Alex Rice

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Education

- **University of Georgia:** Ph.D., Mathematics, 2012
  - Thesis Advisor: Neil Lyall
  - Teaching Mentor: Malcolm Adams
  - Thesis Title: *Improvements and extensions of two theorems of Sárközy*
- **University of Georgia:** B.S., Mathematics, 2008, cum laude, with Honors

Employment History

Professor, Millsaps College . . . . . August 2023 - Present

Associate Professor, Millsaps College . . . . . August 2022 - August 2023

Assistant Professor, Millsaps College . . . . . August 2017 - August 2022

Visiting Assistant Professor, University of Rochester . . . . . September 2014 - May 2017

Visiting Assistant Professor, Bucknell University . . . . . August 2012 - May 2014

Graduate Assistant, University of Georgia . . . . . June 2009 - August 2012

Graduate Assistant, University of Wisconsin, Madision . . . . . August 2008 - May 2009

Research Interests

My research interests lie primarily in the field of arithmetic combinatorics, a rapidly developing area with close connections to number theory, combinatorics, harmonic analysis, and ergodic theory. I am particularly interested in applying analytic and combinatorial methods to locate arithmetic structures in sets of integers. For a representative example, my thesis work and several ongoing projects concern quantitative improvements and extensions of two theorems of Sárközy, the qualitative versions of which state that any set of natural numbers of positive upper density necessarily contains two distinct elements that differ by a perfect square, as well as two elements that differ by one less than a prime number. While continuing my personal research program in arithmetic combinatorics, I have also expanded my umbrella to facilitate collaboration with undergraduate students, and authored some semi-expository work for a broad mathematical audience.

Publications and Preprints

1) *The Furstenberg-Sárközy theorem for polynomials in one or more prime variables* (with John R. Doyle), submitted, `arXiv:2405.00868`.

2) *Determinants of Seidel tournament matrices* (with Sarah Klanderman, MurphyKate Montee, Andrzej Piotrowski, and Bryan Shader), Linear Algebra and Applications vol. 707 (2025), 126-151.

3) *The sum-product problem for small sets* (with Ginny Ray Clevenger, Haley Havard, Patch Heard, Andrew Lott, Brittany Wilson), Involve, vol. 18 (2025), no. 1, 165-180.

4) *A precise probability related to Simpson's paradox*, The College Mathematics Journal, Vol. 55 (2024), Issue 5, 400-405.

5) *Computations and observations on congruence covering systems* (with Raj Agrawal, Prarthana Bhatia, Kratik Gupta, Powers Lamb, Andrew Lott, Christine Rose Ward), INTEGERS Volume 24A (2024): Proceedings of the Integers 2023 Conference, Paper A1.

6) *Schur's theorem in integer lattices* (with Vishal Balaji, Andrew Lott), INTEGERS vol. 22 (2022), Paper A62.

7) *The pigeonhole principle and multicolor Ramsey numbers* (with Vishal Balaji, Powers Lamb, Andrew Lott, Dhruv Patel, Sakshi Singh, Christine Rose Ward), Involve vol. 15 (2022), no. 5, 857-884.

8) *Multivariate polynomial values in difference sets* (with John R. Doyle), Discr. Analysis, 2021:11, 46pp.

9) *Reciprocal sums and counting functions*, Amer. Math. Monthly, Vol. 129 (2022), Issue 10, 903-912.

10) *Sets in $\mathbb{R}^d$ determining k taxicab distances* (with Vajresh Balaji, Olivia Edwards, Anne Marie Loftin, Solomon Mcharo, Lo Phillips, Bineyam Tsegaye), Involve, vol. 13 (2020), no. 3, 487-509.

11) *Lattice configurations determining few distances* (with Vajresh Balaji, Olivia Edwards, Anne Marie Loftin, Solomon Mcharo, Lo Phillips, Bineyam Tsegaye), INTEGERS, vol. 20 (2020), Paper A86.

12) *Sets in $\mathbb{R}^d$ with slowly-decaying density that avoid an unbounded collection of distances*, Proceedings of the AMS 148 (2020), 523-526.

13) *Binary quadratic forms in difference sets*, Combinatorial and Additive Number Theory III, Springer Proceedings of Mathematics and Statistics vol. 297 (2020), 175-196.

