Paul Schwerdtner

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Summary

Computational research scientist specializing in scientific machine learning and high-performance computing to solve large-scale problems in physical simulation and data analysis. My work focuses on creating novel, scalable algorithms, rigorously validated through large experiments, that accelerate simulations and enhance downstream tasks such as uncertainty quantification and controller design, translating theoretical insights into scalable, real-world solutions.

Recent Publications

Hankel Singular Value Regularization for Highly Compressible State Space Models **in review • NeurIPS 2025**
[request preprint] P. Schwerdtner, J. Berman, B. Peherstorfer

Empirical sparse regression on quadratic manifolds **SIAM J. Sci. Comput 2025**
[full text] P. Schwerdtner, S. Gugercin, B. Peherstorfer *(in production)*

Online learning of quadratic manifolds from streaming data for [...] model reduction **Proc. Royal Society A 2025**
[full text] P. Schwerdtner, P. Mohan, A. Pachalieva, J. Bessac, D. O'Mally et al.

Uncertainty quantification in coupled wildfire–atmosphere simulations at scale **PNAS Nexus 2024**
[full text] P. Schwerdtner, F. Law, Q. Wang, C. Gazen, Y.-F. Chen, M. Ihme et al.

Work experience

Courant Institute of Mathematical Sciences, New York University *New York, NY*
Postdoctoral Fellow (Current) *06/2023 – present*

- **Collaborated with Google Research** on swirl_lm to integrate **multilevel Monte Carlo** estimation for combining large-scale physics simulations with deep neural network estimates for reliable **wildfire prediction** at scale. This has led to a **reduction of training time** from 3 months to under 3 hours and predicting the burned area at least twice as accurately compared with physics simulations alone.
- Developed control theory based regularization approach for **highly compressible deep state space models** used in sequence modeling enabling a **10x reduction of the latent state** dimension while retaining 99% of the original accuracy
- Investigated randomized and energy-preserving time integration for **stable neural PDE solvers** leading to a 4x reduced integration time and enabling the conservation of Hamiltonians and other physics quantities to machine precision.
- Implemented **streaming-based** post-processing pipeline to handle **1.1 peta-bytes** of fluid simulation data for quadratic manifold computation to accelerate physics simulations with collaborators at Los Alamos National Labs and National Renewable Energy Labs.

Neurcat GmbH (AI-Startup) *Berlin, Germany*
Scientific Assistant *10/2018 – 01/2021*

- Contributed to proprietary **AI robustness assessment** SAAS tool for **computer vision** models in use by major German OEMs.
- Implemented **adversarial attacks and defenses** for computer vision systems in industry-wide German autonomous driving consortium "KI-Absicherung".

Institute of Mathematics, Technical University Berlin *Berlin, Germany*
Scientific Assistant *10/2018 – 03/2023*

- Developed novel **optimization-based** model order reduction algorithm for **Hamiltonian approximations** of large-scale dynamical systems increasing state of the art methods by several orders of magnitude.
- Investigated optimization-based controller design and **structured system identification** of dissipative systems from **frequency domain data**.

Mitsubishi Electric Research Laboratories *Cambridge, MA*
Research Intern *04/2018 – 09/2018*

- Designed and implemented **constraint-aware controller** algorithms for multi-room HVAC systems.
- Developed and lab-tested robustness enhancing objective functions for **model predictive control** of systems.

Continental AG *Silao, Mexico*
Research and Design Intern *11/2015 – 03/2016*

- Proposed and developed a DNN-based design of experiments to optimize injection-molding parameters for sensor fabrication.
- Invited to present the method at corporate headquarters in Germany after internship completion.

Education

Ph.D. Mathematics *Berlin, Germany*
Technical University Berlin *10/2018 – 01/2023*

- **Thesis:** *Structured Optimization-Based Reduction, Identification, and Control*
- **Research:** Model order reduction, system identification, and robust control for large-scale and structured dynamical systems

M.S. Engineering Science *Berlin, Germany*
Technical University Berlin *10/2016 – 04/2018*

- **Thesis:** On Fixed Order H-infinity Controller Design for Delay Systems
- **Final grade:** 1.0 (German scale: 1.0 = highest, 4.0 = lowest passing)

B.S. Engineering Science *Berlin, Germany*
Technical University Berlin *10/2012 – 09/2016*

- **Thesis:** Numerical Simulation of non-autonomous Dynamical Systems to Investigate Disk-Brake Squeal
- **Final grade:** 1.1 (German scale: 1.0 = highest, 4.0 = lowest passing)

Prizes and extracurricular activities

GAMM Junior Award *10/2018 – 01/2023*
Recognition for outstanding early career researchers in applied mathematics (across Europe)

Contributions to DIN-SPEC 92001 *10/2018 – 03/2019*
Contribution to national standardization document for artificial intelligence safety evaluation

BIMoS Fellowship *10/2018 – 12/2019*
Fellowship funding the first year of my PhD, awarded for an independent research proposal at the Berlin International School in Model and Simulation based research at TU Berlin

Software & Tools

- Programming: Python (jax, flax, numpy, pandas, hydra, absl-py), Julia, MATLAB, SQL/NoSQL
- HPC: Job management with SLURM; Google Cloud VMs

Publications

[1] **P. Schwerdtner**, S. Gugercin, B. Peherstorfer, *Empirical sparse regression on quadratic manifolds,* **SIAM J. Sci. Comput.** (in production), 2025.

