Curriculum Vitae

Akash Singha Roy

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Education

August 2022-July 2025: University of Georgia, PhD program in mathematics.
Advisor: Paul Pollack

September 2021-April 2022: Université de Montréal.

August 2018-April 2021: Chennai Mathematical Institute, Bachelor of Science in Mathematics and Computer Science.

Current and Upcoming Positions

December 2025+: Postdoctoral Researcher at Charles University (Univerzita Karlova), in the number theory group UFOCLAN under the Department of Algebra.
Supervisors: Siu Hang (Gordon) Man, Martin Cech.

Research Interests

Number Theory: Elementary, Analytic, Combinatorial, and Probabilistic Number Theory.

- Distributions of arithmetic functions: Value distributions in residue classes, Benford's Law (Benford behavior of sequences), Erdős–Kac theorem and extensions etc.
- Multiplicative Number Theory: Mean values of multiplicative functions and mean values along arithmetic progressions.
- Anatomy of integers and sieve theory.
- Distributions of primes: Residue races and Chebyshev's bias.
- Interface of number theory with ergodic theory and additive combinatorics.
- Modular forms and L-functions.

Dissertation

Dissertation title: Residue–class distribution of arithmetic functions to varying moduli

Advisor: Paul Pollack
Committee members: Neil Lyall, Akos Magyar, Giorgis Petridis

Link to dissertation: https://akashsingharoy.github.io/AkashSRoyDISSERTATION.pdf

Abstract: The distribution of values of arithmetic functions in residue classes is a problem of significant interest in elementary, analytic and combinatorial number theory. Much work has been done studying this problem for fixed moduli. In this thesis, we extend many of the results in the literature for large classes of additive and multiplicative functions, so as to allow the modulus to vary within a wide range. In fact, we find essentially best possible analogues of the Siegel-Walfisz theorem (from prime number theory) for the joint distribution of families of such functions.

Our primary tools are sieve methods and methods from the "anatomy of integers", which we often use to detect certain "mixing" phenomena in multiplicative groups. Additionally, we use several ideas and machinery from classical analytic number theory, character sums, linear algebra over rings, as well as tools from arithmetic and algebraic geometry.

Note: A more detailed description of the work in my dissertation may be found in the project descriptions of papers 13, 14 and 15 below. These works have also led to paper 16.

Manuscripts

The following are all my works so far, listed in chronological order of **completion** (oldest first).

1. (Book) Steps into Analytic Number Theory: A Problem-Based Introduction (with Paul Pollack), *Springer, Problem Books in Mathematics* 2021.

2. Distribution mod p of Euler's totient and the sum of proper divisors (with Noah Lebowitz-Lockard and Paul Pollack), *The Michigan Mathematical Journal* **74** (2024), 143–166.
   Links to manuscript: Journal version Arxiv version

3. Joint distribution in residue classes of polynomial-like multiplicative functions (with Paul Pollack), *Acta Arithmetica* **202** (2022), 89–104.
   Links to manuscript: Journal version Arxiv version

4. Powerfree sums of proper divisors (with Paul Pollack), *Colloquium Mathematicum* **168** (2022), 287–295.
   Links to manuscript: Journal version Arxiv version

5. Dirichlet, Sierpiński, and Benford (with Paul Pollack), *Journal of Number Theory* **239** (2022), 352–364.
   Link to manuscript: Journal version

6. Benford behavior and distribution in residue classes of large prime factors (with Paul Pollack), *Canadian Mathematical Bulletin* **66** (2023), 626–642.
   Link to manuscript: Journal version

7. On Benford's Law for multiplicative functions (with Vorrapan Chandee, Xiannan Li and Paul Pollack), *Proceedings of the American Mathematical Society* **151** (2023), 4607–4619.

