

Sayak Chakrabarti

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RESEARCH INTERESTS

Foundations of LLMs, algorithms, machine learning, complexity theory, computational algebra

EDUCATION

Columbia University

Sep 2022 – Present

Ph.D. candidate in Computer Science, Advisor: Prof. Josh Alman, Prof. Toniann Pitassi.

GPA: 4.16/4.00.

Indian Institute of Technology (IIT), Kanpur

Jul 2017 – May 2022

Dual B.Tech-M.Tech in Computer Science and Engineering, Advisor: Prof. Nitin Saxena

M.Tech CPI: 10.0/10.0, B.Tech CPI: 9.0/10.0.

Thesis: Root-finding algorithms for multivariate polynomials modulo prime-powers.

(**Best BT-MT Thesis Award**)

VISITS AND EXPERIENCE

Tata Institute of Fundamental Research, Mumbai

Dec 2024

– Visiting Researcher, Host: Prof. Arkadev Chattopadhyay.

International Symposium on Symbolic and Algebraic Computation (ISSAC), Tromsø, Norway

Jul 2023

ACM Symposium on Theory of Computing (STOC), Orlando, FL

Jun 2023

Simons Institute, Berkeley, CA

Jan 2023 – Apr 2023

– Visiting Graduate Student, Meta-Complexity Workshop

Max Planck Institute of Software Systems (MPI-SWS), Germany

May 2020 – Jul 2020

– Remote Research Fellow, Host: Prof. Joël Ouaknine.

PUBLICATIONS AND PREPRINTS

Sayak Chakrabarti, Toniann Pitassi, Josh Alman. *Poly-attention: a general scheme for higher-order self-attention*. Submitted, 2025.

Sayak Chakrabarti, Ashish Dwivedi, Nitin Saxena. *Solving polynomial systems over non-fields and applications to modular polynomial factoring*. Journal of Symbolic Computation 125 (2024): 102314.

Sayak Chakrabarti, Nitin Saxena. *An effective description of the roots of bivariates mod p^k and the related Igusa's local zeta function*. International Symposium on Symbolic and Algebraic Computation (ISSAC), pp: 135-144. 2023.

Aditya Gulati, **Sayak Chakrabarti**, Rajat Mittal. *On Algorithms to Find p -ordering*. Conference on Algorithms and Discrete Applied Mathematics (CALDAM), pp: 333-345. 2021.

Soumendu Sundar Mukherjee, **Sayak Chakrabarti**. *Graphon estimation from partially observed network data*. arXiv:1906.00494.

SELECTED PROJECTS

Expressivity of transformers with bounded precision

Jul 2025 – Present

Prof. Josh Alman, Prof. Toniann Pitassi, Columbia University

- Theoretically analyzed the representational power and limitations of transformers under varying numerical precision.
- Conducted experiments with different-precision transformers on composition tasks, highlighting performance gaps.
- Working on constructing a hard task solvable with an optimal number of precision bits in different precision formats.

Higher-order attention schemes

Feb 2025 – Present

Prof. Josh Alman, Prof. Toniann Pitassi, Columbia University

- Unified diverse higher-order softmax self-attention mechanisms into a single framework, *poly-attention*, and studied their computational complexities and approximation algorithms.
- Developed *tree-attention*, a quadratic-time mechanism that tackles tasks beyond the reach of standard self-attention.

- Empirically validated tree-attention’s effectiveness in benchmark NLP datasets and showed that it is more expressive as well as efficient than self-attention.

Multi-party communication complexity

Dec 2024 – Present

Prof. Arkadev Chattopadhyay, TIFR Mumbai

- Extended upper bound techniques for multi-party communication problems using rectangular cover methods.
- Investigating combinatorial approaches to improve naive bounds for number-in-hand communication complexity.

Graph regularity lemmas and triangle removal

Aug 2024 – Apr 2025

- Surveyed and compared variants of regularity and graph removal lemmas.
- Explored new formulations of graph regularity to strengthen the triangle removal lemma.

Interactive protocols and approximate nearest neighbors

Mar 2024 – Sep 2024

Prof. Josh Alman, Prof. Toniann Pitassi, Columbia University

- Studied links between interactive proof systems and the complexity of approximate nearest neighbor search.
- Explored reductions from multi-round interactive protocols to nearest neighbor search for improved lower bounds.

Root-finding algorithms for multivariate polynomials modulo prime-powers

Jul 2020 – May 2022

Prof. Nitin Saxena, IIT Kanpur

- Designed algorithms for finding roots of multivariate polynomials modulo prime powers.
- Developed new techniques for polynomial system solving and Igusa’s local zeta function via algebraic tools.
- Work culminated in two peer-reviewed publications.

HONORS AND AWARDS

Best BT-MT Thesis Award, IIT Kanpur, Class of 2022

All India Rank 181, JEE Advanced 2017 (200,000 candidates)

All India Rank 287, JEE Main 2017 (1.2M candidates)

State Rank 10, WBJEE 2017 (150,000 candidates)

Qualified Indian National Physics Olympiad (INPhO) 2017 (Top 34 in India)

Qualified Indian National Mathematical Olympiad (INMO) 2016 (Top 30 in India)

All India Rank 115, Kishore Vaigyanik Protsahan Yojana (KVPY) 2015 (100,000 candidates)

TEACHING EXPERIENCE

TA, COMS 3261: CS Theory, Columbia University

Jan 2025 – May 2025

TA, COMS 3261: CS Theory, Columbia University

Sep 2023 – Dec 2023

Tutor, ESC101: Fundamentals of Computing, IIT Kanpur

Oct 2021 – May 2022

TA, CS203: Probability for Computer Science, IIT Kanpur

Mar 2021 – May 2021

TA, CS202: Logic for Computer Science, IIT Kanpur

Jan 2021 – Feb 2021

Academic Mentor, MTH101 & MTH102, IIT Kanpur

Aug 2018 – Apr 2019

SERVICE

Reviewer for conferences: ICLR 2026, ITCS 2026, SODA 2026, ESA 2024, SOSA 2024, MFCS 2023

Reviewer for journals: Information and Computation, Journal of Number Theory

Vice President and Treasurer, Graduate Organization of Computer Science (GroCS)

Jan 2025 – Present

Mentor, Directed Reading Program, Columbia Math Department

Sep 2024 – Dec 2024

Mentor, Association for Computing Activities, IIT Kanpur

Jan 2019 – Apr 2019

Student Guide, Counselling Service, IIT Kanpur

Jul 2018 – Apr 2019

Volunteer, English Teacher, Shiksha Sopan NGO

Apr 2019 – Mar 2020

TECHNICAL SKILLS

Python, C/C++, R, MATLAB, MySQL, PyTorch, Tensorflow, Numpy, OpenCV, Bash, Git, L^AT_EX