INTERNATIONAL PROGRAM (MASTER)

CLASSES: SUMMER SEMESTER 2011

0152200 Riemannian Geometry
Lecture: 4 h, 8 credit points
Tue 9:45-11:15 AOC 101 Geb. 30.45, Wed 11:30-13:00 1C-03 Geb.5.20
Tutorial: 2 h, 2 credit points
Thu 15:45-17:15 1C-04 Geb 5.20
Dr. Oliver Baues

0152600 Stochastic Geometry
Lecture: 4 h, 8 credit points
Mon 11:30-13:00 Z 2 Geb 1.85, Thu 11:30-13:00 Z 2 Geb. 1.85
Tutorial: 2 h, 2 credit points
Wed 15:45-17:15 Z 2 Geb 1.85
apl. Prof. Dr. Daniel Hug

0156200 Differential equations with periodic coefficients
Lecture: 2 h, 4 credit points
Mon 14:00-15:30 1C-03 Geb 5.20
Dr. Vu Hoang

0156400 Spectral Theory
Lecture: 4 h, 8 credit points
Tue 11:30-13:00 1C-04 Geb. 5.20, Fri 11:30-13:00 1C-04 Geb. 5.20
Tutorial: 2 h, 2 credit points
Wed 15:45-17:15 Z 1 Geb. 1.85
Dr. Peer Kunstmann

0160800 Numerical methods for Maxwell's equations
Lecture: 2 h, 4 credit points
Thu 14:00-15:30 1C-02 Geb. 5.20
Prof. Willy Dörfler

0161600 Mathematical modeling and numerical simulation in applications
Lecture: 2 h, 4 credit points
Wed 9:45-11:15 Z 1 Geb 1.85
Dr. Gudrun Thäter

0175200 Seminar: Numerical Functional Analysis
Tue 08:00-09:30 1C-03 Geb. 5.20
Prof. Marlis Hochbruck

0174400 Seminar: Engineering Mathematics and Computing
For further information please contact Dr. Thäter.
Prof. Vincent Heuveline, Dr. Gudrun Thäter

Time-table for lectures

	Monday	Tuesday	Wednesday	Thursday	Friday
08:00-09:30			Adap.Wavel.		
09:45-11:15		Riem.Geom.	Math.Mod.		
11:30-13:00	Stoch.Geom.	Spec.Theo.	Riem.Geom.	Stoch.Geom.	Spec.Theo.
14:00-15:30	Diff.Equ.			Num.Meth.	
15:45-17:15					

GERMAN CLASSES

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

CLASSES: SUMMER SEMESTER 2011

0152200 Riemannian Geometry

Lecture: 4 h, 8 credit points
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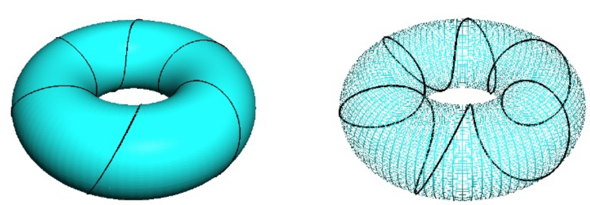
Dr. Oliver Baues

Contents

The course gives an introduction to the study of smooth manifolds and Riemannian metrics. Riemannian metrics are a fundamental tool in the geometry and topology of manifolds, and they are also of equal importance in mathematical physics and general relativity.
We will cover the basic concepts of differentiable manifolds and the properties of Riemannian and Pseudo-Riemannian metrics, the Levi-Civita connection, geodesics and Riemannian curvature. We will also study basic examples, like constant curvature space forms, submanifolds, and Lie groups.



In the second part of the course we will be concerned with the influence of the Riemannian curvature on the global and local geometry, and on the topology of manifolds.

References

B. O'Neill; Semi-Riemannian Geometry.
S. Gallot, D. Hulot, J. Lafontaine; Riemannian Geometry.
I. Chavel; Riemannian Geometry: A modern Introduction.

