Rishi **Raj**

Graduate Researcher · Theoretical Physics

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Education

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

BS (Hons) and MS in Physics with a minor in Mathematics — *Aug 2018 - Aug 2023*

- Received the 'Electronics For You' prize for securing the highest CGPA during an academic year.

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

Joint Entrance Exam (JEE) — *Delhi, India*

Conducted by IIT Kanpur (Advanced) and CBSE (Main) in 2018 — *May 2018*

- Ranked 1398 nationally (among over 100K shortlisted from JEE Main) in JEE Advanced and 332 in JEE Main, entrance exams to top STEM undergraduate programs in India.

Research Experience

High Energy Theory

Deep Learning Gravity — *Chennai, India*

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

- Developing high accuracy neural networks to learn basic features of non-equilibrium processes on asymptotically AdS geometries such as the areas and positions of the event and apparent horizons starting from parameters describing numerical solutions of Einstein's equations.

Black Hole microstates in Matrix models — *Chennai, India*

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

- Developing efficient numerical techniques to perform 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.

Wall Crossing Phenomena 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 approaches for computing the indices were shown to be equivalent in certain cases, and discrepancies were identified in a particular class of charges.
- Identified an interesting connection between the phase space of multi-centered solutions and corresponding attractor flow trees.

Semiholographic Networks — *Chennai, India*

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

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

[1] Ayan Mukhopadhyay, Tanay Kibe, Sukrut Mondkar

Independent Research

Chennai, India

Reading projects 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.
- Learnt about modern relativistic hydrodynamics and how transport coefficients are significantly constrained by consistency requirements with thermal partition functions in QFTs in stationary background spacetimes.
- Developed a good understanding of memory effect, soft theorems, and asymptotic symmetries and their relationship in the infrared physics of quantum field theories.

Other

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 it with the data taken experimentally, systematically taking care of biases and errors. Found a reasonable and expected degree of experimental agreement.

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**

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**

Work Experience and Positions of Responsibility

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.

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.

Horizon Club IITM

Chennai, India

Organizer — *September 2019*

- Organized and delivered a series of four lectures titled 'Relativity from symmetries' to beginning physics enthusiasts.

Skills

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 · Discrete Data Structures and Algorithms · Machine Learning with TensorFlow