

# Avik Pal

PH.D. CANDIDATE · MASSACHUSETTS INSTITUTE OF TECHNOLOGY · AI COMPILERS · AI FOR SCIENCE

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## Education

### Massachusetts Institute of Technology

Cambridge, MA

S.M. & PH.D. IN COMPUTER SCIENCE (TRACK: AI & DECISION MAKING), GPA: **4.9 / 5.0**

Sep. '21 – May '26 (est.)

- Advisors: [Dr. Alan Edelman](#), & [Dr. Chris Rackauckas](#)
- Masters' Thesis: *On Efficient Training and Inference of Neural Differential Equations*

### Indian Institute of Technology Kanpur

Kanpur, India

BACHELOR OF TECHNOLOGY (B.TECH.) IN COMPUTER SCIENCE AND ENGINEERING, GPA: **9.9 / 10.0**

Jul. '17 – May '21

## Selected Publications

550+ citations across all publications and pre-prints. For a complete list of publications check [my Google Scholar profile](#).

### Peer-Reviewed Conference Proceedings / Journal Papers

#### Geometry & Mesh Invariant Neural Surrogates for Hypersonic Flows

[AVIK PAL](#), [ALAN EDELMAN](#), [CHRIS RACKAUCKAS](#), MATHEW C. JONES, STEVEN SPRIEZER, & TYLER E. KORENYI-BOTH

2025

AIAA SciTech Forum (Accepted, To Appear)

#### NonlinearSolve. jl: High-Performance and Robust Solvers for Systems of Nonlinear Equations



[AVIK PAL](#), [FLEMMING HOLTORF](#), [AXEL LARSSON](#), [TORKEL LOMAN](#), ..., [ALAN EDELMAN](#), & [CHRIS RACKAUCKAS](#)

2024

ACM Transactions on Mathematical Software (TOMS) (Accepted, To Appear)

#### Locally Regularized Neural Differential Equations: Some Black Boxes Were Meant to Remain Closed!



[AVIK PAL](#), [ALAN EDELMAN](#), & [CHRIS RACKAUCKAS](#)

2023

International Conference on Machine Learning (ICML)

#### Continuous Deep Equilibrium Models: Training Neural ODEs Faster by Integrating Them to Infinity



[AVIK PAL](#), [ALAN EDELMAN](#), & [CHRIS RACKAUCKAS](#)

2023

IEEE High Performance Extreme Computing (HPEC) (**Best Student Paper Award**)

#### Opening the Blackbox: Accelerating Neural DEs by Regularizing Internal Solver Heuristics



[AVIK PAL](#), [YINGBO MA](#), [VIRAL B. SHAH](#), & [CHRIS RACKAUCKAS](#)

2021

International Conference on Machine Learning (ICML)

### Pre-prints / Peer-Reviewed Workshop Publications

#### Making Waves in the Cloud: A Paradigm-Shift for Scientific Computing and Ocean Modeling through Compiler Technology



[WILLIAM S. MOSES](#), [MOSÈ GIORDANO](#), [AVIK PAL](#), ..., [ALBERT COHEN](#), & [OLEKSANDR ZINENKO](#)

2025

Under Review

#### Semi-Explicit Neural DAEs: Learning Long-Horizon Dynamical Systems with Algebraic Constraints



[AVIK PAL](#), [ALAN EDELMAN](#), & [CHRIS RACKAUCKAS](#)

2025

Under Review

#### Understanding the Limitations of KANs: Convergence Dynamics and Computational Efficiency



[AVIK PAL](#), & [DIPANKAR DAS](#)

2024

NeurIPS Workshop on Science for Deep Learning

#### Differentiable Programming for Differential Equations: A Review



FACUNDO SAPIENZA, JORDI BOLIBAR, ..., [AVIK PAL](#), ..., PER-OLOF PERSSON, & [CHRIS RACKAUCKAS](#)

2024

Under Review at SIAM Review

## Work Experience

### Google Cloud, XLA TPU Performance Optimization | Student Researcher

New York City, NY

MANAGER: [DR. MEHRDAD KHANI](#)

Jun. - Aug. '25

- Designed learned cost models as an alternative to expert-designed heuristic cost models typically used in AI compilers.
- Built a Mixture of Experts (MoE) model achieving under **3% runtime prediction error** for fusions. Optimized MoE inference for batched predictions, **reducing runtime to 1s** on mid-tier CPUs.
- Improved **end-to-end TPU model performance by 1%**, realizing **over 70% of available headroom**.
- Integrated and deployed the learned cost model in the XLA:TPU compiler tool-chain.

## MIT CSAIL, Julia Lab | Graduate Research Assistant

Cambridge, MA

PI(s): [DR. ALAN EDELMAN](#) & [DR. CHRIS RACKAUCKAS](#)

Sept. '21 - Present

- Developed an MLIR-based compiler enabling automatic differentiation and tensor program optimizations for scientific ML and DL.
- Deployed the compiler to scale ocean simulation codes from single-node execution to **1700 TPUs** and **6144 A100 GPUs** with automated parallelization and communication optimizations.
- Introduced a framework for **enforcing physical constraints in neural surrogates of hypersonic flows (AIAA SciTech)**, made scalable through tensor optimizations.
- Created a nonlinear root-finding framework (**ACM TOMS**) that **outperforms PETSc and Sundials**, and applied it to training **constrained neural networks** achieving faster runtimes and improved numerical convergence (tolerances up to  $10^{-10}$  vs.  $10^{-8}$  in prior work).

