Rishi **Raj**

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Education

Indian Institute of Technology (IIT) Madras — *Chennai, India*

B.S. (Hons) and M.S. in Physics with a Math minor — *Aug 2018 - Aug 2023*

- Received the 'Electronics for you' institute award for securing the highest CGPA during an academic year.

Research Experience

Deep Learning Gravity — *Chennai, India*

String Theory Group, IITM[1] in collaboration with Vishnu Jejjala, U. Witwatersrand — *Oct 2022 - Present*

- Working on learning basic features of non-equilibrium processes on asymptotically AdS geometries such as the areas and positions of the event and apparant horizons starting from parameters describing numerical solutions of Einstein's equations.

Simulating Black Holes in Matrix models — *Chennai, India*

String Theory Group, IITM in collaboration with Vishnu Jejjala, U. Witwatersrand — *Aug 2020 - Present*

- Developing efficient numerical techniques to perform both classical and quantum mechanical simulations of the M-theory matrix model for relatively large matrix sizes.
- Understanding thermalization features and entanglement using the massive simulation data.

Counting Multi-Centered Black Holes in $\mathcal{N} = 2$ SUGRA — *Jussieu, Paris*

Internship supervised by Boris Pioline at LPTHE, Sorbonne University — *Summer 2022*

- Implemented various algorithms to compute BPS indices and jumps thereof in the complexified Kähler moduli space of Calabi-Yau threefolds in $\mathcal{N} = 2$ supergravity in four dimensions.
- Two approches for computing the indices were shown to be equivalent in certain cases and discrepencies were identified in a particular class of charges.
- An interesting connection between the phase space of multi-centered solutions and corresponding attractor flow trees was identified.

Magnetically Coupled Pendula — *Mumbai, India*

NIUS Internship mentored by Praveen Pathak, HBCSE — *Nov 2019 - Jan 2020*

- Created an experimental setup of pendula with cylindrical bar magnets attached to their ends and confined to move in a plane.
- Wrote down a simple theoretical model for the system and compared with the data taken experimentally, systematically taking care of biases and errors. Found a reasonable and expected degree of experimental agreement.

Semiholographic Networks, Black Holes and Information Processing — *Chennai, India*

Supervised by Ayan Mukhopadhyay, IIT Madras — *Jul 2019 - Nov 2020*

- Developed a simple set of toy networks of scalar fields coupled with perfect fluids using the Semiholographic approach developed by the supervisor and collegues.
- Analyzed the response of the networks to perturbations and quenches.

Electric-Magnetic type dualities in Field theories — *Chennai, India*

Reading project supervised by Ayan Mukhopadhyay, IIT Madras — *Summer 2019*

- Learnt about the Montonen-Olive and similar duality conjectures, the Witten effect in the context of $\mathcal{N} = 4$ SYM.

Obtaining Hydrodynamics from Equilibrium Partition Functions — *Chennai, India*

Reading project supervised by Ayan Mukhopadhyay, IIT Madras — *Spring 2019*

- Learnt about modern relativistic hydrodynamics and how transport coefficients are significantly constrained by consistency requirements with thermal parition functions in QFTs in stationary background spacetimes.

On the IR triangle — *Chennai, India*

Reading project supervised by Ayan Mukhopadhyay, IIT Madras — *Nov 2018 - Dec 2018*

- Developed a good understanding of memory effect, soft theorems and asymptotic symmetries and the relationship between them in the infrared physics of quantum field theories.

[1] Ayan Mukhopadhyay, Tanay Kibe, Sukrut Mondkar

Relevant Coursework

Advanced Physics

Spring 2022	**Quantum Field Theory II**
Spring 2021	**Quantum Field Theory**
Spring 2021	**Advanced General Relativity**
Spring 2022	**Advanced topics in Quantum Computation and Quantum Information**
Fall 2022	**Advanced Statistical Physics**
Fall 2020	**Mathematical Physics II**
Spring 2021	**Numerical Methods and Programming Lab**

Advanced Mathematics

Fall 2021	**Algebra I**
Fall 2021	**Real Analysis**
Spring 2021	**Representation Theory**
Spring 2022	**Differential Geometry**
Fall 2022	**Differential Topology**

