiomatic modelling, which allows to take into account for instance causality. In addition the systematic, axiomatic modelling allows for stable numerical algorithms for the stable solution of the model equations. In the long run, for photoacoustic imaging this work provides the basis for the stable solution of the inverse problem. This is joint work with R. Kowar from the University of Innsbruck.

Key publications:

1. M. Grasmair, H. Grossauer, M. Haltmeier, F.Lenzen, O. Scherzer, Variational Methods in Imaging, Springer, New York (2009)
2. J. Boulanger, Ch. Kervrann, P. Bouthemy, P. Elbau, J.-B. Sibarita, J. Salamero, Patch-based non-local functional for denoising fluorescence microscopy image sequences, IEEE Trans. on Medical Imaging, 28(12), 2009
3. M. Haltmeier, O. Scherzer, G.Zangerl, Exact Series Reconstruction in Photoacoustic Tomography with Circular Integrating Detectors, Communications in the Mathematical Sciences, 7, 665-678 (2009)
4. M. Fuchs, B. Jüttler, O. Scherzer, H. Yang, Shape Metrics Based on Elastic Deformations, Journal of Mathematical Imaging and Vision, 35, 86-102 (2009)
5. O. Scherzer, B. Walch, Sparsity Regularization for Radon Measures, Proceedings Scale Space 2009, LNCS 5567, 452-463 (2009)
6. F. Lenzen, O. Scherzer, A Geometric PDE for Interpolation of M-channel Data, Proceedings Scale Space 2009, LNCS 5567, 413-425 (2009)

7. J. Abhau, Z. Belhachmi, O. Scherzer, On a Decomposition Model for Optical Flow, Proceedings Energy Minimization Methods in Computer Vision and Pattern Recognition 2009, LNCS 5681, 126-139 (2009)

The following patent has been granted: “Method for reproducing an object and device for carrying out said method”, international patent number WO 2010/006349 A2. RICAM is 50% owner (together with the University of Vienna, where Prof. Scherzer holds a professorship now).

Group “Mathematical Methods in Molecular and Systems Biology”

Group Leaders:
Prof. Dr. Christian Schmeiser
Dr. Philipp Kügler

Researchers funded via ÖAW/Upper Austrian government funds:
Dr. Dmitri Miroshnychenko
Dr. Stefan Müller

Researchers externally funded:
Dr. James Lu
MSc Clemens Zarzer

In 2009, the group consisted - in addition to the group leaders – of 3 PostDocs and 1 PhD student. 2 PostDocs were funded by the ÖAW, the additional funds came from a WWTF project led by P. Kügler together with the cooperation partner C. Flamm (Theoretical Chemistry, University of Vienna).

The group was only founded at the beginning of the year such that effort was also spent on recruiting and organizational integration in the Vienna biocenter. Its establishment in parts was motivated by former activities in the field of life sciences of the RICAM groups on “inverse problems” and “analysis of partial differential equations”. As a consequence the new group’s initial focus was put on techniques from the areas of inverse problems and partial differential equations for solving research problems in systems and molecular biology. Problems addressed include parameter identification in and inverse bifurcation/eigenvalue analysis of biochemical reaction networks [1], [2], [4] data driven modelling of voltage gated ion channels [8] or diffusive transport through cellular membranes [9]. In addition, biomechanical questions at the cellular

level such as actin cytoskeleton dynamics in lamellipodia [5], [6] or the dynamics of large cell ensembles with an emphasis on aggregation phenomena caused by cell-cell adhesion and chemotaxis have been studied.

The group was involved in the research projects Elucidating Spatio-Temporal Coherence of Cellular Processes by Data-Driven Inverse Analysis: Redox Rhythmicity in Yeast and Diffusion controlled Hormone Feedback Cycles (WWTF-project MA07-30, jointly led by Philipp Kügler and the project partner Christoph Flamm, Theoretical Biochemistry, University of Vienna) and How do cells move? Mathematical modelling of cytoskeletal dynamics and cell migration (led by C. Schmeiser, project partner J.V. Small, IMBA, OeAW), both funded by the Viennese Science and Technology Fund WWTF. In addition, P. Kügler led (jointly with H.W. Engl) the project Direct and Inverse Modelling and Simulation of Transport in Membranes and Water Channels, part of the doctoral program Molecular Bioanalytics at the Johannes Kepler University Linz funded by the Austrian Science Fund FWF.

Furthermore, first scientific contacts to the group of Carrie Cowan (IMP) about PDE modelling of cell polarity and asymmetric cell division in *C. elegans* and to the group of Joachim Weckwerth (Molecular Systems Biology, University of Vienna) about inverse problems in plant systems biology were established.

Contributions of individual group members:

Stefan Müller

In 2009, Stefan Müller worked on a new formulation of the Michaelis-Menten law for enzyme kinetics using the total quasi steady state approximation (together with Georg Regensburger from the RICAM group on Symbolic Computation). He was involved in the writing of a review paper [2] about inverse problems in systems biology [2] and he contributed to the formulation of an ODE model for the yeast respiratory cycle, part of the WWTF project MA 07-30. Stefan Müller organized a RICAM seminar series *group presentations* in order to facilitate cooperation between the institute's research groups, and he started a seminar on chemical reaction network theory (jointly organized with J. Hofbauer, University of Vienna).

Clemens A Zarzer

Clemens Zarzer investigated several algorithmic approaches for the minimization of Tikhonov-type functionals with sparsity enforcing penalty terms. Based on the results of [3], the benefits and disadvantages of the nonlinear surrogate approach, the Bregman iteration and the iteratively regularized Levenberg-Marquardt method were numerically studied with respect to the respective non-convex optimization problem. In cooperation with R. Ramlau (Industrial Mathematics Institute, University of Linz) a paper about feasible generalizations of the surrogate functional approachs was written and submitted. In July, Clemens Zarzer presented his results at the Applied Inverse Problems Conference in Vienna. Furthermore, Clemens Zarzer developed a model about HPA axis feedback regulation mechanisms within the WWTF project MA07-30 and prepared the model validation by means of experimental data to be delivered from collaborators at the Max Perutz Laboratories (group of Prof. Köhler). A corresponding poster was presented at the Tenth International Conference on Systems Biology, Stanford University. Also, Clemens Zarzer was involved in modelling the presumably nucleosome mediated genetic regulation in the yeast respiratory cycle.

James Lu

Work has been carried out to develop and implement computational methods for studying inverse qualitative problems of limit cycles. More specifically, a collocation scheme for solving the limit cycle system has been developed, allowing for specifying the period of oscillation and phase relationship between the oscillatory species [4]. In collaboration with the WWTF MA07-30 project partners, the method was applied to the analysis of coarse-grained model for metabolic oscillations in yeast. In collaboration with clinicians from the UK, James Lu investigated wavelet-based measures for capturing clinically important features of glucose variability, for possible application in the detection of glycaemic events and diabetic treatment.

Dmitri Miroshnychenko

D. Myroshnichenko worked together with C. Schmeiser on the modeling of microtubule dynamics with the goal to explain the centering mechanism for the centrosome. Together they supervised a diploma thesis on the polymerization/depolymerization dynamics of microtubules.

Key publications:

1. P. Kügler, E. Gaubitzer, S. Müller, Parameter identification for chemical reaction systems using sparsity enforcing regularization - a case study for the Chlorite - Iodide reaction, Journal of Physical Chemistry A 113 (12), 2775-2785.

2. H.W. Engl, C. Flamm, J. Lu, P. Kügler, S. Müller, P. Schuster, Inverse problems in systems biology, Inverse Problems 25 (2009), 123014.
3. C.A. Zarzer, On Tikhonov regularization with non-convex sparsity constraints. Inverse Problems 25 (2009), pp 13.
4. J. Lu, Inverse eigenvalue problems for exploring the dynamics of systems biology models, Advances in Applied Mathematics and Mechanics, vol. 1:6 (2009).
5. D. Ölz, C. Schmeiser, V. Small, Modeling of the Actin-cytoskeleton in symmetric lamellipodial fragments, Cell Adhesion & Migration 2 (2008), pp. 117-126.
6. D. Ölz, C. Schmeiser, Derivation of a model for symmetric lamellipodia with instantaneous cross-link turnover, to appear in Archive Rat. Mech. Anal. (2010).
7. J. Dolbeault, C. Schmeiser, The two-dimensional Keller-Segel model after blow-up, DCDS-A 25 (2009), pp. 109-121.
8. S. Beyl, P. Kügler, M. Kudrnac, A. Hohaus, S. Hering, E. Timin, Different pathways for activation and deactivation in Ca V 1.2: a minimal gating model, Journal of General Physiology 134 (2009), 231—241
9. J.C. Mathai, A. Missner, P. Kügler, S.M. Saparov, M.L. Zeidel, J.K. Lee, P. Pohl, No facilitator required for membrane transport of hydrogen sulphide, PNAS, 2009, vol. 106 no. 39, 16633-16638

Further publications of the group can be found in section 1.6 in chapter 17 of the Akademis report.

1.4 Research program 2010

Group "Computational Methods for Direct Field Problems"

The research program 2010 follows the lines prescribed by the ongoing research projects presented in Section 1.3, i.e., in particular:

1. High-order Finite Element Methods:

- **S. Beuchler:** Investigation of high order finite element discretization schemes and solvers for optimal control problems; Construction of sparsity optimized high-order shape functions for H(div) and H(curl) for triangular and tetrahedral meshes with applications to fast solvers; Development and analysis of fast domain decomposition based solvers for discretizations of elliptic (potential equations, Lame equations) and mixed problems (Stokes problems) by means of high order finite element in three space dimensions.

- **M. Purrucker:** Theoretical and numerical tests of several preconditioners for the solution of the linear system arising in hp-fem from the discretization of elliptic boundary value problems, Investigation of stable elements for the Stokes problem for hp-FEM, implementation of the preconditioners in a hp-FEM simulation program in 2D using quadrilateral elements.

2. Fast Algebraic Multilevel and Multigrid Solvers:

- **J. Kraus:** Auxiliary space methods for linear elasticity problems with a main focus on problems in nearly incompressible elasticity using “reduced integration“ techniques (FWF project – cooperation with E. Karer and L. Zikatanov); Subspace correction methods for discontinuous Galerkin discretizations of elasticity equations (cooperation with B. Ayuso and L. Zikatanov); Multilevel methods for general (also higher order) discontinuous Galerkin approximations and for H(div)-conforming vector-field problems occurring in functional-type a posteriori error estimates for nonconforming approximations (cooperation with S. Tomar). Optimal AMLI methods for problems with rough, high-contrast coefficients (cooperation with S. Margenov).
- **E. Karer:** Investigation of a auxiliary space preconditioner for a special discretization of the linear elasticity equations with a main emphasis on almost incompressible materials; Finishing the PhD studies on algebraic multigrid and multilevel methods for vector-field problems .
- **I. Georgiev** plans to visit RICAM in April and May 2010 in order to continue the cooperation with J. Kraus on multilevel preconditioners and other topics of the planed FWF project.

3. Isogeometric Analysis, a posteriori Error Estimates, Fast Solvers:

- **S. Tomar:** To develop optimal order iterative solvers and functional-type a posteriori error estimates for a wider class of problems. Moreover, research on isogeometric method for numerical solution of partial differential equations has also been started for the FWF project (P21516-N18). Furthermore, if the joint project (with S. Repin, I457-N18) is approved, then its research work will also be started.

These research topics are of course closely connected. Further research topics depend on the special knowledge of the PostDocs we are going to hire.

Group "Inverse Problems"

Sergei Pereverzyev Hui Cao, Shuai Lu, Sivananthan Sampath

- Clinical experiments with a blood glucose predictor based on a fully adaptive learning algorithm, which has been developed in the course of EU-Project "DIAdvisor"; thesetrials will be made in the Endocrinology Department at Centre Hospitalier Universitare de Montpellier, France
- A successful completion of the project FWF Project P 20235-N18 "Indirect regularization in non-Hilber spaces"

Ngyuen Trungh Thanh

- Inverse scattering theory:
  - Extension of the accuracy analysis of the linear sampling method for Maxwell systems and elasticity.
  - Analysis of the theoretical aspects and numerical methods for boundary value problems for Maxwell equations.
- Inverse heat transfer theory:
  - Reconstruction of piecewise constant heat conductivity using incomplete boundary measurements.
  - Splitting method for reconstructing boundary conditions in multi-dimensional inverse heat conduction problems.

Mourad Sini

- We plan to continue the accuracy issue regarding multiple obstacles. When the obstacles are small (with respect to the wave length), then the Rayleigh conjecture is justified, meaning that the resolution of the detection is of the order of the half the wave length. We are interested to study the resolution issue for extended obstacles, i.e not necessary small. This might explain and quantify the resolution of reconstructing multiple and nearly touching obstacles. The analysis of the behavior of the solutions of PDEs when the obstacles are touching is new and very attractive.
- We started the study of the multi-velocity systems regarding the scattering problems as well as inverse dynamical problems. The main feature here is the existence of several (two for instance) different speeds of propagation. The example we are considering for the moment is the elasticity system. In this case, we have Shear waves and Pressure waves. We want to understand if one of these waves is enough to detect interfaces (elastic scattering problem) and extend the known results for the scalar cases (one velocity

models as acoustic, Maxwell, etc...) to multi-velocity systems using only one of the different waves.

Esther Klann

Esther Klann left RICAM end of September 2009 (end of project runtime). She is applying for a grant within the Hertha Firnberg program of FWF. She plans to continue her research on Mumford-Shah models and to qualify for the next step in her scientific career (Habilitation).

Stephan Anzengruber

He will investigate convergence rates for regularization in Besov space norms for Morozov's Discrepancy Principle and (together with P.Lamm, Michigan State University)
convergence of local regularization for Fredholm integral equations of the first kind.

Michael Aichinger

He will continue his cooperation with IMCC according to the cooperation agreement in the COMET framework on stochasitc volatility models, liquidity at risk and fast solvers for complex derivatives. This work is only partly related to inverse problem. As mentioned, these efforts are the nucleus of a future Transfer Group, into which Dr.Aichinger will be moved as soon as it is formally established. Dr.Aichinger will also continue his earlier work on finite element simulation in density functional theory and on quantum chaos: his roots are in theoretical and computational physics.

Group "Symbolic Computation"

D. Sevilla plans to do systematic research on root parametrizations of algebraic curves together with J. Schicho and a PhD student. He will apply to FWF to get support for this project.

G. Regensburger is planning to move in autumn for 2 years to the INRIA in Nice, France, in order to combine his research on integro-differential operators with new application aspects, especially in systems theory.

The main research topic of G. Hegedüs will be "tropical geometry" a relatively recent branch of algebraic geometry with many combinatorial and computational aspects.

N. Lubbes, a PhD student funded by the FWF-project “Solving Algebraic Equations II”, plans to finish his PhD thesis on the constructive minimal model program in autumn 2010. Afterwards, he is planning to continue to work as a PostDoc in the same project.

J. Schicho plans to publish an algorithm and implementation for surface parametrization in Magma based on various results over the last year by former PhD student and RICAM PostDoc T. Beck.

Group “Analysis of Partial Differential Equations

The following research directions will be addressed.

1. Nonlinear kinetic equations with emphasis on stability at nontrivial steady states and rate of convergence for classical problems in mathematical physics (e.g., Boltzmann equations and Vlasov-Poisson-Boltzmann system); for new models of multiagent interaction phenomena we investigate the formation of patterns; also numerical methods will be studied in this latter context;

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

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

4. Tensor approximation of high dimensional functions is going to be addressed and numerical methods for recovering tensors from minimal sample data are investigated; applications in compressed simulation and data analysis will be considered.

During the next months we will conclude the activities of the WWTF project “Mathematical Methods for Image Analysis and Processing in the Visual Arts” which will end in October 2010.

Group “Optimization and Optimal Control”

In cooperation with A. Schiela (ZIB) the convergence of path-following techniques for optimal control of variational inequalities is analysed. Additionally, we will investigate the performance of Newton's method applied to the smoothed problem. In order to obtain an efficient solution method, it will be important to study the coupling of the path-following method with adaptive mesh refinement.

The work on numerical verification of optimality conditions is continued within the FWF project by D. Wachsmuth and S. Akindeinde (position funded by FWF under project grant P21564-N18). We will focus on error bounds for the eigenvalues of the second-derivatives. We will work on a-posteriori error estimates for optimal control problems subject to control and state constraints (D. Wachsmuth / A. Roesch).

Available error indicators contain the approximation error of measure-valued Lagrange multipliers. However, this error does not necessarily tend to zero if the mesh is refined. Based on new proof techniques residual based error estimators will be derived.
The work on regularization error estimates for optimal control problems without control cost will be continued (D. Wachsmuth / G. Wachsmuth). It will be based on a coupling of a properly chosen source term and an assumption on the structure of active sets.
The investigation of eigenvalue minimization problems in shape design of two-density inhomogeneous materials jointly with K.Liang will be finalized in 2010. Convergence of the FE discretization of an appropriately defined Raleigh’s quotient is proved and error estimates for the extremal eigenvalues will be obtained. An efficient monotonically decreasing numerical algorithm will be provided.

Group “Mathematicl Imaging”

Regularization Theory of Non-Local Functionals

An interesting question for the applications is what happens to the sequence of regularized images if we let the noise of the given image tend to zero. Will it converge to the original (noise free) image? We will try to find an answer for this question in the case of non-local regularization functionals. So we are looking (in analogy to the relaxation results for local

functionals) for results about stability, convergence rates, and source conditions of the relaxation method. A FWF proposal for this topic is planned.

Photoacoustic Imaging

This year the prolongation proposal for the NFN (national research network) "Photoacoustic Imaging in Biology and Medicine" has to be submitted. It will be decided on by the FWF in early 2011. The research in this network requires strong interactions with the Medical University of Innsbruck, where currently in-vitro experiments of heart diseases and biological experiments are performed.

Photo-Emission Electron Microscopy

We plan to propose a project on photo-emission electron microscopy (PEEM). In this modality, one can make an image of the surface of a sample. Moreover, by defocusing the system a surface elevation could be reconstructed. We plan to investigate an approach to estimate from a series of image corresponding to different focus a three dimensional representation of the surface. Another aspect of the project is related to the local spectroscopy that this modality could potentially offer if the noise would be less intense. We thus plan to investigate regularization approaches adapted to this highly multi-spectral context.

Group "Mathematical Methods in Molecular and Systems Biology"

Two natural goals for 2010 are to bring the current WWTF-project MA07-30 to a successful end by joint publications in renowned journals and to launch the new WWTF-funded project *Mathematical modeling of actin driven cell migration* (led by C. Schmeiser jointly with V. Small, IMBA). In the latter, the first year's objective is to model actin polymerization and depolymerization, the mechanical properties of the leading edge of the lamellipodium, and the contribution of motor proteins to the retrograde flow of actin. Furthermore, the group plans to work on the automatic analysis of 3D electron tomographs produced by the project partner and on numerical issues related to simulations of our lamellipodium model. Finally, processes in connection with the growth of lamellipodia will be simulated, such as the reaction to stimulation of polymerization along parts of the leading edge and the `healing' of artificially produced holes in the cytoplasm.

On the methodological side, the objective is to further develop computational methods for determining sparse solutions of underdetermined nonlinear systems and to investigate tools for online parameter identification and their relevance for clinical applications.

