

# Jakob Löber — Curriculum Vitae

PhD in Theoretical Physics | Data Science | Web Development | Augmented Reality

## Professional Background

**since 02/2024**

*Fullstack Developer* — Prosumio GmbH, Berlin

- Development of a Python backend for a web application using Django and Wagtail
- Implementation of REST APIs and Celery for asynchronous task management
- Integration of MQTT (EMQX) for real-time data processing
- Flutter for mobile app development on iOS and Android

**01/2024 – 06/2024**

*Senior Data Scientist* — Teraki GmbH, Berlin

- Object detection in LiDAR and camera data using modern deep learning techniques
- AWS EC2 and S3 for cloud computing and storage
- Spiking neural networks for real-time event camera data analysis

**06/2023 – 12/2023**

*Augmented Reality Software Developer* — BetaRoom UG, Berlin

- Developed the augmented reality application 'KIKI Games'
- Optimized 3D rendering performance for mobile devices
- Porting an AR application from iOS to Oculus Quest 2

**05/2020 – 05/2023**

*Freelance Programmer* — *Freelance, Berlin*

- Developed the augmented reality applications 'KIKI Games' and 'Augmented Berlin'
- Cross-platform development in Unity for iOS and Android
- Designed and implemented custom AR solutions for clients
- Collaborated with designers to create interactive AR experiences

**12/2016 – 11/2018**

*Scientific Assistant* — *Max Planck Institute for the Physics of Complex Systems, Dresden*

- Postdoc in the department 'Biological Physics'
- 13 peer-reviewed scientific publications
- \>20 presentations at conferences

**07/2015 – 11/2016**

*Scientific Assistant — Technical University Berlin*

- Postdoc in the research group 'Nonlinear Dynamics and Pattern Formation'

## **Education**

**2011 – 2015**

*PhD in Theoretical Physics — Technical University Berlin*

Grade: summa cum laude

Title: Optimal Trajectory Tracking

**2002 – 2010**

*Diploma in Physics — Technical University Berlin*

Grade: 1.0

Focus: Statistical physics, Mathematical physics, Thermodynamics

**1993 – 2001**

*High School Diploma — von-Bülow Gymnasium Neudietendorf*

Grade: 1.8

## **Other Activities and Experiences**

**01/2022 – 04/2022**

*Data Science Bootcamp — Data Science Retreat, Berlin*

**12/2018 – 04/2020**

*Cycling trips through South America and Europe — Worldwide*

**01/2013 – 06/2013**

*Research stay with Igor Aronson — Argonne National Lab, Chicago*

**04/2016 – 07/2016**

*Tutor for 'Thermodynamics and Statistical Physics' — Institute for Theoretical Physics, TU Berlin*

**10/2015 – 02/2016**

*Tutor for 'Nonlinear Dynamics and Structure Formation' — Institute for Theoretical Physics, TU Berlin*

**02/2012 – 07/2012**

*Tutor for 'Nonequilibrium Statistical Physics' — Institute for Theoretical Physics, TU Berlin*

**10/2007 – 09/2009**

*Tutor for 'Physics for Engineers' — Institute for Solid State Physics, TU Berlin*

**07/2006 – 09/2007**

*Backpacking through Asia and Africa — Worldwide*

## **Skills Overview**

### **Programming Languages**

Python	■■■■■■■■■□	C#	■■■■■□□□□□
Dart	■■■■■□□□□□	C/C++	■■■■■□□□□□
Java	■■■□□□□□□□	JSON	■■■□□□□□□□
JavaScript	■■□□□□□□□□	HTML	■□□□□□□□□□
CSS	■□□□□□□□□□		

### **Python Ecosystem**

NumPy	■■■■■■■■■□□	matplotlib	■■■■■■■■■□□
PyTorch	■■■■■■■■■□□□	pip	■■■■■■■■■□□□
Jupyter Notebook	■■■■■■■■■□□□	SciPy	■■■■■□□□□□
Conda	■■■■■□□□□□	scikit-learn	■■■■■□□□□□
virtualenv	■■■■■□□□□□	SymPy	■■■■■□□□□□
TensorFlow	■■■■■□□□□□	Pandas	■■■■■□□□□□
typing (type hints)	■■■■■□□□□□	Poetry	■■■■■□□□□□
Plotly	■■■□□□□□□□	seaborn	■■■□□□□□□□
PyTorch Lightning	■■■□□□□□□□	Keras	■■■□□□□□□□
h5py	■■□□□□□□□□		

