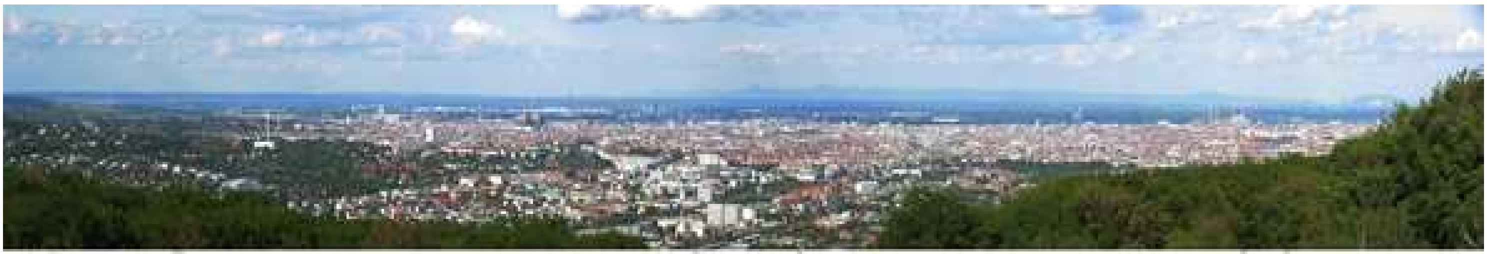

Conference on Applied Inverse Problems

Conference on Applied Inverse Problems

July 20-24, 2009 · Vienna · Austria

Conference Guide

RICAM
JOHANN-RADON-INSTITUTE
FOR COMPUTATIONAL AND APPLIED MATHEMATICS

ÖAW
Austrian Academy of Sciences

AIP 2009 · July 20 — 24
Conference on Applied Inverse Problems 2009
Theoretical and Computational Aspects

Cosponsored by

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Vienna Convention Bureau
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About AIP

The field of Inverse Problems is meanwhile well established within the applied sciences. Today's advances in hardware and algorithms allow to address complex real-world problems of inverse nature. They arise from pressing questions in - among others - medical and industrial applications as well as in life and earth sciences.

The 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 will take place in Vienna from July 20th to 24th in 2009.

Program Committee

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Contents

General Information

Campus map and time schedule are located on the back cover.

Social Events

Evening Reception at Vienna City Hall. Tuesday, July 21, 2009, 7:30 pm, at the City Hall main entrance.

Conference Excursion. Wednesday, July 22, 2009. Meeting Point: 2:30 pm, at Nationalbank, Otto-Wagner-Platz.

Option 1: Historical Vienna with tour through Schönbrunn Palace. Duration is approximately 3 hours.

Option 2: Kahlenberg - Klosterneuburg. Duration is approximately 3.5 hours.

At the end of the excursions, the buses will bring the participants to the conference dinner.

Conference Dinner. Wednesday, July 22, 2009, 6:00 pm, at the Winery Fuhrgassl-Huber, Neustift/Walde 68, 1190 Wien.

Invited Talks

Monday, July 20
9:00 – 10:00

Alfred Louis (Saarland University)
"*Feature reconstruction in tomography*"

14:00 – 15:00

Jeffrey Bamber (Institute of Cancer Research)
"*Progress in quantitative elastography for cancer medicine*"

Tuesday, July 21
9:00 – 10:00

Mohammed Jaoua (Polytech. Nice-Sophia)
"*Detection of small flaws locations using topological asymptotic expansion*"

14:00 – 15:00

Thorsten Hohage (University of Göttingen)
"*Inverse problems with Poisson data*"

Wednesday, July 22
9:00 – 10:00

Barbara Kaltenbacher (University of Stuttgart)
"*Adaptive and multilevel methods for parameter identification in partial differential equations*"

10:30 – 11:30

Patricia Lamm (Michigan State University)
"*Generalized Local Regularization for Ill-Posed Problems*"

11:30 – 12:30

Calderon Prize Lecture

Thursday, July 23
9:00 – 10:00

David Colton (University of Delaware)
"*Faber-Krahn Type Inequalities in Inverse Scattering Theory*"

14:00 – 15:00

George Biros (Georgia Institute of Technology)
"*Variational methods for cardiac motion estimation*"

Friday, July 24
9:00 – 10:00

Gen Nakamura (Hokkaido University)
"*Inverse problems for reconstructing the medium discontinuities*"

10:30 – 11:30

Jin Cheng (Fudan University)
"*The Mathematical Analysis of the Diffusion Process and its Applications*"

11:30 – 12:30

Habib Ammari (CNRS)
"*The Method of Small-Volume Expansions in Emerging Biomedical Imaging*"

Minisymposia

Overview

Date/Room	A	B	C1	C2	D	Aula
Monday 10:30-12:30	Piana	Arridge-Schotland	Pereverzyev-Pinnau	Ascher	Clason	Ring 1
Monday 15:15-17:15	Francini	Griesmaier	Bauer-Pricop 1	Massone	Wright-Zanni 1	Nashed-Tamasan 1
Tuesday 10:30-12:30	McLaughlin	Sini-Potthast	Rondi-Di Cristo	Bredies-Lorenz 1	Rosasco	D'Amore-Sgallari 1
Tuesday 15:15-17:15	Yamamoto	Bal-Schotland	Pötscher-Munk	Bertero-Hohage 1	Haltmeier-Zangerl 1	Lassas-Kurylev
Thursday 10:30-12:30	Nielsen	Cakoni-Haddar	Lu	Quinto	Wright-Zanni 2	Rosen-Wang
Thursday 15:15-17:15	Blum	Hanke	Burger-Nielsen	Bertero-Hohage 2	Stehlik	Nashed-Tamasan 2
Friday 14:00-16:00	Steinbach	Kirsch	Bauer-Pricop 2	Bertero-Hohage 3	Ring 2	D'Amore-Sgallari 2
Friday 16:15-18:15	Fomel	Alpers	Bredies-Lorenz 2	Haltmeier-Zangerl 2	Siltanen	Navasca-Kindermann

Each minisymposium talk is **25** minutes long. After the end of each talk, there are **5** minutes for discussion.

List of Minisymposia

Monday, July 20
10:30 – 12:30

Inverse Problems in Neuroscience, Room A
(Michele Piana)

New developments in Optical Tomography, Room B
(Simon Arridge and John Schotland)

Recent Trends in Iterative Regularization Algorithms, Room C1
(Sergiy Pereverzyev Jr. and Rene Pinnau)

Sparse Solutions in Inverse Problems, Room C2
(Uri Ascher)

Applications of Carleman Estimates in Numerical Methods for Inverse Problems, Room D
(Christian Clason)

New Developments in Geometric Inverse Problems (1), Room Aula
(Wolfgang Ring)

Monday, July 20
15:15 – 17:15

Inverse Problems in Elasticity, Room A
(Elisa Francini)

Application-oriented Sampling Methods for Inverse Scattering Problems, Room B
(Roland Griesmaier)

Interplay between Deterministic and Statistical Inverse Problems (1), Room C1
(Frank Bauer and Mihaela Pricop)

Results from NASA's RHESSI Solar Spectroscopic Imager - Fertile Ground for Inverse Problem Research, Room C2
(Anna Maria Massone)

Optimization-based Approaches in Image Processing (1), Room D
(Stephen J. Wright and Luca Zanni)

Non-smooth Optimization in Inverse Problems (1), Room Aula
(Zuhair Nashed and Alexandru Tamasan)

Tuesday, July 21
10:30 – 12:30

Emerging Techniques and Technologies for Biomechanical Imaging, Room A
(Joyce McLaughlin)

Detection of Complex Interfaces by Nondestructive Evaluations, Room B
(Mourad Sini and Roland Potthast)

Discrete-like Inverse Problems: Analysis and Numerics, Room C1
(Luca Rondi and Michele Di Cristo)

Regularization, Algorithms and Sparsity -Banach Spaces and Beyond (1), Room C2
(Kristian Bredies and Dirk Lorenz)

Regularization Approaches to Learning from High Dimensional Data, Room D
(Lorenzo Rosasco)

Inverse Problems: Computational Aspects and Emerging Applications (1), Room Aula
(Luisa D'Amore and Fiorella Sgallari)

Tuesday, July 21
15:15 – 17:15

Inverse Problems for Industrial Measurement Techniques, Room A
(Masahiro Yamamoto)

Inverse Problems in Optical Imaging, Room B
(Guillaume Bal and John Schotland)

Statistical Inverse Problems, Room C1
(Benedikt Pötscher and Axel Munk)

Image Reconstruction Methods in Astronomyand Microscopy: Sparsity, Nonnegativity, and Poisson data (1), Room C2
(Mario Bertero and Thorsten Hohage)

Recent Developments in Tomography, Room D
(Markus Haltmeier and Gerhard Zangerl)

Analytic and Geometric Methods for Applied Inverse problems, Room Aula
(Matti Lassas and Yaroslav Kurylev)

Thursday, July 23
10:30 – 12:30

Recent Contributions to the Inverse Problem of Electrocardiography, Room A
(Björn Fredrik Nielsen)

The Determination of Boundary Coefficients in Inverse Boundary Value Problems and Scattering Theory, Room B
(Fioralba Cakoni and Houssem Haddar)

Multi-parameter Regularization and its Numerical Realization, Room C1
(Shuai Lu)

Tomographic Inverse Problems, Room C2
(Eric Todd Quinto)

Optimization-based Approaches in Image Processing (2), Room D
(Stephen J. Wright and Luca Zanni)

Computational Methods for Estimation Problems for Distributed Parameter Systems, Room Aula
(Gary Rosen and Chunming Wang)

Thursday, July 23
15:15 – 17:15

Data Assimilation for Geophysical Problems, Room A
(Jacques Blum)

Inverse Problems in Impedance Tomography and Inverse Scattering, Room B
(Martin Hanke-Bourgeois)

Preconditioning in Inverse Problems, Room C1
(Martin Burger and Björn Fredrik Nielsen)

Image Reconstruction Methods in Astronomyand Microscopy: Sparsity, Nonnegativity, and Poisson data (2), Room C2
(Mario Bertero and Thorsten Hohage)

Inverse problems in Statistics and Probability, Room D
(Milan Stehlik)

Non-smooth Optimization in Inverse Problems (2), Room Aula
(Zuhair Nashed and Alexandru Tamasan)

Friday, July 24
14:00 – 16:00

Magnetic Resonance and Magnetic Induction Tomography, Room A
(Olaf Steinbach)

Recent Reconstruction Approaches for Electrical Impedance Tomography and Inverse Scattering by Periodic Media, Room B
(Andreas Kirsch)

Interplay between Deterministic and Statistical Inverse Problems (2), Room C1
(Frank Bauer and Mihaela Pricop)

Image Reconstruction Methods in Astronomyand Microscopy: Sparsity, Nonnegativity, and Poisson data (3), Room C2
(Mario Bertero and Thorsten Hohage)

New Developments in Geometric InverseProblems (2), Room D
(Wolfgang Ring)

Inverse Problems: Compuational Aspects and Emerging Applications (2), Room Aula
(Luisa D'Amore and Fiorella Sgallari)

Friday, July 24
16:15 – 18:15

Regularization strategies in appliedgeophysical inverse problems, Room A
(Sergey Fomel)

Discrete Tomography and Image Reconstruction in Material Science, Room B
(Andreas Alpers)

Regularization, Algorithms and Sparsity -Banach spaces and Beyond (2), Room C1
(Kristian Bredies and Dirk Lorenz)

Recent Developments in Photo- and Thermoacoustic Tomography, Room C2
(Markus Haltmeier and Gerhard Zangerl)

Reconstruction Algorithms and Complex Geometrical Optics, Room D
(Samuli Siltanen)

Ill-posed Problems in Tensor Decomposition, Room Aula
(Carmeliza Navasca and Stefan Kindermann)

List of Minisymposia Talks

Monday, 20 July
10:30 – 12:30

Inverse Problems in Neuroscience

Room: A
Organizer(s): Michele Piana (University of Genova)

Speakers:

Matti Hamalainen (Martinos Center for Biomedical Imaging)
"*Anatomically and Functionally Constrained MEG/EEG Source Estimates*"

Dante Mantini (University of Chieti-Pescara)
"*EEG-based analysis of neuronal activation in fMRI large-scale networks*"

Gian Luca Romani (I.T.A.B.)
"*Localization of correlated cerebral networks from EEG/MEG data*"

Alberto Sorrentino (Universita' di Genova)
"*Random finite sets for dynamic multi-dipole reconstruction with particle filtering in magnetoencephalography*"

New Developments in Geometric Inverse Problems (1)

Room: Aula
Organizer(s): Wolfgang Ring (University of Graz)

Speakers:

Oliver Dorn (University of Manchester)
"*Reconstructing thin shapes by a level set technique.*"

Luca Rondi (Universita' degli Studi di Trieste)
"*Reconstruction of discontinuous functions by perimeter penalization*"

Esther Klann (Johann Radon Institute)
"*A Mumford-Shah level-set approach for tomography data – reconstruction and regularization*"

Elena Hoetzl (University of Graz)
"*Numerical treatment of a Mumford-Shah model for the inversion of tomography data*"

New developments in Optical Tomography

Room: B
Organizer(s): Simon Arridge (University College London),
John Schotland (University of Pennsylvania)

Speakers:

Manabu Machida (University of Pennsylvania)
"*Optical Tomography Based on the Method of Rotated Reference Frames*"

Simon Arridge (University College London)
"*A multi-level type of reconstruction strategy for optical tomography*"

Vadim Soloviev (University College London)
"*Practical application of variational approaches for solving inverse problems in optical tomography*"

Tanja Tarvainen (University of Kuopio)
"*Approximation errors in optical tomography*"

Recent trends in iterative regularization algorithms

Room: C1
Organizer(s): Sergiy Pereverzyev Jr. (Johannes Kepler University Linz),
Rene Pinnau (University of Kaiserslautern)

Speakers:

Andreas Rieder (University of Karlsruhe)
"*Towards a general convergence theory for inexact Newton regularizations*"

Bangti Jin (University of Bremen)
"*Numerical estimation of Robin coefficient*"

Yuesheng Xu (Syracuse University)
"*Fast Multiscale Methods for Solving Ill-posed Integral Equations of the First Kind*"

Jun Zou (The Chinese University of Hong Kong)
"*Parameter choice rules for Tikhonov regularization*"

Sparse solutions in inverse problems

Room: C2
Organizer(s): Uri Ascher (University of British Columbia)

Speakers:

Eldad Haber (Emory University)
"*Dictionary Design for sparse solutions of ill-posed problems* "

Felix Herrmann (University of British Columbia)
"*Compressive seismic imaging with simultaneous acquisition*"

Kees van den Doel (University of British Columbia)
"*Source localization in electromyography*"

Robert Plemmons (Wake Forest University)
"*Parallel algorithms and Optimization Techniques for Multi-Aperture Image Superresolution Reconstruction*"

Applications of Carleman estimates in numerical methods for inverse problems

Room: D
Organizer(s): Christian Clason (University of Graz)

Speakers:

Larisa Beilina (Chalmers University of Technology and Gothenburg University)
"*A globally convergent numerical method and adaptivity for an inverse problem via Carleman estimates*"

Hui Cao (Johann Radon Institute)
"*A Carleman estimate and the balancing principle in the quasi-reversibility method for solving the Cauchy problem for Laplace equation*"

Barbara Kaltenbacher (University of Stuttgart)
"*Identifiability of the nonlinearity in a parabolic PDE with application in nonlinear magnetics*"

Jean-Pierre Puel (Ecole Polytechnique)
"*Non standard approach to a data assimilation problem.*"

Monday, 20 July
15:15 – 17:15

Inverse Problems in Elasticity

Room: A
Organizer(s): Elisa Francini (Universita' di Firenze)

Speakers:

Yves Capdeboscq (Oxford University)
"*Enhanced Resolution in Structured Media*"

Anna Mazzucato (Penn State University)
"*Determination of material properties from boundary measurements in anisotropic elastic media*"

Edi Rosset (Universita' di Trieste)
"*Unique determination of a cavity in an elastic plate by two boundary measurements*"

Elisa Francini (Universita' di Firenze)
"*Determination of elastic inclusions from boundary measurements*"

Non-smooth Optimization in Inverse Problems (1)

Room: Aula
Organizer(s): Zuhair Nashed (University of Central Florida),
Alexandru Tamasan (University of Central Florida)

Speakers:

Annamaria Barbagallo (Universita di Catania)
"*Variational inequalities, infinite-dimensional duality, inverse problem and applications to oligopolistic market equilibrium problem*"

Paul Eggermont (University of Delaware)
"*Conjugate gradients for linear ill-posed problems with weakly bounded noise*"

Florian Potra (University of Maryland, Baltimore County)
"*On the numerical solution of nonlinear complementarity problems arising in nonsmooth multibody dynamics*"

Teresa Reginska (Polish Academy of Science)
"*Application of a weak definition of the normal derivative to wavelet moment regularization of a Cauchy problem for the Helmholtz equation*"

Application-oriented sampling methods for inverse scattering problems

Room: B
Organizer(s): Roland Griesmaier (University of Delaware)

Speakers:

Bastian Gebauer (University of Mainz)
"*Tracking a moving object by current-voltage measurements*"

Nuutti Hyvonen (Helsinki University of Technology)
"*Approximating idealized measurement maps of electric impedance tomography by electrode data*"

Armin Lechleiter (Ecole Polytechnique)
"*Sampling Methods for Scattering in 3D Waveguides*"

Roland Griesmaier (University of Delaware)
"*Reciprocity gap MUSIC-imaging for inverse scattering*"

Interplay between Deterministic and Statistical Inverse Problems (1)

Room: C1
Organizer(s): Frank Bauer (University of Linz),
Mihaela Pricop (University of Goettingen)

Speakers:

Jari Kaipio (University of Kuopio)
"*Nonstationary inversion and reduced order flow modelling*"

Mihaela Pricop (University of Goettingen)
"*Interplay between deterministic and statistical inverse problems*"

Lorenzo Rosasco (Massachusetts Institute of Technology)
"*Inverse Problems Perspective on Learning*"

Gerd Teschke (University of Applied Sciences Neubrandenburg)
"*Compressive Strategies for Solving Inverse Problems*"

Results from NASA's RHESSI Solar Spectroscopic Imager - fertile ground for Inverse Problem research

Room: C2
Organizer(s): Anna Maria Massone (CNR-INFM)

Speakers:

A. Gordon Emslie (Oklahoma State University)
"*Probing Electron Acceleration in Solar Flares through Hard X-ray Imaging Spectroscopy: A Two-Stage Inverse Problem*"

Michele Piana (University of Genova)
"*Regularization methods for the analysis of RHESSI data*"

Jana Kasparova (Academy of Sciences of the Czech Republic)
"*Applications of inversion techniques to RHESSI spatially integrated spectra*"

Gordon Hurford (University of California, Berkeley)
"*Inverse Problems in Solar Imaging Spectroscopy - Future Applications*"

Optimization-based approaches in image processing (1)

Room: D
Organizer(s): Stephen J. Wright (University of Wisconsin)

Speakers:

Uri Ascher (University of British Columbia)
"*Faster gradient descent and artificial time integration*"

Michael Hintermueller (University of Graz)
"*A duality-based variational approach to L1-TV*"

Francesca Pitolli (Universita' di Roma "La Sapienza")
"*Projected gradient methods and applications in magnetic tomography*"

Riccardo Zanella (University of Modena and Reggio Emilia)
"*Scaled gradient projection methods in image deblurring and denoising*"

Tuesday, 21 July
10:30 – 12:30

Emerging Techniques and Technologies for Biomechanical Imaging

Room: A
Organizer(s): Joyce McLaughlin (Rensselaer Polytechnic Institute)

Speakers:

Ralph Sinkus (ESPCI)
"*MR-Elastography: Principles, clinical application to breast, liver and brain and shear rheology*"

Bojan Guzina (University of Minnesota)
"*On the small-defect perturbation and sampling of heterogeneous solids*"

Alison Malcolm (Massachusetts Institute of Technology)
"*Mathematical and Numerical Modeling of Imaging with Ultrasound Vibro-Acoustography*"

Joyce McLaughlin (Rensselaer Polytechnic Institute)
"*Imaging Biomechanical Properties of Tissue Using Wave Propagation Data: Application to Prostate and Liver*"

Inverse Problems: Computational Aspects and Emerging Applications (1)

Room: Aula
Organizer(s): Fiorella Sgallari (University of Bologna)

Speakers:

Raymond Chan (The Chinese University of Hong Kong)
"*Missing Data Recovery by Tight-frame Algorithms with Flexible Wavelet Shrinkage*"

Marco Donatelli (Universita' dell'Insubria)
"*Image deblurring with antireflective boundary conditions*"

Lothar Reichel (University of Kent)
"*A fast edge-preserving multilevel method for deblurring, denoising, and segmentation.*"

Sebastiano Seatzu (Universita degli studi di Cagliari)
"*Numerical Inverse Scattering Transform Solving the Nonlinear Schroedinger Equation*"

Detection of complex interfaces by non destructive evaluations.

Room: B
Organizer(s): Mourad Sini (Johann Radon Institute),
Roland Potthast (University of Reading)

Speakers:

Drossos Gintides (National Technical University)
"*A discrete variational method to determine the index of refraction from far field measurements*"

Hossem Haddar (INRIA)
"*Taking into account roughness of interfaces in the imaging of buried objects*"

Jijun Liu (South-East University, China)
"*Numerical realizations of inverse scattering problems for a complex obstacle*"

Antonino Morassi (University of Udine)
"*Detecting damage in a steel-concrete composite beam by finite eigenvalue measurements*"

Discrete-like inverse problems: analysis and numerics

Room: C1
Organizer(s): Luca Rondi (Universita' degli Studi di Trieste),
Michele Di Cristo (Politecnico di Milano)

Speakers:

Fadil Santosa (University of Minnesota)
"*An inverse problem in the design of progressive lenses*"

Massimo Fornasier (Johann Radon Institute)
"*Inverse free-discontinuity problems and iterative thresholding algorithms*"

Elisa Francini (Universita' di Firenze)
"*Detection of linear cracks in an elastic material*"

Jiguang Sun (Delaware State University)
"*Numerical studies of the reciprocity gap functional method in inverse scattering*"

Regularization, Algorithms and Sparsity - Banach spaces and Beyond (1)

Room: C2
Organizer(s): Kristian Bredies (University of Graz),
Dirk Lorenz (University of Bremen)

Speakers:

Clemens Zarzer (Johann Radon Institute)
"*Regularization with non-convex sparsity constraints*"

Markus Grasmair (University of Innsbruck)
"*Convergence rates for* l^q *regularization*"

Dennis Trede (University of Bremen)
"*Greedy Deconvolution of Point-like Objects*"

Ignace Loris (Vrije Universiteit Brussel)
"*On the convergence rate of iterative* ℓ_1 *minimization algorithms*"

Regularization Approaches to Learning from High Dimensional Data

Room: D
Organizer(s): Lorenzo Rosasco (Massachusetts Institute of Technology)

Speakers:

Andreas Maurer (Compuserve)
"*Bounding the inverse of the sample covariance matrix and applications to machine learning*"

Andrea Caponnetto (City University of Hong Kong)
"*Regularization by operator-valued kernels in Learning Theory*"

Massimiliano Pontil (University College London)
"*Matrix Regularization for Multi-Task Learning*"

Sergei Pereverzyev (Johann Radon Institute)
"*Multi-parameter regularization in Learning theory*"

Tuesday, 21 July
15:15 – 17:15

Inverse Problems for Industrial Measurement Techniques

Room: A
Organizer(s): Masahiro Yamamoto (University of Tokyo)

Speakers:

Jin Cheng (Fudan University)
"*Heat transfer in composite materials and related inverse problems*"

Andreas Rathsfeld (Weierstrass Institute Berlin)
"*Numerical Aspects of the Scatterometric Measurement of Periodic Surface Structures*"

Tomoya Takeuchi (University of Tokio)
"*Mathematics and numerics for a thermographic inverse problem*"

Nataliya Togobytska (Weierstrass Institute Berlin)
"*Parameter identification for the phase transformations in steel*"

Analytic and geometric methods for applied inverse problems

Room: Aula
Organizer(s): Matti Lassas (University of Helsinki),
Yaroslav Kurylev (University College London)

Speakers:

Allan Greenleaf (University of Rochester)
"*Approximate cloaks for acoustic and Schrödinger equations*"

Hiroshi Isozaki (University of Tsukuba)
"*Inverse scattering on non-compact manifolds*"

Katya Krupchyk (University of Helsinki)
"*Inverse spectral problems with data on a hypersurface*"

Samuli Siltanen (Tampere University of Technology)
"*Inverse conductivity problem and the Beltrami equation*"

Inverse Problems in Optical Imaging

Room: B
Organizer(s): Guillaume Bal (Columbia University),
John Schotland (University of Pennsylvania)

Speakers:

Simon Arridge (University College London)
"*Regularisation and Prior Knowledge in Optical Tomography*"

Guillaume Bal (Columbia University)
"*Inverse Transport*"

Scott Carney (University of Illinois)
"*Interferometric Synthetic Aperture Microscopy*"

John Schotland (University of Pennsylvania)
"*Convergence and Stability of the Inverse Scattering Series in Near-field Tomography*"

Statistical Inverse Problems

Room: C1
Organizer(s): Benedikt Poetscher (University of Vienna),
Axel Munk (Goettingen University)

Speakers:

Yuri Golubev (CNRS)
"*On oracle inequalities related to high dimensional linear models.*"

Markus Reiss (University of Heidelberg)
"*Regularization independent of the noise level: an analysis of quasi-optimality*"

Marc Hoffmann (Universite Paris-Est Marne-la-Vallee)
"*Volatility representation under microstructure noise as a statistical ill-posed inverse problem*"

Anselm Johannes Schmidt-Hieber (University of Goettingen)
"*Minimax Estimation of the Volatility in High-Frequency Models Corrupted by Noise*"

Image Reconstruction Methods in Astronomy and Microscopy: Sparsity, Nonnegativity, and Poisson data. (1)

Room: C2
Organizer(s): Mario Bertero (University of Genova),
Thorsten Hohage (University of Goettingen)

Speakers:

Jean-Luc Starck (CEA, Saclay)
"*Compressed Sensing: a solution to the data transfert problem of the ESA Herschel Spacecraft*"

Giuseppe Vicidomini (Max Planck Institute for biophysical Chemistry)
"*Image restoration in super-resolution fluorescence microscopy*"

Christine De Mol (Universite Libre de Bruxelles)
"*Iterative Algorithms for Sparse Recovery*"

Massimo Fornasier (Johann Radon Institute)
"*Multilevel preconditioning in inverse problems with sparsity constraints*"

Recent Developments in Tomography

Room: D
Organizer(s): Gerhard Zangerl (University of Innsbruck),
Markus Haltmeier (University of Innsbruck)

Speakers:

Adel Faridani (Oregon State University)
"*Analysis of PI-line based algorithms in fan-beam tomography*"

Ville Kolehmainen (University of Kuopio)
"*Multiresolution local tomography in dental radiology using wavelets*"

Yaroslav Kurylev (University College London)
"*Some Inverse Problems for Orbifolds*"

Akhtar A. Khan (Rochester Institute of Technology)
"*Optimization-Based Approaches for an Inverse Problem in Elasticity Imaging*"

Thursday, 23 July
10:30 – 12:30

Recent contributions to the inverse problem of electrocardiography

Room: A
Organizer(s): Bjorn Fredrik Nielsen (Simula Research Laboratory)

Speakers:

Robert S. MacLeod (The University of Utah)
"*Lest we forget–the Clinical Expectations and Requirements for Useful Simulation of Cardiac Bioelectricity*"

Michael Seger (UMIT)
"*Non-Invasive Patient Individual Imaging of Cardiac Electrical Function using Multi-lead ECG Data: Drawbacks and Opportunities in the Electrocardiographic Inverse Problem*"

Yuan Jiang (Karlsruhe Institute of Technology)
"*The Inverse Problem of Electrocardiography in Realistic Environment*"

Bjorn Fredrik Nielsen (Simula Research Laboratory)
"*The inverse ischemia problem; mathematical models and validation*"

Computational Methods for Estimation Problems for Distributed Parameter Systems

Room: Aula
Organizer(s): Gary Rosen (University of Southern California),
Chunming Wang (University of Southern California)

Speakers:

Fariba Fahroo (Air Force Office of Scientific Research)
"*Utilizing Natural Observer for the Adaptive Estimation of Second Order Bilinear Infinite Dimensional Systems*"

Gunther Peichl (University of Graz)
"*The Shape Gradient for Problems of Bernoulli Type*"

Chunming Wang (University of Southern California)
"*The Estimation of Ionospheric Driving Force Using 4DVAR Data Assimilation Approach*"

Yulia Piterbarg (University of Southern California)
"*Approximation in the Deconvolution of Drinking Behavior from Transdermal Alcohol Biosensor Data*"

The determination of boundary coefficients in inverse boundary value problems and scattering theory.

Room: B
Organizer(s): Fioralba Cakoni (University of Delaware),
Houssem Haddar (Ecole Polytechnique)

Speakers:

Laurent Bourgeois (ENSTA)
"*Uniqueness and stability for identification of generalized impedance boundary conditions*"

Slim Chaabane (Ecole Nationale d'Ingenier de Tunis)
"*Optimal logarithmic estimates in Hardy-Sobolev spaces $\mathcal{H}^{k,\infty}$: Applications to inverse problems*"

Christian Schuft (University of Goettingen)
"*Nonlinear integral equations for shape and impedance reconstruction from partial Cauchy data*"

Noam Zeev (Old Dominion University)
"*Identification of shape and material properties of thin dielectric objects from far field and near field data*"

Multi-parameter regularization and its numerical realization

Room: C1
Organizer(s): Shuai Lu (Johann Radon Institute)

Speakers:

Claude Brezinski (Universite Lille1)
"*Estimation of the best parameter in Tikhonov regularization method*"

Bernd Hofmann (Chemnitz University of Technology)
"*Multi-parameter regularization for some nonlinear inverse problems in finance and technology*"

Michela Redivo Zaglia (University of Padova)
"*Extrapolation techniques and multiparameter treatment for Tikhonov regularization*"

Ulrich Tautenhahn (University of Applied Sciences Zittau/Goerlitz)
"*Multi-parameter regularization for ill-posed problems with noisy right hand side and noisy operator*"

Tomographic Inverse Problems

Room: C2
Organizer(s): Eric Todd Quinto (Tufts University)

Speakers:

Andreas Rieder (University of Karlsruhe)
"*A new view on phantom views*"

Ryan Hass (Oregon State University)
"*Analysis of 3D reconstruction algorithms in x-ray tomography*"

Thomas Schuster (Helmut Schmidt University)
"*Inversion of the vectorial ray transform on Riemannian manifolds*"

Eric Todd Quinto (Tufts University)
"*Stability estimates for limited data Radon transforms*"

Optimization-based approaches in image processing (2)

Room: D
Organizer(s): Luca Zanni (University of Modena and Reggio Emilia)

Speakers:

Elena Loli Piccolomini (Universita di Bologna)
"*Optimization methods for the regularization of image deblurring and denoising problems*"

Germana Landi (Universita di Bologna)
"*Recent advances in optimization algorithms for image deblurring and denoising*"

Gaetano Zanghirati (University of Ferrara)
"*A novel approach to the joint inversion of loosely connected data*"

Stephen J. Wright (University of Wisconsin)
"*First-order algorithms for approximate total-variation-regularized image reconstruction*"

Thursday, 23 July
15:15 – 17:15

Data assimilation for geophysical problems

Room: A
Organizer(s): Jacques Blum (University of Nice Sophia Antipolis)

Speakers:

David Stauffer (Penn State University)
"*Some Innovative Applications and Approaches Using Nudging Four Dimensional Data Assimilation - Part 1*"

Lili Lei (Penn State University)
"*Some Innovative Applications and Approaches Using Nudging Four Dimensional Data Assimilation - Part 2*"

Didier Auroux (Universite Toulouse 3)
"*Back to the future: the back and forth nudging algorithm*"

Francois Le Dimet (Universite de Grenoble and INRIA (France))
"*Error Propagation and Second Order Information in Variational Data Assimilation*"

Non-smooth Optimization in Inverse Problems (2)

Room: Aula
Organizer(s): Alexandru Tamasan (University of Central Florida),
Zuhair Nashed (University of Central Florida)

Speakers:

Raymond Chan (The Chinese University of Hong Kong)
"*Unified Tight Frame Approach for Missing Data Recovery in Images*"

Linh Nguyen (University of Texas A&M)
"*Inversion formulas in Thermoacoustic Tomography*"

Arian Novruzi (University of Ottawa)
"*Polygons as optimal shapes with convexity constraint*"

Inverse Problems in Impedance Tomography and Inverse Scattering

Room: B
Organizer(s): Martin Hanke (Johannes Gutenberg University Mainz)

Speakers:

Nuutti Hyvonen (Helsinki University of Technology)
"*An inverse backscattering problem in electric impedance tomography*"

Stefanie Reusswig (University of Mainz)
"*Numerical reconstructions from backscatter data in impedance tomography*"

Habib Ammari (CNRS)
"*An optimal Control Approach for Inclusion Reconstruction*"

Herbert Egger (RWTH Aachen University)
"*Efficient inversion in electrical capacitance tomography*"

Preconditioning in Inverse Problems

Room: C1
Organizer(s): Martin Burger (University of Muenster),
Bjorn Fredrik Nielsen (Simula Research Laboratory)

Speakers:

Herbert Egger (RWTH Aachen University)
"*On the preconditioning of regularization methods*"

Bjorn Fredrik Nielsen (Simula Research Laboratory)
"*An operator theoretical approach to preconditioning optimality systems*"

Walter Zulehner (Johannes Kepler University Linz)
"*Robust one-shot multigrid methods for optimal control problems*"

Image Reconstruction Methods in Astronomy and Microscopy: Sparsity, Nonnegativity, and Poisson data. (2)

Room: C2
Organizer(s): Thorsten Hohage (University of Goettingen),
Mario Bertero (University of Genova)

Speakers:

David Mary (Laboratoire Fizeau, Parc Valrose, Nice)
"*Image reconstruction in radio and optical interferometry*"

Christoph Brune (University of Muenster)
"*Bregman-EM-TV Methods for Deconvolution Problems with Poisson Noise*"

Ronny Ramlau (Johann Radon Institute)
"*Tikhonov regularization with sparsity constraints - analysis and applications in imaging*"

Federico Benvenuto (University of Genova)
"*Iterative methods for constrained and regularized least-square problems*"

Inverse problems in Statistics and Probability

Room: D
Organizer(s): Milan Stehlik (Johannes Kepler University Linz)

Speakers:

Daniel Hlubinka (Charles University)
"*Implicit Markov kernels given by moment conditions*"

Klaus Poetzelberger (University of Economics and Business Administration)
"*Asymptotically optimal quantizations*"

Milan Stehlik (Johannes Kepler University Linz)
"*Inverse problems for nonlinear systems*"

Friday, 24 July
14:00 – 16:00

Magnetic Resonance and Magnetic Induction Tomography

Room: A
Organizer(s): Olaf Steinbach (Graz University of Technology)

Speakers:

Sarah Engleder (Graz University of Technology)
"*Magnetic Induction Tomography: Mathematical Model and Boundary Element Methods*"

Doga Guersoy (Graz University of Technology)
"*A sensor optimization algorithm to increase the stability of the magnetic induction tomography inversion*"

Florian Knoll (Graz University of Technology)
"*Towards real-time MR imaging: Data acquisition strategies and image reconstruction*"

Herbert Egger (RWTH Aachen University)
"*Nonlinear Reconstruction Methods for Magnetic Induction Tomography*"

Inverse Problems: Computational Aspects and Emerging Applications (2)

Room: Aula
Organizer(s): Luisa D'Amore (University of Naples Federico II)

Speakers:

Julianne Chung (Emory University)
"*Algorithms for Polyenergetic Breast Tomosynthesis Image Reconstruction*"

Ronny Ramlau (Johann Radon Institute)
"*Multi - level iterative regularization of linear ill posed problems*"

