INTERNATIONAL PROGRAM (MASTER)

CLASSES: SUMMER SEMESTER 2013

0160600 Adaptive Finite Element Methods
Lecture: 2 h, 4 credit points
Thu 11:30-13:00 5.20 1C-03
Tutorial: 2 h
Wed 9:45-11:15 5.20 1C-01
Prof. Willy Dörfler

0150300 Combinatorics in the plane
Lecture: 2 h, 4 credit points
Mon 11:30-13:00 01.85 Z1
Tutorial: 2 h
Tue 8:00-9:30 01.85 Z1
Prof. Maria Axenovich, Dr. Torsten Ueckerdt

0152800 Convex Geometry
Lecture: 4 h, 8 credit points
Tue 14:00-15:30 5.20 1C-04, Wed 11:30-13:00 5.20 1C-04
Tutorial: 2 h
Mon 15:45-17:15 5.20 1C-04
Dr. Daniel Hug

0154100 Geometric Numerical Integration
Lecture: 2 h, 4 credit points
Tue 15:45-17:15 5.20 1C-04
Tutorial: 2 h
Fri 14:00-15:30 5.20 1C-04
Prof. Tobias Jahnke

0159610 Numerical methods in mathematical finance II
Lecture: 4 h, 8 credit points
Thu 8:00-9:30 5.20 1C-03, Fri 11:30-13:00 5.20 1C-03
Tutorial: 2 h
Mon 14:00-15:30 01.85 Z2
Prof. Tobias Jahnke

0156400 Spectral Theory
Lecture: 4 h, 8 credit points
Tue 9:45-11:15 5.20 1C-03, Fri 9:45-11:15 5.20 1C-03
Prof. Lutz Weis

0163700 Mathematical Physics
Lecture: 4 h, 8 credit points
Mon 9:45-11:15 40.32 RPH R. 045, Thu 14:00-15:30 20.40 NH
Tutorial: 2 h
Tue 15:45-17:15 10.23 Nusselt
Prof. Dirk Hundertmark

161300 Lévy Processes
Lecture: 2 h, 4 credit points
Wed 8:00-9:30 5.20 1C-02
Tutorial: 2 h
Fri 11:30-13:00 01.85 Z1
Dr. Vicky Fasen

0175400 Seminar: Engineering Mathematics and Computing
Thu 14:00-15:30, room to be announced
Prof. Vincent Heuveline, Dr. Gudrin Thäter

Time-table for lectures

	Monday	Tuesday	Wednesday	Thursday	Friday
08:00-09:30			Lévy Pro.	Num.Meth.Fin.II	
09:45-11:15	Math.Phys.	Spec.Theo.			Spec.Theo.
11:30-13:00	Combinat.		Conv.Geo.	Ad.Fin.E. Meth.	Num.Meth.Fin.II
14:00-15:30		Conv.Geo.		Math.Phys.	
15:45-17:15				Geo.Num.Int.	

GERMAN CLASSES

Optional German language classes should be attended in the late afternoon and evening.

CLASSES: SUMMER SEMESTER 2013

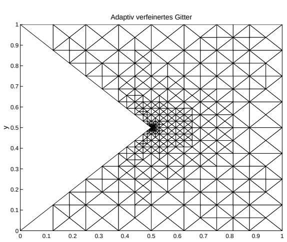
0154100 Adaptive Finite Element Methods

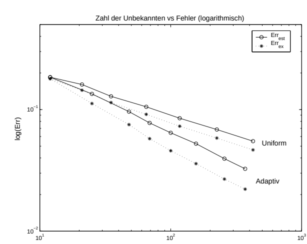
Lecture: 2 h, 4 credit points
Thu 11:30-13:00 5.20 1C-03
Tutorial: 2 h
Wed 9:45-11:15 5.20 1C-01
Prof. Willy Dörfler

Contents

The Finite Element Method is the method of choice for the solution of elliptic boundary value problems. In computing these approximations we follow two aims: We need a computable error bound to judge the quality of an approximation, and we want to reduce the amount of work to obtain an approximation of a prescribed tolerance. The first item is a must since numerical simulations without information about their accuracy are dangerous. This has been seen by some failures in the past, see information about the Sleipner accident on HTTP://WWW.IMA.UMN.EDU/~ARNOLD/DISASTERS/SLEIPNER.HTML .

The latter aim may be achieved by constructing local (e.g. in space) error indicators and perform local refinement where large errors are indicated. We show for a model problem how to construct convergent local refinement algorithms and show that the algorithm has optimal complexity.





Prerequisites: Finite element methods for partial differential equations.

References

M. Ainsworth and T. Oden: A Posteriori Error Estimation in Finite Element Analysis. Wiley-Interscience, New York, 2000.
R. Verfürth: A Review of A Posteriori Error Estimation and Adaptive Mesh-Refinement Techniques. Wiley-Teubner, Chichester, 1996.
R. Becker, R. Rannacher: An Optimal Control Approach to A Posteriori Error Estimation. Acta Numerica 10 (2001).

