Abstracts Plenary Talks

Optimal control of rate-independent systems

Talk on 21.07.2022, 9:30 - 10:45.

Dorothee Knees

Institute for Mathematics
University of Kassel
34132 Kassel, Germany
e-mail: dknees@mathematik.uni-kassel.de

We analyze an optimal control problem governed by a rate-independent system in an abstract infinite-dimensional setting. Many physical phenomena can be modeled as such systems, for example friction, plasticity, or models for damage and fracture evolution. The systems we consider are described by means of an energy functional $\mathcal{I} : [0,T] \times \mathcal{Z} \to \mathbb{R}$ depending on time and states from a state space $\mathcal{Z}$ and a convex dissipation potential $\mathcal{R} : \mathcal{Z} \to [0,\infty)$. They take the following form: given an initial value $z_0 \in \mathcal{Z}$ find $z : [0,T] \to \mathcal{Z}$ that satisfy the (doubly nonlinear) inclusion

$$0 \in \partial\mathcal{R}(\dot{z}(t)) + \mathrm{D}_z\mathcal{I}(t, z(t))\,.$$

In order to obtain a rate-independent system it is assumed that $\mathcal{R}$ is possitively homogeneous of degree one and hence $\partial\mathcal{R}$ denotes the convex subdifferential of $\mathcal{R}$.

In many applications the stored energy functional $\mathcal{I}$ is nonconvex and as a consequence one has to expect solutions that are discontinuous in time. Several different solution concepts were developed for such systems and we refer to [2] for an overview. In this talk we will focus on balanced viscosity solutions (BV solutions). Solutions of this type appear as vanishing viscosity limits of viscously regularized versions of the original rate-independent system.

In this talk we will first give a short introduction to rate-independent systems and solution concepts. We then study the existence of optimal solutions to an optimal control problem that uses external loads as control variable and that is constrained to BV solutions of the rate-independent system. Since BV solutions in general are not unique, as a main ingredient for the existence of optimal solutions the compactness of solution sets for BV solutions has to be established.

This is joint work with Stephanie Thomas (U Kassel), Christian Meyer (TU Dortmund) and Michael Sievers (TU Dortmund).

Literatur

[1] Thomas, Stephanie, Optimal control of a rate-independent system constrained to parameterized balanced viscosity solutions, PhD Thesis, University of Kassel, 2022.

[2] Mielke, Alexander and Roubíček, Tomáš, *Rate-independent systems. Theory and application*, Springer, 2015.

An Operator-Theoretic Approach to PDEs with port-Hamiltonian structure

Talk on 19.07.2022, 9:30 - 10:45.

Timo Reis

Institut für Mathematik
Technische Universität Ilmenau
Ilmenau, Germany
e-mail: timo.reis@tu-ilmenau.den

The port-Hamiltonian way of modelling results in a class of systems which has a special form, and this class is moreover closed under interconnection. Moreover, many partial differential equations have a structure which – at least formally – resembles the one from ordinary port-Hamiltonian systems.

In the talk we are looking for a suitable formulation of infinite-dimensional port-Hamiltonian systems which cover various examples from mechanics and electrodynamics. In particular, our class includes systems with boundary control and observation. Our approach is based on the formulation of infinite dimensional systems via so-called "system nodes" by Staffans [1].

Literatur

[1] Staffans, O.. *Well-Posed Linear Systems*. Cambridge University Press, 2005.

DAEs everywhere

Talk on 18.07.2022, 11:00 - 12:15.

Hans Zwart

Faculty of Electrical Engineering, Mathematics and Computer Science
Department of Applied Mathematics - Mathematical Systems Theory
University of Twente
Enschede, The Netherlands
e-mail: h.j.zwart@utwente.nl

Abstracts Contributed Talks

Spectrum of the Maxwell Equations for a Flat Interface between Homogeneous Dispersive Media

Talk on 21.07.2022, 11:15 - 12:15.