Furthermore, the scientific integration of the RICAM group within the Vienna biocenter shall be advanced by also intensifying existing contacts to C. Cowan (IMP), J. Knoblich (IMBA) and W. Weckwerth (Molecular Systems Biology, University of Vienna).

1.5 Current version of the medium-term research program for 2011-2013

The work from 2011 onwards will be in the direction outlined in the VISION2020:

Mission Statement and Vision 2020

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

This statement was from the beginning considered as remaining valid in the long run and will also be essential for the future development of the Institute. We relate our Vision 2020 to the individual points of the mission statement.

1. RICAM does basic research in Computational and Applied Mathematics according to highest international standards

Basic research in Computational and Applied Mathematics will remain the key mission of RICAM; as today, the backbone of the Institute will be about ten working groups in subfields of Computational and Applied Mathematics which can be considered as central to this area. Those groups will each, in the average, employ five post-doctoral researchers from basic funds and will bring in third party funds, mainly for doctoral students. The aim is to have, on the average,

at least 33 % of the groups' total budgets from outside funds to be obtained after competitive international refereeing, e. g. from the Austrian National Science Foundation FWF.
The requirements for each group will, as today, be

- the ability to do research in their respective fields at the international forefront of research
- the availability of group leaders willing and able to put substantial effort into scientific leadership of the group
- the potential of interaction between the groups and with the outside world (both within and outside mathematics)

The group members to be funded from the basic funds of RICAM will be mainly PostDocs and will be internationally recruited. The normal employment model will be an initial period of three years and, after scientific success and (normally) after having brought in some third party funding for doctoral students, another three years. Tenure will remain a quite exceptional case.

According to our experience and our expectations of the development of Computational and Applied Mathematics, the following groups will fulfill these criteria also in 2020 and will therefore still exist, maybe with slightly different scientific emphasis compared to today:

- Analysis of Partial Differential Equations

(Current group leaders: Prof. Peter Markowich, Vienna/Cambridge, Doz. Dr. Massimo Fornasier, Linz)

- Computational Mathematics for Direct Field Problems

(Current group leader: Prof. Ulrich Langer, Linz)

- Inverse Problems

(Current group leader: Prof. Heinz W. Engl, Linz/Vienna)

- Mathematical Imaging

(Current group leader: Prof. Otmar Scherzer, Vienna)

- Mathematical Methods in Molecular and Systems Biology

(Current group leaders: Dr. Philipp Kügler, Linz/Vienna, Prof. Christian Schmeiser, Vienna)

- Optimization and Optimal Control

(Current group leader: Prof. Karl Kunisch, Graz)

- Symbolic Computation

(Current group leader: Prof. Josef Schicho, Linz)

The recent evaluation of the Institute confirmed that all these groups fulfill the requirements mentioned above. Cooperation between these groups documented by publications is intensive and forms a nearly complete graph. Various cooperations between, on the one hand, symbolic

and analytical/numerical methods and, on the other hand, direct and inverse methods are and will remain to be a key characteristic of RICAM.

Key areas of Computational and Applied Mathematics that are currently still missing and would be desireable to be established up to 2020 are **Stochastics** and **Discrete Mathematics**. Currently, some members of the Institute work in these areas, but strong groups could not yet be established, mainly since appropriate group leaders were not available.

In addition to these more stable groups to be established with a longer perspective, there should also be **junior groups** with a flexible structure. They should be established for about four years, based on international advertisements and be equipped with a position for a group leader and one additional PostDoc position and be expected to bring in third party funding for doctoral students. The concrete sub-areas of Computational and Applied Mathematics where such groups will be established should be mainly determined by the availability of appropriate junior group leaders and scientific links to at least one of the long-term groups. Such junior groups could also be nuclei for new long-term groups. This strategy could also help in filling the current gaps in Stochastics and/or Discrete Mathematics. The establishment of junior groups has been strongly supported by the last evaluation.

2. RICAM obtains the motivation for its research topics also from challenges in other scientific fields and industry

The research in RICAM so far has certainly obtained motivation from other scientific fields, e.g., in the framework of the Special Semesters (to be mentioned below) and also from industry, and the establishment of the group “Mathematical Methods in Molecular and Systems Biology” also shows that RICAM actively contributes to the needs of other scientific disciplines. A further important goal is also to contribute to the application of mathematical methods in industry by establishing a **Transfer Group**: it has been a long-standing strength of mathematics in Linz that both basic research and cooperation with industry have been done on a high level according to international standards. In order to keep sufficient independence of RICAM, direct cooperations with industry will usually not be done on a contractual basis with RICAM, but in cooperation with the Industrial Mathematics Competence Center (IMCC) via the RICAM Transfer Group. RICAM is already a scientific partner of IMCC, this cooperation should be strengthened and expanded.

3. RICAM emphasizes interdisciplinary cooperation between its workgroups and with institutions with similar scope and universities world-wide

The original core of cooperations between working groups was formed by the FWF-supported SFB “Numerical and Symbolic Computation”, which was very successful and also laid the groundwork for the establishment of RICAM. Another cooperation which already was initiated in this SFB was the one between direct and inverse problems. These cooperations will continue and will be strengthened and expanded. E.g., the scientific boundaries between the groups on Inverse Problems, Optimization and Control, and Imaging are fluent. Also, within the Analysis of PDEs-group, a strong program (in the framework of Dr. Fornasier’s START-project) in Imaging has developed.

The potential cooperations with existing working groups will also be a criterion for establishing junior groups.

All groups and the Institute as a whole have a strong visitors’ program and a great variety of international cooperations. These efforts have recently been restricted by the financial situation, but as soon as that improves, will be strengthened further.

4. RICAM cooperates with other disciplines in the framework of Special Semesters on topics of major current interest

Special Semesters, where the aim is to focus on a specific application area where the mathematical methods represented in RICAM play a role or on a specific mathematical area with emphasis on various applications during a whole semester, have been quite successful until 2008. Each of them attracted more than 100 visitors from all over the world, both as long-term visitors and within various workshops. Due to the financial situation, a Special Semester on Inverse Problems had to be cancelled. As soon as the financial situation is stable enough, RICAM will re-introduce Special Semesters. For doing so, medium-term financial security is necessary, since the planning of such semesters has to be done at least two years in advance. For this and also other reasons, RICAM needs a three-year budget period based on performance agreements.

5. RICAM wishes to attract gifted PostDocs from all over the world and to provide an environment preparing them for international careers in academia or industry

The Institute has a strictly international orientation as far as personnel recruitment is concerned, and most contracts are and will be strictly limited in time. A measure of success will be, that those scientists who spend PostDoc years at RICAM have a good chance to get tenured

positions all over the world. So far, we have been quite successful in this. The establishment of the Transfer Group will also strengthen the position of our graduates for industrial employment.

6. RICAM cooperates with universities by involving PhD-students into its research projects

Since the Academy of Sciences cannot grant a PhD degree itself, it is necessary (and also desireable) to cooperate with universities. So far, degrees of our PhD-students have been mainly granted by the Johannes Kepler University Linz and the University of Vienna. It is also of importance, that our PostDocs have the chance to obtain a habilitation, which will (as up to now) be mainly done at those two universities. In the course of reaching habilitation, our PostDocs will also have the chance to do teaching at these and maybe other universities and thus positively influence also the scientific development at our partner universities.

7. RICAM promotes, through its work and reports about it, the role of mathematics in science, industry and society

As mentioned above, RICAM will, in the next years, play a more active role in technology transfer together with IMCC. In addition, RICAM and IMCC have in the past and will also in the future contribute to changing the public perception of the role of mathematics by various reports in mass media.

Structure: Until the current financial crisis, we were happy with the current legal structure of an Academy Institute. All the goals up to 2020 can be reached in such a structure, but budgets should be known in advance over a longer period. We are also open to a different legal structure as long as major decision can be taken by the Scientific Director, based on the allocated budget.

While currently most groups are led by university professors, in 2020 the situation will be different: The current group leaders might retreat to positions as Scientific Advisors and group leaders of a younger generation should be hired after international advertisement, in most cases on tenured positions and/or, if possible, by joint appointment with one of the universities closely related to RICAM.

In 2020, RICAM will have been some years in the new building in the Science Park at the Johannes Kepler Universität Linz, while the group “Mathematical Methods in Molecular and Systems Biology” will reside in the Vienna BioCenter close to many of its cooperation partners. Most groups and thus the core of the Institute will probably still be in Linz in 2020, groups established close to their cooperation partners like the current one in Vienna will still be the

exception. Due to the connection with IMCC and to industrial partners, also the Transfer Group will be located in Linz.
Of course, this Vision 2020 is a plan, and plans will have to be adapted both to new developments and chances and to financial circumstances. We are convinced that if the Institute develops into this direction, future evaluation reports will be as positive as the last one and RICAM can keep and strengthen its position as one of the internationally leading Institutes in Computational and Applied Mathematics.

A key step in 2011 should be the establishment of a *Transfer Group* as outlined above. There is a preliminary commitment of the Upper Austrian Government to co-fund this activity at the IMCC end of this cooperation. The funding and legal structure has to be set up in 2010.

While the preceding paragraphs describe our overall strategy, the medium term research plans of the working groups are as follows:

Group "Computational Methods for Direct Field Problems"

The medium-term research program for 2011 – 2013 follows our basic aim to the develop, analyse and implement novel computational methods for complicated field problems usually described by systems of Partial Differential Equations arising in different applications. We will focus on the topics which are also listed in the special collaborative research project (2009 – 2013) on "*Robust Large-Scale Scientific Computing Methods and Scalable Algorithms*" of our RICAM group with the Institute for Parallel Processing (IPP) of the Bulgarian Academy of Sciences (BAS) at Sofia (Bulgaria) like

- robust algebraic multigrid and multilevel iteration methods for systems of PDEs,
- domain decomposition and related subspace iteration methods,
- scalable parallel algorithms including grid-enable algorithms,

and new research topics like

- isogeometric analysis,
- multiscale methods,
- solvers for non-linear eigenvalue problems arising from PDEs

for different discretization techniques (FEM, DG-FEM, BEM) and different applications (solid and fluid mechanics, electromagnetics, imaging, life sciences etc.). The planed Special Semster 2011 on „Multiscale Simulation and Analysis in Engergy and the Environment" will certainly influence our research program in 2012 and beyond. On the other hand, we will actively contribute to the research activities during the Special Semster.

Group "Inverse Problems"

The key topic of this group will remain the further development of theory-based regularization methods for nonlinear inverse problems and various applications, e.g., in systems biology in close contact with the group in .the Vienna BioCenter. More and more, non-Hilbert space techniques and non-convex regularization functionals will be in the center of interest. This will also increase the links to the Imaging, Control and Mathematical Analysis Groups. Also, since the needs from practice (both in biological and in industrial application) lead to more and complex inverse problems, the combination of physics-based and data-driven models will be a major topic of research. For the inverse problems side. This increases the use of algorithms from learning theory like support vector machines in connection with more "classical" inversion algorithms. On the other hand, the mathematical analysis of such algorithms requires the use of techniques from nonlinear regularization theory. This work will benefit from (and be beneficial to) the intended cooperation with IMCC via the Transfer Group.

Concrete topics to best studied will depend on available PostDocs and the topics of their third-party funded projects. The group has so far been quite successful to attract PostDocs from all over the world and hopes to be able to continue to do so; but this requires flexibility in the concrete emphasis (especially in application fields) of the work.

Group "Symbolic Computation"

G. Regensburger is planning to spend 2 years at INRIA in Nice, France, in order to combine the calculus on integro-differential operators with algebraic systems theory. The symbolic theory for integro-differential operators has been developped over the last years at RICAM, mainly by Regensburger and M. Rosenkranz, but also by B. Buchberger and H. Engl. We hope (assuming that his further work will be successful) to rehire Regensburger in 2012. We expect that the "Symbolic Computation" group will also benefit from the knowledge he will acquire in INRIA, especially on application aspects.

Singularity theory is another strong theme in the group. It was a topic in the FWF project "Solving Algebraic Equations II", a joint effort of the group of Hauser and the Symbolic Computation group at RICAM. This project will end in August 2012, and beyond we hope to continue our joint cooperation with some other way (joint seminars, workshops etc.) In 2012, H. Hauser from the University of Vienna, S. Mori from RIMS, Kyoto, and Schicho plan to organize a Clay Summer School in Austria on Resolution of Singularities (the scientific advisory board of the Clay Mathematical Institute has recently accepted the proposal, the directory of the institute has yet to approve). We hope to interest many young researchers to work in this field, which is not new but has recently seen interesting new developments.

The first phase of the doctoral college “Computational and Applied Mathematics” will be finished in 2011. We expect that the results of PhD student Hodorog, but also the results achieved in joint cooperation with the other participating institutes and with other groups at RICAM will have sufficient potential to define a successor project in the field of symbolic/numeric algorithms for algebraic problems with noisy data. In particular, we believe that Bayesian inversion methods will play a role in such a successor project, which would then be participating in the second phase of the doctoral college. This also has potential for further cooperation with the “Inverse Problems” group.
In addition to these particular topics, it will be necessary and beneficial to discuss regularly and permanently with colleagues from other groups about their computational problems. The perspective is that the symbolic methods could contribute to the solution of subproblems, as it has happened several times in the past and in the presence.

Group “Analysis of Partial Differential Equations

The group will address three following main directions
1. nonlinear kinetic equations for classical mathematical physics models (e.g., Boltzmann equation) and modeling social interactions and biological processes
2. nonlinear hyperbolic equations for nonlinear water wave modeling and traffic flow on networks
3. variational methods for free-discontinuity and free-boundary problems for image processing.
Both analytical studies and numerical methods will be investigated. We would like to list below a few problems which will be addressed for each of the aforementioned research directions.

1. Kinetic models for bird flocking and fish schools will be derived from a particle description, and the emergence of social behavior will be investigated in terms of convergence to stable patterns; hydrodynamic limits will be derived and analyzed either theoretically or numerically; Chemotaxis equations and kinetic equations coupled with the fluid dynamical equations for bio-fluid modeling and simulation; numerical methods for kinetic and hydrodynamic equations;
2. Linear stability results for Burgers-Poisson equation in presence of a shock for both the solution itself and in its gradient; asymptotic stability in the time variable; analysis of equations modeling traffic flow on networks with discontinuous fluxes; construction of entropic solutions for the Riemann Problem, without any assumption on convexity/concavity of the fluxes; numerical methods for hyperbolic equations;
3. Existence of minimizers of Mumford-Shah type functionals when data are given as the result of an application of a singular operator; characterization of discontinuity sets of such solutions;

analysis of the discrete to continuous limit via Gamma-convergence methods; analysis of free-boundary problems involving p-Laplacian, in particular in case of the 1-Laplacian, when the equation is interpreted as the limit of a linearization by means of a re-weighted nonisotropic diffusion. Numerical methods for the solution of free-discontinuity and free-boundary problems with emphasis for image processing applications.

Group "Optimization and Optimal Control"

In the medium-term perspective of optimal control of partial differential equations new trends are expected to emerge. These will include control of quantum mechanical systems, and closed loop control. The group leader has already published on optimal control of the Schrödinger equation. Future work should include higher order methods, and time optimal control problems, and further along, work on control of the nonlinear Schrödinger equation. Closed loop control is still impeded by the curse of dimensionality. Combination of parallel solvers for the Hamilton Jacobi Bellman equation and reduced order methods, based on proper orthogonal decomposition, for example, give sufficiently well founded hope, to make good progress on obtaining a stable, closed loop control synthesis.
We shall also continue the investigations of time-optimal control synthesis in the context of the wave equation. Little is known about efficient solution techniques. Our approach will be based on a semi-smooth Newton - combined with a method-of-mapping technique in time. It will be essential to investigate the connection between controllability results and the well-posedness and stability of the subproblems that arise in the semi-smooth Newton method.
The FWF-project on numerical verification of optimality has funding for a PhD-student position until January 2013. Within the project, we will develop methods to verify optimality of numerical solutions a-posteriori. That is, given a computed solution of a discretized control problem, we will be able to judge a-posteriori whether the numerical solution is near a solution of the original problem or not.

Group "Mathematical Imaging"

The medium-term research program is based on the assumption of getting granted the three research projects to be submitted in 2010:

Photoacoustic Imaging in Biology and Medicine

We apply for the second funding period of the NFN (national research network) "Photoacoustic Imaging in Biology and Medicine". Parts of the subproject on "Mathematical Methods for Photoacoustic Imaging", manifested at the University of Vienna, are carried out at the Radon

Institute. Within this subproject at RICAM we are performing applied research with the groups of Prof. Jaschke (Medical University of Innsbruck) on the possibilities of photoacoustic imaging for cancer diagnosis and heart diseases. Currently all of our experiments in the laser laboratory are performed in-vitro. The second application concerns biological experiments in gene research with zebra fish with fluorescent marked cells. The advantage of photoacoustic imaging - in contrast to standard light microscopy - is that it can penetrate deeper in the organism, without doing harm to the specimen. These are preliminary studies for a collaboration with Prof. Dirk Meyer (University of Innsbruck). For future applications in applied sciences our photoacoustic setup has to be speed up, which will happen till early 2011. Till 2012 we will perform in-vitro studies on biological and medical specimens. 2012 and 2013 we aim for the first in-vivo studies.

Photo-Emission Electron Microscopy

We plan to conduct the project related to photon-emission electron microscopy in two steps. First, we need to define a good approximation of the forward model which would include the main observed effects such as shadowing and blurring. This would be done in collaboration with Dr. Thorsten Wagner from the Institute for Experimental Physics of the Johannes Kepler University in Linz and last approximatively eight months. Next, we would like to solve the inverse problem and propose a method to reconstruct the elevation map of the imaged surface from a series of defocused images. Finally, we would extend this problem to the case of multispectral imaging and numerical experiments would be conducted.

Regularization Theory of Non-Local Functionals

Concerning the regularization theory for non-local functionals, we will focus our attention in the first year on the analytical results, trying to find some criteria for stability and convergence as in the case of local regularization functionals. In the second year, we will then start to numerically test and eventually apply some of these new regularization functionals.

Group "Mathematical Methods in Molecular and Systems Biology"

The principal goal of the group is 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 the systems and molecular biology. Apart from the advancement of the mathematical competence of the group, reaching the above set goal requires to raise the lasting interest of the relevant Viennese research establishments in interdisciplinary co-operations with RICAM. Hence, a seminar series shall be established in which potential partners are convinced of the advantages of the employment of mathematical

techniques for the evaluation and interpretation of experimental data. In addition, the purpose of this seminar series should be to gain a deeper view of the activities in systems and molecular biology at the Vienna Bio Centre and at the Viennese universities, also in order to filter them with respect of the research profile at RICAM. As interface to the Viennese Bio Cluster, it is the intention of the group to prepare and transfer research questions that fall into the core competence of the RICAM groups already established (especially In Inverse Problems), to Linz for joint work.

