

Rafe Jones

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Carleton College
Department of Mathematics
1 North College St.
Northfield, MN 50557

Employment

CARLETON COLLEGE, Northfield, MN

Assistant Professor, 2012 – 2016
Associate Professor, 2016 – present

COLLEGE OF THE HOLY CROSS, Worcester, MA

Assistant Professor, 2008 – 2012

UNIVERSITY OF WISCONSIN, Madison, WI

VIGRE Van Vleck Visiting Assistant Professor, 2005 – 2008

Education

BROWN UNIVERSITY, Providence, RI

Ph.D., Mathematics, May 2005
Advisor: Joseph Silverman
Thesis Title: Galois Martingales and the Density of the p-adic Hyperbolic Mandelbrot Set

ÉCOLE NORMALE SUPÉRIEURE, Paris, France

Visiting student, Département de Mathématiques et Applications, 1998-99

AMHERST COLLEGE, Amherst, MA

B. A., Mathematics and French, June 1998
Summa Cum Laude, with Departmental Distinction in Mathematics
Phi Beta Kappa

Research Interests

- Galois theory and irreducibility of polynomials (particularly involving iterated morphisms)
- Discrete dynamics (particularly iteration of rational functions over global and finite fields)
- Automorphism groups of rooted trees and iterated monodromy groups
- Elliptic curves and torsion fields
- Recurrence sequences

Refereed Publications

1. Spencer Hamblen and Rafe Jones. Roots of unity and higher ramification in iterated extensions. *Proc. Amer. Math. Soc.* **152**(11) (2024), 4687–4702.
2. Andrew Bridy, Rafe Jones, Gregory Kelsey, and Russell Lodge. Iterated monodromy groups of rational functions and periodic points over finite fields. *Math. Ann.* **390** (2024), 439-475.
3. John Doyle, Vivian Olsiewski Healey, Wade Hindes, and Rafe Jones. Galois groups and prime divisors in random quadratic sequences. *Math. Proc. Cambridge Philos. Soc.* **176** (2024), no. 1, 95–122.
4. Peter Illig, Rafe Jones, Eli Orvis, Yukihiro Segawa, and Nick Spinale. Newly reducible polynomial iterates. *Int. J. Number Theory* **17**(6) (2021), 1405-1427.