Giuseppe Rodriguez (Universita di Cagliari)
"*An algorithm for the least-squares solution of rank-deficient linear systems.*"

Ivonne Sgura (Universita del Salento)
"*A variational approach for accuracy assessment of biomedical images*"

Recent reconstruction approaches for electrical impedance tomography and inverse scattering by periodic media

Room: B
Organizer(s): Andreas Kirsch (University of Karlsruhe)

Speakers:

Fabrice Delbary (Goettingen University)
"*Complete electrode model for the inverse impedance tomography : a reconstruction based on polygonal curves*"

Andreas Helfrich-Schkarbanenko (University of Karlsruhe)
"*Complex Electrical Impedance Tomography in Geoelectrics*"

Kai Sandfort (University of Karslruhe)
"*Reconstruction of periodic inhomogeneous media by the Factorization Method*"

Susanne Schmitt (University of Karslruhe)
"*The Factorization Method for EIT in Geoelectrical Imaging*"

Interplay between Deterministic and Statistical Inverse Problems (2)

Room: C1
Organizer(s): Mihaela Pricop (University of Goettingen),
Frank Bauer (University of Linz)

Speakers:

Shuai Lu (Johann Radon Institute)
"*Multi-parameter regularization and its numerical realization*"

Hanna Pikkarainen (Johann Radon Institute)
"*Convergence of Bayesian solutions of linear inverse problems*"

Bernard Mair (University of Florida)
"*Cardiac Image and Motion Estimation from Poisson Data*"

Elena Resmerita (Johann Radon Institute)
"*A dual norm iterative method for minimizing convex functions*"

Image Reconstruction Methods in Astronomy and Microscopy: Sparsity, Nonnegativity, and Poisson data. (3)

Room: C2
Organizer(s): Thorsten Hohage (University of Goettingen),
Mario Bertero (University of Genova)

Speakers:

Robert Stueck (University of Goettingen)
"*Semi-blind Deconvolution in 4Pi Microscopy*"

James Nagy (Emory University)
"*Efficient Iterative Algorithms for Blind Deconvolution*"

Celine Theys (Dep Reseaux & Telecommunications, Sophia-Antipolis)
"*Restoration of astrophysical images acquired with Low Light Level CCD*"

Gerd Teschke (University of Applied Sciences Neubrandenburg)
"*Solving Inverse Problems with Sparsity Constraints*"

New Developments in Geometric Inverse Problems (2)

Room: D
Organizer(s): Wolfgang Ring (University of Graz)

Speakers:

Antoine Laurain (University of Graz)
"*Second-order topological expansion for Electrical Impedance Tomography*"

Hend Ben Ameur (University of Tunis)
"*On some geometric inverse problems in elasticity and thermoelasticity*"

Wolfgang Ring (University of Graz)
"*Numerical treatment of perimeter regularization in the level-set context*"

Friday, 24 July
16:15 – 18:15

Regularization strategies in applied geophysical inverse problems

Room: A
Organizer(s): Sergey Fomel (The University of Texas at Austin)

Speakers:

Ignace Loris (Vrije Universiteit Brussel)
"*Novel regularization techniques for seismic tomography*"

Konstantin Osypov (Schlumberger)
"*We can invert 10m x 10m covariance, now how should we analyze it?* "

Felix Herrmann (University of British Columbia)
"*To be announced*"

Sergey Fomel (The University of Texas at Austin)
"*Shaping regularization*"

Ill-posed Problems in Tensor Decomposition

Room: Aula
Organizer(s): Carmeliza Navasca (Clarkson University),
Stefan Kindermann (Johannes Kepler University Linz)

Speakers:

Alwin Stegeman (University of Groningen)
"*The Candecomp/Parafac decomposition - diverging components and how to avoid them*"

Carmeliza Navasca (Clarkson University)
"*Swamp reducing technique for tensor decomposition*"

Alexander Litvinenko (TU Braunschweig)
"*Application of Sparse Tensor Techniques for Solving Stochastic Transport Equations*"

Discrete Tomography and Image Reconstruction in Material Science

Room: B
Organizer(s): Andreas Alpers (Technical University of Denmark)

Speakers:

Peter Balazs (University of Szeged)
"*Neutron tomography with prior information*"

Joost Batenburg (University of Antwerp)
"*3D reconstruction of nanomaterials by discrete tomography*"

Andreas Alpers (Technical University of Denmark)
"*Grain and orientation map reconstruction from x-ray diffraction data*"

Regularization, Algorithms and Sparsity - Banach spaces and Beyond (2)

Room: C1
Organizer(s): Dirk Lorenz (University of Bremen),
Kristian Bredies (University of Graz)

Speakers:

Torsten Raasch (University of Marburg)
"*Convergence rates of ℓ_1-constrained Tikhonov regularization from the viewpoint of nonlinear approximation*"

Kamil Kazimierski (University of Bremen)
"*Iterative Regularization in Banach spaces*"

Kristian Bredies (University of Graz)
"*A forward-backward splitting method in Banach space for the minimization of Tikhonov functionals*"

Christian Clason (University of Graz)
"*Inverse problems with L^1 data fitting*"

Recent Developments in Photo- and Thermoacoustic Tomography

Room: C2
Organizer(s): Markus Haltmeier (University of Innsbruck),
Gerhard Zangerl (University of Innsbruck)

Speakers:

Markus Haltmeier (University of Innsbruck)
"*Analysis of spatial resolution in photoacoustic and thermoacoustic tomography*"

Plamen Stefanov (Purdue University)
"*A microlocal approach to Thermoacoustic Tomography*"

Gerhard Zangerl (University of Innsbruck)
"*Circular Integrating Detectors in Photoacoustic Tomography*"

Richard Kowar (University of Innsbruck)
"*Modeling and analysis of waves and wave equations obeying attenuation and causality*"

Reconstruction algorithms and complex geometrical optics

Room: D
Organizer(s): Samuli Siltanen (Tampere University of Technology),
Kim Knudsen (Technical University of Denmark)

Speakers:

Jutta Bikowski (Colorado State Universtiy)
"*A 3D direct reconstruction algorithm for Electrical Impedance Tomography*"

Kim Knudsen (Technical University of Denmark)
"*Reconstructing conductivities in three dimensions using a non-physical scattering transform*"

Matti Lassas (University of Helsinki)
"*Regularization of the D-bar method for the two-dimensional inverse conductivity problem*"

Jenn-Nan Wang (National Taiwan University)
"*Reconstruction of inclusions using complex geometrical optics solutions*"

Posters

Poster sessions are always from **17:15** till **18:15** in Foyer.

Monday, July 20

Sarah Bridle (University College London)
"*The GREAT08 and GREAT09 Challenges - an inverse probelm in cosmology*"

Xudong Chen (National University of Singapore)
"*Novel Inversion Technique for Diffuse Optical Tomography*"

Manuel Freiberger (Graz University of Technology)
"*Application of level-set type reconstruction to fluorescence optical tomography*"

Mohammad Rahim Hematiyan (Shiraz University)
"*An artificial heat source method for inverse analysis of solidification problems*"

Ganna Ivanova (IAMM of NASU, Donetsk)
"*Identification of Convection Heat Transfer Coefficient of Secondary Cooling Zone of CCM based on Least Squares Method and Stochastic Approximation Method*"

Maka Karalashvili (AVT-Process Systems Engineering)
"*A decomposition approach for the solution of inverse convection-diffusion problems*"

Daniel Lesnic (University of Leeds)
"*Non-local methods for some inverse problems*"

Silvio Melo (Centro de Informatica - UFPE)
"*A Rational B-splines Tomographic Reconstruction of the Catalyst Density Distribution Function*"

Reimo Palm (University of Tartu)
"*Minimization strategy for choice of the stopping index in conjugate gradient type methods for ill-posed problems*"

Pornsarp Pornsawad (University of Potsdam)
"*Iterative Runge-Kutta type methods for nonlinear ill-posed problems*"

Jianzhong Su (University of Texas at Arlington)
"*Globally Accelerated Reconstruction Algorithm for Diffusion Tomography in an Arbitrary Convex Shape Domain*"

Tuesday, July 21

Marta Betcke (University of Manchester)
"*Rebinning methods for new generation cone beam CT*"

Anna Cysewska-Sobusiak (Poznan University of Technology)
"*Inverse problems in modeling and simulation of light transmission through tissue sets*"

Hermann Gross (Physikalisch-Technische Bundesanstalt)
"*Uncertainty estimates for inverse methods in EUV scatterometry*"

Mark-Alexander Henn (Physikalisch-Technische Bundesanstalt)
"*On numerical reconstructions of lithographic masks in DUV scatterometry*"

Marcin Janicki (Technical University of Lodz)
"*Modification of Function Specification Algorithm for Real Time Estimation of Source Temperature in Electronic Circuits*"

Mirza Karamehmedovic (Technical University of Denmark)
"*Application of the Method of Auxiliary Sources in Characterisation of Micro and Nano Structures by Optical Diffraction Microscopy*"

Anna Kirpichnikova (University of Edinburgh)
"*Focusing waves in unknown media by modified time reversal interation*"

Thomas Migliore (Universite de Nice Sophia-Antipolis)
"*Transport parameter estimation in hydro-geological media*"

Matthias Schlottbom (AICES Graduate School, RWTH Aachen)
"*Enhanced Numerical Methods for Optical Diffusion Tomography*"

Elena Tabarintseva (South Ural State University)
"*A boundary inverse problem for a nonlinear parabolic equation*"

Dumitru Trucu (University of Leeds)
"*Inverse Perfusion Coefficient Identification in Bio-Heat Transient Flow*"

Thursday, July 23

Cara Brooks (Rose-Hulman Institute of Technology)
"*A posteriori parameter selection for local regularization*"

Uno Haemarik (University of Tartu)
"*Minimization strategy for choice of the regularization parameter in case of roughly given or unknown noise level*"

Andreas Helfrich-Schkarbanenko (University of Karlsruhe)
"*Data Transformation Approach in Electrical Impedance Tomography*"

Alexander Kharytonov (University of Kiel)
"*Regularized Solar Particle Spectra and Error Analysis for Measured Data from SOHO/EPHIN*"

Carmeliza Navasca (Clarkson University)
"*A regularization method for tensor decomposition*"

Marco Prato (University of Modena and Reggio Emilia)
"*Reconstruction of solar flare images using interpolated visibilities*"

Susanne Schmitt (University of Karslruhe)
"*REIT - Regularization Methods for Electrical Impedance Tomography in Medical and Geological Sciences*"

Thierry Scotti (CNRS, Laboratoire de Mecanique et d'Acoustique)
"*The Non-Unicity Problem in Non Linear Parametric Identification*"

Cristiana Sebu (Oxford Brookes University)
"*A regularized solution for the inverse conductivity problem using mollifiers*"

Janne Tamminen (Tampere University of Technology)
"*Reconstructing conductivities with boundary corrected D-bar method*"

Necmi Serkan Tezel (Istanbul Technical University)
"*A Second Order Newton Method for Shape Reconstruction of the Sound-soft Obstacle Buried in a Dielectric Cylinder of Arbitrary Shape*"

Tristan van Leeuwen (Delft University)
"*Non-linear inversion of seismic data*"

Abstracts

Andreas Alpers (Technical University of Denmark)
"*Grain and orientation map reconstruction from x-ray diffraction data*"
Minisymposium Talk on Friday, 17:15-17:45. Room B.

The inverse problem of recovering grain and orientation maps from X-ray diffraction data arises as an imaging problem in materials science. Many materials – such as metals, ceramics and alloys – are composed of crystalline elements, which determine many of the materials physical and mechanical properties. These elements, called *grains*, might all share the same crystal lattice structure, but they typically differ in size, shape and orientation of the lattice. X-rays interacting with the crystal can provide information about these parameters, because diffraction spots appear on a detector if and only if the X-ray beam and crystal orientation correlate in a way stated by Bragg's law. Mathematically, the reconstruction problem can be modeled as a particular vector field tomography problem with one of the vector components restricted to be integer-valued.
In this talk, we will present an algorithm for solving this inverse problem. Recent results are shown that are based on real-data collected at the European Synchrotron Radiation Facility (ESRF).

Habib Ammari (CNRS)
"*The Method of Small-Volume Expansions in Emerging Biomedical Imaging*"
Invited Talk on Friday, 11:30-12:30. Room C1.

Inverse problems in medical imaging are in their most general form ill-posed problems. They literally have no solution. If, however, in advance we have additional structural information or supply missing information, then we may be able to determine specific features about what we wish to image with a satisfactory resolution and accuracy. One such type of knowledge could be that the imaging problem is to find unknown small anomalies with a significantly different parameters from those of the surrounding medium. These anomalies might represent potential tumors at early stage.
Over the last few years, the method of small-volume expansions has been developed for the imaging of such anomalies.
Our aim in this talk is to provide a synthetic exposition of the method of small-volume expansions, a technique that has proven useful in many medical imaging problems. Applications of the method of small-volume expansions in medical imaging will also be described. In particular, its use to improve a multitude of emerging imaging techniques will be highlighted. These imaging modalities include electrical impedance tomography, magnetic resonance elastography, impediography, infrared thermography, photo-acoustic tmography, and acoustic radiation force imaging.

Habib Ammari (CNRS)
"*An optimal Control Approach for Inclusion Reconstruction*"
Minisymposium Talk on Thursday, 16:15-16:45. Room B.

We will consider the problem of recovering an inclusion from boundary measurements. We will propose a new optimization approach to have less filtering of the oscillations, which allows us to determine the optimal inclusion shape with better resolution than by any other standard optimization approach. We will provide an optimal representation of the shape of the inclusion which is quite sparse. Indeed, to handle topology changes such as breaking one component into two we will present a level set version of our algorithm. This is a joint work with P. Garapon, F. Jouve, and H. Kang.

Simon Arridge (University College London)
"*A multi-level type of reconstruction strategy for optical tomography*"
Minisymposium Talk on Monday, 11:00-11:30. Room B.

The objective of optical tomography is to reconstruct the absorption and scattering coefficients of tissues from measurements of optical signals on the surface of the tissues. This reconstruction problem, formulated as the inverse problem of the radiative transport equation with angularly-averaged boundary measurements, is highly ill-posed in the sense that assuming uniqueness holds, the reconstruction is exponentially unstable.
We propose here a multilevel type of iterative reconstruction algorithm for optical tomography. Our method is different from traditional multilevel schemes in at least two aspects. First, we solve the forward and inverse problem on two different set of meshes. Second, the refinement of the mesh for is

determined by the size of the data set and the noise level. Numerical examples with synthetic data will be shown to demonstrate the performance of the method.

Simon Arridge (University College London)
"*Regularisation and Prior Knowledge in Optical Tomography*"
Minisymposium Talk on Tuesday, 15:15-15:45. Room B.

Optical Tomography in highly scattering media is non-linear and severely ill-posed. An increasingly widely used approach for image reconstruction is a parameter estimation method based on optimisation of a likelihood function. These kinds of problems always require regularisation which most generally should be interpreted in terms of Bayesian prior term.
In this talk I will describe different regularisation techniques incorporating structural and statistical information. An emphasis will be placed on cross-con struction with an auxiliary image representing a multimodality approach.

Uri Ascher (University of British Columbia)
"*Faster gradient descent and artificial time integration*"
Minisymposium Talk on Monday, 15:15-15:45. Room D.

The integration to steady state of many initial value ODEs and PDEs using the forward Euler method can alternatively be considered as gradient descent for an associated minimization problem. Greedy algorithms such as steepest descent for determining the step size are as slow to reach steady state as is forward Euler integration with the best uniform step size. But other, much faster methods using bolder step size selection exist. Various alternatives are investigated from both theoretical and practical points of view.
The steepest descent method is also known for the regularizing or smoothing effect that the first few steps have for certain inverse problems, amounting to a finite time regularization. We further investigate the retention of this property using the faster gradient descent variants in the context of two or three applications: denoising and deblurring of images, and shape optimization involving data inversion of elliptic PDEs. When the combination of regularization and accuracy demands more than a dozen or so steepest descent steps, the alternatives offer an advantage, even though (indeed because) the absolute stability limit of forward Euler is carefully yet severely violated.
This is joint work with Kees vand den Doel, Hui Huang and Benar F. Svaiter.

Didier Auroux (Universite Toulouse 3)
"*Back to the future: the back and forth nudging algorithm*"
Minisymposium Talk on Thursday, 16:15-16:45. Room A.

The goal of this paper is to generalize the so-called "nudging" algorithm in order to identify the initial condition of a dynamical system from experimental observations.
The standard nudging algorithm consists in adding to the state equations of a dynamical system a feedback term, which is proportional to the difference between the observation and its equivalent quantity computed by the resolution of the state equations. The model appears then as a weak constraint, and the nudging term forces the state variables to fit as well as possible to the observations.
The back and forth nudging algorithm consists in solving first the forward nudging equation and then a backward equation, where the feedback term which is added to the state equations has an opposite sign to the one introduced in the forward equation. The initial state of this backward resolution is the final state obtained by the standard nudging method. After resolution of this backward equation, one obtains an estimate of the initial state of the system. We iteratively repeat these forward and backward resolutions (with the feedback terms) until convergence of the algorithm.
This algorithm has been compared to the 4D-VAR algorithm, which also consists in a sequence of forward and backward resolutions. In our algorithm, it is useless to linearize the system and the backward system is not the adjoint equation but the model equation, with an extra feedback term that stabilizes the ill-posed backward resolution.
We have proved on a linear model that, provided that the feedback term is large enough as well as the assimilation period, we have convergence of the algorithm to the real initial state. Numerical results have been performed on Burgers, shallow-water and layered quasi-geostrophic models. Twice less iterations than the 4D-VAR are necessary to obtain the same level of convergence.
This algorithm is hence very promising in order to obtain a correct trajectory, with a smaller number of iterations than in a variational method, with a very easy implementation. This work has been done in collaboration with Jacques Blum (University of Nice, France).

Guillaume Bal (Columbia University)
"*Inverse Transport*"
Minisymposium Talk on Tuesday, 15:45-16:15. Room B.

We review recent results in inverse transport theory pertaining to the reconstruction of the optical parameters in a linear transport (linear Boltzmann) equation. We address the stability of the reconstruction for various types of measurements: angularly resolved or angularly averaged measurements, time dependent or time independent measurements. We also present some numerical simulations. This is joint work with Alexandre Jollivet and François Monard.

Peter Balazs (University of Szeged)
"*Neutron tomography with prior information*"
Minisymposium Talk on Friday, 16:15-16:45. Room B.

The reconstruction of 3D binary objects is usually done slice-by-slice, i.e, by integrating together the reconstructions of 2D slices of the object. Such a 2D binary slice can be represented by a 2D binary function $f(x, y)$. The *Radon transformation* $\mathcal{R}f$ of f is then defined by

$$[\mathcal{R}f](s, \vartheta) = \int_{-\infty}^{\infty} f(x, y)du \tag{1}$$

where s and u denote the variables of the coordinate system obtained by a rotation of angle ϑ. Given the functions $g(s, \vartheta_1), \ldots, g(s, \vartheta_n)$ (called projections) the reconstruction task aims to find a function f such that

$$[\mathcal{R}f](s, \vartheta_i) = g(s, \vartheta_i) \quad (i = 1, \ldots, n) \; . \tag{2}$$

In practice, instead of finding the exact function f, we are usually satisfied with a good approximation of it. On the other hand – especially if the number of projections is small – there can be several different functions which (approximately) satisfy (2). Fortunately, with additional knowledge of the image to be reconstructed some of them can be eliminated, which might yield that the reconstructed image will be closer to the original one. For this purpose we rewrite the reconstruction task as an optimization problem where the aim is to find the minimum of the objective functional

$$\Phi(f) = \sum_{i=1}^{n} ||\mathcal{R}f(s, \vartheta_i) - g(s, \vartheta_i)||^2 + \gamma \cdot \Psi(f) \; . \tag{3}$$

The first term in the right hand side of (3) guarantees that the projections of the reconstructed image will be close to the prescribed ones. The second term is for incorporating prior information into the reconstruction. It usually represents structural knowledge (e.g., convexity, connectedness) of the expected image or the similarity between the reconstructed and a model image. Finally, γ is a suitably chosen scaling constant to express whether the projections or the prior information is more reliable.
In this talk we present some methods of discrete tomography developed at our department to solve the problem of (3) with several kinds of prior information. We show a pixel-based and an object-based simulated annealing approach, and variants of an object-based genetic algorithm as well. We also analyze the performance of the presented methods on images arising in neutron tomography.

Jeffrey Bamber (The Institute of Cancer Research)
"*Progress in quantitative elastography for cancer medicine*"
Invited Talk on Monday, 14:00-15:00. Room C1.

Palpation has been used for thousands of years to assess the mechanical properties of tissues, and thus detect and characterise disease or injury. It continues to be of value in modern medicine, but is limited to a few accessible tissues and organs, and the interpretation of the information sensed by the fingers is highly subjective. Ultrasound elastography aims to display images that are related to a broad range of tissue viscoelastic parameters, by processing time-varying echo data to extract the spatial and/or temporal variation of a stress-induced tissue displacement or strain. In recent years the method in early form has emerged as a real-time imaging modality available as an option on several commercial ultrasound systems, and is starting to prove clinically valuable, for example in breast cancer diagnosis. Nevertheless, it remains a strongly subjective technique and continues, as with palpation, to require interpretive skills to be learnt. There are good reasons to believe that a more quantitative and objective analysis will lead to clinically more valuable measures of tissue composition, function or state, with images that are easier to interpret. Insufficient knowledge exists to tackle a full multivariate inverse problem, or to know which variables can be ignored or taken advantage of to simplify the problem. We have therefore begun work to gain a better understanding of how to solve specific elastographic problems, at the same time as studying, experimentally and theoretically, the relative importance of a number of mechanical characteristics in various situations. This presentation reviews some of the early work and describes a selection of recent studies, including the use of Young's modulus images for quantitative imaging of radiation dose distribution in gel dosimeters, the detection of changes in the stiffness of breast tissue due to post-treatment radiation fibrosis, the application of poroelastic theory to describe and understand the spatio-temporal distribution of strain in fluid-containing tissues held under a sustained compression, the detection of lymphoedema using poroelastic techniques, the anisotropic, viscoelastic and nonlinear behaviour of skin, the use of stiffness anisotropy in skin for the monitoring lymphoedema, and the estimation of the amount of adhesion at tissue boundaries for disease assessment. Ongoing work includes developing methods for the 3D measurement of time varying displacement and strain, taking advantage of recent developments in 4D ultrasound imaging technology to potentially greatly improve the quality and completeness of the data available for solving the inverse problem.

Annamaria Barbagallo (Universita di Catania)
"*Variational inequalities, infinite-dimensional duality, inverse problem and applications to oligopolistic market equilibrium problem*"
Minisymposium Talk on Monday, 15:15-15:45. Room Aula.

We consider the dynamic oligopolistic market equilibrium problem, in which the equilibrium conditions are equivalently expressed in terms of an evolutionary variational inequality. For such problem whose constraint set has empty interior, we give existence theorems and apply the infinite dimensional duality theory called "empty interior theory", obtaining the existence of Lagrange variables and their explicit expression. The aim of the talk is also to investigate on the stability and inverse theory by means of the Lagrange multipliers. We remark that the variational inequality formulation plays a fundamental role in order to achieve all the above results. This is joint work with Annamaria Barbagallo.

Joost Batenburg (University of Antwerp)
"*3D reconstruction of nanomaterials by discrete tomography*"
Minisymposium Talk on Friday, 16:45-17:15. Room B.

Electron tomography is a powerful tool for investigating the 3D structure of nanomaterials. A small sample is rotated within an electron microscope, while taking images from a range of angles. From these projection images, a 3D reconstruction of the sample can be computed. Most reconstruction algorithms that are used in practice require a large number of projection images to obtain results of acceptable quality. Even if many projections are available, the reconstruction often contains various artifacts. Among other factors, these artifacts are caused by the limited viewing range available during acquisition.
The field of discrete tomography focuses on the reconstruction of images that contain only a few different grey levels. In the case of electron tomography, these grey levels correspond to the different materials in the sample. By exploiting prior knowledge of the set of admissable grey levels in the reconstruction algorithm, the required number of projection images can be reduced substantially. Until now, the application of discrete tomography to electron microscopy images has been hampered by the lack of efficient and robust reconstruction algorithms. Recently, a new algorithm, called DART, has been proposed that can be used effectively on experimental electron tomography datasets.
This talk will introduce the basic concepts of discrete electron tomography, followed by an overview of the DART algorithm. Reconstruction results for a range of nanomaterials will be shown to demonstrate the potential of this approach.

Larisa Beilina (Chalmers University of Technology and Gothenburg University)
"*A globally convergent numerical method and adaptivity for an inverse problem via Carleman estimates*"
Minisymposium Talk on Monday, 10:30-11:00. Room D.

We will consider a globally convergent numerical method for a multidimensional Coefficient Inverse Problem (MCIP) for a hyperbolic equation.Since this method does not use least squares objective functionals, the phenomenon of local minima is avoided. The most difficult step of the method is the numerical solution of a certain nonlinear integral differential equation. The first step of our procedure consists in the "elimination" of the unknown coefficient from the original PDE via the differentiation with respect to the parameter, from which this coefficient does not depend. This is also the first step of the method of Carleman estimates applied to proofs of uniqueness results for CIPs. In addition, we use Carleman Weight Functions directly in the numerical scheme.
We will show that the method provides a good first guess for the so-called Finite Element Adaptive

method, which entails to a synthesis of both approaches. The adaptivity is based on: (1) a posteriori analysis of the error in the Lagrangian and (2) the solution of the dual problem for the Hessian of the Lagrangian. This analysis enables one to find spots where the maximum error of the solution is, and then to refine the spatial mesh locally with the feedback from a posteriori error estimator.
The first main achievement of the adaptivity is that one does not need to know in advance the solution of a corresponding MCIP for a posteriori error analysis. The second main achievement is that the computation of the dual problem for the Hessian of the Lagrangian leads to a good estimate of the error in the reconstructed coefficient, which is the primary quantity of interest. When the adaptivity is applied to an optimal control problem, it is a locally convergent numerical method. The adaptivity leads to a dramatic enhancement of the image quality. Hence, it is intriguing to use the adaptivity in conjunction with globally convergent algorithms. In this synthesis, the solution obtained by the globally convergent numerical method will serve as a good first guess for the adaptivity for further enhancement. Numerical results for both 2-d and 3-d cases show that the subsequent application of the adaptivity would improve reconstruction results.
This work is collaborative effort with Professor Dr. Michael V. Klibanov Department of Mathematics and Statistics University of North Carolina at Charlotte, Charlotte, NC 28223, USA.

Hend Ben Ameur (University of Tunis)
"*On some geometric inverse problems in elasticity and thermoelasticity*"
Minisymposium Talk on Friday, 14:30-15:00. Room D.

This work is devoted to the mathematical analysis and solution of some geometric inverse problems in linear elasticity and thermoelasticity.
We derive identifiability results and stability estimates for the considered geometric inverse problems, namely the detection of cracks and cavities, and we investigate the regularization and numerical solution of these problems.
We split the three-dimensional linear elastic problem into two different two spatial dimensions problems: A planar strain one and an anti-planar problem, and we consider the static thermoelastic problem. The identification process consists in applying some prescribed load on a part of the boundary and taking some measurements on an other part.
In a rather general setting, we prove unique identifiability of the geometry from a boundary measurement of the displacement in the case of linear elastic problem and from boundary measurement of displacement and temperature in case we consider the thermoelastic problem. Moreover, we derive directional Lipschitz stability estimates for transformed shapes, using shape and material derivatives for the least-squares problems associated to these inverse problems.
By allowing rather general topology of the shape to be reconstructed, we also need geometric regularization strategies independent of parameterizations. For cavity identification, we prove that perimeter penalization is indeed a convergent regularization method in the considered case.
For the numerical solution of these geometric inverse problems we use a reciprocity gap approach for crack identification and the level set approach for cavity identification.

Federico Benvenuto (University of Genova)
"*Iterative methods for constrained and regularized least-square problems*"
Minisymposium Talk on Thursday, 16:45-17:15. Room C2.

It is well-known that the least-squares approach to image deblurring, with the addition of the nonnegativity constraint, leads to an ill-posed problem. Iterative methods for its approximate solution have been proposed; we mention the projected Landweber (PL) method and the iterative image space reconstruction algorithm (ISRA). From numerical practice it follows that these methods exhibit semiconvergence so that early stopping of the iterations provides "regularized" solutions. However they are not frequently used in practice because, in general, they require a large number of iterations before providing a sensible result. Starting from the remark that PLM and ISRA are first-order methods, in the sense that they require only the computation of the gradient of the functional, in this talk we discuss the application of recently developed optimization algorithms that greatly improve their efficiency. In particular, in the case of Landweber, we propose the application of gradient projection (GP) methods with line-search along the feasibility direction. On the other hand, remarking that ISRA is a scaled gradient method, we investigate the application of a recently proposed scaled gradient projection (SGP) method (Bonettini et al., Inverse Problem, 2009). Numerical experiments demonstrate that the accelerated methods still exhibit the semiconvergence property and that SGP is definitely the most efficient one, with a gain of an order of magnitude in the number of iterations and of a factor between 3 and 4 in the computational time. Extension of the algorithms to the minimization of regularized functionals is also discussed in the framework of the so-called split-gradient method (SGM), proposed by Lanteri et al. (Inverse Problem, 2002)

Marta Betcke (University of Manchester)
"*Rebinning methods for new generation cone beam CT*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

In the quest of engineering a real time tomograph, the mechanical motion of the gantry was identified as a main bottle neck in increasing speed of measurements acquisition in state of the art cone beam scanners. Therefore in the new generation of the cone beam systems the mechanically rotating gantry was replaced by a stationary ring of sources, which can by quickly switched on and off by the on board electronics, and multiple stationary rings of detectors. To accommodate the stationary ring of sources in the design, it was necessary to divert from the 4th generation CT geometry. The resulting new geometry requires new different reconstruction algorithms than those devised for the standard cone beam CT. In this contribution we present some generalizations of the family of rebinning methods to the new scanner geometry.

Jutta Bikowski (Colorado State Universtiy)
"*A 3D direct reconstruction algorithm for Electrical Impedance Tomography*"
Minisymposium Talk on Friday, 16:15-16:45. Room D.

Direct reconstruction algorithms for electrical impedance tomography (EIT) solve the full nonlinear problem without iterations. While such algorithms exist in the 2D case, namely, the D-bar algorithm, to date no such method has been implemented for 3D. In this talk we consider a 3D direct method introduced by A. Nachman [*Ann. of Math.*, 128 (1988)] and describe the version of this method that we implemented and applied to spherically symmetric conductivity distributions. The results show that the t^{exp}-approximation to the scattering transform, which worked very well in two dimensions, does not represent an accurate estimate of the actual scattering transform near the origin. This limits the potential for reconstructions, especially since the scattering transform near the origin has a strong influence on the reconstructions of the conductivity distribution. However, we demonstrate that high quality reconstructions can be computed from correct knowledge of the scattering transform near the origin.

George Biros (Georgia Institute of Technology)
"*Variational methods for cardiac motion estimation*"
Invited Talk on Thursday, 14:00-15:00. Room C1.

We will present a new method for the analysis of Magnetic Resonance (MR) cardiac images with the goal of reconstructing the motion (deformation) of the right and left ventricular walls. The reconstructed motion is used to compute key cardiac function indicators like ejection fraction and regional wall thickening.
The method consists of two main components. The first component is an intensity-based elastic image registration algorithm that is accelerated by a non-uniform discretization for the deformation field and a parallel geometric multigrid solver for the first-order optimality conditions of the registration functional. In the second component, given a deformation field, we solve a biophysically-constrained 4D inverse problem to recover the forces in the myocardium. The goal of the second step is twofold: (1) extract features (forces along the myocardial fibers) that effectively summarize the motion of the myocardium; and (2) inform and improve existing biomechanical models of the heart. Our main hypothesis is that by incorporating biophysical information, we can generate more informative priors (models) and eventually reconstruct the ventricular wall motion and the myocardial stresses more accurately.
We will discuss the formulation of the problem, the algorithmic and parallel scalability of the numerical algorithms, and present validation results on image datasets from subjects with normal and abnormal cardiac function.
This is a joint work with Christos Davatzikos (University of Pennsylvania), Harold Litt (University of Pennsylvania), Rahul Sampath (Georgia Tech), and Hari Sundar (Siemens).

Laurent Bourgeois (ENSTA)
"*Uniqueness and stability for identification of generalized impedance boundary conditions*"
Minisymposium Talk on Thursday, 10:30-11:00. Room B.

In the context of acoustics in the harmonic regime, we consider the problem of identification of some Generalized Impedance Boundary Conditions (GIBC) at the boundary of an object (which is supposed

to be known) from far field measurements associated with a single incident plane wave at a fixed frequency. The GIBCs are approximate models for thin coatings or corrugated surfaces. After pointing out that uniqueness does not hold in general, we propose some additional assumptions for which uniqueness can be restored. We also consider the question of stability when uniqueness holds. We prove in particular Lipschitz stability when the impedance parameters belong to a compact set.
This is a joint work with Houssem Haddar (INRIA/Ecole Polytechnique).

Kristian Bredies (University of Graz)
"*A forward-backward splitting method in Banach space for the minimization of Tikhonov functionals*"
Minisymposium Talk on Friday, 17:15-17:45. Room C1.

With the emerging study of inverse problems with non-smooth regularization like sparsity constraints or total-variation, for example, there was also growing interest for algorithms computing the minimizers of non-smooth Tikhonov functionals numerically. While many efficient algorithms have been proposed in Hilbert space, only a few methods are available in the Banach space setting, usually basing on subgradient descent and the connection of the space with its dual by the respective duality mappings.
In this presentation, a new algorithm is proposed which can be interpreted as the generalization of a forward-backward splitting algorithm to Banach spaces. It splits the functional into a smooth and non-smooth part, respectively, and uses only the gradient information of the smooth part while performing an implicit step for the non-smooth part. This general approach is applied to Tikhonov functionals for which the regularization consists of the power of a suitable semi-norm. Under smoothness and convexity assumptions on the underlying spaces, convergence to the minimizer with rate $\mathcal{O}(n^{-\alpha})$ is established. Furthermore, some particular applications are addressed. On the one hand, we discuss the ℓ^1-regularization which corresponds to convex sparsity constraints. It turns out that the forward-backward splitting amounts to an iterative thresholding-like algorithm which generalizes the well-known iterative soft-thresholding procedure to Banach spaces. Finally, we discuss the application to a total-variation deblurring problem in three dimensions for which the usual L^2-setting cannot be employed.

Claude Brezinski (Universite Lille1)
"*Estimation of the best parameter in Tikhonov regularization method*"
Minisymposium Talk on Thursday, 10:30-11:00. Room C1.

An important problem in numerical linear algebra is to obtain estimations of the norm of the error. These estimates are used in direct methods for checking the quality of the solution obtained, as well as in iterative ones for stopping the process.
An extrapolation method for obtaining such estimates will be presented. It is based on the SVD of the matrix of the system, but it does not require the knowledge of the singular values. The estimates are cheap and easy to implement. Properties and inequalities they satisfied will be given. Numerical examples will be exhibited.
An application of the estimates to the choice of the optimal parameter in Tikhonov's regularization method for ill-conditioned systems of linear equations will be discussed. Several numerical experiments, and comparisons with other procedures will illustrate the effectiveness of the procedure.
This work was done in collaboration with G. Rodriguez and S. Seatzu.

Sarah Bridle (University College London)
"*The GREAT08 and GREAT09 Challenges - an inverse probelm in cosmology*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

The GRavitational lEnsing Accuracy Testing 2008 (GREAT08) Challenge focuses on a problem that is of crucial importance for fu- ture observations in cosmology. The shapes of distant galaxies can be used to determine the properties of dark energy and the nature of gravity, because light from those galaxies is bent by gravity from the intervening dark matter. The observed galaxy images appear dis- torted, although only slightly, and their shapes must be precisely disentangled from the effects of pixelisation, convolution and noise. The worldwide gravitational lensing community has made significant progress in techniques to measure these distortions via the Shear TEsting Program (STEP). Via STEP, we have run challenges within our own community, and come to recognise that this particular image analysis problem is ideally matched to experts in statistical inference, inverse problems and computational learning. Thus, in order to continue the progress seen in recent years, we are seeking an infusion of new ideas from these communities. The GREAT08 Challenge deadline is 30th April 2009, and we are currently preparing a follow-up containing a more difficult simulation set: the GREAT09 Challenge.