With the group having been launched only in 2009, detailed statements about the thematic orientation of the group are difficult at this stage. Anyhow, existing co-operations in the fields the cellular mechanics, inverse problems in systems biology and ion channel gating shall be intensified and lead to joint third party funded research projects. The new WWTF funded project Mathematical modelling of actin driven cell migration, lasting throughout the period 2011-2013, shall firmly establish the expertise of the group in the field of cytoskeleton modelling. It is expected that this will trigger further cooperation with experimental biologists such as those represented on the MFPL list Membranes and the Cytoskeleton (one (out of 6) of their research areas). Similarly, it is the objective to establish the group within the systems biology community. This requires upgrading the mathematical tools of the group with respect to applicability to large scale problems.

1.6 Publications/talks/poster/ presentations 2009

The complete AkademIs report is attached as DVD.

2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

17. Wissenschaftliche Publikationen	gesamt
A) Bücher / Monographien oder **Editionen**	4
A) Peer-reviewte Beiträge in Fachzeitschriften oder Sammelwerken	110
· davon in indizierten Fachzeitschriften	55
B) Herausgeberschaften	1
B) längere Beiträge ohne Peer-Review in Fachzeitschriften oder Sammelwerken	1
C) Sonstige wissenschaftliche Publikationen	15
Veröffentlichungen von Nachwuchswissenschafter(inne)n/Habilitationen	
(diese Publikationen wurden z.T. bereits in oben angeführten Kennzahlen miterfasst)	
· Diplomarbeiten	0
· Dissertationen	2
· Habilitationen	1
Lexikonartikel	0
Kurze Lexikonbeiträge, summarisch	0

***Neu ab Berichtszeitraum 2008:** Es wird das Veröffentlichungsdatum statt des Annahmedatums berücksichtigt!*

17. Liste

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A) Peer-reviewte Beiträge in Fachzeitschriften oder Sammelwerken

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Abhau, Jochen; Scherzer, Otmar (2009) A Combinatorial Method for Topology Adaptations in 3D Deformable Models. International Journal of Computer Vision. [Scherzer, Otmar: HauptautorIn]; peer-rev.indiziert lang

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2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

17. Liste

A) Peer-reviewte Beiträge in Fachzeitschriften oder Sammelwerken

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C) Sonstige wissenschaftliche Publikationen

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C) Sonstige wissenschaftliche Publikationen

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C. John, D. Wachsmuth (16.09.2009) Optimal Dirichlet boundary control of Navier-Stokes equations with state constraint. Bericht-Nr. RICAM Report 2009-18; RICAM: Linz. [Wachsmuth, Daniel: HauptautorIn];

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M. Cruz, D.Gomez, D. Sadornil (2009) On the linear complexity of the Nao-Reingold generator with elliptic curves. [Gomez, Domingo: HauptautorIn];

N. Brandstätter, W. Meidl, A. Winterhof (2009) Addendum to Sidelnikov sequences over nonprime fields. [Winterhof, Arne: HauptautorIn];

P. Bustillo, D. Gomez, J. Gutierrez, Alvar Ibeas (2009) On the linear complexity of the Naor-Reingold sequence. Information Processing Letters. [Gomez, Domingo: HauptautorIn; Ibeas, Alvar: HauptautorIn]; lang

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Sinwel, Astrid (2009) A New Family of Mixed Finite Elements for Elasticity. Doktorarbeit, Institut für Numerische Mathematik, Johannes Kepler Universität Linz, Linz. [Sinwel, Astrid: AlleinautorIn];

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Beuchler, Sven (2009) Fast solvers for hp-finite element discretizations of elliptic boundary value problems two and three space dimensions. Habilitationsschrift, TNF-Fakultaet, JKU Linz. [Beuchler, Sven: AlleinautorIn];

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18. Wissenschaftliche Vorträge und Präsentationen

	gesamt
Eingeladene wissenschaftliche Vorträge	105
· davon auf internationalen Veranstaltungen	88
· davon Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpt	4
· davon Keynotes und Named Lectures	62
Sonstige wissenschaftliche Vorträge	68
· davon auf internationalen Veranstaltungen	51
· davon Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpt	1
Wissenschaftliche Posterpräsentationen	8
· davon auf internationalen Veranstaltungen	8
· davon Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpt	0

18. Liste

Eingeladene wissenschaftliche Vorträge

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Beuchler, Sven (15.05.2009) High order FEM-fast solvers for tensor product elements. Vortrag: Kolloqium Uni Erlangen/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

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Cao, Hui (16.12.2009) Iterated Tikhonov regularization for the elliptic Cauchy problem. Vortrag: Conference on Control and Inverse Problems (Department of Mathematics, Indian Institute of Science, Bangalore), Bangalore/INDIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

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Constantinescu, Corina (26.10.2009) An algebraic operator approach to risk theory. Vortrag: Colloquim in Department of Mathematics, Oregon State University, Corvallis/UNITED STATES <http://www.math.oregonstate.edu/colloquia_archive>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Duan, Renjun (06.10.2009) Stability for a nonlinear Fokker-Planck equation with density-dependent diffusion. Vortrag: Concentration en vitesse et en espace dans les mod`eles cin´etiques et diffusifs, Paris/FRANCE <http://www.ceremade.dauphine.fr/~dolbeaul/CBDif/workshops/IHP2009/>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Duan, Renjun (22.04.2009) Global solutions of the Coupled Chemotaxis-Fluid Equations. Vortrag: Modern Topics in Nonlinear Kinetic Equations, Cambridge/UNITED KINGDOM.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Fornasier, Massimo (02.09.2009) Compressive Algorithms. Adaptive Solutions of PDEs and Variational Problems. Vortrag: Colloquium, Munich/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Fornasier, Massimo (02.09.2009) Numerical harmonic analysis and real-life applications. Vortrag: Harmonic Analysis Workshop: from Foundation to the Real World at the newly established Institute of Science and Technology, Klosterneuburg/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Fornasier, Massimo (13.05.2009) Sparse Approximation and Optimization in High Dimensions. Vortrag: Colloquium, Vienna/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

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Eingeladene wissenschaftliche Vorträge

Fornasier, Massimo (16.04.2009) Compressive Algorithms. Adaptive Solutions of PDEs and Variational Problems. Vortrag: Colloquium, Oslo/NORWAY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Fornasier, Massimo (18.03.2009) Innovative theories, methods and applications in signal and image processing. Vortrag: Colloquium, Lausanne/SWITZERLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Fornasier, Massimo (23.06.2009) Sparse Approximation and Optimization in High Dimensions. Vortrag: Colloquium, Leipzig/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Georgiev, Dr. Ivan (07.06.2009) Multilevel Preconditioning of Crouzeix-Raviart 3D Pure Displacement Elasticity Problems. Vortrag: 7th International Conference on "Large-Scale Scientific Computations", Sozopol/BULGARIA <http://parallel.bas.bg/Conferences/SciCom09.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Hahn, Markus (20.08.2009) Introduction to Markov Chain Monte Carlo. Vortrag: 22nd International Summer School of the Swiss Association of Actuaries 2009 (Swiss Association of Actuaries), Lausanne/SWITZERLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Klann, E. (09.04.2009) Simultaneous Segmentation and Reconstruction for SPECT/CT data. Vortrag: Oberseminar Angewandte Mathematik (Prof. Dr. Martin Burger; Imaging WorkgroupInstitute for Computational and Applied Mathematics), Münster/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Klann, E. (20.07.2009) A Mumford-Shah like approach for tomography data-- reconstruction and regularization. Vortrag: AIP 2009, Vienna/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Loeffen, Ronnie (14.05.2009) De Finetti's dividend problem with absolutely continuous controls. Vortrag: Seminar at the Financial and Actuarial Mathematics Group of the Vienna University of TechnologyTechnology, Vienna/AUSTRIA <http://www.fam.tuwien.ac.at/events/index.php?setshowpast=true>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Loeffen, Ronnie (14.07.2009) Controlled spectrally negative Levy processes with applications. Vortrag: Seminar "Modern Methods in Applied Stochastics and Nonparametric Statistics", Weierstrass Institute for Applied Analysis and Stochastics, Berlin/GERMANY <http://www.wias-berlin.de/research-groups/stochalg/fgsem/abstracts/loeffen.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Loeffen, Ronnie (25.06.2009) De Finetti's dividend problem with absolutely continuous controls. Vortrag: Optimal Stopping with Applications Symposium, Åbo Akademi University, Åbo/Turku /FINLAND <http://web.abo.fi/fak/mnf/mate/gradschool/optimalstopping2009/>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Lu, Shuai (18.12.2009) Multiparameter regularization in downward continuation of satellite data. Vortrag: The International Workshop on Computational Methods for Ill-Posed Problems, Guangzhou/CHINA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Lu, Shuai (21.09.2009) A model function approach in muti-parameter regularization. Vortrag: Algorithms and Complexity for Continuous Problems, Dagstuhl/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Niederreiter, Harald (26.05.2009) "La discre'pance de suites mixtes". Vortrag: Seminar, Marseille-Luminy/FRANCE.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Pereverzyev, Sergei V. (06.01.2009) Adaptive kernel methods using the balancing principle. Vortrag: Joint Meeting of the American Mathematical Society, Washington DC/UNITED STATES.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pereverzyev, Sergei V. (06.10.2009) Multi-parameter regularization and its numerical realization. Vortrag: Workshop on Advances and Trends in Integral Equations, Chemnitz/Klaffenbach/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pereverzyev, Sergei V. (23.09.2009) Multi-parameter regularization and its numerical realization. Vortrag: Algorithms and Complexity for Continuous Problems, Dagstuhl/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (03.10.2009) Statistical methods for problems in computational mathematics. Vortrag: DK Status Seminar, Strobl/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (15.07.2009) A Bayesian model for root computation. Vortrag: Chemnitz-RICAM-Symposium on Inverse Problems (RICAM und TU Chemnitz), Linz/AUSTRIA <http://www.ricam.oeaw.ac.at/events/symposia/csip/>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (24.07.2009) Convergence of Bayesian solutions of linear inverse problems. Vortrag: Conference of Applied Inverse Problems 2009 - AIP 2009 (RICAM und Universität Wien), Wien/AUSTRIA <http://www.ricam.oeaw.ac.at/conferences/aip2009/>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Regensburger, G.; (03.07.2009) Algebraische Strukturen für Randwertprobleme. Vortrag: Colloqium on the occasion of the retirement of Prof. Ulrich

2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

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Eingeladene wissenschaftliche Vorträge

Oberst (Institut für Mathematik, Universität Innsbruck), Innsbruck/AUSTRIA.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Scherzer, Otmar (05.11.2009) Non-Local Integrals in Imaging. Vortrag: Interdisciplinary Workshop on Fixed-Point Algorithms for Inverse Problems in Science and Engineering, Banff/CANADA <http://www.birs.ca/birspages.php?task=displayevent&event_id=09w5006>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Scherzer, Otmar (07.01.2009) Sparse Regularization with l-q Penalty Term. Vortrag: AMS Joint Mathematics Meetings, Washington/UNITED STATES <http://www.ams.org/amsmtgs/2110_intro.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Scherzer, Otmar (27.10.2009) Impedance-Acoustic Tomography. Vortrag: Mathematical Methods in Emerging Modalities of Medical Imaging, Banff/CANADA <http://www.birs.ca/birspages.php?task=displayevent&event_id=09w5017>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Tomar, Satyendra (13.08.2009) On functional-type a posteriori error estimates for non-conforming approximations of elliptic problems. Vortrag: ICES Seminar, ICES, University of Texas, Austin/UNITED STATES.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (04.11.2009) Pseudorandom numbers and number theory. Vortrag: Mathematical Seminar University Zürich, Zürich/SWITZERLAND.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag

Winterhof, Arne (15.09.2009) Character sums over finite fields. Vortrag: Seminar on finite fields, Istanbul/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (22.01.2009) Linear complexity of Sidelnikov sequences. Vortrag: Berufungsvortrag TU Kaiserslautern, Kaiserslautern/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Winterhof, Arne (25.09.2009) Measures of pseudorandomness. Vortrag: Workshop on coding, cryptography and sequences, Antalya/TURKEY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (29.01.2009) Linear complexity and related complexity measures. Vortrag: Workshop on Mathematical Analysis of Evolution, Information and Complexity of the University Ulm, Reisensburg/GERMANY.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Zarzer, Clemens (21.07.2009) Regularization with non-convex sparsity constraints. Vortrag: Conference on Applied Inverse Problems 2009 - AIP 2009, Vienna/AUSTRIA <http://www.ricam.oeaw.ac.at/conferences/aip2009/welcome.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

Eingeladene wissenschaftliche Vorträge: Keynotes and Named Lectures

Engl, Heinz W. (14.03.2009) Mathematics and Industry – a Relation for Mutual Benefit or Mathematical Modelling and Numerical Simulation: From Iron and Steel Making via Inverse Problems to Finance. Vortrag: Festkolloquium Universität Saarbrücken (Universität Saarbrücken), Saarbrücken/GERMANY.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (01.07.2009) Inverse free discontinuity problems and iterative thresholding algotihms. Vortrag: EPSRC Symposium Capstone Warwick Mathematical Institute, Warwick/UNITED KINGDOM.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (08.09.2009) Compressive Algorithms. Adaptive Solutions of PDE's and Variational Problems. Vortrag: Int. Conf. Surfaces XIII, York/UNITED KINGDOM.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (12.01.2009) Mathematics enters the picture. Vortrag: Seminar, Kaiserslautern/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Fornasier, Massimo (12.02.2009) Kinetic models for flocking. Vortrag: Seminar (Prof. Holger Rauhut), University of Bonn/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Fornasier, Massimo (13.01.2009) Mathematics enters the picture. Vortrag: Seminar, Brussel/BELGIUM.; Typ: Named Lecture (internationale Veranstaltung)

Fornasier, Massimo (13.01.2009) Wavelets, joint sparsity, and image processing. Vortrag: FNRS Contact Group "Wavelets and applications", Brussel/BELGIUM.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (15.06.2009) Compressive algorithms. Multilevel preconditioning and convergence rates. Vortrag: Int. Conf. Modern Methods of Time-Frequency Analysis, Strobl/AUSTRIA.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (15.09.2009) Efficient numerical methods for L1-minimization. Vortrag: Invited seminar, Texas/UNITED STATES.; Typ: Named Lecture (internationale Veranstaltung)

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Eingeladene wissenschaftliche Vorträge: Keynotes and Named Lectures

Fornasier, Massimo (21.07.2009) Inverse free-discontinuity problems and iterative thresholding algorithms. Vortrag: Conference on Applied Inverse Problems 2009 (AIP 2009), Vienna/AUSTRIA.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (21.07.2009) Multilevel preconditioning in inverse problems with sparsity constraints. Vortrag: Conference on Applied Inverse Problems 2009 (AIP 2009), Vienna/AUSTRIA.; Typ: Keynote (internationale Veranstaltung)

Fornasier, Massimo (22.09.2009) Mathematics enters the picture. An Italian touch on mathematical imaging. Vortrag: Invited seminar, Texas/ UNITED STATES.; Typ: Named Lecture (internationale Veranstaltung)

Fornasier, Massimo (26.02.2009) Compressive Algorithms. Adaptive Solutions of PDEs and Variational Problems. Vortrag: Invited seminar, Graz/ AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Fornasier, Massimo (27.02.2009) Special Seminar: A Closer Look to Compressed Sensing. Vortrag: Invited seminar, Graz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Fornasier, Massimo (29.05.2009) Iterative thresholding: domain decompositions, multilevel preconditioning, and adaptivity. Vortrag: Tomography with Wavelets, Observatoire Oceanologique, Villefranche-sur-Mer/FRANCE.; Typ: Keynote (internationale Veranstaltung)

Kraus, J. (03.07.2009) Algebraic Multilevel Methods for Elliptic Finite Element Equations (Habilitation Colloquium). Vortrag: Johannes Kepler Symposium on Mathematics, Linz/AUSTRIA <http://www.numa.uni-linz.ac.at/JKS/2009/>.; Typ: Named Lecture

Kügler, Philipp (06.10.2009) Parameter Identification Problems from Systems Biology. Vortrag: Current Topic Workshop: Computational Challenges in Integrative Biological Modelling, Ohio/UNITED STATES.; Typ: Keynote (internationale Veranstaltung)

Kunisch, Karl (10.02.2009) Semi-smooth Newton Methods in Function Spaces. Vortrag: Conference on Numerical Methods for PDE-Constrained Optimal Control/GERMANY.; Typ: Keynote (internationale Veranstaltung)

Kunisch, Karl (12.05.2009) Path Following Methods. Vortrag: Conference in Applied Mathematics "SMAI 2009", La Colle sur Loup/FRANCE.; Typ: Keynote (internationale Veranstaltung)

Kunisch, Karl (16.06.2009) Optimal COntrol of Bidomain equations. Vortrag: 23rd Biennial Numerical Analysis/UNITED KINGDOM.; Typ: Keynote (internationale Veranstaltung)

Kunisch, Karl (23.07.2009) Optimal Control with Polygonial Constraints. Vortrag: SIAM Conference on Control and Its Applications, Denver/UNITED STATES.; Typ: Keynote (internationale Veranstaltung)

Kunisch, Karl (23.09.2009) Semi-smooth Newton Methods in Function Spaces. Vortrag: 12th Workshop on Well Posedness of Optimization Problems in Trento, Italy/ITALY.; Typ: Keynote (internationale Veranstaltung)

Kunisch, Karl (24.02.2009) Optimal Control of Variational Inequalities. Vortrag: Workshop on Coherence, Control and Dissipation, Minneapolis/ UNITED STATES.; Typ: Keynote (internationale Veranstaltung)

Langer, Ulrich (05.06.2009) Domain Decomposition Solvers for Non-linear Multi-harmonic Potential Problems. Vortrag: 7th International Conference on "Large-Scale Scientific Computations"/BULGARIA.; Typ: Keynote (internationale Veranstaltung)

Langer, Ulrich (08.08.2009) Domain Decomposition Methods for Non-linear Parabolic Problems with Time-Harmonic Excitations. Vortrag: 5th Austrian Numerical Analysis Day, Innsbruck/AUSTRIA.; Typ: Keynote (internationale Veranstaltung)

Langer, Ulrich (24.06.2009) Fast Solvers for Non-linear Time-Harmonic Problems. Vortrag: 23rd Biannial Conference on Numerical Analysis/ UNITED KINGDOM.; Typ: Keynote (internationale Veranstaltung)

Langer, Ulrich (29.10.2009) Domain Decomposition Solvers for Nonlinear Multiharmonic Finite Element Equations. Vortrag: Colloquium Mathematische Methoden in den Natur- und Ingenieurwissenschaften/AUSTRIA.; Typ: Keynote (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (02.12.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (04.11.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (08.10.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz, Linz/ AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (09.12.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (11.11.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.;

2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

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Eingeladene wissenschaftliche Vorträge: Keynotes and Named Lectures

Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (14.10.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (16.12.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (18.11.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (21.10.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (25.11.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Massimo Fonte, Francesco Vecil (28.10.2009) Hyperbolic Conservation Laws. Vortrag: Course at the Johannes Kepler Universität, Linz/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Niederreiter, Harald (14.07.2009) "The asymptotic theory of error-correcting codes". Vortrag: Ninth Internat. Conference on Finite Fields and Their Applications, Dublin/IRELAND.; Typ: Keynote (internationale Veranstaltung)

Niederreiter, Harald (26.09.2009) The Gowers norm of binary sequences. Vortrag: Workshop on Sequences, Codes and Curves, Antalya/TURKEY.; Typ: Keynote (internationale Veranstaltung)