5. David DeMark, Wade Hindes, Rafe Jones, Moses Mispion, and Michael Stoneman. Eventually stable quadratic polynomials over \mathbf{Q} . *New York J. Math.* **26** (2020), 526-561.
6. Wade Hindes and Rafe Jones. Riccati equations and polynomial dynamics over function fields. *Trans. Amer. Math. Soc.* **373**(3) (2020), 1555-1575.
7. Robert Benedetto, Patrick Ingram, Rafe Jones, Michelle Manes, Joseph H. Silverman, and Thomas J. Tucker. Current trends and open problems in arithmetic dynamics. *Bull. Amer. Math. Soc.* **56**(4) (2019), 611-685.
8. Rafe Jones, Jordan Cahn, and Jacob Spear. Powers in orbits of rational functions: cases of an arithmetic dynamical Mordell-Lang conjecture. *Canad. J. Math.* **71**(4) (2019), 773-817.
9. Rafe Jones and Alon Levy. Eventually stable rational functions. *Int. J. Number Theory* **13** (9) (2017), 2299-2318.
10. Andrew Bridy, Patrick Ingram, Rafe Jones, Jamie Juul, Alon Levy, Michelle Manes, Simon Rubinstein-Salzedo, and Joseph H. Silverman. "Finite ramification for preimage fields of postcritically finite morphisms." *Math. Res. Lett.* **24**(6) (2017), 1633-1647.
11. Benjamin Breen, Rafe Jones, Thomas Occhipinti, and Michelle Yuen. Wild ramification in a family of low-degree extensions arising from iteration. *JP J. Algebra Number Theory Appl.* **37**(1) (2015), 69-104.
12. Spencer Hamblen, Rafe Jones, and Kalyani Madhu. The density of primes in orbits of $z^d + c$. *Int. Math. Res. Not. IMRN* **7** (2015) 1924–1958.
13. Rafe Jones. Fixed-point-free elements of iterated monodromy groups. *Trans. Amer. Math. Soc.* **367**(3) (2015) 2023-2049.
14. Robert Benedetto, Patrick Ingram, Rafe Jones, and Alon Levy. Attracting cycles in p -adic dynamics and height bounds for post-critically finite maps. *Duke Math. J.* **163**(13) (2014) 2325-2356.
15. Rafe Jones and Michelle Manes. Galois theory of quadratic rational functions. *Comment. Math. Helv.* **89**(1) (2014), 173-213.
16. Katharine Chamberlin, Emma Colbert, Sharon Frechette, Patrick Hefferman, Rafe Jones, and Sarah Orchard. Newly reducible iterates in families of quadratic polynomials. *Involve: A Journal of Mathematics* **5**(4) (2012), 481-495.
17. Rafe Jones. An iterative construction of irreducible polynomials reducible modulo all primes. *J. Algebra* **369** (2012), 114-128.
18. Nigel Boston and Rafe Jones. Settled polynomials over finite fields. *Proc. Amer. Math. Soc.* **140**(6) (2012), 1849-1863.
19. Rafe Jones. Achievement sets of sequences. *Amer. Math. Monthly* **118**(6) (2011), 508-521.
20. Rafe Jones and Han Peters. Blocks of monodromy groups in complex dynamics. *Geom. Dedicata* **150**(1) (2011), 137–150.
21. Rafe Jones and Jeremy Rouse (with an appendix by Jeffrey D. Achter). Galois theory of iterated endomorphisms. *Proc. Lond. Math. Soc.* **100**(3) (2010), 763-794.
22. Xander Faber, Benjamin Hutz, Patrick Ingram, Rafe Jones, Michelle Manes, Thomas J. Tucker, and Michael Zieve. Uniform bounds on pre-images under quadratic dynamical systems. *Math. Res. Lett.* **16**(1) (2009), 87-101.
23. Nigel Boston and Rafe Jones. The image of an arboreal Galois representation. *Pure Appl. Math. Q.* **5**(1) (Special Issue: In honor of Jean-Pierre Serre, Part 2 of 2) (2009) 213—225.
24. Rafe Jones. The density of prime divisors in the arithmetic dynamics of quadratic polynomials. *J. Lond. Math. Soc.* (2) **78**(2) (2008), 523—544.
25. Rafe Jones. Iterated Galois towers, their associated martingales, and the p -adic Mandelbrot set. *Compositio Math.* **43**(5) (2007), 1108—1126.

26. Nigel Boston and Rafe Jones. Arboreal Galois representations. *Geom. Dedicata* **124(1)** (2007), 27—35.
27. Rafe Jones and Jan Pearce. A postmodern view of fractions and the reciprocals of Fermat primes, *Mathematics Magazine* **73** (2000), 83-97 (Awarded Allendoerfer Prize for excellence in mathematical exposition by the MAA. See Fellowships and Awards.) Reprinted in Arthur Benjamin and Ezra Graham, editors, *Biscuits of Number Theory*, Dolciani Mathematical Expositions number 34, pages 23-38. Mathematical Association of America, Washington, DC, 2009.