Cara Brooks (Rose-Hulman Institute of Technology)
"*A posteriori parameter selection for local regularization*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

The development of local regularization methods stemmed from the theoretical justification of a generalization by P. K. Lamm in 1995 of the practical method due to J. V. Beck for solving the discretized inverse heat conduction problem. Since then the convergence theory associated with a priori parameter selection has evolved to include finitely smoothing linear Volterra problems, nonlinear Hammerstein and autoconvolution problems, as well as linear non-Volterra integral equations such as those arising in image processing.
In recent years, we advanced the development of this theory through the construction of an a posteriori parameter selection principle for local regularization which is theoretically justified and suitable for L^p data as well as for data smoothed in some way. We will present these results, give rates of convergence under suitable source conditions, and illustrate effectiveness of the principle with some numerical examples.

Christoph Brune (University of Muenster)
"*Bregman-EM-TV Methods for Deconvolution Problems with Poisson Noise*"
Minisymposium Talk on Thursday, 15:45-16:15. Room C2.

Measurements in astronomy and nanoscopic imaging suffer from blurring effects concerning different point spread functions (PSF). Some apparatus even have PSFs that are locally dependent on phase shifts. In addition, raw data are affected by Poisson noise, e.g. in fluorescence microscopy resulting from laser sampling and "photon counts". In these applications standard reconstruction methods (EM, filtered backprojection) on their own deliver unsatisfactory and noisy results, mainly due to ill-posedness and lack of regularization.
This talk will address the development of fast and accurate EM-TV-based deconvolution algorithms. Starting from a statistical modeling in terms of a MAP likelihood estimation, we simultaneously combine the iterative EM algorithm with TV regularization techniques. Our nested iteration strategy preserves positivity of the iterates and automatically weights the regularization parameter during the reconstruction process regarding the previous iterate. Regularization steps, more precisely, weighted Rudin-Osher-Fatemi problems with "exact" TV are realized efficiently by dual and parallel primal-dual strategies. Additionally, we investigate anisotropy concepts incorporating a-priori knowledge about the object geometry. We present analytical results concerning well-posedness and convergence of the algorithm. By relating the proposed EM-TV method with forward-backward splitting algorithms we can apply reasonable damping strategies. The latter can be necessary to guarantee a monotone descent of the functional. Typically, TV-based methods deliver reconstructed cartoon-images suffering from contrast reduction. Here, we propose an extension to EM-TV, based on Bregman iterations and inverse scale space methods, in order to attain improved imaging results by simultaneous contrast enhancement. We illustrate the performance of our techniques by synthetic and experimental biological data. This is joint work with A. Sawatzky and M. Burger (University of Münster).

Hui Cao (Johann Radon Institute)
"*A Carleman estimate and the balancing principle in the quasi-reversibility method for solving the Cauchy problem for Laplace equation*"
Minisymposium Talk on Monday, 11:00-11:30. Room D.

The quasi-reversibility method to solve the Cauchy problem for the Laplace's equation in a bounded domain Ω is considered. With the help of the Carleman estimations technique improved error and stability bounds in a subdomain $\Omega_\sigma \subset \Omega$ are obtained. This paves a way for the use of the balancing principle for *a posteriori* choice of the regularization parameter ε in the quasi-reversibility method. As an adaptive regularization parameter choice strategy, the balancing principle does not require *a priori* knowledge of either the solution smoothness or a constant K appearing in the stability bound estimation. Nevertheless, this principle allows an *a posteriori* parameter choice that up to controllable constant achieves the best accuracy guaranteed by the Carleman estimate.

Yves Capdeboscq (Oxford University)
"*Enhanced Resolution in Structured Media*"
Minisymposium Talk on Monday, 15:15-15:45. Room A.

In this talk, we show that it is possible to achieve a resolution enhancement in detecting a target inclusion if it is surrounded by an appropriate structured medium. This work is motivated by the advances in physics concerning super resolution, or resolution beyond the diffraction limit. We first revisit the notion of resolution and focal spot, and then show that in a structured medium, the resolution is conditioned by effective parameters. This is a joint work with Habib Ammari and Eric Bonnetier.

Andrea Caponnetto (City University of Hong Kong)
"*Regularization by operator-valued kernels in Learning Theory*"
Minisymposium Talk on Tuesday, 11:00-11:30. Room D.

We discuss the properties of a large class of learning algorithms defined in terms of classical regularization operators for ill-posed problems. This class includes regularized least-squares, Landweber method and truncated singular value decomposition over hypothesis spaces defined as reproducing kernel Hilbert spaces of vector-valued functions. Universal consistency and statistical adaptation of the methods will be considered.

Scott Carney (University of Illinois)
"*Interferometric Synthetic Aperture Microscopy*"
Minisymposium Talk on Tuesday, 16:15-16:45. Room B.

Methods of computed imaging have historically provided new levels of insight and utility when coupled with established instrumentation. Examples include the growth of X-ray projections into modern computed tomography (CT), nuclear magnetic resonance spectroscopy into magnetic resonance imaging (MRI), and radar ranging into synthetic aperture radar imaging (SAR). Over the last 18 years, optical coherence tomography (OCT) has provided an alternative to physical sectioning and histology that allows for imaging of living samples and even in vivo examination of cell structure and dynamics. Applications range from monitoring the development of engineered tissues to the diagnosis of malignancies. The sectional imaging of OCT is achieved by direct visualization of raw data obtained in focused optical range finding. As a result, there is, in the OCT community, a widely held belief that there exists a trade-off between transverse resolution and the thickness of the volume that may be imaged with a fixed focal plane. The extreme manifestation of this effect may be seen in optical coherence microscopy (OCM) where a single plane is imaged using a highly focused beam to achieve micron scale resolution, but no sectioning is possible because of the defocus away from this plane.
In this talk I will show that solution of the inverse scattering problem leads to algorithms that provide a three-dimensional reconstruction of the object with a spatially invariant point-spread function for the system. The spatial resolution is everywhere equal to the best resolution in the raw data (in the focal plane). Thus the supposed trade-off between resolution and depth of imaging is eliminated. The resultant reconstructions show a marked qualitative improvement in all regions and moreover are quantitatively meaningful. This new modality is formally related to SAR and we refer to it as interferometric synthetic aperture microscopy (ISAM). I will present the theoretical analysis, numerical simulations and experimental results for samples including a tadpole, a human tumor, and a titanium dioxide particle suspension This work was done in collaboration with the Boppart group at the University of Illinois.

Slim Chaabane (Ecole Nationale d'Ingenier de Tunis)
"*Optimal logarithmic estimates in Hardy-Sobolev spaces $\mathcal{H}^{k,\infty}$: Applications to inverse problems*"
Minisymposium Talk on Thursday, 11:00-11:30. Room B.

We prove sharp logarithmic estimates of optimal type in the Hardy-Sobolev spaces $\mathcal{H}^{k,\infty}$ for any $k \in N^*$, extending then earlier cases [1,2]. These estimations are used in particular, to establish an optimal logarithmic stability result for the inverse problem of the identification of Robin's coefficient by boundary measurements.

1. L. Barachart and M. Zerner On the recovery of functions from pointwise boundary values in a Hardy-Sobolev class of the disk, J. Comput. Apll. Math **46** 255-69, (1993).

2. S. Chaabane, I. Fellah, M. Jaoua, J. Leblond Logarithmic stability estimates for a Robin coefficient in 2D Laplace inverse problems, Inverse Problems,no. 20(2004), 1425-1438.

Raymond Chan (The Chinese University of Hong Kong)
"*Missing Data Recovery by Tight-frame Algorithms with Flexible Wavelet Shrinkage*"
Minisymposium Talk on Tuesday, 10:30-11:00. Room Aula.

The recovery of missing data from incomplete data is an essential part of any image processing procedures whether the final image is utilized for visual interpretation or for automatic analysis. In this talk, we first introduce our tightframe-based iterative algorithm for missing data recovery. By borrowing ideas from anisotropic regularization and diffusion, we can further improve the algorithm to handle edges better. The algorithm falls within the framework of forward-backward splitting methods in convex analysis and its convergence can hence be established. We illustrate its effectiveness in few main applications in image processing: inpainting, impulse noise removal, super-resolution image reconstruction, and video enhancement.

Raymond Chan (The Chinese University of Hong Kong)
"*Unified Tight Frame Approach for Missing Data Recovery in Images*"
Minisymposium Talk on Thursday, 15:15-15:45. Room Aula.

In many practical problems in image processing, the observed data sets are often incomplete in the sense that features of interest in the image are missing partially or corrupted by noise. The recovery of missing data from incomplete data is an essential part of any image processing procedures whether the final image is utilized for visual interpretation or for automatic analysis. In this talk, we discuss our iterative algorithm for image recovery for missing data which is based on tight framelets, and its convergence. We consider in particular few main applications in image processing, inpainting, impulse noise removal, super-resolution image reconstruction, and video enhancement.

Xudong Chen (National University of Singapore)
"*Novel Inversion Technique for Diffuse Optical Tomography*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

The Diffusion Equation, used in most Diffuse Optical Tomography reconstruction algorithms, can be analytically modeled as a linear system under the Born or Rytov approximation. The problem of imaging biological tissue is often a severely ill-posed problem due to the finite number of linearly independent measurements, noise, and often complicated structure of the heterogeneities in the tissue. Here, we present a new multistage inversion technique that improves the quality of imaging.
The algorithm consists of three steps as below:

1. Reduction of the domain using signal subspace technique: Considering the linear model as a transformation between the currents on the photon density sources and the measured scattered photon densities on the detectors, it can be said that the vectors containing the measured photon densities corresponding to each source lie in the span of the Green functions vectors corresponding to the radiation from the sources induced at the heterogeneous voxels. We then find and reject the voxels whose Green functions vectors are not in the range of the transformation matrix (meaning that they definitely do not contribute to the measured photon densities).

2. Traditional Inversion: Here, considering the map between the differential absorption coefficient (with reference to the homogeneous background absorption coefficient) at the voxels not rejected in step 1 and the complete set of measurements, we perform the traditional truncated SVD based pseudoinverse to obtain an estimate of the differential absorption coefficient at the voxels not rejected.

3. Rejection of the voxels based on the estimate from stage 2: Since the truncated SVD based pseudoinverse provides the minimum norm solution out of the infinite physically possible solutions, it assigns a negative value at the homogeneous voxels (zero differential absorption coefficient) and a positive but lesser than actual value at the heterogeneous voxels. Based on this fact, we exclude the voxels for which the assigned value is negative and repeat the steps 2 and 3 iteratively till all the voxels used in inversion have positive retrieved values.

In essence, instead of solving the inverse problem for the entire region, we have reduced the number of unknowns in the stage 1 and then iteratively in the stage 3. This has given us two advantages: 1) reduction in the computational intensity of the problem; 2) reduction in the ill-posedness of the overall inversion problem. The concept used in stage 3 enables the imaging of complicated geometries, such as an annulus, which are conventionally difficult to image with the demonstrated precision.

Jin Cheng (Fudan University)
"*The Mathematical Analysis of the Diffusion Process and its Applications.*"
Invited Talk on Friday, 10:30-11:30. Room C1.

In this talk, we will present some results about the diffusion process and related application. It is shown that the mathematical results are useful for contructing the stable numerical algorithms and give more information for the engineers.

Jin Cheng (Fudan University)
"*Heat transfer in composite materials and related inverse problems*"
Minisymposium Talk on Tuesday, 15:15-15:45. Room A.

Now it is well known that anomalous diffusion occurs in nature, and the fractional derivative is quite a useful tool to describe these phenomenons for its non-local property. In this talk, a new time-fractional diffusion equation is considered whose order varies with space compared to those sim- ple traditional time-fractional equations. This new model can be used to characterize the abnormal diffusion process in more complex and inhomogeneous media. A finite difference scheme was proposed to solve the 1-D forward problem. And in practice we not only want to predict the diffusion in the regions which are already known, but also expect to understand the property of the media in those unknown regions, so we use an optimal method to do the parameter estimation in the light of model analysis.

Julianne Chung (Emory University)
"*Algorithms for Polyenergetic Breast Tomosynthesis Image Reconstruction*"
Minisymposium Talk on Friday, 14:00-14:30. Room Aula.

Digital tomosynthesis imaging is becoming increasingly significant in a variety of medical imaging applications. Tomosynthesis imaging involves the acquisition of a series of projection images over a limited angular range, and reconstruction results in a pseudo-3D representation of the imaged object. The partial separation of features in the third dimension improves the visibility of lesions of interest by reducing the effect of the superimposition of tissues. In breast cancer imaging, tomosynthesis is a viable alternative to standard mammography; however, current algorithms for image reconstruction do not take into account the polyenergetic nature of the x-ray source beam entering the object. This results in inaccuracies in the reconstruction, making quantitative analysis challenging and allowing for beam hardening artifacts. We develop a mathematical framework based on a polyenergetic model and develop statistically based iterative methods for polyenergetic tomosynthesis reconstruction for breast imaging.

Christian Clason (University of Graz)
"*Inverse problems with L^1 data fitting*"
Minisymposium Talk on Friday, 17:45-18:15. Room C1.

To be announced.

David Colton (University of Delaware)
"*Faber-Krahn Type Inequalities in Inverse Scattering Theory*"
Invited Talk on Thursday, 09:00-10:00. Room C1.

We first consider the scattering of time harmonic plane waves by a perfectly conducting infinite cylinder of cross section D. We observe that the Dirichlet eigenvalues for the Laplacian in D can be determined from the far field pattern of the scattered wave and hence from the Faber-Krahn inequality we can obtain a lower bound for the area of D. We then consider the corresponding problem for a dielectric cylinder. Here we observe that a relatively new type of spectra called transmission eigenvalues can be determined from the far field pattern of the scattered wave and show that transmission eigenvalues exist and form a discrete set. We then obtain a Faber-Krahn type inequality for transmission eigenvalues which,if D is known, provide a lower bound on the index of refraction n(x). Of special interest is the case when cavities may be present,i.e. regions where n(x)=1.We consider both isotropic and anisotropic materials.

Anna Cysewska-Sobusiak (Poznan University of Technology)
"*Inverse problems in modeling and simulation of light transmission through tissue sets*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

Transillumination is understood as the phenomenon of transmitting optical radiation with defined parameters by an object, which becomes the carrier of information on the characteristic size of the object. In case of biological objects the optical properties of systemic liquids and other tissues are utilized. The answer of a transilluminated object is known, but the cause can be unknown. The inverse problem is complex because more than one tissue composition may share the same resultant intensity transmittance. The complicated object to be transilluminated may be virtually "reproduced" with the designed model based on the "sandwich" structure. This representation is performed with the division of a given object by virtual planes placed perpendicularly to transillumination direction. The structure of a specialized algorithm, which has been proposed, makes possible creating a lot of free variants of reference standards, including changes in a number of layers and their biophysical compositions. During simulations the software built with LabVIEW environment was used. Simulation of different changes in finger tissue composition allows predicting output results of occurring interactions. Experimental verification of the model structure was made with spectrophotometry. The implemented model could be used in estimating the content and thickness of particular layers distinguished in a complex object and prediction of their transillumination efficiency. One of important purposes of presented simulation is evaluating the thickness of tissue at which discontinuity has to appear in the intensity transmittance versus this thickness. The point of transmittance discontinuity indicates a change in optical properties of a calculated layer, determining the intervals where a given transilluminated component of a tissue slab may be treated as optically thin or thick. The presented results may be useful in computer-aided generation of reference data for evaluation of light-tissue spatial transillumination. The long-terms plans of studies are connected with the expected possibility to identify several changes in features of biological objects exposed to selective transmission in the range of wavelength including visible and near infrared radiation.

Christine De Mol (Universite Libre de Bruxelles)
"*Iterative Algorithms for Sparse Recovery*"
Minisymposium Talk on Tuesday, 16:15-16:45. Room C2.

We consider the problem of recovering a sparse object from linear measurements in the framework of both compressed sensing and inverse problems. The most common approach is to reduce the problem to a convex optimization one, involving a penalty or constraint on the ℓ_1 norm of the sequence of coefficients describing the object. We review several iterative and non-iterative algorithms which have been proposed for computing the optimal solution. Some of them, like iterative soft-thresholding, exhibit slow convergence and a lot of recent literature has been dedicated to devise accelerated schemes. We propose a new gradient projection algorithm which compares favorably with the fastest of these algorithms. The method exploits a line-search along the feasible direction and an adaptive steplength selection based on recent strategies for the alternation of the well-known Barzilai-Borwein rules. The performances of this algorithm are carefully compared with those of other iterative methods such as ISTA, FISTA, GPRS and Projected Steepest Descent.
This is joint work with M. Bertero, I. Loris, R. Zanella and L. Zanni.

Fabrice Delbary (Goettingen University)
"*Complete electrode model for the inverse impedance tomography : a reconstruction based on polygonal curves*"
Minisymposium Talk on Friday, 14:00-14:30. Room B.

Impedance tomography used in many domains such as geophysics or medicine arise nonlinear and ill-posed inverse problems.
We can distinguish two main families of methods for solving these inverses problems : Newton-like methods, or iterative methods, and sampling methods. Newton-like methods, often quantitative, usually allow reconstruction with good accuracies but can be quite slow. In contrary, sampling methods can be extremely fast but are often only qualitative, they can be used, in particular, to give initial guesses for iterative methods.
Dr. Eckel and Pr. Dr. Kreß studied the inverse impedance tomography problem using nonlinear integral equations and iteration schemes. In a first work, over-determined data on the boundary of the domain with inclusions, were used in an iterative scheme for solving the inverse problem ; the second work, more realistic, extended the first approach imposing some voltages on electrodes laying on the boundary and measuring currents (or vice versa). An iterative scheme, including the trace and the normal derivative of the solution of the forward problem as unknowns, is used. For both works, unknown inclusions in the domain are approximated by trigonometric polynomial curves, which allow to treat the involved integral equations with a good accuracy.
The method we propose here is an extension of the complete electrodes model developed by Dr. Eckel and Pr. Dr. Kreß, using polygonal curves for the reconstructions, so that we can expect better treatment of

complex geometries. Moreover, polygonal domains and inclusions are often involved in engineering since problems often involve polygonal meshes (or polyhedral meshes for $3D$ problems). Nevertheless, we can expect a loss of precision for the reconstruction of regular inclusions using this kind of approximation.

Marco Donatelli (Universita' dell'Insubria)
"*Image deblurring with antireflective boundary conditions*"
Minisymposium Talk on Tuesday, 11:00-11:30. Room Aula.

We study the imposition of antireflective boundary conditions to image deblurring problems. Antireflective boundary conditions preserve continuity of the image and its (normal) derivative at the boundary. We show that antireflective boundary conditions combined with a reblurring strategy produce superior reconstructions compared to other commonly used boundary conditions, such as periodic, zero and reflective.
We investigate the structure of the blurring matrix in the case of antireflective boundary condition and a quadrantically symmetric (symmetric with respect to each direction) point spread function. In particular, we analyze the eigenvector/eigenvalue structure of such matrix introducing a new antireflective transform. We study both the computational and stability properties of the antireflective transform. The new antireflective algebra of matrices is discussed and combined with the reblurring approach to computing filtered solutions with a Tikhonov-like method. A proof of the regularizing property of such method is given. Numerical tests illustrate the performance of the proposed approach.

Oliver Dorn (University of Manchester)
"*Reconstructing thin shapes by a level set technique.*"
Minisymposium Talk on Monday, 10:30-11:00. Room Aula.

We present a level set based technique to recover key characteristics of a defect or crack (e.g. location, length, and shape) in a two-dimensional material from boundary electrical measurements. The key feature of this work is to extend the usual level set technique for modeling volumetric objects to very thin objects. Two level set functions are employed: the first one models the location and form of the crack, and the second one models its length and connectivity. An efficient gradient based method is derived in order to define evolution laws for these two level set functions aiming at minimizing the least squares data misfit. A finite element method is used to simulate the electric fields in the presence of very thin objects. Numerical experiments demonstrate the performance of this method for simulated but realistic data including a significant noise level.
This is joint work with Diego Álvarez, Miguel Moscoso, and Natalia Irishina (Gregorio Millán Institute, Universidad Carlos III de Madrid, Spain).

Herbert Egger (RWTH Aachen University)
"*On the preconditioning of regularization methods*"
Minisymposium Talk on Thursday, 15:15-15:45. Room C1.

As a model problem, we consider an inverse problem governed by a partial differential equation, which is ill-posed in the sense of Hadamard. After a short analysis of the model problem, we turn to iterative regularization strategies for its stable solution, and we show that the solution process can be accelerated considerably by appropriate preconditioning. Apart from the speed-up in computation time, we also investigate the effect of the preconditioners on the regularizing properties of the iterative algorithms.

Herbert Egger (RWTH Aachen University)
"*Efficient inversion in electrical capacitance tomography*"
Minisymposium Talk on Thursday, 16:45-17:15. Room B.

Electrical Capacitance Tomography (ECT) tries to reconstruct cross-section images of industrial processes, such as multiphase flows or flame combustion, from fast capacitance measurements, which require no contact with the probe.
Mathematically, ECT amounts to a nonlinear inverse problem governed by partial differential equations, i.e., the reconstruction of unkown parameters from measurements of (part of) the Dirichlet-to-Neumann map.
We consider here the efficient numerical implementation of inversion algorithms for the nonlinear inverse problem. In particular, we compare the performance and reconstruction qualities of iterative methods, i.e., linear back-projection and Newton-type methods, to a sampling method based on an adjoint formulation of the factorization method.

Part of the work is joint with M. Hanke and J. Schöberl.

Herbert Egger (RWTH Aachen University)
"*Nonlinear Reconstruction Methods for Magnetic Induction Tomography*"
Minisymposium Talk on Friday, 15:30-16:00. Room A.

Magnetic induction tomography (MIT) is a non-invasive imaging technique with applications in medical imaging and non-destructive testing. Apart from the design of appropriate measurement setups, also the reconstruction of the images is challenging, since the inverse problem of MIT is nonlinear and severely ill-posed, and already the forward simulation of the electromagnetic fields is computationally intensive. In order to cope with the ill-posedness, we propose the use of nonlinear regularization methods that allow to incorporate a-priori knowledge into the solution algorithms. We further compare various simplifications for the electromagnetic forward problems, and discuss their efficient numerical implementation. Finally, we address details of the implementation of algorithms for the solution of the inverse problem, including iterative methods and automated parameter choice strategies.

Paul Eggermont (University of Delaware)
"*Conjugate gradients for linear ill-posed problems with weakly bounded noise*"
Minisymposium Talk on Monday, 15:45-16:15. Room Aula.

We study conjugate gradient methods (minimum residual and minimum error) for the approximate solution of linear ill-posed problems in Hilbert space. In contrast with the classical setting of strongly bounded noise, the novel feature is that we consider weakly bounded noise, which is meant to (also) model random noise in a semi-classical approach.

A. Gordon Emslie (Oklahoma State University)
"*Probing Electron Acceleration in Solar Flares through Hard X-ray Imaging Spectroscopy: A Two-Stage Inverse Problem*"
Minisymposium Talk on Monday, 15:15-15:45. Room C2.

Solar flares accelerate enormous numbers of electrons, which, through their collisional interaction with the solar atmosphere, are responsible for many of the observed flare phenomena. Knowledge of the spectral, spatial and temporal behavior of the accelerated electrons is key to understanding the processes responsible for their acceleration, processes that may well have application to particle acceleration at other sites throughout the universe.
The most direct diagnostic of the accelerated electrons is the hard X-ray bremsstrahlung radiation produced when they scatter off ambient ions in the solar atmosphere. Because the bremsstrahlung process is well-understood and because the emitted radiation is optically thin, the characteristics of the accelerated electron population can, at least in principle, be obtained through an analysis of the spectral, spatial, and temporal properties of the emitted hard X-ray radiation. Such remote sensing analysis is intrinsically an inverse problem involving *two* inversions, one spatial and one spectral, at each instant in the event.
Since the use of focusing optics in the hard X-ray domain has yet to be successfully demonstrated, the most comprehensive imaging spectroscopy information on the hard X-ray emission in flares has come from instrumentation that encodes spatial information through the use of occulting grids or masks, including the Rotating Modulation Collimator design used on the *RHESSI* instrument. For such instrumentation, spatial information is encoded in temporal variations of the detected flux; such a data stream provides not so much a pixel-by-pixel image of the flare, but rather information on spatial Fourier components of the emission, termed *visibilities*. Subsequent papers in this session will provide some of the more technical details of the methodology through which visibility-based hard X-ray imaging spectroscopy data is used to obtain maps of the electron flux distribution in the flare volume. Here I shall review some of the more interesting properties of such maps and their implications for models of particle acceleration in flares.

Sarah Engleder (Graz University of Technology)
"*Magnetic Induction Tomography: Mathematical Model and Boundary Element Methods*"
Minisymposium Talk on Friday, 14:00-14:30. Room A.

Magnetic Induction Tomography is a contactless imaging modality, which aims to obtain the conductivity distribution of the human body. The method is based on exciting the body by magnetic induction using an array of transmitting coils to induce eddy currents. A change of the conductivity distribution in the body results in a perturbed magnetic field, which can be measured as a voltage change in the receiving coils. Based on these measurements, the conductivity distribution can be reconstructed by solving an

inverse problem.
In this talk two models for the corresponding forward problem are presentend. The full model uses the eddy current model, the reduced model reduces the eddy current model to a boundary value problem for the Laplace equation and an evaluation of a Newton potential. Boundary element formulations for both models are discussed and some numerical examples are presented.

Fariba Fahroo (Air Force Office of Scientific Research)
"*Utilizing Natural Observer for the Adaptive Estimation of Second Order Bilinear Infinite Dimensional Systems*"
Minisymposium Talk on Thursday, 10:30-11:00. Room Aula.

In this joint work with Dr. Michael Demetriou at Worcester Polytechnic Institute, We consider adaptive observers for the on-line estimation of parameters for a class of 2nd order bilinear infinite dimensional systems. Unlike earlier approaches on adaptive observers for parameter estimation, wherein the standard approach was to place the system in a first order formulation and then design the observer, we consider here a natural observer. A natural observer retains the second order structure of the system, thereby preserving the physical interpretation of the observer states, namely that the derivative of the estimated position term is indeed the estimated velocity, something that standard first order observers cannot provide. Using the assumption of collocated input and output, a Lyapunov-based scheme is proposed for the estimation of the parameters. Under standard assumptions, the convergence of the parameter estimates to the true values is shown.

Adel Faridani (Oregon State University)
"*Analysis of PI-line based algorithms in fan-beam tomography*"
Minisymposium Talk on Tuesday, 15:15-15:45. Room D.

We analyze reconstruction algorithms for fan-beam tomography that are based on a 2D version of Katsevich's inversion formula for helical tomography and utilize the concept of PI-lines. The algorithms share the simplicity of the standard filtered backprojection algorithm but do not require the so-called 'homogeneous approximation'. As a result these algorithms are preferable in some situations, for example in case of a relatively small source radius. Both theoretical and numerical results will be presented. This is joint work with Ryan Hass.

Sergey Fomel (The University of Texas at Austin)
"*Shaping regularization*"
Minisymposium Talk on Friday, 17:45-18:15. Room A.

Shaping regularization is a general method for imposing constraints on the estimated model in the process of solving an inverse problem. In the case of linear problems, shaping regularization can be integrated into a conjugate-gradient algorithm for iterative least-squares estimation. It provides the advantage of a better control on the estimated model in comparison with traditional regularization methods and, in some cases, leads to a faster iterative convergence. In the case of nonlinear problems, shaping regularization is simply connected to the nonlinear Landweber iteration and related inversion methods.
The general mathematical form of shaping regularization is

$$\widehat{\mathbf{m}} = \left[\mathbf{I} + \mathbf{S}\,(\mathbf{B}\,\mathbf{F} - \mathbf{I})\right]^{-1}\,\mathbf{S}\,\mathbf{B}[\mathbf{d}]\;, \tag{4}$$

where $\widehat{\mathbf{m}}$ is the model estimate, $\mathbf{d}$, $\mathbf{F}$ is the forward operator that relates the model $\mathbf{m}$ to the data, $\mathbf{B}$ is a backward operator that provides an inverse mapping, and $\mathbf{S}$ is a shaping operator that maps the estimated model into the space of admissible models.
In this paper, I describe the general framework for shaping regularization and illustrate it with a number of examples from applied geophysics. The most important practical example is the seismic velocity estimation problem, where different regularization strategies can produce either smooth or blocky models.

Massimo Fornasier (Johann Radon Institute)
"*Inverse free-discontinuity problems and iterative thresholding algorithms*"
Minisymposium Talk on Tuesday, 11:00-11:30. Room C1.

Free-discontinuity problems describe situations where the solution of interest is defined by a function and a lower dimensional set consisting of the discontinuities of the function. Hence, the derivative of the solution is assumed to be a "small" function almost everywhere except on sets where it concentrates as a singular measure. This is the case, for instance, in crack detection from fracture mechanics or in certain digital image segmentation problems. If we discretize such situations for numerical purposes, the free-discontinuity problem in the discrete setting can be re-formulated as that of finding a derivative vector with small components at all but a few entries that exceed a certain threshold. This problem is similar to those encountered in the field of "sparse recovery", where vectors with a small number of dominating components in absolute value are recovered from a few given linear measurements via the minimization of related energy functionals. Several iterative thresholding algorithms that intertwine gradient-type iterations with thresholding steps have been designed to recover sparse solutions in this setting. It is natural to wonder if and/or how such algorithms can be used towards solving discrete free-discontinuity problems. This talk explores this connection, and, by establishing an iterative thresholding algorithm for discrete free-discontinuity problems, provides new insights on properties of minimizing solutions thereof. We also discuss the existence of minimizers for free-discontinuity inverse problems, by restricting the solutions to a class of functions which we called the Rondi's class. This is partially a joint work with Riccardo March (CNR, Italy) and Rachel Ward (PACM, Princeton University, USA).

Massimo Fornasier (Johann Radon Institute)
"*Multilevel preconditioning in inverse problems with sparsity constraints*"
Minisymposium Talk on Tuesday, 16:45-17:15. Room C2.

Gradient iterations intertwined with thresholding operations, i.e., iterative thresholding algorithms, have been recently investigated for addressing inverse problems whose solutions are characterized by a few significant degrees of freedom. Unfortunately these algorithms may perform arbitrarily bad when applied for the inversion of compact operators. Indeed for such operators the (infinite) matrix representation with respect to a "good basis", in the sense that it at least quasi-diagonalizes the operator, turns out to be diagonal dominant with fast decaying diagonal entries. The rate of convergence of such algorithms is related to the "local conditioning" of such a matrix, i.e., how well-conditioned is any relatively small group of columns. This is the case, for instance, when we deal with potential operators, such as in magnetic tomography, and matrix representations with respect to multiscale bases or wavelets. In this talk we discuss how to precondition these problems in order to obtain a uniform condition number of the resulting matrices over any small group of columns. In particular, we will show how block-diagonal preconditioning will produce infinite matrices with a *Restricted Isometry Property* (RIP), as the one introduced for finite dimensional situations in compressed sensing problems. We will use this property in order to show how adaptive numerical iterations can be performed guaranteeing a controlled *linear convergence* of these algorithms. This is a joint work with Stephan Dahlke and Thorsten Raasch.

Elisa Francini (Universita' di Firenze)
"*Determination of elastic inclusions from boundary measurements*"
Minisymposium Talk on Monday, 16:45-17:15. Room A.

We discuss some recent results obtained in collaboration with other coauthors concerning the detection of unknown inclusions in an elastic medium from finitely many boundary measurements.

Elisa Francini (Universita' di Firenze)
"*Detection of linear cracks in an elastic material*"
Minisymposium Talk on Tuesday, 11:30-12:00. Room C1.

We consider the problem of detecting linear thin inclusions in an elastic isotropic and homogenous body from the knowledge of one boundary measurement of displacement and traction on the boundary of the body. We show what kind of perturbation is caused on the displacement field by the presence of thin inclusions. Moreover we use this result to show that the position of the inclusion depends continuously on the boundary data. Our stability estimate relies essentially on the a priori assumption that the inclusions are linear.

Manuel Freiberger (Graz University of Technology)
"*Application of level-set type reconstruction to fluorescence optical tomography*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

Fluorescence diffusion optical tomography (FDOT) is one of the newer imaging technologies showing a huge potential for medical applications. It utilizes a set of sources placed on the surface of the sample under investigation to inject light into the object. The light is scattered into the tissue and absorbed by a fluorescent dye which re-emits part of the photons at a higher wavelength. These photons propagate through the tissue again and are measured on the boundary. From these boundary measurements, the distribution of the fluorophore shall be reconstructed. Regularization methods are needed as this problem is severely underdetermined and ill-posed. In our contribution we investigate the application of quasi level-set methods to FDOT. Level-set methods are advantageous whenever a good a-priori choice of the parameter values inside the perturbation and the background is available and only the shape of the perturbation has to be reconstructed. Furthermore, the distinct boundary of the perturbation in the reconstruction offers the possibility to easily discriminate the background from the object which is needed in certain medical settings like the determination of the position and size of a tumour. The level-set type approach implemented is based on a differentiable approximation of the level-set function where the approximation quality can be controlled by a parameter. For the reconstructions an iteratively regularized Gauss-Newton scheme is used, thus decreasing the influence of regularization in each iteration. Additionally, the approximation quality of the differentiable functional is increased in every step such that the reconstructions from the quasi level-set method approaches the true level-set result. Quasi level-set regularization shows promising results when compared to conventional regularization methods like a L2-penalty term. Currently the quality of the result is limited by the size of the mesh elements. It is expected that adaptive mesh refinement will overcome this limitation to provide more correct reconstructions. Open problems are still the a-priori choice of the parameter niveaus and the implementation of a stopping criterion.

Bastian Gebauer (University of Mainz)
"*Tracking a moving object by current-voltage measurements*"
Minisymposium Talk on Monday, 15:15-15:45. Room B.

We aim to obtain time-resolved images of a moving conductivity anomaly by current-voltage measurements. Using the idea of localized potentials we develop a fast sampling-based algorithm that is able to track an object with only few measurements. We also discuss the more detailed monitoring of a moving region, e.g. the human lung, from a full set of voltage-current pairs measured with realistic electrode configurations.

Drossos Gintides (National Technical University)
"*A discrete variational method to determine the index of refraction from far field measurements*"
Minisymposium Talk on Tuesday, 10:30-11:00. Room B.

In this talk we present a new method to determine the index of refraction from far field data corresponding to scattering of time harmonic acoustic plane waves by a bounded, inhomogeneous medium. From the regularized solution of the far field equation we compute the transmission eigenvalues. Then, we use a Galerkin type approximation method for the variational formulation of the interior transmission eigenvalue problem for this case and reduce the problem to an inverse quadratic eigenvalue problem. Numerical examples are given for the first transmission eigenvalue and constant refractive index showing the applicability of the method.

Yuri Golubev (CNRS)
"*On oracle inequalities related to high dimensional linear models.*"
Minisymposium Talk on Tuesday, 15:15-15:45. Room C1.

This talk focuses on recovering of an unknown vector θ from the noisy data $Y = A\theta + \epsilon$, where A is a known $m \times n$ - matrix and ϵ is a white Gaussian noise. It is assumed that n is large and A is ill-posed. Therefore in order to estimate θ, we apply the spectral regularization technique and our goal is to choose the regularization parameter with the help of the data Y. We study data-driven regularization methods based on the empirical risk minimization principle and derive new oracle inequalities in the case when the variance of the noise is unknown.

Markus Grasmair (University of Innsbruck)
"*Convergence rates for l^q regularization*"
Minisymposium Talk on Tuesday, 11:00-11:30. Room C2.

