

Caroline L. Turnage-Butterbaugh

Carleton College

Department of Mathematics and Statistics

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Research Interests

analytic number theory – zeros and moments of L -functions (e.g. the Riemann zeta-function, Dirichlet L -functions, Dedekind zeta-functions, and automorphic L -functions) and class groups of number fields

Professional Appointments

- 2018 – present **Assistant Professor of Mathematics**, Carleton College
2014 – 2018 **William W. Elliott Assistant Research Professor**, Duke University
Spring 2017 **Postdoctoral Fellow**, Mathematical Sciences Research Institute (MSRI)
2014 – 2015 **Postdoctoral Research Fellow**, North Dakota State University
Summer 2014 **Postdoctoral Undergraduate Research Mentor**, Williams College

Education

- May 2014 **Ph.D. Mathematics**, University of Mississippi
May 2008 **M.A. Mathematics**, Wake Forest University
May 2006 **B.A. Mathematics & French**, Wofford College, *magna cum laude*

Fellowships and Grants

- 2023 – 2028 **National Science Foundation CAREER Grant (P.I.)**
DMS-2239681, \$400,000
2019 – 2023 **National Science Foundation Grant (P.I.)**
DMS-1902193, \$74,980
2019 – 2023 **National Science Foundation FRG Grant (Senior Scientist Consultant)**
DMS-1854398
2020 **Carleton College Hewlett Mellon Fellowship**
2020 **Carleton College Curriculum Development Grant**
2019 **US Junior Oberwolfach Fellow**
2019 **MAA Project NExT Fellow**, Silver'19 cohort
2019 **Carleton College Curriculum Innovation Grant**
2018-2019 **AMS-Simons travel grant**
2014 **AWM/ NSF travel grant**, DMS-1153905
2009-2014 **GAANN Graduate Studies Fellowship**, University of Mississippi

Awards

- 2018 **Top 5% Teaching Evaluations**, Trinity College of Arts & Sciences, Duke University

Awards (continued)

- 2014 **University of Mississippi Class Marshal**
2013 **Graduate Instructor Excellence in Teaching Award**, University of Mississippi
2013 **Graduate Student Research Achievement Award in Mathematics**, University of Mississippi

Publications and Preprints

Preprints

1. S. Baluyot, D. A. Goldston, A. I. Suriajaya, and C. L. Turnage-Butterbaugh, “An unconditional montgomery theorem for pair correlation of zeros of the Riemann zeta function”, *arXiv: 2306.04799*, submitted, p. 13, 2023.
2. S. Baluyot and C. Turnage-Butterbaugh, “Twisted $2k$ th moments of primitive Dirichlet L -functions: Beyond the diagonal”, *arXiv: 2205.00641*, submitted, p. 99, 2022.

