

 0000-0001-9152-2477 • 
  molnar.grant.5772@gmail.com  
 www.grantmolnar.com • 
  github.com/grantmolnar

## Education

**PhD, Mathematics**, *Dartmouth College*, Hanover, NH Fall 2018 - Spring 2023  
 Advisor: John Voight  
 Thesis: *Counting elliptic curves with a cyclic  $m$ -isogeny over  $\mathbb{Q}$*

**MA, Mathematics**, *Dartmouth College*, Hanover, NH Fall 2018 - Winter 2020  
 Advisor: John Voight

**MS, Mathematics**, *Brigham Young University*, Provo, UT Winter 2017 - Summer 2018  
 Advisors: Michael Griffin and Paul Jenkins  
 Thesis: *The arithmetic of modular grids*

**BS, Mathematics**, *Brigham Young University*, Provo, UT Fall 2013 - Fall 2016

## Professional Experience

**Academic Researcher at BYU and Dartmouth** Fall 2013 - Spring 2023  
*At BYU, I proved results about modular forms and algorithms on graphs. At Dartmouth, I instigated successful research into summing divergent series, the Prisoner's Dilemma, and the Ramanujan-Robin criterion. My thesis develops the arithmetic statistics of elliptic curves with cyclic  $m$ -isogeny. See Research Publications and Preprints below.*

**Math Instructor at BYU and Dartmouth** Winter 2017 - Spring 2023  
*I taught 30-student calculus courses in three different styles: lecturing, virtually with a "flipped classroom", and with handouts and group exercises. I TAed for lower-division courses, and by special request for upper-division courses as well. See Teaching Experience below.*

## Computer Skills

### Fluent in...

Bash • Git • Go •  $\LaTeX$  • Python • R • SageMath • YAML

### Experience with...

C++ • HTML • Magma • Mathematica • MatLab • MongoDB • PARI/GP • Rust

## Research Publications

### Counting elliptic curves over the rationals with a 7-isogeny, with John Voight

Research in Number Theory **9**, 75 (2023). arXiv: 2212.11354

We count by height the number of elliptic curves over the rationals, both up to isomorphism over the rationals and over an algebraic closure thereof, that admit a cyclic isogeny of degree 7.

**Reactive means in the Iterated Prisoner’s Dilemma**, with *Caroline Hammond and Feng Fu*  
Applied Mathematics and Computation **458** 128201 (2023). arXiv: 2302.13909

The Iterated Prisoner’s Dilemma (IPD) is a well studied framework for understanding direct reciprocity and cooperation in pairwise encounters. However, measuring the morality of various IPD strategies is still largely lacking. Here, we partially address this issue by proposing a suit of plausible morality metrics to quantify four aspects of justice. We focus our closed-form calculation on the class of reactive strategies because of their mathematical tractability and expressive power. We define reactive means as a tool for studying how actors in the IPD and Iterated Snowdrift Game (ISG) behave under typical circumstances. We compute reactive means for four functions intended to capture human intuitions about “goodness” and “fair play”. Two of these functions are strongly anticorrelated with success in the IPD and ISG, and the other two are weakly anticorrelated with success. Our results will aid in evaluating and comparing powerful IPD strategies based on machine learning algorithms, using simple and intuitive morality metrics.

**The arithmetic of modular grids**, with *Michael Griffin and Paul Jenkins*  
Mathematika **68**, 1080-1119 (2022). arXiv: 2012.14403

A modular grid is a pair of sequences  $(f_m)_m$  and  $(g_n)_n$  of weakly holomorphic modular forms such that for almost all  $m$  and  $n$ , the coefficient of  $q^n$  in  $f_m$  is the negative of the coefficient of  $q^m$  in  $g_n$ . Zagier proved this coefficient duality in weights  $1/2$  and  $3/2$  in the Kohnen plus space, and such grids have appeared for Poincaré series, for modular forms of integral weight, and in many other situations. We give a general proof of coefficient duality for canonical row-reduced bases of spaces of weakly holomorphic modular forms of integral or half-integral weight for every group  $\Gamma \subseteq \mathrm{SL}_2(\mathbb{R})$  commensurable with  $\mathrm{SL}_2(\mathbb{Z})$ . We construct bivariate generating functions that encode these modular forms, and study linear operations on the resulting modular grids.