14) *A maximal extension of the best-known bounds for the Furstenberg-Sárközy Theorem*, Acta Arithmetica 187 (2019), 1-41.

15) *Polynomials and primes in generalized arithmetic progressions* (with Ernie Croot and Neil Lyall), International Mathematics Research Notices (2015), no. 15, 6021-6043.

16) *A purely combinatorial approach to simultaneous polynomial recurrence modulo 1* (with Ernie Croot, Neil Lyall), Proceedings of the AMS 143 (2015), no. 8, 3231-3238.

17) *A quantitative result on Diophantine approximation for intersective polynomials* (with Neil Lyall), INTEGERS Volume 15A (2015), Proceedings of Integers 2013: The Erdős Centennial Conference.

18) *Sárközy's theorem for $\mathcal{P}$-intersective polynomials*, Acta Arithmetica 157 (2013), no. 1, 69-89.

19) *Improved bounds on Sárközy's theorem for quadratic polynomials* (with Mariah Hamel, Neil Lyall), International Mathematics Research Notices (2013), no. 8, 1761-1782.

20) *Polynomial differences in the primes* (with Neil Lyall), Combinatorial and Additive Number Theory 2011-2012, Springer Proceedings of Mathematics and Statistics vol. 101 (2014), 129-146.

21) *Torsion points on elliptic curves with complex multiplication* (author of appendix, paper by Pete Clark, Brian Cook, James Stankewicz), International Journal of Number Theory 9 (2013), 447-479.

22) *Computations on elliptic curves with complex multiplication* (with Pete Clark, Patrick Corn, Jim Stankewicz), LMS J. Comput. Math. 17, no. 1 (2014), 509-535.

Conference Presentations

- *Difference sets and polynomials in one or more prime variables*: AMS Fall Southeastern Sectional Meeting, Georgia Southern Univ. (Savannah), October 2024 (cancelled due to Hurricane Helene)
- *The sum-product problem for small sets*: Southern Regional Number Theory Conference, Louisiana State Univiersity, March 2024
  - Louisiana/Mississippi MAA Sectional Meeting, New Orleans, March 2024
  - PANTS XXXVII, University of Georgia, December 2023
- *Reciprocal sums and counting functions:* JMM in San Francisco, January 2024
  - Louisiana/Mississippi MAA Sectional Meeting, University of Mississippi, March 2023
- *New results on polynomials in difference sets:* AMS Fall Southeastern Sectional Meeting, Univ. of South Alabama, October 2023
  - INTEGERS, University of Georgia, May 2023
  - AMS Spring Southeastern Sectional Meeting, Georgia Tech, March 2023
  - Southern Regional Number Theory Conference, Louisiana State University, March 2022
- *A precise probability related to Simpson's paradox:* MAA Mathfest, Tampa, August 2023
  - Louisiana/Mississippi MAA Sectional Meeting, Northwestern State University, March 2022
- *Generalized arithmetic progressions and diophantine approximation by polynomials:* Combinatorial and Additive Number Theory (CANT), virtual, May 2023
  - Southern Regional Number Theory Conference, Louisiana State University, March 2023
- *New results in classical and arithmetic Ramsey theory:* Combinatorial and Additive Number Theory (CANT), virtual, May 2022
- *Two constructions related to well-known distance problems:* Combinatorial and Additive Number Theory (CANT), virtual, May 2021 (also featured in the Millsaps 2021 Fall Faculty Showcase)
- *Sets with slow-decaying density and unbounded missing distances:* Louisiana/Mississippi MAA Sectional Meeting, Loyola University New Orleans, February 2020
- *Deligne polynomials in difference sets:* CANT, CUNY Graduate Center, May 2019
- *Extending the best-known bounds on the Furstenberg-Sárkoẑy Theorem:* INTEGERS, Augusta St. Univ., October 2018
  - Combinatorial and Additive Number Theory (CANT), CUNY Graduate Center, May 2018
  - CanaDAM Conference, Ryerson Univerity, Toronto, June 2017

