Titles and Abstracts

Prof. David Colton

"Spectral Theory for the Transmission Eigenvalue Problem."

Abstract: The transmission eigenvalue problem is a non selfadjoint eigenvalue problem arising in inverse scattering theory. This problem has attracted considerable interest in recent years since such eigenvalues can be determined from the far field data and yield estimates on the material properties of the scatterer. In this talk we will focus on the simplest example of the transmission eigenvalue problem where the scatterer and eigenfunctions are spherically stratified which reduces the problem to one for ordinary differential equations. We will use this simple model to investigate the spectral properties of the transmission eigenvalue problem. We will conclude the lecture by briefly showing the connection between the location of transmission eigenvalues for automorphic solutions of the wave equation in the hyperbolic plane and the Riemann hypothesis.

Prof. Roland Potthast

"On the Mathematics of Weather and Climate"

Abstract: Simulating the dynamics of weather and climate is one of the big topics of our time. It touches social questions on many layers of our daily activity and deep questions of mankind living on a blue planet.
Numerical Weather Prediction today is very relevant for logistics, air traffic, trains, cars and ships. No plane can leave without a proper weather forecast, and the management of airports today with take-offs and landings in 3-minute frequencies is based on far reaching mathematical techniques. Autonomous driving involves weather from and to the car, and local flooding events can be predicted based on measurements by 3D-Volume RADAR networks over Europe.
The prediction of clouds and winds today is a core ingredient of the energy market, with billions of Euros involved on a daily basis. It is an important prerequisite for the exit from nuclear and fossil-fuel energy, which is a core task of current politics. Atmospheric reanalysis enables the monitoring of climate change as well as modern wind-park planning and urban construction activity.
Weather prediction, climate monitoring and climate projections are based on sophisticated numerical models in combination with data assimilation techniques, based on a very wide set of observations. These include in-situ measurements from classical ground stations and radio sondes, commercial air-plane measurements, ground-based remote sensing networks with RADAR and LIDAR and a rich set of polar-orbiting or geostationary satellites with observations
in the visible, infrared or microwave band. Today, hyper-spectral instruments provide thousands
of frequencies per field of view, such that weather and climate analysis is part of the big data trend and employs modern top-ranking supercomputers for 24/7 analysis, predictions and services.
We will give an introduction into the mathematics of weather and climate, describe the progress which is being made currently and survey recent research developments.

Prof. Timo Heister

"Finite Element Simulations of Phase-field Fracture Problems"

Timo Heister, Thomas Wick:
Abstract: We present an efficient and scalable Finite Element scheme for quasi-static fracture problems. The crack is discretized using a phase-field approach, which allows merging and joining of cracks. An active active set strategy is used to solve the constrained minimization problem. The developed method supports large scale parallel computations and a novel adaptive mesh refinement strategy. Various benchmark problems are shown that demonstrate the method.

Prof. Armin Iske

"From radial kernels to image compression and beyond"

Abstract: Radial kernels - also termed radial basis functions (RBFs) - are well known as powerful tools for multivariate scatted data approximation, where many ground-breaking contributions to the RBF theory were made at the Göttingen NAM institute since the early 1990s. Departing from the standard problem of Lagrange interpolation by RBFs, we explain how to preprocess the input data in order to obtain numerically stable multi-scale interpolation methods. This leads us to a greedy algorithm, termed adaptive thinning (AT), for the construction of a data hierarchy. The utility of AT
for image approximation was discovered in the early 2000s. We demonstrate the good performance of the AT algorithm, where we compare its resulting image compression method with potential competitors, including the industrial standard JPEG2000. If time allows, we will discuss how AT could be made useful for other relevant applications beyond image processing.

Prof. Shoham Sabach

"Proximal minimization algorithms for nonconvex and nonsmooth problems"

Abstract: In this talk, I will discuss a self-contained convergence analysis framework for first-order methods in the setting of nonconvex and nonsmooth optimization problems. Our approach allows for analyzing, under mild assumptions, various classes of nonconvex and nonsmooth problems with semi-algebraic data, a property shared by many optimization models arising in various fundamental applications. We illustrate our results by deriving a new and simple proximal based algorithm, which exploits structure and data information relevant to important applications and paves the way to the derivation of other interesting algorithmic variants.

