

We have art in order not to die of the truth. – Nietzsche

Personal Information

Nome e Cognome Himanshu Sahu
Gender Male
Date of Birth 22-07-2002
Address Department of Instrumental & Applied Physics, Indian Institute of Science, C.V. Raman Avenue, Bengaluru 560012, India
Nationality Indian

[Google Scholar](#) • [iNSPIRE-HEP](#) • [ORCiD](#) • [Linkedin](#) • [Github](#)

Experience

To be joined **Quantum Intern**, IBM Research Lab, Bangalore.
• Under IISc-IBM AI Horizon Network

Education

07/2021–Present **Masters in Physics**, Indian Institute of Science, Bangalore.
IISc stands distinguished as the top-ranked research institution in the nation, as per the Ministry of Education, Government of [India's research rankings](#).
• Three-year MS program with a dedicated year-long research focus • CGPA : 9.10/10 (max. typically ~ 9.4) • On track for Distinction in the Major
06/2018-06/2021 **Bachelor in Physics**, Banaras Hindu University, Varanasi.
BHU holds the 6th position among universities in the country, according to the Ministry of Education, Government of [India's research rankings](#).
• CGPA : 9.15/10 • Passed in First Division with Distinction

Master thesis

Title Quantum walk based simulations & algorithms
Supervisor Prof. CM Chandrashekar
Description To be decided

Research activity

Brief description As a researcher at the 'Quantum Optics and Quantum Information Lab', my work revolves around the exciting fields of quantum computation and quantum information. Within this broad area, my research focuses on simulating quantum phenomena in nature and exploring their potential applications. To achieve this, I primarily work with quantum walks, a powerful computational framework in quantum physics. Apart from these, my research has also focused on investigating the phenomenon of information scrambling and quantum chaos within complex many-body quantum systems.

Research Interests

Main interests Quantum optics, Quantum information, Quantum computation, Quantum simulation, Quantum error correction, Quantum algorithms, Quantum sensing, Quantum many-body physics, Open quantum systems, Quantum communication, Quantum chaos.