Ramlau, Ronny (09.09.2009) Regularization of Inverse Problems with Sparsity Constraints. Vortrag: Talk at University of Cleveland / Boston, University of Cleveland / Boston/UNITED STATES.; Typ: Named Lecture (internationale Veranstaltung)

Ramlau, Ronny (15.05.2009) Regularisierung von schlechtgestellten Problemen Analysis und Anwendung. Vortrag: Vortrag an der Universität Klagenfurt, Klagenfurt/AUSTRIA.; Typ: Named Lecture

Ramlau, Ronny (22.07.2009) Wavelet Based Multilevel Methods for Linear Ill - Posed Problems. Vortrag: AIP Wien (Universität Wien), Wien/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Ramlau, Ronny (23.07.2009) Regularization of Inverse Problems with Sparsity Constraints. Vortrag: AIP Wien (Universität Wien), Wien/AUSTRIA.; Typ: Named Lecture (internationale Veranstaltung)

Ramlau, Ronny (26.05.2009) Regularisierung von schlechtgestellten Problemen Analysis und Anwendung. Vortrag: Vortrag an der Montanuniversität Leoben, Leoben/AUSTRIA.; Typ: Named Lecture

Rosenkranz, M. (16.12.2009) A New Symbolic Method for Linear Boundary Value Problems Using Groebner Bases. Vortrag: Joint Conference of ASCM2009 and MACIS2009 (ASCM), Fukuoka/AUSTRIA <http://gcoe.math.kyushu-u.ac.jp/ascm-macis2009/>.; Typ: Keynote (internationale Veranstaltung)

Scherzer, Otmar (04.02.2009) Methods for the Solution of Inverse Problems. Vortrag: Minicourse on Mathematics of Emerging Biomedical Imaging III, Paris/FRANCE <http://www.cmap.polytechnique.fr/~ammari/Minicourse2009/minicourse09.html>.; Typ: Keynote (internationale Veranstaltung)

Scherzer, Otmar (14.12.2009) Some Remarks on Derivative Free Regularization. Vortrag: Mathematics and Image Analysis 2009, Paris/FRANCE <http://www.ceremade.dauphine.fr/~peyre/mia09/>.; Typ: Keynote (internationale Veranstaltung)

Schicho, Josef (25.09.2009) A Bayesian model for root computation. Vortrag: DMV/OEMG 2009, Graz/AUSTRIA.; Typ: Named Lecture

Schmeiser, Christian (06.05.2009) Measure valued solutions of the 2D Keller-Segel model as limit of a stochastic many particle model. Vortrag: Workshop on Mathematical Biology, Oberwolfach/AUSTRIA.; Typ: Keynote (internationale Veranstaltung)

Schmeiser, Christian (07.10.2009) Measure solutions of the 2D parabolic-elliptic Keller-Segel model. Vortrag: Workshop on Concentration en vitesse et en espace dans les modeles cinetiques et diffusifs (chemotaxis, gravitation, swarming, Paris/FRANCE.; Typ: Keynote (internationale Veranstaltung)

Schmeiser, Christian (10.02.2009) The many body 2D Keller-Segel model. Vortrag: Conference on Mathematical Biology: Modeling and Differential Equations, Barcelona/SPAIN.; Typ: Keynote (internationale Veranstaltung)

Schmeiser, Christian (13.07.2009) Analysis and qualitative properties of a two-dimensional continuum model for cytoskeleton dynamics in the lamellipodium. Vortrag: Workshop on Multiscale Analysis of Self-Organization in Biology, Banff/CANADA.; Typ: Keynote (internationale Veranstaltung)

2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

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Eingeladene wissenschaftliche Vorträge: Keynotes and Named Lectures

Schmeiser, Christian (17.03.2009) Modeling and imaging the actin cytoskeleton in lamellipodia of fish keratocytes and fibroblasts. Vortrag: Mathematical Methods and Modeling of Biophysical Phenomena/BRAZIL.; Typ: Keynote (internationale Veranstaltung)

Schmeiser, Christian (21.10.2009) Friction in the cytoskeleton as a macroscopic limit of the building and breaking of cross-links and adhesions. Vortrag: Seminar/FRANCE.; Typ: Keynote (internationale Veranstaltung)

Schmeiser, Christian (23.06.2009) (Just) a(nother) contribution to hypocoercivity. Vortrag: Workshop on Theory and Applications of Classical and Quantum Kinetic Theory, Banff/CANADA.; Typ: Keynote (internationale Veranstaltung)

Wachsmuth, Daniel (03.06.2009) Optimal Control of Stationary Variational Inequalities: Sufficient Optimality Conditions and Path-following. Vortrag: Workshop on PDE Constrained Optimization of Certain and Uncertain Processes 2009, Trier/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (09.06.2009) Convergence and regularization results for optimal control problems with sparsity functional. Vortrag: MAFELAP 2009, London/UNITED KINGDOM.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (13.11.2009) Optimal Control of Variational Inequalities: Sufficient Optimality Conditions and Path-following. Vortrag: Oberseminar Analysis, Regensburg/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (15.03.2009) Path-following for optimal control of variational inequalities. Vortrag: GPCO 2009/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Wachsmuth, Daniel (19.11.2009) Optimal Control of Variational Inequalities: Sufficient Optimality Conditions and Path-following. Vortrag: Oberseminar Optimierung, Muenchen/GERMANY.; Typ: Named Lecture (internationale Veranstaltung)

Winterhof, Arne (28.05.2009) Pseudozufallszahlen und Anwendungen. Vortrag: Mathematisches Seminar Universität Leoben, Leoben/AUSTRIA.; Typ: Keynote

Sonstige wissenschaftliche Vorträge

Anzengruber, Stephan W (09.07.2009) Morozov's Discrepancy Principle for Tikhonov-type functionals with non-linear operators. Vortrag: DK Statusseminar, Pichl/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Beuchler, Sven (11.06.2009) Fast solvers for hp-FEM using hexahedral elements. Vortrag: Mafelap/UNITED KINGDOM.; Typ: Sonstiger Veranstaltungsbeitrag

Beuchler, Sven (24.09.2009) Fast solvers for hp-FEM using hexahedral elements. Vortrag: OemG-Tagung/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag

Beuchler, Sven (28.09.2009) Fast solvers for hp-FEM using hexahedral elements. Vortrag: Chemnitz FEM-Symposium/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Beuchler, Sven (29.07.2009) Fast solvers for hp-FEM using hexahedral elements. Vortrag: hp-Workshop of implementational aspects/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag

Boulanger, Jérôme; Elbau, Peter (14.01.2009) Mathematical Imaging. Vortrag: RICAM Seminar: Group Presentation "Imaging", Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Constantinescu, Corina (02.06.2009) An algebraic operator approach to the analysis of Gerber-Shiu functions. Vortrag: 2b) or not 2b) conference, Lausanne/SWITZERLAND <http://www.2b-or-not-2b-conference.ch/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Constantinescu, Corina (25.09.2009) An application of symbolic computation techniques to risk theory. Vortrag: 17th ÖMG Congress — Annual DMV Meeting, Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Duan, Renjun (10.12.2009) Hypocoercivity of linear degenerately dissipative kinetic equations. Vortrag: Seminar, Hong Kong/HONG KONG.; Typ: Sonstiger Veranstaltungsbeitrag

Duan, Renjun (16.11.2009) Hypocoercivity of linear degenerately dissipative kinetic equations. Vortrag: Workshop "Theory and Numerics for Kinetic Equations", Saarbrucken/GERMANY <http://www.num.uni-sb.de/rjasanow/workshop2009.html>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Duan, Renjun (21.07.2009) Time decay of some linear kinetic equations. Vortrag: Kinetics and statistical methods for complex particle systems, Lisbon/PORTUGAL.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (06.10.2009) Dehn-Sommerville equations and cellular resolutions. Vortrag: RICAM Symbolic Computation group seminar/ AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

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Sonstige wissenschaftliche Vorträge

Hegedues, Gabor (07.12.2009) Tropical Bezout Theorem. Vortrag: RICAM Symbolic Computation group seminar/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (19.05.2009) Gröbner bases in combinatorics. Vortrag: RICAM Symbolic Computation Group Seminar/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedues, Gabor (22.06.2009) The Lex game and an application. Vortrag: Linz Algebra Day/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Hegedues, Gabor (23.06.2009) Free resolutions in combinatorics. Vortrag: RICAM Symbolic Computation Group Seminar/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hegedus, Gabor (03.11.2009) Upper Bound Theorems. Vortrag: RICAM Group Seminar - Symbolic Computation: Upper Bound Therems, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (01.10.2009) The genus computation problem: symbolic-numeric solutions and beyond. Vortrag: DK Status Seminar, Strobl/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (04.05.2009) A symbolic-numeric algorithm for genus computation. Vortrag: RICAM Group Seminar - Symbolic Computation: A symbolic-numeric algorithm for genus computation, RICAM, Altenbergerstrasse 50, 4040 Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (08.07.2009) A symbolic-numeric algorithm for genus computation. Vortrag: DK Status Seminar, Pichl, Schladming/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (20.10.2009) Why knot? Alternative solution to the genus computation problem. Vortrag: RICAM Group Seminar - Symbolic Computation: Why knot? Alternative solution to the genus computation problem, RICAM, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (25.09.2009) Why knot? Alternative solution to the genus computation problem. Vortrag: INRIA Research Seminar (Galaad team), Sophia-Antipolis, France, INRIA, Sophia-Antipolis/FRANCE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Hodorog, Madalina (27.03.2009) A symbolic-numeric algorithm for genus computation. Vortrag: INRIA Research Seminar (Galaad team), Sophia-Antipolis, France, INRIA, Sophia-Antipolis/FRANCE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Ibeas, Alvar (03.07.2009) Sum of two squares decomposition from approximations. Vortrag: Terceras Jornados de teoria de numeros, Salamanca/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Ibeas, Alvar (10.09.2009) A second round in lattice basis reduction. Vortrag: summer school on provable security, Barcelona/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Ibeas, Alvar (12.06.2009) Noisy interpolation of multivariate sparse polynomials in finite fields. Vortrag: AAECC 18, Madrid/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Karer, Erwin (04.06.2009) Algebraic Multigrid for Problems in Linear Elasticity discretized by DG methods. Vortrag: 7th International Conference on "Large-Scale Scientific Computations" , Sozopol/BULGARIA <http://parallel.bas.bg/Conferences/SciCom09.html>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Klann, E. (21.08.2009) A Mumford-Shah like approach for tomography data-- reconstruction and regularization. Vortrag: Tufts University Applied Mathematics Colloquium, Medford/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Kraus, J. (04.06.2009) Multilevel Preconditioning in H(div) and Applications. Vortrag: 7th International Conference on "Large-Scale Scientific Computations"/BULGARIA <http://parallel.bas.bg/Conferences/SciCom09.html>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (03.06.2009) A convergent overlapping domain decomposition method for total variation minimization. Vortrag: RICAM Informal mini-workshop on sparsity and computations, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (14.10.2009) Subspace Correction Methods for ℓ1-Norm and Total Variation Minimization. Vortrag: Applied Math Colloquium, Los Angeles/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (21.05.2009) Domain decomposition methods for compressed sensing. Vortrag: 8th international conference on Sampling Theory and Applications (SAMPTA09), Marseille/FRANCE.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Langer, Andreas (23.10.2009) Wavelet Space Decomposition for ℓ1-Norm and Total Variation Minimization. Vortrag: Seminar: Applied Mathematics, Los Angeles/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

18. Liste

Sonstige wissenschaftliche Vorträge

Loeffen, Ronnie (03.06.2009) The 2-band strategy in de Finetti's optimal dividend problem. Vortrag: 2b) or not 2b) Conference , University of Lausanne/SWITZERLAND <http://www.2b-or-not-2b-conference.ch/index.html>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Moore, B. (07.05.2009) Two methods for force balancing of Bennett linkages, Computational Kinematics. Vortrag: Computational Kinematics, Duisburg/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Moore, Brian (02.02.2009) Design of dynamically balanced parallel mechanisms. Vortrag: Lower Bavaria - Upper Austria Computer Algebra Seminar (NOCAS), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Moore, Brian (15.04.2009) Application of Symbolic Computation to Robotics. Vortrag: RICAM Seminar: Group Presentation "Symbolic Computation" - Application of Symbolic Computation to Robotics, RICAM, Altenbergerstrasse 69, 4040 Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Moore, Brian (20.03.2009) Balancing of mechanisms . Vortrag: UQTR Mathematics and Computer Science Seminar, Trois-Rivieres/CANADA.; Typ: Sonstiger Veranstaltungsbeitrag

Müller, Stefan (30.08.2009) Inverse Dynamical Problems for Synthetic Biology. Vortrag: The Tenth International Conference on Systems Biology, Palo Alto/UNITED STATES <http://www.icsb-2009.org>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Naoufel Ben Abdallah, María José Cáceres, José Antonio Carrillo and Francesco Vecil (23.04.2009) A deterministic hybrid quantum/classical solver for a nanoscaled MOSFET device. Vortrag: Quantum Systems and Semiconductor Devices: Analysis, Simulation, Applications (Peking University), Beijing (Peking)/CHINA <http://ccse.pku.edu.cn/0904worshop/index.htm>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Niebsch, Jenny (02.09.2009) Imbalances in High Precision Cutting Machinery. Vortrag: International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (ASME), San Diego/UNITED STATES <http://www.asmeconferences.org/idetc2009>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (17.06.2009) Bayes formula and inverse problems. Vortrag: RICAM Seminar: Group presentation "Inverse Problems" (RICAM), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Pikkarainen, Hanna Katriina (21.01.2009) Convergence results for the Bayesian inversion theory. Vortrag: Seminar, Karl-Franzens-Universität Graz, Graz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Purrucker, Martin (08.05.2009) Fast hp-solvers for quadrilateral and hexahedral elements. Vortrag: Numerical Analysis Day 2009/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Purrucker, Martin (29.07.2009) Fast hp-solvers for quadrilateral and hexahedral elements. Vortrag: Berlin hp-Workshop on Implementation Aspects/ GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag

Regensburger, G.; Rosenkranz, M. (25.09.2009) A Skew Polynomial Approach for Integral Operators. Vortrag: Seventeenth Congress of the Austrian Mathematical Society and Annual Conference of the Association of German Mathematicians (Österreichische Mathematische Gesellschaft), Graz/AUSTRIA <http://www.math.tugraz.at/OeMG-DMV/>.; Typ: Sonstiger Veranstaltungsbeitrag

Regensburger, G.; (25.06.2009) Integro-Differential Operators as an Ore Algebra. Vortrag: Applications of Computer Algebra: ACA 2009 (École de Technologie Supérieure (ETS),), Montréal/CANADA <http://aca2009.etsmtl.ca/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Regensburger, Georg (15.04.2009) Symbolic Computation for Boundary Problems. Vortrag: RICAM Seminar: Group Presentation "Symbolic Compuation" - Symbolic Computation for Boundary Problems, RICAM, Altenbergerstrasse 69, 4040 Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Rosenkranz, M.; Regensburger, G.; (02.02.2009) A Skew Polynomial Approach to Integro-Differential Operators. Vortrag: Lower Bavaria - Upper Austria Computer Algebra Seminar (NOCAS) (RICAM), Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Rosenkranz, M.; Regensburger, G.; (06.02.2009) A Skew Polynomial Approach to Integro-Differential Operators. Vortrag: Differential Equations by Algebraic Methods, Hagenberg/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Rosenkranz, M.; Regensburger, G. (24.09.2009) Symbolic Computation for Linear Boundary Problems. Vortrag: Seventeenth Congress of the Austrian Mathematical Society and Annual Conference of the Association of German Mathematicians (Österreichische Mathematische Gesellschaft), Graz/AUSTRIA <http://www.math.tugraz.at/OeMG-DMV/>.; Typ: Sonstiger Veranstaltungsbeitrag

Rosenkranz, M. (16.09.2009) A Symbolic Framework for Operations on Linear Boundary Problems. Vortrag: 11th International Workshop on Computer Algebra in Scientific Computing (CASC'09) (Universität Kobe), Kobe/JAPAN <http://wwwmayr.in.tum.de/konferenzen/CASC2009/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

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Sonstige wissenschaftliche Vorträge

Sevilla, David (09.06.2009) Deciding trigonality of algebraic curves. Vortrag: RICAM Group Seminar - Symbolic Computation, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (13.01.2009) Divisors and curves. Vortrag: Algebraic Geometry Seminar Linz-Wien, Faculty of Mathematics, Nordbergstraße 15, 1090 Wien/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (15.04.2009) What is Symbolic Computation?. Vortrag: RICAM Seminar: Group Presentation "Symbolic Computation", RICAM, Altenbergerstrasse 69, 4040 Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (19.06.2009) Deciding trigonality of algebraic curves. Vortrag: MEGA 2009: Effective Methods in Algebraic Geometry, Barcelona/SPAIN.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sevilla, David (22.06.2009) Radical parametrizations of curves. Vortrag: Linz Algebra Day 2009, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Sevilla, David (25.09.2009) Deciding trigonality of algebraic curves. Vortrag: ÖMG-DMV 2009 (ÖMG-DMV), Graz/AUSTRIA <http://www.math.tugraz.at/OeMG-DMV/>.; Typ: Sonstiger Veranstaltungsbeitrag

Sini, Mourad (15.06.2009) Inverse scattering and boundary value problem for complex structures. Vortrag: Habiliation Coll/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Sini, Mourad (22.04.2009) Inverse obstacle scattering. Vortrag: Ricam Seminar/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Sini, Nguyen Trung Thanh and Mourad (29.04.2009) A brief introduction to Inverse scattering. Vortrag: RICAM Group Seminar - Inverse Problems, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (Internationalität nicht zuordenbar, da nicht mit Veranstaltung verknüpft)

Tomar, Satyendra (08.10.2009) Fast solvers - A gradual approach. Vortrag: NUMA Course at JKU, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Tomar, Satyendra (11.06.2009) Optimal cost for functional-type a posteriori error estimates for discontinuous Galerkin approximations. Vortrag: MAFELAP 2009, London/UNITED KINGDOM <http://people.brunel.ac.uk/~icsrsss/bicom/mafelap2009/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Wachsmuth, Daniel (11.03.2009) Group presentation: Optimal control and optimization. Vortrag: Group presentation: Optimal control and optimization/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Wachsmuth, Daniel (29.09.2009) Convergence and regularization results for optimal control problems with sparsity functional. Vortrag: 22nd Chemnitz FEM Symposium 2009/GERMANY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (14.05.2009) Correlation of the two-prime Sidelnikov sequence. Vortrag: Workshop on Coding and Cryptography, Bergen/NORWAY.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (14.07.2009) Legendre-Sidelnikov sequences. Vortrag: Fq9, Dublin/IRELAND.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Winterhof, Arne (22.06.2009) Nonlinear recurrence sequences over finite fields. Vortrag: Linzer Algebra Tag, Linz/AUSTRIA.; Typ: Sonstiger Veranstaltungsbeitrag

Wissenschaftliche Posterpräsentationen

Boulanger, Jerome (02.09.2009) Discriminant random field and patch-based redundancy analysis for image change detection. Posterpräsentation: IEEE Int. Workshop on Machine Learning for Signal Processing (MLSP'09), Grenoble/FRANCE <mlsp2009.conwiz.dk>.; Typ: Named Lecture (internationale Veranstaltung)

Constantinescu, Corina (29.07.2009) An application of symbolic computation techniques to risk theory. Posterpräsentation: SPA Berlin 2009, Berlin/GERMANY <http://www.math.tu-berlin.de/SPA2009/>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

James Lu, Clemens Zarzer, Rainer Machne, Gottfried Köhler (31.08.2009) Inverse Analysis Of A Negative Feedback Mechanism In Pituitary Gland Cells. Posterpräsentation: The Tenth International Conference on Systems Biology, Palo Alto/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Loeffen, Ronnie (28.07.2009) De Finetti's dividend problem for spectrally negative Levy processes. Posterpräsentation: SPA Berlin 2009, Technische Universität Berlin, Berlin/GERMANY <http://www.math.tu-berlin.de/SPA2009/pages/spa-2009-home/venue.php>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

2. Tabellarische Darstellung und wissenschaftliche Kennzahlen

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Wissenschaftliche Posterpräsentationen

Lu, James (02.11.2009) Mapping dynamics to mechanisms: qualitative inverse problems in biology. Posterpräsentation: MBI Workshop on Dynamics of Signal Transduction and of Gene-Protein Regulatory Networks, Columbus, US/UNITED STATES.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Lu, Shuai (12.10.2009) Regularized total least squares: computational aspects and error bounds. Posterpräsentation: Scientific invited talk by Fudan University, Shanghai/CHINA.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Lu, shuai (24.07.2009) Multi-parameter regularization and its numerical realization. Posterpräsentation: Conference on Applied Inverse Problems, Vienna/AUSTRIA <http://www.ricam.oeaw.ac.at/conferences/aip2009/minisymposia/minisymposium.php?id=102>.; Typ: Sonstiger Veranstaltungsbeitrag (internationale Veranstaltung)

Lu, Shuai (30.10.2009) Regularized total least squares: computational aspects and error bounds. Posterpräsentation: Scientific invited talk by University of Tokyo, Tokyo/JAPAN <http://info.ms.u-tokyo.ac.jp/seminar/2009/sem09-184.html>.; Typ: Sonstiger eingeladener Veranstaltungsbeitrag (internationale Veranstaltung)

1.7 Scientific cooperation 2009

Due to the restrictive definition (by ÖAW/Akademis) of “cooperation partners” the actual list of cooperation partners is much longer than described below.

