Dr. Jan Heiland

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Born: January 21, 1983—Friedrichshafen, Germany
Nationality: German
Marital status: married, 2 kids

Current Position

Team Leader at the Max Planck Institute for Dynamics of Complex Technical Systems
Lecturer at the TU Ilmenau

Areas of Specialization

Dynamical Systems, **Navier-Stokes Equations**, **Robust Control**,
Simulation and data-driven control, optimization, and complexity reduction

Academic Career

2007–2009	Student Employee at Bombardier Transportation, Department *Special Engineering for Aerodynamics and Acoustics*, Berlin
2009–2013	Full-time research assistant at TU Berlin, Department of Mathematics, Berlin
since 2013	Postdoc at MPI Magdeburg, Department *Computational Methods in Systems and Control Theory*, Magdeburg
since 2014	Team leader of the team *Computer Aided Control System Design* at the MPI Magdeburg
2018–2024	Jun.Prof. for *Numerical Methods for Descriptor Systems* at the OVGU Magdeburg
2021–2022	Prof. for *Data Driven Design of Dynamical Systems* at FAU Erlangen-Nürnberg
since 2024	Lecturer in the group *Optimization-based Control* at the TU Ilmenau

Education

2009	DIPLOMA in technical mathematics, TU Berlin
2014	PHD in mathematics, TU Berlin

Scholarships, Research Stays & Honours

2010–2013 PhD scholarship by *Studienstiftung des dt. Volkes*

2012 Research stay at TUCOROM Poitiers, France, invited by Prof. B. Noack

2014 *Research in Pairs* at *Mathematisches Forschungsinstitut Oberwolfach*

since 2015 Open Access Ambassador of the *Max Planck Society*

since 2015 Research stays at Shanghai University, China, as part of the *Recruitment Program of High-end Foreign Experts*

2017 *DAAD travel award* for visiting the *56th IEEE Conference on Decision and Control* in Melbourne, Australia

2020 Research stay at the DeustoTech Research Center in Bilbao, invited by Prof. E. Zuazua (February&March)

Since 2021 Elected member of the *MaRDI Council*[1] – a panel that develops the guiding principles of the *NFDI* consortium *MaRDI* and oversees the adherence to them.

Service to the Community

Reviewing & Editing

since 2014 Reviewer for Adv. Comp. Math. — *Acta Appl. Math.* — *Automatica* — *Electron. Trans. Numer. Anal.* — Eur. J. Control — IEEE Control Syst. Lett. — IEEE Trans. Automat. Control — J. Optim. Theory. Appl. — *Math. Control Signals Systems* — *SIAM J. Cont. Opt.* — *SIAM J. Sci. Comput.* — *Systems Control Lett.* — *DAE Forum* — and others and several conference proceedings

2019–2020 Guest editor at MDPI *mathematics* for the special issue *Robust Stabilization of Linear and Nonlinear Systems*

since 2021 Editor of the book series *Computational and Applied Mathematics* with the *Logos Verlag Berlin*

since 2022 Editor of the Research Topic *Data-based Model Order Reduction and Reduced Order Modelling of Dynamical Systems* at *Frontiers Applied Mathematics and Statistics*

[1] https://mardi4nfdi.de/consortium/organization

Workshop & Symposia Organization

2015 Organization of a minisymposium on *Numerical Approximation of DAEs and Constrained PDEs with Applications* at the ICIAM 2015 in Beijing, China

2016 Workshop *Modelling, Model Reduction, and Optimization of Flows* in Shanghai, China

2017 Minisymposium *MS 28 – Model reduction methods for simulation and (optimal) control* at the Enumath 2017 in Voss, Norway

2018 Young researcher workshop *Analysis and Numerical Approximation of Constrained Systems* in Sion, Switzerland

2018 Chair of the focus session *Model order reduction and low-rank approximation for nonlinear problems* at the EUCCO2018 in Trier, Germany

2019 Minisymposium MS29 *Low-rank modelling in uncertainty quantificatio*n at the Enumath 2019 in Eegmond aan Zee, The Netherlands

2019 Workshop *Machine Learning and Data-driven Methods for Model Reduction and Control* in Shanghai, China

2021 Minisymposium *Data-driven Methods in Model Reduction and Control* at the SIAM Conference on Control and Its Applications (CT21), Spokane (and virtual), United States

2023 Minisymposium *Data-driven Methods and Control* at the GAMM annual meeting, Dresden, Germany

2023 Workshop and barcamp on *Managing Mathematical Research Data* for the *MathCoRe* research training group and the *SPP2458 Combinatorial Synergies* in Magdeburg, Germany

2023 Talks and Lecture Series on *Advanced Topics in Systems and Control* for the *Jiangsu University, China*

2024 Member of the local organization committee for the *GAMM annual meeting 2024*, Magdeburg, Germany

Academic Self-Governance

since 2018 Assistent member of the faculty board at the faculty for mathematics at the OVGU Magdeburg

since 2019 Member of the *Prüfungsausschuss* of the Bachelor program *Mathematikingenieur/in* at the OVGU Magdeburg

since 2021 Person in charge for *research data management* for the research training group *MathCoRe*