- *Difference sets and polynomials:* INTEGERS Conference, University of West Georgia, October 2016
  - Winter Meeting of the Canadian Mathematical Society, Montreal, December 2015
  - Combinatorial and Additive Number Theory (CANT), CUNY Graduate Center, May 2015
  - Southeastern Analysis Meeting (SEAM), University of Georgia, March 2015
- *Squares and primes in generalized arith. progressions:* INTEGERS, Univ. of W. Georgia, Oct. 2013
  - Combinatorial and Additive Number Theory (CANT), CUNY Graduate Center, May 2013
- *Sárközy's theorem for $\mathcal{P}$-intersective Polynomials*: SEAM 28, University of Alabama, March 2012
- *Polynomial patterns in subsets of the integers:* INTEGERS, Univ. of West Georgia, October 2011
  - PANTS XVI, Emory University, September 2011
- *Polynomial differences in the primes:* Add. Combinatorics Mini-Conf., Georgia Tech, June 2010
  - Combinatorial and Additive Number Theory (CANT), CUNY Graduate Center, May 2010

Research Seminar/Colloquium Talks

- *Barriers and breakthroughs in undergrad. math. research:* Belhaven STEM Seminar, March 2024
  - Millsaps College: Art of Research, October 2023; Board of Trustees Meeting, April 2023
- *Generalized arithmetic progressions and diophantine approximation by polynomials:* University of Georgia Analysis Seminar, March 2024
  - Oklahoma State Number Theory Seminar, February 2024
  - University of Mississippi Number Theory Seminar, October 2022
- *New results on polynomials in difference sets*: Oklahoma St. Number Theory Seminar, Oct. 2020
  - Louisiana Tech Algebra and Combinatorics Seminar, October 2019
  - University of Mississippi Number Theory Seminar, February 2019
- *Background and breakthroughs in density Ramsey theory*: Millsaps College Colloquium, Feb. 2017
  - Wake Forest University Colloquium, February 2017
  - University of Rochester Number Theory Seminar, November 2016
- *Squares and primes in generalized arithmetic progressions*: University of Rochester Number Theory Seminar, February 2015
  - UGA Analysis Seminar, January 2013
  - Bucknell University Algebra, etc. Seminar, October 2012
- *Difference sets and polynomials*: University of Rochester Combinatorics Seminar, September 2014
- *Diophantine approximation and polynomial configurations in sumsets:* Bucknell University Algebra, etc. Seminar, September 2013
- *Improvements and extensions of two theorems of Sárközy:* Penn State University Algebra and Number Theory Seminar, November 2012

- *Arithmetic patterns in dense sets of integers:* West Chester University Colloquium, September 2012
  - Bucknell University Colloquium, March 2012
- *Polynomial patterns in subsets of the integers:* UGA Number Theory Seminar, October 2011
  - Georgia Tech Combinatorics Seminar, September 2011
- *Polynomial differences in the primes:* UGA Number Theory Seminar, September 2010

Selected Student-Targeted Presentations

- *Math Isn't Done* (MID) general interest lecture series, Millsaps College
  - *Primes, squares, and beyond: the integers then and now*, September 2018
  - *Too many pigeons, not enough holes*, October 2018
  - *Randomness, structure, and a card game*, February 2019
  - *One person, one vote? The mathematics of elections and gerrymandering*, February 2020
  - *Baseball, birthdays, and bank Robbers: A survey of mathematical paradoxes*, November 2021
- *Joyful Math Jamborees* virtual lecture series, Texas State: *A cab ride with Erdős*, July 2020
- *Background and breakthroughs in density Ramsey theory*: Univ. of Roch. Math Club, March 2017
- Analysis and arithmetic combinatorics learning seminar: Co-organizer with Neil Lyall 2009 - 2012. I gave approximately 20 lectures on topics including Waring's problem, Vinogradov's three primes theorem, Roth's theorem, Sárközy's theorem, and the Green-Tao theorem.
- *Cantor's craziness*: UGA Undergraduate Math Club, September 2009
- *An introduction to elliptic curves* and L^p *spaces and* Λ^p *sets*: UGA VIGRE Graduate Student Seminar, June/September 2009
- *Density and substance: an investigation into the size of integer subsets:* UW-Madison Undergraduate Math Club, September 2008
  - UGA VIGRE Graduate Student Seminar, September 2007
  - UGA Undergraduate Math Club, August, 2007

Teaching Experience (ordered reverse chronologically by first preparation)

