

# Aakash Anand

## Curriculum Vitae

Research Scholar, Department of Physics  
Indian Institute of Science Education and Research, Pune  
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### Professional Summary

PhD candidate in Statistical Physics at IISER Pune, investigating transport phenomena in micro- and nanochannels with spatiotemporally undulating walls. Experienced in analytical and computational modeling of stochastic processes and non-equilibrium systems, specializing in simulations of particle and fluid transport for microfluidic, nanofluidic, and biological applications.

### Personal profile

Nationality Indian.  
Date of birth 29th June, 1995.  
Languages Hindi (fluent), English (fluent).

### Education

2019–Present **PhD, Non-equilibrium Statistical Mechanics**, Indian Institute of Science Education and Research, Pune, India.  
Fluid flow transport in nano-channels. Focusing on applications of fluid dynamics in nano-channels.  
2017–2019 : **Master of Science, Physics**, Indian Institute of Science Education and Research, Pune, India.  
2014–2017 : **Bachelor of Science, Physics Hons.**, Sri Venkateswara College, Delhi University, Delhi, India.

### Publications

**Room temperature flashing Ratcheting in nano-channels**, Aakash Anand, A. Bhattacharyay.  
*Physica A: Statistical Mechanics and its Applications*, **626** (2023): 128889.  
<https://doi.org/10.1016/j.physa.2023.128889>

**Flow cross-overs under surface fluctuations in cylindrical nano-channel**, Aakash Anand, A. Bhattacharyay.

Published in *Physics Letters A*, 2025, Article No. 130676.  
DOI: 10.1016/j.physleta.2025.130676

**Hydrodynamic Ratchet for Tracer Transport in a Soft Microchannel: A Detailed Analysis**, Aakash Anand, A. Bhattacharyay.

Submitted to *Physical Review E*; Preprint: arXiv:2510.12492

### Research Experience

- Computational study of overdamped dynamics of a Brownian particle in nanochannels with undulating walls.**  
Investigated ratcheting transport phenomena, studied the efficiency of the ratcheting process, and analyzed the effects of physical parameters such as temperature on transport behavior.
- Theoretical study of surface-fluctuation driven fluid flow in nanotubes.**  
Developed perturbation analysis for low Reynolds number flow, distinguishing surface-driven flow from bulk flow under pressure head in cylindrical nanochannels.
- Computational study of Gene Regulatory Networks in EMT.**  
Modeled gene regulatory circuits involved in Epithelial to Mesenchymal Transition (EMT) and analyzed conditions for pattern formation and multistability in the system.

#### 4. **Theoretical and computational investigation of transport in soft microchannel.**

Designed a "hydrodynamic ratchet" model where the fluid flow itself, not an external potential, acts as the transport mechanism. This work is being extended to explore the transport properties of multi-particle systems and polymer-like chains of interacting particles.

#### 5. **Path Integrals and Renormalization Group Theory.**

Conducted a year-long project focused on foundational concepts in quantum field theory. Developed strong proficiency in advanced analytical methods, including path integral formulation, group theory, and renormalization group (RG) theory.

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### Independent Learning

#### 1. **Stochastic Calculus and Processes.**

Pursued an in-depth study of stochastic calculus with emphasis on physics-based stochastic processes. Explored Itô and Stratonovich interpretations, their mathematical foundations, and applications to stochastic differential equations. Studied models involving hitting times, mean passage times, and the narrow escape problem, connecting rigorous theory with physical phenomena. Applied this knowledge to analyze Langevin dynamics and noise-induced behavior in complex systems, developing strong expertise in stochastic modeling.

#### 2. **Stochastic gene expression and cellular noise.**

Performed an in-depth study of stochastic models in gene regulation, with emphasis on the roles of intrinsic and extrinsic noise in driving phenotypic variability and state transitions. Explored foundational concepts through key research articles and theoretical frameworks.