Memberships

since 2011 Member of the *GAMM* and the technical committees *Dynamics and Control*, *Scientific Computing*, and *Numerical Analysis*

1 List of Teaching Activities

Courses (since 2017)

2017 Course (4 SWS) on *Funktionentheorie Lehramt*. Winter Term 2017. Otto-von-Guericke-Universität, Magdeburg

2018 Short Course on *Tensor Techniques* for the *Graduiertenkolleg*. Otto-von-Guericke-Universität, Magdeburg

2018 Course (4 SWS) on *Differential Algebraic Equations*. Winter Term 2018. Otto-von-Guericke-Universität, Magdeburg

2019 Seminar (2 SWS) *Geometric formulations of inviscid fluids and their discretization*. Summer Term 2019. Otto-von-Guericke-Universität, Magdeburg

2020 Course (4 SWS) on *Mathematik 2 für Informatiker*. Summer Term 2020. Otto-von-Guericke-Universität, Magdeburg.
Online course: www.janheiland.de/courses/ovgu-mathe-informatik/

2020 Short Course on *Model Reduction for Linear and Nonlinear Systems*. Shanghai University, Shanghai, China

2021 Course (4 SWS) on *Differential Algebraic Equations*. Summer Term 2021. Otto-von-Guericke-Universität, Magdeburg
Online course: www.janheiland.de/courses/ovgu-daes/

2021 Course (4 SWS) on *Mathematik 2 für Informatiker*. Summer Term 2021. Otto-von-Guericke-Universität, Magdeburg.
Online course: www.janheiland.de/courses/mathe2info-21/

2021 Extended Short Course on *Principles of AI for Control and Optimization*. Shanghai University, Shanghai, China (joint with Timm Faulwasser (TU Dortmund) and Enrique Zuazua (FAU Erlangen-Nürnberg))

2021 Course (6 SWS) on *Mathematik für Data Science*. Winter Term 2021. Friedrich-Alexander Universität, Erlangen-Nürnberg.

2022 Course (6 SWS) on *Mathematik für Data Science 2*. Summer Term 2022. Friedrich-Alexander Universität, Erlangen-Nürnberg.

2022 Integrated Course (3 SWS) on *Einführung in die mathematische Datenanalyse*. Summer Term 2022. Friedrich-Alexander Universität, Erlangen-Nürnberg.
Lecture notes (updated weekly): www.janheiland.de/script-emds

2022 Lecturer in the Autumn School on *Model Reduction and Model Predictive Control with Differential Equations* for the research training group *ALOP* at Trier University.
alop.uni-trier.de/event/autumn-school-on-model-reduction-and-model-predictive-control-with-differential-equations/

2023 Course (6 SWS) *Einführung in die Numerische Mathematik* Summer Term 2023 at the Otto-von-Guericke-Universität Magdeburg.

BA/MA Theses

2011 Manuel Baumann, BA, TU Berlin: *Modellierung und Simulation von Dispersionen in turbulenter Strömung*

2015 Maximilian Behr, MA, Otto-von-Guericke-Universität Magdeburg: *Optimierung und Stabilisierung von inkompressiblen Strömungen in M.E.S.S.*

2016 Björn Baran, MA, Otto-von-Guericke-Universität Magdeburg: *Optimal Control of a Stefan Problem with Gradient-Based Methods in FEniCS*

2019 Andreas Roth, BA, Otto-von-Guericke-Universität Magdeburg: *Modelling of the impact of multiple scattering on scalar measurements using luminescent particles*

2019 Frances Weiß, MA, Otto-von-Guericke-Universität Magdeburg: *Simulation, Analysis, and Model Order Reduction for Dynamic Power Network Models*

2020 Hermanth Kumar, MA, Otto-von-Guericke-Universität Magdeburg: *DMD Models for Flow Problems*

2021 Konrad Schindler, BA, Otto-von-Guericke-Universität Magdeburg: *Data-driven surrogate modelling of blood flow*

2022 Kevin Jakisch, MA, Otto-von-Guericke-Universität Magdeburg: *Experimentaldaten-basierte Modellierung des 3-fach Pendels*

2023 Richard Köppe, BA, Otto-von-Guericke-Universität Magdeburg: *Black-Box - Modellprädikative Regelung eines Methanisierungsreaktors*

Supervision of PhD Projects

The asterisk* denotes the project that I have been the main advisor for. For the others, I have served as a second supervisor.

2015–2018 Christoph Trautwein*, Otto-von-Guericke-Universität Magdeburg: *Optimal Control of Stochastic Partial Differential Equations*

2016–2021 Maximilian Behr*, Otto-von-Guericke-Universität Magdeburg: *A Galerkin Method for Large-scale Autonomous Differential Riccati Equations based on the Loewner Partial Order*

2016–2023 Björn Baran, Otto-von-Guericke-Universität Magdeburg: *Riccati Based Feedback Control of Complex Flows*