Millsaps College

- **Mathematics for Data Science (MATH 2400):** Spring 2025
- **Directed study in Calculus III (MATH 2240):** Spring 2025
- **Mathematical Statistics (MATH 4510):** Fall 2024
- **Differential Equations (MATH 3540):** Fall 2024
- **Directed study in Galois theory and number fields (MATH 4750):** Spring 2023

- **Directed study in topology (MATH 4660):** Fall 2022, Spring 2025
- **Abstract algebra (MATH 4620):** Spring 2022, Fall 2023
- **Directed study in analytic number theory (MATH 4752):** Fall 2021
- **Senior seminar (MATH 4902-12):** 2020-21, 2021-22, 2022-23
- **Statistics for behavioral sciences (PSYC 2100):** Fall 2020-23 (remote in '20)
- **Linear algebra (MATH 3650):** Spring 2020
- **Number theory (MATH 3620):** Fall 2019, Fall 2021, Fall 2024
- **Real analysis (MATH 4630):** Spring 2019-21 (remote in '21), '25
- **Calculus II (MATH 2230):** Spring 2019, Spring 2023
- **Calculus I (MATH 1220):** Fall 2018 (×3), Fall 2021-23 (×2 in '22)
- **Topics in math.: How Not to Be Wrong (MATH 1000):** Spring 2018-23 (remote in '21), '25
- **Elementary statistics (MATH 1150):** Spring 2018 (×2)
- **Putnam problem solving seminar (MATH 3751):** Fall 2017-19, '21
- **Complex variables (MATH 3580):** Fall 2017, Spring 2022
- **Precalculus (MATH 1130):** Fall 2017 (×2), Fall 2019 (×2), Fall 2020 (remote)

University of Rochester

- **Number Theory (MTH 230):** Fall 2016
- **Intro. to math. modeling for the life sciences (MTH 218):** Spring 2016, Spring 2017
- **Independent study w/ writing requirement (MTH 391W):** Spring 2016: Waring's problem, Fall 2016: Chebyshev's prime estimates
- **Calculus II (MTH 142):** Spring 2016, Spring 2017
- **Combinatorics (MTH 238):** Fall 2015
- **Linear algebra w/ diff. eq. (MTH 165):** Spring 2015, Fall 2016 (Course Czar)
- **Qualitative theory of ODEs (MTH 263):** Fall 2014
- **Calculus I (MTH 141):** Fall 2014, Spring 2015, Fall 2015

Bucknell University

- **Calculus III (MATH 211):** Spring 2014
- **Independent study:** Roth's theorem on arithmetic progressions, Spring 2014
- **Topics in calculus (MATH 192):** Spring 2014 (×2)
- **Calculus I (MATH 201):** Spring 2013 (×2), Fall 2013 (×2)
- **Differential equations (MATH 212):** Fall 2012, Fall 2013
- **Calculus II (MATH 202):** Fall 2012 (×2), Spring 2013

University of Georgia

- **Calculus with analytic geometry (MATH 2200):** Spring 2011
- **Precalculus (Math 1113):** Fall 2010

University of Wisconsin, Madison

- **Calculus and analytic geometry II (MATH 222):** Spring 2009
- **Calculus and analytic geometry I (MATH 221):** Fall 2008

Undergraduate Research Supervision

- **Kinnaird Institute Research Experience:** Each summer (global pandemics permitting), I supervise up to six Millaps undergraduate students in a four to five-week summer research experience, funded by the math department's Kinnaird Endowment. The following is a list of selected student research products from the program to date:
  - Six research articles (items 1,2,4,5,8, and 9 in the *Publications and Preprints* list above)
  - *Lattice configurations determining few distances*, Anne Marie Loftin: Second place for best presentation at 2020 Millsaps $\beta\beta\beta$ research symposium
  - *Sets in* $\mathbb{R}^3$ *determining one taxicab distance*, Bineyam Tsegaye: presentation at 2020 meeting of LA/MS MAA section
  - *Schur's theorem in integer lattices*, Andrew Lott: presentation at 2022 meeting of LA/MS MAA section (first place in student paper competition), 2023 AMS Southeastern Sectional Meeting, and INTEGERS 2023 conference
  - *Computations and observations on congruence covering systems*, Andrew Lott: presentation at 2023 meeting of LA/MS MAA section (first place in student paper competition) and 2023 Millsaps $\beta\beta\beta$ research symposium (first place for best presentation)
- **Andrew Lott, Millsaps:** Honors thesis in ramsey theory and arithmetic combinatorics (Spring 2022-Spring 2023, won Phi Beta Kappa award for best thesis and presentation), Ford fellowship focused on Calculus I-II (Fall 2022 - Spring 2023)
- **Sergei Kolesnik, Millsaps:** Research in soccer analytics (Spring 2022), Major Experience
- **Drew Hopkins, Millsaps:** Research in probability/game theory (Spring 2021), Major Experience
- **Tim Tribone, Univ. of Rochester:** Research on generalized arithmetic progressions (2016-17)
- **Research Experience for Undergraduates (REU):** I served as an instructor for the REU *Structure and Randomness: An Inivitation to Arithmetic Combinatorics* led by Neil Lyall and Mariah Hamel at the University of Georgia during Summer 2010.