Machine Learning & AI

CNNs	■■■■■■■■■□	Deep Learning	■■■■■■■□□□
Reinforcement Learning	■■■■■■■□□□	Numerical optimization	■■■■■■□□□□
Q-learning	■■■■■□□□□	Copilot	■■■■■□□□□
wandb	■■■■■□□□□□	Object Detection (YOLO)	■■■■■□□□□□
Modern Hopfield Networks	■■■■□□□□□□	Comet	■■■□□□□□□□

Scientific & Engineering Tools

Mathematica	■■■■■■■■■	Lyx	■■■■■■■□□
LaTeX	■■■■■■■□□□	LiDAR	■■■■■□□□□□
Matlab	■■■■□□□□□□	ROS	■■■□□□□□□□
LabView	■□□□□□□□□		

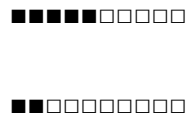
Web Development & Backend

Django	■■■■■■■■■□	MQTT (EMQX)	■■■■■■■□□
Wagtail	■■■■■■■□□□	REST APIs	■■■■■□□□□
Celery	■■■■■□□□□	PostgreSQL	■■■■■□□□□□
Firebase	■■■■■□□□□□	SQLite	■■■■■□□□□□
JWT	■■■■■□□□□□	Redis	■■■■■□□□□□
Nginx	■■□□□□□□□□	MySQL	■■□□□□□□□□
Jinja	■■□□□□□□□□		

