

Arghya Chattopadhyay

POSTDOCTORAL FELLOW AT UPRM AND JUNIOR INVESTIGATOR AT IAIFI
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Research identity

I am a researcher working at the interface of theoretical physics and AI-driven experimental particle physics. By integrating machine-learning tools into both my formal studies (e.g. symmetry-aware networks for matrix/SYK models and holographic systems) and hands-on work with Large hadron Collider open data, I am researching to bridge deep theory with real-time data applications.

Theoretical & Mathematical Physics: My research spans from $0D$ matrix models and $1D$ matrix quantum mechanics (mapping it to $2D$ Yang-Mills theory) through $2D$ Jackiw-Teitelboim gravity, CFTs and their integrable deformations, up to $3-4D$ higher-spin gravities and results in (non)-relativistic fluid/gravity duality for higher dimensions. At the $10D$ end, I study Calabi-Yau compactification, T-duality and Freudenthal duality in supergravity black holes, with side-projects in p-adic holography and other avenues of mathematical physics.

Keywords: Matrix Models | JT gravity | Complexity | Higher spin gravity | Holography | Freudenthal Duality | p -Adic Analysis

Experimental & AI-driven Applications: Alongside my theoretical endeavor, I'm developing machine-learning tools for jet physics and real-time data-quality monitoring for particle accelerators. My work on physics/symmetry-informed neural architectures further unites my theoretical insights with phenomenological and detector-level innovations.

Keywords: Machine learning | Physics Inspired Neural Network | Jet physics | Data Quality Monitoring for accelerator physics

Education

Indian Institute of Science Education and Research Bhopal

Bhopal, MP, India

PhD in Theoretical Physics

2014-2019

- **Advisor:** Prof. Suvankar Dutta
- **Thesis Title:** Emergent Phase Space Description of Unitary Matrix Models and its Applications

Visva-Bharati

Shantiniketan, WB, India

MSc in Physics

2012 - 2014

- **Special paper:** Particle Physics
- **Thesis Supervisor:** Prof. Biplab Raychaudhuri
- **Masters Thesis Title:** Conventionality of Simultaneity and Relativistic Transformations

Visva-Bharati

Shantiniketan, WB, India

BSc (Honours) in Physics

2009 - 2012

- Placed in first class with distinction

Postdoctoral positions

University of Puerto Rico at Mayagüez and IAIFI

Mayagüez, Puerto Rico

Postdoctoral fellow at UPRM and Junior investigator at IAIFI, US

Nov 2024 - Present

- **Project title:** PARTNER: Innovating AI for efficient and insightful data transformation (with MIT)
- **Funding Source:** NSF Award Number:2334265 (1/Sep/2023-31/Aug/2027)

Université de Mons

Mons, Belgium

Connect With(Come to) Wallonia Postdoctoral Fellow

Oct 2022 - Oct 2024

- **Project title:** Topological toolkit and complexity in higher spin gravity (ToTCHty)
- **Funding Source:** European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska Curie grant agreement number 101034383

University of the Witwatersrand

Johannesburg, South Africa

Postdoctoral Fellow

Jun 2020 - Oct 2022

- **Funding Source:** South African Research Chairs Initiative of the National Research Foundation grant number 78554 and Simons Foundation Grant Award ID 509116

Industry Experience

Koehn AI GmbH

AI consultant

Berlin, Germany

Nov 2024

- **Work Profile:** Worked as a developer/consultant on ongoing projects undertaken by Koehn AI.