Group “Computational Methods for Direct Field Problems”

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

Cooperation within RICAM:

- S. Beuchler with D. Wachsmuth (Optimal Control Group) and C. Pechstein (NuMa, JKU Linz) on boundary concentrated FEM for optimal control problems. A joint publication will be finished in 2010..
- I. Georgiev and J. Kraus with J. Schicho (Symbolic Group) on symbolic techniques for optimal M-matrix approximation of (local) finite element stiffness matrices.
- I. Georgiev and J. Kraus with B. Ayuso and L. Zikatanov on robust subspace correction methods for discontinuous Galerkin approximations of elasticity problems.
- E. Karer and J. Kraus with L. Zikatanov on auxiliary space methods for stable discretizations of nearly incompressible elasticity problems based on “reduced integration”.
- J. Kraus and S. Tomar on multilevel methods for discontinuous Galerkin approximations and solution of optimization problems arising in functional-type a posteriori error estimates for nonconforming finite element methods.

National cooperation:

- *S. Beuchler* with P. Pohl and G. Schütz (Institute for Biophysics, JKU Linz) on numerical simulation of the proton transfer along lipid bilayer membranes: FWF project application within the BioDK. Prolongation of the research with T. Renger (Institute for Theoretical Physics, JKU Linz).
- *S. Beuchler* with V. Pillwein (DK W1214, JKU Linz) and S. Zaglmayr (TU Graz) on sparse shape functions for H(div) and H(curl): 2 joint publications will be finished in 2010.
- *J. Kraus* with V. Pillwein (DK W1214, JKU Linz) and *L. Zikatanov* (Penn State University, USA) on polynomial sequences, symbolic techniques for computing their recurrence relations, and applications to the construction of AMLI methods for general elliptic problems. These techniques can also be exploited in efficiently generating the main components of adaptive AMG methods.

- *U. Langer* and *S. Tomar* cooperated with C. Hofreither (DK W1214) on the topic "Boundary Element Simulation of Linear Water Waves in a Model Basis" resulting in a paper that is accepted for publication in the proceedings of the 7th International Conference on Large-Scale Scientific Computations.
- S. *Tomar* with B. Jüttler: On isogeometric method for numerical solution of partial differential equations, within the framework of FWF project P21516-N18.

International 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 for Parallel Processing (IPP) of the Bulgarian Academy of Sciences (BAS) at Sofia (Bulgaria). This cooperation has resulted in numerous joint publications, see [List 17]. In particular, J. Kraus and S. Margenov (IPP) finished a monograph titled “Robust Algebraic Multilevel Methods and Algorithms” that was published by Walter de Gruyter in October 2009.
- S. Beuchler cooperates with L. Demkowicz (Austin, USA) on the development of hp-FEM fast solvers for linear elasticity problems with thin structures (plates).
- E. Karer, J. Kraus and L. Zikatanov (Penn State University, USA) on auxiliary space methods for stable discretizations of nearly incompressible elasticity problems based on “reduced integration”.
- I. Georgiev with P. Boyanova (IPP, BAS, Bulgaria), S. Margenov (IPP, BAS, Bulgaria) and L. Zikatanov (Penn State University, USA) on multilevel preconditioning of graph-Laplacians.
- J. Kraus and S. Margenov (IPP, BAS, Bulgaria) on multilevel methods for problems with rough, high-contrast coefficients.
- I. Georgiev and J. Kraus with B. Ayuso (Universidad Autonoma de Madrid) and L. Zikatanov on robust subspace correction methods for discontinuous Galerkin approximations of elasticity problems.
- J. Kraus with V. Pillwein (RISC+MathDK W1214, JKU Linz) and L. Zikatanov (Penn State University, USA) on polynomial sequences, symbolic techniques for computing their recurrence relations, and applications to the construction of AMLI methods for general elliptic problems. These techniques can also be exploited in efficiently generating the main components of adaptive AMG methods.
- U. Langer cooperated with D. Copeland (Texas A&M University, College Station, USA) on the multiharmonic approach to non-linear parabolic initial-boundary value problems. Two papers were finished and submitted.

- S. Tomar with T.J.R. Hughes (Austin, USA): On isogeometric method for numerical solution of partial differential equations, within the framework of FWF project P21516-N18, and J.T. Oden Faculty research fellowship.
- S. Tomar with S. Repin (St. Peteresburg, Russia): On functional-type a posteriori error estimates. See joint publications in [List 17].
- L. Zikatanov is collaborating with R. Scheichl (University of Bath, England), and Panayot S. Vassilevski (Lawrence Livermore National Lab, USA) on developing AMG and upscaling techniques based on energy minimizing bases with constraints with applications to elasticity and flows in porous media.
- L. Zikatanov is collaborating with B. Ayuso (Universidad Autonoma de Madrid, Spain) on preconditioners for non-symmetric DG discretizations.
- L. Zikatanov is collaborating with J. Brannick (Penn State University, USA), and C. Rebbi and R. Brower (Boston University, USA) on fast solvers for Dirac equation with Applications in Quantum Chromodynamics.

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

Group "Inverse Problems"

Sergei Pereverzyev, Hui Cao, Shuai Lu, Sivananthan Sampath

National cooperation:

- Prof. Luigi del Re (JKU) - cooperation within EU-Project "DIAdvisor"

International cooperation:

- Prof. Willi Freeden (University of Kaiserslautern, Germany) – cooperation in the book project "Handbook of Geomathematics", Springer.
- Prof. Zuhair Nashed (University of Central Florida, USA) - cooperation in the book project "Handbook of Geomathematics", Springer.
- Prof. Giovanni Sparacino (University of Padova, Italy) - cooperation within EU-Project "DIAdvisor"

- Dr. Lorenzo Rosasco (MIT) - joint publication.
- Prof. Michael Klibanov (University of North Carolina at Charlotte, USA) - joint publication, cooperation within FWF-Project P20235-N18.
- Professor Bernd Hofmann (TU Chemnitz, Germany) - joint publication, cooperation within FWF-Project P20235-N18.
- Prof. Ulrich Tautenhahn (University of Applied Sciences Zittau/Görlitz, Germany) - joint publication, cooperation within FWF-Project P20235-N18.
- Prof. Peter Mathe (WIAS-Berlin) - joint publication, cooperation within FWF-Project P20235-N18.
- Dr. Adel Mhamdi and Yi Heng (RWTH Aaachen, Germany) - joint research in progress, cooperation within FWF-Project P20235-N18.
- Prof. Wang Yanfei (Institute of Geology and Geophysics, The Chinese Academy of Sci., Beijing, China) – cooperation in the book project “Optimization and Regularization for Computational Inverse Problems and Applications”, Springer and HEP-China.
- Prof. Phoolan Prasad (Indian Institute of Science, Bangalore, India) - joint research in progress, cooperation within FWF-Project P20235-N18.

Industrial cooperation:

- Dr. Samuel McKennoch (Novo Nordisk A/S, Denmark) - cooperation within EU-Project "DIAdvisor"
- Dr. Jette Randløv (Novo Nordisk A/S, Denmark) - cooperation within EU-Project "DIAdvisor"

Nguyen Thrungh Thanh

Cooperation within RICAM:

- Dr. Mourad Sini (inverse scattering theory)

International cooperation:

- Prof. Dinh Nho Hao, Hanoi Institute of Mathematics, Vietnam (inverse heat transfer theory)

Hanna Pikkarainen

Cooperation within RICAM:

- Prof. Dr. Ronny Ramlau, RICAM / Johannes Kepler Universität Linz (Bayesian methods for obtaining qualitative information about unknowns in inverse problems)
- Prof. Dr. Josef Schicho (Bayesian methods for algebraic computation problems with

approximate data)

National cooperation:

- Dr. Kristian Bredies, Karl Franzens Universität Graz, Austria (regularization of measure-valued inverse problems)
- Dr. Stefan Kindermann, Johannes Kepler Universität Linz, Austria (regularization in financial mathematics)
- Prof. Dr. Andreas Neubauer, Johannes Kepler Universität Linz, Austria (Bayesian inversion theory in infinite-dimensions)

International cooperation:

- Prof. Dr. Thorsten Hohage, Georg-August-Universität Göttingen, Germany (Bayesian inversion theory in infinite-dimensions)
- Dr. Roland Potthast, University of Reading, UK (Bayesian inversion theory in infinite dimensions)

Kattrin Arning

- Martin Burger (Münster, Germany)
- Robert S. Eisenberg (Rush Medical University, Chicago)
- Bärbel Schlake (Münster, Germany)

Mourad Sini

National cooperation:

- Dr. Stefan Kindermann, Johannes Kepler Universität Linz, Austria. (Coupling of iterative and non-iterative methods for detecting interfaces)
- Dr. Thanh Nguyen, RICAM, Linz, Austria. (Accuracy of reconstruction via the linear sampling method)

International cooperation:

- Prof. Gen Nakamura, Hokkaido University, Japan (Point-wise estimates for Green's functions)
- Prof. Jijun Liu, South East University, China (Accuracy of the probing methods and coating effects)
- Prof. C. Roland Potthast, Univ. Reading, UK (Reconstruction of obstacles for Maxwell systems)
- Dr. Eva Sincich, University of Udine, Italy (Improved stability estimates of obstacles for

Elasticity using few incident waves)

- Dr. M. Di-Cristo, Polytechnic school of Milano, Italy (Stability estimates for elasticity using farfield maps)
- Prof. Fioralba Cakoni, University of Delaware., USA. (Asymptotic formulas for conductive obstacles via the linear sampling method)
- Prof. D. Gintides, University of Athens, Greece. (Scattering problems for the elastic Lame system. Uniqueness and reconstruction)

Tapio Helin

- ESO project members within RICAM, IMCC and JKU
- ESO, Garching
- University of Helsinki, Finland:
  - Prof. Matti Lassas
  - Dipl.Ing. Lauri Oksanen

Esther Klann

National cooperation:

- Prof Dr. Ronny Ramlau, Johannes Kepler Universität Linz, Austria (reconstruction and segmentation of tomography data, Mumford-Shah like functionals, regularization theory)
- Prof. Dr. Wolfgang Ring, University of Graz, Austria (reconstruction and segmentation of tomography data, Mumford-Shah like functionals, level-set methods, shape calculus)
- Mag. rer. nat. Elena Hötzl, University of Graz, Austria (reconstruction and segmentation of tomography data, Mumford-Shah like functionals, computational aspects, minimization strategies)

International cooperation:

- Prof. Dr. Lothar Reichel , Kent State University, Ohio, USA (joint research and publication)
- Prof. Dr. Martin Burger, University of Muenster, Germany (joint research)
- Prof. Dr. Eric Todd Quinto, Tufts University, Medford, USA (joint research on limited tomography)

Industrial cooperation:

- Dr. D. Tonova, Carl Zeiss Jena GmbH, Germany – Design of optical coating

Group "Symbolic Computation"

Cooperation within RICAM:

- Together with C. Constantinescu, H. Albrecher and G. Pirsic from the former group "Financial mathematics", Regensburger and Rosenkranz gave closed formulas for Gerber-Shiu functions. This result appeared in [1], and the same group of researchers is working on extending the method to other cases.
- H. K. Pikkarainen from the "Inverse Problems" group and Schicho appled Bayesian methods for root computation of polynomials with noisy coefficients [2].
- I. Georgiev and J. Kraus from the "Numerical Analysis" group, S. Margenov from the Bulgarian Acedemy of Sciences and Schicho compared symbolic different types of locally optimal constructions of M-matrices for element preconditioning [3], one of which is symbolic/algebraic.
- D. Wachsmuth from the "Optimization" group and Sevilla started to work together on a symbolic formula for integrals arising in a numerical optimization scheme.

External cooperation:

The FWF project "Solving Algebraic Equations II" is a joint project with H. Hauser (Univ. Wien). It started in September.

The FWF doctoral college "Computational Mathematics" started in October 2009. It is a cooperation of the symbolic group (PhD student Hodorog, advisor Schicho) and several groups in symbolic computation, numerical analysis, and inverse problems, at the University of Linz.

Key publications:

1. Albrecher, H., Constantinescu, C., Pirsic, G., Regensburger, G., and Rosenkranz, M. (2009) An algebraic operator approach to the analysis of Gerber–Shiu functions. Insurance: Mathematics and Economics, DOI:10.1016/j.insmatheco.2009.02.002
2. H. K. Pikkarainen and J. Schicho. A Bayesian model for root computation. Math. in Comp. Sci., 2:567-586, 2009.
3. I. Georgiev, J. Kraus, S. Margenov, and J. Schicho. Locally optimized MIC(0) preconditioning of Rannacher-Turek FEM systems. Appl. Num. Math., 59, 2009. 2402-2415.

Group "Financial Mathematics""

Prof. Hansjörg Albrecher

External cooperation:

- Michel Denuit (Louvain-la-Neuve, Belgium)
- Jef Teugels (K.U. Leuven, Belgium)
- Soren Asmussen (Aarhus, Denmark)
- Xiaowen Zhou (Montreal, Canada)
- Hans Gerber (Lausanne, Switzerland)
- Hailiang Yang (Hongkong)
- Onno Boxma (Eindhoven, Netherlands)

Dr. Arne Winterhof

Internal cooperation:

- S. Ming (ÖAD)
- D. Gomez (Spanish Science Fund)
- A. Ibeaz (FWF Pseudorandom Sequences)
- R. Marzouk (FWF)
- R. Shaheen (FWF)
- H. Niederreiter

External cooperation:

- S. Balasuriya (Macquarie Sydney)
- I. Shparlinski (Macquarie Sydney)
- H. Aly (Cairo)
- C. van de Woestijne (Leoben)
- N. Brandstätter (Lausanne)
- A. Sarközy (Budapest)
- A. Ostafe (Uni Zürich)
- G. Pirsic (JKU Linz)
- Z. Chen (Fujang)
- W. Meidl (Sabanci Istanbul)
- A. Topuzoglu (Sabanci Istanbul)
- W. Schleich (Uni Ulm)

Dr. Corina Constantinescu

External cooperation:

- Enrique Thomann (Orgean State University, USA)
- Ed Waymire (Orgean State University)
- Stephane Loisel (Lyon, France)
- Zbigeniew Palmowski (Wroclaw, Poland)
- Florin Avram (Pau, France)

Group "Analysis of Partial Differential Equations""

Renjun Duan has ongoing internal cooperation with P. Markowich and M. Fornasier, and an external cooperation with A. Lorz (Univ. of Cambridge, where R. Duan also visited), leading to the publications [10,11]. He has cooperation with R. M. Strain (Princeton University) [12] K. Fellner (University of Cambridge) [9], and T. Yang (City University of Hong Kong) [13]. He started new cooperation with J. A. Carrillo (University of Barcelona).

Massimo Fonte has an ongoing internal cooperation with P. Markowich and external cooperation with A. Bressan (PennState University, USA, where M. Fonte also visited), K. Fellner (DAMTP, University of Cambridge, UK), and F. S. Priuli (SISSA, Italy).
Andreas Langer obviously works with his advisor M. Fornasier and they have an ongoing external cooperation with Carola-Bibiane Schönlieb (DAMTP, Univeristy of Cambridge, UK) which led to the publications [16,19]. This research direction established also a new cooperation with the group of Direct Fields Problems led by Professor Ulrich Langer.

Andreas Langer also visited the Department of Mathematics of the University of California in Los Angeles (Sept.-Dec. 2009) and he activated new ongoing cooperation with Y. Kim, S. Osher, and L. Vese.

M. Fornasier's research visits in 2009 include the Institute for Numerical Simulation (University of Bonn, Germany), the Program in Applied and Computational Mathematics (Princeton University, U.S.A), the Department of Applied Mathematics and Theoretical Physics (Center of Mathematical Sciences, Cambridge University, UK), Department of Mathematics (Univ. Marburg) and the Department of Mathematics (Texas A&M University, U.S.A. in the period Sept.-Oct. 2009). His external cooperation resulting in publications include those with J. Carrillo, J. Rosado (Univ. Barcelona) and G. Toscani (Univ. Pavia) [4-5,15], with I. Daubechies (Univ. Princeton) and R. DeVore (Texas A&M University) [6], R. Ward (Courant Institute, New York

University) [20], R. March (IAC-CNR Rome) [17], S. Dahlke (Univ. Marburg). He led several internal cooperation with the group members.

Jan Haskovec started his work at RICAM on June 2009; he has joint internal cooperation with M. Fornasier [1,15] and C. Schmeiser [21]. He has ongoing cooperation with the University of Oxford where he is currently spending a research visit for two months.
Yunho Kim visited our group in July-Sept. 2009, initiating cooperation with Andreas Langer who later exchanged the visit, going to California in the period Sept.-Dec. 2009 in order to continue the ongoing cooperation.

Karin Schnass started her activity on January 2010.