DevOps, CI/CD & Tooling

Git	■■■■■■■■■□	Docker	■■■■■■■□□
Bitbucket	■■■■■□□□□	make	■■■■■□□□□□

Bitbucket CI/CD  
pipeline  
Kubernetes

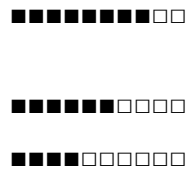


AWS

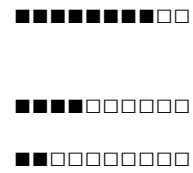


## Testing & Code Quality

unittest  
coverage.py  
Ruff

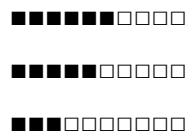


TTD (Test-Driven  
Development)  
pytest  
Black



## Mobile & Cross-Platform Development

Flutter  
Android Studio  
Xcode

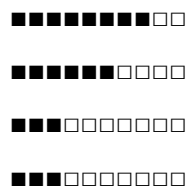


iOS  
Android

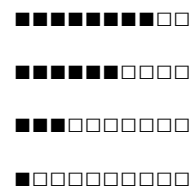


## Visualization, UI & Graphics

OpenCV  
Computer Vision  
Blender  
Inkscape

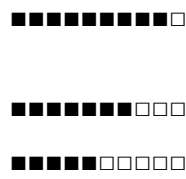


Unity  
3D Visualization  
GIMP  
Qt

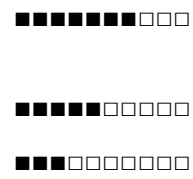


## Operating Systems & Shell

Linux (Ubuntu,  
Debian)  
ssh  
Putty



bash  
GCC  
Unix



## Project & Team Collaboration

Jira ☒☒☒☒☒☒☒☒☒☐☐

Confluence ☒☒☒☒☐☐☐☐☐☐

Slack ☒☒☒☒☒☐☐☐☐☐

Chrome ☒☒☒☒☐☐☐☐☐☐

## Markup & Documentation

Lyx ☒☒☒☒☒☒☒☒☒☒☐

Markdown ☒☒☒☒☒☐☐☐☐☐

LaTeX ☒☒☒☒☒☒☒☒☒☐☐

## Soft Skills & Meta Skills

Scientific Writing ☒☒☒☒☒☒☒☒☒☒☐

University Teaching ☒☒☒☒☒☒☒☐☐☐☐

Mathematical Modeling ☒☒☒☒☒☒☒☐☐☐☐

Teaching ☒☒☒☒☒☒☐☐☐☐☐

Research Skills ☒☒☒☒☒☒☒☒☒☒☐

Presentation Skills ☒☒☒☒☒☒☒☐☐☐☐

Data Analysis ☒☒☒☒☒☒☒☐☐☐☐

## Publications (21)

1. S. Alonso, J. Löber, M. Bär, H. Engel, "Wave propagation in heterogeneous bistable and excitable media", Eur. Phys. J. Spec. Top. 187, 31 (2010).
2. F.J. Schmitt, H. Südmeyer, J. Börner, J. Löber, K. Olliges, K. Reineke, I. Kahlen, P. Hätti, H.J. Eichler, H.J. Cappius, "Handheld device for fast and non-contact optical measurement of protein films on surfaces", Opt. Laser. Eng. 49, 1294 (2011).
3. J. Löber, M. Bär, H. Engel, "Front propagation in one-dimensional spatially periodic bistable media", Phys. Rev. E 86, 066210 (2012).
4. J. Löber, H. Engel, "Analytical approximations for spiral waves", Chaos 23, 043135 (2013).
5. P.V. Paulau, J. Löber, H. Engel, "Stabilization of a scroll ring by a cylindrical Neumann boundary", Phys. Rev. E 88, 062917 (2013).
6. J. Löber, F. Ziebert, I.S. Aranson, "Modeling crawling cell movement on soft engineered substrates", Soft Matter 10, 1365 (2014).

7. J. Löber, H. Engel, "Controlling the position of traveling waves in reaction-diffusion systems", *Phys. Rev. Lett.* 112, 148305 (2014).
8. J. Löber, "Stability of position control of traveling waves in reaction-diffusion systems", *Phys. Rev. E* 89, 062904 (2014).
9. J. Löber, R. Coles, J. Siebert, H. Engel, E. Schöll, "Control of chemical wave propagation", *Engineering of Chemical Complexity II*, pp. 185-207, World Scientific (2014).
10. I.S. Aranson, J. Löber, F. Ziebert, "Phase-field description of substrate-based motility of eukaryotic cells", *Engineering of Chemical Complexity II*, pp. 93-104, World Scientific (2014).
11. J. Löber, S. Martens, H. Engel, "Shaping wave patterns in reaction-diffusion systems", *Phys. Rev. E* 90, 062911 (2014).
12. S. Martens, J. Löber, H. Engel, "Front propagation in channels with spatially modulated cross section", *Phys. Rev. E* 91, 022902 (2015).
13. J. Löber, F. Ziebert, I.S. Aranson, "Collisions of deformable cells lead to collective migration", *Sci. Rep.* 5, 9172 (2015).
14. J. Löber, "Optimal trajectory tracking", Ph.D. thesis, Technical University Berlin (2015).
15. C. Ryll, J. Löber, S. Martens, H. Engel, F. Tröltzsch, "Analytical, Optimal, and Sparse Optimal Control of Traveling Wave Solutions to Reaction-Diffusion Systems", *Control of Self-Organizing Nonlinear Systems*, pp. 189-210, Springer (2016).
16. F. Ziebert, J. Löber, I.S. Aranson, "Macroscopic model of substrate-based cell motility", *Physical Models of Cell Motility*, pp. 1-67, Springer (2016).
17. J. Löber, "Optimal Trajectory Tracking of Nonlinear Dynamical Systems", Springer, ISBN 978-3-319-46573-9 (2017).
18. J. Löber, "Exactly realizable desired trajectories", arXiv:1603.00611 (2016).
19. S. Molnos, J. Löber, J.F. Tutz, H. Engel, "Control of transversal instabilities in reaction-diffusion systems", *New J. Phys.* 20, 053034 (2018).
20. J. Löber, "Linear structures in nonlinear optimal control", arXiv:1604.01261 (2016).
21. D.A. Kulawiak, J. Löber, M. Bär, H. Engel, "Oscillatory Motion in an Active Poroelastic Two-Phase Model", *PLOS ONE* 14, e0217447 (2019).