Tomáš Dohnal

Institute of Mathematics
Martin Luther University Halle-Wittenberg
Halle, Germany
e-mail: tomas.dohnal@mathematik.uni-halle.de

The study of time harmonic electromagnetic waves at the interface of dispersive (i.e. frequency dependent) media leads to the non-self-adjoint operator pencil

$$\nabla \times \nabla \times E - \omega^2 \epsilon(x_1, \omega) E = 0, \quad \nabla \cdot (\epsilon E) = 0,$$

where $\epsilon(x_1, \omega) \in \mathbb{C}$. The dielectric constant ϵ is generally complex in order to allow also for non-conservative media (e.g. metals). A classical application is to surface plasmon polaritons. We assume that the interface is located at $x_1 = 0$ and the media in the two half spaces are spatially homogenous. The dependence of ϵ on the spectral parameter ω (frequency) is generally nonlinear and we make no assumptions on its form.

The whole spectrum consists of eigenvalues and the essential spectrum, but the various standard types of essential spectra do not coincide in all cases. The main tool for determining the essential spectra are Weyl sequences. The functional setting is such that the operator domain is not a subset of the range which brings about a difficulty in defining the discrete spectrum.

This contribution is co-authored by Malcolm Brown (Cardiff), Michael Plum (Karlsruhe), and Ian Wood (Canterbury).

Literatur

[1] Brown, M., Dohnal, T., Plum, M., and Wood, I., Spectrum of the Maxwell Equations for a Flat Interface between Homogeneous Dispersive Media, submitted, 2022. (arXiv:2206.02037)

Analysis of Coupled PDE Systems for Micro-Electro-Mechanical Systems

Talk on 21.07.2022, 13:15 - 14:15.

Runan He

Institut für Mathematik
Martin-Luther-Universität Halle-Wittenberg
Halle(Saale), Germany
e-mail: runan.he@mathematik.uni-halle.de

In this talk, we study some mathematical models for a Micro-Electro-Mechanical System (MEMS) capacitor, consisting of a fixed plate and a flexible plate separated by a fluid. It investigates the wellposedness of solutions to the resulting quasilinear coupled systems, as well as the finite-time blowup (quenching) of solutions. The models considered include a parabolic-dispersive system modelling the fluid flow under an elastic plate, a parabolic-hyperbolic system for a thin membrane, as well as an elliptic-dispersive system for quasistatic fluid flow under an elastic plate. Short-time existence, uniqueness and smoothness are obtained by combining wellposedness results for a single equation with an abstract semigroup approach for the system. Quenching is shown to occur if the solution ceases to exist after a finite time. We also present with a study of self-similar quenching solutions and their stability for a simple hyperbolic membrane model for a MEMS capacitor.

Final state observability estimates and cost-uniform approximate null-controllability for bi-continuous semigroups

Talk on 19.07.2022, 13:15 - 14:15.

Karsten Kruse

Institute of Mathematics
Hamburg University of Technology
Hamburg, Germany
e-mail: karsten.kruse@tuhh.de

In this talk we consider final state observability estimates for bi-continuous semigroups on Banach spaces, i.e. for every initial value, estimating the state at a final time $T > 0$ by taking into account the orbit of the initial value under the semigroup for $t \in [0, T]$, measured in a suitable norm. We state a sufficient criterion based on an uncertainty relation

and a dissipation estimate and provide two examples of bi-continuous semigroups which share a final state observability estimate, namely the Gauß–Weierstraß semigroup and the Ornstein–Uhlenbeck semigroup on the space of bounded continuous functions on $\mathbb{R}^d$. Moreover, if time permits, we generalise the duality between cost-uniform approximate null-controllability and final state observability estimates to the setting of locally convex spaces for the case of bounded and continuous control functions, which seem to be new even for the Banach spaces case.

This contribution is co-authored by Christian Seifert and based on [1].

Literatur

[1] Kruse, K. and Seifert, C. Final state observability estimates and cost-uniform approximate null-controllability for bi-continuous semigroups, *arXiv preprint*, 2206.00562v1, 2022.

Robust stability of PDEs

Talk on 20.07.2022, 11:15 - 12:15.