**Odd, spoof perfect factorizations**, with the *BYU Computational Number Theory Group*  
Journal of Number Theory **234**, 31-47 (2022). Quanta article. arXiv: 2006.10697

We investigate the integer solutions of Diophantine equations related to perfect numbers. These solutions generalize the example, found by Descartes in 1638, of an odd, “spoof” perfect factorization  $3^2 \cdot 7^2 \cdot 11^2 \cdot 22021^1$ . More recently, Voight found the spoof perfect factorization  $3^4 \cdot 7^2 \cdot 11^2 \cdot 19^2 \cdot (-127)^1$ . No other examples appear in the literature. We compute all nontrivial, odd, primitive spoof perfect factorizations with fewer than seven bases – there are twenty-one in total. We show that the structure of odd, spoof perfect factorizations is extremely rich, and there are multiple infinite families of them. This implies that certain approaches to the odd perfect number problem that use only the multiplicative nature of the sum-of-divisors function are unworkable. On the other hand, we prove that there are only finitely many nontrivial, odd, primitive spoof perfect factorizations with a fixed number of bases.

**Zagier duality for level  $p$  weakly holomorphic modular forms**, with *Paul Jenkins*  
The Ramanujan Journal **50**, 93–109 (2019). arXiv: 1709.10023

We prove Zagier duality between the Fourier coefficients of canonical bases for spaces of weakly holomorphic modular forms of prime level  $p$  with  $11 \leq p \leq 37$  with poles only at the cusp at  $\infty$ , and special cases of duality for an infinite class of prime levels. We derive generating functions for the bases for genus 1 levels.

**Graphs with the strong Havel-Hakimi property**, with *Michael Barrus*  
Graphs and Combinatorics **32**, 1689–1697 (2016). arXiv: 1505.00085

The Havel–Hakimi algorithm iteratively reduces the degree sequence of a graph to a list of zeroes. As shown by Favaron, Mahéo, and Saclé, the number of zeroes produced, known as the residue, is a lower bound on the independence number of the graph. We say that a graph has the strong Havel–Hakimi property if in each of its induced subgraphs, deleting any vertex of maximum degree reduces the degree sequence in the same way that the Havel–Hakimi algorithm does. We characterize graphs having this property (which include all threshold and matrogenic graphs) in terms of minimal forbidden induced subgraphs. We further show that for these graphs the residue equals the independence number, and a natural greedy algorithm always produces a maximum independent set.

## Research Preprints

**A database of basic numerical invariants of Hilbert modular surfaces**, with Eran Assaf, Angelica Babei, Ben Breen, Edgar Costa, Juanita Duque-Rosero, Aleksander Horawa, Jean Kieffer, Avinash Kulkarni, Sam Schiavone, and John Voight

Preprint. arXiv: 2301.10302

We describe algorithms for computing geometric invariants for Hilbert modular surfaces, and we report on their implementation.

**Multiplicative summations into algebraically closed fields**, with Robert Dawson

Preprint. arXiv: 2111.09938

In this paper, extending our earlier program, we derive maximal canonical extensions for multiplicative summations into algebraically closed fields. We show that there is a well-defined analogue to minimal polynomials for a series algebraic over a ring of series, the “scalar polynomial”. When that ring is the domain of a summation  $\mathfrak{S}$ , we derive the related concepts of the  $\mathfrak{S}$ -minimal polynomial for a series, which is mapped by  $\mathfrak{S}$  to a scalar polynomial. When the scalar polynomial for a series has the form  $(t - a)^n$ ,  $a$  is the unique value to which the series can be mapped by an extension of the original summation.

**Telescopic, multiplicative, and rational extensions of summations**, with Robert Dawson

Preprint. arXiv: 2105.04592

A summation is a shift-invariant  $R$ -module homomorphism from a submodule of  $R$  to  $R$  or another ring. Dawson formalized a method for extending a summation to a larger domain by telescoping. In this paper, we revisit telescoping, we study multiplicative closures of summations (such as the usual summation on convergent series) that are not themselves multiplicatively closed, and we study rational extensions as a generalization of telescoping.

## Expository Notes

**Fast-growing series are transcendental**, with Robert Dawson

Unpublished. arXiv: 2102.12995

Let  $R$  be a subring of  $\mathbb{C}[[z]]$ , and let  $X \in \mathbb{C}[[z]]$ . The Newton-Puiseux Theorem implies that if the coefficients of  $X$  grow sufficiently rapidly relative to the coefficients of the series in  $R$ , then  $X$  is transcendental over  $R$ . We provide an alternative proof of this result by establishing a relationship between the coefficients of  $A(X)$  and  $A'(X)$ , where  $A(T)$  is a polynomial over  $\mathbb{C}[[z]]$ .

