Arghya Chattopadhyay

Postdoctoral fellow at UPRM and Junior investigator at IAIFI

Scientific Collaborator at Université de Mons

Department of Physics, University of Puerto Rico at Mayagüez

Mayagüez, Puerto Rico

(+1) 9392991459 | arghya.chattopadhyay@gmail.com | A.Chattopadhyay.1 | chattopadhyayA.github.io | chattopadhyayA | the-chattopadhyay

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 (mathematical physics, gravity 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, $3D$ Chern-simons theory and level-rank duality, up to $4D$ 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 and condensed matter 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*

- **Marks Obtained:** 76.4%
- **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*

- **Marks Obtained:** 73.2%
- 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:** EXPAND AI: Innovating AI for efficient and insightful data transformation (with MIT)
- **Funding Source:** US 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

The Institute of Mathematical Sciences *Chennai, TN, India*

Postdoctoral Fellow *May 2019 - May 2020*

- **Funding Source:** The Institute of Mathematical Sciences

Professional Collaboration

Université de Mons *Mons, Belgium*

Collaborateur scientifique volontaire *Academic year 2025-26*

- **Designation status:** Volunteer Scientific Collaborator with the department of Physique de l'Univers, Champs et Gravitation at the University of Mons.

Industry Experience

Koehn AI GmbH *Berlin, Germany*

AI consultant *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

Jet Image Tagging Using Deep Learning: An Ensemble Model
Juvenal Bassa, Vidya Manian, Sudhir Malik, Arghya Chattopadhyay
Accepted for publication in JINST on 17 August (2025). 2025

Reframing Classical Mechanics: An AKSZ Sigma Model Perspective
Thomas Basile, Nicolas Boulanger, Arghya Chattopadhyay
Universe 11.6 (2025) p. 196. 2025

Role of disorder in the third-order anomalous Hall effect in time-reversal symmetric systems
Chanchal K. Barman, Arghya Chattopadhyay, Surajit Sarkar, Jian-Xin Zhu, and Snehasish Nandy
Phys. Rev. B (May 2025) pp. –. American Physical Society, 2025

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, None 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

Manuscripts in progress

Attractor mechanism: The Routhian way
Arghya Chattopadhyay, Alessio Marrani, Sourav Roychowdhury
Manuscript under progress (2025). 2025

Constrained diffusion for generating jets
Shuchin Aeron, Arghya Chattopadhyay, Sudhir Malik, Jesse Thaler
Manuscript under progress (2025). 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 Dualty
- Visitor talks, IPMU, Japan

Consequesnces 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

Computational and Data Science Training for High Energy Physics
Princeton, USA, July 21- 25, 2025

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 Physcis 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 1^{st} February to 1^{st} March 2024
- **Institute:** Université de Mons
- With Loris Cavenaile

As Lecturer or tutor

US CMS Programme for Undergraduate Research SUmmer Experience (PURSUE) 2025
- **Tutor for:** Machine Learning
- 27^{th} May - 6^{th} June, 2025 at Fermi Lab, Illinois, USA

SERC Preparatory School on Theoretical High Energy Physics
- **Tutor for:** General Relativity
- 28^{th} October - 9^{th} November, 2019 at Tezpur, Assam, India

Student Talks on Trending Topics in Theory
- **Lecturer for:** Matrix models
- 17^{th} - 25^{th} July, 2019 at Bhopal, MP, India

Teaching Assistantship

Classical Mechanics 1
- **Instrustor:** Prof. Sudhendu Rai Chaudhary & Dr. Ambar Jain
- **Sessions:** Aug - Dec 2014 & Aug - Dec 2015 at IISER Bhopal

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

Condensed Matter Physics
- **Instrustor:** Prof. Suvankar Dutta
- **Sessions:** Aug - Dec 2016 & Aug - Dec 2017 at IISER Bhopal

Statistical Mechanics 1
- **Instrustor:** Prof. Subhash Chaturbedi
- **Session:** Jan - Jul 2017 at IISER Bhopal

Quantum Physics
- **Instrustor:** Dr. Bhargava Ram Niraghatam
- **Session:** Jan - Jul 2018 at IISER Bhopal

Quantum Mechanics 1
- **Instrustor:** 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

Machine learning workshop for CROEM 2025
- 19^{th} May 2025
- **Organiser:** CROEM School, Mayaguez, Puerto Rico, USA
- **Role:** Lecturer

Career Counselling and Training programme 2022-24

- 9th March 2022, 11th February 2023, 11th January 2024, 28th February 2025
- **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.