

# Guru Kalyan Jayasingh

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Visa Status: F-1

## Education

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### University of California San Diego (UCSD)

*Ph.D. student, Department of Physics*

2022–Present

### Indian Institute of Technology Bombay, India

*Dual Degree (B.Tech + M.Tech) in Engineering Physics*

2017–2022

Specialization: Nanoscience | GPA: 9.44/10,

Honors: Institute Silver Medal · K. Seshia Research Excellence Award · Institute Academic Prizes (2019,2021)

## Publications

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**2025:** **G.K. Jayasingh** and Nigel Goldenfeld, Tricritical directed percolation controls the laminar–turbulent transition in pipes with body forces, *Phys. Rev. Lett.* 135, 104001 (2025).

<https://doi.org/10.1103/46g3-n7cx>

**2026:** **G.K. Jayasingh**, B. Kazsas, C.C. Caulfield and N. Goldenfeld, Transition to turbulence in stably stratified flows (manuscript in preparation)

**2026:** **G.K. Jayasingh** and Nigel Goldenfeld, May's Complexity-Stability hypothesis for neural networks (manuscript in preparation)

**2026:** S. Chakraborty, **G.K. Jayasingh**, H. Pal, Inverse Proximity Effects of a Topological Insulator on a Superconductor in One-Dimensional Heterostructures (manuscript in preparation)

## Honors and Achievements

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**2022:** Received the **Institute Silver Medal**, recognizing the **top-ranked** student in the B.Tech–M.Tech Dual Degree cohort of 2017.

**2022:** Received **K. Seshia Research Excellence Award** for the best Master's thesis in Physics demonstrating research originality and rigor.

**2022:** Received the **Physics Excellence Award** from the Department of Physics, UCSD.

**2021:** Received **Institute Academic Prize** for the **highest GPA** in the physics department for 2020-2021.

**2021:** Ranked **third** all India in Indian Young Physicists League (IYPL), a national theoretical physics competition.

**2020:** Selected for Aalto Science Institute (**ASci**) internship programme to pursue research on Topological matter for 12 weeks at Aalto Institute, Finland.

**2019:** Received **Institute Academic Prize** for the **highest GPA** in the physics department for 2018-2019.

**2017:** Secured **99.62 percentile** in JEE-ADVANCED 2017 among 200,000 applicants.

**2017:** Was in the **top 400** among a total of 40,000 students, selected to appear INChO (Indian National Chemistry Olympiad).

**2017:** Awarded **KVPY (Kishore Vaigyanik Protsahan Yojana) fellowship** by Department of Science and Technology, India for identifying exceptional talent and promoting careers in basic sciences.

**2016:** Secured **National Top 1%** in NSEC (National Standard Examination in Chemistry).

## Conferences and Summer Schools

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**2025:** Participant at Simons Collaboration on Wave Turbulence Annual Meeting, New York City.

**2025:** Invited talk at Joint Institute for Fusion Theory (JIFT) Workshop on Strong Turbulence, Avalanching and Structures in Boundary Plasma Turbulence, University of California San Diego.

**2025:** (Declined) Physics and mathematics of hydrodynamic and wave turbulence at Centre International de Rencontres Mathématiques, Marseille.

**2025:** Contributed talk at APS Joint March and April Meeting Global Physics Summit 2025 , Anaheim California.

## Key Research Experience

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### ***Transition to fluid turbulence as an ecological phase transition***

*Sep 2023 - Present*

Supervisor: Prof. Nigel Goldenfeld, Dept. of Physics, University of California San Diego.

- Turbulence is one of the most complex and unsolved problems in physics, especially in confined flows like pipes. My work explores how turbulence emerges from smooth (laminar) flow, building on the observation that this transition follows patterns seen in directed percolation - a non-equilibrium phase transition relevant to extinction transitions in predator-prey models of ecology.
- Predicted the existence of a tricritical fixed point in the phase diagram of transitional turbulence in curved and heated pipes, explaining recent experimental findings.
- Provided scaling predictions and identified body force strength as a tunable parameter to observe tricritical directed percolation exponents in experiments, guiding future studies on turbulence control in confined flows.