We consider the approximate solution of an ill-posed operator equation $F(u) = v$ on the sequence space l^2. In order to encourage sparse solutions, we employ regularization with a sub-quadratic penalty term $\mathcal{R}(u) = \|u\|_q^q$ for some $1 \leq q < 2$. This method enjoys the same regularizing properties as the classical (quadratic) Tikhonov method.

There is, however, a significant difference between quadratic and sub-quadratic methods regarding convergence rates. In the quadratic case, a condition of the type $u^\dagger \in \operatorname{Ran} F^*$ implies convergence rates of type $O(\sqrt{\delta})$. Moreover it has been shown that, apart from trivial cases, the best possible rates are of type $O(\delta^{2/3})$. In contrast, in the case of an l^q penalty term and a sparse true solution $u^\dagger$, the corresponding source condition $\partial\mathcal{R}(u^\dagger) \in \operatorname{Ran} F^*$ implies rates of type $O(\delta^{1/q})$. For the particular choice $q = 1$, this shows that linear rates are possible.

Allan Greenleaf (University of Rochester)
"*Approximate cloaks for acoustic and Schrödinger equations*"
Minisymposium Talk on Tuesday, 15:15-15:45. Room Aula.

Approximate cloaks consist of isotropic and nonsingular material parameter fields that provide arbitrarily close approximations of the wave propagation occurring for ideal cloaks, which are necessarily anisotropic and singular. I will discuss how approximate cloaks can be constructed for a class of equations that includes the acoustic wave equation and the Schrödinger equation. Applications include new designs for magnetically tunable ion traps. This is joint work with Yaroslav Kurylev, Matti Lassas and Gunther Uhlmann.

Roland Griesmaier (University of Delaware)
"*Reciprocity gap MUSIC-imaging for inverse scattering*"
Minisymposium Talk on Monday, 16:45-17:15. Room B.

We consider the inverse scattering problem to reconstruct the positions of a collection of small metallic objects buried underneath the surface of ground from measurements of Cauchy data of total electromagnetic fields on a bounded part of the surface of ground. Applying an asymptotic analysis of the reciprocity gap functional, we establish a characterization of the scatterers in terms of the measurement data that can be implemented in a MUSIC-type reconstruction algorithm. In contrast to other MUSIC-type methods considered so far, our reciprocity gap MUSIC method does not require to compute the Green's function for the background medium.

Hermann Gross (Physikalisch-Technische Bundesanstalt)
"*Uncertainty estimates for inverse methods in EUV scatterometry*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

We discuss the solution of the inverse problem in scatterometry, i.e. the determination of geometrical profiles of periodic surface structures from light diffraction patterns. Scatterometry is a non-imaging indirect optical method in wafer metrology and is also relevant to lithography masks designed for Extreme Ultraviolet Lithography, where light with wavelengths in the range of 13 nm is applied. The determination of the sought profile parameters, such as line widths and heights or side-wall angles, is incomplete without knowledge of the uncertainties associated with the reconstructed parameters. With decreasing feature sizes of lithography masks, increasing demands on metrology techniques and their uncertainties arise.
The numerical simulation of the diffraction process for periodic 2D structures can be realized by the finite element solution of the two-dimensional Helmholtz equation. For typical EUV masks the ratio period over wave length is so large, that a generalized finite element method has to be used to ensure reliable results. The inverse problem can be formulated as a non-linear operator equation. The operator maps the sought mask parameters to the efficiencies of diffracted plane wave modes. We employ a Gauss-Newton type iterative method to solve this operator equation and end up minimizing the deviation of the measured efficiency or phase shift values from the calculated ones.
Clearly, the uncertainties of the reconstructed geometric parameters essentially depend on the uncertainties of the input data and can be estimated by various methods. We apply a Monte Carlo procedure and an approximative covariance method to evaluate the reconstruction algorithm and to get first estimates for the uncertainties of the reconstructed profile parameters in dependence of different perturbations of the input data. The subject under test is a typical EUV mask composed of TaN absorber lines of about 80 nm height and 140 nm width, a period of 420 nm resp. 840 nm, and with an underlying MoSi-multilayer stack of 300 nm thickness.

Doga Guersoy (Graz University of Technology)
"*A sensor optimization algorithm to increase the stability of the magnetic induction tomography inversion*"
Minisymposium Talk on Friday, 14:30-15:00. Room A.

Magnetic induction tomography (MIT) is a contactless imaging modality which aims to reconstruct the conductivity of the body in a region of interest. It uses magnetic induction to excite the body and an array of receiver coils to detect the perturbations in the magnetic field. The locations of the receiver coils determine the sensitivity of the data channels to the conductivity perturbations, thus, affect the overall quality of the image reconstruction. In the presentation, a deterministic algorithm will be presented to obtain optimum receiver array designs. The design strategy is based on the iterative exclusion of the receiver locations, which yield poor conductivity information, from the space spanning all possible locations until a feasible design is reached. It will also be shown that the algorithm tends to increase the smaller singular values of the Jacobian matrix and can be used to construct stable designs considering inaccurate data.

Bojan Guzina (University of Minnesota)
"*On the small-defect perturbation and sampling of heterogeneous solids*"
Minisymposium Talk on Tuesday, 11:00-11:30. Room A.

This talk aims to extend the application of topological sensitivity, developed for elastic-wave imaging of defects in a homogeneous background solid, to the class of heterogeneous (background) bodies with piecewise-analytic viscoelastic and mass density coefficients. Founded on the premise of time-harmonic wave propagation, the approach employs dimensional analysis to formally establish the expected, yet previously unavailable result wherein the leading behavior of the scattered field caused by a vanishing inclusion is governed by

- the illuminating visco-elastodynamic field and its adjoint companion, both computed for the background body, at the sampling point;
- the geometry and material properties of the vanishing defect, and
- local properties of the (heterogeneous) background solid at the sampling point.

By virtue of this result, an explicit formula for the topological sensitivity is obtained by an asymptotic expansion of a misfit-type cost functional with respect to the nucleation of a trial inclusion in the given background i.e. reference solid. Through numerical examples, it is shown that defined in this way sensitivity provides a computationally-effective platform for preliminary sounding of heterogeneous solids by viscoelastic waves. This is accomplished by computing the topological sensitivity over an arbitrary grid of sampling points inside the reference solid, and identifying those regions where the topological sensitivity attains pronounced negative values with the support of a hidden defect (or a set thereof). The results highlight the potential of topological sensitivity to expose not only the geometry, but also the nature of internal defects through a local, point-wise identification of "optimal" inclusion properties that minimize the topological sensitivity at a given sampling location. The talk will conclude with an application to mechanical-wave imaging and characterization of soft tissues where the data, namely internal tissue displacements due to external vibration, are captured by a magnetic resonance (MR) device in a voxel-averaged sense.

Eldad Haber (Emory University)
"*Dictionary Design for sparse solutions of ill-posed problems* "
Minisymposium Talk on Monday, 10:30-11:00. Room C2.

Recently, there have been a growing interest in application of sparse representation for inverse problems. Most studies concentrated in devising ways for sparsely representing a solution using a given prototype overcomplete dictionary. Very few studies have addressed the more challenging problem of construction of an optimal overcomplete dictionary, and even these were primarily devoted to the sparse coding application. In this talk we present a new approach for dictionary learning. Our approach is based on minimizing the empirical risk, given some training models. We present a mathematical formulation and an algorithmic framework to achieve this goal. The pro- posed framework offers incorporation of non-injective and nonlinear operators, where the data and the recovered parameters may reside in different spaces. We test our algorithm and show that it yields optimal dictionaries for diverse problems.

Hossem Haddar (INRIA)
"*Taking into account roughness of interfaces in the imaging of buried objects*"
Minisymposium Talk on Tuesday, 11:00-11:30. Room B.

We are interested in the problem of imaging buried objects from the knowledge of electromagnetic near field data at a fixed frequency. We consider the case where the background medium is composed of two media with constant index that are separated by rough (thin) interface. This configuration is motivated by sub-soil imaging experiments using electromagnetic waves. We shall discuss the use of sampling methods to solve this inverse problem and strategies to avoid the computation of exact background Green tensor, either by using continuation methods and/or asymptotic models.

Uno Haemarik (University of Tartu)
"*Minimization strategy for choice of the regularization parameter in case of roughly given or unknown noise level*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

We consider linear ill-posed problem with noisy data in Hilbert space. The approximations to the solution are found by the Tikhonov method or by the Lavrentiev method or by iterated or extrapolated variants of these methods. For choice of the regularization parameter we propose the following minimization strategy. In case of known noise level we take for the parameter minimum of certain expressions of parameters from the monotone error rule and from the new rule R2. In case of roughly given or unknown noise level we propose to take for the regularization parameter the minimizer of certain functional, which is an analog of the functional from the quasioptimality criterion. The starting point of the minimization interval is in case of roughly given noise level determined by another parameter choice rule R1 and will be determined in case of unknown noise level from increase condition of the functional to be minimized. Results of extensive numerical experiments are given.

Markus Haltmeier (University of Innsbruck)
"*Analysis of spatial resolution in photoacoustic and thermoacoustic tomography*"
Minisymposium Talk on Friday, 16:15-16:45. Room C2.

High spatial resolution is one of the major aims in tomography. Two main factors limiting the resolution of photo- and thermoacoustic tomography are the detector size and the finite bandwidth of the ultrasound detection system. We present a quantitative analysis of those effects for approximate point detectors and for approximate line detectors.

Matti Hamalainen (Martinos Center for Biomedical Imaging)
"*Anatomically and Functionally Constrained MEG/EEG Source Estimates*"
Minisymposium Talk on Monday, 10:30-11:00. Room A.

Independently, electromagnetic and hemodynamic measurements of brain activity offer compromises between spatial and temporal resolution. Functional Magnetic Resonance Imaging (fMRI) is temporally limited by the slow time course of the hemodynamic response, but can provide a spatial sampling on a millimeter scale. Electroencephalography (EEG) and magnetoencephalography (MEG) in turn provide a temporal resolution of milliseconds, but the localization of sources is more complicated because of the ill-posed electromagnetic inverse problem. Elucidating the spatial distribution and temporal orchestration of human brain regions is thus facilitated by combining information different imaging modalities.
It was recognized very early on that the MEG source estimation problem becomes less ill posed by including constraints provided by anatomical MRI data. Presently, this information is used routinely to delineate boundaries between regions of different electrical conductivities for forward field computations, to restrict the locations and orientations of the sources, and in advanced visualization techniques involving three-dimensional renderings of the cortical mantle and other structures.
The most obvious companion of MEG is EEG. Both simulations and analyses of actual human data have shown that the combination of these two methods yields more reliable estimates of the sources than using one modality alone. Furthermore, these studies indicate that the improvement is not due to the increased number of measurement channels but is attributable to the different sensitivities of MEG and EEG to the cerebral current sources.
The fusion of electromagnetic and hemodynamic data is usually accomplished by confining the sources to the cortical gray matter and by computing a distributed current estimate with a stronger *a priori* weighting at locations with significant fMRI activity. More elaborate methods which attempt to model the two data sets jointly under a common framework are also emerging.

Ryan Hass (Oregon State University)
"*Analysis of 3D reconstruction algorithms in x-ray tomography*"
Minisymposium Talk on Thursday, 11:00-11:30. Room C2.

A major development in 3D computed tomography in recent years has been the emergence of theoretically exact reconstruction algorithms. This talk presents an analysis of the numerical implemenation of the Katsevich 3D reconstruction formula. It includes results on the rate of convergence, a comparison with competing exact 3D reconstruction formulas, and an investigation of errors introduced by x-ray data sets with an unknown center of rotation. Both theoretical and numerical results will be presented. This is joint work with Adel Faridani.

Andreas Helfrich-Schkarbanenko (University of Karlsruhe)
"*Complex Electrical Impedance Tomography in Geoelectrics*"
Minisymposium Talk on Friday, 14:30-15:00. Room B.

Complex Electrical Impedance Tomography (CEIT) is a non-invasive imaging method to obtain a system's inside structure. By injecting an alternating current and analysing the voltage and the phase shift pattern measured on the surface of the sample, inner properties like the conductivity and the chargeability distribution can be reconstructed.
We introduce the theoretical framework of the forward problem in geoelectrics, and solve the problem numerically by a finite element method. The inverse problem solver is based on the forward model, where the error functional is minimized by Tikhonov regularized Newton type methods. We perform some reconstructions for synthetic as well as real geoelectrics data sets. The developed software package CEITiG is able to face 2D and cylindrical 3D problems and it turns out to be an useful instrument for validating new regularizing schemes.

Andreas Helfrich-Schkarbanenko (University of Karlsruhe)
"*Data Transformation Approach in Electrical Impedance Tomography*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

An elliptic boundary value problem is fundamental for electrical impedance tomography. Since the computational solution of the appropriate nonlinear inverse 3D problem is both time- and memory-expensive, in real applications one often switches to the reconstruction of cross sections, assuming some symmetry on the explored material.
This poster presents a novel approach, which solves a cylindric 3D problem in a very cheap way, by the reduction to a 2D problem. The idea is based on a transformation of the meassured data sets and the subsequent use of a 2D reconstruction algorithm. Although the transformation is not exact, the approach provides good results for a class of material property distributions even for complex valued data, comparable to common approaches. It seems that this data transformation can be applied to a wide class of inverse elliptic boundary value problems.

Mohammad Rahim Hematiyan (Shiraz University)
"*An artificial heat source method for inverse analysis of solidification problems*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

In this work, a method for evaluation of unknown heat flux on a part of boundary of two dimensional castings to produce a desired motion of solidification front is presented. With control of solidification front in casting, suitable mechanical properties can be obtained. The unknown heat flux is calculated using an inverse method. In each time step, latent heat effect is applied by introducing an artificial heat source over transition region. By this technique the inverse solidification problem is converted into several inverse heat conduction problems, which can be solved more efficiently. Sensitivity analysis is carried out using finite element method. In the inverse analysis, a main regularization and a secondary regularization are accomplished to obtain more smooth solutions. The main regularization in each time step is carried out by considering some imaginary future time steps. Secondary regularization is applied after main calculations, for better reduction of oscillations in time domain. To show the accuracy and efficiency of the present method, three examples are presented. In these examples solidification of materials with constant and temperature dependent properties are analyzed. In the first example a unidirectional solidification inverse problem is solved. In the second example, the unknown heat flux on the boundary to produce a desired motion of solidification front in a square section is found. In this example, effects of time step size on the results of the inverse analysis are also studied. In the third example, material properties are considered to be temperature dependent. In this example, a more complicated motion for solidification front has been considered. The results obtained from the three examples are satisfactory.

Mark-Alexander Henn (Physikalisch-Technische Bundesanstalt)
"*On numerical reconstructions of lithographic masks in DUV scatterometry*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

The solution of the inverse problem in scatterometry is discussed, i.e. the determination of periodic surface structures from UV or light diffraction patterns. With decreasing size of features of lithography masks, increasing demands on wafer metrology technique arises. Scatterometry as a non-imaging indirect optical method is applied to such periodic line structures in order to determine their critical dimensions (CD) like side-wall angles, heights, top and bottom widths in the range of several ten nanometers for quality evaluation of the manufacturing process. In DUV scatterometry a wave length of 193 nm is applied to determine the profile parameters of a mask. The numerical simulation of diffraction for periodic 2D structures is based on the finite element solution of the Helmholtz equation. The inverse problem seeks to reconstruct the grating geometry from measured diffraction patterns. Restricting the class of gratings and the set of measurements, this inverse problem can be reformulated as non-linear operator equation in Euclidean spaces. The operator maps the grating parameters to special efficiencies of diffracted plane wave modes. We employ a Newton type iterative method to solve this operator equation and end up minimizing the deviation of the measured efficiency or phase shift values from the simulated ones. The reconstruction quality surely depends on the angles of incidence, on the wave lengths and/or the number of propagating scattered wave modes. Moreover, the uncertainties of the measured efficiencies or phase shifts and the uncertainties of the model parameters determine the uncertainties of the reconstructed critical dimensions. Therefore a careful sensitivity analysis to find an optimal measurement configuration for scatterometry is crucial and will be discussed by numerical examples and first experiences with measured DUV data.

Felix Herrmann (University of British Columbia)
"*Compressive seismic imaging with simultaneous acquisition*"
Minisymposium Talk on Monday, 11:00-11:30. Room C2.

The shear size of seismic data volumes forms one of the major impediments for the inversion of seismic data. Turning forward modeling and inversion into a compressive sensing (CS) problem—where simulated data are recovered from a relatively small number of independent simultaneous sources—can effectively mitigate this high-cost impediment. Our key contribution lies in the design of a sub-sampling operator that commutes with the time-harmonic Helmholtz system. As in compressive sensing, this leads to a reduction in simulation cost. This reduction is commensurate with the transform-domain sparsity of the solution, implying that computational costs are no longer determined by the size of the discretization but by transform-domain sparsity of the solution of the CS problem that recovers our data. The combination of this sub-sampling strategy with our recent work on precondioned implicit solvers for the time-harmonic Helmholtz equation provides a viable alternative to full-waveform inversion schemes based on explicit time-domain finite-difference methods.
This is joined work with Tim T. Lin and Yogi Erlangga.

Felix Herrmann (University of British Columbia)
"*To be announced*"
Minisymposium Talk on Friday, 17:15-17:45. Room A.

To be announced.

Michael Hintermueller (University of Graz)
"*A duality-based variational approach to L1-TV*"
Minisymposium Talk on Monday, 15:45-16:15. Room D.

Based on a regularized Fenchel (pre)dual of an image restoration model based on a L1-data fidelity term and TV-regularization we introduce a generalized Newton technique for reconstructing the image. The regularization of the Fenchel dual is necessary as otherwise a reconstruction of the primal solution would not be at hand. Besides theoretical results numerical tests and a comparison with alternative solvers are presented.

Daniel Hlubinka (Charles University)
"*Implicit Markov kernels given by moment conditions*"
Minisymposium Talk on Thursday, 15:15-15:45. Room D.

Having Polish spaces X, Y and Z we shall discuss an existence of $X \times Y$-valued random vector (ξ, η) such that its conditional distributions $K_x = \mathcal{L}(\eta|\xi = x)$ satisfy $e(x, K_x) = c(x)$ or $e(x, K_x) \in C(x)$ for some maps $e : X \times M1(Y) \to Z, c : X \to Z$ or multifunction $C : X \to 2^Z$ respectively. The problem is equivalent to the existence of an universally measurable Markov kernel $K : X \to M1(Y)$ implicitly defined by $e(x, K_x) = c(x)$ or $e(x, K_x) \in C(x)$ respectively. In the talk we shall provide sufficient conditions for the existence of desired Markov kernel. We shall discuss some special solutions of the (e, c) or (e, C) problem and illustrate the theory on generalized moment problem.

Elena Hoetzl (University of Graz)
"*Numerical treatment of a Mumford-Shah model for the inversion of tomography data*"
Minisymposium Talk on Monday, 12:00-12:30. Room Aula.

The topic of the presentation is the identification of a density function of a physical body from a given data as the result of x-rays travelling through the body under different angles and offsets. The mathematical relation between parameter and data is described by the Radon transform. More specifically, the aim of the reconstruction is to find the singularity set of the density — the collection of lines across which the density is discontinuous — and the smooth density distribution on the complement of the singularity set. Mumford-Shah models are designed to extract simultaneously functional and geometric information for inaccessible parameters from indirect measurements. We propose a piecewise smooth Mumford-Shah model for the inversion of the tomography data. In our approach the functional variable is eliminated by solving a classical variational problem for each fixed geometry. The solution is then inserted in the Mumford-Shah cost functional leading to a geometrical optimisation problem for the singularity set. The resulting shape optimisation problem is solved using a shape sensitivity calculus and a propagation of shape variables in the level-set form.
A specific difficulty poses the solution of the optimality system for the fixed geometry, which has the form of a coupled system of integro-differential equations on variable and irregular domains. A finite difference method based approach for the determination of a piecewise smooth density function as the solution of the optimality system is presented. A second order accurate finite difference discretization is proposed. Here a standard five-point stencil is used on regular points of the underlying uniform grid and modifications of the standard stencil are made at points close to the contour. The optimality system is solved iteratively. A fast multipole method is used for the efficient approximation of the Radon transform part in the optimality system.

Marc Hoffmann (Universite Paris-Est Marne-la-Vallee)
"*Volatility representation under microstructure noise as a statistical ill-posed inverse problem*"
Minisymposium Talk on Tuesday, 16:15-16:45. Room C1.

We study the problem of representing the volatility of a financial asset from a statistical point of view; depending on the time scale at which the data are recorded (on an intra-day basis, say) the statistical properties of liquid price processes vary a lot. This has an impact on the volatility estimates across scales. In this talk, we will propose a representation that is compatible with multiple observation schemes at different scales. We will show how the fact that high frequency data are used does not necessarily substantially increase the statistical information. A formal link will be made with so-called microstructure noise effect, by means of the introduction of a random operator that plays an analogous role as in linear ill-posed inverse problems.

Bernd Hofmann (Chemnitz University of Technology)
"*Multi-parameter regularization for some nonlinear inverse problems in finance and technology*"
Minisymposium Talk on Thursday, 11:00-11:30. Room C1.

The use of more than one regularization parameter for the stable approximate solution of ill-posed inverse problems can be justified by very different arguments. For example, it can be useful to choose the penalty term of Tikhonov regularization as a linear combination of ansatz functions. Alternatively, in case of separated data sets such linear combinations are appropriate for the discrepancy term. In both cases the scalar multipliers can be collected in a regularization parameter vector. We give examples for such situations.

First we consider the inverse problem of estimating simultaneously the five parameters of a jump diffusion process based on return observations of a price trajectory. We show that there occur some ill-posedness phenomena in the parameter estimation problem and illustrate the instability effect by a numerical case study. To obtain stable approximate solutions of the estimation problem, we use a multi-parameter regularization approach, where a least-squares fitting of empirical densities is superposed by a quadratic penalty term of fitted semi-invariants with weights.
In a second part we present an inverse problem occurring in the mathematical model for a computer-based simulation of electric fault arc tests. To overcome the ill-posedness Tikhonov regularization, versions of the method of descriptive regularization and multi-parameter regularization approaches are exploited.
Parts of the talk present joint work with Dana Düvelmeyer-Uhlig, Torsten Hein, Peter Mathé and Sergei V. Pereverzev.

Thorsten Hohage (University of Goettingen)
"*Inverse problems with Poisson data*"
Invited Talk on Tuesday, 14:00-15:00. Room C1.

The topic of this talk are inverse problems with random data which are described by a Poisson process, or after binning by a finite number of Poisson distributed scalar random variables. Examples include deconvolution problems in fluorescence microscopy, astronomy, and mass spectroscopy, SPECT, PET as well as phase retrieval and inverse scattering problems in optics and quantum mechanics. We study variational regularization methods in Banach spaces with the Kullback-Leibler divergence as natural data misfit functional. Convergence and convergence rate results are derived as the expected total number of counts (often proportional to an illumination time) tends to infinity. We conclude our talk with some real data examples from 4Pi fluorescence microscopy and x-ray optics.

Gordon Hurford (University of California, Berkeley)
"*Inverse Problems in Solar Imaging Spectroscopy - Future Applications*"
Minisymposium Talk on Monday, 16:45-17:15. Room C2.

Previous papers in this session have shown how the application of spatio-spectral inversion algorithms to the two-stage inverse problems posed by RHESSI Fourier-based imaging and spectroscopic observations has afforded a significant advance in the interpretation of such data. This talk considers the opportunities and challenges posed by applying such techniques to the next generation of related instrumentation.
In the next few years, solar hard x-ray imaging spectroscopy instrumentation will develop along two lines that can directly benefit from these new algorithms. In particular, the techniques can be applied directly to a NASA balloon instrument, GRIPS (Gamma-Ray Imaging Polarimeter for Solar Flares). This is a large-scale instrument that uses a novel modulation technique to directly measure x-ray and gamma-ray visibilities with significantly improved spatial frequency coverage. To exploit the much richer uv-coverage, algorithmic efficiency will become a more significant factor. At the other extreme, a much smaller scale instrument, STIX (Spectrometer/Telescope for Imaging X-rays) is under consideration for flight on ESA's Solar Orbiter mission. Exploiting the advantages of a close approach to the Sun, this instrument also measures x-ray visibilities with high spectral resolution but at only 30 spatial frequencies. The resulting lower image quality implies that the new spatio-spectral inversion algorithms will be particularly vital for the extraction of information on the accelerated electrons.
An alternate observational window on solar-accelerated electrons is provided by imaging-spectroscopy of microwave emission using multi-antenna interferometers. With an interferometer, the correlated signal from each antenna pair measures one visibility at each observing frequency. A new feature of the next generation solar interferometers, the Frequency-Agile Solar Radiotelescope (FASR), and the Chinese Spectral RadioHeliograph (CSRH), are that they observe at a quasi-continuous range of frequencies over decade-wide bandwidths. However, interferometrically-observed visibilities are measured at spatial frequencies that are proportional to the observing frequency. This implies a distinctive linkage between spectral interpretation and spatial information that poses a new and challenging inverse problem. The development of new algorithms to address this will be a key element in the scientific success of these facilities.

Nuutti Hyvonen (Helsinki University of Technology)
"*Approximating idealized measurement maps of electric impedance tomography by electrode data*"
Minisymposium Talk on Monday, 15:45-16:15. Room B.

In electric impedance tomography, one tries to recover the spatial admittance distribution inside a body from boundary measurements of current and voltage. In theoretical considerations, it is usually assumed that the available data is the infinite-dimensional Neumann-to-Dirichlet map, i.e., one assumes to be able to use any boundary current and measure the corresponding potential everywhere on the object boundary. However, in practice the data consists of a finite-dimensional operator that maps the electrode currents onto the corresponding electrode potentials. In addition, the measurements are affected by the contact impedance at the electrode-object interfaces. We show that the introduction of a suitable nonorthogonal projection operator makes it possible to approximate the Neumann-to-Dirichlet map by its electrode counterpart in the topology of bounded linear operators on square integrable functions, with the discrepancy bounded by constant times the distance between centers of adjacent electrodes. In particular, convergence is proved without assuming that the electrodes cover all of the object boundary. To demonstrate the usability of this result, we present electrode-based reconstructions obtained by sampling-type inclusion detection algorithms that were originally designed for idealized boundary measurements.

Nuutti Hyvonen (Helsinki University of Technology)
"*An inverse backscattering problem in electric impedance tomography*"
Minisymposium Talk on Thursday, 15:15-15:45. Room .

We consider (two dimensional) electric impedance tomography with very sparse data that resembles the so-called backscatter data of inverse scattering. Such data arises if a single (infinitely small) pair of electrodes is used for driving currents and measuring voltage differences subsequently at various neighbouring locations on the boundary of the object of interest. We prove that this data uniquely determines an embedded simply connected and insulating (or ideally conducting) inclusion if the object has known constant background conductivity. This result is based on a link between the backscatter measurement and the Schwarzian derivative of a certain conformal mapping.

Hiroshi Isozaki (University of Tsukuba)
"*Inverse scattering on non-compact manifolds*"
Minisymposium Talk on Tuesday, 15:45-16:15. Room Aula.

Given non-compact Riemannian manifolds, can one identify the metric by observing the waves at infinity? More pecisely, we try to identify or recontstruct the metric or the manifold itself by sending waves from infinities of the manifold and observing the scattered waves at infinities. The model of the manifold will thus be a composition of a bounded part and a neighborhood of infinity, on whcih we equip with a metric slightly perturbed from the standard one. Let H_0 and H be the unperturbed and perturbed Laplace-Beltrami operators of this manifold. The waves are created by the Schrödinger equation, $i\partial_t u = Hu$, or the wave equation, $\partial_t^2 u + Hu = 0$. The wave operator $W_\pm$ is defined by $W_\pm = \mathrm{s} - \lim_{t\to\pm\infty} e^{itH}e^{-itH_0}$ or $W_\pm = \mathrm{s} - \lim_{t\to\pm\infty} e^{it\sqrt{H}}e^{-it\sqrt{H_0}}$. We used the same notation $W_\pm$ for both of Schrödinger, and wave equations, since it is known that they usually coincide. The scattering operator is then defined by $S = (W_+)^* W_-$, which assigns to the far field patten of the remote past, the far field pattern of the remote future. Our problem is thus stated as follows : *From the scattering operator, reconstruct the Riemannian metric, or the manifold itself.*
Few is known about this general setting. Even when the metric on the end is asymptotically Euclidean, this problem is still open. The only exception is the recent result of Sa Barreto which deals with the asymptotically hyperbolic metric in the framework of Melrose' scattering metric. However, it is also known that the problem becomes more accessible when we allow only the local perturbation of the metric. Namely, if two metrics are asymptotic to the standard one, and they coincide near infinity, they actually coincide everywhere if their scattering operators coincide. We address to this modest problem, allowing the metric perturbation as general as possible.
To formulate this problem in a proper mathematical setting, we need to develop spectral theory on non-compact Riemannian menifolds, especially the theory of generalized Fourier transformations. We give two examples of asymptotically Euclidean cylidrical ends and hyperbolic metrics. For the asymptotically Euclidean case, we allow the cylindrical ends, which corresponds to the problem of waveguides. For the asymptotically hyperbolic case, our assumption includes all the 2-dimensional hyperbolic manifolds with finite number of ends of funnels, thick parts and cusps.
The result is roughly as follows. We consider two manifolds equipped with metrics of short-range perturbation of the Euclidean or hyperbolic metric. Assume that on one end, these metrics coincide and also the scattering matrix restricted to that end coincide. Then these two manifolds are isometric. For the case of cylindrical ends, this is a joint work with Y. Kurylev, M. Lassas, and for the case of hyperbolic ends, a collaboration with Y. Kurylev.

Ganna Ivanova (IAMM of NASU, Donetsk)
"*Identification of Convection Heat Transfer Coefficient of Secondary Cooling Zone of CCM based on Least*

Squares Method and Stochastic Approximation Method"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

The mathematical model of heat and mass transfer of steel ingot of curvilinear continuous casting machine is proposed. The process of heat and mass transfer is described by nonlinear partial differential equations of parabolic type. Position of phase boundary is determined by Stefan conditions. The temperature of cooling water in mould channel is described by a special balance equation. Boundary conditions of secondary cooling zone include radiant and convective components of heat exchange and account for the complex mechanism of heat-conducting due to airmist cooling. Convective heat-transfer coefficient of secondary cooling zone is unknown and considered as distributed parameter. To solve this problem the algorithm of initial adjustment of parameter and the algorithm of operative adjustment are developed.

Marcin Janicki (Technical University of Lodz)
"*Modification of Function Specification Algorithm for Real Time Estimation of Source Temperature in Electronic Circuits*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

Temperature is an important factor affecting both electronic circuit operation and its reliability. Therefore, certain applications require continuous temperature monitoring during their operation so that to protect circuits from thermal destruction. Obviously, the best solution in such cases is to place temperature sensors directly where heat is generated. However, quite often this is not allowed due to certain design constraints. Then, circuit temperature has to be monitored using remote sensors located away from heat sources and the heat source temperature has to be estimated using some inverse method. Owing to its simplicity and ease of practical digital filter realisation, the best suited from the inverse algorithms for this particular purpose is the Beck's function specification method. However, this algorithm has also some drawbacks. Namely, due to the fact that the exact time instants when changes in the power dissipation occur are not known in the considered application, the function specification method cannot be applied in its classical form and the estimation has to be carried out employing steady state solutions of the heat equation. This however, together with the time averaging of several consecutive samples, leads to significant estimation errors just after each change in the power dissipation pattern. Thus, a modification to the standard function specification algorithm is proposed, where measured temperature values from sensors are delayed according to the distance between sources and particular sensors. The benefits from the proposed modification are illustrated based on the simulated and measured data for the real test integrated circuit containing matrices of heat sources and temperature sensors. For this structure the heat equation was solved using the 3D Green's function method. This research has been supported by the Polish Ministry of Science and Higher Education grant No. N515 008 31/0331.

Mohamed Jaoua (Polytech'Nice-Sophia)
"*Detection of small flaws locations using topological asymptotic expansion*"
Invited Talk on Tuesday, 09:00-10:00. Room C1.

The present work deals with the detection of small cavities in Stokes flow from over-specified boundary data. Such a problem arises for example in moulds filling, since the industrial process may generate small gas bubbles which are trapped inside the material while solidifying. The inverse problem aims to locate these defects in order to decide whether the moulded piece is safe or not. The forward problem simulation relies on quite complex and heavy models, based on the incompressible Navier-Stokes equations in the liquid phase, and taking into account the liquid-gas free surface as well as the solidification process.
In this work we assume that the mould is filled with a viscous incompressible fluid and we aim to locate the unknown gas bubbles locations from boundary measurements. The velocity and pressure of the liquid particles are governed by a simplified model based on the Stokes equations. The gas bubbles are modelled as small cavities having an homogeneous Neumann condition on their boundaries.
We rephrase the geometrical inverse problem under consideration into an optimal design one. The optimal design functional to minimize in order to find out the flaws is the misfit, with respect to some appropriate norm, between a "Dirichlet" solution based on the measurements, and a "Neumann" one based on the prescribed loads. To minimize this misfit functional we resort the topological gradient method. It consists in studying the sensitivity of the cost function with respect to a small topological perturbation of the domain.
In the theoretical part, we derive a topological sensitivity analysis for the Stokes system with respect to the insertion of a small hole (flaw) in the fluid flow domain with Neumann condition on the boundary. The obtained results are general and valid for a large class of cost function. The topological sensitivity of the misfit functional with respect to the presence of a "small flaw" is computed, and it turns out to

rely only on quantities needing to be computed on the safe domain.
In the numerical part, we propose a simple, fast and accurate identification procedure. The flaws location are obtained as the most negative local minima of the misfit functional sensitivity. The efficiency of the proposed method is illustrated by several numerical experiments. The sensitivity of the proposed method to some numerical parameters or practical possibly occurring situations such as the relative mesh/flaw size, the flaw's depth, the noisy data and the multi-flaws situations are discussed.

Yuan Jiang (Karlsruhe Institute of Technology)
"*The Inverse Problem of Electrocardiography in Realistic Environment*"
Minisymposium Talk on Thursday, 11:30-12:00. Room .

The inverse problem of electrocardiography is a promising noninvasive approach to image bioelectrical sources in the heart and can provide straightforward and useful information for the diagnosis of cardiac diseases. It reconstructs the electrophysiological activities in the heart from electrical signals measured on the body surface, i.e., multichannel ECG. The information on the patient's geometry and electrical properties of different tissues is also required to set up the system connecting cardiac sources and body surface ECG. However, this problem is strongly underdetermined and ill-posed. Hence, the inverse solution is not unique and extremely sensitive to the errors occurring in measurement and modeling. Unfortunately, in clinical application errors are nearly unavoidable and cannot be completely eliminated, although many efforts have been taken. Therefore, regularization technique must be deployed in the inverse problem of electrocardiography to get a unique stable meaningful solution.
In the present simulation study a realistic environment is built in order to investigate the influence of the errors simultaneously existing in measurement and modeling on the quality of inverse solution in a scenario close to clinical application. The realistic environment takes into account ECG measurement noise, baseline wander in ECG, the modeling errors induced by neglecting heart motion and respiration, and error in estimation of tissue conductivities. Tested are classical regularization methods like Tikhonov regularization and GMRES, spatio-temporal regularization methods, as well as newly developed hybrid regularization methods.

Bangti Jin (University of Bremen)
"*Numerical estimation of Robin coefficient*"
Minisymposium Talk on Monday, 11:00-11:30. Room C1.

In this talk we discuss an iterative regularization algorithm for the nonlinear inverse problem of estimating the Robin coefficient from boundary measurements of the solution and the heat flux. The inverse problem is formulated as an output least-squares optimization problem with suitable regularization. The finite element method is employed to discretize the nonlinear optimization system. Mathematical properties of both the continuous and discrete optimization problems are studied. The conjugate gradient method is employed to solve the optimization problem, and an efficient preconditioner via the Sobolev inner product is suggested. Numerical results are presented to illustrate the efficiency of the proposed algorithm.

Jari Kaipio (University of Kuopio)
"*Nonstationary inversion and reduced order flow modelling*"
Minisymposium Talk on Monday, 15:15-15:45. Room C1.

