# Annual Meeting of the DFG Priority Programme 1962

## October 1-3, 2018, Brandenburg, Germany

Hotel Sommerfeld,
Beetzer Str. 1a,
D-16766 Kremmen
Brandenburg

SPP 1962

DFG Deutsche Forschungsgemeinschaft

WIAS

**Coordinator**:

Prof. Dr. M. Hintermüller

**Organization committee**:

Dr. A. Alphonse

Dr. C. Löbhard

C. Bonetti

**Steering committee**:

Prof. Dr. M. Heinkenschloss

Prof. Dr. R. Herzog

Prof. Dr. M. Hintermüller

Prof. Dr. B. Kaltenbacher

Prof. Dr. M. Ulbrich

## List of Projects

**Project 1: Approximation of Monge-Kantorovich Problems**

S. Bartels — Z. Wang, A. Bonito, M. Jensen, R. Nochetto

**Project 2: Coupling Hyperbolic PDEs with Switched DAEs: Analysis, Numerics and Application to Blood Flow Models**

R. Borsche, S. Trenn — D. Kocoglu

**Project 3: Numerical Methods for Diagnosis and Therapy Design of Cerebral Palsy by Bilevel Optimal Control of Constrained Biomechanical Multi-Body Systems**

H. Bock, E. Kostina — J. Schlöder, M. Sauter, M. Schlöder

**Project 4: Parameter Identification in Models With Sharp Phase Transitions**

C. Clason, A. Rösch — H. Vu

**Project 5: Multiobjective Optimal Control of Partial Differential Equations Using Reduced-Order Modeling**

M. Dellnitz, S. Volkwein — S. Banholzer, B. Gebken

**Project 6: Analysis and Solution Methods for Bilevel Optimal Control Problems**

S. Dempe, G. Wachsmuth — F. Harder, A. Schiela, M. Ulbrich

**Project 7: Identification of Energies from Observations of Evolutions**

M. Fornasier — M. Maggioni

**Project 8: A Calculus for Non-Smooth Shape Optimization with Applications to Geometric Inverse Problems**

R. Herzog, S. Schmidt — M. Herrmann, J. Vidal

**Project 9: Optimal Control of Dissipative Solids: Viscosity Limits and Non-Smooth Algorithms**

R. Herzog, D. Knees, C. Meyer — A. Stötzner, S. Thomas

**Project 10: Generalized Nash Equilibrium Problems with Partial Differential Operators: Theory, Algorithms, and Risk Aversion**

M. Hintermüller, T. Surowiec — D. Gahururu, S.-M. Stengl

**Project 11: Optimal Control of Elliptic and Parabolic Quasi-Variational Inequalities**

M. Hintermüller — C. N. Rautenberg, A. Alphonse

**Project 13: Simulation and Control of a Nonsmooth Cahn-Hilliard Navier–Stokes System with Variable Fluid Densities**

M. Hintermüller, M. Hinze — C. Gräßle, T. Keil

**Project 14: Algorithms for Quasi-Variational Inequalities in Infinite-Dimensional Spaces**

C. Kanzow, D. Wachsmuth          V. Karl, D. Steck

**Project 15: Non-smooth Methods for Complementarity Formulations of Switched Advection-Diffusion Processes**

C. Kirches, S. Sager          P. Manns, S. Leyffer

**Project 16: Optimal Control of Variational Inequalities of the Second Kind with Application to Yield Stress Fluids**

C. Meyer, B. Schweizer, S. Turek          A. Fatima

**Project 17: Optimizing Fracture Propagation Using a Phase-Field Approach**

I. Neitzel, W. Wollner          A. Hehl, M. Mohammadi, C. Ortner, T. Wick

**Project 18: Optimal Control of Static Contact in Finite Strain Elasticity**

A. Schiela          M. Stöcklein

**Project 19: Shape Optimization for Maxwell's Equations Including Hysteresis Effects in the Material Laws**

S. Schmidt, A. Walther          O. Ebel, A. Griewank

**Project 20: Optimizing Variational Inequalities on Shape Manifolds**

V. Schulz          K. Welker

**Project 21: Multi-Leader-Follower Games in Function Space**

A. Schwartz, S. Steffensen          J. Becker, A. Thünen

**Project 22: Stress-Based Methods for Variational Inequalities in Solid Mechanics: Finite Element Discretization and Solution by Hierarchical Optimization**