Links to manuscript: Journal version Arxiv version

8. Distribution in coprime residue classes of polynomially-defined multiplicative functions (with Paul Pollack), *Mathematische Zeitschrift* **303** (2023), no. 4, paper 93, 20 pages.
Links to manuscript: Journal version Arxiv version

9. Intermediate prime factors in specified subsets (with Nathan McNew and Paul Pollack), *Monatshefte für Mathematik* **202** (2023), 837–855.
Link to manuscript: Journal version

10. The distribution of intermediate prime factors (with Nathan McNew and Paul Pollack), *Illinois Journal of Mathematics* **68** (2024), no. 3, 537–576.
Links to manuscript: Journal version Arxiv version

11. Mean values of multiplicative functions and applications to residue-class distribution (with Paul Pollack), *Proceedings of the Edinburgh Mathematical Society* **68** (2025), no. 3, 712–730.
Link to manuscript: Journal version Full text

12. Anatomical mean value bounds on multiplicative functions and the distribution of the sum of divisors, *The Michigan Mathematical Journal*, accepted for publication.
Link to manuscript: Most recent version

13. Joint distribution in residue classes of families of polynomially-defined additive functions
Submitted to Mathematische Zeitschrift
Link to manuscript: Most recent version

14. Joint distribution in residue classes of families of multiplicative functions I
Submitted to International Mathematics Research Notices.
Link to manuscript: Most recent version

15. Joint distribution in residue classes of families of multiplicative functions II
Submitted to Acta Arithmetica
Link to manuscript: Most recent version

16. The Landau-Selberg-Delange Method for products of Dirichlet L-functions, and applications, I, *Submitted to Journal of the London Mathematical Society*
Link to manuscript: Most recent version

Top three manuscripts among works done so far (with the strongest first)

Paper 16. The Landau-Selberg-Delange Method for products of Dirichlet L-functions, and applications, I. *Submitted to Journal of the London Mathematical Society.* Most recent version

Abstract: The Landau–Selberg–Delange method gives precise asymptotic formulas for the partial sums $\sum_{n\le x} a_n$ of a Dirichlet series $\sum_n a_n/n^s$ that behaves like a complex power of the Riemann zeta function. However, situations often arise when the Dirichlet series behaves like a product of complex powers of several Dirichlet L–functions to a modulus q. In such situations, one often requires sharp asymptotic formulas for the partial sums $\sum_{n\le x} a_n$ that apply in much wider ranges of q than permitted by known forms of the Landau–Selberg–Delange method. In this manuscript, we address this problem, giving new estimates on $\sum_{n\le x} a_n$ in ranges of q that are (in most applications) much wider than attainable from previous results. Our results also weaken certain hypotheses on the size of $\{a_n\}_n$. As applications of our main theorems, we extend Landau's classical results on the distribution of integers with prime factors restricted to progressions, and improve upon Chang,

Martin and Nguyen's work on the distribution of the least invariant factors and least primary factors of multiplicative groups. We also extend the classical Sathe–Selberg theorem and study the local laws of the functions $\Omega_a(n)$ and $\omega_a(n)$, that count (with and without multiplicity, respectively), the number of prime divisors of n lying in the progression a mod q.

Paper 14. Joint distribution in residue classes of families of multiplicative functions I. *Submitted to International Mathematics Research Notices.* Most recent version

Abstract: We study the joint distribution of families of multiplicative functions in residue classes, allowing the moduli to vary within a wide range and assuming some natural control on the average behavior of the functions at (any fixed power of) the primes. As an application, we obtain essentially best possible analogues of the Siegel–Walfisz theorem for families of multiplicative functions that can be controlled by polynomials at the first few powers of all primes. (This class includes several interesting arithmetic functions such as Euler's totient $\varphi(n)$, the sum-of-divisors $\sigma(n)$, and more generally, the sum-of-divisor-powers $\sigma_r(n) := \sum_{d|n} d^r$, and so on.) Our results extend (and give essentially optimal uniform analogues of) works of Narkiewicz, Rayner, Śliwa, Dobrowolski, Fomenko and others. One of the main ideas behind our arguments is the detection of a certain "mixing"/"quantitative ergodicity" phenomenon via methods from sieve theory and the anatomy of integers. Additionally, we also need several ideas and machinery from classical analytic number theory, character sums, linear algebra over rings, as well as arithmetic and algebraic geometry.