# Academic Theses

## Doctoral Thesis

Title: Optimal trajectory tracking

Supervisors: Prof. Harald Engel, Prof. Alexander S. Mikhailov, Prof. Fredi Tröltzsch

Date of Defence: July 2015

Defence Talk: Optimal trajectory tracking

**Abstract:** This thesis investigates optimal trajectory tracking of nonlinear dynamical systems with affine controls. The control task is to enforce the system state to follow a prescribed desired trajectory as closely as possible. The concept of so-called exactly realizable trajectories is proposed. For exactly realizable desired trajectories exists a control signal which enforces the state to exactly follow the desired trajectory. For a given affine control system, these trajectories are characterized by the so-called constraint equation. This approach does not only yield an explicit expression for the control signal in terms of the desired trajectory, but also identifies a particularly simple class of nonlinear control systems. Systems in this class satisfy the so-called linearizing assumption and share many properties with linear control systems. For example, conditions for controllability can be formulated in terms of a rank condition for a controllability matrix analogously to the Kalman rank condition for linear time invariant systems. Furthermore, exactly realizable trajectories, together with the corresponding control signal, arise as solutions to unregularized optimal control problems. Based on that insight, the regularization parameter is used as the small parameter for a perturbation expansion. This results in a reinterpretation of affine optimal control problems with small regularization term as singularly perturbed differential equations. The small parameter originates from the formulation of the control problem and does not involve simplifying assumptions about the system dynamics. Combining this approach with the linearizing assumption, approximate and partly linear equations for the optimal trajectory tracking of arbitrary desired trajectories are derived. For vanishing regularization parameter, the state trajectory becomes discontinuous and the control signal diverges. On the other hand, the analytical treatment becomes exact and the solutions are exclusively governed by linear differential equations. Thus, the possibility of linear structures underlying nonlinear optimal control is revealed. This fact enables the derivation of exact analytical solutions to an entire class of nonlinear trajectory tracking problems with affine controls. This class comprises, among others, mechanical control systems in one spatial dimension and the FitzHugh-Nagumo model with a control acting on the activator.



## Diploma Thesis

Title: Nonlinear Excitation Waves in Spatially Heterogeneous Reaction-Diffusion Systems

Supervisors: Prof. Harald Engel, Prof. Markus Bär

Abstract: Wave propagation in one-dimensional heterogeneous bistable media is studied for the Schlögl model. Starting from the analytically known traveling wave solution for the homogeneous medium, non-localized, spatially periodic variations in kinetic parameters as the excitation threshold, for example, are taken into account perturbatively. Two different multiple scale perturbation methods are applied to derive a differential equation for the position of the front under perturbations. All analytical results are compared to the results of numerical simulations.

## Scientific Presentations (44)

1. Velocity of Fronts in Heterogeneous Reaction-Diffusion Systems — Harz seminar, February 2009, Hahnenklee
2. Chemical Master Equations and Fluctuation Theorem — Group Seminar, February 2011, TU Berlin
3. Control of traveling waves and analytical approximations for spiral waves — GRK Kolloquium, July 2012, TU Berlin
4. Controlling the position of traveling waves — SFB Symposium, November 2012, TU Berlin
5. Stochastic reaction-diffusion systems — Group Seminar, January 2013, TU Berlin
6. Analytical approximations for spiral waves — Harz seminar, February 2013, Hahnenklee
7. Controlling the position of fronts — Spring conference of the German Physical Society, March 2013, Regensburg
8. Controlling the position of traveling fronts — APS March Meeting, March 2013, Baltimore, USA
9. Controlling the position of fronts — IMACS Conference on Nonlinear Waves, March 2013, Athens, Georgia, USA
10. Controlling the position and shape of traveling waves — BCSCCS conference, June 2013, Warnemünde
11. Controlling the position of traveling waves in reaction-diffusion systems — DDays Berlin Brandenburg, October 2013, TU Berlin
12. Modeling crawling cell movement — GRK Kolloquium, October 2013, Graal-Müritz
13. Stability of position control of traveling waves — Group seminar, October 2013, TU Berlin