G. Starke          R. Krause, B. Kober, G. Rovi

**Project 23: Optimization Methods for Mathematical Programs with Equilibrium Constraints in Function Spaces Based on Adaptive Error Control and Reduced Order or Low Rank Tensor Approximations**

M. Ulbrich, S. Ulbrich          L. Hertlein, A. Rauls

**Project 24: Optimization of Non-smooth Hyperbolic Maxwell's Equations in Type-II Superconductivity Based on the Bean Critical State Model**

I. Yousept          L. Betz

# Plenary Talks

### Fractional PDEs: Control, Applications, and Beyond

Harbir Antil (George Mason University)

Fractional calculus and its application to anomalous transport has recently received a tremendous amount of attention. In these studies, the anomalous transport (of charge, tracers, fluid, etc.) is presumed attributable to long–range correlations of material properties within an inherently complex, and in some cases self-similar, conducting medium. Rather than considering an exquisitely discretized (and computationally explosive) representation of the medium, the complex and spatially correlated heterogeneity is represented through reformulation of the PDE governing the relevant transport physics such that its coefficients are, instead, smooth but paired with fractional–order space derivatives. This talk will give an introduction to fractional diffusion. We will describe how to incorporate nonhomogeneous boundary conditions in fractional PDEs. We will cover from linear to quasilinear fractional PDEs and fractional elliptic variational inequalities. Several optimal control strategies will be discussed, including optimization under uncertainty. We will conclude the talk with a new approach that allows the fractional exponent to be spatially dependent. This has enabled us to define novel Sobolev spaces and their trace spaces. Numerical evidence suggests that such spaces are useful in image processing.

### Recent Trends in Algorithmic Optimization

Ekkehard Sachs (Universität Trier and Lawrence Livermore National Laboratory)

In the past 5-10 years, the interest in algorithms for optimization problems has shifted significantly. Methods that are based on first order information have become the focus of current research. In this talk we give some motivation why this trend is taking place. Furthermore, we highlight some of the current research direction. Among those applications machine learning represents an important area and for the analysis of algorithms we consider complexity estimates for optimization problems.

### Uncertainty Quantification for Bayesian Inverse Problems

Claudia Schillings (Universität Mannheim)

Uncertainty Quantification is an interesting, fast growing research area aimed at developing methods to address the impact of parameter, data and model uncertainty in complex systems. Here, we will focus on the identification of parameters through observations of the response of the system – the inverse problem. The uncertainty in the solution of the inverse problem will be described via the Bayesian approach. In cases, where the model evaluations are prohibitively expensive, ad hoc methods such as the ensemble Kalman filter for inverse problems are widely and successfully used by practitioners in order to approximate the solution of the Bayesian problem. Since the method is usually used with a rather small ensemble size (in the range of 20 - 100 ensemble members), the goal of our work is to build analysis for a fixed ensemble size. To do so, we discuss the ensemble Kalman inversion based on the continuous time scaling limits of the method as a derivative free optimization method for the least-squares misfit functional. The interpretation of the ensemble Kalman inversion as a derivative free optimization method opens up the perspective to use the method in various fields of application, e.g. imaging, groundwater flow problems, biological problems as well as in the context of the training of neural networks.

## Program

**Monday, Oct 1**

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| 12:00 - 13:30 | | Registration and coffee |
| 13:30 - 13:45 | | Welcome and opening remarks (<u>M. Hintermüller</u>) |

Chair: V. Schulz

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|---|---|---|
| 13:45 - 14:30 | | **Plenary Session**: Uncertainty Quantification for Bayesian Inverse Problems (C. Schillings) |
| 14:30 - 14:55 | P15 | Non-smooth Methods for Complementarity Formulations of Switched Advection-Diffusion Processes (P. Manns) |
| 14:55 - 15:20 | P22 | Stress-Based Methods for Variational Inequalities in Solid Mechanics: Finite Element Discretization and Solution by Hierarchical Optimization (G. Rovi) |

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|---|---|---|
| 15:20 - 15:45 | | Coffee break |

Chair: S. Bartels

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| 15:45 - 16:10 | P18 | Optimal Control of Static Contact in Finite Strain Elasticity (M. Stöcklein) |
| 16:10 - 16:35 | P24 | Optimization of Non-smooth Hyperbolic Maxwell's Equations in Type-II Superconductivity Based on the Bean Critical State Model (M. Winckler) |
| 16:35 - 17:00 | P10 | Generalized Nash Equilibrium Problems with Partial Differential Operators: Theory, Algorithms, and Risk Aversion (D. Gahururu, S.-M. Stengl) |