2018-2021 Henry von Wahl*, Otto-von-Guericke-Universität Magdeburg: *Unfitted Finite Elements for Fluid-Rigid Body Interaction Problems*

since 2021 Anahita Iravanizad*, Otto-von-Guericke-Universität Magdeburg: *Graph Convolutional Neural Networks and PDEs on Arbitrary Grids and Domains*

since 2021 Yongho Kim*, Otto-von-Guericke-Universität Magdeburg: *Classification of System Regimes and Learning of Controller Selectors*

since 2022 Lei Guo, Otto-von-Guericke-Universität Magdeburg: *Tensorization of Bi-linear EDMD for Stochastic Systems*

since 2023 Fan Wang*, Otto-von-Guericke-Universität Magdeburg: *Complexity Reduction of Multiscale Models with Incomplete Observations with Neural Networks and Classical State Space Methods*

2 Third party funding

2017 DAAD – travel grant – 2700 Euro

2016&2019 *Chinesisch-Deutsches Zentrum für Wissenschaftsförderung* – financing of two international workshops – 275500+280450 RMB (about 36700+37400 Euro) for local expenses plus 25500+23800 Euro for international travel

2015,2016, 2018–2020, 2023 *Chinese State Admistration of Foreign Experts Affairs* and *International Office of Shanghai University* – funding for travel and research stays – about 15000 Euro per year. For 2020, the funding was approved but not instantiated because of travel bans.

2019 Cooperation with company *HASOMED* on the development of a specific control software – 3 months full funding for a student assistant (3000 Euro) plus license fees for the software (1000 Euro per roll out)

2021 *Nationale Forschungsdateninfrastruktur* Consortium *MaRDI4NFDI* at MPI Magdeburg (Spokesperson M. Hintermüller (WIAS, Berlin), 17 participating institutions, overall budget: 9954430 Euro for 5 years, share of the MPI: 771000 Euro, my role: lead of subproject *T2M4:Description and Design of FAIR CSE workflows* (385500 Euro for 5 years))

2021 Research Training Group *Mathematical Complexity Reduction* at OVGU and MPI Magdeburg (Spokesperson S. Sager (OVGU), 9 principal investigators – overall budget: 5582000 Euro for 4.5 years, my share: funding for two PhD students (3 years each, 75% contract plus travels and overhead = 409680 Euro)).

2021 Grant[2] from the *IFAC Activity Fund* (5000 Euro).

2023 Individual Research Grant *Representations and Approximations by Linear Parameter-varying Systems for Nonlinear Controller Design* (212308 Euro for 3 years) from the Deutsche Forschungsgesellschaft (DFG).

[2] https://sites.ifac-control.org/activityfund/activity-fund-sponsored-projects/october-2021-call/

3 Research Statement

My research focus is the robust control and optimization of complex systems at the interface of theory for the ∞-dimensional PDEs and the numerical implementation in the high-dimensional state space. With regard to applications, data-driven methods for modeling, simulation and control have become an important topic in my research.

Systems, Control, and Optimization. For the incompressible Navier-Stokes equations (see e.g. [A4], [B7], [B3]), so-called $\mathcal{H}_\infty$-robust controller can be theoretically defined using projected Riccati equations and implemented numerically efficiently with a guaranteed degree of robustness; see [B8]. In addition, we have shown in the infinite-dimensional model that the required degree of robustness continuously depends on a possible linearization error (cf. [B5], [A13]) and that the error due to Galerkin spatial discretizations can be compensated in theory by such controllers; see [B6].

For more general cases we have been exploring a class of Riccati equations, which are not symmetrical but can be formulated without projections. The results enable a direct generalization of the $\mathcal{H}_\infty$ theory for ODEs (cf. [B12]) and also prove to be useful for qualitative studies of the linear quadratic control problem; see [A16].

In my dissertation [T2], I have investigated the interplay between optimization, discretization, and transformations in the decoupling of (P)DAEs. We adapted the results obtained there with regard to the optimization of flow equations for multi-body systems [A5] and also implemented them for additional couplings [A7]. Building on earlier work on the discrete approximation of I/O maps (cf. [A1] [B1]), we have generalized the POD approach [B4], adapted it for efficient optimization of PDEs on finite time horizons [A10] and currently for PDEs with multivariate uncertainties [A21].

Applications. Generally, the model equations that I have considered describe coupled and possibly high- or ∞-dimensional systems. Direct applications are given in the simulation of flows and multi-body systems; see [A12], [A7], [A5]. Also, my recent inclusions of data-driven approaches enable the consideration of arbitrarily complex systems if only simulation or measurement data is available. On the concrete side, we implemented[3] the control and regulation of an inverted 3-way pendulum with all the difficulties of a real test setup.

During my time at Bombardier Transportations, I experienced model– and simulation-based development in industry. There, I implemented an automated environment for optimizing the shape of regional and high-speed trains [P1] with validation in wind tunnel tests and relevant contributions to the design of the Zefiro train series[4].

Further application-oriented experience with modeling and optimization results from an interdisciplinary project on dispersion processes [P2] and, most recently, from the simulation of a methanation reactor [B13], which is a promising modern tool for energy conversion.

[3] www.mpi-magdeburg.mpg.de/3952045/showcase

[4] See also the relevant publications engineering.esteco.com/resources/success-story/bombardier-uses-modefrontier-to-optimize-high-speed-trains and www.zevrail.de/artikel/die-zefiro-familie-eine-neue-dimension-der-hochgeschwindigkeit.

