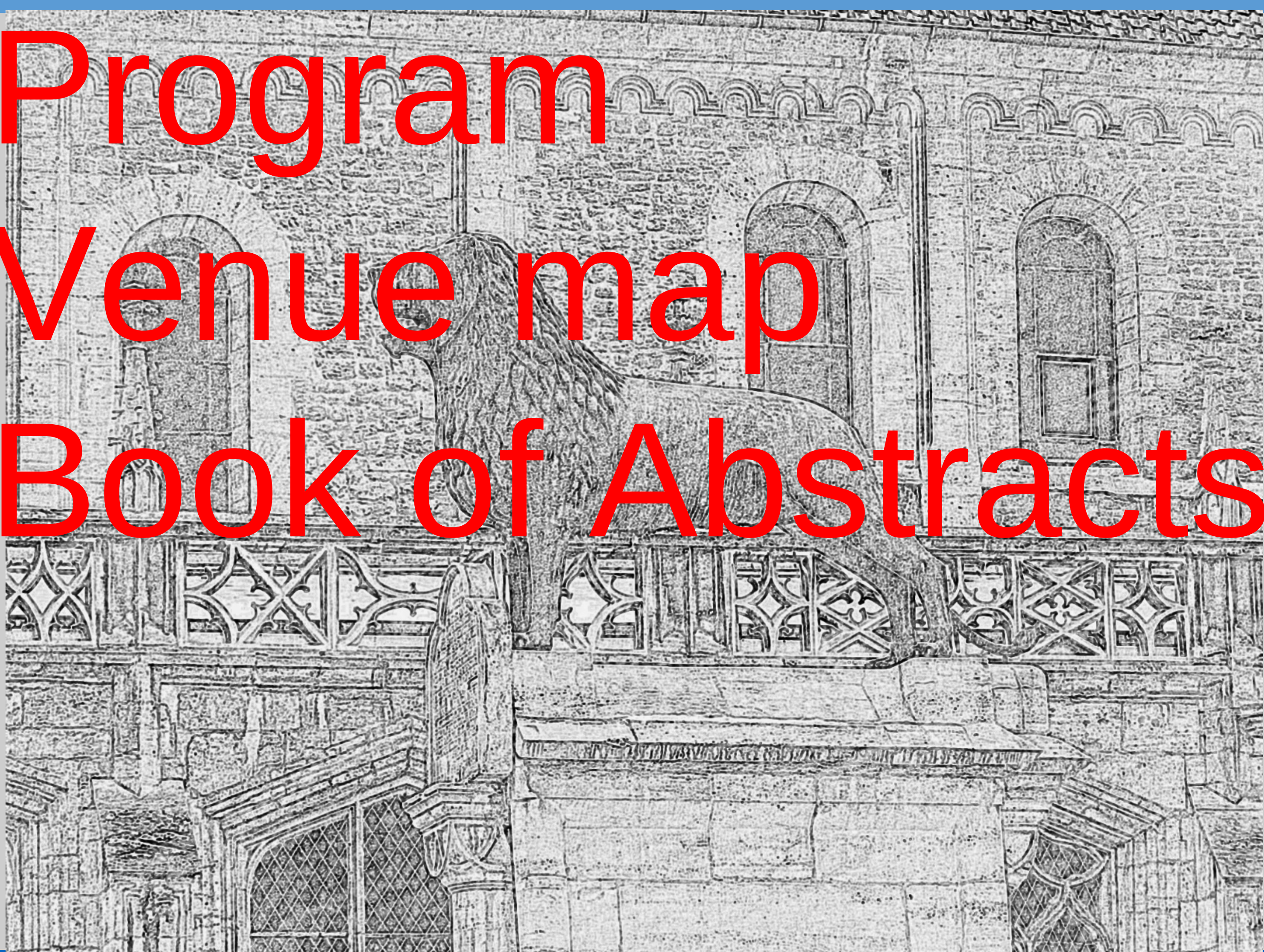
Institut Computational Mathematics
AG Numerik

Technische Universität Braunschweig

NoKo 2018

39th Northern German Colloquium on Applied Analysis and Numerical Mathematic

- June 1 – 2, 2018
- TU Braunschweig, Main Campus
- Contact: noko2018@tu-braunschweig.de



The annual Northern German Colloquium (NoKo) offers researchers in Northern Germany the opportunity to meet and to present their current research results in the area of Applied Analysis and Numerical Mathematics. NoKo particularly aims at enhancing collaboration and networking between the universities in the region.

