STUDENT COMPACT COURSE

VARIATIONAL METHODS FOR FLUIDS AND SOLIDS

OCTOBER 12 - 23, 2020

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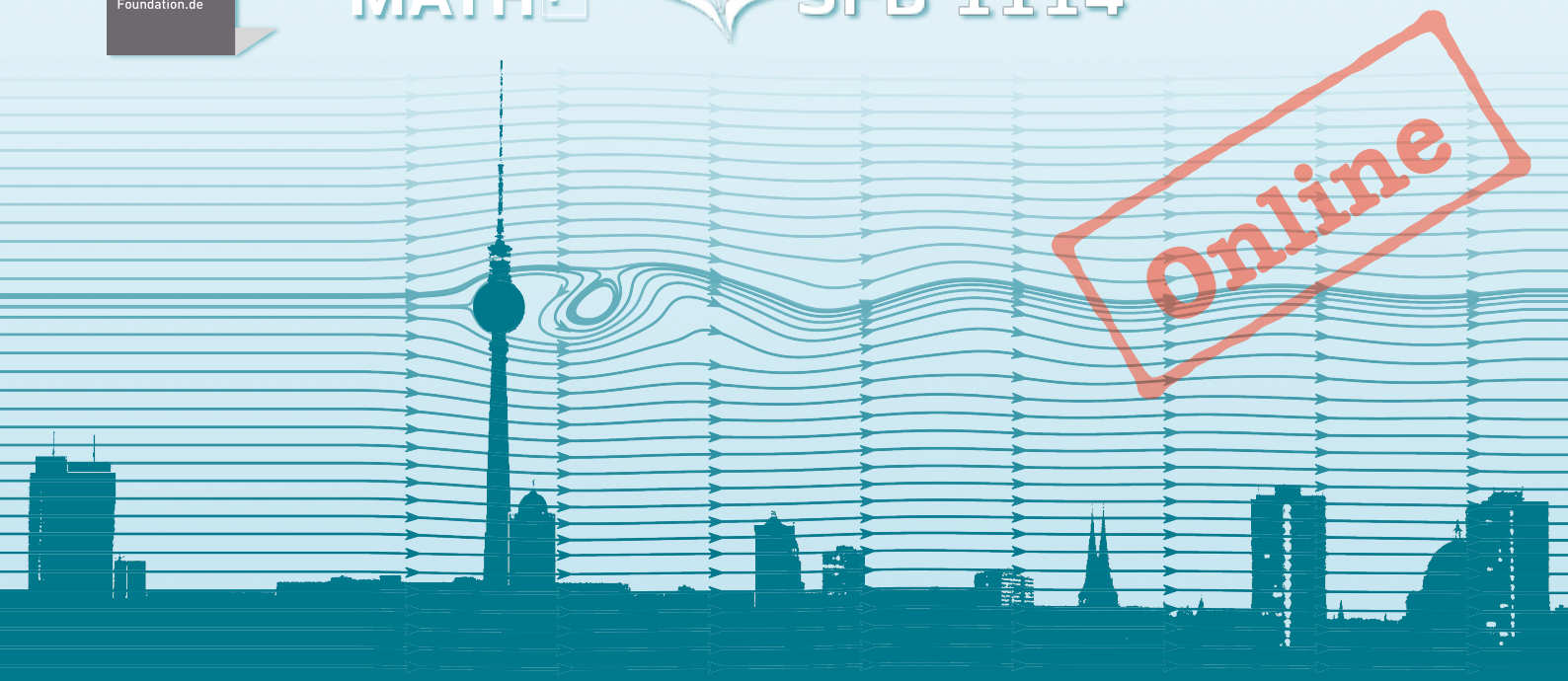

Thematic Einstein Semester

ENERGY-BASED MATHEMATICAL METHODS FOR REACTIVE MULTIPHASE FLOWS

LECTURES BY

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Luca Heltai ..... (SISSA)
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Rupert Klein ..... (FU Berlin)
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Student Compact Course on Variational Methods for Fluids and Solids

Thematic Einstein Semester on Energy-based Mathematical Methods for Reactive Multiphase Flows

October 12–23, 2020

For more information and registration please visit
mathplus.de/topic-development-lab/tes-winter-2020-21/student-compact-course/

Scope

The course will give an in-depth background on the topics of the Thematic Einstein Semester *Energy-based Mathematical Methods for Reactive Multiphase Flows*. The focus is on evolutionary systems whose mathematical formulation exhibits advantageous structures such as port-Hamiltonian, gradient, or GENERIC (General Equations for Non-Equilibrium Reversible Irreversible Coupling) structures. The goals of the compact course are four-fold: We aim at

- giving a detailed overview over the abstract theory of thermodynamically consistent "variational modeling" using Poisson and gradient structures for conservative and dissipative systems and the GENERIC formalism for the coupling of the latter,
- presenting analytical tools to derive effective models for systems with multiple spatial or temporal scales, such as formal asymptotics, coarse graining methods, evolutionary Γ-convergence, and EDP-convergence,
- discussing the application of the abstract theory to concrete examples coming e.g. from fluid-structure interaction, chemistry, biology, but also power networks,
- introducing numerical approaches and discretization schemes that preserve or exploit the variational structure of the underlying equations.

These topics will be pursued within a two-weeks compact course consisting of several connected mini-courses held by experts in the respective fields. Moreover, students will have the opportunity to present their work to the other participants. At the end of the compact course, the participants will get the opportunity to work in groups on selected advanced problems from the course, which they will present at the end of the thematic semester.

We hope that you enjoy this compact course and we are looking forward to engaging in many fruitful and inspiring discussions with you.