Publications

BOOK CHAPTER

Hitchhikers guide to AI, Machine Learning and Career Oppurtunities

Chattopadhyay Arghya

Book: *Career Guidance : Choices Before You* (2024). ISBN:9788196669386, 2024

PEER REVIEWED

Freudenthal duality in conformal field theory

Arghya Chattopadhyay, Taniya Mandal, Alessio Marrani

JHEP 11 (2024) p. 057. 2024

Krylov complexity of deformed conformal field theories

Arghya Chattopadhyay, Vinay Malvimat, Arpita Mitra

JHEP 08 (2024) p. 053. 2024

Weyl formula and thermodynamics of geometric flow

Parikshit Dutta, Arghya Chattopadhyay

Phys. Rev. D 109.10 (2024) p. 105010. 2024

Generalized Freudenthal duality for rotating extremal black holes

Arghya Chattopadhyay, Taniya Mandal, Alessio Marrani

JHEP 03 (2024) p. 170. 2024

Spread complexity as classical dilaton solutions

Arghya Chattopadhyay, Arpita Mitra, Hendrik J. R. Zyl

Phys. Rev. D 108 (2 July 2023) p. 025013. American Physical Society, 2023

Near-extremal Freudenthal duality

Arghya Chattopadhyay, Taniya Mandal, Alessio Marrani

JHEP 08 (2023) p. 014. 2023

Flow of shear response functions in hyperscaling violating Lifshitz theories

Arghya Chattopadhyay, Nihal M, Debangshu Mukherjee

Eur. Phys. J. C 83.8 (2023) p. 771. 2023

Freudenthal duality of near-extremal black holes and Jackiw-Teitelboim gravity

Arghya Chattopadhyay, Taniya Mandal

Phys. Rev. D 105.4 (2022) p. 046014. 2022

From 2d droplets to 2d Yang-Mills

Arghya Chattopadhyay, Suvankar Dutta, Debangshu Mukherjee, Neetu

Nucl. Phys. B 974 (2022) p. 115648. 2022

Quantum mechanics of Plancherel growth

Arghya Chattopadhyay, Suvankar Dutta, Debangshu Mukherjee, Neetu

Nucl. Phys. B 966 (2021) p. 115368. 2021

Chern-Simons Theory on Seifert Manifold and Matrix Model

Arghya Chattopadhyay, Dutta Suvankar, Neetu

Phys. Rev. D 100.12 (2019) p. 126009. 2019

Matrix Model for Riemann Zeta via its Local Factors

Arghya Chattopadhyay, Parikshit Dutta, Suvankar Dutta, Debashis Ghoshal

Nucl. Phys. B 954 (2020) p. 114996. 2020

From Phase Space to Integrable Representations and Level-Rank Duality

Arghya Chattopadhyay, Parikshit Dutta, Suvankar Dutta

JHEP 05 (2018) p. 117. 2018

Emergent Phase Space Description of Unitary Matrix Model

Arghya Chattopadhyay, Parikshit Dutta, Suvankar Dutta

JHEP 11 (2017) p. 186. 2017

Hierarchy of the third-order anomalous Hall effect: from clean to disorder regime

Chanchal K. Barman, Arghya Chattopadhyay, Surajit Sarkar, Jian-Xin Zhu, Snehasish Nandy
arXiv e-prints, arXiv:2409.07993[cond-mat.mes-hall] (Sept. 2024). 2024

Reframing classical mechanics: An AKSZ sigma model perspective

Thomas Basile, Nicolas Boulanger, Arghya Chattopadhyay
arXiv e-prints, arXiv:2504.18826 (Apr. 2025) arXiv:2504.18826. 2025

Talks and lectures

SELECTED TALKS

Spread complexity as classical dilaton solutions

- Bel day mini workshop 2023, KU Leuven, Belgium

Probing Freudenthal Duality through JT gravity

- IISER Mohali, India

Quantum Mechanics of Plancherel Growth

- Chennai String Meeting 2019, IMSc, India

Chern-Simons Theory on Seifert Manifold and Matrix Model

- Indian String Meeting 2018, IISER Thiruvananthapuram, India
- Visitor talks, ICTP, Italy
- Visitor talks, IMSc, India

Level-Rank Duality and Constraint on Large N representations for Chern-Simons Theory on $S^2 \times S^1$

- National String Meeting 2017, NISER Bhubaneswar, India
- Visitor talks, Nagoya University, Japan

From Phase Space to Integrable Representations and Level-Rank Duality

- Visitor talks, IPMU, Japan

Consequences of Integrable Representations on Chern-Simons Theory

- Visitor talks, ICTS, India
- Visitor talks, IMSc, India

LECTURE SERIES

Hitchhiker's guide for Matrix Models

- **Number of Lectures:** 3
- **Organised through:** Student Talks on Trending Topics in Theory 2019

How (and why) to train your machine

- **Number of Lectures:** 2
- **Organised through:** Low energy talks in high energy physics 2022

Online presence

How (and why) to train your machine

- **Youtube Channel:** LETHEP Seminar
- **Hyperlinks:** youtube.com/lect1, youtube.com/lect2