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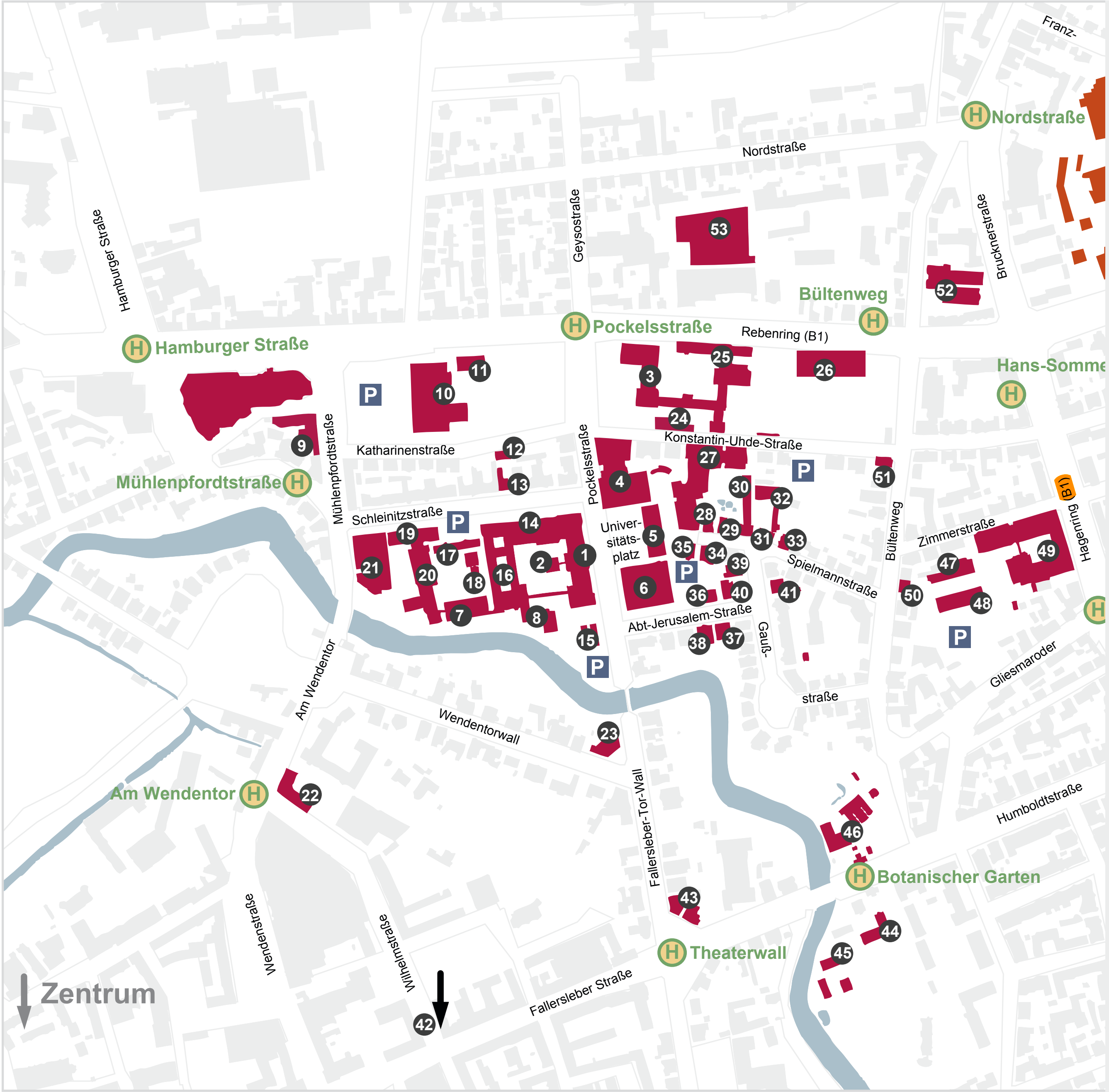

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8 Pockelsstr. 3, Pockelsstr. 3a
9 Mühlenpfordtstr. 4/5
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11 **Studentenwerk, AStA**, Katharinenstr. 1a
12 Katharinenstr. 3
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18 Schleinitzstr. 21d
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24 Kindertagesstätte, Konstantin-Uhde-Str. 20
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26 **Braunschweiger Zentrum für Systembiologie (BRICS)**, Rebenring 56
27 **Biozentrum**, Spielmannstr. 7
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48 **C3 – Carolo Campus Café**, Grotrian, Zimmerstr. 24c, 24d
49 **Chemiezentrum**, Hagenring 30
50 Bültenweg 88
51 **Zentrale Studienberatung** (Umzug in das HDW geplant), **Gleichstellungsbüro**, Bültenweg 17
52 **International Office**, Bültenweg 74/75 (Umzug in das HDW geplant)
53 Rebenpark, Rebenring 31