Paper 10. The distribution of intermediate prime factors (with Nathan McNew and Paul Pollack), *Illinois Journal of Mathematics* **68** (2024), no. 3, 537–576. Journal version Arxiv version

Abstract: Let $P^{\left(\frac{1}{2}\right)}(n)$ denote the middle prime factor of n (taking into account multiplicity). More generally, one can consider, for any $\alpha \in (0,1)$, the α-positioned prime factor of n, $P^{(\alpha)}(n)$. It has previously been shown that $\log\log P^{(\alpha)}(n)$ has normal order $\alpha \log\log x$, and its values follow a Gaussian distribution around this value. We extend this work by obtaining an asymptotic formula for the count of $n \le x$ for which $P^{(\alpha)}(n) = p$, for primes p in a wide range up to x. We give several applications of these results, including an exploration of the geometric mean of the middle prime factors, for which we find that $\frac{1}{x}\sum_{1<n\le x} \log P^{\left(\frac{1}{2}\right)}(n) \sim A(\log x)^{\varphi-1}$, where φ is the golden ratio, and A is an explicit constant. Along the way, we obtain an extension of Lichtman's recent work on the "dissected" Mertens' theorem sums $\sum_{\substack{P^+(n)\le y \\ \Omega(n)=k}} \frac{1}{n}$ for large values of k.

Current ongoing research

1. Joint normality of the number of prime divisors, sum of prime divisors and the sum of proper divisors (with Paul Pollack and Lee Troupe).

Project description: In what is considered as the "Central Limit Theorem of number theory" as well as the birth of probabilistic number theory, Paul Erdős and Mark Kac established the groundbreaking "Erdős–Kac" theorem, – stating that the function $\omega(n)$ (which counts the number of prime divisors of n) can be thought of as a *normally distributed random variable* with mean and variance both equal to $\log\log n$. Two related well–known functions are the "sum-of-proper-divisors" function $s(n)$ and the "sum-of-prime-divisors"/"Alladi–Erdős function" $A(n)$. Pollack and Troupe showed that both of these functions *individually* satisfy an Erdős–Kac type law. In this project, we try to extend this work and establish a *joint* Erdős–Kac type law for these three functions. For instance, we show that $\omega(n)$ and $\omega(s(n))$ can be thought of as *jointly normally distributed random variables* with mean and variance both equal to $\log\log n$.

2. Dual Chebyshev's bias in number fields (with Jiuya Wang).

Project description: Although the Siegel–Walfisz Theorem establishes the *relative* equidistribution of primes among coprime residues, *numerically* however, the primes tend to be more biased towards certain residues over others. This phenomenon was first observed by (and hence named after) Russian mathematician Pafnuty Chebyshev, – who noted that for most values of x, there are more primes up to x that leave a remainder of 3 modulo 4 than those that leave a remainder of 1 modulo 4 (even though the *ratio* of these two quantities approaches 1 as $x \to \infty$, as predicted by Siegel–Walfisz). In their seminal paper, Michael Rubinstein and Peter Sarnak rigorously studied generalizations of this phenomenon, assuming the *Generalized Riemann Hypothesis* and the *Grand Simplicity Hypothesis*. They also described extensions of their work to *number fields*; here, they *fixed the number field, allowed the primes to vary* and looked at the biases in the relative distributions and arithmetic behavior of these varying primes in the number field. They found that there are different kinds of biases that can arise and several new analytic complications they bring, but these can all be resolved with some additional care.