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|---|---|---|
| 17:00 - 17:25 | | Coffee break |

Chair: S. Trenn

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| 17:25 - 17:50 | P14 | Generalized Nash Equilibria and their Computation via Augmented Lagrangian Methods (V. Karl) |
| 17:50 - 18:15 | P23 | Optimization Methods for Mathematical Programs with Equilibrium Constraints in Function Spaces based on Adaptive Error Control and Reduced Order or Low Rank Tensor Approximations (L. Hertlein, A. Rauls) |

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| 18:15 - 18:45 | | *Equal opportunity/women's meeting* |
| 19:00 | | Dinner |

**Tuesday, Oct 2**

Chair: C. N. Rautenberg

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|---|---|---|
| 9:00 - 9:45 | | **Plenary Session**: Fractional PDEs: Control, Applications, and Beyond (H. Antil) |
| 9:45 - 10:10 | P20 | Optimizing Variational Inequalities on Shape Manifolds (K. Welker) |
| 10:10 - 10:35 | P09 | Optimal Control of Dissipative Solids: Viscosity Limits and Non-Smooth Algorithms (S. Thomas) |

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| 10:35 - 11:00 | | Coffee break |

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| 11:00 - 11:25 | P17 | Optimizing Fracture Propagation Using a Phase-Field Approach (A. Hehl) |
| 11:25 - 11:50 | P21 | Multi-Leader-Follower Games in Function Space (J. Becker) |
| 11:50 - 12:15 | P06 | Analysis and Solution Methods for Bilevel Optimal Control Problems (F. Harder) |
| 12:15 - 14:00 | | Lunch |
| 14:00 - 14:15 | | *Presentation of activities concerning equal opportunity (A. Walther)* |

|  |  | Chair: I. Yousept |
|---|---|---|
| 14:15 - 14:40 | P08 | A Calculus for Non-Smooth Shape Optimization with Applications to Geometric Inverse Problems (M. Herrmann) |
| 14:40 - 15:05 | P02 | Coupling Hyperbolic PDEs with Switched DAEs: Analysis, Numerics and Application to Blood Flow Models (S. Trenn) |
| 15:05 - 15:30 | | Coffee break |

|  |  | Chair: D. Wachsmuth |
|---|---|---|
| 15:30 - 15:55 | P19 | Shape Optimization for Maxwell's Equations Including Hysteresis Effects in the Material Laws (O. Ebel) |
| 15:55 - 16:20 | P16 | Optimal Control of Variational Inequalities of the Second Kind with Application to Yield Stress Fluids (C. Meyer) |
| 16:20 - 16:45 | P13 | Simulation and Control of a Nonsmooth Cahn–Hilliard Navier–Stokes System with Variable Fluid Densities (C. Gräßle, T. Keil) |
| 17:00 - 18:30 | | Parallel sessions: <br> *PI meeting* <br> *Young researchers' meeting* |
| 19:00 | | Dinner |

**Wednesday, Oct 3**

|  |  | Chair: I. Neitzel |
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| 9:00 - 9:25 | P05 | Multiobjective Optimal Control of Partial Differential Equations Using Reduced-Order Modeling (S. Banholzer, B. Gebken) |
| 9:25 - 9:50 | P01 | Approximation of Monge–Kantorovich Problems (S. Bartels) |
| 9:50 - 10:15 | P11 | Optimal Control of Elliptic and Parabolic Quasi-Variational Inequalities (A. Alphonse) |
| 10:15 - 10:40 | P03 | Numerical Methods for Diagnosis and Therapy Design of Cerebral Palsy by Bilevel Optimal Control of Constrained Biomechanical Multi-Body Systems (M. Schlöder) |
| 10:40 - 11:05 | | Coffee break |

|  |  | Chair: R. Krause |
|---|---|---|
| 11:05 - 11:30 | P04 | Parameter Identification in Models With Sharp Phase Transitions (A. Rösch) |
| 11:30 - 12:15 | | **Plenary Session**: Recent Trends in Algorithmic Optimization (E. Sachs) |
| 12:15 - 12:25 | | Closing remarks |