Awards and External Grants

- **B.J. Ball Scholarship** (UGA, outstanding graduate student) **:** Received Spring 2012
- **Outstanding Graduate Teaching Award** (UGA, Departmental)**:** Received Spring 2012
- **Outstanding Teaching Assistant Award** (UGA, University-wide)**:** Received March 2012
- **NSF VIGRE Fellowship** ($25000/11 months)**:** 2009-2010, 2011-2012
- **NSF VIGRE Summer Fellowship** ($5000/2 months)**:** 2009, 2011
- **Commendation for Excellence in Teaching** (Millsaps)**:** every year 2017-18 – 2022-23
- **Commendation for Excellence in Scholarship** (Millsaps)**:** every year 2018-19 – 2022-23
- **Commendation for Excellence in Service** (Millsaps)**:** 2018-19, 2021-22, 2022-23
- **Richard A. Smith Award for Excellence in Scholarship or Creative Work** (Millsaps)**:** Received May 2023 for 2021-22 academic year
- **Janet R. Langley Award for Excellence in Academic Advising** (Millsaps)**:** Received May 2023 for 2021-22 academic year
- **Paul R. Halmos-Lester R. Ford Award:** Received at MAA MathFest 2023; This award is given by the MAA to recognize authors of articles of expository excellence published in *The American Mathematical Monthly*. Up to four awards are presented each year.
- **AMS-Simons Research Enhancement Grant for PUI Faculty**: 2023-26, $10,800/3 years

Selected Conferences/Workshops Attended (in addition to aforementioned presentations)

- **Structured Quartet Research Ensemble (SQuaRE)** — Pasadena, CA
  American Institute of Mathematics — *July 2023*

  This was a continuation meeting, funded on a competitive basis, for research conducted at the REUF workshop discussed in the next item.

- **Research Experience for Undergraduate Faculty (REUF)** — San Jose, CA
  American Institute of Mathematics — *August 2022*

  I was selected on a competitive basis to participate in a week-long research workshop for faculty from primarily undergraduate institutions, with paid-for travel and accommodations in San Jose.

- **ACS Social Justice Mathematics Symposium** — Atlanta, GA
  Spelman College — *June 2019*
- **Georgia Discrete Analysis Conference** — Athens, GA
  University of Georgia — *May 2018*
- **Spring Mini-Courses in Analysis and Geometry** — Baton Rouge, LA
  Louisiana State University — *February 2018*
- **IMA Workshop: Additive and Analytic Combinatorics** — Minneapolis, MN
  Institute of Mathematics and Applications — *September-October 2014*

- **IPAM Workshop: Kakeya, Restriction, and Sum-product Theory** — Los Angeles, CA
  Institute of Pure and Applied Mathematics — *May 2014*
- **Kent State Informal Analysis Seminar** — Kent, OH
  Kent State University — *March 2014*
- **Additive Combinatorics in Paris 2012** — Paris, France
  Institut Henri Poincaré — *July 2012*
- **Summer School** — Catalina Island, CA
  Catalina Canyon Resort — *June 2012*

