

## Ranveer Kumar Singh

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### RESEARCH INTERESTS

- Mathematical physics : Applications of number theory in string theory
- Mathematics : Automorphic forms, number theory.
- Physics : Quantum field theory, string theory.

### EDUCATION

- **Indian Institute of Science Education and Research Bhopal**,  
Degree - BS-MS (Integrated Bachelor of Science and Master of Science),  
Major - Mathematics, Minor - Physics  
Aug. 2015 - April, 2020  
CPI : 9.12/10.00  
Major CPI : 9.545/10.00
- **Nancy Convent Senior Secondary School**, Nainital, Uttarakhand  
Class XII (Senior Secondary Examination), CBSE  
July 2015 Aggregate 95.00%
- **Nancy Convent Senior Secondary School**, Nainital, Uttarakhand  
Class X (Secondary Examination), CBSE  
July 2013 CGPA: 10/10

### EMPLOYMENT

- Aug 2020 - Present  
Project JRF (Junior Research Fellow) - Mock Modularity in CHL Models.  
Supervisor - Dr. Nabamita Banerjee.  
The aim of the project is to understand the appearance of mock (Jacobi) modular forms in string theory as discovered by Dabholkar-Murthy-Zagier in [arXiv:1208.4074](https://arxiv.org/abs/1208.4074) and generalise their results to more general class of string theories - CHL models for example.
- June 2018 - Present  
Chegg India - Advanced Mathematics Subject Expert.
- Feb. 2018 - Present  
Transtutors - Advanced Mathematics and Physics Subject Expert.

### PUBLICATIONS AND PREPRINTS

1. (With Karam Deo Shankhadhar) An Analogue of Weil's Converse Theorem for Harmonic Maass Forms, [In Preparation].
2. (With Ajit Bhand) Mock modular forms associated to Cohen class number, [In Preparation].
3. (With Ajit Bhand) Zagier's weight  $3/2$  mock modular form, Preprint.
4. Mock Eisenstein Series, Preprint: [ArXiv:2011.07796](https://arxiv.org/abs/2011.07796).
5. Isomorphism of Skew-Holomorphic Harmonic Maass-Jacobi Forms and Certain Weak Harmonic Maass Forms, Preprint: [ArXiv:2011.07540](https://arxiv.org/abs/2011.07540).
6. (With Nabamita Banerjee, Ajit Bhand, Suvankar Dutta and Ashoke Sen) Bhargava's Cube and Black Hole Charges, Preprint : [ArXiv:2006.02494](https://arxiv.org/abs/2006.02494) (2020), To appear in Research in the Mathematical Sciences.
7. (With Bishvanwasha Panda, Bikash K. Behera, Prasanta K. Panigrahi) Demonstration of a general fault-tolerant quantum error detection code for  $(2n+1)$ -qubit entangled state on IBM 16-qubit quantum computer, Preprint: [ArXiv:1807.02883](https://arxiv.org/abs/1807.02883).
8. Getting Started With Quantum Computation: Experiencing The Quantum Experience, Ranveer Kumar Singh, Prathamesh Ratnaparkhi, Bikash K. Behera and Prasanta K. Panigrahi, *Student Journal of Physics*, Vol. 7, No. 4, Oct-Dec. 2018, <https://www.iopb.res.in/~sjp/74final/3.pdf>

9. On the classical dynamics of charged particle in special class of spatially non-uniform magnetic field, Singh, R.K. *Indian J Phys* (2019) **93**: 503. <https://doi.org/10.1007/s12648-018-1316-z>

## PROJECTS AND INTERNSHIPS

- May 2019 - April 2020  
MS Thesis Research - Applications of number theory in black hole physics.  
Supervisor - [Dr. Ajit Bhand](#).  
The aim of the project was to study two recent papers . For the first paper, the goal was to study modular forms, Jacobi forms, Siegel modular forms, mock modular forms and understand the relation of mock modular forms to the statistical entropy of black hole in string theory ([arXiv:1208.4074](#)). In another project, I read a paper which relates the U-duality classes of black holes in string theory to class groups associated with binary quadratic forms ([arXiv:1807.00797](#)). We also attempted to answer the questions posed in this paper. This project was done in collaboration with [Dr. Nabamita Banerjee](#) and [Dr. Suvankar Dutta](#).
- Jan. 2019 - March 2019  
Introduction to Modular forms and Sphere Packing Problem.  
Supervisor - Dr. Ajit Bhand  
In this project, I studied the basics of modular forms. It included modular forms on  $SL_2(\mathbf{Z})$  and its congruence subgroups, Eisenstein series, modular functions, Ramanujan cusp form, Hecke theory for modular forms of level 1. Finally, we studied the sphere packing problem and the recent breakthrough by Maryna Viazovska for packings in dimension 8 as an application.
- 21 May 2018 - 17 July 2018  
Indian Academy of Sciences Fellow - Demonstration of a general fault-tolerant quantum error detection code for  $(2n+1)$ -qubit entangled state on IBM 16-qubit quantum computer. Supervisor - [Prof. P.K. Panigrahi](#)  
In this project, we studied quantum error correction and several codes for fault-tolerant error detection and correction. We also proposed a code for fault tolerant quantum error detection for entangled states and demonstrated it on IBM quantum computer. We also studied coupled quantum systems and Rabi-oscillations. ([Link](#) to project report).
- 26 Nov. 2017 - 16 Dec. 2017  
Reading Project - Rademacher's series representation of partition function.  
Supervisor - [Dr. Ajit Bhand](#)  
The aim of this project was to understand the proof of the the convergent infinite series formula for partition function obtained by Hans Rademacher. We first studied the basic concepts of generating functions, Möbius transformations, Farey fractions and Ford circles. The main proof was then studied using these ideas and basic complex analysis. Thereafter a few auxiliary results like the asymptotic formula first presented by Hardy and Ramanujan were studied.
- 15 May 2017 - 30 June 2017  
Summer Internship - Supersymmetric Quantum mechanics and Solitons.  
Supervisor - [Prof. C.N. Kumar](#)  
The aim of the project was to study non-linear integrable systems like KdV equation, sine Gordan equation, nonlinear Schrödinger equation etc. and analyse the properties of the soliton solutions. We also studied solitary wave behaviour of rogue waves and trapped Bose-Einstein condensate. The project also included study of isospectral partners of Hamiltonians and soliton wavefunctions arising in different Hamiltonians. The project ended with the study of negative index materials ([Link](#) to project report).
- 15 Oct 2016 - 20 Nov 2016  
Reading project - Quantum teleportation of an arbitrary two qubit state and its relation to multipartite entanglement.  
Supervisor - [Dr. Auditya Sharma](#), IISER Bhopal

