# PETR KARNAKOV, PhD

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## SUMMARY

Research scientist with over 10 years of experience in developing software and numerical algorithms for simulation and control of complex physical systems. Diverse skills in software engineering, high-performance computing, and machine learning. Proven ability to advance even well-established areas.

## EXPERIENCE

**Research Associate** 2023–present
Harvard University, United States

- Developed a machine learning framework ODIL for solving inverse and control problems that accelerates physics-informed neural networks by 100 000 times
- Designed a model-based optimal control algorithm that outperforms reinforcement learning
- Technology used: Python, TensorFlow, JAX

**Head Instructor** 2022
Harvard University, United States

- Delivered a graduate course on numerical methods for 80 students, leading a team of 5 assistants
- Created reproducible visual materials

**Scientific Assistant / Researcher** 2016–2022
ETH Zurich, Switzerland

- Developed a distributed multiphysics solver Aphros for simulating flow with bubbles in electrochemical reactors
- Proposed a curvature estimation algorithm improving low-resolution accuracy over state-of-the-art method
- Proposed an algorithm for efficient simulation of foams
- Performed the largest simulations of foaming by breakup and mixing of air in water with 10 000 bubbles on 2000 compute nodes on a supercomputer
- Analyzed data and derived reduced-order models from large-scale simulations of cavitation
- Identified effects of interventions in epidemic data throughout Europe using Bayesian inference
- Technology used: C++, Python, MPI, OpenMP, OpenCL

**Research Engineer** 2013–2016
FRC ICT, Novosibirsk, Russia

- Developed simulation software for multiphase flow and fracture mechanics applied in petroleum industry
- Technology used: C++, Fortran

## COLLABORATIONS & LEADERSHIP

- Completed 5 common projects with 9 researchers within the lab at ETH Zurich and Harvard University
- Closely collaborated with 10 researchers from external groups at EPFL, MIT, UZH, and TUM
- Mentored 3 graduate and 4 undergraduate students
- Assisted 15 external users of Aphros and ODIL
- Contributed to open-source simulation software basilisk with a critical patch
- Participated in the Blueprint program by venture firm The Engine for prospective startup founders

## EDUCATION

**PhD Mechanical Engineering** 2021
ETH Zurich, Switzerland

**MSc Mechanics and Mathematical Modeling** 2016
Novosibirsk State University, Russia

**BSc Mechanics** 2014
Novosibirsk State University, Russia

## SKILLS

Programming
C++, Python, JavaScript, OpenGL, Fortran, x86 assembly

High Performance Computing
MPI, OpenMP, OpenCL, CUDA, HDF5, vectorization

Mathematics
Numerical methods, linear algebra, optimization

Machine Learning
TensorFlow, JAX, reinforcement learning, stochastic methods, Bayesian inference, neural networks

Visualization & Simulation
Matplotlib, ParaView, Ansys Fluent, COMSOL

Development Tools
Git, Unix shell, CMake, Docker, CI/CD

Presentation & Publishing
LaTeX, HTML, Keynote, reveal.js

Communication
Published 15 peer-reviewed articles, including 9 as first author. Presented 8 talks at international conferences.

Languages
English (fluent), Russian (native), German (beginner)

## OPEN-SOURCE PROJECTS

**Aphros** github.com/cselab/aphros
Distributed multiphysics solver in C++ with MPI for simulating flow with bubbles in electrochemical reactors.

**ODIL** github.com/cselab/odil
Python framework for solving inverse problems for physical models using TensorFlow and JAX.

**autodiff** github.com/pkarnakov/autodiff
Automatic differentiation framework in C++ with GPU support through OpenCL and CUDA.

## HONORS & AWARDS

- Work on foam simulation covered by 8 news outlets, including Physics World, Phys.org, and C&EN (2022)
- Gallery of Fluid Motion Award for video on foam simulation, American Physical Society (2019)
- Scholarships from BP and Baker Hughes (2014)

## HOBBIES & INTERESTS

Classical choral singing, musical instruments, political philosophy, and running.