Publications

1. D. A. Goldston, T. S. Trudgian, and C. L. Turnage-Butterbaugh, “On the Montgomery- Odlyzko method regarding gaps between zeros of the zeta-function”, *Journal of Mathematical Analysis and Applications*, vol. 527, no. 2, Paper No. 127548, 7, 2023.
2. A. Simonič, T. S. Trudgian, and C. L. Turnage-Butterbaugh, “Some explicit and unconditional results on gaps between zeroes of the Riemann zeta-function”, *Trans. Amer. Math. Soc.*, vol. 375, no. 5, pp. 3239–3265, 2022.
3. E. Carneiro, M. K. Das, A. Florea, A. V. Kumchev, A. Malik, M. B. Milinovich, C. Turnage-Butterbaugh, and J. Wang, “Hilbert transforms and the equidistribution of zeros of polynomials”, *J. Funct. Anal.*, vol. 281, no. 9, Paper No. 109199, 25, 2021.
4. L. B. Pierce, C. L. Turnage-Butterbaugh, and M. M. Wood, “On a conjecture for ℓ -torsion in class groups of number fields: From the perspective of moments”, *Math. Res. Lett.*, vol. 28, no. 2, pp. 575–621, 2021.
5. C. David, A. Gafni, A. Malik, N. Prabhu, and C. L. Turnage-Butterbaugh, “Extremal primes for elliptic curves without complex multiplication”, *Proc. Amer. Math. Soc.*, vol. 148, no. 3, pp. 929–943, 2020.
6. L. B. Pierce, C. L. Turnage-Butterbaugh, and M. M. Wood, “An effective Chebotarev density theorem for families of number fields, with an application to ℓ -torsion in class groups”, *Invent. Math.*, vol. 219, no. 2, pp. 701–778, 2020.
7. J. B. Conrey and C. L. Turnage-Butterbaugh, “On r -gaps between zeros of the Riemann zeta-function”, *Bull. Lond. Math. Soc.*, vol. 50, no. 2, pp. 349–356, 2018.
8. H. M. Bui, W. P. Heap, and C. L. Turnage-Butterbaugh, “Gaps between zeros of Dedekind zeta-functions of quadratic number fields. II”, *Q. J. Math.*, vol. 67, no. 3, pp. 467–481, 2016.
9. W. D. Banks, T. Freiberg, and C. L. Turnage-Butterbaugh, “Consecutive primes in tuples”, *Acta Arith.*, vol. 167, no. 3, pp. 261–266, 2015.
10. M. B. Milinovich and C. L. Turnage-Butterbaugh, “Moments of products of automorphic L -functions”, *J. Number Theory*, vol. 139, pp. 175–204, 2014.
11. C. L. Turnage-Butterbaugh, “Gaps between zeros of Dedekind zeta-functions of quadratic number fields”, *J. Math. Anal. Appl.*, vol. 418, no. 1, pp. 100–107, 2014.

Publications and Preprints (continued)

Publications with Undergraduates (SMALL 2014 REU)

1. A. Best, P. Dynes, X. Edelsbrunner, B. McDonald, S. J. Miller, K. Tor, C. Turnage-Butterbaugh, and M. Weinstein, “Gaussian distribution of the number of summands in generalized Zeckendorf decomposition in small intervals”, *Integers*, vol. 16, 2016.
2. A. Best, P. Dynes, X. Edelsbrunner, B. McDonald, S. J. Miller, K. Tor, C. Turnage-Butterbaugh, and M. Weinstein, “Benford behavior of Zeckendorf decompositions”, *Fibonacci Quart.*, vol. 52, no. 5, pp. 35–46, 2014.
3. A. Best, P. Dynes, X. Edelsbrunner, B. McDonald, S. J. Miller, K. Tor, C. Turnage-Butterbaugh, and M. Weinstein, “Gaussian behavior of the number of summands in Zeckendorf decompositions in small intervals”, *Fibonacci Quart.*, vol. 52, no. 5, pp. 47–53, 2014.

Book Contributions

1. A. Best, P. Dynes, X. Edelsbrunner, B. McDonald, S. J. Miller, K. Tor, C. Turnage-Butterbaugh, and M. Weinstein, “Benford behavior of generalized Zeckendorf decompositions”, in *Combinatorial and additive number theory. II*, ser. Springer Proc. Math. Stat. Vol. 220, Springer, Cham, 2017, pp. 25–37.
2. O. Barrett, F. W. K. Firk, S. J. Miller, and C. Turnage-Butterbaugh, “From quantum systems to L -functions: Pair correlation statistics and beyond”, in *Open problems in mathematics*, Springer, [Cham], 2016, pp. 123–171.
3. B. Mackall, S. J. Miller, C. Rapti, C. Turnage-Butterbaugh, and K. Winsor, “Some results in the theory of low-lying zeros of families of L -functions”, in *Families of automorphic forms and the trace formula*, ser. Simons Symp. Springer, [Cham], 2016, pp. 435–476.

