

# Joshua Southerland

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## Current position

*Fifth Year Graduate Student*, University of Washington, Seattle

## Research Interests

My primary research interests are in flat surfaces and homogeneous dynamics. I enjoy when problems can be approached via the use of geometric or topological methods in combination with techniques from harmonic analysis or number theory. I have recently extended a method that Vladimir Finkelstein used to prove a shrinking target property for toral automorphisms to show that the action of derivatives of affine linear automorphisms (the Veech group) of square-tiled surfaces exhibit a similar shrinking target property. This provides new arithmetic information about congruence subgroups of  $SL_2(\mathbb{Z})$ . There is a very natural question that follows from this work: can a similar theorem be proven for lattice surfaces? I am currently exploring avenues to extend my previous work to this setting. Another question coming out of this work involves more classical mathematics: the proof method involves an extension of Fourier analysis to a non-commutative setting and I am hopeful to extend this line of exploration to trace formulas and their relation to geodesics on singular surfaces.

Additionally, I have been studying the tropical geometry analogue of the Riemann-Roch theorem from an analytical perspective. This has led to two primary areas of study: Laplacians on vector bundles over graphs and trace formulas for metric (quantum) graphs. I hope to one day merge this work with my work in flat surfaces.

## Education

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| 2022 | PhD in Mathematics, University of Washington (expected)            |
| 2019 | MSc in Mathematics, University of Washington                       |
| 2009 | BSc in Mechanical Engineering, Minor in Music, Columbia University |

## Work Experience

2009-2016 Senior Mechanical Engineer and Sustainability Consultant, BuroHappold Consulting Engineers, New York

## Honors & awards

2020-2021 Nominated for Excellence in Teaching Award, University of Washington  
2018-2019 Excellence in Teaching, University of Washington Mathematics Departmental Award

## Publications

2019 (Master's Thesis) Southerland, Josh (2019), "The Laplacian: An Exploration and Historical Survey Tailored for Translation Surfaces"  
2021 (In preparation) Southerland, Josh (2021), "Shrinking Targets on Square-Tiled Surfaces"

## Talks

### GRADUATE DYNAMICS SEMINAR, UNIVERSITY OF WASHINGTON

Feb 2020 *Arnoux-Rauzy IETs: Minimality and Unique Ergodicity (following Dynnikov, Hubert, and Skripchenko)*  
Mar 2020 *Structure Theory of Veech Groups*  
Mar 2020 *Examples of Shrinking Target Problems*  
Feb 2020 *Hyperbolic Toral Automorphisms are Mixing*  
Jan 2020 *Borel-Cantelli and Shrinking Targets*  
Nov 2019 *Quantum-Classical Correspondence on the Upper Half-Plane*  
Oct 2019 *An Analytic Approach to Real Hodge Theory*  
Jan 2019 *Complex Exponentials, Eigenfunctions, Algebra Homomorphisms and Invariant Subspaces of  $L^2G$*   
Jan 2019 *Fourier Analysis on  $\mathbb{R}^n$  and the  $n$ -Torus*  
Nov 2018 *Lie Algebras and Representation Theory: Vector Fields on Lie Groups*  
Oct 2018 *Lie Algebras and Representation Theory: Engel's Theorem*  
Apr 2018 *The Laplacian on a Graph*  
Apr 2017 *Definition of Topological Entropy*  
Jan 2017 *Continued Fractions*

### DEFENSES & EXAMS

Apr 2020 *Shrinking Targets on a Square-Tiled Surface*  
Mar 2019 *The Laplacian: An Exploration and Historical Survey Tailored for Translation Surfaces*

## Teaching

Spring 2021 Teaching Assistant, Linear Algebra (*Remote*)  
Winter 2021 Teaching Assistant, Linear Algebra (*Remote*)  
Fall 2020 Teaching Assistant, Linear Algebra (*Remote*)  
Summer 2020 Pre-Doctoral Instructor, Linear Algebra (*Remote*)

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|-------------|---|
| Spring 2020 | Pre-Doctoral Instructor, Linear Algebra ( <i>Remote</i> ) |
| Winter 2020 | Pre-Doctoral Instructor, Linear Algebra                   |
| Fall 2019   | Pre-Doctoral Instructor, Linear Algebra                   |
| Summer 2019 | Pre-Doctoral Instructor, Linear Algebra                   |
| Spring 2019 | Pre-Doctoral Instructor, Multivariable Calculus           |
| Winter 2019 | Pre-Doctoral Instructor, Multivariable Calculus           |
| Fall 2018   | Teaching Assistant, Topology                              |
| Summer 2018 | Pre-Doctoral Instructor, Multivariable Calculus           |
| Spring 2018 | Teaching Assistant, Precalculus                           |
| Winter 2018 | Teaching Assistant, Introductory Multivariable            |
| Fall 2017   | Teaching Assistant, Differential Calculus                 |
| Summer 2017 | Teaching Assistant, Introductory Real Analysis            |
| Spring 2017 | Teaching Assistant, Introductory Multivariable            |
| Winter 2017 | Teaching Assistant, Differential Calculus                 |
| Fall 2016   | Teaching Assistant, Integral Calculus                     |

## Service to the Community

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|-------------|---|
| 2020 - 2021 | Co-Organizer, Washington Directed Reading Program, <a href="https://sites.uw.edu/wdrp">sites.uw.edu/wdrp</a>  |
| Spring 2021 | Mentor, M.C. Escher and Hyperbolic Tesselations, Washington Directed Reading Program, Mentee: Emma Favier <a href="https://sites.uw.edu/wdrp/winter-2021">sites.uw.edu/wdrp/winter-2021</a>       |
| Spring 2021 | Mentor, M.C. Escher and Hyperbolic Tesselations, Washington Directed Reading Program, Mentee: Zheng (James) Cao <a href="https://sites.uw.edu/wdrp/winter-2021">sites.uw.edu/wdrp/winter-2021</a> |
| Winter 2021 | Mentor, M.C. Escher and Hyperbolic Tesselations, Washington Directed Reading Program, Mentee: Haley Riggs <a href="https://sites.uw.edu/wdrp/winter-2021">sites.uw.edu/wdrp/winter-2021</a>       |
| 2019 - 2020 | Co-Organizer, Washington Directed Reading Program, <a href="https://sites.uw.edu/wdrp">sites.uw.edu/wdrp</a>  |

## References

JAYADEV ATHREYA

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