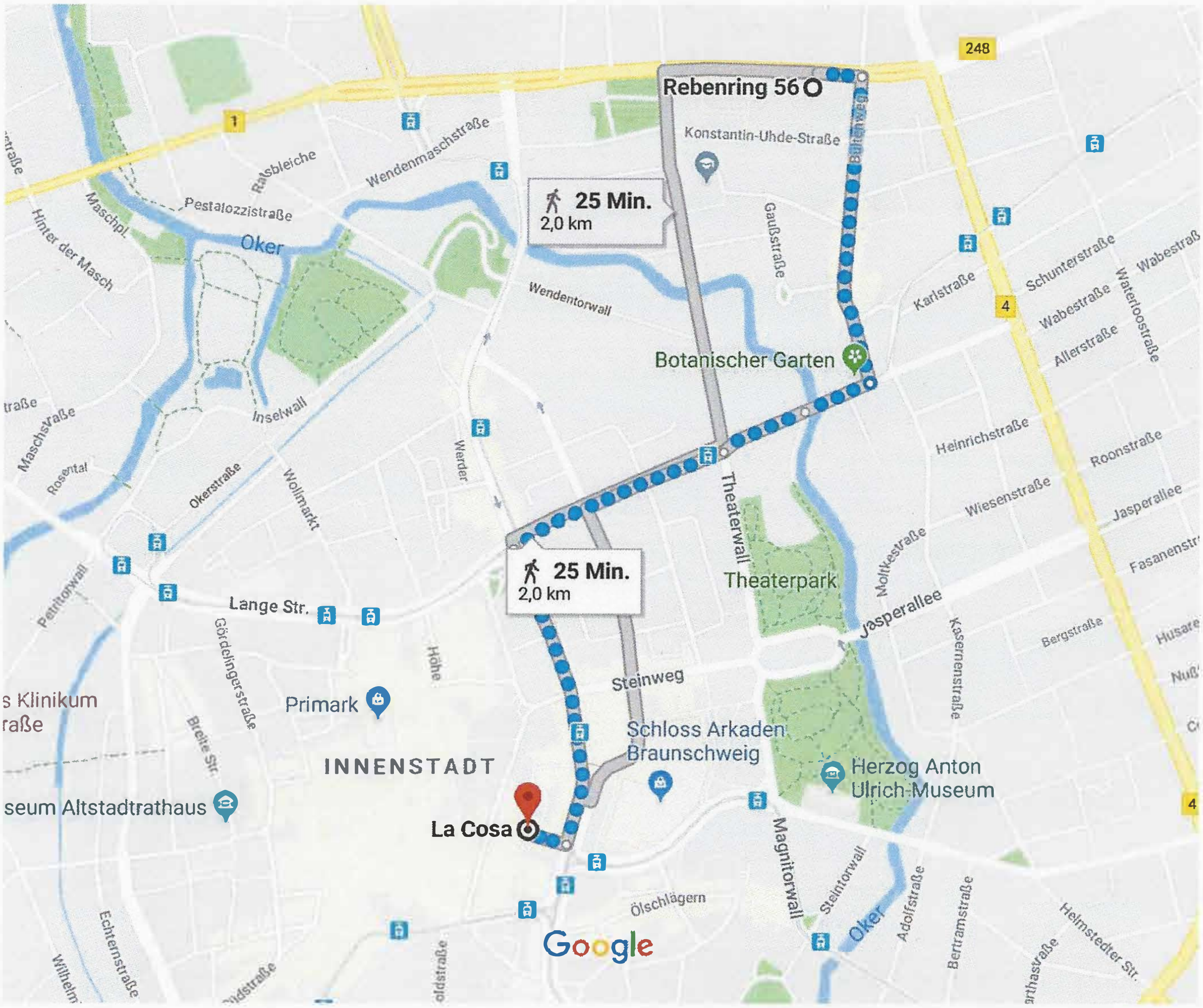
Technische Universität Braunschweig

NoKo 2018 takes place at BRICS (Building 26).
There is a parking lot behind the building, access from Konstantin-Uhde-Straße (one-way street, access from Bültenweg).

Google Maps

Rebenring 56, 38106 Braunschweig nach La Cosa, Schlosspassage, Braunschweig

Zu Fuß 2,0 km, 25 Min.



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Dinner, June 1, 7:00 pm at La Cosa, Schlosspassage 8-9, 38100 BS

Each participant attending has to pay on his/her own.

Friday, June 1

13:00	-	13:05	Opening
13:05	-	13:30	Malte Braack, Kiel *A local pressure correction scheme for the Stokes and Navier-Stokes equations*
13:30	-	13:55	Michael Eden, Bremen *Homogenization of Moving Boundary Problems with Prescribed Normal Velocity*
13:55	-	14:20	Jens Starke, Rostock *Multiscale Analysis of Collective Behavior in Particle Models*
14:20	-	14:55	Coffee Break
14:55	-	15:20	Peter Benner, Magdeburg *A Low-Rank Inexact Newton-Krylov Method for Stochastic Eigenvalue Problems*
15:20	-	15:45	Andreas Rößler, Lübeck *Approximation of Iterated Stochastic Integrals in Infinite Dimensions*
15:45	-	16:10	Alexey Chernov, Oldenburg *Estimation of probability density functions by the Maximum Entropy method*
16:10	-	16:35	Coffee Break
16:35	-	17:00	Michael Hinze, Hamburg *A fully certified reduced basis method for optimal control of PDEs with control constraints*
17:00	-	17:25	Katrin Mang, Hannover *Parallelization of pressurized phase-field fractures using Sneddon's benchmark*
17:25	-	17:50	Maha Youssef, Greifswald *Poly-Sinc Collocation Method for Solving Coupled Systems of Burgers Equations*
17:50	-	18:15	Thomas Wick, Hannover *A variational partition-of-unity dual-weighted residual estimator for partial differential equations*
19:00	-		Dinner at the restaurant La Cosa

Saturday, June 2

9:00	-	9:25	Philipp Morgenstern, Hannover *Adaptive Refinement of regular quadrilateral meshes with linear complexity*
9:25	-	9:50	Jan Heiland, Magdeburg *Stable Time-integration of Incompressible Navier-Stokes Equations*
9:50	-	10:15	Laura Blank, Berlin *An unconditionally stable, low order, and robust finite element method for the numerical simulation of porous media flow*
10:15	-	10:40	Jan Glaubitz, Braunschweig *Application of discrete least squares approximations to numerical partial differential equation solvers*
10:40	-	11:05	Coffee Break
11:05	-	11:30	Ming Zhou, Rostock *Improving Chebyshev-type estimates for restarted Krylov subspace eigensolvers*
11:30	-	11:55	Hanna Veselovska, Lübeck *Properties of bivariate Prony-type polynomials*
11:55	-	12:20	Markus Wageringel, Osnabrück *Algebraic properties of local mixtures*
12:20	-	12:45	Sören Schulze, Bremen *Musical Instrument Separation on Shift-Invariant Spectrograms via Stochastic Dictionary Learning*
12:45	-	12:50	Closing