[2] P. Weder, **P. Schwerdtner**, B. Peherstorfer, *Nonlinear model reduction with Neural Galerkin schemes on quadratic manifolds*, **J. Comput. Phys.**, 2025.

[3] **P. Schwerdtner**, et al., *Online learning of quadratic manifolds from streaming data for nonlinear dimensionality reduction and nonlinear model reduction*, **Proc. Royal Society A**, 2025

[4] **P. Schwerdtner** and M. Schaller, *Structured Optimization-Based Model Order Reduction for Parametric Systems*, **SIAM J. Sci. Comput.**, 2025.

[5] T. Holicki, J. Nicodemus, **P. Schwerdtner**, B. Unger, *Energy matching in reduced passive and port-Hamiltonian systems,* **SIAM J. Control Optim.**, 2025

[6] **P. Schwerdtner**, F. Law, Q. Wang, C. Gazen, Y.-F. Chen, M. Ihme, B. Peherstorfer, *Uncertainty quantification in coupled wildfire–atmosphere simulations at scale*, **PNAS Nexus**, 2024.

[7] **P. Schwerdtner**, P. Schulze, J. Berman, B. Peherstorfer, *Nonlinear embeddings for conserving Hamiltonians and other quantities with Neural Galerkin schemes,* **SIAM J. Sci. Comput.**, 2024.

[8] J. Berman, **P. Schwerdtner**, B. Peherstorfer, *Neural Galerkin schemes for sequential-in-time solving of partial differential equations with deep networks*, Handbook of Numerical Analysis (Volume: **Numerical Analysis Meets Machine Learning**), 2024.

[9] **P. Schwerdtner**, T. Moser, V. Mehrmann, M. Voigt, *Optimization-based model order reduction of port-Hamiltonian descriptor systems*, **Systems Control Lett.**, 2023.

[10] **P. Schwerdtner** and M. Voigt, *SOBMOR: Structured Optimization-Based Model Order Reduction*, **SIAM J. Sci. Comput**., 2023.

[11] **P. Schwerdtner** and M. Voigt, *Fixed-Order H-Infinity Controller Design for Port-Hamiltonian Systems*, **Automatica J. IFAC**, 2023.

[12] S. A. Bortoff, **P. Schwerdtner**, C. Danielson, S. D. Cairano, and D. J. Burns, *H-Infinity Loop-Shaped Model Predictive Control With HVAC Application*, **IEEE Trans. Control Syst. Technol.**, 2022.

[13] **P. Schwerdtner** and M. Voigt, *Adaptive Sampling for Structure-Preserving Model Order Reduction of Port-Hamiltonian Systems*, **IFAC-PapersOnline**, 2021.

[14] **P. Schwerdtner**, E. Mengi, and M. Voigt, *Certifying Global Optimality for the L-infinity-Norm Computation of Large-Scale Descriptor Systems*, **IFAC-PapersOnLine**, 2020.

[15] M. W. H. Böse, D. Hildebrand, F. Beuer, C. Wesemann, **P. Schwerdtner**, S. Pieralli, and B. C. Spies, *Clinical Outcomes of Root-Analogue Implants Restored with Single Crowns or Fixed Dental Prostheses: A Retrospective Case Series*, **J. Clinical Medicine**, 2020.

[16] **P. Schwerdtner**, S. A. Bortoff, C. Danielson, S. D. Cairano, and D. J. Burns, *Projection-Based Anti-Windup for Multivariable Control with Heat Pump Application*, **18th European Control Conference (ECC)**, 2019.

[17] S. A. Bortoff, **P. Schwerdtner**, C. Danielson, S. D. Cairano, and D. J. Burns, *H-infinity loop-shaped model predictive control with heat pump application*, **18th European Control Conference (ECC)**, 2019.

[18] **P. Schwerdtner** and M. Voigt, *Computation of the L-infinity-Norm Using Rational Interpolation*, **IFAC-PapersOnLine**, 2018.

[19] N. Aliyev, P. Benner, E. Mengi, **P. Schwerdtner**, and M. Voigt, *Large-Scale Computation of L-infinity Norms by a Greedy Subspace Method*, **SIAM J. Matrix Anal. Appl.**, 2017.