In this project, I read a paper by Prof. Gustavo Rigolin which proposes a protocol to teleport an arbitrary two qubit entangled state and generalises it to n-qubit state ([Link](#) to paper). The paper also proposes a new measure of entanglement called “Entanglement of Teleportation”.

- 15 May 2016 - 30 June 2016  
Summer Internship - Quantum Foundation, Quantum Information and Quantum Computation.  
Supervisor - [Prof. Guru Prasad Kar](#), ISI Kolkata  
In this project, I studied EPR paradox and hidden variable theories, quantum teleportation, superdense coding, projective and POVM measurements, Krauss operators, measures of entanglement, quantum key distribution and other protocols in quantum cryptography. I also learned important concepts in quantum information theory like the Shannon entropy, Von Neumann entropy, the Holevo bounds etc.

## COURSES TAKEN

- Mathematics  
Calculus of One Variable, Linear Algebra, Multivariable Calculus, Probability and Statistics, Real Analysis I, Group Theory, Elementary Number Theory, Advanced Linear Algebra, Ordinary Differential Equations, Topology, Rings and Modules, Lie Groups and Lie Algebras, Fields and Galois Theory, Real Analysis II, Partial Differential Equations, Complex Analysis, Measure and Integration, Differential Geometry of Curves and Surfaces, Analytic Number Theory, Functional Analysis, Algebraic Topology, Introduction to Differentiable Manifolds and Lie Groups, Introduction to Modular Forms.
- Physics  
Mechanics, Electromagnetism, Modern Physics, Basic Electronics, Quantum Mechanics I, Classical Mechanics, Quantum Mechanics II, Statistical Mechanics, Quantum Field Theory I, Electrodynamics and Special Relativity, Decoherence and Open Quantum Systems, Quantum Field Theory II, General Theory of Relativity, Nuclear and Particle Physics.

## TEST SCORES

- General GRE - 320/340
- Physics GRE - 780/990.
- TOEFL - 105/120
- Council for Scientific and Industrial Research, National Eligibility Test (CSIR Net) - 96<sup>th</sup> rank in Mathematics, December 2018, Roll no : 402010.

## SEMINARS AND CONFERENCES ATTENDED

- 29 June 2020 - 3 July 2020  
Strings 2020, Public Talk by Prof. Shamit Kachru – The hidden symmetries of spacetime.
- 24 Oct. 2019  
The Gelfand-Kazhdan theorem for  $GL_2(F)$  - IISER Bhopal, India
- 9 Jan 2017 to 11 Jan 2017  
Nobel prize series via Ideathon contest - Ahmedabad, Gujrat, India
- 2 June 2017-15 June 2017  
Partial differential equation - IISER Bhopal, India
- 6 May 2018 - 12 May 2018  
Modern Physics and Ancient Indian Wisdom - NIAS Bangalore, India

## TALKS AND PRESENTATIONS

- Quantum teleportation of an arbitrary two qubit state and its relation to multipartite entanglement - 24<sup>th</sup> Oct. 2016, Physics club, IISER Bhopal ([Slides](#))
- Special to General Theory of Relativity, From Newton to Einstein - 28<sup>th</sup> Aug. 2017, Physics club, IISER Bhopal ([Slides](#))
- The proof of Lindeman-Weierstrass theorem - 11<sup>th</sup> Sept. 2018, IISER Bhopal.
- Introduction to Modular forms [Modular forms and string theory reading group] - 1<sup>st</sup> – 10<sup>th</sup> May 2019, IISER Bhopal
- Introduction to Bosonic String Theory - Aug. 2020 - Present (Biweekly talks), [String Theory Research Group], IISER Bhopal.

## REFERENCES

- Prof. Ashoke Sen  
Professor  
Department of Physics, Harish Chandra Research Institute  
Email - [sen@hri.res.in](mailto:sen@hri.res.in)  
Webpage - <http://www.hri.res.in/~sen/>
- Dr. Ajit Bhand  
Assistant Professor  
Department of Mathematics, IISER Bhopal  
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- Dr. Nabamita Banerjee  
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- Dr. Karam Deo Shankhadhar  
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