PRATIK NANDY

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RESEARCH INTERESTS

My current research interests include:

1) Investigation of quantum information aspects of quantum chaos in many-body systems and gravity. My approach leverages tools such as Random Matrix Theory, Krylov space methods, and quantum computational techniques, with an eye toward their implementation on near-term quantum devices.

2) A particular focus on non-Hermitian and open quantum systems, which are ubiquitous in nature and unavoidable in quantum computers. A broad goal is to simplify Hamiltonian systems in a manner amenable to quantum computation, while preserving key features such as entanglement structure and quantum chaotic behavior.

3) Exploring mathematical frameworks—particularly free probability theory—to reinterpret quantum chaotic dynamics. I am interested in how these perspectives may shed light on physical phenomena such as thermalization and the mechanisms underlying black hole dynamics.

ACADEMIC APPOINTMENTS

• **Yukawa Institute for Theoretical Physics (YITP), Kyoto University &**
RIKEN Center for Interdisciplinary Theoretical and Mathematical Sciences. *2022–2025*
Extreme Universe Collaboration postdoctoral researcher.

VISITING RESERACH EXPERIENCES

• **Berkeley Center for Theoretical Physics, University of California, Berkeley, USA.** *2024*
RIKEN-Berkeley ASPIRE visiting researcher.

• **Princeton Center for Theoretical Science, Princeton University, USA.** *2023*
Extreme Universe Collaboration visiting researcher.

EDUCATION

• **Centre for High Energy Physics,**
Indian Institute of Science (IISc), Bengaluru, India. *2017–2022*
PhD in Physics.
Supervisor: Prof. Aninda Sinha (IISc Bengaluru, India, and University of Calgary, Canada).

• **Indian Institute of Technology Kanpur (IIT-K), India.** *2015–2017*
Master of Science (M.Sc) in Physics (received academic excellence award).

• **Presidency University, Kolkata, India.** *2012–2015*
Bachelor of Science (B.Sc) in Physics.

PUBLICATIONS/PREPRINTS

Papers are listed in reverse chronological order, *i.e.,* latest papers appearing first. In most cases, the authors are listed alphabetically, which is conventional in the high-energy theory (hep-th) community. There are a few exceptions, marked with *, which are arranged according to the author's contributions.

*21. Free Probability approach to spectral and operator statistics in Rosenzweig-Porter random matrix ensembles, V. Jahnke†, **P. Nandy**†, K. Pal, H. A. Camargo, K-Y. Kim [arXiv:2506.04520 [hep-th]]. († equal contribution)

*20. A Krylov space approach to Singular Value Decomposition in non-Hermitian systems, **P. Nandy**, T. Pathak, Z-Y. Xian, J. Erdmenger [Phys. Rev. B 111, 064203 (2025)].

19. Tridiagonal Hamiltonians modeling the density of states of the Double-Scaled SYK model, **P. Nandy** [JHEP 01 (2024) 094].

18. Krylov fractality and complexity in generic random matrix ensembles, B. Bhattacharjee, **P. Nandy** [Phys. Rev. B 111, L060202 (2025) (Letter)].

17. Probing quantum chaos through singular-value correlations in sparse non-Hermitian SYK model, **P. Nandy**, T. Pathak, M. Tezuka [Phys. Rev. B 111, L060201 (2025) (Letter)].

*16. Quantum Dynamics in Krylov Space: Methods and Applications, **P. Nandy**, A. S. Matsoukas-Roubeas, P. Martínez-Azcona, A. Dymarsky, A. del Campo, [Phys.Rept. 1125-1128 (2025) (Invited review)].

15. Operator dynamics in Lindbladian SYK: a Krylov complexity perspective, B. Bhattacharjee, **P. Nandy**, T. Pathak, [JHEP 01 (2024) 094].

14. On Krylov complexity in open systems: an approach via bi-Lanczos algorithm, A. Bhattacharya, **P. Nandy**, P. P. Nath, H. Sahu, [JHEP 12 (2023) 066].

13. Operator growth in open quantum systems: lessons from the dissipative SYK, B. Bhattacharjee, X. Cao, **P. Nandy**, T. Pathak, [JHEP 03 (2023) 054].

12. Krylov complexity in large-q and double-scaled SYK model, B. Bhattacharjee, **P. Nandy**, T. Pathak, [JHEP 08 (2023) 099].

*11. Probing quantum scars and weak ergodicity-breaking through quantum complexity, B. Bhattacharjee, S.Sur, **P. Nandy** [Phys. Rev. B 106, 205150 (2022)].

10. Operator growth and Krylov construction in dissipative open quantum systems, A. Bhattacharya, **P. Nandy**, P. P. Nath, H. Sahu, [JHEP 12 (2022) 081].

9. Krylov complexity in saddle-dominated scrambling, B. Bhattacharjee, X. Cao, **P. Nandy**, T. Pathak, [JHEP 05 (2022) 174].

8. Balanced Partial Entanglement and Mixed State Correlations, H. A. Camargo, **P. Nandy**, Q. Wen, H. Zhong, [SciPost Phys. 12 (2022) 137].