0150300 Combinatorics in the plane

Lecture: 2 h, 4 credit points
Mon 11:30-13:00 01.85 Z1
Tutorial: 2 h
Tue 8:00-9:30 01.85 Z1
Prof. Maria Axenovich, Dr. Torsten Ueckerdt

Contents

This course is an introduction to a variety of standard and non-standard concepts in plane combinatorics. This contains but is not limited to planar point sets, intersection patterns, order relations, and geometric arrangments.
The concepts are presented problem-driven, i.e., are motivated by a typical problem in the field, such as coloring problems, extremal questions, structural questions, or representability problems.
Gaining knowledge of basic concepts in combinatorial geometry, in particular planar point sets, intersection patterns, order relations, and geometric arrangments. Acquiring skills in handling coloring-type problems, representability questions, counting problems, and on-line problems.

Prerequisites

Students should know the basic concepts in discrete mathematics, such as graphs, permutations and algorithms, as well as have some background in mathematics, such as induction principle, double counting, and linear algebra.
The course is addressed to students studying mathematics, computer science or a related subject in their 3rd year or later.

References

Will be announced in the lecture.

0152800 Convex Geometry

Lecture: 4 h, 8 credit points
Tue 14:00-15:30 5.20 1C-04, Wed 11:30-13:00 5.20 1C-04
Tutorial: 2 h
Mon 15:45-17:15 5.20 1C-04
Dr. Daniel Hug

Contents

Convexity is a fundamental notion in mathematics which has a combinatorial, an analytic, a geometric and a probabilistic flavour. Basically, a given set A in a real vector space is called convex if with any two points of A the segment joining the two points is also contained in A.

This course provides an introduction to the geometry of convex sets in a finite-dimensional real vector space and to basic properties convex functions. Results and methods of convex geometry are particularly relevant, for instance, in optimization theory and in stochastic geometry.
The following topics will be covered: 1. Geometric foundations: combinatorial properties, support and separation theorems, extremal representations; 2. Convex functions; 3. The Brunn-Minkowski Theory: basic functionals of convex bodies, mixed volumes, geometric (isoperimetric) inequalities; 4. Surface area measures and projection functions; 5. Integral geometric formulas.
If time permits, we also consider additional topics such as symmetrization of convex sets or sets of constant width.
Lectures notes in English (by D. Hug and W. Weil) will be available.

Prerequisites

This course is suited for everybody with a firm background in analysis and linear algebra.

References

Gruber, Peter: Convex and Discrete Geometry, Grundlehren der mathematischen Wissenschaften, vol. 336, Springer, Berlin, 2007.
Schneider, Rolf: Convex Bodies: the Brunn-Minkowski theory, Cambridge University Press, Cambridge, 1993.

0154100 Geometric Numerical Integration

Lecture: 2 h, 4 credit points
Tue 15:45-17:15 5.20 1C-04
Tutorial: 2 h
Fri 14:00-15:30 5.20 1C-04
Prof. Tobias Jahnke

Contents

The numerical simulation of time-dependent processes in science and technology often leads to the problem to solve a system of ordinary differential equations (ODEs) with a suitable method. In many applications it can be shown that the exact solution or flow exhibits certain qualitative or "geometric"properties. For example, it is well-known that the exact flow of a Hamiltonian system is symplectic, and that the energy remains constant along the exact solution although the solution itself changes in time. When the solution or the flow is approximated by a numerical integrator, it is desirable to preserve these geometric properties (at least approximately), because reproducing the correct qualitative behavior is important in most applications. It turns out, however, that many numerical schemes destroy the structure of the solution, and that only selected methods respect the geometric properties of the dynamics. These methods are called geometric numerical integrators.

In this lecture we will investigate: why certain methods are (or are not) geometric numerical integrators, how to construct geometric numerical integrators, which properties are conserved, and in which sense, how structure conservation is related to the long-time error behavior of the method.
We will mainly focus on geometric integrators for Hamiltonian systems of ODEs. If time permits, geometric numerical integration for partial differential equations will also be discussed.

Exercise class:
In the exercise class, students will be asked to write Matlab programs which illustrate the theoretical results presented in the lecture. The exercises can be solved in pairs or alone, and with the assistance of the tutor.

Prerequisites

The lecture will be suited for students in mathematics, physics and other sciences with a basic knowledge in ordinary differential equations and Runge-Kutta methods. In particular, students should be familiar with concepts such as, e.g., order, consistency, convergence, A-stability, and so on. The course "Numerische Methoden für Differentialgleichungen" provides a good basis.

References

Ernst Hairer, Christian Lubich, and Gerhard Wanner: Geometric numerical integration. Structure-preserving algorithms for ordinary differential equations. Second edition, Springer, 2006.
Ernst Hairer, Christian Lubich, and Gerhard Wanner: Geometric numerical integration illustrated by the Störmer-Verlet method. Acta Numerica 12, 399-450 (2003).