Book of Abstracts

A Low-Rank Inexact Newton-Krylov Method for Stochastic Eigenvalue Problems

June 1
2:55pm

Peter Benner
Max-Planck-Institut für Dynamik komplexer technischer Systeme, Magdeburg

We discuss the efficient numerical solution of stochastic eigenvalue problems. Such problems arise when the considered physical or technical system contains uncertain parameters and the uncertainty in the resulting eigenvalues/-modes is to be quantified. When discretized with the stochastic Galerkin method, such problems often lead to very high dimensional systems with tensor product structure that can hardly be solved using standard techniques. Here, we suggest to exploit this inherent tensor product structure and develop a globalized low-rank inexact Newton method with which we tackle the stochastic eigenproblem. We illustrate the effectiveness of our solver with numerical experiments.

This is joint work with Akwum Onwunta (Max-Planck-Institut für Dynamik komplexer technischer Systeme, Magdeburg) and Martin Stoll (TU Chemnitz, Fakultät für Mathematik).

References:
[1] P. Benner, A. Onwunta, and M. Stoll. An Inexact Newton-Krylov Method for Stochastic Eigenvalue Problems. arXiv Preprint arXiv:1710.09470, October 2017.

June 2
9:50am

An unconditionally stable, low order, and robust finite element method for the numerical simulation of porous media flow

Laura Blank

Weierstrass Institute for Applied Analysis and Stochastics, Berlin

The topic of this talk is the numerical simulation of flow through porous media based on the Brinkman model as a unified framework that allows the transit between Darcy and Stokes problems. Therefore an unconditionally stable low order finite element approach, which is robust with respect to the physical parameters, is proposed. This approach is based on the combination of stabilized equal order finite elements with a non-symmetric penalty-free Nitsche method for the weak imposition of essential boundary conditions. Focusing on the two-dimensional case, optimal a priori error estimates in a mesh-dependent norm, which allows to extend the results also to the Stokes and Darcy limits, are obtained.

A local pressure correction scheme for the Stokes and Navier-Stokes equations

June 1
1:05pm

Malte Braack
Mathematisches Seminar, Cristian-Albrechts-Universität zu Kiel

Pressure correction methods constitute the most widely used solvers for the time-dependent Navier-Stokes equations. There are many known different pressure correction methods, but each time step usually consist in a predictor step for a non-divergence-free velocity, followed by a Poisson problem for the pressure (or pressure update), and a final velocity correction to obtain a divergence-free vector field. In some situations, the equations for the velocities are solved explicitly, so that the numerical most expensive step is the elliptic pressure problem. We here propose to solve this Poisson problem by a domain decomposition method which does not need any communication between the sub-regions. Hence, this system is perfectly adapted for parallel computation. Numerical examples for the Stokes system show the effectivity of this new pressure correction method. A convergence order $\mathcal{O}(\Delta t^{3/2})$ for the resulting velocity fields is observed.

This is joint work with J. Ahlkrona and U. Kaya (University of Kiel).

June 1
3:45pm

Estimation of probability density functions by the Maximum Entropy method

Alexey Chernov
Institute for Mathematics, Carl von Ossietzky University, Oldenburg

Approximate recovery of a probability density functions (PDF) on the basis of incomplete information on the observable is a prominent problem in statistics and information theory. One way to solve it is to recover the PDF from a truncated sequence of statistical moments (see the recent work [3] for an alternative approach). This task (also known as solving the truncated moment problem) is by no means trivial and has been extensively studied in measure and probability theory. It is well known that depending on the prescribed moments, the truncated moment problem may have no solution or multiple (infinitely many) solutions.
Assuming that the truncated moment sequence is admissible, one needs a criterion to select a PDF which is the "most appropriate" among infinitely many solutions to the truncated moment problem. The strategy of selecting the least biased estimate brings us to the concept of the Maximum Entropy (ME) method [4]. The ME solution is the (nonnegative) maximiser of the Shannon entropy constraint at the prescribed moment values. Obviously, the error of this approximation depends on the number of statistical moments and the accuracy of the estimated moments. Under appropriate assumptions the original constraint Maximum Entropy formulation is equivalent to the matching of moments with a density function whose logarithm is approximated by a polynomial.
Extending fundamental results from [1] we develop a rigorous error analysis of this class of ME methods and obtain error bounds in terms of i) the number of statistical moments, ii) statistical error and iii) deterministic discretization error (the latter emerges e.g. when the observable depends on a numerical solution of a PDE computed by the Finite Element Method). We derive complexity estimates for the proposed approach in the case of the plain and Multilevel Monte Carlo sampling [2] and test its performance on a set of numerical experiments.

This is joint work with Claudio Bierig (Carl von Ossietzky University, Oldenburg).