In this project, we explore a "dual" version of their work: Suppose we *fix the prime* and allow the *number fields to vary*. Would biases still arise or would they get dissolved? If biases do arise, would they still look like the biases obtained by Rubinstein and Sarnak? How would the aforementioned analytic complications show up here? What conditions (if any) would we need on the fixed prime for the biases (if any) to approach some tractable "limiting behavior"?

3. Mean values of multiplicative functions in (generalized) progressions.

Project description: A close cousin of the well-known problem of estimating mean values of multiplicative functions, is that of investigating their *mean values along arithmetic progressions*, namely, the problem of estimating the sums $S_f(x, q, a) = \sum_{\substack{1 \le n \le x \\ n \equiv a \bmod q}} f(n)$ for a multiplicative function f; here the sum is taken over all positive integers $n \le x$ that leave a remainder of a modulo q. This problem has connections with several important notions in analytic number theory, such as *the Large Sieve, the Landau–Siegel zeros conjecture, and the Generalized Riemann Hypothesis*. While precise asymptotic formulas on $S_f(x, q, a)$ are known for *small* moduli q, these formulas are useful only in extremely limited ranges of q. In applications, one often requires sharp asymptotic formulas that are valid in *much wider* ranges of q than permitted by known results. In this work, we aim to find such sharp and precise asymptotics on $S_f(x, q, a)$ in these much wider ranges, allowing q to grow rapidly with x, and allowing as much flexibility in f as possible. We also investigate the more general kinds of sums of the form $\sum_{\substack{1 \le n \le x \\ g(n) \equiv a \pmod q}} f(n)$, with $g : \mathbb{N} \to \mathbb{Z}$ being an arithmetic function.

More ongoing/upcoming research projects will soon be announced in:
https://akashsingharoy.github.io/research.

Programming skills and experience with mathematical software

- Have used Sage, Pari/GP, Magma and Macaulay2 as part of research.
- Can also program in C++, Java, Python and Haskell.

Research Talks and Conferences (Slides available here)

- PAlmetto Number Theory Series (PANTS) XXXVII (December 2023)

Distribution in coprime residue classes of Euler's totient and the sum of divisors

- University of Georgia Number Theory/Arithmetic Geometry Seminar (April 2024)
  Joint distribution in residue classes of families of "polynomially-defined" multiplicative functions
- Dartmouth College Algebra and Number Theory Seminar (November 2024)
  Distribution and mean values of families of multiplicative functions in arithmetic progressions
- University of Waterloo Number Theory Seminar (January 2025)
  Residue-class distribution and mean values of multiplicative functions
- American Mathematical Society (AMS) Spring Eastern Sectional Meeting 2025: Special session on Counting and Asymptotics in Number Theory (April 2025)
  Distribution in residue classes of families of multiplicative functions
- INTEGERS Conference 2025 at the University of Georgia: In Honor of the 80th Birthdays of Melvyn Nathanson and Carl Pomerance (May 2025)
  Joint distribution in residue classes of families of multiplicative functions
- Combinatorial and Additive Number Theory CANT 2025 (May 2025)
  Joint distribution in residue classes of families of multiplicative functions
- ELAZ 2026, Conference on elementary and analytic number theory (February 2026)
  The Landau-Selberg-Delange method for Dirichlet L-functions, and applications
- Charles University (Univerzita Karlova) Number Theory Seminar (March 2026)
  The Landau-Selberg-Delange method for Dirichlet L-functions, and applications
- Simons Summer School and Workshop on Discrete Harmonic Analysis and Analytic Number Theory (May 2026)
  The Landau-Selberg-Delange method for Dirichlet L-functions, and applications

Awards, Grants and Scholarships

- Supported by PRIMUS/25/SCI/008 grant from the Charles University, Department of Algebra: December 2025–May 2027.
- Will be supported by ERC grant of Prof. Tamar Ziegler for upcoming postdoctoral position at the Einstein Institute of Mathematics, Hebrew University of Jerusalem: May 2027+.
- Graduate Student Excellence-in-Research Award (2026), University of Georgia: University-wide award "recognizing the highest level of doctoral research achievement and scholarly impact". Awarded to a small number of graduate students annually across all disciplines; awarded to a Mathematics graduate student four times since its inception in 1999 (including 2026).