## Intel Labs, Parallel Computing Lab | Graduate Research Intern

Santa Clara, CA

MANAGER: [DR. DIPANKAR DAS](#)

May - Aug. '24

- Explored Kolmogorov–Arnold Networks (KANs) as a **parameter-efficient alternative to MLPs** in scientific ML and vision tasks.
- Developed a systematic evaluation of KANs across Neural ODEs, computer vision, and operator learning benchmarks. Introduced Hessian eigenvalue spectrum analysis to study convergence dynamics.
- Quantified computational trade-offs providing insights into the scalability and practical applicability of KANs.
- Publication: Convergence Dynamics and Eigenvalue Analysis of B-Spline KANs (**NeurIPS 2025 Workshop on Science for Deep Learning**).

## Google AI | Student Researcher

Mountain View, CA

MANAGER(S): [DR. ANDREY ZHMOGINOV](#), & [DR. LILY HU](#)

May - Aug. '22

- Proposed a deep learning method to **augment coarse-grained simulations for approximating fine-grained wildfire dynamics**.
- Showed that black-box neural simulators fail to capture stable long-term dynamics in limited-data regimes.
- Developed probabilistic neural simulators that model the full range of possible wildfire outcomes.
- Released open-source **wildfire simulator based on percolation models in JAX**.

## University of Toronto & Vector Institute | Research Intern

Toronto, CAN








PI: [DR. SANJA FIDLER](#)

Jan. - Dec. '20








- Developed multi-agent reinforcement learning (MARL) environments where **driving rules emerge naturally** from optimizing traffic flow.
- Analyzed how POMDP design factors, such as perception noise and agent density, shape cooperative driving behaviors.
- Demonstrated emergent behaviors including lane following, right of way, fast lanes, communication, and safe distances.
- Released an **open-source suite of driving environments** to support MARL research in self-driving.
- Publication: Emergent Road Rules in Multi-Agent Driving Environments (**ICLR 2021**).

## Open Source Software

For a complete list of open source software I have worked on, check [my GitHub profile](#).

- |   |  |                |
|---|--|----------------|
|  | <b>Lux.jl</b> , Elegant and performant deep learning in Julia powered by the XLA compiler.   | Julia          |
|  | <b>Enzyme-JAX</b> , MLIR-based compiler enabling automatic differentiation, sharded-communication optimizations, and various platform-agnostic high-level optimizations. | C++, MLIR, Jax |
|  | <b>Reactant.jl</b> , Optimize Julia functions with MLIR and XLA for execution on heterogeneous hardware.   | Julia, C++     |
|  | <b>NonlinearSolve.jl</b> , High-performance and differentiation-enabled nonlinear solvers with sparsity support.   | Julia          |
|  | <b>NeuralPDE.jl &amp; NeuralOperators.jl</b> , PINN solvers of PDEs for accelerated simulation.  | Julia          |
|  | <b>torchgan</b> , Research framework for easy and efficient training of GANs based on Pytorch.   | Pytorch        |
|  | <b>social-driving</b> , Multi-agent environments and reward functions for social driving behavior emergence.   | Pytorch        |

## Selected Presentations

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|------|--|---|
| 2025 | <b>Accelerating Machine Learning in Julia using Lux &amp; Reactant</b> , JuliaCon / CSAIL Alliances Workshop |  |
| 2025 | <b>Semi-Explicit Neural DAEs: Learning Long Horizon Constrained Dynamical Systems</b> , SIAM CSE             |  |
| 2025 | <b>The Tricks Required for Scientific Machine Learning to Work on Real Data</b> , SIAM CSE                   |  |
| 2025 | <b>Accelerating Physics Informed Machine Learning in Julia using Reactant and Lux</b> , AAAI                 |  |
| 2022 | <b>Lux.jl: Explicit Parameterization of Neural Networks in Julia</b> , JuliaCon                              |  |
| 2022 | <b>Mixing Implicit and Explicit Deep Learning with Skip DEQs</b> , SciMLCon                                  |  |
| 2019 | <b>Differentiable Rendering and its Applications in Deep Learning</b> , JuliaCon                             |  |

## Professional Activities

- '24, '25 **International Conference on Learning Representations (ICLR)**, Reviewer for 6 + 3 papers
- '23 - '25 **Neural Information Processing Systems (NeurIPS)**, Reviewer for 6 + 6 + 5 papers
- '22 **International Conference on Machine Learning (ICML)**, Reviewer for 3 papers

## Honors, Awards & Recognitions

- |         |   |            |
|---------|---|------------|
| 2023    | <b>Best Student Paper Award</b> , IEEE High Performance Extreme Computing Conference    | USA        |
| 2017-20 | <b>Academic Excellence</b> , Top 10% students in 3 Consecutive Academic Year            | IIT Kanpur |
| 2017    | <b>Inspire Scholarship for Higher Education</b> , Top 1% students in 10+2 board results | India      |