Planned Research Projects

Data-informed Galerkin-approximations of Multivariate Uncertainty Quantification and Optimization Problems. Especially with regard to optimization and control in applications, I will continue to work on the generalization of the data-informed Galerkin method (cf. [A10], [A21]) and further establish this approach to the numerical analysis and simulation of optimization problems under uncertainties. This approach also allows the complexity reduction of optimization problems without having to rely on model equations (cf. [B13]), creates direct links to various applications for example in bioengineering and is also the link in my existing cooperation with the department for process engineering at the MPI Magdeburg.

Analysis of Convolutional Neural Networks for Parametrizations of PDE State Spaces. When advancing our works ([A8], [B7], [A23]) on extended linearizations towards efficient nonlinear feedback controller design by so-called *gain scheduling*[5] or other LPV[6] techniques, it appeared that very low-dimensional parametrizations of state spaces are incredibly useful for these approaches.
Standard linear model reduction approaches have their natural limits that are best overcome by nonlinear reduction techniques. In a recent proof of concept for the use of neural networks for model reduction of flow equations (see [A19] and [B14]), we showed that convolutional neural networks can provide the right compromise between a drastic complexity reduction and accuracy.
In a current PhD project, using the links to well understood wavelet approximations, we are developing the analysis of convolutional neural networks for the quantitative and qualitative approximation in Sobolev spaces. In parallel, we will combine the numerical treatment of PDEs with the optimization of network parameters which brings both needs and potentials for the development of efficient algorithms for modern hardware.

Data-driven Model Synthesis and Interdisciplinary Application Oriented Projects. For situations where a model is not available at all or simply too complex for, say, long time simulations, I want to further develop on completely data-driven methods like *DMD* and *operator inference* (cp. e.g. [A14] and [A17]) that we have been exploring in Master– and Bachelor projects for an inverted triple pendulum and a flow setup from medical engineering. These methods can be applied to the design, inferrence, and analysis of models in all natural and life sciences in particular if combined with relevant knowledge of measurements or simulation data from high-fidelity models.
Generally, my relevant experience with data-based model synthesis and model reduction provides a direct link to, say, applications and modelling in engineering science and an asset in possible interdisciplinary research projects and grant proposals.

[5] *Gain scheduling* – an approach to interpolate locally valid, linear controllers to a globally valid, nonlinear controller.

[6] here, we will make use of the embedding of nonlinear systems into the class of LPV (linear parameter varying) systems

4 Publications

All articles are original research articles.

Journal Publications

[A25] *Low-complexity linear parameter-varying approximations of incompressible Navier-Stokes equations for truncated state-dependent Riccati feedback*, to appear in IEEE Control Systems Letters. (with Y. Kim and S.W.R. Werner).
arxiv:2401.10620

[A24] *Projective Lag Quasi-Synchronization of Coupled Systems with Mixed Delays and Parameter Mismatch: A Unified Theory*, early view in *Neural Computing and Applications*. (with V. Kumar and P. Benner) DOI:10.1007/s00521-023-08980-5

[A23] *Low-complexity linear parameter-varying approximations of incompressible Navier-Stokes equations for truncated state-dependent Riccati feedback*, IEEE Control Systems Letters. Vol. 7, pp. 3012–3017, 2023. (with S.W.R. Werner).
arxiv:2303.11515 – DOI:10.1109/LCSYS.2023.3291231

[A22] *Exponential Lag Synchronization of Cohen-Grossberg Neural Networks with Discrete and Distributed Delays on Time Scales*, Neural Processing Letters, 2023. (with V. Kumar and P. Benner) arxiv:2209.00401 – DOI:10.1007/s11063-023-11231-2

[A21] *Space and Chaos-Expansion Galerkin POD Low-order Discretization of PDEs for Uncertainty Quantification*, Int. J. for Numerical Methods in Engineering, Vol. 124(12), pp. 2801–2817, 2023. (with P. Benner). DOI:10.1002/nme.7229 – arxiv:2009.01055

[A20] *A low-rank solution method for Riccati equations with indefinite quadratic terms*, Numerical Algorithms, Vol. 92, pp. 1083–1103, 2023. (with P. Benner and S.W.R. Werner) DOI:10.1007/s11075-022-01331-w – arxiv:2111.06516

[A19] *Convolutional Neural Networks for Very Low-dimensional LPV Approximations of Incompressible Navier-Stokes Equations*. Frontiers Applied Mathematics and Statistics, 2022. (with P. Benner and R. Bahmani) DOI:10.3389/fams.2022.879140

[A18] *Robust output-feedback stabilization for incompressible flows using low-dimensional $\mathcal{H}_\infty$-controllers*. Comput. Optim. Appl., Vol. 82, 2022. (with P. Benner and S. Werner) DOI:10.1007/s10589-022-00359-x – arxiv:2103.01608

[A17] *Identification of linear time-invariant systems with Dynamic Mode Decomposition*. MDPI Mathematics, Vol. 10(3), 2022. (with B. Unger)
DOI:10.3390/math10030418 – arxiv:2109.06765