References:
[1] A.R. Barron, C.-H. Sheu, Approximation of density functions by sequences of exponential families. *Ann. Stat.* 19 (3) (1991) 1347–1369.
[2] C. Bierig and A. Chernov, Approximation of probability density functions by the Multilevel Monte Carlo Maximum Entropy method, *J. Comput. Physics* 314 (2016), 661– 6681.
[3] Michael B. Giles, Tigran Nagapetyan, and Klaus Ritter. Multilevel Monte Carlo approximation of distribution functions and densities. *SIAM/ASA J. Uncertain. Quantif.*, 3(1):267–295, 2015.
[4] E.T. Jaynes, Information theory and statistical mechanics, *Phys. Rev.* (2) 106 (1957) 620–630.

Homogenization of Moving Boundary Problems with Prescribed Normal Velocity

June 1
1:30pm

Michael Eden
Center for Industrial Mathematics (ZeTeM), University of Bremen

Mathematical homogenization is an umbrella term for tools and methods used to deduce the macroscopic behavior of a particular medium based on its microscopic properties. Free boundary problems are usually given via PDEs where the underlying domain (representing some physical medium) is at least partially free to move/deform and where this evolution is not known at the outset. Phase transformation processes (e.g., *water/ice* or different *phases in steel*) are typical examples of problems where the geometry is allowed to evolve and where microscopic effects (growing *nucleation cells*) determine the macroscopic properties of the system.
In this talk, we present and analyze a thermoelasticity model describing such phase transformation processes. Starting with the prescribed normal velocity of the interface separating the competing phases, a specific transformation of coordinates, the so-called Hanzawa transformation, is constructed. This is achieved by

(i) solving a non-linear system of ODEs characterizing the motion of the interface and

(ii) using the Implicit Function Theorem to arrive at the height function characterizing this motion.

Based on uniform estimates for the functions related to the transformation of coordinates, the strong two-scale convergence of these functions is shown. Finally, these results are used to establish the corresponding homogenized model.

References:
[1] M. Eden, A. Muntean. Homogenization of a fully coupled thermoelasticity problem for a highly heterogeneous medium with a priori known phase transformations. Math. Methods Appl. Sci. 40 (2017), 3955-3972.
[2] M. Eden. Homogenization of Thermoelasticity Systems Describing Phase Transformations. PhD thesis, University of Bremen, 2018.

June 2
10:15am

Application of discrete least squares approximations to numerical partial differential equation solvers

Jan Glaubitz
Institut *Computational Mathematics*, TU Braunschweig

Since it was introduced independently by Gauss (1795) and Legendre (1805), the principle of least squares is omnipresent in many fields of numerical mathematics. The same holds for the more general *discrete least squares (DLS) approximations*

$$u_{p,N} = \text{argmin}_{v \in \mathbb{P}_p} ||u - v||_N \approx u,$$

where the norm $|| \cdot ||_N$ is induced by a discrete inner product

$$\langle u, v \rangle_N = \sum_{n=1}^{N} \omega(x_n) u(x_n) v(x_n).$$

Yet, the principle of discrete least squares is still of limited use in numerical methods for time-dependent (hyperbolic) partial differential equations. Generalising the concepts of interpolation and pseudo L^2-projections, however, a variety of new tools arises.

In this talk, we will investigate these tools and their advantages in constructing (novel) stable high-order methods. Following the results from [1] as well as extending them, we are able to prove entropy stability for linear and non-linear test problems using certain nodal collocation-type discontinuous Galerkin methods on any set of collocation points. To carry entropy stability over to non-linear problems, we note the possibility to enforce interpolation or fixed values at points (one of the above mentioned tools). This allows the construction of entropy stable discretisations without introducing complicated (sometimes even unknown) skew-symmetric correction terms [2]. Finally, we also note that stability in the sense of positivity (for instance for the pressure of a system) can be enforced by incorporating linear inequality constraints in the DLS approximation.

This talk is a joined work with Thomas Sonar (TU Braunschweig) and Philipp Öffner (University of Zürich, Switzerland).

References:

[1] J. Glaubitz, P. Öffner. A novel discontinuous Galerkin method using the principle of discrete least squares. MPIM preprint series: 2017-63 (2017).
[2] H. Ranocha, J. Glaubitz, P. Öffner, T. Sonar. Stability of artificial dissipation and modal filtering for flux reconstruction schemes using summation-by-parts operators. Applied Numerical Mathematics 128 (2018), 1 –23.

Stable Time-integration of Incompressible Navier-Stokes Equations

June 2
9:25am

Jan Heiland

Max-Planck-Institut für Dynamik komplexer technischer Systeme, Magdeburg &
Otto-von-Guericke-Universität Magdeburg

We consider the spatially discretized incompressible Navier-Stokes that in velocity v and pressure p variables is written as

$$M\dot{v} = N(v,v) + Av + J^T p + f, \quad v(0) = v_0, \tag{1}$$
$$0 = Jv + g, \tag{2}$$

where M, $A \in \mathbb{R}^{n,n}$ are the mass matrix and the stiffness matrix, where $N\colon \mathbb{R}^n \times \mathbb{R}^n \to \mathbb{R}^n$ models the convection, $J \in \mathbb{R}^{m,n}$ is the discrete divergence operator and J^T approximates the gradient, and where $v_0 \in \mathbb{R}^n$ is the initial value and f and g model possibly nonzero boundary conditions. We assume that (1) results from a space discretization by stable *mixed Finite Elements* so that M is symmetric positive definite and $JM^{-1}J^T$ is invertible.