Nonstationary inversion is a subfield of Bayesian paradigm for inverse problems. The most common formulation is based on the state space representation, or the evolution-observation representation, for the underlying problem. The stochastic convection-diffusion equation is the most common evolution model in industrial problems. This model contains the flow field as a vector-valued distributed parameter, and this parameter is commonly not known exactly. The simultaneous estimation of the state variable (typically conductivity or concentration) and the flow field is an unidentifiable problem with measurement models that correspond to inverse problems. It is possible, however, to estimate a low-dimensional approximation of the flow field simultaneously. We discuss the selection of the representations and the general statistical, numerical and computational aspects of this problem.

Barbara Kaltenbacher (University of Stuttgart)
"*Adaptive and multilevel methods for parameter identification in partial differential equations*"
Invited Talk on Wednesday, 09:00-10:00. Room C1.

In this talk we give an overview on basically two fundamental ideas for efficiently solving large scale inverse problems in the context of PDEs, that are motivated by previously developed approaches for the forward solution of PDEs. One of them consists of multilevel strategies making use of an appropriate combination of fine grid smoothing and coarse grid correction in a hierarchical discretization and therewith shifting as much computation as possible to coarsly discretized and hence cheaply to solve problems. The other one is adaptive discretization based on error estimators that allows to efficiently refine and coarsen the computational grid for the PDE solution, or the seached for parameter, or even both of them in such a way that the accuracy requirements are met with a number of of degrees of freedom as small as possible. In both cases, special care has to be taken due to the ill-posedness of the underlying inverse problem in the sense that either stability has to be additionally incorporated or the stabilizing effect of discretization has to be approproately exploited. Therefore, key tasks in this context are on one hand to prove regularization properties for the resulting methods and on the other hand to show their efficiency for the solution of large scale inverse problems. We intend to give an at least partial overview on existing literature and report on our own research, which includes joint work with Hend Benameur, Anke Griesbaum, Josef Schicho, and Boris Vexler.

Barbara Kaltenbacher (University of Stuttgart)
"*Identifiability of the nonlinearity in a parabolic PDE with application in nonlinear magnetics*"
Minisymposium Talk on Monday, 11:30-12:00. Room D.

This talk is based on a joint paper [1] with Michael Klibanov, where we use Carleman estimates to prove identifiability of a coefficient function in a nonlinear parabolic PDE from initial and boundary data. Here, the coefficient is a function the spatial derivative of the PDE solution and appears in the principal part of the differential operator.
In this talk we will demonstrate applicability of the result to the problem of identifying nonlinear magnetic permeability curves.
We will show numerical experiments with a Newton type method based on a multiharmonic formulation of the problem.

[1] B. Kaltenbacher and M. Klibanov. An inverse problem for a nonlinear parabolic equation with applications in population dynamics and magnetics. *SIAM Journal of Mathematical Analysis*, 39:1863–1889, 2008.

Maka Karalashvili (AVT-Process Systems Engineering)
"*A decomposition approach for the solution of inverse convection-diffusion problems*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

In this talk, we present the recently published incremental approach for the identification of a model for transport coefficients in convection-diffusion systems on the basis of high-resolution measurement data. The transport is represented by a convection term with known convective velocity and by a diffusion term with an unknown, generally state-dependent transport coefficient. The identification of the transport model for this transport coefficient constitutes an ill-posed nonlinear inverse problem. A novel decomposition approach splits this inverse problem into a sequence of transient inverse source- and steady-state inverse coefficient-subproblems.
We consider the methodology in the new context of local identifiability analysis for the unknown transport coefficient out of the measurement data, within which we demand for targeted experimental settings for the identifiabiliy of this coefficient. The methodology will be illustrated for a three-dimensional convection-diffusion equation which has its origin in the modeling and simulation of energy transport in a laminar wavy film flow.

Mirza Karamehmedovic (Technical University of Denmark)
"*Application of the Method of Auxiliary Sources in Characterisation of Micro and Nano Structures by Optical Diffraction Microscopy*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

The design process and industrial use of materials with embedded micro and nano structures require rapid and non-destructive techniques of characterisation of these structures. One such technique is the Optical Diffraction Microscopy, where features of the sample under investigation are reconstructed from the measured optical power in the scattered far field. Since the structures of interest are typically comparable to the wavelength of the illuminating light, it is advantageous to approach the inverse scattering problem using the full classical electromagnetic model, rather than asymptotic formulations. The Method of Auxiliary Sources (MAS) is an efficient, non-asymptotic numerical technique applicable to forward and inverse electromagnetic scattering. We illustrate the use of a simple MAS implementation in the approximation of solution of relevant inverse problems which arise in Optical Diffraction Microscopy.

Jana Kasparova (Academy of Sciences of the Czech Republic)
"*Applications of inversion techniques to RHESSI spatially integrated spectra*"
Minisymposium Talk on Monday, 16:15-16:45. Room C2.

Contrary to previous speakers, this contribution disregards spatial information and focuses only on inversion of spatially integrated RHESSI spectra exploiting their high energy resolution. The talk presents the inversion techniques from a user's point of view and reviews results achieved by the inversion techniques applied to such observational data.
Namely, it will show that inversion techniques are essential for recovering detailed spectral features and as such they should be preferred to parametric forward-fitting methods widely used in solar X-ray spectroscopic community. Those spectral features can potentially be of a great importance and pose a challenge to generally accepted models for particle acceleration and propagation. The talk will also present how the inversion approach can give us an insight into characteristics of acceleration processes, e.g. anisotropy of bremsstrahlung emitting electrons, or how secondary effects such as the photospheric albedo can be dealt with and used to our advantage.
Possible future applications of inverse problem approach in the RHESSI spectra analysis will be discussed.

Kamil Kazimierski (University of Bremen)
"*Iterative Regularization in Banach spaces*"
Minisymposium Talk on Friday, 16:45-17:15. Room C1.

We introduce and discuss an iterative method of relaxed Landweber type for the regularization of the solution operator of the operator equation $F(x) = y$, where X and Y are Banach spaces and F is a (non-)linear, continuous operator mapping between them. We assume that the Banach space X is smooth and convex of power type. We will show that under the so-called approximate source conditions convergence rates may be achieved.
The presented results are joint work with Torsten Hein, University of Chemnitz.

Akhtar A. Khan (Rochester Institute of Technology)
"*Optimization-Based Approaches for an Inverse Problem in Elasticity Imaging*"
Minisymposium Talk on Tuesday, 16:45-17:15. Room D.

This talk will focus on a comparison of various optimization-based techniques for the recovery of shear modulus in elasticity imaging. Adaptive finite element techniques will be used to solve the direct problem. This is joint work with B. Jadamba.

Alexander Kharytonov (University of Kiel)
"*Regularized Solar Particle Spectra and Error Analysis for Measured Data from SOHO/EPHIN*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

Joint work with E.Boehm and R.F.Wimmer-Schweingruber (Institute of Experimental and Applied Physics, Kiel University, Germany).
The telescope EPHIN (Electron, Proton, Helium INstrument) on the SOHO (SOlar and Heliosspheric Observatory) spacecraft measures the energy deposit of solar particles passing through the detector system. The original energy spectrum of solar particles is obtained by regularization methods from EPHIN measurements. It is important not only to obtain the solution of this inverse problem but also to estimate errors or uncertainties of the solution. The basis of solar particle spectra calculation is the Fredholm integral equation of the first kind with the instrument response function (IRF) as the kernel which is obtained by the Monte Carlo technique in matrix form. The original integral equation reduces to a singular system of linear algebraic equations. The nonnegative solution is obtained by optimization with constraints. For the starting value we use the solution of the algebraic problem that is calculated by regularization methods such as the singular value decomposition (SVD) or the Tikhonov methods. We estimate the errors from special algebraic and statistical equations that are considered as direct or inverse problems. Inverse problems for the evaluation of errors are solved by regularization methods. This inverse approach with error analysis is applied to data from the solar particle event observed by SOHO/EPHIN on day 1996/191. We have studied the impact of various error sources on the quantity of uncertainties in the solution of the ill-posed problem. We considered errors in the experimental data and the discrete forward operator or matrix. In the error analysis we use well-known and newly developed methods, such as the

inverse problem for error propagation and the Monte Carlo method with random perturbations in both the matrix and in measurement vector. The error estimation obtained here correlates with the statistical accuracy in both the observation vector and in the discrete forward operator (IRF). We find that the various methods have different strengths and weaknesses in the treatment of statistical and systematic errors. Based on obtained results we claim that the Monte Carlo method with random perturbations provides the best error estimation.

Anna Kirpichnikova (University of Edinburgh)
"*Focusing waves in unknown media by modified time reversal interation*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

We study the wave equation on a bounded domain or on a compact Riemannian manifold with boundary. Assume that we do not know the coefficients of the wave equation but only know the Robin-to-Dirichlet map that corresponds to physical measurements on a part of the boundary. We show that for a fixed time a wave can be cut off outside a suitable set. We consider how to focus waves, that is, how to find Robin boundary values so that at a given time the corresponding waves converges to a delta distribution δ_x while the time derivative of the wave converges to zero. Such boundary values are generated by an iterative sequence of measurements. In each iteration step we apply time reversal and other simple operators to measured data and compute boundary values for the next iteration step. A key feature of this result is that it does not require knowledge of the coefficients in the wave equation, that is, the material parameters inside the media. However, we assume that the point x where the wave focuses is known in travel time coordinates, and x satisfies a certain geometrical conditions.
This work was done in collaboration with Matti Lassas and Matias Dahl (Helsinki University of Technology)

Esther Klann (Johann Radon Institute)
"*A Mumford-Shah level-set approach for tomography data – reconstruction and regularization*"
Minisymposium Talk on Monday, 11:30-12:00. Room Aula.

We deal with a level-set based approach for the simultaneous reconstruction and segmentation of mass and/or activity distributions from tomography data.
We present reconstructions from synthetic SPECT/CT data with different noise levels as well as regularization theory for the Mumford-Shah like method for linear operators.
SPECT/CT is a hybrid imaging technique enabling a direct correlation of anatomical information (density distribution) from CT (Computerized Tomography) and functional information (activity distribution) from SPECT (Single Photon Emission Computerized Tomography). We model activity and density distributions as piecewise constant functions. The segmenting contours and the corresponding function values of both the activity and the density distribution are found simultaneously as minimizers of a Mumford-Shah like functional over the set of admissible contours and – for fixed contours – over the spaces of piecewise constant density and activity distributions which may be discontinuous across their corresponding contours. For the latter step we use a Newton method to solve the nonlinear optimality system. We use shape sensitivity calculus to find a descent direction for the cost functional with respect to the geometrical variable which leads to an update formula for the contours in the level-set framework.
The identification of mass and/or activity distributions from tomography data is an ill-posed problem. After introducing a proper notion of convergence for the space of piecewise constant functions, we present results on the existence and convergence of minimizers for the Mumford-Shah like functional for linear operators.
This is joined work together with R.Ramlau (University of Linz & RICAM) and W.Ring (University of Graz).

Florian Knoll (Graz University of Technology)
"*Towards real-time MR imaging: Data acquisition strategies and image reconstruction*"
Minisymposium Talk on Friday, 15:00-15:30. Room A.

Many important clinical applications of MRI, like time resolved MR angiography or perfusion imaging, require high resolution data sets in the spatial and temporal domain. Currently, there is always a tradeoff between temporal and spatial resolution. The only way to accelerate image acquisition is to collect less data, but this leads to aliasing artifacts when using conventional image reconstruction methods. With special sampling patterns, the introduction of a priori knowledge about the sensitivities of the receiver coils, or by using penalty functions that penalize the structure of the aliasing artifacts, it is possible to

reconstruct artifact-free images from highly undersampled data sets, thus providing the desired temporal resolution.
Experimental results of phantom- and in vivo measurements will be presented. It will also be shown that by using the computation power of modern graphic processing units, it is possible to solve these image reconstruction problems in real time, even for large 3D data sets.

Kim Knudsen (Technical University of Denmark)
"*Reconstructing conductivities in three dimensions using a non-physical scattering transform*"
Minisymposium Talk on Friday, 16:45-17:15. Room D.

The inverse conductivity problem (or the so-called Calderón problem) was formulated mathematically in Calderóns seminal paper from 1980. The problem is concerned with the unique determination and reconstruction of a conductivity distribution in a bounded domain from knowledge of the Dirichlet-to-Neumann map on the boundary of the domain. For the two-dimensional problem the uniqueness and reconstruction questions are well understood theoretically and also numerical implementations of the theoretical algorithms has been developed and investigated. In higher dimensions (for smooth conductivities) the uniqueness and reconstruction problems were addressed and solved in theory more than 20 years ago in a series of papers authored by A. Nachman, J. Sylvester and G. Uhlmann. The basic idea is to introduce an intermediate object, the so-called (non-physical) scattering transform, defined as a non-linear Fourier tranform with the aid of complex geometrical optics solutions. The scattering transform can be computed from the boundary data, and by using either a large complex frequency limit or by solving a multidimensional D-bar equation the conductivity can be computed from the scattering transform.
In this talk I will discuss some new theoretical results related to the outlined algorithm and show how this relates to Calderón's original linearization method. Moreover, it will be shown how to compute numerically the non-physical scattering transform for a given conductivity, and in addition it will be shown how the numerical reconstruction of the conductivity can be computed from the scattering transform.

Ville Kolehmainen (University of Kuopio)
"*Multiresolution local tomography in dental radiology using wavelets*"
Minisymposium Talk on Tuesday, 15:45-16:15. Room D.

A Bayesian multiresolution model for local tomography is proposed. In this model a wavelet basis is used to represent the x-ray attenuation density of the tissues and the prior information is modeled in terms of Besov norms. The number of unknowns in the local tomography problem is reduced by abandoning fine-scale wavelets outside the region of interest (ROI). This multiresolution approach allows significant reduction in the dimensionality of the image reconstruction problem without loss of reconstruction accuracy inside the ROI. The feasibility of the proposed method is tested with two-dimensional (2D) examples of local tomography in dental radiology.

Richard Kowar (University of Innsbruck)
"*Modeling and analysis of waves and wave equations obeying attenuation and causality*"
Minisymposium Talk on Friday, 17:45-18:15. Room C2.

In this talk we show that the standard causality condition for attenuated waves, i.e. the Kramers-Kronig relation that relates the attenuation law and the phase speed of the wave, is necessary but not sufficient for causality of a wave. By causality of a wave we understand the property that its wave front speed is bounded. Although this condition is not new, the consequences for wave attenuation have not been analysed sufficiently well. We discuss the causality behaviour of waves obeying the frequency power attenuation law and model the wave equation (for a homogeneous and isotropic medium) obeying attenuation and causality. Moreover, we discuss the causality behaviour of Szabo's wave equation and the thermo-viscous wave equation. Finally, we present a generalization of the thermo-viscous wave equation which may be used for Thermoacoustic Tomography.

Katya Krupchyk (University of Helsinki)
"*Inverse spectral problems with data on a hypersurface*"
Minisymposium Talk on Tuesday, 16:15-16:45. Room Aula.

We consider two inverse problems on a closed connected Riemannian manifold. To formulate the first one, assume that the Riemannian manifold is divided by a hypersurface into two components and we are given the eigenvalues of the Laplacian on the manifold as well as the Cauchy data on the hypersurface of

the corresponding eigenfunctions. We prove that these data determine the Riemannian manifold up to an isometry.
In the second problem we are given much less data, namely the eigenvalues of the Laplacian on the manifold and the traces on the hypersurface of the corresponding eigenfunctions. If the hypersurface consists of at least two components we are still able to recover the manifold assuming some generic conditions on the spectra of the Laplacian in subdomains of the manifold obtained by cutting along the hypersurface.
This is a joint work with Yaroslav Kurylev and Matti Lassas.

Yaroslav Kurylev (University College London)
"*Some Inverse Problems for Orbifolds*"
Minisymposium Talk on Tuesday, 16:15-16:45. Room D.

Orbifolds is a generalization of manifolds which naturally occurs in the modern physics, like fields' theory. They may be treated as limits of manifolds collapsing in one dimensions. In this talk (joint with M.Lassas and T.Yamaguchi) we consider some inverse problems of the reconstruction of an orbifold from the data on its boundary or an given open part of the orbifold.

Patricia Lamm (Michigan State University)
"*Generalized Local Regularization for Ill-Posed Problems*"
Invited Talk on Wednesday, 10:30-11:30. Room C1.

In this talk we will briefly review the development of the theory of local regularization as an efficient "structure-preserving" method for solving linear and nonlinear ill-posed problems. The application of this method has primarily been for problems of Volterra type, and in recent years an effective discrepancy principle has been added to the theory. In addition, the theory has been extended to nonlinear problems such as the Hammerstein problem and the autoconvolution problem.
One appealing feature of the method of local regularization for nonlinear problems is that localized domains defined simply for the purposes of regularization can also be used to facilitate the linearization of such problems, further adding to the efficiency of these regularization methods.
Finally, we will describe a class of "generalized local regularization methods" which includes both the method of local regularization as well as the method of Lavrentiev (or "simplified regularization") as special cases. Not only does the generalized method have the potential for application to far more general inverse problems, but the theory behind generalized local regularization also gives insight into why local regularization often outperforms the method of Lavrentiev in numerical testing.
The work presented here is joint with Cara Brooks and includes collaborative efforts with Zhewei Dai and Xiaoyue Luo.

Germana Landi (Universita di Bologna)
"*Recent advances in optimization algorithms for image deblurring and denoising*"
Minisymposium Talk on Thursday, 11:00-11:30. Room D.

Image deblurring and denoising often require the solution of an inequality constrained minimization problem. For example, when an approximation of the noise level is known, the image denoising problem can be advantageously formulated as a minimization problem with one quadratic constraint representing the fitting of the measured data. Moreover, nonnegatively constrained image deblurring problems are obtained when the a priori knowledge that the image is nonnegative is explicitly enforced. This talk, which is about joint work with E. Loli Piccolomini and F. Zama, presents two recently developed methods for efficiently solving large-scale constrained image deblurring and denoising problems. The first method is a feasible direction method for the noise-constrained problem; the second one is a projected inexact Newton-type method for nonnegative image deblurring.

Matti Lassas (University of Helsinki)
"*Regularization of the D-bar method for the two-dimensional inverse conductivity problem*"
Minisymposium Talk on Friday, 17:15-17:45. Room D.

Calderón's inverse conductivity problem, which forms the mathematical foundation of Electrical Impedance Tomography (EIT), is the question of whether an unknown conductivity distribution inside a domain in R^n, modelling e.g. the Earth or a human thorax, can be determined from voltage and current measurements made on the boundary. We will consider this inverse problem in two dimensions for smooth conductivities.

In this talk, a strategy for regularizing the inversion procedure for the two-dimensional D-bar reconstruction algorithm for electrical impedance tomography is presented. The D-bar method we consider is based on the uniqueness proof by A. Nachman.
Our reconstruction strategy utilizes truncation of the boundary integral equation and the scattering transform. This leads to a stable reconstruction of the conductivity. In particular, the error in the reconstructed conductivity can explicitly be estimated in terms of the errors in the boundary measurements and a priori conditions for the conductivity. We consider also the numerical results.
The presented research is collaboration with Kim Knudsen, Jennifer Mueller and Samuli Siltanen

Antoine Laurain (University of Graz)
"*Second-order topological expansion for Electrical Impedance Tomography*"
Minisymposium Talk on Friday, 14:00-14:30. Room D.

Second-order topological expansions in electrical impedance tomography problems with piecewise constant conductivities coefficients are considered. First order expansions usually consist of local terms typically involving the state and the adjoint solutions and their gradients estimated at the point where the topological perturbation is performed. In the case of second-order topological expansions, non-local terms which have a high computational cost appear. Interactions between several simultaneous perturbations are also considered. The study is aimed at determining the relevance of these non-local and interaction terms from a numerical point of view.

Francois Le Dimet (Universite de Grenoble and INRIA (France))
"*Error Propagation and Second Order Information in Variational Data Assimilation*"
Minisymposium Talk on Thursday, 16:45-17:15. Room A.

At the origin, methods of Data Assimilation were conceived for retrieving the state of a geophysical fluid at a given date: a preliminary and mandatory stage before carrying out a prediction. Variational Methods based on Optimal Control methods are presently used by the main meteorological centers. They are well adapted to the non linear character of the fluids and doesn't require any linearization.
The ingredients of a variational methods are the model, the observations and also the statistics of error on the the observations and on the prediction. With the variational approach an Optimaly System (O.S.) is derived: it has the characteristic property of containing all the available information.
Since one decade, the direction of research has slightly changed toward the propagation of uncertainties in order to estimate the quality of the prediction issued from the assimilation. The basic errors are on the observations and on the model itself, through the process of data assimilation they are propagated toward the initial condition then to the prediction. Ensemble-type methods are presently used for this purpose but justifying the choice of perturbations remains an open problem.
In the proposed approach, thanks to a second order analysis, from the O.S. we can deduce a relation between the Hessian of the cost function multipied by the perturbation on the initial condition and the perturbations on both the observations and the model. Using a GMRES-type methods we can estimate this perturbation without an explicit computation of the Hessian: an impossible task according to the dimensions of the models. The algorithm provide natural directions for ensemble methods.
A numerical application will be displayed with an advection diffusion equation, both in the cases of dominating diffusion then dominating non linear advection.
This work has been done in collaboration with Igor Gezadje (University of Strathclyde, UK) and Victor Shutyaev (Russian Academy of Sciences).

Armin Lechleiter (Ecole Polytechnique)
"*Sampling Methods for Scattering in 3D Waveguides*"
Minisymposium Talk on Monday, 16:15-16:45. Room B.

We consider scattering of acoustic waves by a bounded object contained in three-dimensional waveguide which is bounded by two planes. Together with suitable boundary conditions, this setting can be used as a simple model for the acoustic behavior of an ocean with flat bottom. After briefly reviewing existence and uniqueness for the direct scattering problem, we investigate sampling methods for the corresponding inverse scattering problem, which consists in determining the scattering object from measurements of scattered waves. We show that a Factorization method can be applied to rigorously characterize the scatterer in terms of measured data. There are by the way different options where to measure this data and we investigate their influences on the method's behaviour. We also discuss links to other sampling methods and their application to inverse problems in waveguides.

Lili Lei (Penn State University)
"*Some Innovative Applications and Approaches Using Nudging Four Dimensional Data Assimilation - Part 2*"
Minisymposium Talk on Thursday, 15:45-16:15. Room A.

In the second part of the talk, a hybrid nudging ensemble Kalman Filter (HNEnKF) approach is demonstrated using the non-linear Lorenz three-variable model and a two-dimensional shallow water model. The HNEnKF effectively combines the ensemble Kalman filter (EnKF) and nudging by computing the nudging coefficients from the flow-dependent, time-varying error covariances of the EnKF. It also transforms the gain matrix of the EnKF into additional terms in the model's predictive equations. The HNEnKF extends the specified influence function used in nudging to one based on flow-dependent error correlations and observation errors. This new approach is shown to contribute to more rapid assimilation of the data and better fit of an analysis to the data compared to both the nudging and EnKF. Its more gradual assimilation of the data in time promotes better intervariable consistency and observation retention than the EnKF. These simplified models provide a testbed to investigate this hybrid FDDA approach for future transition to three-dimensional mesoscale models (e.g., Weather Research and Forecast (WRF) model).

Daniel Lesnic (University of Leeds)
"*Non-local methods for some inverse problems*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

The ill-posed parabolic equation backward in time

$$u_t + Au = 0,\ 0 < t < T, \|u(T) - f\| \leq \epsilon$$

with the positive self-adjoint unbounded operator A and $\epsilon > 0$ being given is regularized by the well-posed non-local boundary value problem

$$v_{\alpha t} + Av_\alpha = 0, \quad 0 < t < aT, \alpha v_\alpha(0) + v_\alpha(aT) = f$$

with $a \geq 1$ being given and $\alpha > 0$, the regularization parameter.
Similarly, the ill-posed Cauchy problem for elliptic equations

$$u_{tt} - Au = 0,\ 0 < t < T, \|u(0) - \varphi\| \leq \epsilon, u_t(0) = 0$$

is regularized by the well-posed non-local boundary value problem

$$u_{tt} - Au = 0,\ 0 < t < aT, u(0) + \alpha u(aT) = \varphi, u_t(0) = 0.$$

A priori and a posteriori parameter choice rules are suggested which yield order-optimal regularization methods. Numerical results based on the boundary element method are presented and discussed to confirm the theory.
This is joint work with Dinh Nho Hao (Hanoi Institute of Mathematics, Vietnam) and Nguyen Van Duc (Vinh University, Vietnam).

Alexander Litvinenko (TU Braunschweig)
"*Application of Sparse Tensor Techniques for Solving Stochastic Transport Equations*"
Minisymposium Talk on Friday, 17:15-17:45. Room Aula.

In this work we consider a transport equation with stochastic coefficients which model pollution concentration

$$\begin{aligned} -\mathrm{div}(\varrho(x,\omega_d,\omega_t)) &= f(x,\omega_t) \ \text{ in } \ \mathcal{G}\times\Omega,\ \mathcal{G}\subset R^3, \\ \varrho(x,\omega_d,\omega_t) &= a(x,\omega_t)\nabla c(x,\omega_d,\omega_t) - \vec{q}(x,\omega_d)c(x,\omega_d,\omega_t), \\ c &= 0 \ \text{ on } \ \partial\mathcal{G}, \end{aligned}$$

where ω_d, ω_t are random variables, $a(x,\omega_t)$ be a diffusion coefficient, modelled by a random field, $c(x,\omega_d,\omega_t)$ is the concentration of one substance in another substance and $\vec{q}(x,\omega_d)$ is a flow and the source term is modelled by $f(x,\omega_t)$. The flow $\vec{q}(x,\omega_d)$ can be computed from the equation predicting the groundwater flow through the aquifer $\mathcal{G}$. The governing equations are

$$\begin{aligned} -\mathrm{div}(\vec{q}(x,\omega_d)) &= p(x,\omega_d) \ \text{ in } \ \mathcal{G}\times\Omega_d, \mathcal{G}\subset R^3, \\ u &= g(x) \ \text{ on } \ \partial\mathcal{G}, \end{aligned}$$

where $\vec{q}(x, \omega_d) := \kappa(x, \omega_d)\nabla u(x, \omega_d)$, the conductivity coefficient $\kappa(x, \omega_d)$, the right-hand side $p(x, \omega_d)$ and the solution $u(x, \omega_d)$ are random fields. The term ∇u models the pressure gradient.
Application of the stochastic Galerkin method yields to huge matrices which require a cheap numerical representation. We offer to use hierarchical matrices and sparse tensor formats. These sparse data formats result in very efficient matrix (tensor) arithmetic with almost linear complexity. In the conclusion we give a numerical example.

Jijun Liu (South-East University, China)
"*Numerical realizations of inverse scattering problems for a complex obstacle*"
Minisymposium Talk on Tuesday, 11:30-12:00. Room B.

Inverse scattering problems are important research areas in inverse problems. These problems aim to detect the property of a scatterer from the information about the scattered wave such as its far field data, while the wave may be acoustic or electromagnetic waves, which are governed by the Helmholtz equation or the Maxwell equation, respectively. The inverse scattering problems for an obstacle with sound-soft or sound-hard have been researched theoretically and numerically. The present methods for such problems belong to two categories: approximation methods based on the optimization technique using finite incident waves and exact methods based on some blowing-up properties of indicator using infinite incident waves.
In this talk, we will introduce our recent work on inverse problems for some complex obstacle. By complex obstacles, we mean the obstacle in the following senses:

- the obstacle considered may include many obstacles, each of them is of smooth closed boundary with one of the boundary condition: sound-soft, sound-hard, or impedance boundary;
- the obstacle is of smooth closed boundary, but with different kind of boundary property in different part of the boundary;
- the obstacle is just an arc with different kinds of conditions at two sides of arc. The arc can be considered as the limitation of some classical obstacle shrunk in some direction.

We will present the numerical realizations of the boundary reconstruction for the complex obstacles, using the so-called exact method. That is, we construct some indicator function of the obstacle boundary and use the blowing-up property of indicator to reconstruct the boundary. The realization schemes as well as the approximation error analysis will be presented.
This is a joint work with Dr. M.Sini.

Elena Loli Piccolomini (Universita di Bologna)
"*Optimization methods for the regularization of image deblurring and denoising problems*"
Minisymposium Talk on Thursday, 10:30-11:00. Room D.

Regularization methods are necessary to solve image denoising and image deblurring problems. A large class of efficient regularization methods consists in the minimization of the function

$$J(\mathbf{x}) = F(\mathbf{x}) + \lambda R(\mathbf{x})$$

where $F(\mathbf{x})$ describes the data fitting, $R(\mathbf{x})$ is the regularization term and λ is the regularization parameter.The choice of $F(\mathbf{x})$ depends on the kind of the noise present on the data, while the choice of $R(\mathbf{x})$ is related to the characteristics of the images to be restored. For example, the classical Tikhonov quadratic term and the Total Variation function are widely used in astronomical and medical applications.
This talk is on a joint work with G. Landi and F. Zama, where superlinear iterative methods for the minimization of $J(\mathbf{x})$ (with different functions F and R) are considered.
A crucial point in the regularization process is the choice of λ. We also propose iterative methods computing both a good value of λ and the solution of the minimization problem in an efficient way.

Ignace Loris (Vrije Universiteit Brussel)
"*On the convergence rate of iterative ℓ_1 minimization algorithms*"
Minisymposium Talk on Tuesday, 12:00-12:30. Room C2.

Recently, applications of sparse methods in signal analysis and inverse problems have received a great deal of attention. An approach, applicable to the regularization of linear inverse problems $Kx = y$ with noisy data y, consists of adding a 'sparsity-promoting' ℓ_1-norm penalty to a least squares functional: $\bar{x}(\lambda) = \arg\min_x \|Kx - y\|^2 + 2\lambda\|x\|_1$. Quite a number of different iterative algorithms exist for finding

the minimizer $\bar{x}(\lambda)$. It is therefore necessary to discuss robust ways of evaluating and comparing the performance of these 'competing' methods. The aim of this talk is to propose a procedure that assesses the strengths and weaknesses of these minimization algorithms for a *range* of penalty parameters λ.
As examples, both strongly ill-conditioned operators and Gaussian random matrices (less ill-conditioned) are considered, the former being more demanding on the algorithms. We also compare the performance of two warm-start strategies that yield a whole set of minimizers (for different penalty parameters) in a single run. I will also discuss a novel gradient projection algorithm (with steplength selection rules), which compares favorably with the fastest algorithms available to date for ℓ_1 penalized least squares minimization.
Application of these algorithms to problems of seismic tomography, often with millions of variable and highly incomplete data, is also briefly discussed.

Ignace Loris (Vrije Universiteit Brussel)
"*Novel regularization techniques for seismic tomography*"
Minisymposium Talk on Friday, 16:15-16:45. Room A.

The effects of several novel regularization techniques are discussed in the framework of 3D seismic tomography. These include traditional ℓ_2 penalties, but also a sparsity promoting ℓ_1 penalty and a total variation penalty. Which of these algorithms is judged optimal depends on the specific requirements of the scientific experiment. If the correct reproduction of model amplitudes is important, classical damping towards a smooth model using an ℓ_2 norm works almost as well as minimizing the total variation but is much more efficient. If gradients (edges of anomalies) should be resolved with a minimum of distortion, we prefer ℓ_1 damping of Daubechies-4 wavelet coefficients. We did not test curvelets or shearlets. It has the additional advantage of yielding a noiseless reconstruction, contrary to simple ℓ_2 minimization which should be avoided. Surprisingly, nonlinear ℓ_1 methods for finding sparse models can be competitive in speed with the widely used ℓ_2 methods, certainly under noisy conditions, so there is no need to shun ℓ_1 penalizations.

Alfred Louis (Saarland University)
"*Feature reconstruction in tomography*"
Invited Talk on Monday, 09:00-10:00. Room C1.

The motivation for tomographic examinations is to get information on the internal structures of the scanned object, either a human being in medical imaging or a work piece in non-destructive testing. So far the information was presented in form of series of images, and the task then was to extract the searched-for features. As a first step often image enhancement methods are applied, disregarding the reconstruction procedure. In edge detection for example the image is again smoothed and then differentiated.
The aim of this presentation is to provide a general strategy for optimally combining these two steps of image reconstruction and image enhancement in just one procedure, leading to very efficient algorithms. The theoretical background is formulated for abstract inverse problems and the application of linear operators on the reconstructed objects. To this end, the reconstruction kernel in the approximate inverse is modified depending on the desired features and the smoothing properties of the involved operators. Suitable invariance properties preserve the efficiency of the reconstruction algorithm for computing the features.
As example we discuss x-ray tomography in two and three dimensions combined with edge detection, smoothing for very noisy data and finally for the calculation of wavelet coefficients of the object. Numerical results are presented for synthetic and for measured data.

Shuai Lu (Johann Radon Institute)
"*Multi-parameter regularization and its numerical realization*"
Minisymposium Talk on Friday, 14:00-14:30. Room C1.

In this talk, we propose and analyze a choice of parameters in multi-penalty regularization. A modified Morozov discrepancy principle is presented within the multi-parameter framework. An order optimal error bound is obtained under some smoothness assumptions. We also propose a numerical realization of the multi-parameter discrepancy principle based on the model function approach. Numerical experiments on a series of testing problems support theoretical results.

Manabu Machida (University of Pennsylvania)
"*Optical Tomography Based on the Method of Rotated Reference Frames*"
Minisymposium Talk on Monday, 10:30-11:00. Room B.

We solve an inverse problem for the radiative transport equation. Light traveling in a turbid medium is governed by the radiative transport equation. When the angular dependence of the specific intensity of light is weak, the light is also described by the diffusion equation. In optical tomography, theory of imaging is often formulated based on the diffusion equation because of its mathematical simplicity. However, the diffusion equation works well only away from the boundary of the turbid medium. Our formulation is based on the radiative transport equation and applicable to the whole region. In the formulation, the radiative transport equation is solved with the method of rotated reference frames. Since this method is semi-analytic, our method realizes fast reconstruction of three-dimensional objects in a slab-shaped chamber.

Robert S. MacLeod (The University of Utah)
"*Lest we forget–the Clinical Expectations and Requirements for Useful Simulation of Cardiac Bioelectricity*"
Minisymposium Talk on Thursday, 10:30-11:00. Room A.

The ultimate goal of any bioelectric field inverse solution is clinical application for diagnostic or monitoring of patients. Despite several decades of active research, this goal has been only rarely achieved so that the clinical impact of the discipline remains elusive. In this presentation, we will review the current state of the field with special focus on two aspects: clinical need and new approaches to problem formulation. The use and importance of the ECG in clinical applications continues to decrease as other modalities improve and provide more specific diagnostic information for a range of abnormalities. The ascending opportunity for applications of inverse problems lies arguably in the domain of cardiac mapping, i.e., recording potentials directly from or near the heart by means of catheter based electrode systems.
The possibility of new problem formulations seems the brightest spot on the horizon for clinically relevant inverse solutions in cardiac electrophysiology. Perhaps most promising is the emerging interest in identifying the locations of myocardial ischemia, a condition that arises due to inadequate blood supply to the tissues of the heart. While other imaging modalities like MRI can visualize infarcted (scarred) regions of the heart weeks to months after the ischemia, and ultrasound in the hands of a skilled operator can coarsely localize areas of weak contraction during acute ischemia, there is no clinically viable means of estimating the extent and magnitude of ischemia that is accurate in space and acute in time. The challenge for the inverse problem of ischemia then becomes to develop a realistic source model that both represents the underlying electrophysiology and leads to a mathematically tractable (and unique) inverse solution. We will present some of our recent experimental and simulation studies aimed at formulating such a source model and describe some of the surprising results about the very nature of acute myocardial ischemia.

Bernard Mair (University of Florida)
"*Cardiac Image and Motion Estimation from Poisson Data*"
Minisymposium Talk on Friday, 15:00-15:30. Room C1.