Teaching Experience

Carleton College

- Math 111 *Introduction to Calculus* – Fall 2018, Winter 2019, Fall 2019, Fall 2020
- Math 120 *Calculus 2* – Fall 2019, Winter 2020
- Math 210 *Calculus 3* – Winter 2020, Winter 2023, Winter/Spring 2024 (upcoming)
- Math 232 *Linear Algebra* – Winter 2021, Fall 2022
- Math 236 *Mathematical Structures* – Winter 2023, Fall 2023
- Math 261 *Functions of a Complex Variable* – Spring 2019
- Math 282 *Elementary Theory of Numbers* – Fall 2023
- Math 312 *Elementary Theory of Numbers* – Spring 2019 (adjusted and now offered at the 200-level)
- Math 321 *Real Analysis I* – Fall 2020, Fall 2023
- Math 361 *Complex Analysis* – Spring 2020, Winter 2024 (upcoming)
- Math 395 *Introduction to Analytic Number Theory* – Spring 2021, Spring 2023
- Math 390 *Independent Study* (2 credits), *Dirichlet Characters*, 1 student, Spring 2020
- Math 391 *Independent Reading* (2 credits), *The Circle Method*, 3 students, Spring 2023

Teaching Experience (continued)

- Math 392 *Independent Research* (3 credits), *Random Matrix Theory and Zeros of the Riemann Zeta-function*, 2 students, Spring 2023

Duke University

- Math 221 *Linear Algebra and Applications* – Fall 2015, Fall 2016, Fall 2017
- Math 305s *Elementary Number Theory Seminar* – Spring 2016, Spring 2018

North Dakota State University

- Math 165 *Calculus I* – Fall 2014, Spring 2015
- Math 472/672 *Elementary Number Theory* – Spring 2015

University of Mississippi (instructor of record)

- Math 123 *Trigonometry* – Spring 2012, Spring 2013
- Math 125 *Precalculus* – Fall 2010, Spring 2011, Fall 2011
- Math 267 *Business Calculus I* – Fall 2009
- Math 261 *Calculus I* – Fall 2013, Fall 2012
- Math 597 *Introduction to Analytic Number Theory*, co-instructor with M. Milinovich, Spring 2014

Senior Comps Advising, Carleton College

Group Comps Advising

- 2023-2024 – 5 students, Project Title: *Binary Quadratic Forms*
- 2022-2023 – 3 students, Project Title: *A User-friendly Guide to Riemann's Memoir*
- 2020-2021 – 4 students, Project Title: *Bernoulli Numbers and the Class Groups of Cyclotomic Fields*
- 2018-2019 – 4 students, Project Title: *Number Theory in Polynomial Rings*

Independent Comps Co-Advising

- 2023-2024 – 3 students (Fall '23)
- 2022-2023 – 1 student (Fall '22), 1 student (Winter '23)
- 2020-2021 – 1 student (Winter/Spring '21)
- 2019-2020 – 2 students (Fall '19)

Research Visits for Collaboration

- Kansas State University – April 2024 (upcoming)
- Duke University – December 2022, September 2022, December 2019, January 2015
- École Polytechnique Fédérale de Lausanne (EPFL), September 26 - 30, 2022

Research Visits for Collaboration (continued)

- NSF Focused Research Group, American Institute of Mathematics (AIM) – February-March 2022, August 2021, August/September 2019
- Department of Mathematics, University of New South Wales - Canberra – March 2018
- Institute for Advanced Study (IAS) – May 2018
- Max Planck Institute of Mathematics (MPIM) – July 2018
- Institute for Computational and Experimental Research in Mathematics (ICERM) – November 2015
- Department of Mathematics, University of Missouri – November 2013