7. Q-curvature and Path Integral Complexity, H. A. Camargo, P. Caputa, **P. Nandy**, [JHEP 04 (2022) 081].

6. Bath deformations, islands and holographic complexity, A. Bhattacharya, A.Bhattacharyya, **P. Nandy**, A. K Patra, [Phys. Rev. D 105, 066019 (2022)].

5. Partial islands and subregion complexity in geometric secret-sharing model, A. Bhattacharya, A.Bhattacharyya, **P. Nandy**, A. K Patra, [JHEP 12 (2021) 091].

4. Eigenstate capacity and Page curve in fermionic Gaussian states, B. Bhattacharjee, **P. Nandy**, T. Pathak, [Phys. Rev. B 104, 214306 (2021)].

3. Capacity of entanglement in local operators, **P. Nandy**, [JHEP 07 (2021) 019].

2. Islands and complexity of eternal black hole and radiation subsystems for a doubly holographic model, A. Bhattacharya, A.Bhattacharyya, **P. Nandy**, A. K Patra, [JHEP 05 (2021) 135].

1. Renormalized Circuit Complexity,
A. Bhattacharyya, **P. Nandy**, A. Sinha, [Phys. Rev. Lett. 124, 101602 (2020)].

INVITED TALKS AND SEMINARS

- (upcoming) At the conference "Da Nang, Holography and String Theory, 8th", Duy Tan University, Da Nang, Vietnam [link]. *Aug. 2025*
- At iTHEMS Theoretical Physics Seminar, RIKEN, Japan [link]. *July 2025*
- At the 4th young researchers' workshop of the Extreme Universe Collaboration, Kyukamura Irago, Aichi, Japan [link]. *July 2025*
- At the CERN Heavy Ion Theory group, CERN, Switzerland [link]. *June 2025*
- At conference "Quantum Connections: Linking Information, Gravity, and Many-Body Physics, Jeju, South Korea [link]. *June 2025*
- At the Institute of Solid State Physics (ISSP), University of Tokyo, Japan [link]. *May 2025*
- At Department of Physics, Gakushuin University, Tokyo, Japan [link]. *May 2025*
- At the "Workshop on Low-dimensional Gravity and SYK Model", Matsumoto, Japan [link]. *March 2025*
- At Department of Physics, Gwangju Institute of Science and Technology (GIST), Gwangju, South Korea. *March 2025*
- At NCTS, National Tsing Hua University, Hsinchu, Taiwan. *Nov. 2024*
- At the workshop "Focus Week on Non-equilibrium Quantum Dynamics" Kavli IPMU, University of Tokyo, Japan [link]. *Oct. 2024*
- At the 3rd young researchers' workshop of the Extreme Universe Collaboration, Grand Park Otaru, Hokkaido, Japan [link]. *Sept. 2024*
- At the workshop "Holography in Beijing 2024", Kavli Institute of Theoretical Sciences (KITS), UCAS, Beijing, China [link]. *July 2024*
- At Department of Physics and Astronomy, University of Kentucky, USA. *June 2024*
- At the Department of Physics, Osaka University, Osaka, Japan. *Feb. 2024*
- At the 2nd young researchers' workshop of the Extreme Universe Collaboration, Shirahamaso, Shiga, Japan [link]. *Feb. 2024*
- At Dept. of Physics & Material Science, University of Luxembourg, Luxembourg. *Jan. 2024*
- At the Kobayashi-Masakawa Institute, Nagoya University, Nagoya, Japan. *Jan. 2024*
- At the Department of Physics, Saitama University, Saitama, Japan. *Dec. 2023*
- At the Department of Physics, The University of Tokyo, Tokyo, Japan. *Nov. 2023*
- At the Theory Division, Saha Institute of Nuclear Physics, Kolkata, India. *Oct. 2023*
- At the conference "Integrability, Deformations, and Chaos", Okinawa Institute of Science and Technology (OIST), Okinawa, Japan [link]. *July 2023*
- At the workshop "Entanglement, Large N and Black Hole", Asia Pacific Center for Theoretical Physics (APCTP), Pohang, South Korea [link]. *May 2023*
- At the 1st young researchers' workshop of the Extreme Universe Collaboration, Nagoya University, Japan [link]. *Feb. 2023*

• NITHeCS lectures on "Recent progress on Krylov complexity" [link], *June 2022*
Department of Mathematics & Applied Mathematics, University of Cape Town, South Africa.