Estimating myocardial perfusion and metabolism at different phases of the cardiac cycle from PET and SPECT data present significant challenges due to short imaging times and cardiac motion. I will present a method that combines reconstruction of the heart wall at all phases of a single heart beat and estimation of the cardiac motion between these phases in a single algorithm.Â A novel feature of this method is the mutual influence between the reconstructed images and motion estimates. The method is implemented by using a new statistical algorithm for penalized maximum likelihood image reconstruction and standard deterinistic algorithms for non-rigid image registration.

Alison Malcolm (Massachusetts Institute of Technology)
"*Mathematical and Numerical Modeling of Imaging with Ultrasound Vibro-Acoustography*"
Minisymposium Talk on Tuesday, 11:30-12:00. Room A.

Ultrasound vibro-acoustography is a novel imaging technique in which the nonlinear interaction of two focused high-frequency beams is exploited to form a low-frequency image of the tissue at the focus point. Understanding the forward and inverse problems for this imaging modality is complicated by the inherent nonlinearity, the variety of scales involved, as well as uncertainties in the mathematical model underlying the technique. Through the use of a simplified acoustic model, we have developed a numerical modeling strategy tailored to the various scales, to improve our understanding of the forward problem. Understanding the forward problem enables us to investigate the inverse problem of estimating, both linear and nonlinear, parameters of the medium based on recorded image values. This presentation will address several approaches to the inverse problem including: adjoint methods, adapting the imaging technique to isolate relevant parameters and gradient-descent approaches. This work is joint with Fernando Reitich, James Greenleaf and Mostafa Fatemi.

Dante Mantini (University of Chieti-Pescara)
"*EEG-based analysis of neuronal activation in fMRI large-scale networks*"
Minisymposium Talk on Monday, 11:00-11:30. Room A.

Two major non-invasive techniques in cognitive neuroscience, electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), have complementary advantages with regard to their spatial and temporal resolution. Recent hardware and software developments have made it feasible to acquire EEG and fMRI data simultaneously. We propose the integration of EEG and fMRI recordings, enabling the EEG temporal dynamics of information processing to be characterized within spatially well-defined fMRI large-scale networks. First, the fMRI data are decomposed into networks by means of spatial independent component analysis (sICA), and those responding to the task performance are selected by using information from EEG at selected electrodes. Next, the EEG data over all sensors are averaged with respect to event timing, thus calculating event-related potentials (ERPs). The ERPs are decomposed by means of temporal ICA (tICA), and the resulting components are localized with the weighted minimum norm (WMNLS) algorithm using the task-related networks as fMRI priors. The average current source activity within the regions of interest (ROIs) in each network is measured for each ERP component. Therefore, the contribution of the ERP component in each area belonging to the fMRI large-scale networks is estimated. For demonstrating the effectiveness of the proposed approach, we used simultaneous EEG-fMRI recordings from 13 healthy subjects, who performed a visual target detection task. The analysis of fMRI data showed the activation of three large-scale networks in response to the presentation of targets: the visual, the core and the ventral attention networks. Using fMRI-weighted EEG localization, different activation timing of these networks could be observed. The visual network was mostly dedicated to sensory processing, with a response at about 90 ms. The core network showed a response between 200 and 250 ms, that could be related to task monitoring. The ventral attention network showed a biphasic brain response between 280 and 350 ms, that can be ascribed to change detection and related memory processes. These findings suggest that P3a and P3b components, commonly observed in EEG when presenting novel and salient stimuli respectively, are related to the neuronal activation in large-scale networks, operating at different latencies and associated with different functional processes.

David Mary (Laboratoire Fizeau, Parc Valrose, Nice)
"*Image reconstruction in radio and optical interferometry*"
Minisymposium Talk on Thursday, 15:15-15:45. Room C2.

Astronomical interferometry is the process of collecting information about the two-dimensional Fourier spectrum of a celestial scene. Ideally, each spatial configuration of the receivers (antennas or telescopes) corresponds to a measure of the Fourier spectrum sampled at a particular frequency.
The number of the achievable configurations of receivers is limited ; the number of data samples is thus (much) less than the number of image pixels that could be reconstructed by inverting the fully sampled Fourier spectrum.
The problem is usually even more difficult in optical interferometry for which the current detectors allow to measure only partial information on the phases of Fourier samples, or just no phase information at all. From the point of view of the image reconstruction, astronomers face therefore an undertermined inverse problem which is linear in radio interferometry, and usually non linear in optical interferometry.
Because astronomical images are usually compressible, there are strong connections between the problems arising in interferometry and the Compressed Sensing (CS) framework using partial Fourier matrices.
During the last five years, theoretical CS results have been obtained on the interplay between the degree of sparsity of the sensed signals and the number of measurements required to achieve their reliable reconstruction. In addition many algorithms involving convex optimisation techniques have been designed in connection with the CS approach in order to practically reconstruct reliable images.
This work investigates the relevance of the theoretical results obtained so far in CS for the two interferometric techniques mentioned above. We also present recent results of methods using sparsity or compressibility as an *a priori* knowledge in interferometric imaging, and compare them to existing techniques. We investigate how other types of constraints could help regularizing the reconstruction, in particular constraints involving multiwavelengths observations, as those will soon become routinely

achievable in the new generation of interferometers.

Andreas Maurer (Compuserve)
"*Bounding the inverse of the sample covariance matrix and applications to machine learning*"
Minisymposium Talk on Tuesday, 10:30-11:00. Room D.

I give a probabilistic lower bound on the distance from a fixed point to the span of a small iid sample of a bounded random vector with values in a Hilbert space. The bound is expressed in terms of norms of the covariance operator associated with the random vector. Applied to linear regression with square loss it leads to small sample size lower error bounds for kernel algorithms.

Anna Mazzucato (Penn State University)
"*Determination of material properties from boundary measurements in anisotropic elastic media*"
Minisymposium Talk on Monday, 15:45-16:15. Room A.

We discuss recent results on the unique determination of material properties (elastic moduli and density) in anisotropic elastic media from displacement-traction measurements made at the boundary.

Joyce McLaughlin (Rensselaer Polytechnic Institute)
"*Imaging Biomechanical Properties of Tissue Using Wave Propagation Data: Application to Prostate and Liver*"
Minisymposium Talk on Tuesday, 12:00-12:30. Room A.

The goal is to image shear stiffness biomechanical properties, the tissue properties felt by the doctor in the age old diagnostic technique, the palpation exam. To achieve the data needed to create images, a single frequency or pulse excitation is made either on the surface of the body or by focusing ultrasound successively in the interior of the body. This excitation is very low amplitude and not uncomfortable for the individual. In all cases a wave propagates either with a front, as a single frequency excitation, or as a combination of two single (nearly the same but different frequencies) harmonic waves. Successive ultrasound or MR images are processed to obtain a movie(s) of the propagating wave whose amplitude is on the order of microns. In some cases a movie is created for only the largest component of displacement; in others movies are made of all three components. The movie(s) that is (are) created has (have) sufficient frame rate to resolve the space and time changes of the propagating wave.
For these dynamic experiments, the linear equations of elasticity (or for the viscoelastic case, the linear solid model) is used when more than one displacement component is measured; the wave equation or the viscoelastic wave equation are used when only one component of displacement is measured. Based on these models, the imaging functionals satisfy a first order system of p.d.e.'s.
A common approximation is to eliminate the first order derivatives and image the resulting functional as a solution of an algebraic equation. We will exhibit an error bound for difference between this approximate functional and the true imaging functional. Three robust algorithms will be presented that each find the imaging functionals by solving the first order p.d.e. The algorithms are based on finite difference techniques and can be applied even in irregularly shaped domains. Application will be shown for in vivo data for the liver.

Silvio Melo (Centro de Informatica - UFPE)
"*A Rational B-splines Tomographic Reconstruction of the Catalyst Density Distribution Function*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

A novel method of tomographic reconstruction is presented. Based on the Algebraic Reconstruction Technique (ART), our method represents the density distribution function of the object being reconstructed as a rational B-splines surface. The application focused in this work is the reconstruction of the catalyst density distribution in an FCC cracking unit, called riser, present in any oil refinery. A traditional ART method takes as unknowns the intensity of all the atomic cells (pixels) in the grid where the reconstructed model is supposed to be represented. With the use of weighted control points, and assuming that the density distribution function is smooth, it is possible to reduce the size of the resulting linear system up to 50

Thomas Migliore (Universite de Nice Sophia-Antipolis)
"*Transport parameter estimation in hydro-geological media*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

Antonino Morassi (University of Udine)
"*Detecting damage in a steel-concrete composite beam by finite eigenvalue measurements*"
Minisymposium Talk on Tuesday, 12:00-12:30. Room B.

This paper deals with the inverse problem of detecting damage in a composite system formed by the connection of a steel beam and a reinforced concrete beam. The small vibrations of the composite beam are described by a differential system where a coupling takes place between longitudinal and bending motions. The free vibrations are governed by two second order and two fourth order differential operators, which are coupled in the lower order terms by the shearing, k, and axial, μ, stiffness coefficients of the connection. The coefficients k and μ define the mechanical model of the connection at the interface between the steel beam and the concrete beam, and they contain direct information on the integrity of the system. In this paper we study the inverse problem of determining k and μ by finite eigenvalue data. The inverse problem is formulated as a variational problem for a least-square functional and, based on analytical expressions of the eigenvalue derivatives, a gradient descent method is proposed for identifying the unknown coefficients. Numerical simulations on real steel-concrete beams show the performance of the resulting algorithm. The stability of the identification method in presence of noise on the data and the role of some a priori information on the solving procedure are also investigated.
This paper is a joint work with Shuichi Jimbo, Gen Nakamura (both from Department of Mathematics, Hokkaido University) and Kenji Shirota (Department of Mathematics and Information Science, Ibaraki University).

James Nagy (Emory University)
"*Efficient Iterative Algorithms for Blind Deconvolution*"
Minisymposium Talk on Friday, 14:30-15:00. Room C2.

In many imaging situations, such as in astronomy and microscopy, the observed image is degraded by blurring and noise, and computational post processing techniques are often needed to improve the resolution of the image. This post processing is usually called deconvolution when the true blurring operator is known, whereas blind deconvolution implies that the blurring operator is not known. Blind deconvolution typically requires using iterative methods to solve large scale, nonlinear optimization problems. In this talk we describe an efficient variable projection Gauss-Newton method to solve the blind deconvolution problem. Tikhonov regularization is incorporated using an iterative Lanczos hybrid scheme, where regularization parameters are chosen automatically using a weighted generalized cross validation method, thus providing a nonlinear solver that requires very little input from the user. In addition, we consider approaches that incorporate nonnegativity constraints and preconditioning, which provide both additional prior information and help to improve computational efficiency. Numerical examples will be presented to illustrate the performance of the proposed methods. This is joint work with Julianne Chung and Veronica Mejia-Bustamante.

Gen Nakamura (Hokkaido University)
"*Inverse problems for reconstructing the medium discontinuities*"
Invited Talk on Friday, 09:00-10:00. Room C1.

In about 15 years or so several reconstruction schemes have been proposed for the inverse scattering problems. This is the problem to recover the unknown discontinuities such as cracks, cavities and inclusions inside a known medium from the measurements which measure the so called far field patterns of scattered waves generated by the unknown discontinuity and giving incident waves of plane wave type from infinitely many directions. The other familiar schemes are the factorization method, singular sources method, probe method, no-response method, range and enclosure method.
As far as the unknown discontinuities are compact, it is known that this inverse scattering problem is equivalent to the so called inverse boundary value problem. That is taking a domain with Lipschitz boundary which contains all the unknown discontinuities of the medium, recover the discontinuities from the so called Dirichlet to Neumann map defined on the boundary of this domain whose graph is the set of all the Cauchy data on the boundary of this medium for all the solutions to the governing equation which describes the waves propagating inside the medium. Here it should be remarked that the waves

considered here so far are all stationary waves with fixed wave number. For the inverse boundary value problem, there are also corresponding schemes for the above mentioned reconstruction schemes.
Recently, dynamical probe method for the inverse boundary value problem has been developed. This is reconstruction scheme for identifying unknown discontinuities inside a known medium. The measured data for this method are infinitely many sets of temperature and the corresponding heat flux at the boundary of the mediums. For simplicity, such an inverse boundary value problem will be referred as inverse boundary value problem for heat equation. The advantage of this method is that it is easy to repeat the measurement in a short time so that many measured data can be easily collected. Because of this, infinitely many measurements can become more realistic for this method.
In my talks I will mainly focus on the inverse scattering problem for stationary waves with fixed wave number and inverse boundary value problem for heat equation. For inverse scattering problem, several links between aforementioned reconstruction schemes and a framework which can unify these reconstruction schemes will be given. Although the idea is not new, the dynamical probe method has been newly developed. Hence, I will try to give a short overview of the method and current state of its study.

Carmeliza Navasca (Clarkson University)
"*Swamp reducing technique for tensor decomposition*"
Minisymposium Talk on Friday, 16:45-17:15. Room Aula.

To be announced.

Carmeliza Navasca (Clarkson University)
"*A regularization method for tensor decomposition*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

Tensor decomposition has been applied in many fields, such as, signal processing, data mining, chemometrics, and scientific computing. To facilitate the applicability of tensor analysis, the numerical techniques must improve to accommodate new data. We present a new numerical method for tensor decomposition. The method is based on the iterated Tikhonov regularization and a parameter choice rule. Together these elements dramatically accelerate the well-known Alternating Least-Squares method. In most techniques, choosing the regularization parameter requires the noise level. In this paper, we use the quasi-optimality criterion to find the regularization parameter without requiring knowledge of the noise level.

Linh Nguyen (University of Texas A&M)
"*Inversion formulas in Thermoacoustic Tomography*"
Minisymposium Talk on Thursday, 15:45-16:15. Room Aula.

I will present a family of backprojection type inversion formulas in Thermoacoustic Tomography that contains as particular cases most of previously known closed form reconstructions for acoustically homogeneous media. This is joint work with Peter Kutchment.

Bjorn Fredrik Nielsen (Simula Research Laboratory)
"*The inverse ischemia problem; mathematical models and validation*"
Minisymposium Talk on Thursday, 12:00-12:30. Room A.

The bidomain model is a set of differential equations modelling the electrical activity of the heart. It was developed during the seventies and is now extensively used for simulating the voltage distribution in the myocardium. We explore the possibilities for using this model, biomedical knowledge, the theory of inverse problems and ECG recordings for identifying ischemic heart disease. Myocardial ischemia is a reversible precursor of heart infarction and one of the most common diseases worldwide.
In the first part of the talk we will address modelling issues and various mathematical aspects. It turns out that the problem can conveniently be split into two subtasks;

a) the computation of the potential at the heart surface from ECG measurements,

b) the computation of the shift in the transmembrane potential, i.e. the ischemic region, from the heart surface voltage distribution determined in step a).

Problem a), which can be regarded as the classical Cauchy problem for an elliptic PDE, is well-known to be severely ill-posed. We have proven that b) is a stable problem but does not have a unique solution, further apriori information must be invoked.

The second part of the presentation is devoted to our experience with real world data recorded by our collaborators at Rikshospitalet HF (one of Norway's largest hospitals).
This talk summarizes results obtained by a number of scientists at Simula Research Laboratory and Rikshospitalet HF in Oslo, Norway and University of Münster, Germany.

Bjorn Fredrik Nielsen (Simula Research Laboratory)
"*An operator theoretical approach to preconditioning optimality systems*"
Minisymposium Talk on Thursday, 15:45-16:15. Room C1.

We propose a rather general preconditioning strategy for the numerical treatment of linear optimality systems (OS) arising in connection with inverse problems for partial differential equations. If this kind of inverse problems are stabilized with Tikhonov regularization then it follows from classical theory that the associated OS is well-posed, provided that the involved state equation is well-behaved.
The purpose of our work is to explain and analyze how certain mapping properties of the operators appearing in the OS can be employed to define efficient preconditioners for finite element (FE) approximations of the involved saddle point problem. More specifically, it turns out that it is possible to define a scheme such that the number of iterations needed to solve the preconditioned problem is bounded independently of the mesh parameter h, used in the FE discretization, and only increases moderately as the regularization parameter α tends towards zero. In fact, if the associated energy norm is used to define the stopping criterion for the iteration process, then the number of iterations required (in the severely ill-posed case) cannot grow faster than $O((\ln(\alpha))^2)$. This result is obtained by carefully analysing the properties of the involved operators and thereby revealing the distribution of the eigenvalues of the preconditioned OS.
Our theoretical results will be illuminated by a number of numerical experiments.
This is joint work with Kent-André Mardal, Simula Research Laboratory, Oslo, Norway.

Arian Novruzi (University of Ottawa)
"*Polygons as optimal shapes with convexity constraint*"
Minisymposium Talk on Thursday, 16:15-16:45. Room Aula.

In this work, we focus on the following general shape optimization problem:

$$\min\{J(\Omega) : \Omega \; convex, \; \Omega \in \mathcal{S}_{ad}\},$$

where $\mathcal{S}_{ad}$ is a set of 2-dimensional admissible shapes and $J : \mathcal{S}_{ad} \to R$ is a shape functional.
Using a specific parametrization of the set of convex domains, we derive some extremality conditions (first and second order) for this kind of problem. Moreover, we use these optimality conditions to prove that, for a large class of functionals (satisfying a concavity like property), any solution to this shape optimization problem is a polygon. This is joint work with J. Lamboley of Ecole Normale Superieure de Cachan, Antenne de Bretagne, France.

Konstantin Osypov (Schlumberger)
"*We can invert 10m x 10m covariance, now how should we analyze it?* "
Minisymposium Talk on Friday, 16:45-17:15. Room A.

Joint work with Dave Nichols, WesternGeco.
Velocity model building is one of the most challenging problems in seismic exploration. 3D tomographic analysis has become the key technology to tackle this problem. However, the tomographic inverse problem is ill-posed, which leads to big uncertainties and ambiguities in the reconstruction. The necessity to account for anisotropy in seismic velocities complicates this issue even further. To circumvent this, various forms of regularization are used. However, regularizing tomography still remains a subjective virtue, if not black magic. An alternative way to solving the inverse problem by means of a Bayesian framework for model estimation requires knowledge of prior information and data uncertainty. In general, for seismic 3D seismic tomography, prior information can come from other geophysical and borehole data, or more often as a geoscientist's input. In the latter approach it becomes difficult to rigorously quantify this input in terms of probability functions.
Singular value decomposition (SVD) provides an elegant framework for analysis of most significant dependencies between model and data. However, direct SVD application to seismic exploration tomographic problems counting $10^6 - 10^7$ model parameters and $10^7 - 10^8$ data samples is computationally prohibited. Alternatively, our approach deals with Lanczos iterations for inverse of the posterior covariance matrix in the preconditioned space. In our case, preconditioner is a smoothing operator. I'll primarily focus on analysis of some insights for the process of tomographic regularization and on strategies for uncertainty

and resolution quantification using the apparatus of eigendecomposition. One way to overcome the complexity of analyzing huge covariance matrix is to map it on a simpler (less dimensional) space. In our application, we translate posterior covariance matrix for anisotropic parameters into the covariance for structures imaged by seismic.

Reimo Palm (University of Tartu)
"*Minimization strategy for choice of the stopping index in conjugate gradient type methods for ill-posed problems*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

We consider ill-posed problem with linear continuous operator acting between Hilbert spaces. For finding approximate solution we use conjugate gradient type methods CGLS and CGME, minimizing in Krylov subspace the discrepancy or the error, respectively. If the noise level of data is known, we propose to take for the stopping index the minimum of certain expressions of stopping indexes from the discrepancy principle and from the monotone error rule. In case of roughly given or unknown noise level we propose to take for the stopping index the minimizer of certain functional in interval [1, N]. This functional is the product of decreasing function (difference of discrepancies on different iteration steps) and increasing function (which characterizes possible magnification of the data error on current iteration step) in method CGLS and discrepancy in method CGME. The endpoint N of the minimization interval is found from certain parameter choice rule (in CGME method and in CGLS method in case of roughly given noise level) or from increase condition of the functional to be minimized (in CGLS method in case of unknown noise level). Results of extensive numerical experiments are given.

Gunther Peichl (University of Graz)
"*The Shape Gradient for Problems of Bernoulli Type*"
Minisymposium Talk on Thursday, 11:00-11:30. Room Aula.

The shape derivative of the cost functional in a Bernoulli-type problem is characterized. The technique to calculate the derivative of the cost does not use the shape derivative of the state variable and is achieved under mild regularity conditions on the boundary of the domain.
This is joint work with J. Haslinger (Charles University Prague), K. Ito (North Carolina State University), T. Kozubek (VSB-Technical University Ostrava), K. Kunisch (University of Graz).

Sergei Pereverzyev (Johann Radon Institute)
"*Multi-parameter regularization in Learning theory*"
Minisymposium Talk on Tuesday, 12:00-12:30. Room D.

It has been observed that the problem of learning from examples can be reduced to an ill-posed operator equation with perturbed operator and free term. At the same time, in Numerical Analysis such equations are usually treated by Regularized Total Least Squares (RTLS) or by Dual Regularized Total Least Squares (DRTLS), that has been proposed recently. In both these methods a regularized solution is constructed as a minimizer of some Tikonov-type functional with two penalty terms. Thus, an application of RTLS and DRTLS to equations appearing in learning from examples is a natural and straightforward way for introducing multi-parameter regularization in the context of Learning theory. On the other hand, Mikhail Belkin, Partha Niyogi and Vikas Sindhwani (2006) have been proposed a family of learning algorithms based on the minimization of a Tikonov-type functional with two penalties to incorporate unlabeled data in a learning process. In the talk we are going to discuss a relationship between both of these approaches. In particular, we will show how a model function method proposed by Karl Kunisch and Jun Zou (1998) to realize the discrepancy principle in a one-parameter Tikonov regularization can be used in the context of learning.
Joint research with Shuai Lu, Sanaa Moussa, Sergiy Pereverzyev jun., Sivananthan Sampath and Ulrich Tautenhahn.

Michele Piana (University of Genova)
"*Regularization methods for the analysis of RHESSI data*"
Minisymposium Talk on Monday, 15:45-16:15. Room C2.

Much of the information on electrons accelerated in solar flares must come from remote sensing analysis of the bremsstrahlung radiation signature produced by the accelerated electrons. The quantity of central interest in this framework is the electron phase space distribution function which depends on the electron

energy and on the position of the source within the image. However, even neglecting significant second-order effects like albedo corrections or anisotropies in the emission, the inverse problem of determining information on this electron distribution function from measurements of the emitted radiation is highly ill-posed in the sense of Hadamard and therefore potentially affected by notable numerical instability. In this talk an overview of mathematical methods utilized to address this problem is given together with a discussion of possible future developments.
A necessary condition for reliably solving this inverse problem is the availability of high quality measurements. To this end, RHESSI has the unprecedented property of combining a high spectral resolution (1 keV in the range 10-100 keV) with a high spatial resolution (2 arcsec up to 100 keV), which makes this satellite the best hardware tool for performing imaging spectroscopy of the solar atmosphere.
RHESSI may provide two kinds of data. Spatially integrated spectroscopy, i.e. the reconstruction of the electron distribution integrated over the entire source region, utilizes as input data the count spectrum detected by RHESSI crystals at different count energies. The data formation problem is here modeled as a Volterra integral equation of the first kind whose integral kernel codes information on the probability of the emission process and on the response function of the detectors. Then, imaging spectroscopy can be performed by processing fully calibrated measurements of the Fourier transform of the radiation flux, named visibilities, encoded by means of the Rotating Modulation Collimators within the instrument. The image processing technique in this case is based on Fourier methods while the spectral inversion requires again the solution of a Volterra equation.
The mathematical and computational characteristics of both the spectroscopy and imaging spectroscopy problems will be described in the talk by using physically plausible synthetic data and applications to real measurements recorded in correspondence of flaring events.

Hanna Pikkarainen (Johann Radon Institute)
"*Convergence of Bayesian solutions of linear inverse problems*"
Minisymposium Talk on Friday, 14:30-15:00. Room C1.

We study convergence of regularized solutions of linear inverse problems obtained by Bayesian approach in the Ky Fan metric. We are interested in convergence issues when a linear inverse problem between real separable Hilbert spaces is discretized via projection. We show that the finite dimensional conditional mean estimate cannot converge in the Ky Fan metric to the least squares minimum norm solution as the dimension tends to infinity and the noise tends to zero. We propose a weighted Bayesian approach which can be obtained by changing the norm in the underlying space. We prove that both the weighted conditional mean estimate and the weighted posterior distribution obtain order optimal convergence rates when measured in the Ky Fan metric.
The work has been done in collaboration with Prof. Andreas Neubauer, Johannes Kepler University Linz, Austria.

Yulia Piterbarg (University of Southern California)
"*Approximation in the Deconvolution of Drinking Behavior from Transdermal Alcohol Biosensor Data*"
Minisymposium Talk on Thursday, 12:00-12:30. Room Aula.

Biosensor measurement of transdermal alcohol concentration in perspiration exhibits significant variance from subject to subject and device to device. Short duration data collected in a controlled clinical setting is used to calibrate a forward model for ethanol transport from ingestion to the blood to the sensor. The calibrated model is then used to invert transdermal signals collected in the field (short or long duration) to obtain an estimate for breath measured blood alcohol concentration and ingested alcohol as a function of time. A distributed parameter model for the forward transport of ethanol from the gut to the blood through the skin and its processing by the sensor is developed. Model calibration is formulated as a nonlinear least squares fit to data. The fit model is then used as part of an impulse train based scheme in the form of a frequency domain approach to determining temporal locations of drinking epochs and a regularized, non-negatively constrained linear deconvolution. Fully discrete, steepest descent based schemes for solving the resulting optimization problems are developed. The adjoint method is used to accurately and efficiently compute requisite gradients. Efficacy is demonstrated on subject field data. This is joint work with Drs. Alan Schumitzky and Yuliya Piterbarg of the University of Southern California, Dr. Linda Tempelman of Giner, Inc.in Newton, Massachusetts, and Dr. Robert Swift of the Alpert Medical School at Brown University and the Providence Veterans Administration Hospital in Providence, Rhode Island.

Francesca Pitolli (Universita' di Roma "La Sapienza")
"*Projected gradient methods and applications in magnetic tomography*"
Minisymposium Talk on Monday, 16:15-16:45. Room D.

The magnetic tomography (MT) aims at spatially resolving an unknown vector-valued current distribution from its magnetic field measured in the outer space.
MT has applications in many fields, i.e. geophysics, archaeological investigations, medicine, microelectronics, nondestructive testing. In particular, we focus our interest on magnetoencephalography (MEG) and nondestructive evaluation (NDE) of structures, where an image of the current distribution within the object under investigation has to be reconstructed in a noninvasive way. The drawbacks of MT is in that the measurements are distorted by high noise with often unknown statistical properties. In order to produce a current distribution image, we have to solve an inverse problem which is ill-conditioned and ill-posed.
Actually, in MEG and NDE applications the regions where the current flows are usually small. This means that the current distribution we want to reconstruct is spatially inhomogeneous and can be represented as a sum of weighted basic currents where only few terms are relevant. To reconstruct quantities with sparse patterns a regularization technique based on l_1-penalization can be used.
Our aim is to solve the magnetic inverse problem by using a gradient method with projection on l_1-balls. An implementation of the corresponding accelerated iterative algorithm, based on linear steepest descent method, is shown. Some numerical tests will be also displayed.
This is a joint work with Gabriella Bretti and Massimo Fornasier.

Robert Plemmons (Wake Forest University)
"*Parallel algorithms and Optimization Techniques for Multi-Aperture Image Superresolution Reconstruction*"
Minisymposium Talk on Monday, 12:00-12:30. Room .

Computational resolution enhancement (superresolution) for multiple images is generally regarded as a memory intensive inverse problem due to the large matrix-vector calculations involved. The shear magnitude of the data is one of the major impediments for combining multiple low resolution images into a high resolution image. A detailed study of the structure of the superresolution matrix associated with modern multi-aperture imaging cameras is used to decompose the overall system. As a result, previously large matrix vector products can be broken into many small, parallelizable products. An algorithm is presented that utilizes the structural results to perform superresolution on compact, highly parallel architectures such as Field-Programmable Gate Arrays (FPGAs). Tests are reported on our recently designed Practical Enhanced-Resolution Integrated Optical-Digital Imaging Camera (PERIODIC) system.
This is joint work with R. T. Guy and Q. Zhang.

Klaus Poetzelberger (University of Economics and Business Administration)
"*Asymptotically optimal quantizations*"
Minisymposium Talk on Thursday, 15:45-16:15. Room D.

We give a brief introduction to results on the asymptotics of quantization errors. The topics discussed include the quantization dimension, asymptotic distributions of sets of prototypes, asymptotically optimal quantizations, approximations and random quantizations.

Massimiliano Pontil (University College London)
"*Matrix Regularization for Multi-Task Learning*"
Minisymposium Talk on Tuesday, 11:30-12:00. Room D.

We present a method for learning representations shared across multiple tasks. The method consists in learning a low-dimensional subspace on which task regression vectors lie. Our formulation is a convex optimization problem, which we solve with an alternating minimization algorithm. This algorithm can be shown to always converge to an optimal solution. Our method can also be viewed as learning a linear kernel shared across the tasks and hence as an instance of kernel learning in which there are infinite kernels available. Moreover, the method can easily be extended in order to learn multiple tasks using nonlinear kernels. To justify this, we present general results characterizing representer theorems for matrix learning problems like the one above, as well as standard representer theorems. Finally, we briefly describe how our method connects to approaches exploiting sparsity such as group Lasso.
(Joint work with Andreas Argyriou, Thedoros Evgeniou, and Charles Micchelli)

Pornsarp Pornsawad (University of Potsdam)
"*Iterative Runge-Kutta type methods for nonlinear ill-posed problems*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

We consider a Fréchet-differentiable nonlinear ill-posed operator equation

$$F(w^{\varepsilon}) = g^{\varepsilon} \tag{5}$$

where $F : \mathcal{D}(F) \subset X \to Y$ with a non-closed range $\mathcal{R}(F)$ and a locally uniformly bounded Fréchet derivative $F'(\cdot)$ of F in $\mathcal{D}(F)$. Here X and Y are infinite-dimensional real Hilbert spaces. We assume that (5) has a solution w_* for exact data. We apply the Runge-Kutta (RK) method to the method of asymptotical regularization and then we obtain

$$w_{k+1}^{\varepsilon} = w_k^{\varepsilon} + \tau_k b^T \left(\delta + \tau_k A F'(w_k^{\varepsilon})^* F'(w_k^{\varepsilon})\right)^{-1} \mathbb{1} F'(w_k^{\varepsilon})^* \left(g^{\varepsilon} - F(w_k^{\varepsilon})\right), \tag{6}$$

where τ_k is the step size parameter, the $(s \times s)$ matrix A and the $(s \times 1)$ vector b are the given parameters which are corresponding to the specific RK method. The notation $\mathbb{1}$ means the $(s \times 1)$ vector of identity opertors of the appropriate spaces. Here δ is the $(s \times s)$ diagonal matrix of bounded linear operators with identity operator on the entire diagonal and zero operators outside of the main diagonal. Under a local property of the nonlinear operator in a ball we can prove that the RK-type iterative method (6) is a regularization method if the termination index k_* satisfies the discrepancy principle. The RK-type iterative method is successfully applied to the calculation of the aerosol extinction coefficient profile in our Earth atmosphere.
This is joint work with C. Böckmann, and it was supported by the European Commission with respect to the EARLINET-ASOS Project under grant 025991 (RICA).

Florian Potra (University of Maryland, Baltimore County)
"*On the numerical solution of nonlinear complementarity problems arising in nonsmooth multibody dynamics*"
Minisymposium Talk on Monday, 16:15-16:45. Room Aula.

The most accurate time-stepping schemes for simulating multibody systems with contacts and friction require the solution of a nonlinear complementarity problem at each integration step. We compare two methods for for solving this problem. The first method is based on a nonsmooth Newton method, while the second one is based on an interior point algorithm applied to a related linear complementarity problem over second order cones. The second approach seems to have some advantages when applied to inverse problems in nonsmooth multibody dynamics.

Marco Prato (University of Modena and Reggio Emilia)
"*Reconstruction of solar flare images using interpolated visibilities*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

One possibility to create images of high energy X-rays (or other radiations that cast shadows) is the use of a set of Rotational Modulation Collimators (or RMCs). The combined effect of the collimators' grids and the hardware rotation is a set of spatial Fourier components, called visibilities, sampled on spatial frequencies distributed over a set of concentric circles. I will introduce a fast and reliable method for X-ray imaging by applying an inverse FFT code to interpolated visibilities. I will also show that super-resolution effects can be obtained by utilizing a projected iterative algorithm.

Mihaela Pricop (University of Goettingen)
"*Interplay between deterministic and statistical inverse problems*"
Minisymposium Talk on Monday, 15:45-16:15. Room C1.

In this talk we consider nonlinear inverse problems both in a deterministic and statistical framework. We review the latest developments in the methodology, emphasizing the similarities but also the specifics related to the nature of the setting.
Furthermore, we present a convergence analysis for these methods and optimality results. In the end, new ideas are suggested for the theoretical study of this class of inverse problems.
The talk will be jointly given with Frank Bauer (Department of Knowledge-based Mathematical Systems, Johannes Kepler University Linz, Altenbergerstr. 69, 4040 Linz, Austria)

Jean-Pierre Puel (Ecole Polytechnique)
"*Non standard approach to a data assimilation problem.*"
Minisymposium Talk on Monday, 12:00-12:30. Room D.

We consider evolution problems like diffusion convection equations, or linearized Navier Stokes system, or related systems, which we would like to "predict" on a time interval $(T_0, T_0 + T)$ but for which the initial value of the state variable is unknown. On the other hand "measurements" of the solutions are known on a time interval $(0, T_0)$ and, for example, on a subdomain in space variable. The classical approach in variational data assimilation is to look for the initial value at time 0 and this is known to be an ill-posed problem which has to be regularized. Here we propose to look for the value of the state variable at time T_0 (the end time of the "measurements") and we prove on some basic examples that this is a well-posed problem. We give a result of exact reconstruction of the value at T_0 which is based on global Carleman inequalities and we give an approximation algorithm which uses classical optimal control auxiliary problems. We also show why Tychonov regularization for variational data assimilation works in practical situations corresponding to realistic applications, using the same mathematical arguments. Examples of computations will be given for a simple model of large scale ocean motion.

Eric Todd Quinto (Tufts University)
"*Stability estimates for limited data Radon transforms*"
Minisymposium Talk on Thursday, 12:00-12:30. Room C2.

We will define local and microlocal Sobolev seminorms and prove local and microlocal inverse continuity estimates for the Radon hyperplane and line transform in these seminorms. The relation between the Sobolev wavefront set of a function f and of its Radon transform is well-known (e.g., [Quinto SIAM J. Math. Analysis, 24(1993), 1215–1225]). However, Sobolev wavefront is a qualitative measure of singularities (a singularity is either in a specific Sobolev wavefront set or not) and therefore the relation in [*ibid.*] is qualitative. Our results will make the relation between singularities of a function and those of its Radon transform quantitative. This could be important for practical applications, such as limited data X-ray tomography or electron microscopy, in which the data are smooth but can have large derivatives. This is joint work with Hans Rullgård.

Torsten Raasch (University of Marburg)
"*Convergence rates of ℓ_1-constrained Tikhonov regularization from the viewpoint of nonlinear approximation*"
Minisymposium Talk on Friday, 16:15-16:45. Room C1.

We are concerned with ℓ_1-sparse Tikhonov regularization of continuous ill-posed problems $F(x) = y$ with noisy data y^δ. Traditionally, convergence rates of the associated reconstructions to the ideal solution x^+ are measured in powers of the data error δ, as δ tends to zero. The concrete algebraic rates that may be expected to hold under sparsity assumptions on x^+ have recently been analyzed by several authors. However, when arguing from the viewpoint of nonlinear approximation, another aspect comes into play. For fixed noise level δ and regularization parameter α, the corresponding Tikhonov regularization has a finite expansion in the underlying ansatz system. Therefore, one might ask how the number of active coefficients scales as δ and α tend to zero. At most, we can expect to observe the best N-term approximation rate of x^+. Questions of this type are well-known from the convergence and optimality analysis of adaptive discretization methods for well-posed operator equations, and some strategies can indeed be carried over to the case of inverse problems.