  Link to announcement (scroll down for announcement on the specific award)
- William Armor Wills Memorial Scholarship Award (2024), Department of Mathematics, University of Georgia: Departmental award presented annually to one or two PhD students "in recognition of excellence in research".
- Travel Grant from the American Mathematical Society (AMS), in partial support for speaking at and participating in the AMS Spring Eastern Sectional Meeting 2025.

- Travel Grant from UGA Graduate School in partial support for speaking at and participating in the AMS Spring Eastern Sectional Meeting 2025.
- UGA Graduate School Dean's Award: April 2023.
- UGA Graduate School Research Assistantship: August 2022 to May 2023.
- UGA Department of Mathematics Teaching Assistantship: August 2023 to May 2025.
- Exemplary Counselor Award at Ross/Asia Mathematics Program 2019:
  "in recognition of outstanding work at the Ross/Asia Mathematics Program".
- Full scholarship and monthly stipend during undergraduate studies at the Chennai Mathematical Institute: August 2018 to April 2021.
- Stipend and Travel Grant from the Ross/Asia Mathematics Program for performing Counselor duties at the program: 2019.
- Full Scholarship and Travel Grant from the Ross Mathematics Program (Columbus, Ohio) for attending the program as Junior Counselor: 2018.
- Mehta Fellowship for attending the Ross Mathematics Program: 2017.
  Highly competitive scholarship for students from India for attending mathematics programs abroad. Pays the full tuition fees, and provides support for travel and lodging expenses.
- Simon Marais Mathematics Competition (SMMC) 2019, International rank (as per score): 15. Top quartile. Overall second from Chennai Mathematical Institute in Individual Category.
- Madhava Mathematics Competition 2020 Prize Winner (National rank: 11). Also accepted into Madhava Mathematics Competition camp 2019.
- Indian National Mathematical Olympiad (INMO) 2017 Merit Certificate awardee.
  Regional Mathematical Olympiad (RMO) 2016 and 2017 awardee.
- Enumeration 2020 organized by the Indian Institute of Science (IISc) Bangalore: second prize.
- Scholarship from Camp Euclid for attending the program: 2016.

Selected list of conferences, seminars, summer schools, workshops and short courses attended and participated in

1. Recent short conferences spoken/participated in: ELAZ 2026; Combinatorial and Additive Number Theory (CANT) 2025; INTEGERS 2025; AMS Spring Eastern Sectional Meeting 2025; Joint Athens–Atlanta Number Theory Seminar Spring 2025; PAlmetto Number Theory Series XXXVII 2023; CANT 2022; Maine-Quebec Number Theory Conference 2021; Chennai-Tirupati Number Theory Conference 2020.
2. Regular participant in the following seminars for the given durations:
   - Charles University (Univerzita Karlova) Number Theory Seminar: December 2025+
   - UGA Mathematics Department Seminars: Number Theory/Arithmetic Geometry Seminars, Oberseminars, and Math Department Colloquia: August 2022 to July 2025. Also participated in UGA Analysis Seminars and Graduate Student Seminars (GSS).

- Quebec-Vermont Number Theory Seminar (QVNTS) and Montréal Online Biweekly Inter-University Seminar on Analytic Number Theory (MOBIUS ANT) organized by the Centre Interuniversitaire en Calcul Mathématique Algébrique (CICMA): 2021–2022.
- Institute of Mathematical Sciences (IMSc) Number Theory seminars: 2019–2021.