[A16] *Classical System Theory Revisited for Turnpike in Standard State Space Systems and Impulse Controllable Descriptor Systems*. SIAM J. Control and Optimization, Vol. 59(5), 2021. (with E. Zuazua) DOI:10.1137/20M1356105 – arxiv:2007.13621

[A15] *Galerkin Trial Spaces and Davison-Maki Methods for the Numerical Solution of Differential Riccati Equations*. Applied Mathematics and Computation, Vol. 410, 2021. (with M. Behr and P. Benner) DOI:10.1016/j.amc.2021.126401 – arxiv:1910.13362

[A14] *Operator inference and physics-based learning of low-dimensional models for incompressible flows*. Electron. Trans. Numer. Anal. 56, 2022. (with P. Benner, P. Goyal, and I. P. Duff) DOI:10.1553/etna_vol56s28 – arxiv:2010.06701

[A13] *Convergence of Coprime Factor Perturbations for Robust Stabilization of Oseen Systems*. AIMS Mathematical Control & Related Fields, 2021.
DOI:10.3934/mcrf.2021043 – arxiv:1911.00983

[A12] *Numerical benchmarking of fluid-rigid body interactions*. Computers & Fluids, Vol. 193, 2019. (with H. von Wahl, T. Richter, C. Lehrenfeld and P. Minakowski)
DOI:10.1016/j.compfluid.2019.104290 – arxiv:1908.04637

[A11] *Solution Formulas for Differential Sylvester and Lyapunov Equations*. Calcolo, Vol 56, 2019 (with M. Behr and P. Benner)
DOI:10.1007/s10092-019-0348-x (Open Access) – arxiv:1811.08327

[A10] *Space-Time Galerkin POD with application in optimal control of semi-linear parabolic partial differential equations*. SIAM Journal on Scientific Computing, Vol. 40(3), pp. A1611–A1641, 2018. (with P. Benner and M. Baumann)
DOI:10.1137/17M1135281 – arxiv:1611.04050

[A9] *Regularization and Rothe Discretization of Semi-Explicit Operator DAEs*. International Journal of Numerical Analysis and Modeling, Vol. 15(3), pp. 452–477, 2018. (with R. Altmann)
www.math.ualberta.ca/ijnam/Volume-15-2018/No-3-18/2018-03-08.pdf (Open Access)

[A8] *Exponential Stability and Stabilization of Extended Linearizations via Continuous Updates of Riccati Based Feedback*. International Journal of Robust and Nonlinear Control, Vol. 28, pp. 1218–1232, 2018. (with P. Benner)
DOI:10.1002/rnc.3949 – arxiv:1607.08441

[A7] *Optimal Control of a Stefan Problem Fully Coupled with Incompressible Navier-Stokes-Equations and Mesh Movement*. Analele Stiintifice ale Universitatii Ovidius Constanta - Seria Matematica, 26(2), 11–40, 2018. (with B. Baran, P. Benner, J. Saak)
DOI:10.2478/auom-2018-0016 (Open Access)

[A6] *Moment-Matching Based Model Reduction for Navier–Stokes Type Quadratic-Bilinear Descriptor Systems*. ZAMM - Journal of Applied Mathematics and Mechanics, Vol. 97(10), pp. 1252–1567, 2017. (with M. I. Ahmad, P. Benner, and P. Goyal) DOI:10.1002/zamm.201500262 – www2.mpi-magdeburg.mpg.de/preprints/2015/MPIMD15-18.pdf

[A5] *Simulation of Multibody Systems with Servo Constraints through Optimal Control*. Multibody System Dynamics, Vol. 40(1), pp. 75–98, 2017. (with R. Altmann) DOI:10.1007/s11044-016-9558-z – publications.mfo.de/handle/mfo/1105

[A4] *A Differential-Algebraic Riccati Equation for Applications in Flow Control*. SIAM Journal on Control and Optimization, Vol. 54(2), pp. 718–739, 2016. DOI:10.1137/17M1135281 – hdl.handle.net/11858/00-001M-0000-002A-1EE0-3

[A3] *Finite Element Decomposition and Minimal Extension for Flow Equations*. M2AN - Mathematical Modelling and Numerical Analysis, Vol. 49(5), pp. 1489–1509, 2015. (with R. Altmann) DOI:10.1051/m2an/2015029 – hdl.handle.net/21.11116/0000-0001-5E76-2 (Postprint)

[A2] *Time-dependent Dirichlet Conditions in Finite Element Discretizations*. ScienceOpen Research, 2015. (with P. Benner) DOI:10.14293/S2199-1006.1.SOR-MATH.AV2JW3.v1 (Open Access)

[A1] *Distributed Control of Linearized Navier–Stokes Equations via Discretized Input/Output Maps*. ZAMM - Journal of Applied Mathematics and Mechanics. Vol. 92(4), pp. 257–274, 2012. (with V. Mehrmann) DOI:10.1002/zamm.201100069 – www3.math.tu-berlin.de/preprints/files/HeiM11_ppt.pdf

Under Review

[a8] *Low-order Linear Parameter Varying Approximations for Nonlinear Controller Design for Flows*. Submitted to *European Control Conference 2024* in November 2023. (with A. Das) arxiv:2311.05519