System (1) is a differential-algebraic equation of *differentiation index* 2, which poses certain difficulties for the time integration. For example, in inexact arithmetics, an *implicit Runge Kutta* discretization of (1) will suffer from an error that scales with $1/\tau$, where τ is the length of the time-step that was employed; see [3]. A similar instability is to be observed [2], if the underlying infinite-dimensional Navier-Stokes equation is first discretized in time and then in space.

A remedy is provided by the application of *index reduction* prior to the time integration, i.e. by a reformulation of the system as an equivalent system with *differentiation index* 1. In fact, established numerical methods for the time integration can be interpreted as an implicit index reduction; see [1].

In this talk, we will illustrate the mechanism that leads to the undesired growth of the error and propose a variant of the index reduction method of *minimal extension* [4]. In its original form, *minimal extension* requires a variable transform $\tilde{v} = Q^{-1}v$ through a regular matrix $Q \in \mathbb{R}^{n,n}$ such that the constraint (2) writes as

$$Jv = JQQ^{-1}v =: \tilde{J}\tilde{v} = \begin{bmatrix} 0 & R \end{bmatrix} \tilde{v},$$

with R being invertible. In order to overcome the costly computation of Q, we extend the theory to formulations of type

$$Jv = JPP^Tv =: \hat{J}\tilde{v} = \begin{bmatrix} J_1 & J_2 \end{bmatrix} \hat{v},$$

where $P \in \mathbb{R}^{n,n}$ is a permutation such that J_2 is invertible. This approach is memory efficient since P merely swaps columns or rows and thus preserves sparsity. We show how P can be determined constructively for the common finite element schemes *Taylor-Hood* and *Crouzeix-Raviart* and present numerical results.

This is joint work with Robert Altmann (Universität Augsburg).

References:

[1] R. Altmann and J. Heiland. Continuous, semi-discrete, and fully discretized Navier-Stokes equations. In *Applications of Differential-Algebraic Equations: Examples and Benchmarks*, Differential-Algebraic Equations Forum. Springer, 2018. to appear.
[2] R. Altmann and J. Heiland. Regularization and Rothe discretization of semi-explicit operator DAEs. *Int. J. Numer. Anal. Model*, 15(3):453 – 478, 2018.
[3] R. Altmann and J. Heiland. Finite element decomposition and minimal extension for flow equations. *ESAIM: M2AN*, 49(5):1489 – 1509, 2015.
[4] P. Kunkel and V. Mehrmann. Index reduction for differential-algebraic equations by minimal extension. *Z. Angew. Math. Mech.*, 84(9):579–597, 2004.

A fully certified reduced basis method for optimal control of PDEs with control constraints

June 1
4:35pm

Michael Hinze
Fachbereich Mathematik, Universität Hamburg

With this talk we present a novel reduced-basis approach for optimal control problems with constraints, which seems to deliver lower dimensional RB spaces as reported in the literature so far for the same problem class, but with the same approximation properties, and which allows to prove an error equivalence as known from finite element a posteriori error analysis. Numerical test confirm our theoretical findings.

June 1
5:00pm

Parallelization of pressurized phase-field fractures using Sneddon's benchmark

Katrin Mang
Institut für Angewandte Mathematik, Leibniz Universität Hannover

Sneddon and Lowengrub [1] proposed a two-dimensional prototype test of a driven cavity with a constant pressure in a crack. This test is well-suited to model pressurized fractures numerically. We use a phase-field approach in which the fracture is represented through a smoothed indicator variable. This variable is called phase-field and is subject to an inequality constraint representing the crack irreversibility. A phase-field approach for pressurized fractures in elasticity and poroelasticity was first computationally analyzed in great detail in [2]. After temporal discretization, the incremental problem formulation consists of an energy minimization problem at each time step and an inequality constraint for the irreversibility of the crack growth. One penalization approach to enforce the crack irreversibility is a primal-dual active set strategy [3]. Merged with the Newton method, the fully-coupled nonlinear partial differential equation is discretized using finite elements. The parallelization of the proposed phase-field fracture model is established by comparing runtime and scalability properties. Here, we employ Sneddon and Lowengrub's configuration as a numerical test case.

This is joint work with Thomas Wick (Leibniz Universität Hannover) and Winnifried Wollner (TU Darmstadt).

References
[1] I. N. Sneddon, M. Lowengrub. Crack Problems in the Classical Theory of Elasticity. John Wiley & Sons, Inc. (1969).
[2] M. F. Wheeler, T. Wick, W. Wollner. An augmented-Lagrangian method for the phase-field approach for pressurized fractures. Computer Methods in Applied Mechanics and Engineering 271 (2014), pages 69–85.
[3] T. Heister, M. F. Wheeler, T. Wick. A primal-dual active set method and predictor-corrector mesh adaptivity for computing fracture propagation using phase-field approach. Computer Methods in Applied Mechanics and Engineering 290 (2015), pages 466–495.

Adaptive Refinement of regular quadrilateral meshes with linear complexity

June 2
9:00am

Philipp Morgenstern
Institut für Angewandte Mathematik, Leibniz Universität Hannover

Adaptive Finite Element Methods (AFEM) are commonly used for partial differential equations that require high resolution in small regions of the domain (due to local singularities such as re-entering corners) while keeping a coarse mesh on other parts of the domain. This requires an algorithm for adaptive mesh refinement which preserves the shape of the elements as well as the regularity of the mesh (i.e., the absence of hanging nodes). Moreover, theoretical purposes such as optimality of the convergence rates require an algorithm that provides overlays of bounded cardinality and has linear memory complexity. All these requirements are satisfied by the Newest Vertex Bisection for triangular meshes [1, 2]. For quadrilateral meshes, Zhao, Mao and Shi [4] presented an algorithm that preserves mesh regularity and shape regularity, but they did not account for overlays or computational complexity. We introduce an alternative algorithm for the local refinement of regular quadrilateral meshes, developed in [3]. This algorithm preserves the shape regularity of the initial mesh, allows the construction of overlays and has linear memory complexity. The latter means that the number of generated elements in the fine mesh is essentially bounded by the number of marked nodes in the preceeding meshes.