Basic

Spring 2019	**Differential Equations**
Fall 2019	**Probability, Statistics and Stochastic Processes**
Fall 2019	**Mathematics on Computer**
Fall 2020	**Classical Mechanics**
Fall 2020	**Quantum Mechanics I**
Spring 2021	**Quantum Mechanics II**
Spring 2020	**Statistical Mechanics**

Audited / Self-Study

Fall 2022	**Supersymmetry and Supergravity**
Fall 2022	**String Theory**
Spring 2022	**Conformal Field Theory**
Spring 2021	**Mathematics of Quantum Mechanics**
Spring 2021	**Functional Analysis**
Fall 2020	**Geometrical Anatomy of Theoretical Physics**
Spring 2019	**Dynamical Systems and Chaos**

Fellowships and Achievements

KVPY Fellow — *Bangalore, India*

Department of Science and Technology (DST), Govt. of India — *Aug 2018 - Present*

- Awarded for ranking 332 all India in a competitive national exam.
- Receive funding for the entire duration of the BS-MS program at IIT Madras.

National Initiative on Undergraduate Sciences (NIUS) Fellow in Physics — *Mumbai, India*

Homi Bhabha Centre for Science Education, TIFR — *May 2019 - Jan 2020*

- Selected among India's top research undergraduates for a fast-paced science camp leading up to research projects.
- Received funding and mentorship to conduct original research in computational/experimental physics

JEE (Advanced) — *Delhi, India*

Conducted by IIT Kanpur in 2018 — *May 2018*

- Ranked 1398 nationally (among over 100K partipants) in an intense national entrance exam for top STEM undergraduate programs in India.

JEE (Main) — *Delhi, India*

Conducted by CBSE (Central Board of Secondary Education) — *April 2018*

- Ranked 376 nationally (among over 1M partipants) in a competitive national exam that leads up to JEE (advanced)

Work Experience

Teaching Assistant — *Chennai, India*

PH5060 (Physics Lab 1) — *Jul 2022 - Nov 2022*

- Taught and helped students work through various computational problems such as understanding the phase portrait of chaotic dynamical systems, studying probability distributions and monte carlo simulations.
- Took viva interviews, graded the reports and prepared the final exam.

Extracurricular Activity

Music Club IITM

Chennai, India

Coordinaor

Jul - Nov 2019

- Worked for the student-run music club of the institute in organizing various musical events in the Fall 2019 semester and for the annual social and cultural festival of IITM, Saarang.
- Playedthe bass guitar for a live performance by the then coordinators on a freshmen event. Picked up strong teamwork and collaboration traits.

Boltzmann Sessions, Horizon Club IITM

Chennai, India

Lecturer

September 2019

- Delivered a series of four lectures titled 'Relativity from Symmetries' to beginning physics enthusiasts about the modern way of looking at physics in terms of symmetry principles with a fresher on group theory, focusing particularly on special relativity, the Lorentz and Poincare group, the corresponding action principle and physical implications.

Microsoft Codefundoo++

Chennai, India

Competitive Event

Oct - Nov 2018

- Developed a startup idea for the Codefundo++ competition on the theme of tackling natural disasters. Along with Ananya Shetty in a team of two, we came up with BluFarm: an application to help farmers in the time of droughts.
- Cleared the last phase of the competition and won the participation prize.

Skills

Mathematics	Linear Algebra · Real and Complex Analysis · Several Complex Variables · Algebra and Representation Theory · Dynamical Systems and Chaos · Algebraic Geometry and Categorical language
Scientific Computation	Mathematica · Boost C++ · GNU Scientific Library (GSL) · Python · Cadabra
Typesetting	LaTeX · HTML5 / CSS3 · Google Office Suite
Programming	Python · Javascript/Typescript · C / C++
Misc	Git / GitHub · Statistical Inference · Research Methodology · Discrete Data Structures and Algorithms · Machine Learning with TensorFlow
Languages	English · Hindi · French (beginner)
Soft Skills	Team collaboration · Communication · Critical observation and problem solving · Conflict resolution and Negotiation · Leadership · Time management / Scheduling