Work published in [Physical Review Letters](#)

### ***Universality class of turbulent transitions in stably stratified flows***

*Jan 2026 - Present*

Supervisor: Prof. Nigel Goldenfeld, Dept. of Physics, University of California San Diego.

- In geophysical shear flows such as ocean thermoclines and atmospheric boundary layers, stable density stratification suppresses vertical motion and competes with shear-driven turbulence, determining whether turbulence is sustained or decays to a laminar state. The laminar to turbulent transition in unstratified shear flows is now understood as a directed percolation (DP) phase transition, with universal critical scaling near  $Re_c$ . Whether stratification shifts  $Re_c$ , alters the critical exponents, or moves the transition into a different universality class remains an open question with both fundamental and geophysical importance.
- With our collaborators C.-C. Caulfield and B. Kaszas, I am investigating this in stratified Waleffe flow, developing finite-size scaling to study the critical behaviour from numerical simulations.

### ***Complexity-Stability Hypothesis in Neural Networks***

*Jan 2026 - Present*

Supervisor: Prof. Nigel Goldenfeld, Dept. of Physics, University of California San Diego.

- May's 1972 theorem establishes that sufficiently complex random systems are generically unstable, yet evolved ecosystems systematically violate this prediction through structural mechanisms implemented by natural selection.
- The central question of this project is whether other optimized systems, such as neural networks trained by gradient descent, develop analogous stabilizing structure, or remain in the random-matrix regime. Currently in progress.

### ***Characterizing topological insulator-superconductor junctions***

*May 2021- Present*

Master's Thesis

Supervisor: Prof. Hridis Kumar Pal, Dept. of Physics, IIT Bombay.

- Investigated the characteristics of a superconductor-topological insulator (SC-TI) junction, including the transition temperature ( $T_c$ ) and critical fields, to understand the role of surface states in determining superconducting properties.
- Studied the characteristics of superconductor-metal junctions, learning the quasi-classical Green's function method to analyze heterostructures, and explored recent developments on the SC-TI junction problem.
- Derived a nonlocal Ginzburg-Landau functional for order parameter, and investigated the effects of topology in superconductor-topological insulator heterostructures.[\[Report\]](#)

## Talks

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### **Tricritical directed percolation and transitional turbulence**

*Invited talk at JIFT Workshop on Strong Turbulence, Avalanching, and Structures in Boundary Plasma Turbulence*

Aug 2025

Presented a talk exploring how external body forces modify the universality and phase structure of the laminar–turbulent transition in pipe flows. The work extends the directed percolation framework to include body-force effects, revealing a tricritical regime bridging continuous and discontinuous transitions. The resulting theory explains the emergence of bistability, coexistence, and relaminarization observed in experiments on curved and centrifugal pipes, providing a unifying perspective on forced transitional turbulence.

### **Laminar-turbulent transition in pipes with body forces: continuous, discontinuous or both?**

*Contributed talk at APS Joint March and April Meeting Global Physics Summit 2025*

Mar 2025

Presented work on how body forces modify the laminar–turbulent transition in pipe flow. Extending the directed percolation framework to include external forcing, we showed that sufficiently strong body forces induce a tricritical point separating continuous and discontinuous transitions. The resulting phase diagram explains bistability and spatial intermittency observed in experiments and simulations of forced pipe turbulence.

### **Low rank hypothesis of complex systems**

*Course presentation for BGGN246A AI and Brains neuroscience course at Salk Institute*

Feb 2025

Presented a talk on the low rank Hypothesis of complex systems, discussing how high-dimensional complex systems—such as ecosystems, neural networks, and social structures—exhibit effective low-rank behavior, enabling dimension reduction and interpretable dynamics. The talk covered Singular Value Decomposition (SVD) as a tool for analyzing low-rank structures, empirical validation of the hypothesis across real and random networks, and implications for neural dynamics, epidemiology, and physics. It also addressed cases where the hypothesis fails, such as the brain's criticality conjecture, and discussed open challenges in predictive modeling of low-rank structures. [Slides]