This talk is joined work with Carsten Carstensen (Inst. f. Mathematik, HU Berlin) and Daniel Peterseim (IAM, Uni Augsburg).

References:

[1] P. Binev, W. Dahmen, and R. DeVore, *Adaptive Finite Element Methods with convergence rates*, Numerische Mathematik **97** (2004), no. 2, 219–268.
[2] J. Cascon, C. Kreuzer, R. Nochetto, and K. Siebert, *Quasi-Optimal Convergence Rate for an Adaptive Finite Element Method*, SIAM Journal on Numerical Analysis **46** (2008), no. 5, 2524–2550.
[3] P. Morgenstern, *Lokale Verfeinerung regulärer Triangulierungen in Vierecke*, Master's thesis, Institut für Mathematik, Humboldt-Universität zu Berlin, 2013.
[4] X. Zhao, S. Mao, and Z. Shi, *Adaptive Finite Element Methods on Quadrilateral Meshes Without Hanging Nodes*, SIAM Journal on Scientific Computing **32** (2010), no. 4, 2099–2120.

June 1
3:20pm

Approximation of Iterated Stochastic Integrals in Infinite Dimensions

Andreas Rößler
Institute of Mathematics, Universität zu Lübeck

Higher order numerical schemes for SPDEs, that do not possess commutative noise, require the simulation of iterated stochastic integrals. In this presentation, algorithms for the approximation of two-times iterated integrals with respect to an infinite dimensional Q-Wiener process in case of a trace class operator Q are proposed. Error estimates in the mean-square sense are derived and discussed. In contrast to the finite dimensional setting, which is contained as a special case, the error estimates depend on the covariance operator Q. This difference arises as the stochastic process is of infinite dimension.

This is joint work with Claudine Leonhard (Department of Mathematics, CAU Kiel).

Musical Instrument Separation on Shift-Invariant Spectrograms via Stochastic Dictionary Learning

June 2
12:20pm

Sören Schulze

University of Bremen, Fachbereich 3, AG Computational Data Analysis

We propose a method for the blind separation of audio signals from musical instruments. While the approach of applying non-negative matrix factorization (NMF) has been studied in many papers, it does not make use of the pitch-invariance that instruments exhibit. This limitation can be overcome by using tensor factorization, in which context the use of log-frequency spectrograms was initiated, but this still requires the specific tuning of the instruments to be hard-coded into the algorithm. Our method exploits the shift-invariance of the log-frequency spectrogram in order to find patterns of peaks related to specific instruments, while non-linear optimization enables it to represent arbitrary frequencies and incorporate inharmonicity, and the reasonability of the representation is ensured by a sparsity condition. The relative amplitudes of the harmonics are saved in a dictionary, which is trained via a modified version of ADAM. For a realistic monaural piece with acoustic recorder and violin, we achieve qualitatively good separation with a signal-to-distortion ratio (SDR) of 15.0 dB, a signal-to-interference ratio (SIR) of 28.6 dB, and a signal-to-artifacts ratio (SAR) of 15.2 dB, averaged.

This is joint work with Emily J. King (University of Bremen).

June 1
1:55pm

Multiscale Analysis of Collective Behavior in Particle Models

Jens Starke
Institute of Mathematics, University of Rostock

The coarse behavior and its parameter dependence in complex systems is investigated. For this, a numerical multiscale approach called equation-free analysis (see e.g. [1]) is further improved in the framework of slow-fast dynamical systems. The method allows to perform numerical investigations of the macroscopic behavior of microscopically defined complex systems including continuation and bifurcation analysis on the coarse or macroscopic level where no explicit equations are available. This approach fills a gap in the analysis of complex real-world applications including particle models with intermediate number of particles where the microscopic system is too large for direct investigations of the full system and too small to justify large-particle limits. An implicit equation-free method is presented [2] which reduces numerical errors of the analysis considerably. It can be shown in the framework of slow-fast dynamical systems, that the implicitly defined coarse-level time stepper converges to the true dynamics on the slow manifold. The method is demonstrated with applications to particle models of traffic as well as pedestrian flow situations [2, 3, 4]. The results include an equation-free continuation of traveling wave solutions, identification of saddle-node and Hopf-bifurcations as well as two-parameter continuations of bifurcation points.

References:
[1] Kevrekidis, I. G., & Samaey, G. (2009). Equation-Free Multiscale Computation: Algorithms and Applications. *Annual Review of Physical Chemistry*, **60**.
[2] Marschler, C., Sieber, J., Berkemer, R., Kawamoto, A., & Starke, J. (2014). Implicit Methods for Equation-Free Analysis: Convergence Results and Analysis of Emergent Waves in Microscopic Traffic Models. *SIAM Journal on Applied Dynamical Systems*, **13**(3), 1202–1238.
[3] Corradi, O., Hjorth, P. & Starke, J. (2012). Equation-free detection and continuation of a Hopf bifurcation point in a particle model of pedestrian flow. *SIAM Journal on Applied Dynamical Systems*, **11**(3), 1007 – 1032.
[4] Panagiotopoulos, I., Starke, J., Sieber, J. & Just, W. (2018). Control-based Continuation of a Particle Model: Hysteresis in Pedestrian Flows of an Evacuation Scenario. Manuscript.

