

# Arghya Chattopadhyay

POSTDOCTORAL FELLOW AT UPRM AND JUNIOR INVESTIGATOR AT IAIFI

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## Research identity

My research exploration starts from 0 dimensions with matrix models and continues to 1 dimensional matrix quantum mechanics as well as SYK models. In 2 dimensions I am investigating Jackiew-Itelboim gravity theory as well as two dimensional conformal field theory and their integrable deformations. I have also recently started working on 3 and 4 dimensional higher spin gravity theories. My work with fluid/gravity duality can be thought of as my contribution towards 5 dimensional theories. On the opposite spectrum of 10 dimensional theories, I am interested in both the mathematical and phenomenological effects of Calabi-Yau compactifications and T-duality. I am actively working on dualities enjoyed by blackholes in supergravity especially the mathematical aspects of Freudenthal duality. Additionally I am trying to understand different ideas on p-adic holography and interesting problems in physics inspired mathematics. Coming to the Phenomenological aspects, I am currently working with machine learning approach to innovate effective methods that can be utilised for the CMS experiment at CERN. My research interests involving symmetries also continues as a side-hustle to understand and implement symmetries in neural networks.

**Keywords:** Matrix Models | JT gravity | Deformed CFT | Complexity | Higher spin gravity | Holography  
Fluid/Gravity | Freudenthal Duality | p-Adic Analysis | Machine learning

## 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

### The Institute of Mathematical Sciences

Chennai, TN, India

Postdoctoral Fellow

May 2019 - May 2020

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

## Publications

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### 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

### ARXIV SUBMISSIONS / IN COMMUNICATION

#### **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

## Talks and lectures

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### 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**

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### **How (and why) to train your machine**

- **Youtube Channel:** LETHEP Seminar
- **Hyperlinks:** [youtube.com/lect1](https://youtube.com/lect1), [youtube.com/lect2](https://youtube.com/lect2)

### **Probing Freudenthal Duality through JT gravity**

- **Youtube Channel:** HEP Journal Club, IISER Mohali
- **Hyperlink:** [youtube.com/iisermohali](https://youtube.com/iisermohali)

## **In person workshops and conferences**

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### **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

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### **PROJECT SUPERVISION**

#### **Membrane at the Horizon**

- **Course:** Master's Internship Project from 1<sup>st</sup> February to 1<sup>st</sup> 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
- 28<sup>th</sup> October - 9<sup>th</sup> November at Tezpur, Assam, India

#### **Student Talks on Trending Topics in Theory**

- **Lecturer for:** Matrix models
- 17<sup>th</sup> - 25<sup>th</sup> 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 Chaturvedi
- **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

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

**Frameworks & Libraries** Scikit-learn | PyTorch | Tensorflow

**Scripting Language** Bash Shell Script |  $\text{\LaTeX}$  | HTML | CGI programming

## Outreach activity

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### Career Counselling and Training programme 2022-24

- 9<sup>th</sup> March 2022, 11<sup>th</sup> February 2023, 11<sup>th</sup> 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

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**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.