Volker Mehrmann
Alexander Mielke
Dirk Peschka
Marita Thomas
Barbara Wagner *(Berlin, September 2020)*

Courses

The following courses will take place:

- Modeling via energy and entropy functionals. *Marita Thomas (WIAS Berlin)*
- Port-Hamiltonian systems. *Volker Mehrmann (TU Berlin)*
- Variational structures for the analysis of PDE systems. *Alexander Mielke (WIAS Berlin and HU Berlin)*
- Basics of classical thermodynamics: A systems perspective. *Arjan Van der Schaft (U Groningen)*
- Introduction to algebraic constraints in port-Hamiltonian systems.
  Arjan Van der Schaft (U Groningen)
- Formal asymptotics and coarse graining for multiscale problems.
  Rupert Klein (FU Berlin) and Barbara Wagner (WIAS Berlin)
- Evolutionary Γ-convergence for multiscale problems. *Matthias Liero (WIAS Berlin)*
- Variational structures and particle systems. *Michiel Renger (WIAS Berlin)*
- Entropy methods for diffusion equations.
  Ansgar Jüngel (TU Vienna)
- Bulk-surface coupling via GENERIC.
  Marita Thomas (WIAS Berlin)
- Port-Hamiltonian differential-algebraic systems. *Volker Mehrmann (TU Berlin)*
- Port-Hamiltonian model hierarchies for energy transport networks. *Volker Mehrmann (TU Berlin)*
- Fluid-structure interaction.
  Luca Heltai (SISSA) and Dirk Peschka (WIAS Berlin)
- tba. *Elena Celledoni (NTNU)*
- Structure preserving discretization and model reduction methods for port-Hamiltonian systems in energy transport networks.
  Volker Mehrmann (TU Berlin)
- Model reduction, control, and optimization.
  Volker Mehrmann (TU Berlin)

Time table – First week, October 12–16, 2020

Time	Monday	Tuesday	Wednesday	Thursday	Friday
10:00 – 10:45	Modeling via energy and entropy functionals: Bulk GENERIC, Part I (M. Thomas)	Variational structures for the analysis of PDE systems, Part I (A. Mielke)	Formal asymptotics and coarse graining for multiscale problems, Part I (R. Klein, B. Wagner)	Evolutionary Γ-convergence for multiscale problems, Part I (M. Liero)	Entropy methods for diffusion equations, Part I (A. Jüngel)
10:45 – 11:05	Student presentation				
11:05 – 11:20	Coffee break				
11:20 – 12:05	Modeling via energy and entropy functionals: Bulk GENERIC, Part II (M. Thomas)	Variational structures for the analysis of PDE systems, Part II (A. Mielke)	Formal asymptotics and coarse graining for multiscale problems, Part II (R. Klein, B. Wagner)	Evolutionary Γ-convergence for multiscale problems, Part II (M. Liero)	Entropy methods for diffusion equations, Part II (A. Jüngel)
12:05 – 12:30	Discussion				
12:30 – 14:00	Lunch break				
14:00 – 14:20	Student presentation				
14:20 – 15:05	Port-Hamiltonian systems, Part I (V. Mehrmann)	Basics of classical thermodynamics: a systems perspective (A. van der Schaft)	Formal asymptotics and coarse graining for multiscale problems, Part III (R. Klein, B. Wagner)	Variational structures and particle systems, Part I (D.R.M. Renger)	Variational structures and particle systems, Part III (D.R.M. Renger)
15:05 – 15:20	Coffee break				
15:20 – 16:05	Port-Hamiltonian systems, Part II (V. Mehrmann)	Introduction to algebraic constraints in port-Hamiltonian systems (A. Van der Schaft)	Formal asymptotics and coarse graining for multiscale problems, Part IV (R. Klein, B. Wagner)	Variational structures and particle systems, Part II (D.R.M. Renger)	Variational structures and particle systems, Part IV (D.R.M. Renger)
16:05 – 16:30	Discussion				

Time table – Second week, October 19–23, 2020

Time	Monday	Tuesday	Wednesday	Thursday	Friday
10:00 – 10:45	Modeling via energy and entropy functionals: Bulk-interface coupling, Part III (M. Thomas)	Port-Hamiltonian differential-algebraic systems (V. Mehrmann)	Structure preserving discretization and model reduction methods for port-Hamiltonian systems in energy transport networks, Part I (V. Mehrmann)	Model reduction, control, and optimization, Part I (V. Mehrmann)	tba**, Part I (E. Celledoni)
10:45 – 11:05	Project teaser				
11:05 – 11:20	Coffee break				
11:20 – 12:05	Modeling via energy and entropy functionals: Bulk-interface coupling, Part IV (M. Thomas)	Port-Hamiltonian model hierarchies for energy transport networks (V. Mehrmann)	Structure preserving discretization and model reduction methods for port-Hamiltonian systems in energy transport networks, Part II (V. Mehrmann)	Model reduction, control, and optimization, Part II (V. Mehrmann)	tba**, Part II (E. Celledoni)
12:05 – 12:30	Discussion				
12:30 – 14:00	Lunch break				
14:00 – 14:20	Project teaser				
14:20 – 15:05	Evolutionary Γ-convergence for multiscale problems, Part III (M. Liero)	Fluid-structure interaction, Part I (D. Peschka, L. Heltai)	Fluid-structure interaction, Part III (D. Peschka, L. Heltai)	Optional project discussion	Optional project discussion
15:05 – 15:20	Coffee break				
15:20 – 16:05	Evolutionary Γ-convergence for multiscale problems, Part IV (M. Liero)	Fluid-structure interaction, Part II (D. Peschka, L. Heltai)	Fluid-structure interaction, Part IV (D. Peschka, L. Heltai)	Optional project discussion	Optional project discussion
16:05 – 16:30	Discussion				