Invited Conference and Workshop Participation

- Institut Mittag-Leffler – March 2024 (upcoming)
- Delta Symbols and the Subconvexity Problem, AIM – October 2023
- Arithmetic, Algebra, and Algorithms, International Centre for Mathematical Sciences – April 2023
- 50 Years of Number Theory & Random Matrix Theory Conference, IAS – June 2022
- Automorphic Forms and Arithmetic, Oberwolfach – August/September 2020
- MathFest (Project NExT Fellow) – July/August, 2020
- Analytic Number Theory, Oberwolfach – November 2019
- MathFest (Project NExT Fellow) – July/August 2019
- Women in Numbers 4 (WIN4), Banff International Research Station – August 2017
- Moments of Zeta and Correlations of Divisor Sums, AIM – August/September 2016
- Bounded Gaps Between Primes, AIM – November 2014

Invited Research Lectures and Presentations

Plenary Talks

- Pittsburgh Links among Analysis and Number Theory, University of Pittsburgh & Carnegie Mellon University – March 2024 (upcoming)
- 47th Annual New York Regional Graduate Mathematics Conference, Syracuse University – April 2022

Department Colloquia

- University of Illinois Urbana-Champaign, December 2023 (upcoming)
- Vanderbilt University, November 2023 (upcoming)
- University of New South Wales Canberra – March 2018

Department Colloquia (continued)

- Oberlin College – November 2017
- Wake Forest University – April 2016
- Williams College – January 2015, June 2014
- Wofford College – April 2014

Summer Programs for Graduate Students and Postdocs

- ANTeater, University of California Irvine – August 2022
- *L*-functions: Open Questions and Current Methods, Summer school on *L*-functions, Hausdorff Center for Mathematics – June 2018 (3 lectures)
- New Trends in Analytic Number Theory, LMS-CMI Research School, University of Exeter – August 2018

REU Talks

- PRiME (Pomona Research in Mathematics Experience) Colloquium – July 2022
- Summer Research Seminar, Wofford College – June 2021
- Bridging Theoretical and Applied Mathematics REU, Winthrop University – June 2016
- WADE Into Research REU, Wake Forest University – June 2016

Seminar Talks

- Number Theory Seminar, University of Illinois Urbana-Champaign, December 2023 (upcoming)
- Joint Athens-Atlanta Number Theory Seminar, October 2023
- Algebra and Number Theory Seminar, University of Rochester, March 15, 2023
- Number Theory Seminar, Duke University, December 7, 2022
- Number Theory Seminar, École Polytechnique Fédérale de Lausanne, September 28, 2022
- Algebraic Geometry and Number Theory Seminar, Chalmers University of Technology / University of Gothenburg – October 2021
- Focused Research Group (FRG) Graduate Seminar, American Institute of Mathematics – October 2021
- Number Theory Seminar, Vanderbilt University – May 2021
- Quebec-Maine Number Theory Seminar, University of Montreal – April 2021
- Number Theory Seminar, University of Virginia – April 2021
- Analytic Number Theory and Harmonic Analysis Seminar, Purdue University – March 2021
- Focused Research Group Seminar, American Institute of Mathematics – March 2021
- Number Theory Seminar, Kansas State University – March 2021
- ViBrANT Seminar (Virtual Brazilian Analytic Number Theory) – February 2021

Seminar Talks (continued)

- Number Theory Seminar, University of Mississippi – February 2021
- VaNTAGe (Virtual seminar on open conjectures in Number Theory & Arithmetic Geometry) – February 2020
- Number Theory Seminar, University of Minnesota – December 2018
- Number Theory Seminar, University of New South Wales Sydney – March 2018
- Pure Maths Seminar, University of New South Wales Sydney – March 2018
- Number Theory Seminar, MPIM – July 2018
- PLeaSANTS, MPIM – July 2018
- Algebra and Number Theory Seminar, University of Cologne – July 2018
- Algebra, Geometry, and Number Theory Seminar, Tufts University – November 2017
- Algebraic Geometry and Number Theory Seminar, Rice University – April 2017
- Number Theory Seminar, University of South Carolina – November 2016
- Number Theory Seminar, University of Illinois Urbana-Champaign – April 2016
- UNC-Duke Number Theory Seminar, Duke University – January 2015

