

Curriculum Vitae

Robert G. Niemeyer, Ph.D.
Assistant Professor

Biographical information.

Education.

- Ph.D. in Mathematics - University of California, Riverside June, 2012
Adviser: Michel L. Lapidus
Dissertation: *An Investigation of the Koch Snowflake Fractal Billiard: Experimental and Theoretical Results*
- M.S. in Mathematics - University of California, Riverside June, 2008
- B.S. in Mathematics - University of California, Riverside June, 2006
Adviser: Michel L. Lapidus
Senior Thesis: *Nondifferentiable functions and their applications*

Citizenship.

- U.S. Citizen

Positions.

- Assistant professor (tenure track), University of the Incarnate Word, August 2017 – present
- Term assistant professor, University of Maine, September 2015 – August 2017
- Visiting postdoctoral fellow, University of New Mexico, May, 2016
- NSF Mentoring through Critical Transition Points Postdoctoral Fellow, University of New Mexico, August 2012 – August 2015

Awards and Honors.

- UMaine STEM Faculty Collaborative Fellow
- NSF MCTP Postdoctoral Fellow, University of New Mexico, Albuquerque, 2012–2015
- University of California President's Dissertation Year Fellow recipient 2011–2012
- University of California Chancellor's Fellow, 2006–2012

Recent Funding Sources.

- UIW Faculty Development Fund (Fall 2018)
- UIW Faculty Development Fund (Fall 2017)
- College of Liberal Arts and Sciences Travel Award (Spring 2016)
- UMaine STEM Faculty Collaborative Honorarium
- NSF MCTP Postdoctoral Fellowship (2012-2015; DMS-1148801)

Research Activities. I am a dynamicist working in topological dynamics, as well as mathematical modeling and experimental mathematics. Broadly speaking, my interests lie in the fields of dynamics, ergodic theory, fractal geometry, and mathematical modeling, with an emphasis on computer-aided investigations and methods of proof.

One aspect of my research is primarily focused on laying the foundations for a fascinating subject called *fractal billiards and fractal flat surfaces*. Specifically, the focus is on determining a topological dichotomy for a self-similar fractal billiard table and, eventually, an analog of the Veech Dichotomy for particular fractal billiard tables. Accordingly, an emphasis is put on drawing parallels between the area of study concerning rational billiards and their

associated flat surfaces. Computational tools have thus far facilitated the discovery of various interesting dynamical properties of a fractal billiard table. We have proved a variety of conjectures regarding billiard dynamics on fractal billiard tables and continue to investigate numerous open problems.

Other aspects of my research involve mathematical modeling and numerical analysis of dynamical systems arising from the social sciences, analyzing the billiard flow of polygonal Andreev billiards, determining the fractal dimension of particular variants of Pascal's triangle, and, recently, mathematical algorithms used in digital steganography.

Publications.

- *The box-counting dimension of Pascal's Triangle mod p* (with D. Bradley, A. Khalil and E. Ossanna), *Fractals*, doi: 10.1142/S0218348X18500718.
- *Nontrivial paths and periodic orbits of the T -fractal billiard* (with M. L. Lapidus and R. L. Miller), *Nonlinearity* **29** (2016), 2145–2172. (Available here on the arXiv)
- *Periodic billiard orbits of self-similar Sierpinski carpets* (with J. P. Chen), *J. Math. Anal. Appl.* **416** (2014), 969–994. (Available here on the arXiv)
- *The current state of fractal billiards* (with M. L. Lapidus), in: “*Fractal Geometry and Dynamical Systems in Pure and Applied Mathematics II: Fractals in Applied Mathematics*” (D. Carfi, M. L. Lapidus, M. van Frankenhuijsen, E. P. J. Pearse, eds.), *Contemporary Mathematics*, Amer. Math. Soc., Providence, RI, **601** (2013), pp. 251-288. (Available here on the arXiv)
- *Sequences of compatible periodic hybrid orbits of prefractal Koch snowflake billiards* (with M. L. Lapidus), *Disc. Cont. Dyn. Sys. – Ser. A.*, **33** No. 8 (2012), 3719-3740. (Available here on the arXiv)
- *Towards the Koch snowflake fractal billiard—Computer experiments and mathematical conjectures*¹ (with M. L. Lapidus), in “*Gems in Experimental Mathematics*” (T. Amdeberhan, L. A. Medina and V. H. Moll, eds.), *Contemporary Mathematics*, Amer. Math. Soc., Providence, R. I., **517** (2010), 231-263. (Available here on the arXiv)

Submitted for publication.