0152600 Stochastic Geometry

Lecture: 4 h, 8 credit points
Mon 11:30-13:00 Z 2 Geb 1.85, Thu 11:30-13:00 Z 2 Geb. 1.85
Tutorial: 2 h, 2 credit points
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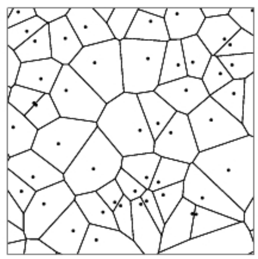

Contents

In Stochastic Geometry mathematical models are developed for describing and analyzing random geometric structures. The course provides an introduction to the foundations of this field which is also highly interesting from an applied point of view.
In the first part, random closed sets and point processes are introduced as basic models. Then specific geometric characteristics of random structures will be developed. It is also planned to include an introduction to random tessellations. Specific topics to be covered include: geometric point processes and random closed sets, stationarity and isotropy, Poisson and related point processes, germ-grain models and Boolean model, specific intrinsic volumes, contact distributions, random tessellations.

Prerequisites

Basic concepts of probability theory (including some measure theory), convex geometry and stochastic processes are helpful, but not required.

References

I. Molchanov: Statistics of the Boolean Model for Practitioners and Mathematicians, Wiley, 1997.
J. Ohser, F. Mücklich: Statistical Analysis of Microstructures in Materials Science, Wiley, 2000.
R. Schneider, W. Weil: Stochastic and Integral Geometry, Springer, 2008.
D. Stoyan, W. S. Kendall, J. Mecke: Stochastic Geometry and its Applications, Wiley, 1995, 2nd ed.

0156200 Differential equations with periodic coefficients

Lecture: 2 h, 4 credit points
Mon 14:00-15:30 1C-03 Geb 5.20
Dr. Vu Hoang

Contents

Periodic media (e.g. structures which are constructed by indefinite repetition of a basic unit cell) are becoming increasingly important in technical applications, especially in optical nanotechnology, which is thought to be a key science in the 21st century.
The lecture gives an introduction to the mathematical analysis of partial differential equations with periodic coefficients modeling the acoustic or electromagnetic wave propagation in these media.
The lecture starts with an introduction to the physical situations in which PDE's with periodic coefficients appear. The first major part of the lecture will be devoted to the study of the *Floquet Bloch (* or *Gelfand) transform*, defined at first for compactly supported $f \in L^2(\mathbb{R}^d)$ by

$$Uf(x,k) = \frac{1}{(2\pi)^d} \sum_{m \in \mathbb{Z}^d} e^{ik\cdot m} f(x-m), \quad ((x,k) \in (0,1)^d \times (-\pi,\pi)^d).$$

In particular, we are interested in the mapping properties of U. Next we will explain how to use the Floquet transform to transform elliptic problems with periodic coefficients on the whole space to boundary value problems on a unit cell (Floquet-Bloch decomposition). Throughout the lecture, we will make extensive use of quadratic forms to streamline the presentation as much as possible, at the same time imposing only weak regularity assumptions on the coefficients.
If enough time remains, we will discuss further spectral properties of periodic differential operators, such as the absolute continuity of spectra or some boundary value problems involving semi-infinite structures, where the usual Floquet-Bloch theory cannot be applied.
I will try to make the lecture reasonably self-contained, but some familiarity with functional analysis and Sobolev spaces will be helpful.

References

Kato, T. : Perturbation Theory for Linear Operators. Springer.
Kuchment, P : Floquet theory for Partial Differential Equations. Basel, Birkhäuser Verlag.

0156400 Spectral Theory

Lecture: 4 h, 8 credit points
Fri 11:30-13:00 1C-04 Geb. 5.20, Tue 11:30-13:00 1C-04 Geb. 5.20
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Dr. Peer Kunstmann

Contents

Spectral theory is concerned with invertibility properties of linear operators in Banach spaces. These operators may be bounded or unbounded, the former case is simpler but the latter is perhaps more interesting with respect to applications.
Given a linear operator A in a complex Banach space X with domain $D(A)$, the *spectrum* $\sigma(A)$ is the set of all complex λ such that $\lambda I - A : D(A) \to X$ is **not** an isomorphism (here $D(A)$ is equipped with the graph norm). Most prominent and already known from finite dimensions (linear algebra) are eigenvalues λ, but in infinite dimensions new phenomena arise.
The complement $\rho(A) := \mathbb{C} \setminus \sigma(A)$ is called the *resolvent set of* A, and the map

$$\rho(A) \mapsto \mathscr{L}(X), \quad \lambda \mapsto (\lambda I - A)^{-1}$$

is called the *resolvent of* A.
Central topics in spectral theory are properties of the spectrum $\sigma(A)$ including investigation of eigenvalues and eigenvectors, properties of the resolvent map $\lambda \mapsto (\lambda I - A)^{-1}$, decomposition of the space X in subspaces that are invariant under the action of A, and existence of functional calculi for A.
In the lecture we shall study in particular