[a7] *Implicit and Explicit Matching of Non-Proper Transfer Functions in the Loewner Framework*. Submitted to *European Control Conference 2024* in November 2023. (with I.V. Gosea) arxiv:2311.05519

[a6] *Convolutional Autoencoders, Clustering, and POD for Low-dimensional Parametrization of Flow Equations*, submitted to *Computer Methods in Applied Mechanics and Engineering* in September 2023. (with Y. Kim) arxiv:2302.01278

[a5] *Adaptive H_∞ controller for disturbance rejection of linear systems with partially modeled disturbances*, submitted to *Int. J. of Robust and Nonlinear Control* in May 2023 (with J.J. Zhang, P. Benner, X. Du)

[a4] *Frequency-dependent Switching Control for Disturbance Attenuation of Linear Systems*, submitted to *IEEE Transactions Automatic Control* in May 2023 (with J.J. Zhang, P. Benner, X. Du) arxiv:2306.01120

[a3] *Smoothing Gradient Method for Group-Structured Sparse Feedback Stabilization*, submitted to *Systems & Control Letters* in February 2023 (with A. Tang, G. Hu)

[a2] *Sequential Convex Optimization with Adaptive Feasible Sets for Fixed-order Dynamic Output Feedback Control*, submitted to *IEEE Transactions on Automatic Control* in December 2022. (with Y.Y. Ren and D.W. Ding)

[a1] *Exponential Synchronization of BAM Neural Networks with Delay on Arbitrary Time Domain*, submitted to *IEEE Transactions on Neural Networks and Learning Systems* in March 2022 (with V. Kumar and P. Benner)

Peer-reviewed Conference Proceedings and Book Chapters

[B15] *A quadratic decoder approach to nonintrusive reduced-order modeling of nonlinear dynamical systems*, Proceedings in Applied Mathematics and Mechanics 23(1), 2023. (with P. Benner, P. Goyal, and I. Pontes) DOI:10.1002/pamm.202200049 – arxiv:2209.15412.

[B14] *Convolutional Auto Encoders and Clustering for Low-dimensional Parametrization of Incompressible Flows*, IFAC-PapersOnLine 55(30), pp. 430–435, 2022. (with Y. Kim) DOI:10.1016/j.ifacol.2022.11.091 (Open Access)

[B13] *Non-intrusive Time Galerkin POD for Optimal Control of a Fixed-Bed Reactor for CO_2 Methanation*. IFAC-PapersOnLine 54(3), pp. 122–127, 2021. (with J. Bremer, P. Benner, and K. Sundmacher) DOI:10.1016/j.ifacol.2021.08.229 (Open Access)

[B12] *Equivalence of Riccati-based Robust Controller Design for Index-1 Descriptor Systems and Standard Plants with Feedthrough* European Control Conference (ECC), pp. 402–407, 2020. (with P. Benner)
ieeexplore.ieee.org/document/9143771 –
www.janheiland.de/publication/ben-h-20/ben-h-20.pdf

[B11] *PD Controllers to Solve Single-input, Index-1 DAE based LQR Problems* European Control Conference (ECC), pp. 1795–1800, 2020. (with P. Benner and C. Bhawal)
ieeexplore.ieee.org/document/9143633 –
www.janheiland.de/publication/ben-h-20/bha-hb-20.pdf

[B10] *Continuous, Semi-discrete, and Fully Discretised Navier-Stokes Equations*. In DAE Forum Volume *Applications of Differential-Algebraic Equations: Examples and Benchmarks*, pp. 277–312, 2019. (with R. Altmann)
DOI:10.1007/11221_2018_2 – arxiv:1901.04002

[B9] *Frequency-selective Filter Based Frequency Separated Feedback Control of Linear Systems: State Feedback Case*. 2019 Chinese Control Conference (CCC), pp. 191–196. (with D. Xin, Y. Yang, and K. Okyay)
DOI:10.23919/ChiCC.2019.8865706

[B8] *Robust Controller versus Numerical Model Uncertainties for Stabilization of Navier-Stokes Equations*. IFAC-PapersOnLine 52(2), pp. 25–29, 2019. (with P. Benner and S. Werner)
DOI:10.1016/j.ifacol.2019.08.005 (Open Access)

[B7] *Nonlinear Stabilizing Feedback Design for Incompressible Flows via Updated Riccati-Based Gains*. Proceedings of the 56th IEEE Conference on Decision and Control, CDC 2017, pp. 1163–1168. (with P. Benner)
DOI:10.1109/CDC.2017.8263813 –
www.janheiland.de/publication/ben-h-17-b/ben-h-17-b.pdf

[B6] *Convergence of Approximations to Riccati-based Boundary-feedback Stabilization of Laminar Flows*. IFAC-PapersOnLine 50(1), pp. 12296–12300, 2017. (with P. Benner)
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[B4] *Discrete Input/Output Maps and their Relation to Proper Orthogonal Decomposition*. Numerical Algebra, Matrix Theory, Differential-Algebraic Equations and Control Theory. Festschrift in Honor of Volker Mehrmann. Springer, pp. 585–608, 2015. (with M. Baumann and M. Schmidt)
DOI:10.1007/978-3-319-15260-8_21 –
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[B2] *Systematic Discretization of Input/Output Maps and Control of Partial Differential Equations*. Mathematical Methods, Models and Algorithms in Science and Technology, World Scientific, 2010. (with V. Mehrmann and M. Schmidt)
DOI:10.1142/8063 – www3.math.tu-berlin.de/preprints/files/HeiMS10b_ppt.pdf

