Himanshu Sahu

Curriculum Vitæ

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

03/2024-Present	**Quantum Intern**, IBM Research Lab, Bangalore.

Education

Fall 2024	**PhD in Quantum Computation and Quantum Communication**, University College London, London, UK. • EPSRC Centre for Doctoral Training in Delivering Quantum Technologies
07/2021–Present	**Masters in Physics**, Indian Institute of Science, Bangalore. • CGPA : 9.10/10 (max. typically $\sim$ 9.4) • On track for Distinction in the Major
06/2018-06/2021	**Bachelor in Physics**, Banaras Hindu University, Varanasi. • CGPA : 9.15/10 • Passed in First Division with Distinction

Master thesis

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

Research activity

Brief description	I am a physicist broadly interested in the ideas at the intersection between condensed matter theory, quantum computing, and information theory. A significant fraction of my research is naturally devoted to the development and use of quantum algorithms and simulations. I'm also interested in studying quantum information scrambling in many-body 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 Instutute 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 Instutute 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 111 (Apr 2024), iNSPIRE-HEP
h-index 2 total citations 82 (Apr 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
• A semi-finalist for the prestigious Rhodes Scholarship, representing the STEM category. • Acknowledged for exceptional academic and leadership qualities during the Rhodes Scholarship application process

2021-2024 IISC MS scholarship
• Beneficiary of the academic and financial provisions provided to Integrated PhD scholars at IISc Bangalore.

2018-2021 INSPIRE Scholarship Awardee (SHE Program)
  - Awarded the prestigious INSPIRE Scholarship for Higher Education, a selective grant awarded to top 1% performers in XII standard 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

Other skills

Computer skills

OS	Windows, Linux, HPC
Languages	Python, Processing3, JavaScript, CSS, HTML
Software	Mathematica, LaTeX, Matlab, Microsoft office, Origin, . . .
Libraries	Numpy, Scipy, Qiskit, QuSpin, QuTip, joblib, p5.js, . . .

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 • $\sim 262K$ 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 Brach, July-August 2023.

References

Prof. **CM Chandrashekar**, Adjunt 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.