Andrii Mironchenko

Faculty of Computer Science and Mathematics
University of Passau
Passau, Germany
e-mail: andrii.mironchenko@uni-passau.de

In this talk we discuss recent results and open problems in the robust stability analysis of PDEs. We show direct and converse Lyapunov results for input-to-state stability (ISS) of a broad class of infinite-dimensional control systems with distributed disturbances. Next we discuss the limitations of the classical Lyapunov method for ISS analysis of boundary control systems. We introduce the so-called non-coercive ISS Lyapunov functions and explain how they enhance our toolbox for ISS analysis, and why they are useful for stability analysis of boundary control systems. Finally, we discuss open problems and give some ideas on how one can approach these problems.

This talk is based on a joint work with Birgit Jacob, Jonathan Partington, Felix Schwenninger, and Fabian Wirth.

Dissipativity in infinite dimensions

Talk on 18.07.2022, 14:30 - 15:30.

Friedrich Philipp
Department of Mathematics
Technical University of Ilmenau
Ilmenau, Germany
e-mail: friedrich.philipp@tu-ilmenau.de

The notions of dissipativity and strict dissipativity of dynamical systems, introduced by Jan Willems in his seminal works [4, 5], are central in analyzing the behavior of dynamical systems as they ensure an energy inequality for trajectories in terms of a storage function and a supply rate. Whereas dissipativity states that the stored energy can not increase by more than the supplied energy, strict dissipativity as its strengthened version includes an additional dissipation term.

Dissipativity for optimal control, where the supply rate is the cost function, has direct applications in, e.g., the design of stabilizing controllers and stability analysis for Model Predictive Control. Dissipativity also plays an important role for optimally operated steady states and the so-called turnpike property at an optimal equilibrium.

In finite dimensions, (strict) dissipativity for generalized LQR problems and its connection to the turnpike property is very well understood (see, e.g., [1, 2]). However, characterizations for dissipativity in optimal control subject to infinite-dimensional dynamics have so far not been established. In this talk, we provide such a characterization by means of an inequality of Lyapunov-type in terms of forms. Furthermore, it is proved that exponential detectability implies this form inequality and that the converse implication holds under an additional assumption.

The talk is based on joint work with Lars Grüne and Manuel Schaller [3].

Literatur

[1] Grüne, L. and Guglielmi, R. Turnpike properties and strict dissipativity for discrete time linear quadratic optimal control problems, *SIAM J. Cont. Optim.*, **56**:1282–1302, 2018.

[2] Grüne, L. and Guglielmi, R. On the relation between turnpike properties and dissipativity for continuous time linear quadratic optimal control problems, *Mathematical Control & Related Fields*, **11**:169–188, 2021.

[3] Grüne, L., Philipp, F., and Schaller, M. Strict dissipativity for generalized linear-quadratic problems in infinite dimensions, *Proceedings of MTNS 2022*, submitted.

[4] Willems, J.C. Dissipative dynamical systems. I. General theory, *Arch. Rational Mech. Anal.*, **45**:321–351, 1972.

[5] Willems, J.C. Dissipative dynamical systems. II. Linear systems with quadratic supply rates, *Arch. Rational Mech. Anal.*, **45**:352–393, 1972.

On L^∞-Laplace–Carleson embeddings

Talk on 18.07.2022, 13:15 - 14:15.

Felix L. Schwenninger

Department of Applied Mathematics
University of Twente
Enschede, The Netherlands
e-mail: f.l.schwenninger@utwente.nl

Laplace–Carleson embeddings deal with the Laplace transform when considered as mapping from $\mathrm{L}^p(0,\infty)$, viewed as "time-domain", to $\mathrm{L}^q(\mathbb{C}_+, \mathrm{d}\mu)$-spaces, interpreted as frequency-domain, where μ is a given measure. Besides the interest in these operators from a purely harmonic analysis view, their boundedness can be related to questions arising in infinite-dimensional (linear) systems theory. More precisely, properties like admissibility and, more recently, input-to-state stability can be assessed through this abstract framework, typically allowing for sharper space-time estimates than with more direct techniques.