Other Publications

1. Rafe Jones. *A Singular Mathematical Promenade* – A Book Review. *Notices Amer. Math. Soc.* 66 (2019), no. 11, 1867–1870.
2. Rafe Jones. Odds are it won't snow like this again for, well, do the math. Op-ed in the *Minneapolis Star-Tribune*, Feb. 28, 2019.
3. Rafe Jones. Roman numerals, so prominent this week, have their place – in the past. Op-ed in the *Minneapolis Star-Tribune*, Jan. 31, 2018.
4. Rafe Jones. *Enlightening Symbols: A Short History of Mathematical Notation* – A Book Review. *Math. Intelligencer* **38(2)** (2016), 85-86.
5. Rafe Jones. Galois representations from pre-image trees: an arboreal survey. *Publications Mathématiques de Besançon: Algèbre et Théorie des Nombres* (2013) special issue devoted to the proceedings of the conference “Number theory and its applications,” held at the Centre International de Rencontres Mathématiques, Luminy, France, January 2012.
6. Rafe Jones. *Numbers: A Very Short Introduction* – A Book Review. *Notices of the AMS* January 2012: 50-51 (this review furnished the inspiration for the cover of the January 2012 issue).
7. Rafe Jones. Do the math: a new way of thinking about the economy. Op-ed in the *Worcester Telegram & Gazette*, February 10, 2009 and *The Providence Journal*, February 18, 2009.
8. Rafe Jones. Galois actions on rooted trees. Appears in Pro-p extensions of global fields and pro-p groups. Abstracts from the workshop held May 21–27, 2006. Organized by Nigel Boston, John Coates, and Fritz Grunewald. *Oberwolfach Rep.* **3** (2006), no. 2, 1463—1535.
9. Rafe Jones. Ninety-one years [Poem]. *New Millennium Writings* 14 (June 2004): 180-81.
10. Rafe Jones. *In Code: A Mathematical Journey* – A Book Review. *Notices of the AMS* April 2003: 460-461.
11. Rafe Jones. A summer at discovery.com. *Notices of the AMS* June/July 2002: 694-696.
12. Rafe Jones. Stern perfection: mathematics as a fine art. *The Catalyst Special Edition*, Brown University, 2002.

Research Mentoring

Research resulting from 2017-2018 comps project, as well as research conducted with students winter break 2017 and summer 2018, “Newly reducible polynomial iterates.”

- In the fall of 2017 and spring of 2018, I advised Peter Illig, Eli Orvis, Nick Spinale, and Yuki Segawa on a comps project studying very rare examples of quadratic polynomials with rational coefficients whose first two iterates are irreducible over the rationals, but whose third iterate factor. Such polynomials are said to have newly reducible third iterate. I had found only a handful of examples of these polynomials before the students started on their project. During their first term of work, the students found an infinite family of them! This discovery disproved a conjecture made by another researcher. We wrote up our results, and the paper was published in the *International Journal of Number Theory* in 2021.

Research resulting from 2016-2017 comps project, “Eventually stable quadratic polynomials over \mathbb{Q} .”

- In the winter and spring of 2017, I advised David Demark, Moses Misplon, and Michael Stoneman, on a comps project exploring a recalcitrant family of quadratic polynomials: one where existing methods for studying the factorization properties of iterates failed in a unique way. I had hoped for a proof that members of this family had iterates that factored in a well-behaved way, but the family proved itself to be even more recalcitrant than I had thought. Undaunted, the students came up with some very clever partial results, and we were able say quite a lot about the family in the end. We wrote up our results, and the paper was published in the *New York Journal of Mathematics* in 2020.

Research resulting from 2013-2014 comps project, “Wild ramification in a family of low-degree extensions arising from iteration.”

- In the winter and spring of 2014, I advised Hanan Abo Sakr, Trey Brademan, Ben Breen, and Michelle Yuen on a comps project exploring the ramification properties of the prime 2 in extensions of \mathbb{Q} generated by the roots of the second iterate of the map $f(x) = x^2 + c$, where c is an integer. These properties hadn't been studied before, and are of interest to the research community. The students obtained a partial classification of this behavior as part of their project. Ben and Michelle expressed an interest in continuing to work on the problem, and in writing up the results for publication. I enlisted Tommy Occhipinti, one of our visiting faculty members who is also a number theorist, to help out. Together we worked through this surprisingly thorny question – just stating the main result takes nearly a full page! The paper was published in 2015 in the *JP Journal of Algebra, Number Theory, and Applications*.