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### Seminar and Conferences attended

- 2019 **SERB School on Non-linear Dynamics 2019**, Indian Institute of Technology (IIT), Patna, India.
- 2020 **Bangalore School on Statistical Physics XI**, International Centre for Theoretical Sciences (ICTS), Bangalore, India.
- 2022 **Conference on Nonlinear Systems and Dynamics(CNSD) 2022**, Indian Institute of Science Education and Research (IISER), Pune, India.
- 2023 **Perspectives in Non-Linear Dynamics 2023**, Indian Institute of Technology (IIT), Madras, India.
- 2023 **Complexity and Non-Linear Dynamics in STEM 2023**, Indian Institute of Technology (IIT), Hyderabad, India.
- 2023 **International Conference on Non-Linear Science and Applications 2023**, Indian Institute of Technology (IIT), Bhubaneswar, India.
- 2024 **Data Dynamics Summit 2024**, Indian Institute of Science Education and Research, Pune, India.
- 2024 **Presentation on Stochastic Nature of Gene Expression**, as part of an audited course at IISER Pune.
- 2025 **Workshop on Mathematical Finance (Time Series and Risk Modelling)**, Indian Institute of Science Education and Research, Pune, India.

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### Fellowships, Awards & Academic Achievements

- 2020–Present Council of Scientific & Industrial Research (CSIR), India (Grant No. 09/936(0296)/2021- EMR-I).
- 2018 Qualified *CSIR-NET (Council of Scientific and Industrial Research – National Eligibility Test)*, June 2018, with Rank 59.
- 2017 Qualified *JEST (Joint Entrance Screening Test )* with Rank 91.
- 2017 Qualified *IIT-JAM (Joint Admission Test for Masters)* with Rank 319.
- 2017 *Second Rank Holder*, B.Sc. Physics Hons., University of Delhi (South Campus).

## Computational and Technical Skills

Programming Languages	MATLAB, Python, C++, and Fortran with OpenMP parallelization; proficient in high-performance computing environments, including supercomputer access and cluster computing for large-scale simulations.
Computational Fluid Dynamics (CFD)	Experience in implementing finite difference methods for solving incompressible Navier–Stokes equations in cylindrical and channel geometries; numerical solution of Laplace and Poisson equations for pressure and potential fields; analysis of flow instabilities and transport phenomena in confined geometries, Lattice Boltzmann Methods (LBM) for Fluid dynamics simulations, Upwind schemes for Advection and Convection problems, MacCormack method, Lax-Wendroff method.
Machine Learning in Physics	Applied reinforcement learning and surrogate-based optimization to determine parameters for maximum ratcheting in stochastic models; implemented ensemble-based SDE simulations in Python and analyzed trajectories to extract optimal transport characteristics.
Mathematical Modelling	Proficient in developing and analyzing models, including stochastic differential equations, partial differential equations, Monte Carlo simulations, molecular dynamics simulations, polymer dynamics simulations, Multiparticle collision Dynamics (MPCD), Symplectic integrators (leap-frog methods, Verlet integration), mean first passage time calculations, stochastic simulation of chemical reactions using the Gillespie algorithm, and percolation theory.
Analytical Techniques	Linear algebra, perturbation methods, singular perturbation methods, multiple scale analysis, mean first passage time models, spectral methods, percolation theory, path integral formulation, group theory, renormalization group (RG) theory, statistical data analysis, visualization, and differential equations.
Software & Tools	L <sup>A</sup> T <sub>E</sub> X, Microsoft Office and Excel .

## Teaching Assistantship

Fall 2019	<b>Introductory Mechanics (PH1113).</b> Teaching Assistant for first-year BS-MS students at IISER Pune under <b>Dr. Sudarshan Ananth</b> and <b>Dr. Mukul Kabir</b> .
Spring 2020	<b>Introductory Electricity and Magnetism (PH1213).</b> Teaching Assistant for first-year BS-MS students at IISER Pune under <b>Dr. Diptimoy Ghosh</b> .
Fall 2020	<b>Gravitation and Cosmology (PHY351).</b> Teaching Assistant for third-year BS-MS students at IISER Pune under <b>Dr. Suneeta Varadrajan</b> .

## Referees

1. **Prof. Arijit Bhattacharyay.**  
Professor, Department of Physics, Indian Institute of Science Education and Research (IISER) Pune  
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Phone: +91-20-25908095
2. **Dr. Bijay Kumar Agarwalla.**  
Associate Professor, Department of Physics, Indian Institute of Science Education and Research (IISER) Pune  
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3. **Prof. Sagar Chakraborty.**  
Professor, Department of Physics, Indian Institute of Technology Kanpur (IIT Kanpur)  
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