Research Experience

- 05/2022-05/2023 **Neutrino oscillations in a quantum walk framework**
PI: Prof. CM Chandrashekar (Dept. of Instrumentation & Applied Physics, Indian Institute of Sciences)
Summary: By viewing the position space of a quantum walk as an environment, I've developed a novel approach to simulate neutrino flavor change dynamics within an open quantum system framework. This reduces the resource required for simulating quantum walk which include position space.
- 05/2022-03/2023 **Krylov complexity in open systems**
PI: Dr. Aranya Bhattacharya (Centre for High Energy Physics, Indian Institute of Science)
Team/Collaborators: Pratik Nandy (Yukawa Institute for Theoretical Physics, Kyoto University), Pingal Pratyush Nath (Centre for High Energy Physics, Indian Institute of Science)
Summary: Our work extended the Krylov construction framework to dissipative open quantum systems coupled to a Markovian bath. This approach accommodates non-Hermitian effects due to the environment. Our investigation of the dissipative transverse-field Ising model and dissipative interacting XXZ chain reveals that initial Lanczos coefficients distinguish integrable and chaotic evolution during weak coupling. As dissipative effects intensify, higher Lanczos coefficients exhibit heightened fluctuations, culminating in similar late-time complexity saturation for both integrable and chaotic scenarios, casting doubt on the concept of late-time chaos.
- 06/2023-08/2023 **Quantum circuit complexity of quantum walk**
PI: Dr. Kallol Sen (ICTP-South American Institute of Fundamental Research) & Dr. Aranya Bhattacharya (Institute of Physics, Jagiellonian University)
Team/Collaborators: Dr. Ahmadullah Zahed (ICTP, Trieste)
Summary: We studied circuit complexity of quantum walk. Notably, we unveil that the Nielson complexity during unitary evolution oscillates, centering around an average circuit depth. Additionally, we reveal that the complexity of the step-wise evolution operator exhibits cumulative and linear growth in relation to the number of steps taken. This observation, from a quantum circuit perspective, implies a sequential application of (approximately) constant-depth circuits, contributing to the attainment of the final state. We explicitly constructed the quantum circuit, and verified the observation. This study contribute to our understanding of relation between quantum complexity and circuit complexity.
- 06/2023-01/2024 **Out-of-Time-Ordered Correlator's Growth Rate in a \mathcal{PT} -symmetric Chaotic System**
PI: Prof. Subroto Mukerjee (Department of Physics, Indian Institute of Science)
Team/Collaborators: Kshitij Vijay Sharma (Department of Physics, Indian Institute of Science)
Summary: In ongoing work, we studied OTOC as well as complex level-spacing ratio as a diagnose of quantum chaos for the \mathcal{PT} -symmetric quantum kicked rotor – a textbook driven chaotic system. The analysis based on complex level-spacing ratio shows that phase space consists of unbroken integrable and chaotic phases, and broken chaotic phase while broken integrable phase is absent. The OTOC shows exponential growth at early time in chaotic phase, as well as at late time in broken \mathcal{PT} -symmetric phase.
- 07/2023-10/2023 **Quantum search algorithm**
PI: Dr. Kallol Sen (ICTP-South American Institute of Fundamental Research)
Summary: Building upon the quantum search algorithms, we have extended their applicability to a diverse range of problems spanning multiple fields, such as real-time object tracking, network management, and routing. Our approach involves expanding the database by introducing an additional dimension, similar to error-correction codes, which provides supplementary information, including the category of the search data points. We have applied this method to develop an algorithm for tracking moving particles, but its potential reaches far beyond this specific problem.
- 08/2023-12/2023 **Krylov complexity in non-local systems**
PI: Dr. Aranya Bhattacharya (Institute of Physics, Jagiellonian University)
Team/Collaborators: Pingal Pratyush Nath (Centre for High Energy Physics, Indian Institute of Science)
Summary: Motivated by recent works in spin systems with nonlocal interactions, this study investigates operator growth using the Lanczos algorithm in various versions of the Ising model. We find that the non-locality results in a faster scrambling of the operator to all sites. The corresponding Krylov complexities still carry the distinguishability between integrable and chaotic theories in a suppressed way than the local Hamiltonian, which is a result of the faster scrambling for nonlocal Hamiltonian at early times. We investigate behavior of level statistics and spectral form factor as a probe of quantum chaos to study the integrability breaking due to non-local interactions.

- 11/2023-Present **Spready Complexity of Random Unitary Circuits**
Team/Collaborators: Dr. Aranya Bhattacharya (Institute of Physics, Jagiellonian University), Pingal Pratyush Nath (Centre for High Energy Physics, Indian Institute of Science)
Summary: In ongoing work, I devised the formulation for evaluating the spread complexity of random unitary circuits. Using this formulation, we studied the complexity in random-haar unitary circuits as well as monitored RUCs.
- 12/2023-Present **Information scrambling in Time Crystals**
Team/Collaborators: Fernando Iemini (Universidade Federal Fluminense), Pingal Pratyush Nath (Centre for High Energy Physics, Indian Institute of Science)
Summary: In ongoing work, We are studying information scrambling in Time crystals