• At the Department of Computer Science, Texas Tech. University, Lubbock, USA. *Dec. 2021*

• At the workshop "Quantum Information in QFT and AdS/CFT-II" [link]. *Aug. 2021*

• At the workshop "Quantum Information in QFT and AdS/CFT-I" [link]. *Aug. 2020*

• Three pedagogical lectures on "Tensor networks and complexity",
Student Talks on Trending Topics in Theory, ST4-2020, India [link]. *July 2020*

CONTRIBUTED TALKS AND POSTER PRESENTATIONS

Contributed talks

• At the symposium on Physics of Open Systems: Resonance, Symmetry and Topology,
University of Tokyo, Kashiwa, Japan. [link]. *Aug. 2025*

• At the conference "Hydrodynamics of low-dimensional interacting systems: Advances, challenges, and future directions", YITP, Kyoto University, Japan [link]. *June 2025*

• At the conference "Kyushu IAS-iTHEMS workshop: Non-perturbative methods in QFT",
Kyushu University, Fukuoka, Japan [link]. *March 2025*

• At the workshop "East Asia Joint Workshop on Fields and Strings"
National Sun-Yat Sen University, Kaohsiung, Taiwan [link]. *Nov. 2024*

• At the conference "Quantum Extreme Universe: Matter, Information, and Gravity"
Okinawa Institute of Science and Technology (OIST), Okinawa, Japan [link]. *Oct. 2024*

• At the conference "Quantum Information, Quantum Field Theory and Gravity"
International Centre for Theoretical Sciences (ICTS), Bengaluru, India [link]. *Aug. 2024*

• At the "KEK Theory Workshop 2023", Tsukuba, Ibaraki, Japan [link]. *Nov. 2023*

• At the conference "Quantum Information, Quantum Matter and Quantum Gravity",
Yukawa Institute for Theoretical Physics (YITP), Kyoto, Japan [link]. *Sept. 2023*

Poster Presentations

• At the event "iTHEMS Now & Next 2025", RIKEN, Japan [link]. *July 2025*

• At the 19th Asian Winter School on Strings, Particles and Cosmology,
Tsinghua Sanya International Mathematics Forum (TSIMF), Sanya, China [link]. *Jan. 2025*

• At the fourth Annual Meeting of Extreme Universe Collaboration,
Osaka University, Osaka, Japan [link]. *Sept. 2024*

• At the 17th Kavli Asian Winter School on Strings, Particles and Cosmology,
Institute for Basic Science, Daejeon, South Korea [link]. *Jan. 2023*

• At the second Annual Meeting of Extreme Universe Collaboration,
Kobe Convention Center, Kobe, Japan [link]. *Dec. 2022*

• At the 14th Kavli Asian Winter School on Strings, Particles and Cosmology,
Tohoku University, Sendai, Japan [link]. *Jan. 2020*

ACADEMIC ACHIEVEMENTS, GRANTS AND FELLOWSHIPS

• Adopting Sustainable Partnerships for Innovative Research Ecosystem (ASPIRE) fellowship, Japan Science and Technology Agency (JST), Grant No. JPMJAP2318, Japan. *2024*

• Extreme Universe Overseas researcher fellowship, KAKENHI Grant No. 21H05182, Japan. *2023*

• Extreme Universe Postdoctoral fellowship, Japan Society for Promotion of Science (JSPS), Grant-in-Aid for Transformative Research Areas (A) "Extreme Universe" No. 21H05190. *2022–2025*

• SRF-Senior Research Fellowship (PhD), University Grants Commission (UGC), India. *2019–2022*

• JRF-Jenior Research Fellowship (PhD), University Grants Commission (UGC), India *2017–2019*

• Academic Excellence Award (M.Sc), Indian Institute of Technology Kanpur, India *2017*

• INSPIRE Scholarship (B.Sc), Department of Science and Technology (DST), India *2012–2015*

NEWSLETTERS, PRESS RELEASES AND MEDIA COVERAGE

• Understanding dynamics & quantum chaos through Krylov space, RIKEN newsletter [link]. *2025*

• Optimizing efficiency of quantum circuits at Phys.org [link]. *2020*

• IISc team proposes efficient design for quantum circuits [link] [link]. *2020*

TEACHING EXPERIENCES

• NITHeCS lectures on "Recent progress on Krylov complexity" [link], *2022*
Department of Mathematics & Applied Mathematics, University of Cape Town, South Africa.

• Three pedagogical lectures on "Tensor networks and complexity",
Student Talks on Trending Topics in Theory, ST4-2020, India [link]. *2020*

• Graduate Teaching Assistant: General Relativity, Indian Institute of Science, Bengaluru. *2019–2020*

ORGANIZING EXPERIENCES

• (upcoming) Japan-UK Workshop on Quantum Gravity - 2025, RIKEN Kobe, Japan [link]. *2025*

• Workshop on Students talk on trending topics in Theory (ST4) - 2022,
Indian Institute of Technology, Indore, India [link]. *2022*

• Math-Physics seminar series, Indian Institute of Science, Bengaluru, India. *2021–2022*

REFEREED JOURNALS

Journal of High Energy Physics (JHEP), SciPost Physics, Physical Review B (PRB), Physical Review D (PRD), Physical Review E (PRE), Physical Review Research (PRR), Journal of Statistical Mechanics: Theory and Experiment (JSTAT), The European Physical Journal C (EPJC), Progress of Theoretical and Experimental Physics (PETP).

COMPUTATIONAL AND TECHNICAL SKILLS

Languages Mathematica, Python.
Software LaTeX, MS Office.