## Manuscripts in Preparation

**A family of analogues to the Ramanujan-Robin criterion**, with Steve Fan and Mits Kobayashi

**Odd, spoof quasiperfect factorizations**, with Jonathon Hales

**Visualizing Basel’s problem**, with Mits Kobayashi

## Selected Git Projects

**Spoof Quasiperfect Factorizations**

Fall 2021

<https://github.com/grantmolnar/Spoof-Quasiperfect-Factorizations>

## Awards and Fellowships

Dartmouth Graduate Fellowship

Fall 2018 - Summer 2023

Gridley Fund for Graduate Mathematics

Fall 2018 - Summer 2019

NSF Graduate Research Fellowship Honorable Mention

April 2018

BYU Academic Scholarship	Spring 2015 - Winter 2016
BYU Math Department Scholarship	Fall 2016
BYU Math Department Scholarship	Fall 2015
BYU Academic Scholarship	Fall 2013 - Winter 2014

## Teaching Experience

### Dartmouth College, Hanover, NH (Instructor)

Math 8 (Calculus of One and Several Variables)	Fall 2021
Math 1 (Algebra and Calculus)	Fall 2020

### Dartmouth College, Hanover, NH (Teacher's Assistant)

Math 100 / Computer Science 49/149 (Random Walk)	Spring 2022
Math 100 / Computer Science 49/149 (Decision Theory)	Spring 2021
Math 23 (Differential Equations)	Winter 2020
Math 3 (Calculus)	Fall 2019
Math 22 (Linear Algebra)	Spring 2019
Math 22 (Linear Algebra)	Fall 2018

### Brigham Young University, Provo, UT (Instructor)

Math 112 (Calculus I)	Summer 2017
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### Brigham Young University, Provo, UT (Teacher's Assistant)

Math 112 (Calculus I)	Fall 2017
Math 113 (Calculus II)	Winter 2017

### Brigham Young University, Provo, UT (Grader)

Math 570 (Matrix Analysis)	Winter 2017
Math 112 (Calculus I)	Fall 2015

## Thesis Defenses

<b>Counting elliptic curves with a cyclic <math>m</math>-isogeny over <math>\mathbb{Q}</math></b> Dartmouth College PhD Thesis Defense	April 24, 2023
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<b>The arithmetic of modular grids</b> BYU Master's Thesis Defense	June 22, 2018
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## Invited Talks

<b>Counting elliptic curves with a cyclic <math>m</math>-isogeny</b> Job Talk at Metron	February 9, 2023
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<b>Counting elliptic curves with a 7-isogeny</b> BYU Colloquium	January 19, 2023
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<b>Counting elliptic curves with a 7-isogeny</b> Simons Collaboration Annual Meeting	January 11, 2023
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<b>Counting 7-isogenies</b> 2023 Joint Mathematics Meeting	January 6, 2023
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**A family of analogues to the Ramanujan-Robin Criterion** October 27, 2022  
BYU Number Theory Seminar

## Other Conference Talks

**Intersecting varieties with transcendental graphs** March 8, 2023  
Arizona Winter School 2023: Unlikely Intersections

**The LCM product and Grönwall's theorem** October 3, 2021  
2021 Maine-Québec Number Theory Conference (virtual)

**Formal summation of divergent series** September 26, 2020  
2020 Conférence de Théorie des Nombres Québec-Maine (virtual)

**The arithmetic of modular grids** October 5, 2019  
2019 Maine-Québec Number Theory Conference

**The arithmetic of modular grids** March 8, 2019  
33<sup>rd</sup> Automorphic Forms Workshop

**The arithmetic of modular grids** July 17, 2018  
Building Bridges: 4th EU/US Summer School + Workshop on Automorphic Forms

**Zagier duality in level  $p$  modular spaces** March 21, 2018  
32<sup>nd</sup> Automorphic Forms Workshop

**Zagier duality in level  $p$  modular spaces** March 3, 2018  
2018 BYU Student Research Conference

**Zagier duality in level  $p$  modular spaces** May 24, 2017  
Modular Forms are Everywhere Conference

**Weakly holomorphic modular forms of level 11** March 7, 2017  
31<sup>st</sup> Automorphic Forms Workshop

**Weakly holomorphic modular forms of level 11** March 4, 2017  
2017 BYU Student Research Conference

**Congruence relations in modular forms of prime levels greater than 7** March 21, 2015  
2015 BYU Student Research Conference