Ronny Ramlau (Johann Radon Institute)
"*Tikhonov regularization with sparsity constraints - analysis and applications in imaging*"
Minisymposium Talk on Thursday, 16:15-16:45. Room C2.

In this talk, we consider the regularization of (in general nonlinear) inverse problems $F(x) = y$ by Tikhonov regularization with sparsity constraints. To this end, the usually in function spaces defined operator F has to be transformed to a sequence setting, which is usually done by expressing a function through its coefficients with respect to a suitable frame or basis. The penalty term in the Tikhonov regularization is then defined as weighted ℓ_p norm with $p \in (0, 2)$. Using, e.g., a wavelet basis for the representation of a function, it is well known that Tikhonov regularization with sparsity constraints provides stable reconstructions. In particular, edges in images are much better reconstructed than it is the case for a standard reconstruction. We will present parameter choice rules, regularization results and convergence rate results for different types of operators. Also, we will introduce optimization methods that reconstruct minimizers of the Tikhonov functional, which is of particular interest if the penalty is given by the ℓ_p - "norm" with $0 < p < 1$. We will also investigate the problem of blind deconvolution, which is important in astronomy, and present an fast algorithm based on denoising the measured data by Tikhonov regularization with a sparsity type penalty.

Ronny Ramlau (Johann Radon Institute)
"*Multi - level iterative regularization of linear ill posed problems*"
Minisymposium Talk on Friday, 14:30-15:00. Room Aula.

In this talk, we consider the efficient regularization of linear inverse problems $A(x) = y$ by iterative methods. In order to solve the equation, which is usually defined in a function space setting, a discretization is needed, which transforms the operator equation into a matrix equation. For certain applications, the size of the matrix can be rather large, and also fast methods like conjugate gradient method need many iterations for the reconstruction of the solution. In order to reduce the numerical costs, we will introduce a cg variant that starts with a coarse discretization, leading to a small matrix and therefore to a cheap reconstruction on the coarse level. Based on the residual and a discrepancy principle, the discretization is subsequently refined. Only at the end of the iteration the finest discretization is used. In our approach, we use a discretization based on the wavelet decomposition of a function, and will subsequently refine the reconstruction by extending the current iterate to the next wavelet level. We will give analytical results of the method as well as numerical reconstructions. Also, we will present first results for a cg method that is based on an adaptive evaluation of the matrix. The work was done jointly with E. Klann and L. Reichel.

Andreas Rathsfeld (Weierstrass Institute Berlin)
"*Numerical Aspects of the Scatterometric Measurement of Periodic Surface Structures*"
Minisymposium Talk on Tuesday, 15:45-16:15. Room A.

Many optical phenomena, including the diffraction of light by masks or the illumination of photoresist in lithography, can be simulated mathematically by boundary value problems for the time-harmonic Maxwell equations and for the Helmholtz equation, respectively. For scatterometric measurements, however, an unknown object is illuminated by laser light and the reflected resp. transmitted wave modes are measured. In other words, the mathematical task of scatterometry is to solve the inverse problem, i.e., to determine the geometry from the values of the electro-magnetic field solution measured in the far-field.
Clearly, the high demands of scatterometric metrology on accuracy or precision cannot be satisfied by solving the full extremely ill-posed posed problem. Fortunately, the geometry reconstruction can be reduced to the determination of a small number of essential parameters. In our case, we may assume a periodic line-space structure with lines of a trapezoidal cross section. This structure is placed over a fixed multilayer system. It remains to determine parameters like width (critical dimension), height, and side-wall angles of the lines. We solve the direct problem by finite elements and the inverse problem by gradient based optimization methods. The latter minimize the least square deviation of the measured data from the simulated light data corresponding to the line-space structure with given geometry parameters. Of course, for scatterometric measurements, it is important to estimate the uncertainties of the reconstructed parameters. Such stochastic perturbations can be analyzed e.g. by the Monte Carlo method. For small perturbations, an approximate covariance matrix is easy to compute. Particularly, we discuss measurement uncertainties caused by deviations in the fixed model parameters such as the widths of the layers in the multilayer system beneath the line-space structure.
This is joint work with H.Gross.

Michela Redivo Zaglia (University of Padova)
"*Extrapolation techniques and multiparameter treatment for Tikhonov regularization*"
Minisymposium Talk on Thursday, 11:30-12:00. Room C1.

Tikhonov regularization method is a well-known technique for the solution of ill-conditioned systems of linear equation. The procedure depends on a parameter λ, and the main problem is to choose its best value.
An idea is to compute the regularized solution for several values of the regularization parameter λ. Then, these solutions are extrapolated at $\lambda = 0$ by various vector rational extrapolations techniques built for that purpose. These techniques are justified by an analysis of the regularized solutions based on the singular value decomposition and the generalized singular value decomposition. Numerical results illustrate the effectiveness of the procedures.

Then, we consider the case of several regularization terms added simultaneously, thus overcoming the problem of the best choice of the regularization matrix. The error of this procedure is analyzed and numerical results prove its efficiency.
This work was done in collaboration with C. Brezinski, G. Rodriguez, and S. Seatzu.

Teresa Reginska (Polish Academy of Science)
"*Application of a weak definition of the normal derivative to wavelet moment regularization of a Cauchy problem for the Helmholtz equation*"
Minisymposium Talk on Monday, 16:45-17:15. Room Aula.

We consider an ill-posed boundary value problem for the Helmholtz equation under Dirichlet and Neumann conditions posed on a part Γ of the boundary $\partial\Omega$ of Ω. Such a problem is sometimes called a Cauchy problem for the Helmholtz equation. The problems of existence of a solution and its uniqueness are considered for a general case of Lipschitz domains. The Cauchy problem is formulated in terms of a moment problem defined on the part $\partial\Omega \setminus \Gamma$ of the boundary $\partial\Omega$. In [1], by using a weak normal derivative we prove the corresponding equivalence theorem for arbitrary Lipschitz domain in R^d under the assumption that μ is not an eigenvalue of Neumann-Laplace operator on this domain. Moreover, uniqueness of a solution is shown for a general case when Γ is a non-empty open subset of $\partial\Omega$.
A method of regularization of the moment problem by projection with application of Meyer wavelet subspaces is introduced and analyzed in [2] for the two dimensional case. For the exact data an approximation error bound is found in the Besov spaces $B^s_{2,q}$, ($s < \frac{1}{2}$, $0 < q < \infty$). For noisy data, a rate of convergence is evaluated under a priori choice of projection level depending on a data error bound. Convergence and stability of the method are proved. The presented results extend a class of domains for which this method can be applied.
References
[1] W. Arendt, T. Regińska, An ill-posed boundary value problem for the Helmholtz equation on Lipschitz domains,*Ulmer Seminare 2007, Funktionalanalysis und Differentialgleichungen, Ulm University*
[2] T. Regińska, A. Wakulicz, Wavelet moment method for Cauchy problem for the Helmholtz equation, doi:10.1016/j.cam.2008.01.005, *J. Comp. Appl. Math*, (2008),

Lothar Reichel (University of Kent)
"*A fast edge-preserving multilevel method for deblurring, denoising, and segmentation.*"
Minisymposium Talk on Tuesday, 11:30-12:00. Room Aula.

We describe a fast edge-preserving cascadic multilevel image restoration method for reducing blur and noise in contaminated images. The method also can be applied to segmentation. Our multilevel method blends linear algebra and partial differential equation techniques. Regularization is achieved by truncated iteration on each level. Prolongation is carried out by nonlinear edge-preserving and noise-reducing operators. A thresholding updating technique is shown to reduce "ringing" artifacts. Our algorithm couples deblurring, denoising, and segmentation within a single framework. The talk presents joint work with Serena Morigi, Fiorella Sgallari, and Andriy Shyshkov.

Markus Reiss (University of Heidelberg)
"*Regularization independent of the noise level: an analysis of quasi-optimality*"
Minisymposium Talk on Tuesday, 15:45-16:15. Room C1.

The quasi-optimality criterion chooses the regularization parameter in inverse problems without taking into account the noise level. This rule works remarkably well in practice, although Bakushinskii has shown that there are always counterexamples with very poor performance. We propose an average case analysis of quasi-optimality for spectral cut-off estimators and we prove that the quasi-optimality criterion determines estimators which are rate-optimal on average. Its practical performance is illustrated with a calibration problem from mathematical finance. (joint with F. Bauer, Linz)

Elena Resmerita (Johann Radon Institute)
"*A dual norm iterative method for minimizing convex functions*"
Minisymposium Talk on Friday, 15:30-16:00. Room C1.

Continuous optimization methods have been frequently employed in solving inverse problems in the last decades, especially for Hilbert space and reflexive space settings. In this work, we consider nonreflexive Banach spaces which are duals of some Banach spaces (such as BV, ℓ_1), for which we propose an inexact version of the proximal point method for the minimization of a convex function and show its convergence.

The method can be applied to various classes of inverse problems.

Stefanie Reusswig (University of Mainz)
"*Numerical reconstructions from backscatter data in impedance tomography*"
Minisymposium Talk on Thursday, 15:45-16:15. Room B.

In this talk, we present numerical reconstructions from very sparse data in (two dimensional) electric impedance tomography. These data are the analogue to so-called backscattering data in inverse scattering. They arise in practice if the same single pair of electrodes is used to drive currents and measure voltage differences subsequently at various locations on the boundary of the object to be imaged.
We present two methods for the detection of inclusions within an object. The first one reconstructs a single inclusion by determining the conformal map that takes the outside of the inclusion onto an annulus. The second method reconstructs the so-called convex source support associated with the inclusions, which is a subset of their convex hull. The results presented here arise from joint research with Martin Hanke and Nuutti Hyvönen.

Andreas Rieder (University of Karlsruhe)
"*Towards a general convergence theory for inexact Newton regularizations*"
Minisymposium Talk on Monday, 10:30-11:00. Room C1.

We develop a general convergence analysis for a class of inexact Newton-type regularizations for stably solving non-linear ill-posed problems. Each of the methods under consideration consists of two components: the outer Newton iteration and an inner regularization scheme which, applied to the linearized system, provides the update. In this talk we give a novel and unified convergence analysis which is not confined to a specific inner regularization scheme but applies to a multitude of schemes including Landweber and steepest decent iterations, iterated Tikhonov method, and method of conjugate gradients. This is joint work with Armin Lechleiter.

Andreas Rieder (University of Karlsruhe)
"*A new view on phantom views*"
Minisymposium Talk on Thursday, 10:30-11:00. Room C2.

The phantom view reconstruction algorithm is designed to reduce streak artifacts in 2D-CT reconstructions caused by angular under-sampling. Basically this algorithm is the filtered backprojection algorithm (FBA) augmented by 'phantom views' which are created by interpolating the Radon data linearly with respect to the angular variable.
We investigate the convergence behavior of the phantom view method and show that its convergence order in the angular variable may indeed exceed the order in the lateral one. Accordingly optimal convergence in the lateral variable can be achieved while under-sampling the angular variable.
Moreover, we interpret the phantom view method as an angular average of FBA and are now able to characterize those edges in the images which get blurred by introducing phantom views.
This is joint work with Arne Schneck.

Wolfgang Ring (University of Graz)
"*Numerical treatment of perimeter regularization in the level-set context*"
Minisymposium Talk on Friday, 15:00-15:30. Room D.

Penalization of the perimeter is a standard regularization technique for ill-posed geometrical inverse problems. In the level-set context the perimeter term yield an additional mean-curvature term to the shape gradient term of unregularized the cost function. We discuss possibilities of semi-implicit discretizations for the regularization term and their influence to the quality of the reconstruction.

Giuseppe Rodriguez (Universita di Cagliari)
"*An algorithm for the least-squares solution of rank-deficient linear systems.*"
Minisymposium Talk on Friday, 15:00-15:30. Room Aula.

We will discuss a method for computing the least-squares solution to a rank-deficient linear system, based on the LU factorization of a suitable augmented matrix. This algorithm also provides information about the numerical rank and the null space of the coefficient matrix, and can be optimized in order to save computational time and storage when applied to some kind of structured matrices.

Gian Luca Romani (I.T.A.B.)
"*Localization of correlated cerebral networks from EEG/MEG data*"
Minisymposium Talk on Monday, 11:30-12:00. Room A.

Magnetoencephalography (MEG) and electroencephalography
(EEG) allow real-time tracking of synchronously firing neural populations and are, therefore, optimally suited for characterizing dynamical functional coupling among cerebral areas. Nevertheless, the non–uniqueness of the inverse problem makes the identification of neuronal source signals from measured electromagnetic fields non trivial without additional assumptions. A possible strategy to overcome such intrinsic limitation is to exploit important properties contained in the data without the need for additional assumptions. To this end, we first consider the problem of unmixing the contribution of uncorrelated sources, or equivalently uncorrelated cerebral networks, to a measured field. This problem is solved by developing a principal component analysis–based method, namely, the source principal component analysis (sPCA), which exploits the underlying assumption of orthogonality for sources, estimated from linear inverse methods, for the extraction of essential features in signal space. We then consider the problem of unmixing the contribution of correlated sources within each of the uncorrelated cerebral networks identified by using sPCA. While the sPCA orthogonality assumption is sufficient to separate uncorrelated networks, it cannot separate the individual sources within each network. To address that problem, we introduce the Minimum Overlap Component Analysis (MOCA), employing a pure spatial criterion to unmix pairs of correlates (or coherent) sources. The proposed methods are tested in simulations and applied to EEG data from human μ and α rhythms.

Luca Rondi (Universita‘ degli Studi di Trieste)
"*Reconstruction of discontinuous functions by perimeter penalization*"
Minisymposium Talk on Monday, 11:00-11:30. Room Aula.

We consider inverse problems where the determination of discontinuous functions is involved. For example, we may focus on the inverse conductivity problem with discontinuous conductivities, or the inverse crack or cavity problem, where the discontinuous function is the electrostatic potential whose discontinuities are located along the unknown crack or the boundary of the unknown cavity.
We present different possible regularizations of such problems. The regularizations used are linked to perimeter-like penalizations and we show their validity by convergence results.

Lorenzo Rosasco (Massachusetts Institute of Technology)
"*Inverse Problems Perspective on Learning*"
Minisymposium Talk on Monday, 16:15-16:45. Room C1.

We discuss how to formalize the problem of supervised learning as a linear inverse problem. Our goal is to show the intimate connection between Learning Theory and Regularization Theory for ill-posed problems, while giving a self contained introduction to the problem of learning from examples from an inverse problem perspective. Towards this end we give a survey of several recent results on this topic and present them in a unifying framework using the concepts of reproducing kernel and feature map.

Edi Rosset (Universita' di Trieste)
"*Unique determination of a cavity in an elastic plate by two boundary measurements*"
Minisymposium Talk on Monday, 16:15-16:45. Room A.

We consider a thin elastic plate subjected to a couple field applied at its boundary and we study the inverse problem consisting in determining an unknown cavity inside the plate by measuring the transversal displacement and its normal derivative at the boundary of the plate. We prove uniqueness with two measurements.
This is a joint work with Antonino Morassi (Università di Udine, Italy) and Sergio Vessella (Università di Firenze, Italy).

Kai Sandfort (University of Karslruhe)
"*Reconstruction of periodic inhomogeneous media by the Factorization Method*"
Minisymposium Talk on Friday, 15:00-15:30. Room B.

Scattering of acoustic and electromagnetic waves by bounded media occurs and is used in a large number of common applications, including remote sensing, non-destructive testing, and device design. Due to the strong development in material design and nanotechnology during the last decade, new applications of this kind arise. Here, the inverse problem consists in the reconstruction of the medium from measurements of the scattered waves. Mostly, the focus is on the detection or the optimization of its shape rather than on the complete characterization of the material. A well-known method for the shape identification is the Factorization Method, cf. the monograph "The Factorization Method for Inverse Problems" by Kirsch and Grinberg. In recent years, applications become increasingly important in which the scattering media have some periodic structure and can, in relation to the wavelength(s) of the radiation used, be considered in a mathematical model as infinite in size. The talk presents an extension of the Factorization Method to this problem in theory and in numerics. We follow a volume integral equation approach and consider, in particular, inhomogeneous periodic media. These include the practically relevant media with a piecewise constant, multivalued refractive index in modern acoustics and optics, e.g. diffraction gratings and photonic crystals. For the numerical example, however, we confine ourselves to a periodic medium with a continuous refractive index. We adapt the fast solver by Vainikko for the corresponding direct problem and reconstruct the medium by means of the simulated data.

Fadil Santosa (University of Minnesota)
"*An inverse problem in the design of progressive lenses*"
Minisymposium Talk on Tuesday, 10:30-11:00. Room C1.

A progressive lens is an ophthalmic lens worn by patients who needs a correction for far distance viewing and another correction for viewing objects that are near. This is accomplished by creating a lens which has a different corrective power depending on the direction of gaze of the eye. The corrective properties of a lens can be modeled by geometrical optics. We show how the design problem can be viewed as an inverse problem, and how, in a particular approximation, it leads to a nonlinear partial differential equation. Current research approaches will be presented.

Matthias Schlottbom (AICES Graduate School, RWTH Aachen)
"*Enhanced Numerical Methods for Optical Diffusion Tomography*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

Optical Diffusion Tomography (ODT) is a medical imaging technique based on absorption and scattering of near infrared light in biological tissue. The propagation of light in dense media is usually modelled by the Boltzmann equation, in which the scattering and absorption properties of the tissue under investigation enter as coefficients. For solving the inverse problem of determining the tissue properties from transmission measurements, the so-called diffusion approximation of the Boltzmann equation is most widely used. The inverse problem then reduces to a parameter estimation problem in an elliptic respectively parabolic pde. While on the one hand, the diffusion approximation facilitates the solution of the inverse problem, it also introduces a substantial modeling error on the other hand. As a result only qualitative reconstruction can be obtained. In order to obtain quantitative results, we investigate better approximations of the Boltzmann equation by higher order moment methods and other Galerkin methods in the velocity space, and compare to results obtained by the diffusion approximation.

Anselm Johannes Schmidt-Hieber (University of Goettingen)
"*Minimax Estimation of the Volatility in High-Frequency Models Corrupted by Noise*"
Minisymposium Talk on Tuesday, 16:45-17:15. Room C1.

In this talk we provide a theory for estimation of volatility in a Brownian motion model which is additionally corrupted by so called microstructure noise. These models play an important role in geostatistics and in the analysis of financial data which result from trading on very short time intervals. We investigate the ill posedness of the problem and show minimax rates for the scale functions. Further we construct estimators which rely on a very fine spectral analysis of the underlying processes. This is joint work with Axel Munk (Universität Göttingen), Tony Cai (UPENN, The Wharton School) and Marc Hoffmann (Paris VI).

Susanne Schmitt (University of Karslruhe)
"*The Factorization Method for EIT in Geoelectrical Imaging*"
Minisymposium Talk on Friday, 15:30-16:00. Room B.

In electrical impedance tomography (EIT) for geoelectrical imaging current is injected to the surface of the ground and the induced voltage is measured at the surface. From a set of these measurements one can obtain information about the conductivity distribution inside the ground.

The factorization method is a very successful method for detecting inclusions in EIT, i.e. domains in which the conductivity is different from the backgound for the cases of bounded bodies or the half-space geometry. The factorization method can be derived for a new geometry that is used in geoelectrical imaging. This geometry consists of a half space that is perturbed by topographical deviations at the surface and is bounded artificially from below such that energy absorbtion by the background is modelled. It is shown that inclusions with a higher or lower conductivity than the background as well as inclusions with a positive chargeability can be detected using the factorization method applied to this geometry. The advantage of using the new method is the boundedness of the computation domain, which allows a large flexibility concerning the actual topography and the background conductivity. The novel method has been integrated into the reconstruction software CEITiG using different electrode models, and reconstructions for several examples are performed.

Susanne Schmitt (University of Karslruhe)
"*REIT - Regularization Methods for Electrical Impedance Tomography in Medical and Geological Sciences*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

REIT is a joint project that brings together mathematical groups as well as applied groups in medicine, physics and geophysics who work on electrical impedance tomography (EIT) for thorax imaging, mammography and geoelectrical imaging. One aim of the project is to develop appropriate mathematical models for EIT in these applications, i.e. geometries, electrode models, realistic assumptions on the conductivity and on the measurable data. Moreover, the objective is the extension of recent regularization approaches to the inverse EIT problem such as the factorization method or integral equation based methods and their application to the mathematical models and real measurement data from medical as well as geophysical applications. Recent results and future developments are presented.

John Schotland (University of Pennsylvania)
"*Convergence and Stability of the Inverse Scattering Series in Near-field Tomography*"
Minisymposium Talk on Tuesday, 16:45-17:15. Room B.

The US National Nanotechnology Initiative has identified the problem of "seeing" matter at the nanoscale as a grand challenge. In this talk I will consider the problem from the standpoint of near-field optics and inverse scattering theory for wavefields with evanescent components. I will discuss recent work on inversion of the Born series and related convergence and stability results.

Christian Schuft (University of Goettingen)
"*Nonlinear integral equations for shape and impedance reconstruction from partial Cauchy data*"
Minisymposium Talk on Thursday, 11:30-12:00. Room B.

In a simply connected planar domain D a pair of Cauchy data of a harmonic function u in D is given on an accessible part of the boundary curve. On the non-accessible part, u is supposed to satisfy a homogeneous impedance boundary condition. We consider the inverse problem to recover the non-accessible part of the boundary or the impedance function. Our approach arises from a method that has been suggested by Kress and Rundell (2005) for recovering the interior boundary curve of a doubly connected planar domain. It is based on a system of nonlinear and ill-posed integral equations which is solved iteratively by linearization. In this talk we will present the foundation of the method and, in particular, show injectivity for the linearized system at the exact solution. Numerical reconstructions will show the feasibility of the method.

Thomas Schuster (Helmut Schmidt University)
"*Inversion of the vectorial ray transform on Riemannian manifolds*"
Minisymposium Talk on Thursday, 11:30-12:00. Room C2.

The vectorial ray transform measures line integrals over projections of a vector field onto the line of integration. It states the mathematical model in vector field tomography, where one tries to reconstruct a velocity field of a moving fluid or gaz from ultrasonic measurements. In some applications as seismics or polarization tomography however the ray is deflected away from straight lines but follows a geodesic in a non-Euclidean metric. In that case we get a vectorial ray transform on a Riemannian manifold

$$\mathbf{Rf}(x,\xi) = \int_{\tau_-(x,\xi)}^{0} \langle \mathbf{f}(\gamma_{x,\xi}(t)), \dot{\gamma}_{x,\xi}(t)\rangle \,\mathrm{d}t \qquad x \in M\,,\ \xi \in S^{n-1}$$

as mathematical model, where $\gamma_{x,\xi} : [\tau_-(x,\xi), 0] \to M$ is a geodesic satisfying the initial conditions $\gamma_{x,\xi}(0) = x \in \partial M$, $\dot{\gamma}_{x,\xi}(0) = \xi \in S^{n-1}$ and $M \subset R^n$ is a Riemannian manifold.
In the talk we are concerned with the inversion of that transform with the help of Fourier integral operators. The next step is the computation of reconstruction kernels where we can adopt some concepts from the Euclidean case. The talk includes also some first numerical results that are achieved by the method of approximate inverse.

Thierry Scotti (CNRS, Laboratoire de Mecanique et d'Acoustique)
"*The Non-Unicity Problem in Non Linear Parametric Identification*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

The subject of this contribution falls into the category of problems concerned with finding the location, shape, orientation and material characteristics of an object embedded in a well-characterized homogeneous, homogenized or heterogeneous unbounded medium by inversion of scattered waveform resulting from the propagation of probe radiation within the medium. Generally the ill posed nature of such problem is bypassed by adding to the cost function a penalty term involving a-priori information of the target. The present paper propose an alternative that does not appeal to any explicit regularization in order to incorporate the minimum amount of a-priori information in the process of parameter identification of a target.

Sebastiano Seatzu (Universita degli studi di Cagliari)
"*Numerical Inverse Scattering Transform Solving the Nonlinear Schroedinger Equation*"
Minisymposium Talk on Tuesday, 12:00-12:30. Room Aula.

The initial-value problem for the focusing nonlinear Schrödinger (NLS) equation

$$iut = u_{xx} + 2|u|^2 u\,, \quad (x,t) \in R^2;$$

is solved numerically by following the various steps of the inverse scattering transform (IST). First, by interpreting $u(x,0)$ as the potential in the focusing Zakharov-Shabat system

$$\frac{d}{dx}\begin{pmatrix} \psi_1(\lambda,x) \\ \psi_2(\lambda,x) \end{pmatrix} = \begin{pmatrix} \frac{i\lambda}{u(x,0)} & -u(x,0) \\ u(x,0) & -i\lambda \end{pmatrix} \begin{pmatrix} \psi_1(\lambda,x) \\ \psi_2(\lambda,x)\ , \end{pmatrix} \qquad x \in R$$

the Fourier transforms of the scattering Jost solutions are computed by solving a Volterra integral equation. Then the Marchenko integral kernel is evaluated by solving a Wiener-Hopf integral equation. Next, this kernel is propagated in time by a convolution integral. Finally, the time evolved Marchenko integral equation, which has a kernel depending on the sum of its arguments, is solved to yield the NLS solution $u(x,t)$. With the exception of the Volterra equation, upon discretization all steps lead to structured matrix systems for which numerical methods of low complexity are readily available. The numerical results are compared with those obtained by the split-step Fourier method.

Cristiana Sebu (Oxford Brookes University)
"*A regularized solution for the inverse conductivity problem using mollifiers*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

The inverse conductivity problem has attracted much attention because although it is relatively easy to state, it turns out to be both nonlinear and, above all, extremely ill-posed. Furthermore it has a practical realisation which is known as Electrical Impedance Tomography (EIT). Substantial progress has been made in designing practical reconstruction algorithms applicable to noisy measurement data. While the iterative methods based on formulating the inverse problem in the framework of nonlinear optimisation techniques are promising for obtaining accurate reconstructed conductivity values, they may be slow to converge and are quite demanding computationally particularly when addressing the three dimensional problem. This concern has encouraged the search for reconstruction algorithms which reduce the computational demands. Some use a priori information to reconstruct piecewise constant conductivity distributions e.g. [1,2] while others are based on reformulating the inverse problems in terms of integral equations [3-6].

In this paper we describe a reconstruction method suitable for $W^{2,\infty}$ conductivity distributions. It uses a simple transformation to establish a connection between the equations defining the inverse conductivity problem and those used in Inverse Scattering [7]. By combining this process with the powerful concept of mollifiers [8,9] we are able to obtain conductivity reconstructions for arbitrary geometry, extremely rapidly and without relying on accurate a priori information. This is achieved by reformulating the inverse problem in terms of a pair of coupled integral equations, one of which is of the first kind which we solve using mollifier methods. An interesting feature of this method is that the kernel of this integral equation is not given, but can be modified for the choice of mollifier. We also discuss the choice of optimal boundary data.
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Michael Seger (UMIT)
"*Non-Invasive Patient Individual Imaging of Cardiac Electrical Function using Multi-lead ECG Data: Drawbacks and Opportunities in the Electrocardiographic Inverse Problem*"
Minisymposium Talk on Thursday, 11:00-11:30. Room .

Computer modeling of bioelectric activity is of interest in cardiac electrophysiology and, furthermore, the non-invasive imaging of the electrical function from electrocardiogram (ECG) has become a powerful diagnosis tool in clinical applications. By combining measurements obtained by electrocardiographic body surface mapping with four-dimensional (3D and time) anatomical data, the electrical activation sequence of the patient individual human heart can be imaged non- invasively. This combination enables to solve the electrocardiographic inverse problem, which is commonly referred to as estimation of the source from measured fields. In the electrocardiographic inverse problem, the electrical distribution is reconstructed from body surface maps by employing an electrical source-model description. Because of the generally unknown individual cardiac fiber orientation, electrical isotropy is assumed in the surface heart model approach based on the bidomain theory. This imaging technique provides information about the spread of electrical excitation in order to assist the cardiologist in developing strategies for treatment of cardiac arrhythmias with highly reduced patient risk. In many cases it is possible to trace back common cardiac arrhythmias to accessory pathways, atrial or ventricular foci, e.g., from the pulmonary veins, and reentrant circuits. The non-invasive computational identification of the origin of the ectopic focus or the location of an accessory pathway provides essential information for treatment strategies, like catheter ablation. We performed detailed clinical studies (45 patients) for sinus (normal and Wolff-Parkinson-White syndrome) and paced rhythm data. The results show that the approach could become clinical applicable in near future.

Ivonne Sgura (Universita del Salento)
"*A variational approach for accuracy assessment of biomedical images*"
Minisymposium Talk on Friday, 15:30-16:00. Room Aula.

In this talk we present a variational approach based on the Mumford & Shah (MS) functional [1] to solve the *magnification or zooming* problem for a given digital image.
The MS model has been extensively considered for the noise suppression (*smoothing*) and extraction of shape (*edge detection*) and several numerical approaches have been proposed to approximate a minimizer (see e.g. [2]). In [3] was proposed a modification of the MS functional to deal also with the so called *inpainting* of a given image. This is a reconstruction (interpolation) problem aiming to recover some parts of the original images that are missing or damaged. A straightforward application of the inpainting approach is also the so called *magnification or zooming problem.* In this case the goal is to produce,

starting from an image with poor information on *few* pixels, an *improved* image which size in pixels is doubled or magnified a certain number of times. Typical interpolation schemes using information from neighboring pixels become problematic when the starting image is noisy. Hence, a suitable modification of the MS model can be a good alternative since denoising and magnification can be obtained simultaneously in a single framework. In [4], this idea has been addressed by a curve evolution and minimization algorithm. In our approach, we solve the Euler-Lagrange PDE equations associated with the modified MS functional by an iterative technique based on the finite difference method introduced in [5]. In particular, we show that this algorithm applied for the accuracy assessment of biomedical images for myocardial infarction prediction [6] and can be successfully integrated in a hardware design to improve cardio-vascular images [7].

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Samuli Siltanen (Tampere University of Technology)
"*Inverse conductivity problem and the Beltrami equation*"
Minisymposium Talk on Tuesday, 16:45-17:15. Room Aula.

The two-dimensional inverse conductivity problem of Caldeón is to recover an unknown electric conductivity inside a planar domain from voltage-to-current measurements at the boundary of the domain. The problem is the mathematical model of a practical imaging method called Electrical Impedance Tomography (EIT), which can be used for medical or industrial applications. Calderón posed in 1980 the following questions: is a strictly positive and essentially bounded conductivity function uniquely determined by electric boundary measurements? If so, how to calculate the conductivity from measurement data? Astala and Päivärinta [Ann. of Math. 2006] provided a positive answer to both of these questions in dimension two by making use of complex geometrical optics (CGO) solutions constructed via a Beltrami equation. However, as the EIT problem is severely ill-posed, or sensitive to measurement errors, the construction of Astala and Päivärinta must be regularized in order to apply it to realistic noisy data. In this talk, progress in the design of a practical EIT reconstruction method based on the Beltrami equation is reported. First, it is shown how to compute numerically CGO solutions for a given conductivity by solving a Beltrami equation. This part is related to the direct problem and its purpose is to provide test methods for candidate reconstruction methods. Second, preliminary reconstruction approaches are explained and illustrated by numerical computations.

Ralph Sinkus (ESPCI)
"*MR-Elastography: Principles, clinical application to breast, liver and brain and shear rheology*"
Minisymposium Talk on Tuesday, 10:30-11:00. Room A.

Ever since, palpation has been an integral and important part in the diagnostic procedures of for instance breast cancer detection or liver disease assessment. Thus, the clinical importance of the physical parameter ”elasticity = stiffness” is undisputed. Unfortunately, until now, it was not possible to measure elasticity non-invasively and with high spatial resolution in a tomographic manner. Elastography is overcoming the former technical limitations and fills an important gap: the non-invasive assessment of tissues mechanical parameters via MRI or ultrasound. Thus, former manual palpation turns now into a technique providing absolute physical numbers which can be used to for instance determine the grade of liver fibrosis or characterize the malignancy of a breast lesion.

None of the currently available non-invasive imaging techniques like MRI, CT or ultrasound are directly sensitive to elasticity. Thus, elasticity can only be inferred via an intermediate step. Elastography uses the fact that the propagation of low-frequency mechanical waves (similar to the hum of your shaver) is tightly linked to the underlying mechanical properties. Mechanical waves will propagate fast in stiff regions and slow in soft regions. Since MRI and ultrasound are techniques sensitive to motion (remember for instance MR-angiography or Doppler ultrasound), it is possible to image the propagation of these waves inside the body. The waves are typically generated via dedicated transducers on the surface and propagate deep into the body. Thus, MRI and ultrasound turn effectively into ”digital cameras” whose sole purpose is to capture the propagation of these waves. In a second step it is now necessary to ”convert” these waves into values of elasticity and viscosity, with viscosity being an indicator of tissue’s ability to absorb the mechanical wave. This ”inversion step” requires a fair amount of physics and math: in general it is necessary to image at least several adjacent slices and two components of the 3D wave field. Ultrasound elastography utilises a very specific mode of wave generation and can thus ”survive” with less stringent requirements. This, however, penalizes final data precision when compared to MRI. One interesting application of MRE is the domain of breast cancer. Breast cancer often shows a desmoplastic stroma reaction in terms of a reactive proliferation of connective tissue so that a dense layer of fibroblasts accumulates around malignant breast epithelial cells. This leads to a hardening of the breast tissue which can be diagnosed by palpation. The diagnostic importance of palpation within the domain of breast cancer diagnosis is undisputed in terms of breast self examination as well as clinical breast examination. However, this method lacks precision and objectivity because it relies on individual perception and skill. Moreover sensitivity is low especially in case of small tumors. Thus, MRE as an objective technique for the assessment of mechanical properties of lesions is expected to provide useful diagnostic information. Currently, MR-mammography (MRM) is performed in combination with the administration of contrast agent. Here, one follows the temporal change of the MR-signal intensity within the lesion after intravenous application of a contrast medium bolus (typically gadopentetate dimeglumine). Dynamic MRM has demonstrated such an enormous sensitivity that a non-enhancing invasive malignant lesion merited initially a case report. Thus, when applying MRE to the breast it is mandatory to combine it with the already established technique of MRM. Typically the patient is in prone position with the breasts gently attached to a mechanical transducer. The local wavelength of the shear wave increases typically at the location of the lesion. Reconstruction provides the images of Gd (real part of the complex shear modulus G*) and Gl (imaginary part of G*) indicating that the viscoelastic properties of the lesion are strongly altered when compared to the surrounding background tissue. Recently, our group conducted a study to explore the potential diagnostic gain provided by the viscoelastic shear properties of breast lesions for the improvement of the specificity of contrast enhanced dynamic MR-mammography. The combination of the BIRADS categorization obtained via MR-mammography with viscoelastic information lead to a substantial rise in specificity. Analysis of 39 malignant and 29 benign lesions showed a significant diagnostic gain with an increase of about 20% in specificity at 100% sensitivity.

Two other clinical applications will also be presented: application of MRE to liver (fibrosis and focal lesions) and to neuro-degenerative diseases such as for instance Alzheimer’s leading to demyelination in certain brain structures. Concerning liver, a total of 141 patients were assessed with different degree of fibrosis. It is shown that MRE is capable to non-invasively stage liver fibrosis and outperforms ultrasound based elastography (Fibroscan) as well as blood tests (APRI). The areas under the receiver operating characteristic curves of magnetic resonance elasticity (0.994 for F 2; 0.985 for F 3; 0.998 for F = 4) were larger (P ¡ .05) than those of ultrasound elasticity, APRI, and the combination of ultrasound elasticity and APRI (0.837, 0.709, and 0.849 for F 2; 0.906, 0.816, and 0.936 for F 3;0.930, 0.820, and 0.944 for F =4, respectively). Concerning brain, recent results using a mouse model which causes demyelination in the corpus-callosum show that MRE is sensitive to structural changes in white matter and the obtained values follow well the predicted changes in myelin content during the time course of the disease model.