Prof. Carola Schönlieb

“Data-driven regularisation for inverse problems”

Abstract: In this talk we discuss the idea of data-driven regularisers for inverse imaging problems. We are in particular interested in the combination of model-based and purely data-driven inversion approaches. In this context we will make a journey from “shallow” learning for computing optimal parameters for variational regularisation models by bilevel optimization to the investigation of different approaches that use deep neural networks for solving inverse imaging problems. The talk is furnished with application of these ideas to medical imaging, in particular computed tomography.

This talk is based on S. Arridge, P. Maass, O. Öktem, C.-B. Schönlieb, Solving inverse problems using data-driven models, Acta Numerica, 28, 1-178, 2019

Prof. Andreas Kirsch

"A Radiation Condition for Periodic Waveguides."

Abstract: We consider a closed waveguide with an index of refraction which is periodic with respect to the axis of the waveguide. We will formulate a radiation condition which is motivated by the limiting absorption principle and show uniqueness and existence by rather elementary arguments. A key tool is an old singular perturbation result by Rainer Kress just 40 years ago.

Dr. Martin Petry

“We need (more) mathematicians.”

Abstract: Mathematicians are in high demand in the industry. This had been the case in the past decades already and is even more true today. The much-hyped Digital Transformation has changed the way industrial companies work and – consequently – the profiles of people companies are hiring.

Prof. Holger Wendland

“Kernel-based reconstructions for parametric PDEs”

Abstract: In uncertainty quantification, an unknown quantity has to be reconstructed which depends typically on the solution of a partial differential equation. This partial differential equation itself may depend on parameters, some of them may be deterministic and some may be random. To approximate the unknown quantity one therefore has to solve the partial differential equation (usually numerically) for several instances of the parameters and then reconstruct the quantity from these simulations. As the number of parameters may be large, this becomes a high-dimensional reconstruction problem.
In this talk, I will address the topic of reconstructing such unknown quantities using kernel-based reconstruction methods on sparse grids. I will introduce into the topic, explain the reconstruction process and provide error estimates.
This talk is based upon joint work with C. Rieger (Bonn) and R. Kempf (Bayreuth).

Dr. Gerd Rapin

"A Mathematician at Volkswagen - Experiences and Challenges"

Abstract: In this talk I give an overview about my experiences at Volkswagen. It will be shown, where mathematical knowledge could be useful in automotive industry.

First of all I focus on external aerodynamics and explain the consequences of the Worldwide harmonized Light vehicles Test Procedure (WLTP) and the new CO_2 limits.

In the second part I talk about the efforts and strategies to integrate more and more software functions and electronic devices.

Prof. Ulrich Bauer

"Persistent homology: from theory to computation."

Abstract: In this talk, I will survey some recent results on theoretical and computational aspects of applied topology. I will focus on three aspects of persistent homology as a topological descriptor: its use for the inference and simplification of topological features, its stability with respect to perturbations of the data, and efficient methods for its computation on a large scale.
These questions will be motivated and illustrated by concrete examples and problems, such as
- reconstruction of a shape and its topological properties from a point cloud,
- denoising of isosurfaces for the visualization of medical images,
- faithful simplification of contours lines of a real-valued function, and
- the existence of unstable minimal surfaces.

Prof. Anja Fischer

"Non-linear combinatorial optimization meets facility layout problems"

Abstract: In this talk we give an overview on some solution and lower bounding methods in non-linear combinatorial optimization. The approaches are illustrated on an application from real-world factory planning. Indeed, we consider the single and double row facility layout problem (called SRFLP and DRFLP). Given a set of departments and pairwise connectivities between these one asks for a non-overlapping arrangement of the departments on one side or on both sides of a common path such that the weighted sum of the center-to-center distances is minimized.