- *The wild, elusive singularities of the T -fractal surface* (with C. C. Johnson), 2018.

Papers in progress.

- *Generating upward sweeps in population using the Turchin–Korotayev model* (with R. E. Niemeyer), 2016. (Available here on the arXiv)
- *Properties of the flow on a polygonal Andreev billiard*, 2018. (Available here on the arXiv)
- *A fractal flat surface for the Koch snowflake fractal billiard* (with C. C. Johnson), 2018.
- *A computational investigation of a particular nontrivial path of the T -fractal billiard* (with C. C. Johnson), 2018.
- *Determining optimal steganography with multi-level embedding* (with J. Collins), 2018.

¹*Taking a Cue From Infinite Kinkiness*, *Science Magazine: A Publication of the AAAS*. A description of my joint work with Michel L. Lapidus presented at the 2009 Joint Mathematics Meeting in Washington DC. February, 2009; an article in *Science Magazine* written by Dr. Barry Cipra.

Areas of interest and collaborative efforts.

- Determining a fractal flat surface for a fractal billiard. In collaboration with Charles C. Johnson.
- Determining an infinite interval exchange transformation for a fractal translation surface. In collaboration with Charles C. Johnson.
- Determining classical billiard properties in the context of a fractal billiard table. In collaboration with various people: Michel L. Lapidus, Robyn L. Miller, Joe P. Chen, Charles C. Johnson.
- Investigating the consequences for billiard dynamics on polygonal billiard tables when collision in one side is subject to Andreev reflection.
- Mathematical social science. Using predator-prey models to model social and geopolitical phenomena. In collaboration with Richard E. Niemeyer.
- Computer science. Determining algorithms for computing testable scenarios in digital steganography.

Teaching & Mentoring Experience.

◇ Courses taught

Course title	Number of times taught
Precalculus	5
Calculus I	2
Calculus II	1
Calculus III	1
Mathematics for the Humanities	2
Foundations of Mathematics	1
Real Analysis	2
Differential Equations	1
Linear Algebra for Engineerings	2
Linear Algebra with Proofs	1
History of Mathematics	1
Mathematical Billiards	1
Topological Dynamics (A five-week seminar)	1
Abstract Algebra (Groups, Rings, Fields)	1
Lebesgue Measure and Integration (Independent study)	1
Fractal Geometry	1

◇ Mentees

- Graduate
 - Audrey Padilla (Masters Thesis in the area of fractal geometry, 2014-2015).
 - Martha Byrne, Dusty Brooks (as part of the NSF MCTP program, 2012-2013).
 - David Weirich, Eli Dean, Fredy Vides (as part of an effort to mentor students on the importance of conferences and networking.)
 - Samuel Collopy (a physics Ph.D. student at New Mexico Tech seeking professional and academic advice.)
 - Anand Paturi (a computer science Ph.D. student at New Mexico Tech needing input on the use of fractal geometry in calculating locality measurements.)

- Undergraduate
 - John S. Hennessy II (2018)
 - Christopher J. Montez (2018)
 - Camille Guerre (2017-2018) (Honors Real Analysis class project)
 - Daniel Carrera (2017)
 - Nolan Gagnon (2016)
 - Marcello Codiani (Senior Thesis in the area of dynamical systems and mathematical biology, 2014)
 - Reeve Garrett (2012)
 - Leo Vu (2011)
 - Tawni Flot (2011)
 - Elizabeth Mullin (2009)
- Highschool
 - Max Kolomaznik (2013)

Recent presentations.

Conferences.