This talk discuss recent findings with an emphasis on L^∞-estimates (in time, that is, $p = \infty$) recently obtained in the context of input-to-state stability and related to extrapolation problems for such Laplace–Carleson embeddings.

This contribution is co-authored by Birgit Jacob, Jonathan Partington, Sandra Pott and Eskil Rydhe.

Systems in Banach spaces: Controllability, Observability, Stabilizability

Talk on 19.07.2022, 14:30 - 15:30.

Christian Seifert

Institut für Mathematik
Technische Universität Hamburg
Hamburg, Germany
e-mail: christian.seifert@tuhh.de

Given systems Σ determined by $\begin{pmatrix} -A & B \\ C & 0 \end{pmatrix}$ in Banach spaces, we will first recall the well-known duality between cost-uniform approximate null-controllability of $\begin{pmatrix} -A & B \\ 0 & 0 \end{pmatrix}$

and final state observability of $\begin{pmatrix} -A' & 0 \\ B' & 0 \end{pmatrix}$ in finite time. We then extend this duality to weaker notions as cost-uniform α-controllability for $\alpha > 0$, open-loop stabilizability (i.e. exponential null-controllability in infinite time) and a weak observability. Further, we discuss sufficient and necessary conditions for (weak) observability, and demonstrate some examples.

The talk is based on joint works with Clemens Bombach, Michela Egidi, Fabian Gabel, Dennis Gallaun, Jan Meichsner and Martin Tautenhahn.

Port-Hamiltonian systems on multidimensional spatial domains

Talk on 19.07.2022, 11:15 - 12:15.

Nathanael Skrepek

Institute of Applied Analysis
TU Freiberg
Freiberg, Germany
e-mail: nathanael.skrepek@math.tu-freiberg.de

We consider a port-Hamiltonian system on an open spatial domain $\Omega \subseteq \mathbb{R}^n$ with bounded Lipschitz boundary. We show that there is a boundary triple associated to this system. Hence, we can characterize all boundary conditions that provide unique solutions that are non-increasing in the Hamiltonian. As a by-product we develop the theory of quasi Gelfand triples, which allows us to state the boundary conditions in the pivot space $\mathrm{L}^2(\partial\Omega)$. Amongst others this framework can be applied to the wave equation, Maxwell's equations and Mindlin plate model.

Exponential Stability for port-Hamiltonian Systems

Talk on 21.07.2022, 14:30 - 15:30.

Marcus Waurick

Institute of Applied Analysis
TU Bergakademie Freiberg
Freiberg, Germany
e-mail: marcus.waurick@math.tu-freiberg.de

In the talk, we consider an energy-dissipating port-Hamiltonian system and provide a characterisation of the exponential decay of the energy via the model ingredients under mild conditions on the Hamiltonian density. This characterisation leads to generalisations for sufficient criteria in the literature particularly concerning the regularity of the Hamiltonian density. Exponentially stable port-Hamiltonian systems with only strictly positive essentially bounded densities are provided.

This contribution is based on [1] co-authored by Sascha Trostorff, CAU Kiel, Germany.

Literatur

[1] Sascha Trostorff and Marcus Waurick, Characterisation for Exponential Stability of port-Hamiltonian Systems, *arXiv:2201.10367*, 2022.

Abstracts Poster

The Backwards in Time Adjoint of Material Laws

Andreas Buchinger

Institute of Applied Analysis
Technische Universität Bergakademie Freiberg
Freiberg, Germany
e-mail: Andreas.Buchinger@math.tu-freiberg.de

In control theory, adjoint systems are of particular interest. For a given system

$$\begin{aligned} x' &= Ax \\ x(0) &= x_0 \end{aligned}$$

its adjoint system is given by

$$\begin{aligned} -\varphi' &= A^*\varphi \\ \varphi(T) &= \varphi_T. \end{aligned}$$

This latter system is then considered backwards in time in order to analyze observability properties of the initial system.

