

Erik Löffelholz

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PERSONAL PROFILE & RESEARCH INTERESTS

Mathematical Physics M.Sc. with a background in differential geometry, PDE theory and field theory, now working mainly on scientific software and machine learning. I am as comfortable with the maths as with the code: I have built differentiable physics simulators, graph generative models, and a discrete differential geometry library, most of it written from scratch in PyTorch. My recurring interest is how structured systems grow out of simple local rules.

EDUCATION

Oct 2021 - Sep 2025	M.Sc. Mathematical Physics Universität Leipzig, Faculty of Physics and Earth System Sciences Selected coursework: Advanced PDE and Analysis · Differential Geometry · Quantum Field Theory · General Relativity · Group Theory
Oct 2018 - Mar 2022	B.Sc. Physics Universität Leipzig, Faculty of Physics and Earth System Sciences
Aug 2010 - Jun 2018	Abitur Luther-Melanchthon-Gymnasium, Lutherstadt Wittenberg

RESEARCH EXPERIENCE

Apr 2025 - May 2026	Scientist Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany Started as a student research assistant (Wissenschaftliche Hilfskraft) and was promoted to Scientist for the last two months. - Built GPU-accelerated tooling in PyTorch and Three.js for embedding discrete meshes into Riemannian manifolds (Euclidean, spherical and hyperbolic spaces) by spring-mass energy minimization with analytic differentials. This became the computational basis for our co-authored Bridges 2026 paper on illustrating hyperbolic surfaces. - Implemented a discrete differential geometry library: cotangent Laplacians, mass matrices, Gaussian and mean curvature, heat-method geodesic distances, isotropic remeshing and dihedral-angle bending energy, running on CUDA, MPS and CPU. - Developed Ricci-flow surface evolution and procedural strand and weave generation on curved surfaces using a half-edge mesh, with interactive 3D visualization. - Wrote differentiable mesh-based physics simulators with a binary WebSocket protocol that streamed PyTorch state to the browser, roughly 10 to 20 times faster than JSON.
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2025 - Present

Independent Researcher & Developer

Graph ML, Computational Geometry & Differentiable Physics

- Built a graph ML framework from scratch in pure PyTorch (no PyG or DGL) for generating 3D tree morphologies. It covers joint discrete-continuous diffusion and autoregressive spatial-tree VAEs over both graph topology and 3D node positions, evaluated with Sholl analysis and spatial MMD.
- Developed DiffQFT, a differentiable holographic QFT framework in Euclidean AdS_2 : Witten-diagram Monte Carlo integration through PyTorch autograd, neural surrogates, and a PINN for the Klein-Gordon equation.
- Implemented a PINN solver for ten classical PDEs, plus browser-based physics demos: a neural ODE that learns chaotic Lorenz dynamics from scratch, and a real-time particle and cloth simulation with an optional PyTorch backend.
- Work fluently with agentic coding models and LLM-assisted development.

2025 - Present

Subject-Matter Expert, STEM & Coding

Outlier.ai, AI Training & Model Evaluation

- Write and review graduate-level mathematics, physics and science prompts and solutions for large-language-model training.
- Rate and compare model outputs (RLHF) for correctness, reasoning quality and helpfulness.
- Do coding and code-review tasks in Python, C++, JavaScript and front-end coding.
- Contribute German (de-DE) prompt and audio-prompt tasks.

TEACHING & ACADEMIC SERVICE

Mar 2024 - Feb 2025

Working Student, Mathematics Editorial

Ernst Klett Verlag GmbH, Leipzig

- Reviewed mathematics content for school textbooks, checking it for technical correctness and clarity.

PUBLICATIONS & CONFERENCES

Fabian Lander, **Erik Löffelholz**, Diaaeldin Taha, Steve Trettel, Anna Wienhard.

"Illustrating Hyperbolic Surfaces with Mesh Embeddings."

Submitted to the **Bridges Conference 2026** (Regular Papers Track). *Under Review.*

RELEVANT SKILLS & LANGUAGES

Programming

Python · JavaScript · TypeScript · C++

Scientific Computing

Numerical Integration (Runge-Kutta, Monte Carlo) ·
Differentiable Simulation · NumPy · SciPy

Tools & Workflow

Git · Docker · FastAPI · LaTeX · Agentic Coding Models ·
AI Data Labeling · RLHF / LLM Evaluation

Machine Learning

PyTorch (Autograd, PINNs, GNNs) · Diffusion Models ·
VAEs · Neural ODEs

Mathematical Methods

Functional analysis · PDE theory · variational methods ·
differential geometry · discrete differential geometry ·
group theory

Languages

German (native) · English (C1, full professional
proficiency)

REFEREES

Dr. Diaaeldin Taha

Research Group Leader (Mathematical Structures in AI)
Max Planck Institute for Mathematics in the Sciences, Leipzig
taha@mis.mpg.de

SELECTED PROJECTS

Mesh Embeddings & Discrete Differential Geometry. GPU mesh embedding into hyperbolic and spherical spaces by spring-mass energy minimization, with a discrete differential geometry operator library (cotangent Laplacian, curvature, heat-method geodesics). Computational basis for the Bridges 2026 paper.

Graph ML Lab. GCN, GAT, graph VAE, discrete diffusion, and joint discrete-continuous diffusion over graph structure and 3D positions, all from scratch. PyTorch only, no external GNN libraries. github.com/erik2810/ml-projects

DiffQFT. Differentiable quantum field theory in Euclidean AdS_2 : Witten-diagram integration, neural surrogates, and a PINN solver for the Klein-Gordon equation. github.com/erik2810/DiffQFT

Differentiable Physics Engine. A neural ODE that learns chaotic Lorenz dynamics from scratch in the browser, with backpropagation and an Adam optimizer written by hand in JavaScript. github.com/erik2810/differentiable-physics-engine

Full project portfolio with live demos at erik2810.github.io/projects