Informal project advisor, University of Minnesota-Duluth REU, 2014, “On arboreal Galois representations of rational functions.”

- At the request of the REU direction, Joseph Gallian, I proposed some possible projects before the summer began. Joe then selected this one for the student Ashvin Swaminathan, and I corresponded at length with him about his results, his proofs, and where he could look for additional problems and research directions. I read several drafts of his paper, which was published in 2017 in the *Journal of Algebra*.

Summer research project, 2013: “Perfect powers in orbits of rational functions.”

- I worked with Carleton rising sophomores Jordan Cahn and Jacob Spear on a project studying under what conditions a rational function with coefficients in a number field can have an orbit containing infinitely many m th powers, for a fixed m greater than 1. This precise question evolved over discussions with Jordan and Jacob, after we started with a somewhat different and much more limited question. The students then pushed hard to find a solution to the most general form of the question, with impressive results. We wrote our findings up as a research article, which attracted the interest of several mathematicians. In fact, another group of researchers proved one of our conjectures a few months after we posted our preprint on the ArXiv! The article was published in the *Canadian Journal of Mathematics*.

The Following projects predate my time at Carleton, so I will only list brief descriptions.

Summer research project 2012: “Newly reducible iterates in families of quadratic polynomials.” By Katherine Chamberlin, Emma Colbert, Patrick Hefferman, Sarah Orchard.

Senior Thesis, 2011-2012: “Irreducibility of iterates of a second degree polynomial,” by Katherine Chamberlin.

University of Georgia VIGRE Summer School in Arithmetic Dynamics, May 2011. Series of lectures on Galois theory of iterated maps, and mentoring of graduate student projects.

Senior Thesis, 2009-2010: “The proportion of k -cycles for polynomials modulo primes,” by Jonathan Root.

Arizona Winter School, March 2010. “Graph components and dynamics over finite fields” by Ryan Flynn and Derek Garton

University of Wisconsin Research Experience for Undergraduates (REU) in Number Theory, Summer 2006. "Primitive prime divisors in polynomial arithmetic dynamics," by Brian Rice, and "Quadratic recurrences with a positive density of prime divisors," by Richard Gottesman and Kwokfung Tang.

Grants

AMS-Simons Research Enhancement Grants for Primarily Undergraduate Institution (PUI) Faculty, \$10,800. Awarded in July 2023.

NSF Grant DMS-0852826. Title: "Arboreal Galois representations and applications to arithmetic dynamics," \$84,353, August 20, 2008 – July 31, 2011. (Extended to July 31, 2012)

NSA Young Investigators. Title: "Arboreal Galois representations and applications to arithmetic dynamics," August 2008-August 2010. Grant awarded but declined due to rules against holding NSA and NSF grants concurrently.

Fellowships and Awards

- Project NExT National Fellow, 2008-2009
- Mathematics Department Outstanding Teaching Award, Brown University, December 2004
- Dissertation Fellowship, Brown University, Fall 2003
- VIGRE Graduate Trainee, Brown University, Spring 2002 and Spring 2003
- American Association for the Advancement of Science/American Mathematical Society Mass Media Fellowship; host site was Discovery.com in Bethesda, MD. Summer 2001.
- Allendoerfer Prize for mathematical exposition. Awarded by the Mathematical Association of America for the paper "A Postmodern View of Fractions and the Reciprocals of Fermat Primes," June 2001
- University Fellowship, Brown University, Fall 1999-Spring 2000

Recent Presentations and Conferences

Front Range Number Theory Day (Colorado State), invited speaker, October 2024.

Dynamical Days in Montreal, invited speaker, June 2024.

Brown University Algebra seminar, invited speaker. March 2023.

AMS Special Session, "Recent Progress in Arithmetic Dynamics," Joint Mathematics Meetings. Invited speaker. January 2023.