### **Bosonization and some applications**

*Condensed Matter Journal Club, IIT Bombay*

Sep 2021

Spanning 2 sessions, the first talk focused on derivation of Bosonization identities while second talk presented a physical and heuristic view of the technique. Discussed applications by calculating conductance in impurity-ridden Luttinger wire (employing renormalization group) to illustrate new physics spawning due to reduced dimensions, interactions, and mesoscopic nature of transport. [Slides]

### **Aspects of unconventional superconductivity**

*Condensed Matter Journal Club, IIT Bombay*

Aug 2022

Discussed classification of order parameters within a generalized BCS theory and nature of physical observables for different pairing symmetries. [Slides]

### **Fractals**

*Invited talk at non-linear dynamics course at IIT Bombay*

Aug 2018

Presented the notion of fractional dimension, methods to characterize dimension of a fractal, and relevance of fractals for stochastic processes to the non-linear dynamics class at the invitation of the course instructor.

## Relevant Course Projects

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### **Structural Response Prediction and Fault Detection from Time Series, Machine Learning** Mar 2025

- Built multivariate LSTM to forecast structural accelerations from excitation inputs on a 3-story dataset (with 34M+ entries) with 17 structural states (healthy and damaged).
- Achieved MSE about 0.00276 on baseline (undamaged) data (representing <2% prediction error); observed about 10x higher MSE on damaged states indicating degradation.
- Implemented logistic regression with frequency-domain features (Welch PSD) to classify structural health states; attained over 85% accuracy.

### **Investigation of Fukushima-Daiichi Nuclear Disaster, Nuclear and Particle Physics**

Oct 2020

- Analyzed publicly available datasets to formulate a diffusive model that quantifies the spread of radioactive debris post-explosion.
- We modeled spread as a function of distance, time and direction. Our analysis successfully folded in the effect of two consecutive explosions. [Slides]

## Teaching and Academic Service

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### **University of California San Diego**

2022–2024

Courses (UC San Diego): Emergent States of Matter (Graduate, taught by Prof. Nigel Goldenfeld), Phys 1–2 Series (Undergraduate: Mechanics, Electromagnetism, Waves & Oscillations Labs)

- Led weekly discussion sections for both graduate and undergraduate courses, reinforcing lecture material and guiding students through advanced problem sets.
- Held office hours to address conceptual questions and provide one-on-one academic support.
- Assisted faculty with grading, exam preparation, and logistical coordination of course activities.

### **Indian Institute of Technology Bombay**

2019–2022

Courses (IIT Bombay) : Statistical Physics (Spring 2022), Advanced Statistical Mechanics (Autumn 2021), Complex Analysis (Autumn 2020) & Electromagnetism (Summer 2019)

- Conducted weekly tutorial sessions (both online and offline) for a batch of over 35 students throughout the course and helped clear conceptual doubts through individual interaction.
- Assisted instructors in conducting exams, correcting answer sheets, and selecting relevant problems for practice sets.

## Technical Skills

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**Languages:** Python, C/C++ (familiar), Mathematica

**Packages:** Pytorch, Tensorflow, NumPy, Pandas, SciPy, scikit-learn, Matplotlib, Seaborn

**Software/Tools:** Git, Jupyter, Linux (familiar), LaTeX, Markdown

## Key Courses

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**Physics** - Advanced Condensed Matter, Advanced Statistical Mechanics, Semiconductor Physics, Graduate Non-Equilibrium physics, Graduate Quantum Field Theory, Advanced Quantum Mechanics, Nonlinear Dynamics.

**Math** - Complex Analysis, Calculus, Group Theory, Partial Differential Equations, Numerical Analysis.

**Programming & Miscellaneous** - Machine learning, Programming, Data Analysis

## Scientific Outreach

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### **Manager, Maths and Physics Club, IIT Bombay**

Apr 2019 - Apr 2020

- Led a team of 5 sophomores to foster enthusiasm in the pure sciences, tending to a community of 400 - 500 on campus with an online presence of over 9000.
- Organized a trip to Atomic Physics and Quantum Optics Lab at IISER Pune. Lab hosts presented experiments using ultracold atoms for quantum information processing, atom interferometry, quantum chaos, etc.
- Oversaw a fivefold increase in participation in PhysX GC - an experimental physics cum engineering themed event requiring participants to build the longest-running Rube Goldberg machine with maximum complexity.