MASTER DEGREE COURSES OFFERED IN ENGLISH IN SUMMER SEMESTER 2018

- 0102700 **Mathematical Topics in Kinetic theory**,
  Dr. Ried

  In this course we will introduce and discuss the basic questions in kinetic theory, and the methodical approaches to their solutions. In particular, we will focus on the following topics: - Boltzmann equation: Cauchy problem and properties of solutions - entropy and the H theorem - equilibrium and convergence to equilibrium

  Prerequisites: Functional Analysis (including measure theory, L^p spaces and basic knowledge of Sobolev spaces), some PDE knowledge.

- 0150400 **Extremal Graph Theory**,
  Dr. Yuditsky

  The course will cover fundamental results and tools in the field of extremal graph theory as well as several recent advances. The topics will include extremal functions, structure of extremal graphs, Szemerédi's Regularity Lemma, Ramsey theory for graphs and hypergraphs, and graph colorings.

  Prerequisites: Solid knowledge of Graph Theory and Linear Algebra.

- 0157500 **Boundary and Eigenvalue Problems**,
  Dr. Mandel

  A boundary value problem consists of an elliptic (or ordinary) differential equation posed on some domain, together with additional conditions required on the boundary of the domain, e.g. prescribed values for the unknown function. Typical origins of boundary value problems are steady-state (i.e. time-independent) situations in physics and engineering. An eigenvalue problem for a differential equation is a linear and homogeneous boundary value problem depending linearly on an additional parameter, and one is interested in values of this parameter such that the boundary value problem has nontrivial solutions. Eigenvalue problems arise e.g. after separation of variables in time-dependent problems. The lecture course will start with a series of examples for occurrence of boundary value problems in mathematical physics, followed by the comparatively simple existence theory for ordinary linear regular boundary value problems. A large part of the lecture course will then be covered by an existence theory for linear elliptic boundary value problems; for this purpose, weak formulations of boundary value problems, Sobolev spaces, trace theory, the Lax-Milgram Lemma, Fredholm's Alternative, and other tools will be introduced. Additionally, qualitative properties of the obtained solutions (e.h. their regularity) will be discussed. In a natural way, the existence theory for boundary value problems connects to eigenvalue problems. Based upon the Spectral Theorem for compact symmetric operators in Hilbert spaces an eigenvalue theory for symmetric elliptic differential operators will be presented.

- 0159810 **Commutative Algebra**,
  Dr. Januszewski

  This module continues the study of commutative rings and modules from the module "Algebra" via abstract algebraic methods. In particular, we will investigate noetherian rings and modules more thoroughly and introduce the concepts of localization and completion. We will also be concerned with functorial properties of various algebraic constructions and related general categorical and homological notions. This will be particularly fruitful in understanding the behavior of the tensor product and extensions of modules over general rings. This module provides good background for more specialized classes in Algebraic Geometry and Algebraic Number Theory.

- 0161300 **Numerical Analysis of Highly Oscillatory Problems**,
  JProf. Schratz

  In this lecture we will focus on highly-oscillatory problems from a numerical point of view.

  Highly-oscillatory problems are numerically very demanding due to the highly oscillatory behavior of the solution. Most classical numerical methods break down as they fail to resolve the oscillations within the solution. To obtain an good approximation severe step size restrictions need to be imposed which leads to huge computational efforts and does not permit reasonably accurate simulations. In this lecture we will consider the Klein-Gordon equation as a toy-model and derive efficient numerical schemes in oscillatory regimes based on asymptotic approximation techniques.

  In the exercises we will deepen some theoretical results and carry out practical implementations.

  Prerequisites: One should be familiar with basic concepts of the numerical time integration of ODEs and PDEs and functional analysis. A basic knowledge of the theory of semigroups is helpful.

- 0161600/0161610 **Numerical Methods in Fluid Mechanics**,
  Prof. Dörfler

  In this lecture we are concerned with the modelling and computation of flow of liquid and gas. Examples are the Navier–Stokes equations (for incompressible viscous flows) and the Euler equations (for incompressible inviscid flows). Moreover we consider the Stokes equation (for dominant viscous effects), the compressible Navier–Stokes equations and equations for multiphase flows. The numerical techniques we consider are the finite element method, the finite volume method and the discontinuous Galerkin method.

  Requirements: Basic lectures in Partial Differential Equations and Numerical Methods of Partial Differential Equations.

- 0164400 **Uncertainty Quantification**,
  Prof. Frank

  "There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – there are things we do not know we don't know." (Donald Rumsfeld)

  In this class, we learn to deal with the "known unknowns", a field called Uncertainty Quantification (UQ). More specifically, we focus on methods to propagate uncertain input parameters through differential equation models. Given uncertain input, how uncertain is the output? The first part of the course ("how to do it") gives an overview on techniques that are used. Among these are: Sensitivity analysis, Monte-Carlo methods, Spectral expansions, Stochastic Galerkin method, Collocation methods, sparse grids. The second part of the course ("why to do it like this") deals with the theoretical foundations of these methods. The so-called "curse of dimensionality" leads us to questions from approximation theory. We look back at the very standard numerical algorithms of interpolation and quadrature, and ask how they perform in many dimensions.

- 0164500 **Numerical Methods for Time-dependent PDEs**,
  Prof. Hochbruck

  The aim of this lecture is to construct, analyze and discuss the efficient implementation of numerical methods for time-dependent partial differential equations (pdes). We will consider traditional methods and techniques as well as very recent research.

  The students are expected to be familiar with the basics of the numerical analysis of the time integration of ordinary differential equations

(Runge-Kutta and multistep methods) and of finite element methods for elliptic boundary element methods. The lecture starts with a review on Runge-Kutta and multistep methods. Some basic knowledge in functional analysis and the analysis of boundary value problem is helpful but the main results will be repeated in the lecture.

- 0167000/0167010 **Numerical Methods in Computational Electrodynamics**,
  Prof. Dörfler
  We focus on theory and numerics of Maxwell equations for the approximation of photonic bandstructures or waveguides.
  Contents: The Maxwell system, aspects of modeling. Boundary and interface conditions. Analytical tools. The curl curl source problem. The curl curl eigenvalue problem. Finite element methods for the Maxwell equations. Bandstructure computations, simulation and optimisation of waveguides.
  Requirements: Basic lectures in Partial Differential Equations and Numerical Methods of Partial Differential Equations.

- 0178000 **Time Series Analysis**,
  Prof. Gneiting
  A time series is a sequence (x_t) of data where the subscript t indicates the time at which the datum x_t was observed. The course provides an introduction to the theory and practice of statistical time series analysis. Topics covered include stationary and non-stationary stochastic processes, autoregressive and moving average (ARMA) models, state-space models and the Kalman filter, model selection and estimation, forecasting and forecast assessment, and an outline of spectral techniques.