[B1] *A new discretization framework for input/output maps and its application to flow control*. Active Flow Control. Papers contributed to the Conference, Springer, pp. 357–372, 2010. (with V. Mehrmann and M. Schmidt)
DOI:10.1007/978-3-642-11735-0_23 –
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Proceedings, Posters, and Selected Reports

[P7] *MaRDIFlow: A Workflow Framework for Documentation and Integration of FAIR Computational Experiments*. 2023. (with P. Veluvali and P. Benner)
DOI:10.52825/cordi.v1i.323

[P6] *Example Setups of Navier–Stokes Equations with Control and Observation: Spatial Discretization and Representation via Linear-quadratic Matrix Coefficients*. 2017. (with M. Behr and P. Benner)
arxiv:1707.08711

[P5] *Best Practices for Replicability, Reproducibility and Reusability of Computer-Based Experiments Exemplified by Model Reduction Software*. AIMS Mathematics Vol. 1(3), 2016. (with J. Fehr, C. Himpe, and J. Saak)
DOI:10.3934/Math.2016.3.261 (Open Access) - arxiv:1607.01191

[P4] *Wie steuert man einen Kran?*. Snapshots of modern mathematics from Oberwolfach, 2015. (with R. Altmann)
publications.mfo.de/handle/mfo/462

[P3] *A generalized POD space-time Galerkin scheme for parameter dependent dynamical systems*. Poster at MoRePaS 2015 - Model Reduction of Parametrized Systems III, Trieste, Italy. (with M. Baumann and P. Benner)
DOI:10.14293/P2199-8442.1.SOP-MATH.P8ECXQ.v1 (Open Access)

[P2] *Simulation and Control of Drop Size Distributions in Stirred Liquid/Liquid Systems*. Proc. 4th International Conference on Population Balance Modelling, September 15-17 2010, Berlin. (with M. Baumann, A. Walle, V. Mehrmann, and M. Schäfer)
Poster – Proceeding – www3.math.tu-berlin.de/numerik/NumMat/DFGProjekte/Drocon

[P1] *Shape Optimization in Train Aerodynamics*. Proceedings of Euromech Colloquium 509 Vehicle Dynamics, Berlin, 2009. (with A. Herbst, J. Mauss, and A. Orellano)
DOI:10.14279/depositonce-2169 (Open Access)

Theses

[T2] PhD thesis – *Decoupling and optimization of differential-algebraic equations with application in flow control*. TU Berlin, 2014.
DOI:10.14279/depositonce-4069 (Open Access)

[T1] Diploma thesis – *Distributed Control of Semidiscretized Oseen Equations*. TU Berlin, 2009. www.janheiland.de/publication/hei-09/hei-09.pdf

Publication of Code

[C6] `Numerical benchmarking of fluid-rigid body interactions`. The raw simulation data and the complete code of a benchmark case for a fluid-structure interaction case in two and three dimensions. 2019. (with H. v. Wahl, T. Richter, P. Minakowski, C. Lehrenfeld)
DOI:10.5281/zenodo.3253455 – Preprint: arxiv:1908.04637v2

[C5] `nse-quadform-mats`. Data and example code for pure *Python/Octave/Matlab* implementations of example setups of distributed or boundary control of incompressible flows. 2017.
DOI:10.5281/zenodo.834940 – Preprint: arxiv:1707.08711

[C4] `spacetime-genpod-burgers`. A *Python* implementation of a generalized space-time POD method with application to optimal control of the Burgers' equation. 2017.
DOI:10.5281/zenodo.583296 – Preprint: arxiv:1611.04050

[C3] `NSE-DAE-Riccati`. A *Python* implementation of an index-2 differential Riccati equation solver for the solution of large-scale tracking problems for Navier-Stokes equations. 2016.
DOI:10.5281/zenodo.192348 – pip:sadptprj-riclyap-adi
Postprint: hdl.handle.net/11858/00-001M-0000-002A-1EE0-3

[C2] `lqgbt-oseen`. A *Python* implementation of the LQGBT approach and related methods for the design of low-dimensional controllers for the stabilization of incompressible flows. Application example: Stabilization of the cylinder wake. 2015.
github.com/highlando/lqgbt-oseen –
Preprint: cscproxy.mpi-magdeburg.mpg.de/preprints/2014/MPIMD14-04.pdf

[C1] `dolfin-navier-scipy`. A *Python* interface between *FEniCS* for Finite Element discretizations of flow equations and *Scipy* for time integration, model reduction, or control algorithms. 2014.
DOI:10.5281/zenodo.3238622 – pip:dolfin-navier-scipy –
github.org/highlando/dolfin_navier_scipy

5 Selected Talks (since 2018)

2023-06-01 *Polytopic Autoencoders for Higher-order Expansions of Nonlinear Feeback Laws*. At the Warwick Workshop on *New Trends in Optimal Control* 2024, Venice. (**Invited talk**)
warwick.ac.uk/fac/sci/maths/research/events/2023-2024/venicecontrol2024