The cooperation of Francesco Vecil with Ben Abdallah (Univ. Paul Sabatier), M.J. Caceres (Univ. Granada) J. Carrillo (Univ. Barcelona), led to the publication [3]. Moreover, he also contributed to the work [5] which involved the internal cooperation with M. Fornasier.
Jan Vybiral started his activity in October 2009, and he has ongoing cooperation with the University of Jena and the Charles University of Prague.

Group "Optimization and Optimal Control""

Here we list those cooperation which result in joint publications.

D. Wachsmuth with D. Sevilla (Ricam, Symbolic): Symbolic integration of truncated quadratic polynomials, which can be applied in variational discretization of optimal control problems with higher order finite elements, publication submitted. [1]

D. Wachsmuth with S. Beuchler (Ricam, Comp. Methods for Direct Field Problems), C. Pechstein (JKU Linz): Work on the boundary concentrated finite element method for boundary control problems, publication in preparation.

D. Wachsmuth with C. John (TU Berlin): Optimal boundary control of steady-state Navier-Stokes equations with state contraints, [2].
D. Wachsmuth with G. Wachsmuth (Chemnitz): Convergence and regularization for optimal control problems with a sparsity functional, submitted [3].

D. Wachsmuth with A. Roesch (Duisburg): Numerical verification of optimality conditions,[4]

K. Kunisch continued long range cooperation with the Department of Mathematics at North Carolina State University, and more recently University of Tokyo. In a joint work with K. Ito, a novel method for solving time optimal control problems with bang bang controls was developed which does not rely on a-priori knowledge of the switching structure of the controls. [5]

K. Kunisch's collaborated with B. Jin, University of Bremen, and guest of the Inverse group at the Radon institute, on automatic parameter choice strategies in inverse problems with L^1 fit-to-data term[6].

X. Lu with B. Jin (Bremen Univ.): An inverse problem of estimating spatially-and-temporally dependent Robin coefficients arising in transient heat conduction problems was investigated. A regularization approach is proposed, and the properties of the functional are investigated based on the analysis of the parameter-to-state map, especially differentiability results are established. The finite element method is adopted for discretizing the continuous problem, and the convergence of the finite element approximation is established. Two algorithms for solving the discretized problems are described. Numerical results for one- and two-dimensional problems with both smooth and nonsmooth solutions are presented to illustrate the algorithms in [7].
X. Lu with P. Lin (Dundee Univ.): The estimation of numerical approximation of harmonic heat flow with Dirichlet boundary condition was studied. Extra regularity of the solution can be obtained if the initial data is close to the steady state in the sense of the H^1 energy of initial data is close to the energy of steady state. Two numerical schemes were analyzed and numerical tests were given in [8].

A finite element method for the penalty formulation of the time dependent Navier-Stokes equations was considered P. Lin and X. Lu . An improper choice of the finite element space would lead to an error estimate that depends on the penalty parameter. We use the classical P_1 nonconforming finite element space for the spatial discretization. Optimal uniform error estimations for both velocity and pressure are obtained in [9].

Key publications:

1. D. Sevilla and D. Wachsmuth: Polynomial integration on regions defined by a triangle and a conic, submitted to ISSAC 2010.
2. C. John and D. Wachsmuth: Optimal Dirichlet boundary control of Navier-Stokes equations with state constraint. Numerical Functional Analysis and Optimization 30(11&12), 1309-1338 (2009).

3. G. Wachsmuth and D. Wachsmuth: Convergence and regularization results for optimal control problems with sparsity functional. RICAM Report 2009-07, submitted.
4. A. Roesch and D. Wachsmuth: How to check numerically the sufficient optimality conditions for infinite-dimensional optimization problems. In: Optimal Control of Coupled Systems of Partial Differential Equations. ISNM Vol. 158. Kunisch, Leugering, Sprekels, Tröltzsch (Eds.), 297-317. Birkhäuser (2009).
5. K. Ito and K. Kunisch: Semi-smooth Newton Methods for Time-Optimal Control for a Class of ODEs, submitted.
6. Christian Clason, Bangti Li. A and K. Kunisch, A semismooth Newton method for L^1-data fitting with automatic choice of regularization parameters and noise calibration, submitted
7. B. Jin and X. Lu, Numerical estimation of an inverse Robin problem in transient heat conduction, in preparation.
8. P. Lin, X. Lu and J. Zhou, Numerical error estimates for harmonic heat flow, in preparation
9. P. Lin and X. Lu, Error estimate of the P_1 nonconforming finite element method for the penalized unsteady Navier-Stokes equations, appeared in Numer. Math.

Group "Mathematical Imaging""

In 2009, we pursued our collaboration with Inria Rennes in France (Charles Kervrann and Patrick Perez). We also worked with Institute Curie in Paris (Jean Salamero, Alexandre Gidon and Anatole Chessel), with the University of Bordeaux (Jean-Baptiste Sibarita), and with the University of San Francisco (John Sedat).

Joint collaborations with Prof. Jorge Zubelli have been initiated during the Special Semester on Finance Analyzed by Stochastic Methods, September 1st, 2008 - December 5th, 2008, organized by RICAM, Austrian Academy of Sciences. The work has lead to two publications, which have been submitted recently. Together with Elena Resmerita a joint work on finite dimensional approximations in Banach spaces has been initiated. This is joint work also with C. Poeschl, who is currently visiting Prof. V. Caselles at the University of Barcelona.

Group "Mathematical Methods in Molecular and Systems Biology"

Scientific cooperation:

- Pratik Choudhary, King's College London, UK (J. Lu)
- J. Dolbeault, Universite Paris Dauphine: modeling of chemotaxis (C. Schmeiser)

- C. Flamm, Institute for Theoretical Chemistry, University of Vienna: co-leader of the WWTF project Elucidating Spatio-Temporal Coherence of Cellular Processes by Data-Driven Inverse Analysis: Redox Rhythmicity in Yeast and Diffusion controlled Hormone Feedback Cycles (P. Kügler, J. Lu, S. Müller, C.A. Zarzer)
- J. Haskovec, PDE analysis group, RICAM: modelling of chemotaxis (C. Schmeiser)
- S. Hering, Department of Pharmacology and Toxicology, University of Vienna: modelling of voltage gated ion channels (P. Kügler)
- J. Hofbauer, Institute for Mathematics, University of Vienna: joint seminar on Chemical Reactions Network Theory (S. Müller)
- G. Köhler, Biomolecular Optical Spectroscopy Group, Max F. Perutz Laboratories, Vienna: partner of the WWTF project Elucidating Spatio-Temporal Coherence of Cellular Processes by Data-Driven Inverse Analysis: Redox Rhythmicity in Yeast and Diffusion controlled Hormone Feedback Cycles (P. Kügler, J. Lu, C.A. Zarzer)
- D. Murray, Institute for Advanced Biosciences, Keio University, Japan: partner of the WWTF project Elucidating Spatio-Temporal Coherence of Cellular Processes by Data-Driven Inverse Analysis: Redox Rhythmicity in Yeast and Diffusion controlled Hormone Feedback Cycles (P. Kügler, J. Lu, S. Müller, C.A. Zarzer)
- P. Pohl, Institute for Biophysics, Johannes Kepler University, Linz (P. Kügler)
- R. Ramlau, Institute for Industrial Mathematics, Johannes Kepler University,
- Linz (C.A. Zarzer)
- G. Regensburger, Symbolic Computation group, RICAM: quasi-steady state approximations in enzyme kinetics (S. Müller)
- C. Sainsbury, Centre for Mathematics Applied to the Life Sciences, University of Glasgow, UK (J. Lu)
- J.V. Small, IMBA, OeAW: partner of the WWTF-project How do cells move? Mathematical modelling of cytoskeletal dynamics and cell migration (C. Schmeiser)

Joint publications see section 1.3.

Research stays:

Institute for Systems Biology, Seattle, USA (P. Kügler): 03. August -08. August 2009

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 these 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 the 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 2009, the following talks were given in these categories mentioned above:

RADON COLLOQUIA
Prof. Dr. Roberto Natalini Istituto per le Applicazioni del Calcolo „M. Picone“ Consiglio Nazionale delle Ricerche, Rome, Italy Tuesday, September 15, 2009, 11:00 Uhr Johannes Kepler University, BA 9908
Title: Cell movements from diffusion to Transportation
Abstract: We present and discuss some models concerning the movement of cells, to deal both with bacteria and eukaryotic cells. We start from classical diffusion models and discuss some specific applications (amoeba, immune response to TBC infection, stem cells after a brain ischemic event). In the second part we shall introduce finite speed propagation models (i.e.: hyperbolic), to have a more accurate description of the self-organization of some kind of cells. A general 'abstract' chemotactic model will be presented and analyzed in detail, including analytical and numerical issues. Finally, remaining in the same mood, a realistic

model for biofilms will be described.

Prof. Wilfred F. van Gunsteren

Laboratory of Physical Chemistry, Swiss Federal Institute
of Technology, ETH, Zuerich
ERC Advanced Investigator Research Grants Preisträger
Monday, April 20, 2009, 11:00 Uhr s.t.
Johannes Kepler University, HF 9901

Title: Thirty years of (bio)molecular simulation: How far have we come?

Abstract:

Computation based on molecular models is playing an increasingly important role in biology, biological chemistry, and biophysics. Since only a very limited number of properties of biomolecular systems is actually accessible to measurement by experimental means, computer simulation can complement experiment by providing not only averages, but also istributions and time series of any definable – observable or non-observable – quantity, for example conformational distributions or interactions between parts of molecular systems. Present day biomolecular modelling is limited in its application by four main problems:

1) the force-field problem,
2) the search (sampling) problem,
3) the ensemble (sampling) problem, and
4) the experimental problem.

These four problems will be discussed and illustrated by practical examples. Progress over the past thirty years will be briefly reviewed. Perspectives will be outlined for pushing forward the limitations of molecular modelling.

Prof. Ludmil Zikatanov

Department of Mathematics, The Pennsylvania State University
Wednesday, May 6, 2009, 17:15 Uhr
Johannes Kepler University, HF 9901

Title: Energy Minimizing Bases for Efficient Multiscale Modeling and Linear Solvers

Abstract:

We discuss convergence results for general subspace correction methods, such as Multigrid and Domain Decomposition methods. These multilevel techniques are used to build efficient iterative methods for solving and preconditioning systems of equations arising from finite element discretizations of elliptic problems. As an application of the abstract theory, we will derive lower bounds on the convergence rate for two level methods. We further discuss

some of the techniques used in algebraic multigrid methods (AMG) to construct coarse scale discretizations (models). We focus on the choice of coarse spaces and their approximation properties, relation to compatible relaxation technique, and construction of piecewise harmonic bases via energy minimization. We will comment on the optimal algorithms for constructing energy minimizing bases with prescribed sparsity and their applications in multiscale modeling. The talk is based on ongoing and recent joint works with with J. Xu and J. Brannick (Penn State), R. Scheichl and I. Graham (University of Bath, UK), P. Vassilevski and R. Falgout (Lawrence Livermore National Lab).

RADON SEMINARS

Dr. Esa Räsänen

University of Jyväskylä, Finland

Wednesday, June 3, 2009, 15:00

Johannes Kepler University, HF136

Title: Quantum optimal control of nanoscale systems

Abstract:

Coherent control of quantum systems by time-dependent fields such as laser pulses is a long-term goal in physics and chemistry. Several theoretical approaches have been developed to find optimal external fields, for example, brute-force optimization, stimulated-Raman-adiabatic-passage, and genetic algorithms. However, the most appealing approach for many applications is optimal-control theory (OCT) extended to a quantum-mechanical formulation in late 1980s [1]. Here we present an OCT scheme to control quasi-two-dimensional nanodevices [2, 3] as well as small molecules [4] by terahertz laser pulses. In particular, we have applied OCT to design coherent spin switches in quantum rings [1] and charge switches in double quantum dots [2]. Both schemes, respectively, open a path into coherent single-qubit gates. In addition, we have shown that OCT is a powerful tool to enhance the ionization rate in small molecules [4].

[1] A. P. Peirce et al., Phys. Rev. A 37, 4950 (1988); R. Kosloff et al., Chem. Phys. 139, 201 (1989).

[2] E. R=E4s=E4nen et al., Phys. Rev. Lett. 98, 157404 (2007).

[3] E. R=E4s=E4nen et al., Phys. Rev. B 77, 085324 (2008).

[4] A. Castro et al., submitted.

RADON GROUP SEMINARS

GROUP: Computational Methods for Direct Field Problems

Dr. Blanca Ayuso

Departamento de Matematicas

Universidad Autonoma de Madrid

Wednesday, May 6, 2009, 15:30

HF 136

Title: Discontinuous Galerkin methods for the Vlasov-Poisson System

Abstract:

One of the simplest model problems in the kinetic theory of plasma--physics is the Vlasov-Poisson system with periodic boundary conditions. Such system describes the evolution of a plasma of charged particles (electrons and ions) under the effects of the transport and self-consistent electric field. In this talk, we present some new Discontinuous Galerkin (DG) methods for the approximation of the Vlasov-Poisson system. The proposed schemes couple DG approximation for the Vlasov equation (transport equation) with finite element (conforming, non-conforming or mixed) approximation to the Poisson problem. We provide the error analysis of the methods and discuss further properties of the proposed schemes. The talk is based on joint work with J.A.Carrillo (ICREA & Universitat Autonoma de Barcelona) and Chi-Wang Shu (Brown University).

Prof. Olaf Steinbach

Technische Universität Graz - Institut für Numerische Mathematik

Wednesday, November 25, 2009, 16:30

MT 128 (Science Park)

Title: Dirichlet Control Problems: Analysis and Numerics

Abstract:

In this talk we discuss the formulation of Dirichlet control problems when the control is considered in the energy trace space. We discuss finite and boundary element discretizations of the resulting varional inequality and present some numerical examples.
This talk is based on joint work with G. Of and T.X.Phan.

Dr. Gerhard Unger

Technische Universität Graz

Institut für Numerische Mathematik

Wednesday, November 25, 2009, 15:30

MT 128 (Science Park)

Title: Analysis of Boundary Element Methods for Eigenvalue Problems

Abstract:

For the solution of Laplacian eigenvalue problems we propose a boundary element method which is used to solve equivalent nonlinear eigenvalue problems for related boundary integral operators. We use the concept of eigenvalue problems for holomorphic Fredholm

operator functions to establish a convergence and error analysis for a Galerkin discretization of boundary integral operator eigenvalue problems. The Galerkin discretization of such problems leads to algebraic nonlinear eigenvalue problems which can be solved by iterative schemes. We analyze different methods as the inverse iteration, the Rayleigh functional iteration and Kummer's method. For the latter method we give convergence rates with respect to the multiplicity of the eigenvalues. Finally, numerical examples are presented which confirm the theoretical results.

Alexander Zimin
Saint-Petersburg State University
Thursday, May 28, 2009, 13:45
HF 136

Title: Multilevel spline approximations on non-uniform grid

Abstract:
The approach with biorthogonal system of functionals to construct multilevel spline approximations on uniform grid was developed by Yu.K. Demjanovich (SPbSU) in 2003. I present results of my thesis on construction of these approximations in case when only one knot is inserted into a non-uniform grid. Considered cases include grid on a line and on a smooth manifold.

Dr. Joerg Willems
(Texas A&M University)
Friday, January 8, 2010, 10:00
HF136

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

Abstract:
A two-scale finite element method for solving Brinkman's equations is presented. This system of equations models fluid flows in highly porous media. Motivated by industrial applications we focus on the case of these media having a complicated internal structure represented by a heterogeneous permeability field. The method uses a recently proposed discontinuous Galerkin FEM for Stokes equations by Wang and Ye and the concept of subgrid approximation developed by Arbogast for Darcy's equations. In order to reduce boundary layer errors and to ensure convergence to the globalfine solution, the algorithm is put in the framework of alternating Schwarz iterations using subdomains around the coarse-grid boundaries. Several numerical examples are presented to demonstrate the performance of this iterative procedure.

GROUP: Mathematical Imaging

Jutta Bikowski

Monday, June 22, 15:00 s.t.

HF136

Title: Two and Three Dimensional Reconstruction Algorithms for Electrical Impedance Tomography

Abstract:

In this presentation we consider two reconstruction algorithms. One goes back to A. Calderon and is a linearization method. We applied our implementation of this method to numerical and experimental data. The other algorithm is a so called direct method which solves the full nonlinear problem without iterations. Two dimensional implementations of such algorithms showed promising results. In the current work we implemented a direct method for three dimensional reconstructions. First results will be shown and discussed in this presentation.

Pierre Garapon

École Polytechnique

Monday, February 23, 14:30

Kepler Gebäude 153C

Title: About an example of inverse coefficient problem

Abstract:

In this presentation, I shall explain about Elastography, which is a new medical imaging technique that aims to remotely measure elasticity of biological tissues. It is useful for the diagnosis of various pathologies such as breast cancer, liver fibrosis, ...An inverse problem arises when one wants to reconstruct the shear modulus form the vibration field induced by exterior excitation. We perform both theoretical and numerical analysis of the spatial resolution of such an imaging system, we also discuss stability of the technique when noise is added.

I will also discuss an optimal control approach for an inverse scattering problem.

GROUP: Inverse Problems

Prof. Amin Boumenir

West Georgia College, USA

Tuesday, May 26, 2009, 15:00

HF136

Title: Transformation Operators for Strings

Abstract:

We investigate the existence and representation of transformation operators for strings,

which were defined by M.G. Krein in the fifties. Recall that transformation operators of Volterra type play an essential role in the Gelfand-Levitan theory. Using measure theory and functional analytic methods we prove their existence and study their representations. We show that in general they are not close to unity since their representation does not involve a Volterra operator but rather the eigenvalue parameter. We also obtain conditions under which the transformation is either a bounded or a compact operator. Explicit examples show that they cannot be reduced to Volterra type operators. This is joint work with Vu kim Tuan.

Bangti JIN
Zentrum für Technomathematik, Universität Bremen
Wednesday, May 13, 2009, 10:30
HF136

Ttile: Augmented Tikhonov regularization

Abstract:
In this talk, we will introduce a novel regularization functional of Tikhonov type for linear inverse problems, which determines the noise level and the regularization parameter automatically along with the inverse solution. The functional is derived by drawing ideas from Bayesian statistical analysis. The existence of a minimizer to the functional is shown, and properties of the minimizers are investigated. An alternating iterative algorithm is suggested for its numerical realization, and its convergence is established. Numerical results demonstrating the accuracy and efficiency of the new method will be presented and compared with existing regularization parameter choice rules.

Prof. Samuli Siltanen
University of Helsinki
Thursday, December 10, 2009, 14:00
HF136

Title: Regularized D-bar method for the inverse conductivity problem

Abstract:
A strategy for regularizing the inversion procedure for the two dimensional D-bar reconstruction algorithm for the ill-posed inverse conductivity problem is presented. The strategy utilizes truncation of the boundary integral equation and the scattering transform. It is shown that this leads to a bound on the error in the scattering transform and a stable reconstruction of the conductivity; an explicit rate of convergence in appropriate Banach spaces is derived as well. Numerical results are also included, demonstrating the convergence of the reconstructed conductivity to the true conductivity as the noise level tends to zero. The results provide a link between two traditions of inverse problems research:

theory of regularization and inversion methods based on complex geometrical optics. Also, the procedure is a novel regularized imaging method for electrical impedance tomography.