  I was selected as one of sixteen participants for a highly competitive one-week summer school in harmonic analysis, geometric measure theory, and additive combinatorics, with paid-for travel and accommodations at Catalina Canyon Resort.
- **Oscillatory Integrals in Harmonic Analysis** — Edinburgh, Scotland
  ICMS — *June 2011*
- **Workshop on Discrete Methods in Ergodic Theory** — Evanston, IL
  Northwestern University — *February 2011*
- **Southeastern Analysis Meeting (SEAM) 26** — Atlanta, GA
  Georgia Tech — *March 2010*
- **MAA MathFest**
  Madison, Lexington, Tampa — *August 2008, 2011, 2023*
- **AMS/MAA Joint Meetings**
  S.D., D.C., New Orleans, Boston, Balt., Atl. — *January 2008, '09, '11, '12, '14, '17*
- **NSF FRG Conference: New Developments in Harmonic Analysis** — Athens, GA
  University of Georgia — *October 2007*

Millsaps College Committe Work

- **Divisional Personnel Committee:** Elected to serve beginning Fall 2023.
- **Faculty Council:** Represented Sciences division Summer 2020 - Spring 2022.
- **Faculty Assessment Committee:** Elected to serve beginning in Spring 2018, reviewed MYRAs for the Sciences Division and drafted the final committee report.
- **Curriculum Committee:** Elected to serve beginning Fall 2022, temporary chair for Fall 2023
- **Honors Committee:** Served Fall 2018 - Spring 2021 before taking over as program director.
- **Honors Program Director:** Fall 2021 - Spring 2025
- **STEM and Data Science Pathway Coordinator:** Fall 2021 - Spring 2024
- **Recruitment and Enrollment Strategic Initiative Working Group:** Spring - Summer 2019
- **Cost Reduction Strategic Initiative Working Group:** Spring - Summer 2019
- **Pathways Working Group:** Fall 2019
- **All College Council:** 2018-19
- **Athletics Committee:** 2018-19

Additional Service

- **Millsaps College High School Mathematics Competition:** Competitions held on campus at Millsaps in October or November 2019, 2021, 2022, 2023, and 2024, each with 50-70 students representing 9-13 Mississippi high schools. All five events (with a gap due to the pandemic in between) were big successes, and I hope to continue and expand the event in the future.
- **LA/MS MAA Sectional Meeting:** Each spring since 2019 (global pandemics permitting), I have taken a group of students to the annual meeting of the LA/MS section of the Mathematical Association of America, in order for them to attend talks, give presentations, and/or participate in the event's two annual competitions, the integration bee and the team competition. While competitive success is not the primary goal, we have had some: for the integration bee, Bineyam Tsegaye finished second in 2019, Andrew Lott finished third in 2023, and Raj Agrawal finished fourth in 2023. Millsaps won the team competition in 2022, finished second in 2023, and finished third in 2024. Also, Andrew Lott won the student paper competition in both 2022 and 2023.
- **Putnam Problem Solving Seminar:** Beginning Fall 2017, I have led (co-led with Dr. Emlee Nicholson the first year) a weekly seminar to prepare interested Millsaps students for the Putnam Exam, the world's most prestigious undergraduate mathematics competition.
- **Putnam Exam Grader:** Helped grade the 81st Putnam Exam (as mentioned in the previous item) in February-March 2021, and the 82nd competition in December 2021. I served as a "problem captain" while grading the 83rd-85th competitions in December 2022-24.
- **Math Olympiad Grader:** I served as a "problem captain" for grading the United States Math Olympiad in March 2024.
- **Mississippi Mu Alpha Theta:** I wrote problems for the 2021, 2022, and 2023 annual convention competitions for Mississippi Mu Alpha Theta, the state high school mathematics honors society. I was invited to visit the convention and speak to students in April 2022.
- **Referee:** Proceedings of the AMS, Journal of Number Theory, Acta Arithmetica, American Mathematical Monthly, Involve: A Mathematics Journal, Compositio Mathematica, Annales Academiae Scientiarum Fennicae Mathematica, Communications in Algebra, Minnesota Journal of Undergraduate Mathematics, Rocky Mountain Journal of Mathematics, Ramanujan Journal, International Mathematics Research Notices, Integers, Electronic Journal of Combinatorics
- **Reviewer for MathSciNet and ZbMATH:** Several reviews per year.
- **MATHCOUNTS Question Writing Committee:** From April 2016 to November 2018, I served on a six-person committee that writes all of the questions for the school, chapter, state, and national levels of the largest middle school math competition in the U.S.
- **University of Georgia High School Math Tournament:** I contributed several questions to the written exam and helped run the tournament in 2006, 2007, 2009, 2010, and 2011.

Technical Skills

- LaTeX, SageMath, Python, Java