Lecturers:

Anna Dittus
University of Rostock, Germany

Kurt Frischmuth
University of Rostock, Germany

Thomas Lorenz
RheinMain University of Applied Sciences
Wiesbaden Rüsselsheim, Germany

Alexander Meister
University of Rostock, Germany

Jan Kloppenborg Møller
Technical University of Denmark, Denmark

Klaus Neymeyr
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Ilias Panagiotopoulos
University of Rostock, Germany

Jens Starke
University of Rostock, Germany

Uffe Høgsbro Thygesen
Technical University of Denmark, Denmark

www.math.uni-rostock.de/complexsystems

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Practical information:

Prerequisites
Basic mathematical knowledge (as typically contained in the first two years studying math, science or engineering at university level) including analysis, linear algebra, ordinary differential equations, statistics, and Matlab.
Note: For those who do not meet these prerequisites we provide additional references or material for independent preparation.

Workload
Approximately 110-150 hours in total, including work during the course period at the University of Rostock (lectures, exercises, discussions) as well as preparatory required reading before course start and performing follow-up course work.

Study Material
Course material will be provided to the participants. Preparatory reading of some of the material is required.

Language
All lectures will be given in English.

Certificates
ECTS points: 3+2. To pass the course, active participation in all activities is required; this includes successful exercise work during the course, student presentations of the exercise (3 ECTS) and hand-in of follow-up course work (add. 2 ECTS).

Registration and Registration Fee
Please register on the website given below not later than 15th of August, 2018. Submission of a CV with a list of passed courses is required. The course fee is 100 EUR (to be paid on arrival) and includes course material, a welcome BBQ, joint breakfast each morning, numerous coffee/tea breaks with cookies and an excursion. Travel expenses, accomodation and meals should be covered by the participants themselves.

Location and Housing
The location is Inst. of Mathematics, Ulmenstraße 69, Haus 3. Lodging in Rostock is available at a moderate cost. Reservation in good time is highly recommended. A limited number of scholarships to cover this are available based on application.

For further details and registration see:
www.math.uni-rostock.de/complexsystems

Universität Rostock Traditio et Innovatio

One week
summerschool
at bachelor level

Mathematical Modelling, Nonlinear Dynamics, Stochastic and Complex Systems

August 19 – August 25, 2018
Rostock, Germany

Organizer:

Jens Starke
University of Rostock
Institute for Mathematics
Ulmenstr. 69, Haus 3
D-18057 Rostock
Germany
complexsystems@uni-rostock.de

www.math.uni-rostock.de/complexsystems

Content:

This summer school will give a unique introduction into modelling with differential equations combined with data analysis. This includes both deterministic dynamical systems theory as well as stochastic systems. Lectures will cover mathematical techniques for analysing complex systems of various fields in science and engineering. All theoretical parts of the course will be accompanied with hands on exercises using real life examples ranging from mechanics over medicine to economy.

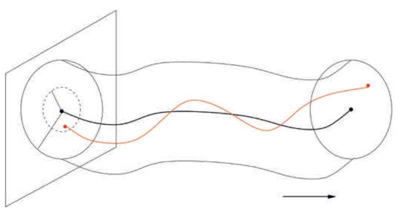
Teaching starts on 19th of August at 2 PM sharp and ends on 25th of August at 1 PM. The program is intense with lectures from 9 AM until 6 PM including a one hour lunch break. Every day the organisers will provide breakfast from 8:00 – 8:45. On Sunday the 19th we will have a barbecue in the evening and we will offer a sight-seeing tour in Rostock one afternoon during the week.

Lectures include:

Mathematical modelling, differential equations, existence and stability theory

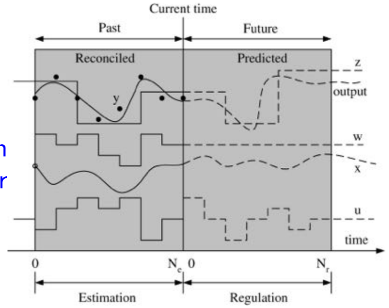
Important examples of differential equations in science and engineering, mathematical modelling, elementary solution methods, existence and uniqueness, numerical solutions, phase space, Lyapunov stability, asymptotic stability and Lyapunov functions.

Practical exercise:
Numerical solution of a differential equation with the Picard iteration. Infection modelling and stability analysis of the model.



Numerical methods

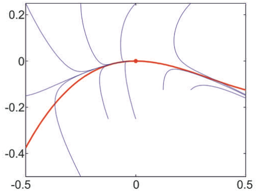
Runge-Kutta methods for non-stiff and stiff systems, error estimation, adaptive step size control, sensitivity equations, dynamic optimization, parameter estimation and optimal control.



Practical exercise:
Optimal control in an artificial pancreas for type 1 diabetics.

Theory of invariant manifolds

Stable manifolds, unstable manifolds, center manifolds, homoclinic orbits, heteroclinic orbits and center manifold reduction.

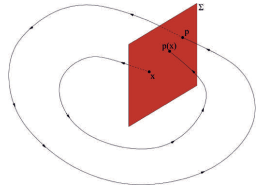


Practical exercise:
Sensitivity of dependence on initial values in a chemical reaction.

Periodic solutions

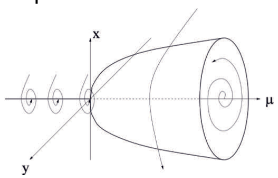
Theorem of Poincaré-Bendixon, Poincaré-sections, stability of periodic orbits and forced oscillators.

Practical exercise:
Modelling a swing; analysis of the Mathieu equation.



Bifurcations and the implicit function theorem

Implicit function theorem, structural stability, saddle-node bifurcation, transcritical bifurcation, pitchfork bifurcation, Hopf bifurcation and continuation techniques.

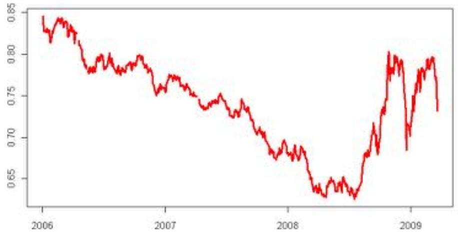


Practical exercise:
Modelling an electric circuit and Van der Pol oscillator.

Time series analysis

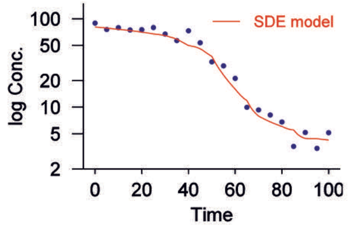
Characteristics for time series, parametric and non-parametric modelling, models for linear and non- linear time series, model identification, estimation and verification, predictions in time series.

Practical exercise: Prediction of bond prices.



Stochastic differential equations

Introduction to stochastic differential equations, Itô and Stratonovich integrals, grey-box modelling, parameter estimation and model building.



Practical exercise: Stochastic modelling of the insulin glucose relation.

Travelling waves and pattern formation

Nonlinear partial differential equations, travelling waves and soliton solutions, Korteweg de Vries equation, complex pattern formation in reaction diffusion equations, reduction to systems of ordinary differential equations, homoclinic and heteroclinic connections.

Practical exercise:
Spiral waves in the Belousov-Zhabotinsky reaction.