2023-06-01 *Computational Approaches to H∞-robust Controller Design and System Norms for Large-scale Systems*. At GAMM annual meeting, 2023, Dresden. (keynote talk for S22:Scientific Computing)
jahrestagung.gamm-ev.de/annual-meeting-2023/program/sections/

2023-05-26 *Low-dimensional LPV approximations for large-scale nonlinear controller design*. Conference on *Nonlinear Model Reduction for Control* at Virginia Tech, Blacksburg, USA. personal.math.vt.edu/borggajt/nlromc/index.html (**keynote talk**)

2023-01-16 *Numerical Methods in Control and Optimization of Dynamical Systems*. *BIMoS Day* at TU Berlin. www.tu.berlin/bimos – www.janheiland.de/event/23-bimos/
(extended seminar talk/tutorial)

2022-06-07 *Data-driven identification of encoding on quadratic-manifolds for high-fidelity dynamical models*. ECCOMAS Congress, Oslo, Norway.
www.eccomas2022.org/frontal/ProgSesion.asp?id=155
www.janheiland.de/22-quadmf-opi

2021-08-07 *Convolutional autoencoders for low-dimensional parameterizations of Navier-Stokes flow*. Virtual IFAC Seminar *Data-driven Methods in Control*.
https://ie3.etit.tu-dortmund.de/details/ifac-seminar-10080/ (Seminar Talk)

2021-01-19 *Space and Chaos-Expansion Galerkin POD for UQ of PDEs with Random Parameters*. GAMM Fachausschuss *Computational Science and Engineering* Workshop (virtual)
www.mb.uni-siegen.de/nm/workshops/gamm-cse-2021/programme.html?lang=de (Seminar Talk)

2020-10-08 *Control of a Triple Pendulum in Theory and Practice*. Musen Seminar Series. Musen Center at TU Braunschweig (virtual)
www.tu-braunschweig.de/musen/ws2020 (Seminar Talk)

2020-07-01 *Mathematical Modeling of Infectious Disease*. MathCoRe Seminar. OvGU Magdeburg
www.mathcore.ovgu.de/index.php?show=teaching_seminars&year=2020&term=sose
(Seminar Talk)

2020-05-13 *Equivalence of Riccati-Based Robust Controller Design for Index-1 Descriptor Systems and Standard Plants with Feedthrough*. European Control Conference - ECC2020, Saint Petersburg, Russia (virtual). https://youtu.be/CLE6uDpq5pE?t=8328. (Contributed Talk)

2020-02-25 *Turnpike in linear systems theory*. Math Encounter at CCM at Deusto University, Bilbao, Spain. https://cmc.deusto.eus/events-calendar/math-encounter/

2019-11-21 *A benchmark for fluid rigid body interaction with standard CFD packages*. GAMM CSE Workshop, Günzburg.
www.uni-ulm.de/mawi/institut-fuer-numerische-mathematik/forschung/gamm-cse-workshop-2019/

2019-11-04 *Uncertainties in Oseen Linearizations as Smooth Coprime Factor Perturbations*. LIA COPDESC and Lions Magenes Days, Paris, France.
https://liacopdesclm.sciencesconf.org/program (**Invited Talk**)

2019-10-17 *Multidimensional Galerkin-POD for Optimal Control of PDEs with Uncertainties*. Workshop on Machine learning and data-driven methods for model reduction and control. Shanghai, China. www.mpi-magdeburg.mpg.de/shanghaiws19. (Contributed Talk)

2019-10-02 *Stability Analysis of Time Stepping Schemes for Incompressible Flows from a DAE Perspective*. Enumath, Eegmond an Zee, The Netherlands.
www.enumath2019.eu/program/show_slot/103 (Contributed Talk)

2019-07-18 *Tensor-space Galerkin POD for parametric flow equations*. ICIAM, Valencia, Spain. https://iciam2019.com/programa/sesiones.html?codSes=MS%20FT-2-4%208
(Contributed Talk)

2019-07-17 *Robust observer-based feedback for the incompressible Navier-Stokes equation*. ICIAM, Valencia, Spain. https://iciam2019.com/programa/sesiones.html?codSes=MS%20ME-1-4%207 (Contributed Talk)

2019-07-03 *Robust control for compensation of linearization and discretization errors in stabilization of incompressible flows*. Seminar am Lehrstuhl für Mathematik mit Schwerpunkt Dynamische Systeme, Passau. https://www.fim.uni-passau.de/dynamische-systeme/gaeste/. (Seminar Talk)

2019-03-19 *Robust Control for Incompressible Fluid Flow*. Descriptor, Paderborn.
www.mpi-magdeburg.mpg.de/descriptor2019. (Contributed Talk)

2018-10-18 *Stability Analysis of Semi-Explicit Time Stepping Schemes for Index-2 DAEs*. Seminar of the Math Department of the Shanghai Normal University, Shanghai. (Seminar Talk)

2018-06-02 *Stable Time-integration of Incompressible Navier-Stokes Equations*. NOKO, Braunschweig. https://www.tu-braunschweig.de/inum/noko2018/schedule (Contributed Talk)