Elastography provides - apart from mechanical information like elasticity and viscosity - further insight into the micro-architecture of tissue. The according physical effect is very similar to anomalous diffusion, where tracer molecules are used to probe the microstructure of materials. In our case, mechanical waves traverse a maze of obstacles when propagating in tissue due to the presence of the vasculature. The resulting effective wave propagation seen at the macroscopic level is actually affected by the spatial arrangement of the obstacles at the microscopic level. Thereby, elastography has the potential to provide information about the spatial architecture of the underlying micro-vasculature of for instance tumours.

Vadim Soloviev (University College London)
"*Practical application of variational approaches for solving inverse problems in optical tomography*"
Minisymposium Talk on Monday, 11:30-12:00. Room B.

We explore application of variational approaches in the time and Fourier domains for combined reconstitution of fluorescent and optical parameters in turbid media with embedded fluorescent inclusions. Algorithms are designed as an iterative solution of a system of differential equations of the diffusion and Helmholtz types correspondingly. Approach are based on allowing the unknown optical and fluorescent parameters to depend on the time or the Fourier spectral parameter, respectively. Parameters are found by minimizing their time or frequency derivatives. Algorithms were applied to a large time-gated experimental dataset acquired by imaging a highly scattering cylindrical phantom concealing small fluorescent tubes. It was shown that the time domain approach is able to localize fluorescent inclusions together with reconstruction of optical parameters by using a small number of time windows. However, it has a limited applicability. Thus, fluorescent lifetime could not be reliably reconstructed from recovered time evolution of powers of fluorescent sources due to a large error associated with the time domain approach. Unlike the time domain, the Fourier domain approach is able to recover optical parameters together with the fluorescent lifetime. Moreover, the lifetime was reconstructed with acceptable accuracy. On the other hand, the Fourier domain approach requires acquisition of many time windows for reliable application of the Fast Fourier Transform, which clearly makes experimental studies more tedious.

Alberto Sorrentino (Universita' di Genova)
"*Random finite sets for dynamic multi-dipole reconstruction with particle filtering in magnetoencephalography*"
Minisymposium Talk on Monday, 12:00-12:30. Room A.

The inverse problem in magnetoencephalography concerns the reconstruction of the neural currents from the measured magnetic fields. Assuming that the neural source can be approximated by a finite number of point-wise currents, the inverse problem is non-linear and the difficulty is exhacerbated by the fact that the number of sources is unknown and has to be estimated from the data; furthermore, due to the high frequency of the measurements, the number of sources is a dynamic variable, as well as the source parameters. In a particle filtering approach, where the posterior densities are approximated by finite sets of weighted samples, such a situation comprising an unknown number of sources is traditionally faced through considering a collection of spaces of different dimensionality and resorting to the so-called reversible jumps between these spaces. However, this approach still neglects the permutation symmetry of the posterior density, which in turn prevents using the standard estimators (such as Maximum a Posteriori and the Conditional Mean). In this talk we address the problem with the Random Finite Set theory, which overcomes these limitations by re-phrasing the problem in a more sophisticated mathematical framework.

Jean-Luc Starck (CEA, Saclay)
"*Compressed Sensing: a solution to the data transfert problem of the ESA Herschel Spacecraft*"
Minisymposium Talk on Tuesday, 15:15-15:45. Room C2.

We briefly review the concept of Compressed Sensing (CS), the new sampling theory, which is certainly one of the most important discovery in data processing during the last ten years. Indeed, CS provides an alternative to the well-known Shannon sampling theory. Then we will show how some problems in astronomy such interferometric image deconvolution or gammay ray image reconstruction can be handled differently using CS.
Finally, we will show how CS could lead to an elegant and effective way to solve the problem ESA is faced with, for the transmission to the earth of the data collected by PACS, one of the instruments onboard the Herschel spacecraft which will launched in 2009. We show that CS should enable to recover data with a spatial resolution enhanced up to 30..

David Stauffer (Penn State University)
"*Some Innovative Applications and Approaches Using Nudging Four Dimensional Data Assimilation - Part 1*"
Minisymposium Talk on Thursday, 15:15-15:45. Room A.

The first part of the talk presents an overview of the versatile nowcast-prediction systems that have been developed at Penn State for military-defense applications. Nudging four-dimensional data assimilation (FDDA) is used to support Army field artillery operations using mobile computing platforms in the back of HMMWVs on the battlefield to provide nowcasts. Nowcasts are defined here as gridded meteorological fields from a high-resolution mesoscale model assimilating available observations and staying just ahead of the clock to provide current weather conditions. The prediction system uses FDDA to dynamically initialize forecasts for rapidly relocatable domains anywhere in the world from a centralized Department of Defense (DoD) / Defense Threat Reduction Agency (DTRA) computing facility responsible for hazard prediction and consequence assessment. Both systems use a full-physics nonhydrostatic mesoscale model with continuous observation and/or analysis nudging FDDA.

Plamen Stefanov (Purdue University)
"*A microlocal approach to Thermoacoustic Tomography*"
Minisymposium Talk on Friday, 16:45-17:15. Room C2.

We study the thermoacoustic tomography problem with variable speed and measurements on a time interval [0,T], where T is greater than the geodesic diameter of the domain. We show that one can write an explicit solution in terms of a convergent Neumann series expansion. Next, we study the case where the measurements are done on a part of the boundary. We formulate sufficient and necessary condition that would guarantee that this inverse problem has unique (and possibly unstable) solution, and another sufficient and necessary condition under which the solution is stable.

Alwin Stegeman (University of Groningen)
"*The Candecomp/Parafac decomposition - diverging components and how to avoid them*"
Minisymposium Talk on Friday, 16:15-16:45. Room Aula.

Candecomp/Parafac (CP) is the most well-known decomposition of multi-way arrays or tensors. For a given array, CP yields a best rank-R approximation in terms of R rank-1 components, where the number of components R is prespecified. As such, CP can be seen as a multi-way generalization of Principal Component Analysis (PCA) or the (truncated) Singular Value Decomposition (SVD) for matrices. An attractive feature of CP is that it yields rotationally unique components under relatively mild conditions. This is not the case for PCA. A disadvantage of CP is that an optimal CP solution may not exist. That is, unlike a matrix, a multi-way array may not have a best rank-R approximation. If this is the case, then a CP algorithm will terminate with diverging components, which is also referred to as "degeneracy". Diverging components can be avoided by imposing additional restrictions in CP, such as orthogonality or nonnegativity. However, they are a significant problem in the practical application of unrestricted CP. In this talk, the mathematical background of diverging CP components will be discussed. Moreover, for 3-way arrays with two slices, i.e. $p \times q \times 2$ arrays, a method will be presented that avoids the problems of diverging CP components. Instead of CP, we fit the Generalized Schur Decomposition (GSD). Using the GSD method, we are able to obtain the nondiverging CP components separately. Also, we can obtain a Tucker3 decomposition of the limit point of the diverging CP components.

Milan Stehlik (Johannes Kepler University Linz)
"*Inverse problems for nonlinear systems*"
Minisymposium Talk on Thursday, 16:15-16:45. Room D.

During the talk we will illustrate on examples the inverse problems for nonlinear models in statistics and probability. In particular, we will discuss fractal growth related problems with applications to cancer risk assessment and nonlinear regres- sion problems. Fractal growth modeling and testing play a crucial role in a cancer diagnostics for a specific types of tumors (see [Baish and Jain (2000)]). We will provide an approach based on Tsallis entropy to obtain the continuous jump probability related to fractal with Hausdorff dimension less than 2. We will consider also dependance of two groups of tissues modeled through pseudoexponential model (see [Filus, Filus and Stehlik (2008)]). Digression to the topological fractals will be also given. In a nonlinear regression estimation of parameters plays a crucial role. We will provide the illustrative examples for various inverse problems and possible solutions for both correlated a uncorrelated errors. We also apply this approaches to modeling of IBNR reserves (see [Potocky and Stehlik (2008)]) and ICRP protocols of Radiactive protection (see [Stehlik et al. (2008)]).

Robert Stueck (University of Goettingen)
"*Semi-blind Deconvolution in 4Pi Microscopy*"
Minisymposium Talk on Friday, 14:00-14:30. Room C2.

4Pi microscopy has been invented by Stefan Hell to improve the resolution of confocal fluorescence microscopy along the optical axis. The convolution kernel (or point spread function, short psf) of a 4Pi microscope differs from the psf of a corresponding confocal microscope approximately by a squared cosine factor resulting in a main peak of much smaller band-width and several (typically at least two) side lobes. The size and position of the main peak and the side lobes of the 4Pi psf depend on a phase parameter, which has been assumed to be space-invariant so far, yielding standard deconvolution problems with positivity constraint. However, this assumption is violated e.g. for inhomogeneous refractive indices, and the space dependence of the psf is considered one of the main problems in 4Pi microscopy. In this project the joint recovery of the three-dimensional density of fluorescent markers and the slowly varying phase function is considered as a nonlinear inverse problem, which is tackled by a regularized Newton method. We study the convergence of an iteratively regularized Gauß-Newton method incorporating nonnegativity constraints and present reconstruction results both for synthetic and real data.

Jianzhong Su (University of Texas at Arlington)
"*Globally Accelerated Reconstruction Algorithm for Diffusion Tomography in an Arbitrary Convex Shape Domain*"
Poster Presentation on Monday, 17:15-18:15. Room Foyer.

In this paper, a new numerical imaging algorithm is presented for reconstruction of optical absorption coefficient from Near Infrared light data with a continuous-wave source. As a continuation of earlier efforts of the authors in developing a series of methods called "Globally Convergent Reconstruction Methods", this numerical algorithm solves the inverse problem through solving a boundary value problem for a Volterra type integral-partial-differential equation. This paper deals with the particular issues in solving the inverse problems in an arbitrary convex shape domain. It is demonstrated in numerical studies that this reconstruction technique is highly efficient and stable with respect to the complex distribution of actual unknown absorption coefficient. The method is particularly useful for reconstruction from a large data set obtained from a tissue or organ of particular shape such as prostate. Numerical reconstructions of a simulated prostate-shaped phantom with 3 different settings of absorption-inclusions are presented.

Jiguang Sun (Delaware State University)
"*Numerical studies of the reciprocity gap functional method in inverse scattering*"
Minisymposium Talk on Tuesday, 12:00-12:30. Room C1.

We shall present some numerical and analytical studies of the reciprocity gap functional method (RGM) for inverse scattering. The RGM method requires limited a priori information of the physical properties of the scatterer and involves only ill-posed linear integral equations. We give some analytical results in the case of a circular scatterer which can be used for guidance about what to expect when a regularized scheme is applied in the RGM. The numerical results in this paper provide useful benchmarks of the capability of the RGM in various situations including limited aperture data.

Elena Tabarintseva (South Ural State University)
"*A boundary inverse problem for a nonlinear parabolic equation*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

A boundary inverse problem for a semi-linear parabolic equation is considered. A method to get a stable approximate solution for the ill-posed problem under consideration is suggested. Sharp error estimates for the approximate solution are obtained.

Tomoya Takeuchi (University of Tokio)
"*Mathematics and numerics for a thermographic inverse problem*"
Minisymposium Talk on Tuesday, 16:15-16:45. Room A.

We consider a non-destructive testing by non-stationary thermography and our purpose is detect defects near the surface of thin plate productions. The governing equation is a heat equation and we observe surface temperature over time interval after heating the surface. Then our inverse problem is the determination of surface anomaly caused by defects by surface temperature.
We first establish the theoretical results such as the uniqueness and the stability. Second we present a numerical scheme with numerical test. We plan to show experimental results at a laboratory.

Janne Tamminen (Tampere University of Technology)
"*Reconstructing conductivities with boundary corrected D-bar method*"
Poster Presentation on Thursday, 17:15-18:15. Room .

The aim of electrical impedance tomography is to form an image of the conductivity distribution inside an unknown body using electric boundary measurements. The computation of the image from measurement data is a non-linear ill-posed inverse problem and calls for a special regularized algorithm. One such algorithm, the so-called D-bar method, is improved in this work by introducing new computational steps that remove the so far necessary requirement that the conductivity should be constant near the boundary. The numerical experiments presented suggest two conclusions. First, for most conductivities arising in medical imaging, it seems the previous approach of using a best possible constant near the boundary is sufficient. Second, for conductivities that have high contrast features at the boundary, the new approach produces reconstructions with smaller quantitative error and with better visual quality.

Tanja Tarvainen (University of Kuopio)
"*Approximation errors in optical tomography*"
Minisymposium Talk on Monday, 12:00-12:30. Room B.

Image reconstruction in (diffuse) optical tomography (OT) is a non-linear ill-posed inverse problem. Thus, the reconstruction problem tolerates measurement and modelling errors poorly. The modelling errors arise, for example, from using approximate forward models which are unable to describe the measurements correctly. Further, a model reduction by using too coarse discretization in the solution of the forward problem can cause errors to the solution.
In OT the most typical approach is to use the diffusion approximation (DA) to the radiative transfer equation (RTE) as forward model. The DA is basically a special case of the first order spherical harmonics approximation to the RTE, and thus it has some limitations. Firstly, the medium is assumed to be scattering dominated, and secondly, light propagation can not be modelled accurately close to the collimated light sources and boundaries.
Recently, a Bayesian approach for the treatment modelling errors has been proposed (Kaipio and Somersalo 2005 *Statistical and Computational Inverse Problems*). In the Bayesian framework, all variables are modelled as random variables. In the approximation error approach, also the computational model inaccuracy is represented as a random variable and the statistical properties of the modelling errors are computed before the reconstructions. In (Arridge et al 2006 *Inverse Problems* 22:175-195), the approximation error approach was utilized in OT image reconstruction. In that paper, the interplay between the mesh density and measurement accuracy was investigated using the DA as light transport model.
In this study, we consider utilizing the approximation error approach for compensating modelling errors between the RTE and the DA. Further, different density discretizations of the forward solution are investigated.
This is joint work with S.R. Arridge, J.P. Kaipio and V. Kolehmainen.

Ulrich Tautenhahn (University of Applied Sciences Zittau/Goerlitz)
"*Multi-parameter regularization for ill-posed problems with noisy right hand side and noisy operator*"
Minisymposium Talk on Thursday, 12:00-12:30. Room C1.

The goal of this talk is to present recent results for solving linear ill-posed problems $A_0x = y_0$ where $A : X \to Y$ is a bounded operator between Hilbert spaces X and Y. We are interested in problems where

(i) instead of $y_0 \in \mathcal{R}(A_0)$ we have noisy data $y_\delta \in Y$ with $\|y_0 - y_\delta\| \le \delta$,

(ii) instead of $A_0 \in \mathcal{L}(X,Y)$ we have a noisy operator $A_h \in \mathcal{L}(X,Y)$ with $\|A_0 - A_h\| \le h$.

Since $\mathcal{R}(A_0)$ is assumed to be non-closed, the solution $x^\dagger$ of the operator equation $A_0x = y_0$ does not depend continuously on the data. Hence, for solving $A_0x = y_0$ with noisy data (y_δ, A_h) some regularization methods are required. In the present talk we study the method of Tikhonov regularization with differential operators and the method of dual regularized least squares (dual RTLS) in which some estimate $(\hat{x}, \hat{y}, \hat{A})$ for the unknown triple $(x^\dagger, y_0, A_0)$ is determined by solving the constrained minimization problem

$$\|Bx\| \to \min \ \text{ subject to } \ Ax = y, \ \|y - y_\delta\| \le \delta, \ \|A - A_h\| \le h,$$

see [1]. Under certain smoothness assumptions for $x^\dagger$ we provide order optimal error bounds that characterize the accuracy of the regularized approximations . In addition we discuss computational aspects. We show that dual RTLS can be reduced to a special multi-parameter regularization method where one of the two regularization parameters is negative. In particular, special algorithms for the computation of the regularization parameters are provided. These algorithms are (i) globally and monotonically convergent (for Tikhonov regularization with differential operators) and (ii) allow a fast computation of the two regularization parameters that arise in dual RTLS. The results extend earlier results where the operator is exactly given. Some of our theoretical results are illustrated by numerical experiments. This talk is a joint work with Shuai Lu, Sergei Pereverzev and Yuanyuan Shao.

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Gerd Teschke (University of Applied Sciences Neubrandenburg)
"*Compressive Strategies for Solving Inverse Problems*"
Minisymposium Talk on Monday, 16:45-17:15. Room C1.

In this talk we discuss strategies for solving inverse problems that allow an efficient reconstruction of sparse solutions. In principle we consider two aspects. The first focus is on algorithmic compression strategies to accelerate standard iteration schemes (as the Landweber method). The second focus is on the involvement of compressive sampling/compressed sensing techniques. The presentation of our ongoing work will be furnished with actual applications in the field of imaging.

Gerd Teschke (University of Applied Sciences Neubrandenburg)
"*Solving Inverse Problems with Sparsity Constraints*"
Minisymposium Talk on Friday, 15:30-16:00. Room C2.

In this talk we discuss iterative strategies for nonlinear inverse problems with sparsity constraints, i.e. with strategies for problems which are in general non-convex and non-differentiable. In particular, we focus on problems in which the solution and the data can be multi-channel functions (as it is case for many problems, e.g. in astrophysical data processing, medical data processing, or spectral data processing). For the multi-channel framework we consider special sparsity measures that take into account the possible joint morphology of the multi-channel solution to be reconstructed.

Necmi Serkan Tezel (Istanbul Technical University)
"*A Second Order Newton Method for Shape Reconstruction of the Sound-soft Obstacle Buried in a Dielectric Cylinder of Arbitrary Shape*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

A new second order Newton method for reconstructing the shape of a sound-soft scatterer buried in an arbitrary shaped dielectric cylinder from the measured far-field pattern is presented. This method extends a hybrid between regularized Newton iterations and decomposition. The main idea of our iterative method is to use Huygen's principle, i.e., represent the scattered field as a single-layer potential by using Green's fuction of domain containing dielectric cylinder. Given an approximation for the boundary of the scatterer, this leads to an ill-posed integral equation of the first kind that is solved via Tikhonov regularization. Then, in a second order Taylor expansion, the so sound-soft boundary condition is employed to update the boundary approximation. In an iterative procedure, these two steps are alternated until some stopping criterium is satisfied. We describe the method in detail and illustrate its feasibility through examples with exact and noisy data.

Celine Theys (Dep Reseaux & Telecommunications, Sophia-Antipolis)
"*Restoration of astrophysical images acquired with Low Light Level CCD*"
Minisymposium Talk on Friday, 15:00-15:30. Room C2.

Restoration of astrophysical images is a classical applied inverse problem. The astronomical object is first blurred by the Point Spread Function of the instrument-atmosphere set. The resulting convolved image is corrupted by a Poissonian noise due to low light intensity, then, a Gaussian white noise is added during the electronic read-out operation by the Charge Coupled Device (CCD) camera. Very recent technology proposes to acquire astrophysic data with Low Light Level CCD (L3CCD) cameras in order to avoid the read-out noise due to the classical CCD acquisition. The physical process leading to the data can be described by a Poisson Gamma Gaussian density. We propose to discuss this statistical model and to derive an iterative algorithm for the deconvolution of such data. Some simulation results are given on synthetic astrophysic data pointing out the interest of using L3CCD cameras for acquisition of very low intensity images.

Nataliya Togobytska (Weierstrass Institute Berlin)
"*Parameter identification for the phase transformations in steel*"
Minisymposium Talk on Tuesday, 16:45-17:15. Room A.

Dilatometric investigations are often employed in the metallurgy for the analysis of the phase transformations in steel during the heat treatments. The goal is a mathematical investigation of dilatometer experiments to measure the kinetics of solid-solid phase transitions in steel upon cooling from the high temperature phase. In the case of several coexisting product phases, lavish microscopic investigations have to be performed to obtain the resulting fractions of the different phases. In contrast, one can show that the complete phase transition kinetics including the final phase fractions are uniquely determined by the dilatometer data and present some numerical identification results.

Dennis Trede (University of Bremen)
"*Greedy Deconvolution of Point-like Objects*"
Minisymposium Talk on Tuesday, 11:30-12:00. Room C2.

The orthogonal matching pursuit (OMP) is an algorithm to solve sparse approximation problems. In [2] a sufficient condition for exact recovery is derived, in [1] the authors transfer it to noisy signals. We will use OMP *not* for sparse approximation problems but for reconstruction of an inverse problem, namely the deconvolution problem

$$Ku = u * k = v.$$

Obviously, there are differences of these two areas: In sparse approximation problems one has to deal with the problem of redundancy of a dictionary, i.e. the atoms are not linearly independent. However, one expects them to be approximatively orthogonal. To quantify the magnitude of redundancy the concept of coherence is introduced.
This idea cannot be transfered to ill-posed inverse problems: Here, if the operator K is injective, the atoms indeed are linearly independent but typically far from orthogonal. The ill-posedness of the (typically compact) operator K causes that the correlation of two distinct atoms gets huge, i.e. that two atoms can look much alike.
In this talk, we will investigate an alternative condition for exact recovery for the inverse convolution problem with noiseless data v and for the case only noisy data v^ε with noise level $\|v^\varepsilon - v\| \leq \varepsilon$ are available. For our source u we assume that it consists of a superposition of point-like objects with an a-priori known distance ρ. We will apply it exemplarily to Dirac peaks convolved with Gaussian kernel as used in mass spectrometry, and characteristic functions convolved with Fresnel kernel as used in digital holography.
Joint work together with Dirk A. Lorenz.

[1] Donoho, Elad, and Temlyakov. Stable recovery of sparse overcomplete representations in the presence of noise. *IEEE Trans. Info. Theory*, 2006.

[2] Tropp. Greed is good: Algorithmic results for sparse approximation. *IEEE Trans. Info. Theory*, 2004.

Dumitru Trucu (University of Leeds)
"*Inverse Perfusion Coefficient Identification in Bio-Heat Transient Flow*"
Poster Presentation on Tuesday, 17:15-18:15. Room Foyer.

The governing equation for the heat transfer process within the human body tissue, namely

$$\Delta T - P_f T + S = \frac{\partial T}{\partial t}, \tag{7}$$

has important applications in many biomedical investigations. Among other theoretical aspects that we are concerned with regard to this equation, the perfusion coefficient P_f receives a particularly important interest because of its physical meaning, that is $P_f = \frac{w_b c_b l^2}{k_t}$, where w_b is the perfusion coefficient of blood, c_b is the heat capacity of blood, l^2 is the characteristic dimension of the tissue and k_t is the thermal conductivity of the tissue. We focus our attention toward the inverse problems that enable us to accurately recover the perfusion coefficient, P_f, from measurements considered in terms of mass, flux, or temperature, sampled over the specific regions of the media under investigation. We are using analytical and numerical techniques to investigate the existence and uniqueness of the solution for this inverse coefficient identification problem. In our analysis we consider the non-steady state case with P_f

dependent on either time, space, temperature, both space and time, or both space and temperature. At the conference the solution of these inverse problems will be presented both from analytical and numerical stand points.
The first author would like to acknowledge the European Union, European Research Commission, that is fully supporting the research work and attendance at this conference through the award of a Marie Currie Research Fellowship in the Centre for Computational Fluid Dynamics at The University of Leeds.
This is joint work with Professor Daniel Lesnic and Professor Derek B Ingham.

Kees van den Doel (University of British Columbia)
"*Source localization in electromyography*"
Minisymposium Talk on Monday, 11:30-12:00. Room C2.

he inverse problem of recovering the electrical source distribution in a 3D domain from measurements of the potential on the surface is ill-posed, and no unique solution exists, even with complete data on the surface and no measurement errors. This necessitates the use of problem specific a-priory constraints in order to arrive at a unique solution.
We consider the problem of Computed Myography (CMG) which has the goal of recovering the pattern of electrical sources in muscle fibers from measurements of the potential on the skin. We discuss two methods: 1) The Laplacian weighted minimum 2-norm solution, which results in the smoothest distribution and 2) the sparsest solution obtained by minimizing the L1 norm of the solution in an appropiate basis. The latter approach makes use of the fact that the electrical sources consist of (a few thousand) localized tripoles with many known properties. It is shown that the sparse method can significantly outperform the smooth method at the expense of significant numerical complications.

Tristan van Leeuwen (Delft University)
"*Non-linear inversion of seismic data*"
Poster Presentation on Thursday, 17:15-18:15. Room Foyer.

The seismic survey is a widely used tool to obtain an image of the subsurface. Usually, an explosive source is placed just below the surface and the scattered wavefield is recorded at the surface. The physical parameters that describe the subsurface, in particular the soundspeed, can now be obtained by solving a PDE-constrained, strongly non-linear optimization problem. The problem can be linearized under the assumption that waves scatter only once in the subsurface. The linearized inverse problem can be solved by simple back-projection. Its solution represents the discontinuities of the medium parameters, e.g., the layer boundaries. This still leaves the slowly varying part of the medium parameters unresolved. Fortunately, there are algorithms to deal with these kind of problems. They first resolve the linear part of the unknowns, given the non-linear part. The remaining inverse problem then only depends on the non-linear parameters. With the latter, we can recompute the linear part of the parameters, and so on. Unfortunately, the linear problem has to be solved very accurately at each iteration. If not, the non-linear optimization may result in a wrong solution. As a remedy, we propose a different formulation of the functional for the non-linear optimization. We include numerical examples to illustrate the approach.

Giuseppe Vicidomini (Max Planck Institute for biophysical Chemistry)
"*Image restoration in super-resolution fluorescence microscopy*"
Minisymposium Talk on Tuesday, 15:45-16:15. Room C2.

Fluorescence far field microscopy is a indispensable tool in modern life science. However, the resolution of conventional microscopy is limited by diffraction to ~ 200 nm in the focal plane and ~ 600 nm along the optical axis. In order to discern details which are much closer than this, a new class of super-resolution microscopy techniques has been designed, which push resolution to the ultimate limit of diffraction in all dimensions or even broke the diffraction barrier altogether. Frequently, the image formation process of such super-resolution systems can not be described by a simple convolution with a point-spread function (PSF).
In order to alleviate the asymmetry between axial and lateral performance, a number of these methods use interference of wave front of two opposing lenses, an approach known as 4Pi arrangement. The PSF of such systems are characterized by multiple maxima or sidelobes, which not only blur the object but also replicate it in the image. Therefore image restoration is essential to render unambiguous imaging and genuine axial resolution improvement. The positions and the relative heights of the multiple maxima or sidelobes of the PSF depend on the phase difference between the two wave fronts at the focal point. Unfortunately, phase difference is not known *a-priori* and in some practical cases the phase difference is

not a constant but is a function of the position in the image domain. Simultaneous estimation of the object and the phase difference function leads to an undetermined blind image restoration problem.
We propose a maximum *a-posteriori* method in which we assume a mathematical model for the phase difference function that depends on a small number of parameters. Furthermore, edge-preserving regularization is introduced in the method in order to obtain reliable solutions. Tests on synthetic and real data show that the method is able to simultaneously estimate the phase difference parameters, remove the replicates in the image and reduce the blur. A generalization of the method to other super-resolution techniques is also proposed.
This is a joint work with Andreas Schönle, Jan Keller, Roman Schmidt, Claas von Middendorff and Stefan W. Hell.

Chunming Wang (University of Southern California)
"*The Estimation of Ionospheric Driving Force Using 4DVAR Data Assimilation Approach*"
Minisymposium Talk on Thursday, 11:30-12:00. Room Aula.

The one of the most crucial aspects in the forecasting the conditions in the Earth's ionosphere is the determination of key driving forces. These forces include solar radiation intensity, thermospheric wind velocity and neutral particle density, and electric field intensity. With the availability of large quantity of measurement of the Total Electron Content (TEC) along the paths linking GPS satellite and ground or space based receivers a data assimilation approach is developed to estimate the ionospheric driving forces using the TEC measurements. In this presentation, the formulation of parameter estimation as a 4-Dimensional Variational (4DVAR) data assimilation problem is introduced. An adjoint equation based technique is developed to efficiently evaluate the gradient of the cost functional for the nonlinear least square optimization problem. The numerical results will also be presented to demonstrate the capability of this approach in determining ionospheric driving forces.

Jenn-Nan Wang (National Taiwan University)
"*Reconstruction of inclusions using complex geometrical optics solutions*"
Minisymposium Talk on Friday, 17:45-18:15. Room D.

In this talk, I would like to talk about the reconstruction of the shape of the inclusion by boundary measurements. The main tool is the CGO solutions. I will outline a framework in the dimensional case in which we have more freedom in choosing the phases of the CGO. For concrete examples, I will discuss the conductivity equation and the isotropic elasticity (both static and stationary).

Stephen J. Wright (University of Wisconsin)
"*First-order algorithms for approximate total-variation-regularized image reconstruction*"
Minisymposium Talk on Thursday, 12:00-12:30. Room D.

Image restoration models based on total variation (TV) have become popular since their introduction by Rudin, Osher, and Fatemi (ROF) in 1992. This talk discusses application of gradient projection (GP) algorithms to the dual formulation. We test variants of GP with different step length selection and line search strategies, including techniques based on the Barzilai-Borwein method. Global convergence can in some cases be proved by appealing to existing theory. Computational experiments show that the proposed approaches perform well in a wide range of applications and that some are significantly faster than previously proposed methods, particularly when only modest accuracy in the solution is required. We conclude by discussing implementation of these methods on graphical processing units (GPUs).
The talk represents joint work with Mingqiang Zhu, Tony Chan, and Sangkyun Lee.

Yuesheng Xu (Syracuse University)
"*Fast Multiscale Methods for Solving Ill-posed Integral Equations of the First Kind*"
Minisymposium Talk on Monday, 11:30-12:00. Room C1.

There is much interest recently on developing fast multiscale methods for solving ill-posed integral equations. Multiscale bases are used to discretize the regularized equation and matrix compression techniques are employed to approximate the full matrix so that fast methods can be designed. We will report recent development in solving ill-posed Fredholm integral equations of the first kind by using multiscale methods.

Riccardo Zanella (University of Modena and Reggio Emilia)
"*Scaled gradient projection methods in image deblurring and denoising*"
Minisymposium Talk on Monday, 16:45-17:15. Room D.

Gradient type methods are widely used approaches for nonlinear programming in image processing, due to their simplicity, low memory requirement and ability to provide medium-accurate solutions without excessive computational costs. In this talk we discuss some improved gradient projection methods for constrained optimization problems in image deblurring and denoising. Crucial feature of these approaches is the combination of special steplength rules and scaled gradient directions, appropriately designed to achieve a better convergence rate. The steplength selection consists in an adaptive alternation of the Barzilai-Borwein rules while the diagonal scaling matrices are derived by a decomposition of the gradient of the objective function. Convergence results are given by exploiting monotone or nonmonotone line-search strategies along the feasible direction. The effectiveness of the algorithms is evaluated on the problems arising from the maximum likelihood approach to the deconvolution of images and from the edge-preserving removal of Poisson noise. Numerical results obtained by facing large scale problems involving images of several mega-pixels on graphics processors are also reported.
The talk is a joint work with Mario Bertero, Patrizia Boccacci, Silvia Bonettini and Luca Zanni.

Gerhard Zangerl (University of Innsbruck)
"*Circular Integrating Detectors in Photoacoustic Tomography*"
Minisymposium Talk on Friday, 17:15-17:45. Room C2.

Photoacoustic tomography is based on the generation of acoustic waves, i.e. pressure, inside tissue by pulsed stimulation with electromagnetic waves, which are measured outside the stimulated sample and converted into a three dimensional (3d) image. In this talk we are concerned with the reconstruction when the acoustic waves are measured with circular integrating detectors which offer high contrast and resolution

Gaetano Zanghirati (University of Ferrara)
"*A novel approach to the joint inversion of loosely connected data*"
Minisymposium Talk on Thursday, 11:30-12:00. Room .

We develop a technique for a joint inversion of two different kinds of tomographic data. The "objects" to be recovered are connected just through a topological constraint based on the following weak assumption linking the two considered data sets: if any inhomogeneity is present in the investigated volume, it modifies the values of both the two recorded physical properties. In comparison with the classical case, where the inversions are performed independently on each data set and then assembled a posteriori, the additional a priori information that we use is the spatial agreement (shape and position) of the anomalies in the two reconstructed models. The constraint is imposed by introducing, within the Tikhonov regularization framework, a stabilizing "joint functional" which couples the two types of data to be reconstructed. We propose as the joint functional a "Minimum Support Stabilizer" acting on the model spaces. We test this methodology for the joint inversion of two different time-of-flight tomographies concerning radar and elastic waves propagation. A preliminary numerical experience on synthetic data shows that the coupling term allows a better reconstruction of the anomalies shape and better estimates of the physical properties inside them.

Clemens Zarzer (Johann Radon Institute)
"*Regularization with non-convex sparsity constraints*"
Minisymposium Talk on Tuesday, 10:30-11:00. Room C2.

The class of Tikhonov type regularization methods can be effectively employed for identifying and computing sparse solutions to (non linear) inverse problems. Previous results and applications show the regularizing and sparsity promoting characteristics of the ℓ_1 norm penalization term. A possible and natural extension of this idea is the utilization of the general ℓ_p (quasi) norm, for $0 < p < 1$. This framework raises several questions, as the triangle inequality is not valid any more and one faces a non-convex constraint. It is therefore not clear whether usual regularization properties can be obtained and what benefits may be expected compared to other approaches. Eventually, suitable algorithms have to be developed to cope with the arising minimization problem. In the talk some of these questions are addressed with an emphasis on the regularization theory. It is shown that the Tikhonov type approach with the ℓ_p penalization term provides a regularization method in a general setting. Further an approach toward convergence rates is presented and a particular result in the respective Hilbert space topology is given. Finally the issue of minimization is addressed and it is shown that the transformation operator used to overcome the non-convexity in the theory may also be utilized in developing practical algorithms.

Noam Zeev (Old Dominion University)
"*Identification of shape and material properties of thin dielectric objects from far field and near field data*"
Minisymposium Talk on Thursday, 12:00-12:30. Room B.

Important problems in nondestructive testing include the detection of flaws in materials in specific (typically thin) areas, as well as the determination of the integrity of thin coatings. We consider the inverse scattering problem of determining the shape and information about the thickness and physical properties of a thin dielectric infinite cylinder having an open arc as cross section from knowledge of the TM-polarized scattered electromagnetic field at a fixed frequency. We investigate two reconstruction approaches, namely the linear sampling method and the reciprocity gap functional method, using far field or near field data, respectively. We then use these solutions as initial guesses in an iterative algorithm based on a Newton-type method. Numerical examples are given showing the efficaciousness of our algorithms.

Jun Zou (The Chinese University of Hong Kong)
"*Parameter choice rules for Tikhonov regularization*"
Minisymposium Talk on Monday, 12:00-12:30. Room C1.

In this talk we shall discuss some new rules for choosing regularization parameters in Tikhonov regularization. Firstly, we derive a new functional that determines the regularization parameter simultaneously with the inverse solution. Some properties, e.g. existence, variance estimate and consistency, of the functional are shown. An efficient algorithm with practically desirable monotonic convergence is proposed. Secondly, the classical Morozov's discrepancy principle is revisited for inverse problems in Banach space. Theoretical properties of the discrepancy equation, e.g. existence, uniqueness, error estimates and bounds, are investigated. Its efficient numerical realization via the model function approach and quasi-Newton's method is also briefly discussed. This is a joint work with Bangti Jin and was supported by Hong Kong RGC grants (Projects 404105 and 404606).

Walter Zulehner (Johannes Kepler University Linz)
"*Robust one-shot multigrid methods for optimal control problems*"
Minisymposium Talk on Thursday, 16:15-16:45. Room C1.

In this talk we consider optimal control problems of tracking type with elliptic state equations. For a class of such problems, a one-shot multigrid method is presented for solving the discretized optimality system (Karush-Kuhn-Tucker system). Under mild assumptions we show the convergence of the multigrid method with convergence rates which are robust with respect to the involved regularization parameter. Numerical experiments are presented for illustrating the theoretical results.
The material presented in this talk is based on joint work with René Simon (Faculty of Mathematics, University Duisburg-Essen, Germany) and Joachim Schöberl (Center for Computational Engineering Science, RWTH Aachen, Germany).

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