Publications

Peer-reviewed journals

- [1] A. Bhattacharya, P.P. Nath & H. Sahu, Krylov complexity for non-local spin chains. *Phys. Rev. D* **109**, 066010 (2024)
[All authors contributed equally to this work.](#)
- [2] A. Bhattacharya, H. Sahu, A. Zahed, and K. Sen, Complexity for one-dimensional Discrete Time Quantum Walk Circuits. *Phys. Rev. A* **109**, 022223 (2024)
- [3] H. Sahu & K. Sen, Quantum-walk search in motion. *Scientific Reports* **14**, 2815 (2024)
- [4] H. Sahu & C.M. Chandrashekar, Open system approach to Neutrino oscillations in a quantum walk framework. *Quantum Information Processing* **23**, 7 (2024)
- [5] A. Bhattacharya, P. Nandy, P.P. Nath & H. Sahu, On Krylov complexity in open systems: an approach via bi-Lanczos algorithm. *Journal of High Energy Physics* **2023**, 66 (2023)
[All authors contributed equally to this work.](#)
- [6] A. Bhattacharya, P. Nandy, P.P. Nath & H. Sahu, H. Operator growth and Krylov construction in dissipative open quantum systems. *Journal of High Energy Physics* **2022**, 81 (2022)
[All authors contributed equally to this work.](#)

Pre-prints under review

- [1] A. Bhattacharya, P.P. Nath & H. Sahu, Speed limits to the growth of Krylov complexity in open quantum systems, (2024). [arXiv:2403.03584 \[quant-ph\]](#)
[All authors contributed equally to this work.](#)
- [2] K.V. Sharma, H. Sahu & S. Mukerjee, Quantum chaos in \mathcal{PT} -symmetric Quantum Kicked Rotor, (2023). [arXiv:2401.07215 \[quant-ph\]](#)

In-preparation

- [1] H. Sahu, A. Bhattacharya, and P.P. Nath, Spready Complexity in Random Unitary Circuits
 The order of the author and article title may vary in bibliographic citations.

Bibliometric parameters

Indices h-index 2 total citations 90 (Feb 2024), iNSPIRE-HEP
 h-index 2 total citations 51 (Jan 2024), Google-Scholar

Conferences, Seminars, and Schools

Talks

- 2023 Quantum Information Scrambling in non-local systems
 CHEP In-House Symposium, Centre for High Energy Physics, Indian Institute of Science, Bangalore, India
 18-19 November 2023

Posters

- 2023 Simulating Neutrino Oscillations Using Quantum-walk
 Quantum Information Processing and Applications, Harish-Chandra Research Institute, Prayagraj, India 04-10
 December 2023.

- 2023 Quantum Information Scrambling in Dissipative Open Quantum Systems
Emerging Topics in Quantum Technology, Indian Institute of Technology, Palakkad, India 02-04 November 2023.
- 2023 Operator Complexity in Open Quantum System
Condensed Matter meets Quantum Information, International Centre for Theoretical Sciences (ICTS), Bengaluru, India 25 Sep-06 Oct 2023.
- 2023 Neutrino oscillations in discrete-time quantum walk framework
Student Conference in Optics and Photonics, Physical Research Laboratory, Ahmedabad, India 27-29 September 2023.
- 2023 Exploring Operator Growth and Krylov Complexity in Dissipative Open Quantum Systems
It from Qubit, Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada 31 July-4 August 2023 (Online)

Attended Conferences

- 2023 Quantum Information Processing and Applications
Harish-Chandra Research Institute, Prayagraj, India 04-10 December 2023.
- 2023 Emerging Topics in Quantum Technology
Indian Institute of Technology, Palakkad, India 02-04 November 2023.
- 2023 Student Conference in Optics and Photonics
Physical Research Laboratory, Ahmedabad, India 27-29 September 2023.
- 2023 Photonics 2023
Indian Institute of Science, India 05-08 July 2023.

Virtually Attended Conferences

- 2023 It from Qubit
Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada 31 July-4 August 2023.
- 2023 Machine Learning for Quantum Many-Body Systems
Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada 12-17 June 2023.
- 2023 Quantum Simulators of Fundamental Physics
Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada 05-10 June 2023.

Attended Schools

- 2023 Condensed Matter meets Quantum Information
International Centre for Theoretical Sciences (ICTS), Bengaluru, India 25 Sep-06 Oct 2023
- 2021 Introductory Summer School in Astronomy and Astrophysics
Inter-University Centre for Astronomy and Astrophysics, India 10 May-11 June 2021.