The notion of causality underpinning the setting of evolutionary equations presupposes that we consider systems forward in time. For the purpose of understanding control theory in the setting of evolutionary equations, it is our aim to provide a definition of adjoint systems and more generally of systems considered backwards in time. In this poster, I will highlight an idea of how the change in the direction of time and the adjoining of the differential operator could be combined in a convenient manner. This is done by computing the adjoint with respect to a suitable time-sensitive inner product.

A Model for Ultrasonic Transducers with Dynamic Boundary Conditions under a High-Temperature Regime

Michael Doherty

The Department of Mathematics and Statistics
The University of Strathclyde
Glasgow, Scotland
e-mail: m.doherty@strath.ac.uk

Ultrasonic transducers are devices which are both ubiquitous in application and the subject of much contemporary interest. Applications range from non-destructive testing to medical imaging and beyond. Yet, in practice, manufacturing constraints mean that the modelling of these devices focuses on their elastic and electromagnetic properties whilst neglecting any effects of a high-temperature regime. In this poster I will present an abstract model to describe ultrasonic transducers taking into account the effects of high-temperature and a range of boundary conditions (including Robin and non-standard inhomogeneous impedance boundary conditions). Here, the system describing ultrasonic transducers (a set of coupled thermo-piezo-electromagnetic equations) is extended with tools from abstract boundary data spaces in order to encode boundary conditions within the system. The aim of the model is to highlight those systems which are well-posed as evolutionary equations (i.e. both Hadamard well-posed and causally dependent on the data). I will consider the well-posedness of the model under a particular set of inhomogeneous boundary conditions which are of particular interest as they extend those of a known piezo-electromagnetic system.

Perspectives in port-Hamiltonian modelling of energy systems

Hannes Gernandt

FG Numerische Mathematik
Technische Universität Berlin
Berlin, Germany
e-mail: gernandt@math.tu-berlin.de

The ongoing transition of the German energy system by incorporating more renewable energy sources, as well as couplings between different energy carriers like heat, gas and electricity leads to highly volatile and complex systems. One of today's major challenges is to develop real-time simulation, optimization and control strategies for these complex and coupled energy systems. In this talk, we show how the recent energy based port-Hamiltonian modeling approach can be used to model and control power systems. In particular, we focus on modelling and control of electric vehicle charging stations and stability analysis of networks of coupled PDEs describing e.g. gas or electrical transmission networks. This poster is based on joint works with Dorothea Hinsen, Volker Mehrmann, Bernardo Severino, Kai Strunz and Xinyi Zhang (all TU Berlin).

Input-to-state stability for unbounded bilinear feedback systems

René Hosfeld

School of Mathematics and Natural Sciences
University of Wuppertal
Wuppertal, Germany
e-mail: hosfeld@uni-wuppertal.de

We study *input-to-state stability (ISS)* of systems of the form

$$\begin{cases} \dot{z}(t) &= Az(t) + B_1 u_1 + B_2 N(z(t), y(t)),\ t \geq 0, \\ z(0) &= z_0, \\ y(t) &= Cz(t),\ t \geq 0, \end{cases} \tag{Σ^N}$$

where A is the generator of a C_0-semigroup on a Banach space X, the input u_1 and the bilinear feedback $N(z, y)$ enter the system through possibly unbounded operators B_1, B_2 defined on Banach spaces U_1, U_2. Further, the observation operator C, associated to the output y, is also considered to be unbounded. The initial value is denoted by z_0.
The concept of *input-to-state stability* (ISS) as introduced by Sontag in [2] unifies asymptotic stability with respect to initial values and robustness with respect to external inputs. We will focus on ISS with respect to input functions in L^2. More precisely, Σ^N is called L^2-ISS if it possesses for every $z_0 \in X$ and $u_1 \in \mathrm{L}^2(0, \infty; U_1)$ a unique continuous (mild) solution $z : [0, \infty) \to X$ which satisfies the L^2-*ISS estimate*

$$\|z(t)\|_X \leq \beta(\|z_0\|_X, t) + \gamma(\|u_1\|_{\mathrm{L}^2(0,t;U_1)}),$$

where β and γ are of Lyapunov classes $\mathcal{KL}$ and $\mathcal{K}$ respectively.
We derive sufficient conditions for a global in time well-posedness result for small initial values and inputs as well as sufficient conditions for a L^2-ISS estimate. This extends recent investigations on bilinear systems, where a second control was considered instead of an output ([1]). The developed results are applied to a Burgers equation.