GROUP: Optimization and Optimal Control

Fayyaz Ahmad

Department of Mathematics

University of Barcelona

Tuesday, October 13, 2009, 13:00 s.t.

HF136

Title: Asymptotic Behavior in Flocks

Abstract:

Cucker and Smale provide a model (for both continuous and discrete time) describing the evolution of a flock. Our model is parameterized by a constant ß capturing the rate of decay - which in our model is polynomial - of the influence between birds in the flock as they separate in space. Our main result shows that when ß < 1/2 convergence of the flock to a common velocity is guaranteed, while for convergence is guaranteed under some condition on the initial positions and velocities of the birds only. We introduce some parameters (say for 3-Agents q1, q2, q3) in way that they do not affect the convergence results and agents can achieve the feasible desired target velocity.

Martin Bernauer

TU Chemnitz

Monday, September 7, 2009, 14:00

HF136

Title: Optimal Control of the Two-Phase Stefan Problem Using Extended Finite Elements

Abstract:

This talk is concerned with optimal control problems for the two-phase Stefan problem. The focus here is on a motion planning problem. The formulation of the direct problem is based on heat conduction in the solid and in the liquid phase and a level set representation of the interface that separates the two phases. The objective functional of the considered control problem is set up to facilitate control of the interface motion. The heat flux through the container wall acts as the control variable. First order optimality conditions in the absence of constraints are derived in the first part of the talk using the formal Lagrange approach and shape calculus tools. In the second part, the numerical approximation of the forward and the adjoint systems of coupled partial differential equations is discussed. In both cases, the temperature variable is approximated using extended finite element spaces. The level set

equation in the forward system and its adjoint equation are both discretized in space using a discontinuous Galerkin method. A gradient method is used to solve the unconstrained optimization problem. To illustrate the potential of this approach a numerical example is presented in the last part of the talk.

Benoit Chaigne

Tuesday, December 1, 2009, 10:00 s.t.

HF136

Title: Multilevel preconditioning for parametric shape inverse problems - application to antenna design

Abstract:

A reflector antenna is a device that is widely used for satellite communication. The life length of such a device depends highly on the fatigue due to the energy consumption for the signal emission. Thus, one of the goals of the optimal design of an antenna is to improve the productivity of systems designed for a given task, for a fixed input power. A reflector antenna is characterized by radiating surfaces whose geometry is the main parameter that can be controlled to fulfill the task. Based on the time-harmonic wave propagation simulation in free space, numerical procedures for the optimal design of the shape of radiating structures are examined. In this framework, classical optimization methods are often submitted to challenging difficulties related to the fact that the problems are ill-posed because multimodal and numerically stiff. Since the control is the geometry of the reflectors, we have investigated the potential enhancements of basic algorithms using hierarchical parametric representations. The theoretical foundations of the proposed algorithms rely on the Multigrid methods for solving PDE. A theoretical example for shape optimization is considered in order to derive different multilevel strategies. These strategies are then applied to real-case problems for the optimal design of reflector antennas. Numerical experiences show that basic algorithms are effectively enhanced in terms of robustness and convergence rate. In addition, a bi-criterion optimization problem is considered to be solved as a Nash game for which the split of the territory is optimal in a least perturbation sense.

Ayalew Getachew

TU Bergakademie Freiberg

Monday, May 4, 2009, 14:30

HF136

Title: Feasible direction method for nonlinear bilevel programming problems

Abstract:

In the talk, an introduction to bilevel programming problems, one of the challenging classes

of mathematical optimization problems will be presented. One of the mostly used reformulation methods, the application of the KKT conditions to the lower level problem, along with its associated problems and difficulties will be discussed. The application of the feasible direction method developed by Topkis and Veinott is considered. Under some assumptions this approach is shown to converge to a Bouligand stationary point for the bilevel programming problem with a convex lower level problem.

Adama Souleymane KAMARA
ICTP Triest
Monday, August 3, 2009, 13:00 s.t.
HF136

Title: Optimization in infinite dimension - Variational Calculus

Abstract:
The optimization methods which deal with determination of minima or maxima of a given real valued function, are applicable in many areas such:
economic management, optimal design, automation robotics, signal processing, etc. Furthermore, optimization problems are closely related to variational principles of mechanics and physics.
The aim of this dissertation is to give the principal mathematical results on minimization problems (or more generally on optimization). These results bear on the one hand on the existence of minima and on the other hand on their characterization by giving some necessary conditions and in some cases some sufficient conditions. In each chapter, we will give some examples to illustrate the importance of optimization, the variety of the application areas that are concerned and the diversity of mathematical problems formulated as optimization problems.

Sven-Joachim Kimmerle
Humboldt University, Berlin
Monday, October 19, 2009, 15:30
HF136

Title: Macroscopic diffusion models for precipitation in crystalline GaAs - Modelling, analysis and simulation

Abstract:
From a thermodynamically consistent model for precipitation in gallium arsenide crystals including mechanics we derive different mathematical models to describe the size evolution of arsenic-rich liquid droplets in crystalline gallium arsenide. These models generalise the well-known Mullins-Sekerka model for Ostwald ripening.

In particular we consider models, which lead to a quasilinear parabolic PDE for the chemical potential, which is coupled to an elliptic boundary value problem for the displacement and to ODEs for the free boundaries.
Due to different scales for typical distances between droplets and typical radii of liquid droplets we can reduce this problem by homogenisation methods to a large system of ODEs coupled by a mean field, so-called mean field models.
The mean field models capture the main properties of our system and are better adapted for numerics and stability analysis than the original problem. Numerical simulations allow to decide in which case which one of the models might be appropriate to the experimental situation.

Anton Schiela

Zuse Institute Berlin

Tuesday, October 20, 2009, 11:00

HF136

Title: Techniques for the Analysis of Path-Following Methods in Optimal Control

Abstract:
We review and discuss a couple of well known and not so well known techniques for path-following methods in optimal control with state constraints. Particular emphasis is placed on the application of these techniques to different types of path-following methods, which yields some insights into their similarities and differences.

Dr. Tuomo Valkonen

University of Yvaaskyla

Monday, December 21, 2009, 10:00

HF136

Title: Image interpolation with discontinuous optical flow

Abstract:
We study a formulation of the transport equation that remains
meaningful with discontinuous velocity fields. We then apply this study to the problem of fitting to available data a space-time image subject to the optical flow constraint.

RESEARCH PROJECT: Applied Discrete Mathematics and Cryptography

Prof. Roberto M. Avanzi

(HGI, Ruhr-University Bochum, Germany; Global Young Faculty,
Germany and epigenesys.com, Italy)

Thursday, December 3, 2009, 15:00 s.t.

AS 50

Title: Trace Zero Varieties: Cryptographic Applications

Abstract:

Given a low genus hyperelliptic curve defined over a finite field F, a Trace Zero Variety is a specific subgroup of the divisor class group of the curve over small degree extension of F. Trace Zero Varieties are interesting for cryptographic applications since their properties can be exploited to achieve fast arithmetic and group construction.

We review here recent results on the performance of trace zero varieties in some different contexts relevant to cryptography, from scalar multiplication to the computation of pairings.

Based on joint works with: Emanuele Cesena, Tanja Lange.

GROUP: Analysis of Partial Differential Equations

Renjun Duan

RICAM

Friday, August 7, 2009, 13:30

HF136

Title: Introduction to Models and Mathematical Studies in Animal Aggregation

Abstract:

Description of the collective and interactive motion of multi-agents such as a school of fish, a flocking of birds or a swarm of bacteria appears in many applications, e.g., biology, network and economics. Recently, there has been increasing interest for both the numerical and theoretical study of some mathematical models which expose the formulation and transition of some different self-organized patterns in the collective motion. In this talk, first of all some related models on the basis of different motion mechanisms are introduced at both the particle and kinetic level. And then, a concrete example is given to show a study of the well-posedness theory from the nonlinear PDE point of view. Some possible open problems will be proposed at the end.

Dr. Alberto Favaron

Politecnico di Milano

Monday, March 2, 2009, 14:00 s.t.

HF136

Title: Recovering time and space dependent memory kernels related to viscoelastic materials with symmetries

Dr. Daniele Graziani

INRIA, Sopia Antipolis - France

Monday, March 2, 2009, 10:00 s.t.

HF136

Title: Detecting Points in 2-D Biological Images

Abstract:

Detecting fine structures, like points or curves in two or three dimensional images respectively, is an important issue in image analysis. In biological images a point may represent a viral particle whose visibility is compromised by the presence of other structures like cell membranes or some noise. From a variational point of view the problem of isolating points is a difficult task, since it is not clear how these singularities must be classified in term of a some differential operator. In this talk we propose a new variational formulation involving the notions of p-capacity and divergence measure. This approach allows to give a rigorous mathematical definition of discontinuity without jump and to isolate the points via minimization of a suitable functional F. In the last part of the talk we suggest a possible approximation via Γ-convergence of the energy F.

Jan Haskovec

TU Wien

Tuesday, March 3, 2009, 14:00 s.t.

HF136

Title: Stochastic Particle Approximation for Measure Valued Solutions of the 2D Keller-Segel System

Abstract:

The Keller-Segel model for chemoaxis is a well known system of PDEs describing aggregation phenomena in biology. In its simplified version, it consists of a drift-diffusion equation for the cell density, coupled to a Poisson equation for the concentration of the chemoattractant. In the 2D whole space setting, it has been shown that there exists a critical mass, such that one has global existence of solutions with subcritical mass, but the solution will blow up in finite time in the supercritical case. Recently, the behavior of the system has been described even after these blow-up event in terms of global measure-valued solutions. We construct an approximation to the measure valued, global in time solutions in 2D, based on systems of stochastic interacting particles. The advantage of our approach is that it reproduces the dichtomy in the qualitative behavior of the system and, moreover, captures the solution even after the possible singular events.

We present a numerical method based on this approach and show some numerical results. Moreover, we make a first step toward the convergence analysis of our scheme by proving the convergence of the stochastic particle approximation for the Keller-Segel model with a regularized interaction potential. The proof is based on a BBGKY-like approach for the corresponding particle distribution function. The convergence analysis of the non-regularized

scheme is a very challenging problem, and we are able to obtain a complete description only in the case of limited number of particles.

Yunho Kim

RICAM

Monday, August 3, 2009, 14:00 s.t.

HF136

Title: Image recovery via BV and homogeneous Sobolev spaces

Abstract:

There are many techniques to decompose images into cartoon (piecewise smooth part) and texture (oscillatory part). If we can differentiate these two characteristics, then it becomes easier to recover from damages images. One of the difficult problems is that images can be damaged by various kinds of blurring effects and these smooth out oscillations in the images, which means that we have to find a way to add more oscillations to the images. We will see that the BV space

(BV) and the homogeneous Sobolev spaces (W) are good candidates by introducing a convex functional on BVxW which models cartoon and texture separately in the two different spaces and minimizing it. We will see theoretical and numerical results and also numerical comparison with another model proposed by Daubechies & Teschke.

Dr. Erik Lindgren

KTH, Stockholm

Thursday, March 12, 2009, 14:00 s.t.

HF136

Title: Two-phase free boundary problems

Abstract:

In this talk I will discuss regularity properties of some two-phase free boundary problems. I will try to explain how two-phase problems differ from one-phase problems and what extra difficulties this leads to. Some techniques that can be used attacking these kind of problems will also be presented.

Dr. Peter Richtarik

Department of Mathematical Engineering, Louvain-la-Neuve, Belgium

Thursday, March 12, 2009, 16:30

HF136

Title: Linearize and optimize: symmetric linear programming and sparse principal component analysis

Abstract:

In this talk we describe two gradient-type algorithms for different sets of optimization problems, with the common trait that both use a “linearize and optimize" philosophy at each iteration. The first method solves several related optimization problems simultaneously, in relative scale, and is based on rank-one matrix up-dates. The problems include 1) centrally-symmetric linear programming, 2) a convex minimization problem over the unit simplex, 3) finding the least l1 norm solution of an underdetermined linear system, 4) computing the intersection of a ray with a centrally symmetric convex polytope, 5) minimizing the maximum of absolute values of linear functions on a hyperplane and a 6) semidefinite program with rank-one objective and constraint matrices. We show that the algorithm has natural interpretation in all cases.

The second method is designed for maximization of convex functions on compact sets. We argue that the problem of computing sparse approximate eigenvectors can be formulated so as to ¯t this setting, leading to a generalization of the well-known power method. The analysis is most revealing in the case when the objective function or the feasible set are strongly convex. Preliminary computational experiments suggest that the new approach is highly scalable with dimension and leads to a substantial speedup when compared to the best current algorithms.

Both algorithms are equipped with iteration complexity estimates.

Jan Vybiral

Friedrich-Schiller University, Jena, Germany

Wednesday, July 15, 2009, 14:00 s.t.

HF136

Title: Sobolev embedding and its compactness

Abstract:

Sobolev embedding is an embedding of one Sobolev space into another space of this kind.

As such, it represents a certain kind of trade off between smoothness and integrability.

We work in a more general scales of Besov and Triebel-Lizorkin spaces, which allows us to use certain discretization techniques (i.e. wavelets) to characterise the properties of this embedding. We are particularly interested in measuring the compactness of this embedding. We discuss briefly several possibilities: entropy, Gelfand, Kolmogorov and approximation numbers. Finally, we present some extensions and direction of further research.

GROUP: Symbolic Computation

Dominic Walter

Arbeitsbereich Geometrie und CAD, Leopold-Franzens-Universität Innsbruck

27th January, 10:00

HF136

Title: A Complete Kinematic Analysis of the SNU 3-UPU Parallel Robot

Abstract:

Several articles have been published about the SNU 3-UPU parallel robot, since the prototype built at the Seoul National University (SNU) showed a rather unexpected behavior, being completely mobile although none of the prismatic joints was actuated. In this talk a brief introduction is given how to describe all possible poses of the robot by a system of algebraic equations using Study parameters, such that theoretical questions concerning assembly modes and mobility can be answered on the basis of the solutions of this system. A complete analysis of the forward kinematics is given showing that the manipulator has theoretically up to 78 assembly modes, most of them being always complex. Investigating the system's Jacobian it can be shown that for equal limb lengths the manipulator has some highly singular poses.

Furthermore possible operation modes of the manipulator are discussed.

To obtain these modes methods from algebraic geometry prove to be very useful. Moreover it is examined for which fixed design and joint parameters the mechanism allows self-motion and it is shown that there are only two such mobile robots.

Manfred Husty

Arbeitsbereich Geometrie und CAD, Leopold-Franzens-Universität Innsbruck

January 27th, 11:00

HF136

Title: Singularity free assembly mode change of parallel manipulators

Abstract:

Non singular assembly mode change of parallel manipulators has been discussed for a while within the robotics community. This term means that a parallel robot can pass from one solution of the direct kinematics into another without crossing a singularity. In this presentation we will show that opposed to the accepted opinion all general planar 3-RPR parallel manipulators have this ability. Using geometric properties of the singularity surface of this manipulator we will give a rigorous mathematical proof for this proposition.

This proof will use the fact that the singularity surface is a fourth order surface having only very special singularities. A secondary result of this proof will be the first proof for the widespread used property that the singularity surface divides the workspace of the manipulator into two aspects that are path connected. For the first time we give a simple technique how to construct singularity free paths that join all assembly modes of one aspect to the other.

Christian Aistleitner

RISC

Tuesday, March 10, 2009, 10:00

AS50

Title: Travel guide through differential characteristic set computations

Abstract:

Differential characteristic set computations can be used to extract information from systems of differential equations and thereby help to solve such systems. We present the basic setting for differential characteristic set computations and travel to the most crucial and interesting places in differential characteristic set theory.

Dr. Gabor Hegedüs

RICAM

Tuesday, November 3, 2009, 10:00

AS50

Title: Upper Bound Theorems

Dr. Gabor Hegedüs

RICAM

Tuesday, October 6, 2009, 10:00

AS50

Title: Dehn-Sommerville equations and cellular resolutions

Dr. Gabor Hegedüs

RICAM

Monday, December 7, 2009, 10:00

AS50

Title: Tropical Bezout Theorem

Abstract:

Tropical geometry is a rather new field of algebraic geometry. The main idea is to replace algebraic varieties by certain piece-wide objects in Rn, which can be studied with the aid of combinatorics. I present here a tropical version of the famous Bézout Theorem.

Dr. Gabor Hegedüs

RICAM

Gröbner basis in combinatorics

Tuesday, May 19, 2009, 10:00

AS50

Title: Gröbner basis in combinatorics

Abstract:

In this talk I summarize our previous research with Lajos Rónyai.

The main theme of our work is the description of the Gröbner bases and the standard monomials of finite set of points of combinatorial significance. This line of research has its roots in linear algebra methods of combinatorics.

My research related to incidence matrices and the polynomial subspace method, which have been developed and applied by Alon, Babai, Blokhuis, Frankl, Lovász, Wilson, and many others. On the algebraic side we build on the general theory of Gröbner bases. We found applications of Gröbner basis techniques (in particular, standard monomials and Gröbner reduction) to problems of extremal combinatorics. A conjecture of L. Babai and P. Frankl was solved this way. Our methods offer a new approach to the rank computation of inclusion matrices.

Dr. Gabor Hegedüs

RICAM

Tuesday, June 23, 2009, 10:00

AS50

Title: Free resolution in combinatorics

Abstract:

Let B(n,k) denote the number of permutations of n elements with k inversions. It was a challenging open problem in algebraic combinatorics to give an explicit formula for this number B(n,k). We solve this problem using free resolutions of graded modules and Gröbner basis theory.

Madalina Hodorog

RICAM

Monday, May 4, 2009, 10:00

AS50

Title: A symbolic-numeric algorithm for genus computation

Abstract:

We propose a symbolic-numeric algorithm for computing the genus of a complex algebraic curve. In the complex case, the singularities can be characterized by their link, which is defined as the intersection of the curve with a 3-sphere with sufficiently small radius.

When this radius is chosen carefully, one can compute the topological type of the link in a numerically stable way. The link can be uniquely identified by its corresponding Alexander polynomial. We base the study of our algorithm on several important results from algebraic topology proven by Milnor for the general case of algebraic varieties over infinite fields. We

use for our implementation the Axel algebraic modeler developed in the research team Galaad at INRIA which provides algebraic tools for the manipulation and the computation with implicit curves and surfaces.

Madalina Hodorog

RICAM

Tuesday, October 20, 2009, 10:00 s.t.

AS50

Title: Why knot? Alternative solution to the genus computation problem.

Abstract:

We report on an alternative method for computing the genus of a plane complex algebraic curve based on knot theory. The method leads to significant results concerning the topology of singular points of complex algebraic curves, allowing us to derive a general formula for the delta-invariant of the curve singularities. We propose a symbolic-numeric algorithm for this method, which is expected to give good results for complex algebraic curves whose defining polynomials have numeric coefficients. Together with its main functionality to compute the genus, the algorithm provides also tools for computational operations in knot theory, and algebraic geometry. We split the main algorithm into several interdependent subalgorithms. We base some of our subalgorithms on general algorithms from computational geometry (e.g. Bentley-Ottman). Whenever required, we design our own subalgorithms for solving the specific problems (e.g. computation of the Alexander polynomial). We use for the implementation the Axel algebraic geometric modeler, developed at INRIA, Sophia-Antipolis.