## List of Participants

| | | |
|---|---|---|
| 1 | Alphonse, Amal | WIAS |
| 2 | Antil, Harbir | George Mason University |
| 3 | Banholzer, Stefan | University of Konstanz |
| 4 | Bartels, Soeren | University of Freiburg |
| 5 | Becker, Jan | TU Darmstadt |
| 6 | Betz, Livia | Universität Duisburg-Essen |
| 7 | Brokate, Martin | TU München |
| 8 | Dellnitz, Michael | Paderborn University |
| 9 | Dempe, Stephan | TU Bergakademie Freiberg |
| 10 | Deng, Yu | TU Bergakademie Freiberg |
| 11 | Ebel, Olga | Paderborn University |
| 12 | Fatima, Arooj | TU Dortmund |
| 13 | Gahururu, Deborah | Philipps-Universität Marburg |
| 14 | Gebken, Bennet | Paderborn University |
| 15 | Gräßle, Carmen | Universität Hamburg |
| 16 | Harder, Felix | BTU Cottbus-Senftenberg |
| 17 | Hehl, Andreas | Universität Bonn |
| 18 | Herrmann, Marc | Universität Würzburg |
| 19 | Hertlein, Lukas | TU München |
| 20 | Herzog, Roland | TU Chemnitz |
| 21 | Hintermüller, Michael | WIAS |
| 22 | Hinze, Michael | Universität Hamburg |
| 23 | Kanzow, Christian | University of Würzburg |
| 24 | Karl, Veronika | University of Würzburg |
| 25 | Keil, Tobias | WIAS |
| 26 | Kirches, Christian | TU Braunschweig |
| 27 | Knees, Dorothee | Universität Kassel |
| 28 | Kocoglu, Damla | TU Kaiserslautern |
| 29 | Kostina, Ekaterina | Heidelberg University |
| 30 | Krause, Rolf | USI, Lugano |
| 31 | Löbhard, Caroline | WIAS |
| 32 | Manns, Paul | TU Braunschweig |
| 33 | Mehlitz, Patrick | BTU Cottbus |
| 34 | Meyer, Christian | TU Dortmund |
| 35 | Mohammadi, Masoumeh | TU Darmstadt |
| 36 | Müller, Georg | University of Konstanz |

| 37 | Neitzel, Ira | Universität Bonn |
|----|---------------|------------------|
| 38 | Rauls, Anne-Therese | TU Darmstadt |
| 39 | Rautenberg, Carlos | WIAS |
| 40 | Rovi, Gabriele | USI, Lugano |
| 41 | Rösch, Arnd | Universität Duisburg-Essen |
| 42 | Sachs, Ekkehard | Universität Trier |
| 43 | Sauter, Marta | Heidelberg University |
| 44 | Schiela, Anton | Universität Bayreuth |
| 45 | Schillings, Claudia | University of Mannheim |
| 46 | Schlöder, Matthias | Heidelberg University |
| 47 | Schmidt, Stephan | University Würzburg |
| 48 | Schulz, Volker | Universität Trier |
| 49 | Schwartz, Alexandra | TU Darmstadt |
| 50 | Starke, Gerhard | Universität Duisburg-Essen |
| 51 | Steck, Daniel | University of Würzburg |
| 52 | Stengl, Steven-Marian | WIAS |
| 53 | Stoecklein, Matthias | University of Bayreuth |
| 54 | Stötzner, Ailyn | TU Chemnitz |
| 55 | Surowiec, Thomas Michael | Philipps-Universität Marburg |
| 56 | Thomas, Stephanie | Universität Kassel |
| 57 | Thünen, Anna | RWTH Aachen |
| 58 | Trenn, Stephan | University of Groningen |
| 59 | Ulbrich, Michael | TU München |
| 60 | Ulbrich, Stefan | TU Darmstadt |
| 61 | Vu, Huu Nhu | Universität Duisburg-Essen |
| 62 | Vidal-Nunez, Jose | TU Chemnitz |
| 63 | Wachsmuth, Daniel | Universität Würzburg |
| 64 | Wachsmuth, Gerd | BTU Cottbus-Senftenberg |
| 65 | Walther, Andrea | Universität Paderborn |
| 66 | Wang, Zhangxian | University Freiburg |
| 67 | Welker, Kathrin | Universität Trier |
| 68 | Winckler, Malte | Universität Duisburg-Essen |
| 69 | Wollner, Winnifried | TU Darmstadt |
| 70 | Yousept, Irwin | Universität Duisburg-Essen |