This contribution is co-authored by Birgit Jacob, Felix Schwenninger, and Marius Tucsnak.

Literatur

[1] Hosfeld, R., Jacob, B., and Schwenninger, F. Integral input-to-state stability of unbounded bilinear control systems, *Mathematics of Control, Signals, and Systems.* 10.1007/s00498-021-00308-9, 2022

[2] Sontag, E. Smooth stabilization implies coprime factorization, *IEEE Trans. Automat. Control*, 34(4), 435–443, 1989.

Stability and Approximation of Dispersive Electromagnetic Surface Waves

Mathias Ionescu-Tira

Institute of Mathematics
Martin-Luther-University Halle-Wittenberg
Halle-Saale, Germany
e-mail: mathias.ionescu-tira@mathematik.uni-halle.de

We study Maxwell equations at an interface between optical media with memory and saturable nonlinearity. As an evolutionary equation, this system is well-posed in an exponentially weighted Bochner-type Hilbert space. Moreover, under spectral conditions on the material functions, solutions to small data decay exponentially with time.

The linearization admits a family of evanescent surface modes. Constructing an ansatz based on these modes for the nonlinear system, an amplitude equation can formally be derived. Exponential stability of the error equation provides a strategy to justify the amplitude equation over long time scales.

Controllability of port-Hamiltonian systems is relative generic

Jonas Kirchhoff

Institute of Mathematics
Technische Universität Ilmenau
Ilmenau, Germany
e-mail: jonas.kirchhoff@tu-ilmenau.de

We want to apply the concept of genericity as used by Wonham [4] to "controllability" of linear port-Hamiltonian differential-algebraic equations of the form

$$\tfrac{\mathrm{d}}{\mathrm{d}t}Ex = (J - R)Qx + Bu \tag{1}$$

with $E, J, R, Q \in \mathbb{R}^{n\times n}$, $B \in \mathbb{R}^{n\times m}$ so that $J = -J^\top$, $R = R^\top \geq 0$, $E^\top Q = Q^\top E \geq 0$. "Controllable" stands for the five controllability concepts of freely initializable (controllable at infinity), impulse controllable, controllable in the behavioural sense, strongly controllable and completely controllable systems, whose algebraic characterizations can be found in the survey article [1] by Berger and Reis. We study (1) as matrix quintuples in the vector space

$$V^{\mathrm{pH}}_{n,m} = \left\{ (E, J, R, Q, B) \,\middle|\, E, J, R, Q \in \mathbb{R}^{n\times n}, B \in \mathbb{R}^{n\times m}, J = -J^\top, R = R^\top \right\}$$

Analogously to [2], where genericity of controllability for general linear differential algebraic systems was proven, we want to show that the rank of the (polynomial) block matrices appearing in the aforementioned algebraic criteria is full on a generic subset of the set

$$\left\{(E,J,R,Q,B)\in V_{n,m}^{\mathrm{pH}}\,\middle|\,R\geq 0, E^\top Q = Q^\top E\geq 0\right\}.$$

The additional structure of the algebraic variety

$$\mathbb{V}_{n,m}^{\mathrm{pH}} = \left\{(E,J,R,Q,B)\in V_{n,m}^{\mathrm{pH}}\,\middle|\,E^\top Q = Q^\top E\right\}$$

has to be taken into account. Therefore, Wonhams concept of genericity has to be modified to relative genericity; see [3]. As an interim result, we can prove, using the results from [2], that controllability is relative generic in the reference set

$$\left\{(E,J,R,Q,B)\in \mathrm{Reg}(\mathbb{V}_{n,m}^{\mathrm{pH}})\,\middle|\,R\geq 0, E^\top Q = Q^\top E\geq 0\right\},$$

where $\mathrm{Reg}(\mathbb{V}_{n,m}^{\mathrm{pH}})$ denotes the nonsingular points of the variety $\mathbb{V}_{n,m}^{\mathrm{pH}}$. Therefore, we conclude analogously to [3] that a system (1) given by random, but continuously distributed matrices from $\mathrm{Reg}(\mathbb{V}_{n,m}^{\mathrm{pH}})$ is almost surely controllable.