Madalina Hodorog

RICAM

Tuesday, April 28, 2009, 10:00

AS50

Title: A symbolic-numeric algorithm for genus computation

Abstract:

We propose a symbolic-numeric algorithm for computing the genus of a complex algebraic curve. In the complex case, the singularities can be characterized by their link, which is defined as the intersection of the curve with a 3-sphere with sufficiently small radius.

When this radius is chosen carefully, one can compute the topological type of the link in a numerically stable way. The link can be uniquely identified by its corresponding Alexander polynomial. We base the study of our algorithm on several important results from algebraic topology proven by Milnor for the general case of algebraic varieties over infinite fields. We use for our implementation the Axel algebraic modeler developed in the research team

Galaad at INRIA which provides algebraic tools for the manipulation and the computation with implicit curves and surfaces.

Prof. Lajos Ronyai

University of Budapest

Tuesday, August 11, 13:30

AS50

Title: Combinatorics and Groebner Basis

Prof. Josef Schicho

RICAM

Wednesday, August 12, 13:30

AS50

Title: The state of the art of the parametrization problem for algebraic surfaces

Prof. Josef Schicho

RICAM

Tuesday, May 12, 2009, 10:00

AS50

Title: On steering problems of a planar parallel mechanism

Abstract:

A planar parallel mechanism consists of a moving planar figure -- the hand -- that is connected to a fixed platform by three telescope arms. The mechanism is moved by extending and contracting the three arms. The length of the arms do not uniquely specify the position and orientation of the hand, there are up to 6 different possibilities. Can we steer the mechanism from one possible case to another?

In this talk, we will study this question with methods from topology and differential geometry. This is joint work with Manfred Husty, Univ. Innsbruck.

Dr. David Sevilla

RICAM

Tuesday, June 9, 2009, 10:00

AS50

Title: Deciding trigonality of algebraic curves

Abstract:

Let C be a non-hyperelliptic algebraic curve of genus at least 3.

Enriques (1919) and Babbage (1939) proved that its canonical image is the intersection of the quadrics that contain it, except when C is trigonal (that is, it has a linear system of degree 3 and dimension 1) or C is isomorphic to a plane quintic (genus 6). We present a method to

decide whether a given algebraic curve is trigonal, and in the affirmative case to compute a map from C to the projective line whose fibers cut out the linear system. It is based on the Lie algebra method presented in Schicho et al. (2006). Our algorithm is part of a larger effort to determine whether a given algebraic curve admits a radical parametrization.

Bilge Sipal
Universität Passau
Wednesday, October 7, 2009, 13:00 s.t.
AS50

Title: Border bases

Abstract:
Our talk is devoted to a trend 'Border Bases' that has emerged quite recently. Border bases are in some sense a generalization of Groebner bases. We present their theory extensively including the essential (border) polynomial division and construction algorithms that this theory relies on. We include evidence that suggests that border bases display better combinatorial behaviors.

Special Semester 2009

The Special Semester on Inverse Problems planned for 2009 had to be held in a severely reduced form due to budgetary constraints. Only a Mini Special Semester on Inverse Problems could be organized and RICAM was also the organizer of the international **Applied Inverse Problems** Conference in Vienna.

Mini Special Semester on Inverse Problems

Linz, May 18-July 15, 2009

This Mini Special Semester has been organized by Prof. Bernd Hofmann (Chemnitz), who had planned to organize the whole (cancelled) Special Semester and had, for this purpose, planned to spend a sabbatical semester in Linz.

Long term guests

Jin Cheng, Fudan University, Shanghai China
Bernd Hofmann, Chemnitz University of Technology, GermanyVictor Isakov, Wichita State University, USA
Antonio Leitao, Federal University of Santa Catarina, Florianopolis, Brazil
Peter Mathé, Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany
William Rundell, Texas A & M University, USA
Ulrich Tautenhahn, University of Applied Sciences Zittau/Görlitz, Germany

Monday Lecture Series

Program:

May 25, 2009: Jin Cheng, Fudan University, Shanghai China

Heat Transfer in Composite Materials and Related Inverse Problems

In this talk, we will present some results about the heat transfer in a composite materials with Stefan-Boltzmann interface conditions. The related inverse problems with the applications in the steel industry are also discussed.

June 8, 2009: Victor Isakov, Wichita State University, USA

On the inverse doping profile problem in semiconductors theory

We consider the problem of determining doping profile in semiconductors from standard voltage boundary measurements. We derive a dual inverse problem, obtain its asymptotic

simplification (for large contrast of conductivities), and prove first uniqueness results in the important unipolar case.

June 15, 2009: William Rundell, Texas A & M University, USA

June 22, 2009: Ulrich Tautenhahn, University of Applied Sciences Zittau/Görlitz, Germany

Regularization with differential operators -- some old and some new results

Regularization with differential operators became in particular attractive after Natterer's paper on Error bounds for Tikhonov regularization in Hilbert scales, Appl. Anal. 18 (1984). Since that time, many aspects in the regularization theory with differential operators have been studied. We give a review on some old aspects and add some new aspects concerning general source conditions and additional perturbations in the forward operator.

June 29, 2009: Peter Mathe, Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany

Discretization under general smoothness assumptions

We shall study the regularizing properties of discretization, specifically projection schemes in Hilbert space. Focus is on identifying approximation theoretic characteristics and geometric properties of the chosen discretization spaces to allow for order optimal approximation. Focus is on solution smoothness given in terms of general source sets, thus including non-traditional smoothness beyond Sobolev spaces. To do so we exhibit some calculus in variable Hilbert scales.

The results allow to compare traditional regularization schemes and discretization from a unified perspective.

July 6, 2009: Antonio Leitao, Federal University of Santa Catarina, Florianopolis, Brazil

On Kaczmarz type methods for regularizing systems of nonlinear ill-posed equations

We investigate modified iterative methods (namely Landweber, steepest-descent, EM, Levenberg-Marquardt and iterated Tikhonov) coupled with a loping Kaczmarz strategy for obtaining stable solutions of nonlinear systems of ill-posed operator equations. We show that the proposed methods are convergent regularization methods and present some numerical tests.

July 13, 2009: Bernd Hofmann, Chemnitz University of Technology, Germany

An extended approach to source conditions and variational inequalities in regularization with general residual term

This is joint work with Jens Geissler (Chemnitz) which addresses Tikhonov like regularization methods with convex penalty functionals for solving nonlinear ill-posed operator equations formulated in Banach or, more general, topological spaces. We present an approach for proving convergence rates that combines advantages of approximate source conditions and variational inequalities. Precisely, our technique provides both a wide range of convergence rates and the capability to handle general and not necessarily convex residual terms as well as nonsmooth operators. The approach is extensively discussed for Banach and Hilbert space situations, showing that it generalizes some well-known convergence rates results.

Since Prof. Hofmann had organized meetings on inverse problems in earlier years in Chemnitz, it was natural to organize as a culmination of the Mini Special Semester, a

Chemnitz RICAM Symposium on Inverse Problems

in Linz (from July 14. to July 15 DATEN!), which may be the start of a (bi-)annual joint conference series. This symposium also was the bridge to the much larger AIP conference a fortnight later in Vienna (see below).

This symposium had the following speakers:

External invited speakers:

Victor Isakov (Opening talk), Wichita State University, USA
Thomas Bonesky, University of Bremen, Germany
Martin Burger, University of Münster, Germany
Jin Cheng, Fudan University, Shanghai China
Melina Freitag, University of Bath, UK
Uno Hämarik, University of Tartu, Estonia
Jaan Janno, Tallinn University of Technology, Estonia
Antonio Leitao, Federal University of Santa Catarina, Florianopolis, Brazil
Peter Mathe, Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany
Volker Michel, University of Siegen, Germany
Hans-Jürgen Reinhardt, University of Siegen, Germany
William Rundell, Texas A & M University, USA

Ulrich Tautenhahn, University of Applied Sciences Zittau/Görlitz, Germany
Masahiro Yamamoto, University of Tokyo, Japan

Speakers from RICAM and related Austrian groups:
Kristian Bredies
Markus Grasmair
Philipp Kügler
Sergei V. Pereverzyev
Hanna K. Pikkarainen
Ronny Ramlau
Mourad Sini

Speakers from Chemnitz:
Radu I. Boţ
Jens Geißler
Torsten Hein
Marcus Meyer

In total, there were 23 external participants from eight different countries and fourteen from the Inverse Problems Group of RICAM.

AIP (Applied Inverse Problems) Conference

The biannual series of AIP Conferences aims to provide a primary international forum for researchers working on diverse aspects of applied inverse problems - ranging from mathematical modelling via functional analytic theories and methods towards computational approaches. Each conference presents invited talks by international experts as well as a sequence of minisymposia on topics of current interest. The venues are chosen to encourage a strong interaction between the participants. The AIP conference is held every two years at alternating locations, hosting places so far have been Montecatini (2001), Lake Arrowhead, California (2003), Cirencester, UK Cotswold region (2005) and Vancouver (2007). The fifth conference took place in Vienna from July 20th to 24th in 2009[1], organized by RICAM.
319 people from 35 different countries participated in the AIP Conference

[1] http://www.ricam.oeaw.ac.at/conferences/aip2009/boa/aip2009_conference_guide.pdf

Program Committee

Mario Bertero (University of Genoa)

Marc Bonnet (Ecole Polytechnique)

Martin Burger (University of M¨unster)

Heinz Engl, Chair (RICAM & University of Vienna)

Bernd Hofmann (Chemnitz University of Technology)

Matti Lassas (Helsinki University of Technology)

Joyce McLaughlin (Rensselaer Polytechnic Institute)

Michele Piana (University of Genova)

Roland Potthast (Georg-August-University Goettingen)

William Rundell (Texas A&M University)

Erkki Somersalo (Helsinki University of Technology)

Gunther Uhlmann (University of Washington)

Masahiro Yamamoto (University of Tokyo)

Jun Zou (Chinese University of Hong Kong)

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Philipp Kügler (RICAM)

Andreas Neubauer (Johannes Kepler University of Linz)

Sergiy Pereverzyev Jr. (Johannes Kepler University of Linz)

Ronny Ramlau (Johannes Kepler University of Linz)

Invited Talks

Monday, July 20
Alfred Louis Saarland University 9:00 – 10:0
Title: “Feature reconstruction in tomography”
Jeffrey Bamber Institute of Cancer Research 14:00 – 15:00

Title: “Progress in quantitative elastography for cancer medicine”
Tuesday, July 21
Mohammed Jaoua Polytech. Nice-Sophia 9:00 – 10:00
Title: “Detection of small flaws locations using topological asymptotic expansion”
Thorsten Hohage University of Göttingen 14:00 – 15:00
Title: “Inverse problems with Poisson data”
Wednesday, July 22
Barbara Kaltenbacher University of Stuttgart 9:00 – 10:00
Title: “Adaptive and multilevel methods for parameter identification in partial differential equations”
Patricia Lamm Michigan State University 10:30 – 11:30
Title: “Generalized Local Regularization for Ill-Posed Problems”
Calderon Prize Lecture 11:30 – 12:30
Thursday, July 23
David Colton University of Delaware 9:00 – 10:00
Title: “Faber-Krahn Type Inequalities in Inverse Scattering Theory”
George Biros Georgia Institute of Technology 14:00 – 15:00
Title: “Variational methods for cardiac motion estimation”
Friday, July 24
Gen Nakamura Hokkaido University

9:00 – 10:00
Title: “Inverse problems for reconstructing the medium discontinuities”
Jin Cheng Fudan University 10:30 – 11:30
Title: “The Mathematical Analysis of the Diffusion Process and its Applications”
Habib Ammari CNRS 11:30 – 12:30
Title: “The Method of Small-Volume Expansions in Emerging Biomedical Imaging”

Minisymposia: Topics and organizers

Andreas Alpers Technical University of Denmark (Organizer) 24 July, 2009, 16:15-18:15
Discrete Tomography and Image Reconstruction in Material Science
Simon Arridge University College London (Organizer) **John Schotland** University of Pennsylvania (Coorganizer) 20 July, 2009, 10:30-12:30
New developments in Optical Tomography
Uri Ascher University of British Columbia (Organizer) 20 July, 2009, 10:30-12:30
Sparse solutions in inverse problems
Guillaume Bal Columbia University (Organizer) **John Schotland,** University of Pennsylvania (Coorganizer) 21 July, 2009, 15:15-17:15
Inverse Problems in Optical Imaging
Frank Bauer University of Linz (Organizer) **Mihaela Pricop**

University of Goettingen (Coorganizer) 20 July, 2009, 15:15-17:15
Interplay between Deterministic and Statistical Inverse Problems (1)
Mihaela Pricop University of Goettingen (Organizer) **Frank Bauer** University of Linz (Coorganizer) 24 July, 2009, 14:00-16:00
Interplay between Deterministic and Statistical Inverse Problems (2)
Elisa Francini Universita' di Firenze (Organizer) 20 July, 2009, 15:15-17:15
Inverse Problems in Elasticity
Kristian Bredies University of Graz (Organizer) **Dirk Lorenz** University of Bremen (Coorganizer) 21 July, 2009, 10:30-12:30
Regularization, Algorithms and Sparsity - Banach spaces and Beyond (1)
Dirk Lorenz University of Bremen (Organizer) **Kristian Bredies** University of Graz (Coorganizer) 24 July, 2009, 16:15-18:15
Regularization, Algorithms and Sparsity - Banach spaces and Beyond (2)
Martin Burger University of Muenster (Organizer) **Bjorn Fredrik Nielsen** Simula Research Laboratory (Coorganizer) 23 July, 2009, 15:15-17:15
Preconditioning in Inverse Problems
Christian Clason University of Graz (Organizer) 20 July, 2009, 10:30-12:30
Applications of Carleman estimates in numerical methods for inverse problems

Fiorella Sgallari University of Bologna (Organizer 21 July, 2009, 10:30-12:30
Inverse Problems: Computational Aspects and Emerging Applications (1)
Luisa D'Amore University of Naples Federico II (Organizer) 24 July, 2009, 14:00-16:00
Inverse Problems: Computational Aspects and Emerging Applications (2)
Fioralba Cakoni University of Delaware (Organizer) **Houssem Haddar** Ecole Polytechnique (Coorganizer) 23 July, 2009, 10:30-12:30
The determination of boundary coefficients in inverse boundary value problems and scattering theory.
Roland Griesmaier University of Delaware (Organizer) 20 July, 2009, 15:15-17:15
Application-oriented sampling methods for inverse scattering problems
Gerhard Zangerl University of Innsbruck (Organizer) **Markus Haltmeier** University of Innsbruck (Coorganizer) 21 July, 2009, 15:15-17:15
Recent Developments in Tomography
Gerhard Zangerl University of Innsbruck (Organizer) **Markus Haltmeier** University of Innsbruck (Coorganizer) 24 July, 2009, 16:15-18:15
Recent Developments in Photo- and Thermoacoustic Tomography
Martin Hanke Johannes Gutenberg University Mainz (Organizer) 23 July, 2009, 15:15-17:15
Inverse Problems in Impedance Tomography and Inverse Scattering

Mario Bertero University of Genova (Organizer) **Thorsten Hohage** University of Goettingen (Coorganizer) 21 July, 2009, 15:15-17:15
Image Reconstruction Methods in Astronomy and Microscopy: Sparsity, Nonnegativity, and Poisson data. (1)
Thorsten Hohage University of Goettingen (Organizer) **Mario Bertero** University of Genova (Coorganizer) 23 July, 2009, 15:15-17:15
Image Reconstruction Methods in Astronomy and Microscopy: Sparsity, Nonnegativity, and Poisson data. (2)
Thorsten Hohage University of Goettingen (Organizer) **Mario Bertero** University of Genova (Coorganizer) 24 July, 2009, 14:00-16:00
Image Reconstruction Methods in Astronomy and Microscopy: Sparsity, Nonnegativity, and Poisson data. (3)
Matti Lassas University of Helsinki (Organizer) **Yaroslav Kurylev** University College London (Coorganizer) 21 July, 2009, 15:15-17:15
Analytic and geometric methods for applied inverse problems
Shuai Lu Johann Radon Institute (Organizer) 23 July, 2009, 10:30-12:30
Multi-parameter regularization and its numerical realization
Anna Maria Massone CNR-INFM (Organizer) 20 July, 2009, 15:15-17:15
Results from NASA's RHESSI Solar Spectroscopic Imager - fertile ground for Inverse

Problem research
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Statistical Inverse Problems
Carmeliza Navasca Clarkson University (Organizer) **Stefan Kindermann** Johannes Kepler University Linz (Coorganizer) 24 July, 2009, 16:15-18:15
Ill-posed Problems in Tensor Decomposition
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Recent contributions to the inverse problem of electrocardiography
Michele Piana University of Genova (Organizer) 20 July, 2009, 10:30-12:30
Inverse Problems in Neuroscience
Eric Todd Quinto Tufts University (Organizer) 23 July, 2009, 10:30-12:30
Tomographic Inverse Problems
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New Developments in Geometric Inverse Problems (1)
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New Developments in Geometric Inverse Problems (2)
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Discrete-like inverse problems: analysis and numerics
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Regularization Approaches to Learning from High Dimensional Data
Samuli Siltanen Tampere University of Technology (Organizer) **Kim Knudsen** Technical University of Denmark (Coorganizer) 24 July, 2009, 16:15-18:15
Reconstruction algorithms and complex geometrical optics
Mourad Sini Johann Radon Institute (Organizer) **Roland Potthast** University of Reading (Coorganizer) 21 July, 2009, 10:30-12:30
Detection of complex interfaces by non destructive evaluations.
Olaf Steinbach Graz University of Technology (Organizer) 24 July, 2009, 14:00-16:00
Magnetic Resonance and Magnetic Induction Tomography
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Inverse Problems for Industrial Measurement Techniques
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Optimization-based approaches in image processing (1)
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Optimization-based approaches in image processing (2)
Gary Rosen University of Southern California (Organizer) **Chunming Wang** University of Southern California (Coorganizer) 23 July, 2009, 10:30-12:30
Computational Methods for Estimation Problems for Distributed Parameter Systems
Zuhair Nashed University of Central Florida (Organizer) **Alexandru Tamasan** University of Central Florida (Coorganizer) 20 July, 2009, 15:15-17:15
Non-smooth Optimization in Inverse Problems (1)
Alexandru Tamasan University of Central Florida (Organizer) **Zuhair Nashed** University of Central Florida (Coorganizer) 23 July, 2009, 15:15-17:15
Non-smooth Optimization in Inverse Problems (2)
Sergey Fomel The University of Texas at Austin (Organizer) 24 July, 2009, 16:15-18:15
Regularization strategies in applied geophysical inverse problems
Sergiy Pereverzyev Jr. Johannes Kepler University Linz (Organizer) **Rene Pinnau** University of Kaiserslautern (Coorganizer) 20 July, 2009, 10:30-12:30
Recent trends in iterative regularization algorithms
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Data assimilation for geophysical problems
Milan Stehlik Johannes Kepler University Linz (Organizer)

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Inverse problems in Statistics and Probability
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Recent reconstruction approaches for electrical impedance tomography and inverse scattering by periodic media
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Emerging Techniques and Technologies for Biomechanical Imaging