Conference/Workshop Talks

- AMS Special Session on Analytic Number Theory and Related Fields, Omaha, October 2023 (upcoming)
- Number Theory Days, EPFL, September 30-October 1, 2022
- AMS Special Session Analytic Theory of Automorphic Forms & L -Functions, JMM – January 2020
- Analytic Number Theory Workshop, Oberwolfach Research Institute for Mathematics – November 2019
- NSF-CBMS Conference: L -functions & Multiplicative Number Theory, U. of Mississippi – May 2019
- Analytic Aspects of Automorphic Forms, Université de Lille – April 2019
- Value Distribution of Zeta and L -functions and Related Topics, RIKEN Institute – March 2019
- CMS Special Session, CMS Winter Meeting, Vancouver – December 2018
- AMS Special Session, AMS Sectional Meeting Washington State University – March 2017
- Connections for Women, Analytic Number Theory Workshop, MSRI – February 2017
- AMS Special Session on Analytic number theory and arithmetic, JMM – January 2017
- 30th Automorphic Forms Workshop, Wake Forest University – March 2016
- Computational aspects of L -functions, ICERM – November 2015
- Elementary, analytic, and algorithmic number theory: Research inspired by the mathematics of Carl Pomerance, University of Georgia – June 2015

Conference/Workshop Talks (continued)

- AMS Special Session on Analytic Methods in Elementary Number Theory, AMS Spring Southeastern Sectional Meeting, University of Alabama – March 2015
- Exciting New Faces in Analytic Number Theory (ENFANT), Hausdorff Center for Mathematics, Bonn – July 2014
- AMS Special Session on Modern Methods in Analytic Number Theory, AMS Sectional Meeting, University of Mississippi – March 2013

Talks for High School Students

- Summer Workshop in Mathematics (SWIM) (2 week course instructor), Duke University – June 2017
- Harkness Table Series, Spartanburg Day School – October 2016
- Summer Workshop in Mathematics (SWIM), Duke University – June 2016

Professional Service

- AMS-Simons Travel Grants Selection Committee – February 2024-2027 (upcoming appointment)
- Application Reviewer, Women and Mathematics (WAM), Institute for Advanced Study – Spring 2023
- NFS Review Panelist – 2020, 2021, 2023
- Referee – Algebra & Number Theory, Algorithmic Number Theory Symposium Proceedings, American Mathematical Monthly, Bulletin of the London Mathematical Society, Cambridge Philosophical Society, Crelle's Journal (Journal für die reine und angewandte Mathematik), Indagationes Mathematicae, INTEGERS, International Mathematical Research Notices, International Journal of Number Theory, Journal of the European Mathematical Society, Journal of Number Theory, Mathematika, Quarterly Journal of Mathematics, Transactions of the AMS, Women in Numbers Proceedings
- Co-organizer (with H. Tran and Y. Tang), AWM Research Symposium Special Session *Number Theory*, Institute for Mathematics and its Applications, Minneapolis, Minnesota – 2022
- External PhD Thesis Committee, Quanli Shen, University of Lethbridge – 2021
- Co-organizer (with A. Malik and G. Martin), MCA Special Session *Advances in algebraic and analytic number theory*, MCA, Montreal, Quebec – 2017
- Co-director (with A. Alvarado, J. Fuselier, H. Hahn, and L. Pierce), re:boot Number Theory 2017, Duke University – June 6-9, 2017 www.math.duke.edu/~pierce/Reboot2016.shtml
- Co-organizer (with M. Nastasescu), MAA Invited Paper Session *L-functions and other animals*, JMM in Atlanta, Georgia – 2017
- Co-director (with A. Bucur, H. Hahn, P. Pajananen, and L. Pierce), re:boot Number Theory 2016, Duke University – March 17-20, 2016 www.math.duke.edu/~pierce/Reboot2016.shtml