Literatur

[1] T. Berger and T. Reis. Controllability of linear differential-algebraic systems – a survey. In A. Ilchmann and T. Reis, editors, *Surveys in Differential-Algebraic Equations I*, pages 1-61. Springer, Berlin, 2013.

[2] A. Ilchmann and J. Kirchhoff. Differential-algebraic systems are generically controllable and stabilizable. *Mathematics of Control, Signals, and Systems*, 33:359-377, 2021.

[3] J. Kirchhoff. Linear port-Hamiltonian systems are generically controllable. *IEEE Transactions on Automatic Control*, 67:3220-3222 2022.

[4] W.M. Wonham. *Linear Multivariable Control: A Geometric Approach.* Springer, Berlin, 1974.

Exponential decay of perturbations in optimal control of PDEs

Manuel Schaller

Department of Mathematics
Technische Universität Ilmenau
Ilmenau, Germany
e-mail: manuel.schaller@tu-ilmenau.de

We will present a stability property of dynamic optimal control problems subject to abstract evolution equations guaranteeing the decay of perturbations of initial resp. terminal conditions and dynamics over time. The former induces a a turnpike property stating that the optimal state and control of the dynamic problem reside close to a particular steady state for the majority of the time [1]. The latter provides robustness with respect to numerical errors which can be leveraged for efficient space-time discretization in Model Predictive Control [2].

We will illustrate the theoretical and numerical results by means of examples governed by linear and nonlinear heat equations with distributed and boundary control.

This contribution is co-authored by Lars Grüne and Anton Schiela.

Literatur

[1] Grüne, L., Schaller, M., and Schiela, A. Exponential sensitivity and turnpike analysis for linear quadratic optimal control of general evolution equations, *Journal of Differential Equations*, **268(12)**:7311–7341, 2020.

[2] Grüne, L., Schaller, M., and Schiela, A. Efficient Model Predictive Control for parabolic PDEs with goal oriented error estimation, *SIAM Journal on Scientific Computing*, **44(1)**:A471-A500, 2022

Rigorous Asymptotic Analysis and Numerics for 2D Maxwell's Equations with Interface

Daniel Tietz

Institute for Mathematics
Martin Luther University of Halle-Wittenberg
Halle (Saale), Germany
e-mail: daniel.tietz@mathematik.uni-halle.de

We consider Maxwell's Equations in 2D for two Kerr isotropic media with a planar interface. For space-dependent material functions we formally construct an approximative solution with the method of amplitude equations where the envelope is given by a nonlinear Schrödinger equation. By extending an existing well-posedness result with the help of a bootstrapping argument we show the exact approximation properties on a large time-scale analytically.

We also present numerical methods to compute the asymptotic solution and suitable initial values close to the ansatz such that solutions of Maxwell's equations exist.

This contribution is co-authored by Tomáš Dohnal and Roland Schnaubelt.

On BIBO-stability of infinite-dimensional systems

Alexander A. Wierzba

Department of Applied Mathematics
University of Twente
Enschede, The Netherlands
e-mail: a.a.wierzba@utwente.nl

We investigate the BIBO-stability (bounded-input-bounded-output stability) of infinite-dimensional dynamical systems represented in state space form. There the challenge lies within the intricate interplay between the L^∞-norms and the Hilbert space structure.

Apart from studying sufficient conditions guaranteeing BIBO-stability in the special case of Riesz-spectral systems, we discuss to which extent this notion is preserved under additive and multiplicative perturbations of the system. We find that, while the latter do in general not preserve BIBO-stability, certain additive perturbations of systems with analytic semigroups do.

This contribution is based upon joint work with Felix L. Schwenninger and Hans Zwart.