Arithmetic Dynamics International Online Seminar (ADIOS), Invited speaker. February 2022.

AMS Special Session, "Current Trends in Arithmetic Dynamics," Joint Mathematics Meetings (virtual). Invited speaker. January 2021.

Five College Number theory seminar (virtual), invited speaker. October 2020.

AMS Special Session, "Arithmetic Galois Actions," Joint Mathematics Meetings, Denver, CO. Invited speaker. January 2020.

MAA Panel, "How to Write Op-eds for Newspapers: Shaping Public Thinking on Math," Joint Mathematics Meetings, Denver, CO. Invited panelist. January 2020.

AMS Special Session, "Arithmetic Dynamics", Spring Central and Western Joint Sectional Meeting, Honolulu, HI. Invited speaker. March 2019.

AMS Special Session, "Arithmetic Dynamics", Spring Eastern Sectional Meeting, Boston, MA. Invited speaker. April 2018.

Portland State University Maseeh Mathematics and Statistics colloquium. Invited speaker. October 2017.

Washington and Lee University colloquium. Invited speaker. March 2017.

American Institute of Mathematics workshop on “The Galois theory of orbits in arithmetic dynamics” Palo Alto, CA. Leadoff speaker. May 2016.

AMS Special Session, “Arithmetic Dynamics”, Joint Mathematics Meetings, Seattle, WA. Invited speaker. January 2016.

University of Rochester Number Theory seminar. Invited speaker. November 2015.

Silvermania (A conference in honor of Joseph Silverman’s 60th birthday). Invited speaker. August 2015.

Brown University Algebra Seminar. Invited speaker. March 2015.

Front Range Algebraic Geometry and Number Theory seminar, Colorado State University. Invited speaker. September 2014.

American Institute of Mathematics workshop on “Post-critically finite maps in complex and arithmetic dynamics,” Palo Alto, CA. Invited participant. March 2014.

St. Olaf undergraduate seminar. Invited speaker. December 2013.

Laboratoire Mathématiques de Besançon, conference titled “Algebraic and explicit methods in number theory.” Invited to give a 60-minute talk. September 2013.

Banff International Research Station, conference titled “The art of iterating rational functions over finite fields,” invited participant. March 2013.

Teaching Experience

At Carleton

- *Number Theory (Math 282), Winter 2024 (course aimed at sophomores)*
- *Real Analysis I (Fall 2021), Real Analysis II – Measure Theory (Spring 2021, Winter 2022), Real Analysis II – Functional Analysis (Spring 2023)*
- *Topics In Abstract Algebra (Galois Theory) (Math 352), Spring 2020, Spring 2024.*
- *Abstract Algebra (Math 342), Winter 2018, Fall 2018, Spring 2025.*
- *Calculus 2 (Math 120), Fall 2018, Fall 2019, Winter 2020, Fall 2021, many more.*
- *Topics in the Theory of Elliptic Curves (Math 395), Spring 2017, Winter 2019.*
- *Multivariable Calculus (Math 211), Winter 2015, Fall 2017.*
- *Mathematical Structures (Math 236), Spring 2014, Winter 2017, Winter 2019.*
- *Algebraic Number Theory (Math 395), Winter 2014.*
- *Number Theory (Math 312), Spring 2013, Fall 2014.*
- *Linear Algebra (Math 232), Winter 2013, Winter 2014, Winter 2015, Spring 2015, many more.*
- *Calculus II (Math 121), Fall 2012, Winter 2013, Fall 2013, Fall 2014, Winter 2017.*

Service at Carleton

Departmental Service:

Chair of the Math and Stats department, Fall 2023-present

Associate Chair of the Math and Stats department, 2021-2022, Spring 2023.

Hiring Committee chair for mathematics visiting faculty search (2 positions), Spring 2023.

Hiring Committee for mathematics tenure-track search 2018-2019, 2019-2020, 2021-22.

Organizer of the Math and Stats department research discussion group (a.k.a. the Circle of Least Confusion), 2017-2022.