Probing Freudenthal Duality through JT gravity

- **Youtube Channel:** HEP Journal Club, IISER Mohali
- **Hyperlink:** youtube.com/iisermohali

In person workshops and conferences

Emergent Geometries from Strings and Quantum Fields

Florence, Italy, July 2- 16, 2023

SYK models: from strongly correlated systems to quantum gravity

Brussels, Belgium, June 27- 28, 2023

Chennai String Meeting

Chennai, India, November 23-24, 2019

Spring School on Superstring Theory and Related Topics

Trieste, Italy, March 28-April 5, 2019

Third Mandelstam Theoretical Physics School and workshop

Durban, South Africa, January 9 - 19, 2019

Indian String Meeting

IISER Trivandrum, India, December 16 - 21, 2018

Supersymmetric Localization and Exact Results

IHES, France, July 16 - July 27, 2018

Strings 2018

OIST, Japan, June 25 - 29, 2018

Nonperturbative and Numerical Approaches to Quantum Gravity, String Theory and Holography

ICTS, Bangalore, India, January 27 - February 3, 2018

Kavli Asian Winter School (KAWS) on Strings, Particles and Cosmology

ICTS, Bangalore, India, January 8 - 18, 2018

National String Meeting

NISER Bhubaneswar, India, December 5 - 10, 2017

School and Workshop on Modular Forms and Black Holes

NISER Bhubaneswar, India, January 5 - 14, 2017

Indian String Meeting

IISER Pune, India, December 15 - 21, 2016

National String Meeting

IISER Mohali, India, December 6 - 11, 2015

SERC Main School in Theoretical High Energy Physics

BITS-Pilani, Pilani, India, November 16 - December 5, 2015

SERC Preparatory School in Theoretical High Energy Physics

IISER Bhopal, India, June 29 - July 25, 2015

Teaching experience

PROJECT SUPERVISION

Membrane at the Horizon

- **Course:** Master's Internship Project from 1st February to 1st March 2024
- **Institute:** Université de Mons
- With Loris Cavenaile

AS LECTURER OR TUTOR

SERC Preparatory School on Theoretical High Energy Physics

- **Tutor for:** General Relativity
- 28th October - 9th November at Tezpur, Assam, India

Student Talks on Trending Topics in Theory

- **Lecturer for:** Matrix models
- 17th - 25th July, 2019 at Bhopal, MP, India

TEACHING ASSISTANTSHIP

Classical Mechanics 1

- **Instructor:** Prof. Sudhendu Rai Chaudhary & Dr. Ambar Jain
- **Sessions:** Aug - Dec 2014 & Aug - Dec 2015 at IISER Bhopal

General Laboratory

- **Instructor:** Prof. Sudhendu Rai Chaudhary
- **Sessions:** Jan - Jul 2015 & Jan - Jul 2016 at IISER Bhopal

Condensed Matter Physics

- **Instructor:** Prof. Suvankar Dutta
- **Sessions:** Aug - Dec 2016 & Aug - Dec 2017 at IISER Bhopal

Statistical Mechanics 1

- **Instructor:** Prof. Subhash Chaturbedi
- **Session:** Jan - Jul 2017 at IISER Bhopal

Quantum Physics

- **Instructor:** Dr. Bhargava Ram Niraghatam
- **Session:** Jan - Jul 2018 at IISER Bhopal

Quantum Mechanics 1

- **Instructor:** Prof. Suvankar Dutta
- **Session:** Aug - Dec 2018 at IISER Bhopal

Computer skills

Programming Language C | C++ | Fortran | Python | Haskell | Machine Language

Frameworks & Libraries Scikit-learn | PyTorch | Tensorflow

Scripting Language Bash Shell Script | \LaTeX | HTML | CGI programming

Outreach activity

Career Counselling and Training programme 2022-24

- 9th March 2022, 11th February 2023, 11th January 2024
- **Organiser:** Asutosh College, Kolkata, WB, India
- **Role:** Resource person
- **Talk title:** Guide to machine learning and getting a career out of it

Extra academic interests

Music Writing, composing and recording music and playing string instruments like guitar, ukulele, violin, dotara.

Linux Since 2010, I have been using Linux. I recently switched to Mac OS, which feels like linux barring the open-source freedom.

Cooking From the time of pandemic I have become fond of trying newer recipes in kitchen.