3. Number Theory Web Seminar series: frequent participation from May 2020 onwards.
4. Summer schools, conferences and short courses participated in:
   - Summer school on 'Applications of Expander Graphs to Number Theory and Computer Science': *Conducted by The University of North Carolina at Greensboro (May 2021).*
   - Conference on Analytic and Probabilistic Number Theory commemorating Prof. Ramachandran Balasubramanian's 70th Birthday: *Conducted by the Institute of Mathematical Sciences (IMSc) Chennai (March 2021).*
   - Symposium on Number Theory in honor of Prof. M.V. Subbarao: *Conducted by the Indian Institute of Science Education and Research (IISER) Pune (July 2021).*
   - SPARC Lecture Series on "Algebraic numbers of small height", by Yuri Bilu (March 2021): *Work of Vesselin Dimitrov on the Schinzel-Zassenhaus conjecture.*
   - Short course on "p-adic numbers and Diophantine Equations" at the Institute of Mathematical Sciences IMSc (January 2020), instructed by Yuri Bilu.
   - Lecture series on "Effective Andre-Oort on products of modular curves" at the Indian Institute of Technology IIT Madras (February 2020), instructed by Yuri Bilu.

Other undergraduate research

- *Mahler measures, Lehmer's problem, the Schinzel-Zassenhaus conjecture*: with Sinnou David, IMJ-PRG (2020). Based on works of F. Amoroso, P.E. Blanksby, J. W. S. Cassels, V. Dimitrov, R. Dvornicich, K. Mahler, H. L. Montgomery, A. Schinzel, C. J. Smyth, and H. Zassenhaus.

Work Experience: Teaching and Service

Refereeing

Have refereed for the following journals from 2023 onwards:

- Monatshefte für Mathematik.
- "Women in Numbers Europe IV: Research Directions in Number Theory", Springer, Association for Women in Mathematics Series.
- Rose–Hulman Undergraduate Mathematics Journal.

Teaching and Service at UGA

- Served on committee for UGA High School Math Tournament 2024
  Contributed several questions and was involved in the design of the contest.

- Instructor of MATH 2250 (Calculus I) at UGA: Spring 2024, Fall 2024.
  Flipped/hybrid classroom structure.
- Served on committee for design of MATH 2250 final exam at UGA in Spring 2024 (was involved in the design of the exam). Also contributed to MATH 2250 final exam in Fall 2024.
- UGA MATH 2250 Active Learning Working Group: Spring 2024.
- Instructor for MATH 1113 (Precalculus) at UGA: Fall 2023.
  Flipped classroom structure.
- Grader for MATH 3100 (Sequences and series): Fall 2023.
  Instructed by Prof. Paul Pollack
- UGA Math Study Hall tutor: Spring 2024, Fall 2024, Spring 2025.
- Grader for MATH 4010/6010 (Modern Algebra II): Spring 2025.
  Instructed by Prof. Nate Harman
- Grader for MATH 3000 (Introduction to Linear Algebra): Spring 2025.
  Instructed by Prof. Joseph H. G. Fu

Teaching and Service prior to UGA

- Counselor in the Ross/Asia Mathematics program 2019.
  The Ross Program is a five to six week residential summer math program for high school students, primarily focused on algebra and number theory, – where students are immersed in the process of mathematical discovery via problem–solving. As a Counselor, I mentored the students, helped develop their problem–solving ability and provided detailed feedback on their work. We also discussed interesting research problems, and I gave several informal lectures introducing a variety of undergraduate and graduate–level math topics.

  Received the "Exemplary Counselor Award" which is given to a selected number of Counselors "in recognition of outstanding work at the Ross/Asia Mathematics Program".
- Served on committee for evaluating applications to the Ross Mathematics Program: 2020, 2021.
- Teaching assistant in the courses Algebra III and Algebra IV at the Chennai Mathematical Institute: 2020–2021.
- Contributed questions to and served as grader for the Scholastic Test for Excellence in Mathematical Sciences (STEMS) conducted by the Chennai Mathematical Institute: 2019.
- Junior Counselor in the Ross Mathematics Program at the Ohio State University: 2018.