0159610 Numerical methods in mathematical finance II

Lecture: 4 h, 8 credit points
Thu 8:00-9:30 5.20 1C-03, Fri 11:30-13:00 5.20 1C-03
Tutorial: 2 h
Mon 14:00-15:30 01.85 Z2
Prof. Tobias Jahnke

Contents

Based on the first part of this lecture given in the winter term, more models and methods for option pricing will be presented. The central theme is the construction and analysis of numerical methods which approximate the solution of the corresponding differential equations in a stable, accurate and efficient way.

The following topics will (probably) be discussed: Multi-level Monte-Carlo methods, Historical and implicit volatility, Asiatic options, Jump-diffusion models and integro-diferential equations, Finite element methods for the Black-Scholes equation, Sparse grids for basket options and other high-dimensional problems.

Exercise class: In the exercise class, students will be asked to write Matlab programs which illustrate the theoretical results presented in the lecture. The exercises can be solved in pairs or alone, and with the assistance of the tutor.

Prerequisites

Participants should be familiar with part 1 of the lecture, see
http://www.math.kit.edu/ianm3/edu/nummathfin2012w/en

References

Will be announced in the lecture.

0156400 Spectral Theory

Lecture: 4 h, 8 credit points
Tue 9:45-11:15 5.20 1C-03, Fri 9:45-11:15 5.20 1C-03
Prof. Lutz Weis

Contents

Spectral theory generalizes the theory of eigenvalues and normal forms of matrices to infinite dimensional operators on function spaces such as differential- and integral operators . It provides an essential technique for many areas of applications such as partial differential equations, mathematical physics and numerical analysis.
We will cover
– spectra and resolvents of linear (unbounded) operators
– the spectral theory of compact operators and the Fredholm alternative
– the functional calculus of self adjoint operators
– the holomorphic functional caculus of sectorial operators
– the Cauchy problem for sectorial operators
This lecture will prepare for further courses or seminars on deterministic and stochastic evolution equations .

Prerequisites

We assume a basic knowledge in functional analytic methods as provided by one of the courses “Differentialgleichungen und Hilberträume” or “Funktionalanalysis”.

References

D. Werner , Funktionalanalysis
Reed and Simon, Modern methods of mathematical physics I

0163700 Mathematical Physics

Lecture: 4 h, 8 credit points
Mon 9:45-11:15 40.32 RPH R. 045, Thu 14:00-15:30 20.40 NH
Tutorial: 2 h
Tue 15:45-17:15 10.23 Nusselt
Prof. Dirk Hundertmark

Contents

This lecture is aimed at students of Physics, Mathematics, and (Theoretical) Chemistry, who want to get an insight in the mathematical foundation of Quantum Mechanics. Understanding Quantum Mechanics is an ambitious goal, since even Feynman said that "no-one really understand Quantum Mechanics.SSo we will focus on a mathematical understanding of Quantum Mechanics, which will nevertheless help to avoid the pitfalls one often encounters in Quantum Mechanics courses and which are usually dismissed by vigorous hand–waving or by claiming that the solutions which 'do not look right' are 'unphysical'.
As time permits, we intend to cover the following topics:

- The time evolution: Basics of Hilbert spaces and self-adjoint operators.
- Bound States and variational methods.
- The Coulomb potential: Stability of Hydrogen, many–body Coulomb problems, stability of matter.
- Some basics of scattering theory.

We will develop the mathematical foundations in the lectures.

Prerequisites

Prerequisites are a good knowledge of analysis and linear algebra. Knowledge of the theory of partial differential equations, functional analysis, and spectral theory is helpful.

161300 Lévy Processes

Lecture: 2 h, 4 credit points
Wed 8:00-9:30 5.20 1C-02
Tutorial: 2 h
Fri 11:30-13:00 01.85 Z1
Dr. Vicky Fasen

Contents

Lévy processes as continuous-time analogue of random walks are one of the most basic and fundamental classes of stochastic processes including Brownian motion and Poisson processes. They have many applications in stochastic modeling as for instance in insurance, finance, queuing theory and telecommunication. This course gives a basic introduction into the theory of Lévy processes. The aim of this course is to have a basic knowledge of Lévy processes and infinitely divisible distributions. This includes the famous Lévy-Ito decomposition and path properties. In particular, subordinators and stable Lévy processes will be investigated in detail.

Prerequisites

Probability theory as it is treated in the standard course "Wahrscheinlichkeitstheorie".

References

Applebaum, D.: (2004) Lévy Processes and Stochastic Calculus. Cambridge University Press.
Bertoin, J.: (1996) Lévy Processes. Cambridge University Press.
Kyprianou, A. E.: (2006) Introductory Lectures on Fluctuations of Lévy Processes with Applications. Springer.
Sato, K.: (1999) Lévy Processes and Infinitely Divisible Distributions. Cambridge University Press.
Schoutens, W.: (2003) Lévy Processes in Finance. John Wiley & Sons.