- spectrum and resolvent for bounded and unbounded operators,
- spectral properties of compact operators in Banach spaces,
- the spectral theorem for self adjoint operators in Hilbert space,
- applications to differential operators and boundary value problems.

Prerequisites

Functional analysis.

References

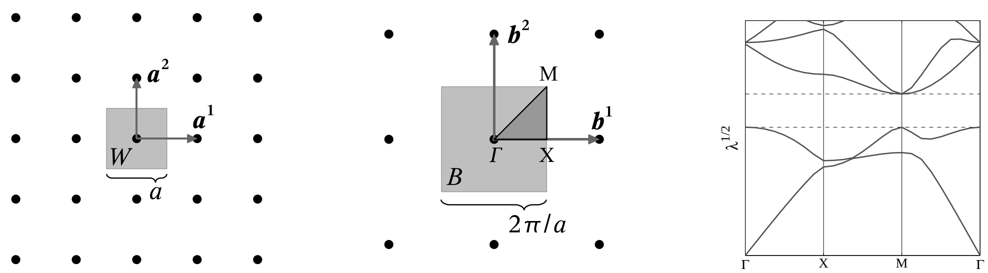
J.B. Conway: A Course in Functional Analysis, Springer.
N. Dunford, J.T. Schwartz: Linear Operators, Part I: General Theory, Wiley.
T Kato: Perturbation Theory of Linear Operators, Springer.
S.Lang: Real and Functional Analysis, Springer.
W. Rudin: Functional Analysis, McGraw-Hill.
D. Werner: Funktionalanalysis, Springer.

0160800 Numerical methods for Maxwell's equations

Lecture: 2 h, 4 credit points
Thu 14:00-15:30 1C-02 Geb. 5.20
Prof. Willy Dörfler

Contents

We focus on theory and numerics of Maxwell equations for the approximation of photonic bandstructures or waveguides.



Orthogonal lattice (of size a) with Wigner–Seitz cell W (left), dual lattice with Brillouin zone B, the fundamental region and the high symmetry points (right).
Photonic bandstructure of the 5 smallest eigenvalues along the path Γ, X, M, Γ (the high symmetry points, see Figure left) around the Brillouin zone B. There is a bandgap between the second and third band.

1. The Maxwell system, aspects of modelling,
2. Boundary and interface conditions,
3. Analytical tools,
4. The curl curl source problem,
5. The curl curl eigenvalue problem,
6. Finite element methods for tha Maxwell equations,
7. Interpolation estimates,
8. Bandstructure computations.

Prerequisites

Lectures in Partial Differential Equations and Numerical Methods of Partial Differential Equations.

The lecture is part of the education of the "Schwerpunkt Partielle Differentialgleichungen" of the Departement and the "Graduiertenkolleg Analysis, Simulation und Design nanotechnologischer Prozesse".

References

R. Hiptmair: Finite elements in computational electromagnetism. Acta Numerica, 11:237-339, 2002.
P. Monk: Finite Element Methods for Maxwell's Equations. Clarendon Press, Oxford, 2003.

0161600 Mathematical modeling and numerical simulation in applications

Lecture: 2 h, 4 credit points
Wed 9:45-11:15 Z 1 Geb 1.85
Dr. Gudrun Thäter

Contents

Mathematics as way of thinking (via modeling) and as technique (i.e. providing tools) meets problems arising in everyday life. The problems themselves are easy to understand and the lecture will not rely on too much previous knowledge. Basic understanding of probability and Ordinary Differential equations will do. But you should bring along some enthusiasm to use computers. Themes will comprise

1) difference equations
2) population models
3) traffic modeling
4) growth modeling
5) game theory
6) chaos
7) problems in mechanics and fluid dynamics