Carleton College Service

Service to the Department of Mathematics and Statistics

- Hiring Committee for 2023-2024 VAP Mathematics search, member – Winter/Spring 2023
- NUMS (Northfield Undergraduate Mathematics Symposium), co-organizer – Fall 2018, Fall 2019, Fall 2020, Fall 2021, Fall 2022, Fall 2023
- Department of Mathematics & Statistics Colloquium, co-organizer – 2020-2021, 2022-2023
- Interviewer for 2021-2022 Assistant Professor of Mathematics search, December 2021– January 2022 - While on sabbatical, I assisted the hiring committee with first round Zoom interviews in December 2021 and participated in all of the usual departmental hiring duties during January 2022.
- SWiMS+ (Society for Women in Mathematics & Statistics), faculty co-organizer – 2018-2020
- Math Skills Center Tutor Training, faculty liaison – 2019-2020
- Graduate School Panel, panelist – Fall 2018

Service to the College

- Advising – 2019-2021, 2022-present
- College Council, untenured-when-elected faculty committee member – 2022-present
- Campus Recreation Advisory Committee, faculty member – 2019-2021
- FOCUS, colloquium speaker – Fall 2019
- Inside Carleton Alumni Magazine *For the Love of Teaching*, cover – Spring 2019

Previous Departmental and Institutional Service

- ONTO-Math, committee member, Duke University – Fall 2016
- Summer Workshop in Mathematics (SWIM), faculty advisory committee, Duke University – June 2016
- Graduate Student Seminar, Department of Mathematics, U. of Mississippi – founder and organizer
- Allies @ Ole Miss, Ally, Fall 2012 – Spring 2014 - member of network of faculty who are visibly supportive of students from the LGBTQ+ community
- Graduate Women's Group, U. of Mississippi – Committee member, Fall 2012 – Spring 2013

Outreach

- Letters to a Pre-Scientist, penpal – 2019-2020
- Science Question from a Toddler, fivethirtyeight.com – October 2017
– consultant for the article [cnn](http://cnn.com) – consultant for the article *What Would Happen If There Were No Number 6?*
www.fivethirtyeight.com/features/what-would-happen-if-there-were-no-number-6
- SWIM (Summer Workshop in Mathematics), Duke University – June 2017
– course instructor for workshop for female high school students
www.math.duke.edu/SWIM/SWIM2017

Outreach (continued)

- Southeastern Conference for Undergraduate Women in Mathematics, Duke University – Nov. 2016
– invited speaker for introduction lecture and activity “How to Conference Like a Professor”
designed to encourage and facilitate networking among the conference’s undergraduate participants
- Dinner for 8, Duke University – October 2016
– invited by a current student to co-host a dinner with members of the UNC-Duke University
Robertson Scholar Program to share my experiences in academia
- Harkness Series Lecture, Spartanburg Day School – October 2016
– lecture on primes given to upper school students at Spartanburg Day School in Spartanburg, SC
- SWIM Lecture, Duke University – June 2016
– lecture on primes given to female rising high school students at SWIM 2016 held at Duke
University
- NDSU Math Department Outreach Activity – April 2015
– visited a local elementary school to demonstrate tic-tac-toe on a torus
- Nebraska Conference for Undergraduate Women in Mathematics – January 2012
– invited graduate panelist for discussions and break-out sessions
- Gear Up Mississippi Summer College Lecture – July 2009, July 2010
– lecture on fractals with hands-on activities demonstrating connection between mathematics and art

Training and Workshop Participation

- Mental Health First Aid Training, Carleton College – May 2019
- Structuring the Classroom for Inclusive Teaching, CIT, Duke University – October 2016
- Center for Instructional Technology (CIT) Showcase, Duke University – October 2016
 - *Critical Race Theory for Improving College Courses*, workshop
 - *Ideas for Great Group Work*, workshop
 - *Improve Your Teaching with Meaningful Student Feedback*, workshop
- P.R.I.D.E Training, Center for Sexual and Gender Diversity, Duke University – April 2016

Professional Organization Memberships

- American Mathematical Society
- Association for Women in Mathematics
- National Association of Mathematicians
- Math Alliance
- Mathematical Association of America