Organizer or co-organizer of the Carleton math department problem-solving group, 2012-2022.

Departmental mentor for Alex Barrios, 2018-2022.

Carleton Tour of Math organizer, 2014.

College-wide service:

Faculty Secretary, Fall 2023-present.

Faculty Compensation Committee, Chair, 2020-2022. Member 2017-2019.

Junior Faculty Affairs Committee, 2013-2015.

Professional Service

Doctoral committee member, Zheng Zu (University of Rochester, 2025), Ophelia Adams (Brown University, 2023), Valentin Huguin (University of Toulouse, 2021), Nicole Looper (Northwestern, 2017), Wade Hindes (Brown University, 2015).

NSF Grant Panelist, Arithmetic Geometry panel, December 2020.

Co-organizer (with Joseph Silverman and Nicole Looper) of AMS special session on Arithmetic Dynamics at Joint Mathematics Meetings, Denver, CO, January 2020.

Member, MAA committee to award the Carl. B. Allendoerfer prize, for expository excellence of an article appearing in *Mathematics Magazine* (2016-2017). Chair of this same committee (2018-2020).

Co-organizer (with Joseph Silverman and Michelle Manes) of American Institute of Mathematics weeklong program "The Galois theory of orbits in arithmetic dynamics", Palo Alto, CA, May 2016.

Co-organizer (with Colleen Duffy) of AMS Special Session on Number Theory at AMS Central Sectional, Eau Claire, WI, September 2014.

Co-organizer (with Farshid Hajir and Michael Bush) of AMS Special Session on Number Theory, Arithmetic Topology, and Arithmetic Dynamics at AMS Eastern Sectional, Worcester, MA, April 2011.

Co-organizer (with Joseph Silverman and Michelle Manes) of AMS special session Arithmetic and Non-archimedean Dynamics at Joint Mathematics Meetings, San Francisco, CA, January 2010.

Reviewer for NSA grant proposals, 2006-present (4 proposals).

Co-organizer of Project NEXT session "Putting together pre-tenure review materials," Mathfest, Portland, OR, 2009.

Reviewer for Math Reviews: 28 article reviews, 2 book reviews.

Reviewer for Zentralblatt Math: 5 reviews.

Referee for the following publications (4 referee reports written this year):

- Proceedings of the American Mathematical Society (6 papers)
- American Mathematical Monthly (5 papers)
- Journal of Number Theory (4 papers)
- Bulletin of the London Mathematical Society (3 papers)
- International Mathematics Research Notices (3 papers)
- Acta Arithmetica (2 papers)
- Canadian Mathematical Bulletin (2 papers)
- Involve (2 papers)
- Journal de Théorie des Nombres de Bordeaux (2 papers)
- Journal of Algebra (2 papers)
- Journal of the London Mathematical Society (2 papers)
- Manuscripta Mathematica (2 papers)
- New York Journal of Mathematics (2 papers)
- Advances in Mathematics (1 paper)
- Algebra Number Theory (1 paper)
- Archivum Math. Brno (1 paper)
- Canadian Journal of Mathematics (1 paper)
- Crelle's Journal (1 paper)
- Ergodic Theory Dynamical Systems (1 paper)
- Duke Mathematical Journal (1 paper)
- Experimental Mathematics (1 paper)
- Glasgow Mathematical Journal (1 paper)
- Indagationes Mathematicae (1 paper)
- Integers (1 paper)
- La Matematica (1 paper)
- LMS Journal of Computation and Mathematics (1 paper)
- Mathematische Zeitschrift (1 paper)
- Proceedings of the WIN 4 conference (1 paper)
- Research in Number Theory (1 paper)
- Rocky Mountain Journal of Mathematics (1 paper)
- Revista Matemática Iberoamericana (1 paper)
- Topological Methods in Nonlinear Analysis (1 paper)
- Transactions of the London Mathematical Society (1 paper)