14. Controlling the position of traveling waves in reaction-diffusion systems — Dynamics Days US 2014, January 2014, Georgia Tech, Atlanta, USA
15. Position and shape control of nonlinear waves — Harz seminar, February 2014, Hahnenklee
16. Modeling crawling cell movement — Group seminar, April 2014, TU Berlin
17. Controlling the position of traveling waves in reaction-diffusion systems — Nonlinear Dynamics of Deterministic and Stochastic Systems: Unraveling Complexity, May 2014, Saratov, Russia
18. Modeling crawling cell motility — BCSCCS Seminar, June 2014, FHI Berlin
19. Modeling crawling cell motility — Seminar, July 2014, HU Berlin
20. Modeling crawling cell motility — Mini-Symposium on cell motility, July 2014, TU Berlin
21. Controlling the position of traveling waves in reaction-diffusion systems — SIAM Nonlinear Waves and Coherent Structures, August 2014, Cambridge, UK
22. Modeling crawling cell motility — Dynamics Days Europe, September 2014, Bayreuth
23. Trajectory controllability, optimal trajectory tracking, exact linearization, and all that — Group seminar, October 2014, TU Berlin
24. Analytical approximations for nonlinear optimal trajectory tracking problems — SFB Symposium, February 2015, TU Berlin
25. Modeling crawling cell motility — Spring conference of the German Physical Society, March 2015, TU Berlin
26. Modeling crawling cell motility — BCSCCS conference, June 2015, Munich
27. Optimal trajectory tracking — Ph.D. thesis defence, July 2015, TU Berlin
28. Modeling crawling cell motility — NECD15 conference, October 2015, Potsdam
29. Free boundary problems and phase field methods — Group seminar, November 2015, TU Berlin
30. Modeling crawling cell motility — Harz seminar, February 2016, Hahnenklee
31. Thermodynamics of mechanochemical reactions — Group seminar, June 2016, TU Berlin
32. Poroelastic two-phase model for Physarum polycephalum with free boundaries — Group seminar, November 2016, TU Berlin
33. Poroelastic two-phase model for Physarum polycephalum with free boundaries — MPIPKS Biophysics Group Retreat, January 2017, Oberwiesenthal

34. Phase separation via Density Functional Theory — Droplet Meeting, March 2017, Dresden
35. Cross-linked Gels — Droplet Meeting, July 2017, Dresden
36. Cross-linked Gels — Cortex Day, August 2017, Lichtenhain
37. Rheology of cross-linked polymer networks — Group seminar, September 2017, Dresden
38. Thermorheology of polymer gels — Internal seminar, October 2017, Dresden
39. Rheology of polymer networks: chain length distribution — Droplet Meeting, October 2017, Dresden
40. Thermomechanical Manipulation of Gels — Droplet Meeting, December 2017, Dresden
41. Polymer gels and the two-fluid model — Group seminar, January 2018, Berlin
42. Phase separation in polyelectrolytes — MIPKS Biophysics Group Retreat, January 2018, Oberwiesenthal
43. Transport through and chemical reactions at membranes — Droplet Meeting, February 2018, Dresden
44. Two-fluid model for crawling cell motility — Harz seminar, February 2018, Hahnenklee

## **Posters (11)**

1. Velocity of Fronts in Periodic-Heterogeneous Reaction Diffusion Systems — spring conference of the German Physical Society, March 2009, Dresden
2. Kinematic Theory of Spiral Waves — BCSCCS conference, June 2011, Berlin
3. Controlling the position of a front — GRK conference, October 2012, Potsdam
4. Analytical approximations for spiral waves — GRK conference, October 2012, Potsdam
5. Curvature-dependent feedback control of two-dimensional excitation waves — DPG conference, March 2013, Regensburg
6. Analytical approximations for spiral waves — GRK defence, June 2013, TU Berlin
7. Controlling the position of a front — Dynamics Days Europe, September 2014, Bayreuth
8. Front propagation in three-dimensional corrugated reaction-diffusion media — Dynamics Days Europe, September 2014, Bayreuth
9. Modeling cell movement on heterogeneous substrates — Model systems for understanding biological processes, February 2015, Bad Honnef
10. Linear structures in nonlinear optimal control — Control of Complex Systems and Networks, September 2016, Heringsdorf

11. Position Control of Traveling Spots — Control of Complex Systems and Networks,  
September 2016, Heringsdorf