Seminars and Panels

- 2023 Climate Change and Disaster Risk Reduction : Making Sustainability a Way of Life
Y20 Panel Discussion, Indian Institute of Science, Bangalore, India 12 August 2023.

Teaching Activity

Teaching Assistant

- Spring 2023 UP 204 - Intermediate Thermal Physics
 - Undergraduate Course Grader
 - Organized exams, graded exam sheets, and provided students with detailed feedback.

Honors, Awards & Scholarships

- 2023 Semi-Finalist, Rhodes Scholarship
 - Recognized as a Semi-Finalist for the prestigious Rhodes Scholarship, representing the STEM category.
 - Advanced to the semi-final round in the highly competitive selection process for the Rhodes Scholarship
 - Acknowledged for exceptional academic and leadership qualities during the Rhodes Scholarship application process

- 2021-Present IISC MS scholarship
• Beneficiary of the academic and financial provisions provided to Integrated PhD scholars at IISc Bangalore.
- 2018-23 **INSPIRE Scholarship Awardee (SHE Program)**
• Awarded the prestigious INSPIRE Scholarship for Higher Education, a selective grant awarded to top 1% performers in XII standard • Acknowledged for academic excellence in Natural or Basic Sciences, receiving financial support through the SHE program • Among top-ranking students nationally, recognized and supported by the Department of Science and Technology, Government of India
- 2017 **State Government Academic Excellence Award**
• Acknowledged by the State Government for academic achievements in Class X • Awarded a laptop as a recognition of academic excellence • Selected among top-performing students statewide for this merit-based honor

Other skills

Computer skills

OS	Windows, Linux, Clusters
Languages	Python, Processing3
Software	Mathematica, \LaTeX , Matlab, Microsoft office, Origin, ...
Libraries	Numpy, Scipy, Qiskit, QuSpin, QuTip, joblib, ...

Linguistic skills

Hindi	Mother tongue
English	Fluent : TOEFL iBT Score - 99/120 (L:28-R:25-W:25-S:21)

Volunteering

- 2020-Present Contributor on **Physics Stack Exchange**
• Top 2% overall • 11K+ Reputation • ~ 262K people reached
- 2023-Present IISC Nature Club Coordinator
• Raising awareness towards the need to protect environment • Organize walks in the forest and treks
- 2023 IISC Annual Open Day
• On 4th March 2023 • Presented experiments and counselled youths for a career in science.
- 2023 Waste Collector in GOA Monsoon Trekking 2023
- 2023 Behavioral Experiment Test Subject Volunteer : Vision Lab IISC
- 2023 EEG Experiment Test Subject Volunteer : MILE Lab IISC
- 2023 Functional MRI Experiment Test Subject Volunteer : Centre for Neuroscience IISC

Extracurricular

- 2023 National Monsoon Trekking cum Training Expedition- Goa, 2023
Youth Hostels Association of India Goa State Branch, July-August 2023.

References

- Prof. **CM Chandrashekar**, Adjunct Faculty at Instrumentation and Applied Physics, Indian Institute of Sciences, Bengaluru, India
Email: chandracm@iisc.ac.in
- Prof. **Subroto Mukerjee**, Associate Professor, Indian Institute of Science, Bengaluru, India
Email: smukerjee@iisc.ac.in
- Dr. **Aranya Bhattacharya**, Postdoc at Institute of Physics, Jagiellonian University, Krakow, Poland
Email: aranya.bhattacharya@uj.edu.pl
- Prof. **Sumilan Banerjee**, Associate Professor, Indian Institute of Science, Bengaluru, India
Email: sumilan@iisc.ac.in

Dr. **Kallol Sen**, Postdoc at ICTP-SAIFR, Sao Paulo, Brazil
Email: kallolmax@gmail.com

Github Directories

- q-complexity** The directory contains code files related to work done in finding the quantum circuit complexity of quantum walk.
- q-search** The directory contains code files related to work done in quantum-walk search in motion.