- *The geometry of wild, elusive singularities of the T-fractal surface.* Fall eastern sectional meeting of the AMS, AMS Special Session on Billiard Dynamics: Standard and Alternative Collision Models. Newark, DE. September 2018.
- *On the existence of fractal flat surfaces.* Fall western sectional meeting of the AMS, AMS Special Session on Analysis and Geometry of Fractals. Riverside, CA. November 2017.
- *Reaching the elusive points of a fractal billiard.* 2016 Summer School on Fractal Geometry and Complex Dimensions: In celebration of the 60th birthday of Michel Lapidus. San Luis Obispo, CA. June 2016.
- *A fractal perturbation of a nanowire.* Joint Mathematics Meeting of the AMS & MAA, AMS Special Session on Fractal Geometry and Dynamical Systems. Seattle, WA. January 2016.
- *Results on the T-fractal billiard.* Central Spring Sectional Meeting of the AMS. East Lansing, MI. March, 2015.
- *Nontrivial paths of the T-fractal billiard in rational and irrational directions.* Joint Mathematics Meeting of the AMS & MAA, MAA Invited Paper Session on Fractal Geometry and Dynamics (in honor of Robert Devaney). San Antonio, TX. January, 2015.

Selected Service Activities.

While at the University of the Incarnate Word.

- Co-organizer for the Special Session on Geometry, Analysis, Dynamics and Mathematical Physics on Fractal Spaces as part of the Spring Central and Western Joint Sectional Meeting of the AMS, Honolulu, HI. March 2018 (Co-organizers: Joe P. Chen, Tim Hung Lu, Machiel Van Frankenhuijsen)
- Faculty Chaperone for Texas Undergraduate Mathematics Conference Fall 2018
- Faculty Chaperone for MAA Spring Sectional 2018
- Meet the Mission (Fall 2018)
- President's Day of Service (March 24th, 2018) (service project organizer)
- Meet the Mission (Fall 2017)

- GoFundMe campaign for earthquake victims in Mexico City
- Co-editor of a volume of Contemporary Mathematics, a proceedings of the 2016 Summer School on Fractal Geometry and Complex Dimensions: In celebration of the 60th birthday of Michel Lapidus (in collaboration with Erin Pearse, John Rock and Anthony Samuel)

While at the University of Maine.

- Main organizer for a research seminar in dynamical systems (for students and faculty), Fall 2016
- STEM Faculty Collaborative (A one-year teaching development program)
- Twice-monthly committee meetings on implementing curriculum changes to Freshman Calculus
- Graduate faculty member
- Coordinator of a topics seminar in billiards and ergodic theory

Memberships.

- American Mathematical Society
- MAA-TX Project NeXT

Related skills.

- Computational Mathematics and Symbolic Computing (C++, Matlab, Python), L^AT_EX, basic HTML
- Basic managerial skills
- Basic training in conflict management

References.

General references.

- Professor Michel L. Lapidus, University of California, Riverside (PhD adviser)
 - lapidus@math.ucr.edu
 - Phone: (951) 827-3113
- Professor Terry A. Loring, University of New Mexico, Albuquerque (Postdoctoral adviser)
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 - Phone: (505) 277 4613
- Professor Serge Troubetzkoy, Université de la Méditerranée, Marseille.
 - troubetz@iml.univ-mrs.fr
 - Phone: 04.91.26.96.66
- Professor Sergei Tabachnikov, The Pennsylvania State University, State College.
 - tabachni@math.psu.edu
 - Phone: (814) 865-7527
- Professor André Khalil, The University of Maine, Orono.
 - andre.khalil@maine.edu
 - Phone: (207) 581-3911
- Professor Alexander Teplyaev, University of Connecticut, Storrs.
 - alexander.teplyaev@uconn.edu
 - Phone: (860) 486-3923
- Professor Daniel Thompson, Ohio State University, Columbus.
 - thompson@math.osu.edu

– Phone: (614) 292-0365

Teaching references.

- Professor Benjamin Steinhurst
 - bsteinhurst@mcdaniel.edu
 - Phone: N/A
- Professor Natasha Speer
 - natasha.speer@maine.edu
 - Phone: (207) 581-3937
- Professor Robert Franzosa
 - franzosa@math.umaine.edu
 - Phone: (207) 581-3916
- Ms. Jennifer Tyne (*Service courses coordinator and lecturer in mathematics*)
 - jennifer.tyne@maine.edu
 - Phone: (207) 581-3926
- Professor John A. Rock, California State Polytechnic University, Pomona.
 - jarock@csupomona.edu
 - Phone: (909) 869-2404