Properties of bivariate Prony-type polynomials

June 2
11:30am

Hanna Veselovska

Institute of Mathematics of NAS of Ukraine, Kyiv, Ukraine and Institute of Mathematics, University of Lübeck

The parameter estimation of non-harmonic frequencies out of sampling values is an essential problem in signal processing. Namely, considering an N-sparse bivariate exponential sum

$$s_{k_1,k_2} = \sum_{j=1}^{N} a_j \exp\left(-\mathrm{i}k_1 w_{j,1} + k_2 w_{j,2}\right),$$

where $(w_{1,j}, w_{2,j}) \in (0,\pi]^2$, $(k_1, k_2) \in \mathbb{Z}_+^2$, $a_1, a_2, \ldots, a_N \in \mathbb{C}\backslash\{0\}$, the goal is to find the vectors $(w_{1,j}, w_{2,j})$, $j = 1, ..., N$, given finitely many samples of s_{k_1,k_2}. In one-dimensional case, a solution of such a problem can be found by the well-known Prony method or its approximate versions [1]. In recent years, a lot of research has been carried out in order to obtain such a method in higher dimensions (see, e.g., [3]).

Based on the one-dimensional approach developed in [2] and the general Gröebner basis theory, we propose to find the parameters $(w_{1,j}, w_{2,j})$, $j = 1, ..., N$, as common zeros of some bivariate Prony-type polynomials. The Prony-type polynomials have special orthogonality properties with respect to the pointwise measure on the two dimensional torus $\mathbb{T}^2$ that allows stability under the noise data conditions.

References:

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June 2
11:55am

Algebraic properties of local mixtures

Markus Wageringel
Institut für Mathematik, Universität Osnabrück

We study local mixtures of Dirac distributions and show that they possess nice algebraic properties, highlighting connections to algebraic statistics, geometry and signal processing. In particular, we study the moment variety, the algebraic variety defined by the moments of these distributions, and characterize it by providing defining equations. Further, we consider mixtures of these distributions and investigate the problem of recovering the parameters of such a distribution from its moments.

This is joint work with Alexandros Grosdos (Osnabrück University).

A variational partition-of-unity dual-weighted residual estimator for partial differential equations

June 1
17:50pm

Thomas Wick

Institut für Angewandte Mathematik, Leibniz Universität Hannover

The dual weighted residual method (DWR) for a posteriori error estimation and its localization for mesh adaptivity applied to partial differential equations is investigated. The contribution of this talk is to introduce a novel localization technique based on the introduction of a partition of unity [1]. This new technique is very easy to apply, as neither strong residuals nor jumps over element edges are required. This facilitates significantly the application of the DWR method to PDE systems and multiphysics problems with internal interfaces. Several numerical tests substantiate our theoretical investigations that also include comparisons to classical localization techniques [2] and [3]. Recent extensions to polygonal meshes [4] and multiple goal functional evaluations [5] are briefly discussed as well.

This talk is joint work with Thomas Richter (Institut für Analysis und Numerik, Universität Magdeburg).

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[1] T. Richter, T. Wick. Variational localizations of the dual weighted residual estimator. J. Comp. Appl. Math. 279 (2015) 192-208.
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June 1
5:25pm

Poly-Sinc Collocation Method for Solving Coupled Systems of Burgers Equations

Maha Youssef

Institute of Mathematics and Computer Science, University of Greifswald

A collocation algorithm for the solution of coupled system of Burgers equations is presented. The algorithm uses a collocation technique based on polynomial approximation at Sinc points [1,2]. The main theorem of the convergence rate of the collocation technique is discussed. The scheme is tested for some coupled systems of Burgers nonlinear equations. For each example the error formula of the approximation is discussed and verified in a comparison of the analytic solution. The numerical results obtained by the Poly-Sinc method are compared to those obtained by using different numerical techniques, for example, the Chebyshev spectral collocation method and a Fourier Pseudo-spectral method.

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Improving Chebyshev-type estimates for restarted Krylov subspace eigensolvers

June 2
11:05am

Ming Zhou
Institut für Mathematik, Universität Rostock

Computing the smallest eigenvalues of very large and sparse matrices which derive from the discretization of elliptic partial differential operators is an important and challenging problem. Restarted (preconditioned) Krylov subspace iterations belong to the most efficient solvers for such eigenvalue problems. In this talk we present recent results on the convergence theory of such iterations. We start with a classical Ritz value estimate of Chebyshev-type from [1] and its generalization from [2] concerning arbitrarily located Ritz values. Numerical examples show that these Chebyshev-type estimates are not sharp. An improvement has been achieved in [3] by using geometric arguments and more supporting eigenvalues. The new estimates in terms of interpolating polynomials can easily be compared with the Chebyshev-type estimates.

References:
[1] A.V. Knyazev. Convergence rate estimates for iterative methods for a mesh symmetric eigenvalue problem. Russian J. Numer. Anal. Math. Modelling 2 (1987), 371–396.
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