**Residues and independence numbers of graphs** March 15, 2014  
2014 BYU Student Research Conference

## Other Seminar Talks

**The Fox  $H$ -function** March 28, 2023  
Dartmouth Graduate Student Seminar

**Geometric deep learning** February 14, 2023  
Dartmouth Graduate Student Seminar

**Nearing nearings** September 14, 2022  
Dartmouth Graduate Student Seminar

**Universal algebra and coalgebra** March 30, 2022  
Dartmouth Graduate Student Seminar

**Cogalois theory** February 16, 2022  
Dartmouth Graduate Student Seminar

**Cyclic resolution of singularities** January 25, 2022  
Reading Seminar on Hilbert Modular Surfaces

<b>What if the Riemann hypothesis is false?</b> Dartmouth Graduate Student Seminar	January 19, 2022
<b>Inverse semigroups: groups without identity</b> Dartmouth Graduate Student Seminar	November 9, 2021
<b>Counting 7-isogenies</b> Dartmouth Algebra and Number Theory Seminar	November 8, 2021
<b>A sober look at pointless topology</b> Dartmouth Graduate Student Seminar	September 21, 2021
<b>Fast-growing series are transcendental</b> Dartmouth Graduate Student Seminar (virtual)	April 21, 2021
<b>Coalgebras and Hopf algebras</b> Reading Seminar on Affine Group Schemes (virtual)	April 15, 2021
<b>Absurd equalities and Runge's method: the degenerate case</b> Dartmouth Algebra and Number Theory Seminar (virtual)	March 30, 2021
<b><math>p</math>-adic Hodge theory</b> Reading Seminar on Classical and Quadratic Chabauty (virtual)	March 2, 2021
<b>Odd, spoof quasiperfect factorizations</b> Dartmouth Algebra and Number Theory Seminar (virtual)	February 9, 2021
<b>A primer in social choice theory</b> Dartmouth Graduate Student Seminar (virtual)	January 20, 2021
<b>Examples of Kedlaya's algorithm</b> Reading Seminar on Classical and Quadratic Chabauty (virtual)	November 19, 2020
<b>The LCM product and Grönwall's theorem</b> Dartmouth Algebra and Number Theory Seminar (virtual)	November 17, 2020
<b>Reactive means and the prisoner's dilemma</b> Dartmouth Graduate Student Seminar (virtual)	October 7, 2020
<b>Formal summation of divergent series: an algebraic approach</b> Dartmouth Algebra and Number Theory Seminar (virtual)	April 28, 2020
<b>On the infinitude of the natural numbers</b> Dartmouth Graduate Student Seminar	February 12, 2020
<b>Variations of Hodge structures</b> Reading Seminar on Shimura Varieties	November 26, 2019
<b>Hodge structures</b> Reading Seminar on Shimura Varieties	November 14, 2019
<b>Savage's expected utility and making good decisions</b> Dartmouth Graduate Student Seminar	November 13, 2019
<b>Geometric and generalized calculus</b> Dartmouth Graduate Student Seminar	October 8, 2019
<b>Summing divergent series</b> Dartmouth Graduate Student Seminar	July 31, 2019
<b>Real analysis: a nonstandard approach</b> Dartmouth Graduate Student Seminar	April 17, 2019
<b>Why save the universe? Set theory with a universal set</b> Dartmouth Graduate Student Seminar	January 16, 2019

<b>The arithmetic of modular grids</b> Dartmouth Graduate Student Seminar	September 26, 2018
<b>Dioids and idempotent geometry II</b> BYU Algebra Seminar	March 13, 2018
<b>Dioids and idempotent geometry I</b> BYU Algebra Seminar	February 27, 2018
<b>Zagier duality in level <math>p</math> modular spaces</b> BYU Number Theory Seminar	February 22, 2018
<b>Average values of arithmetic functions</b> BYU Number Theory Seminar	October 12, 2017
<b>Weakly holomorphic modular forms of level 11</b> BYU Number Theory Seminar	February 9, 2017
<b>Generating functions for canonical bases of certain level 11 weakly holomorphic modular forms</b> BYU Number Theory Seminar	January 26, 2017
<b>High rank elliptic curves with prescribed torsion</b> BYU Number Theory Seminar	December 1, 2016
<b>Heuristics for elliptic curves of high rank</b> BYU Number Theory Seminar	October 20, 2016
<b>A lemma regarding the Feit-Thompson conjecture</b> BYU Number Theory Seminar	November 12, 2015
<b>Algebraic number theory and the Feit-Thompson conjecture</b> BYU Number Theory Seminar	October 1, 2015
<b>Congruence relations in modular forms of prime levels greater than 7</b> BYU Number Theory Seminar	March 19, 2015
<b>Hensel's lemma</b> BYU Number Theory Seminar	February 12, 2015
<b>Newton polynomials</b> BYU Number Theory Seminar	March 27, 2014

## Leadership and Community Service

### Referee

<i>Journal of Number Theory</i>	2018 - Present
<i>Mathematische Zeitschrift</i>	2022 - Present
<i>Ramanujan Journal</i>	2022 - Present
<i>Theory and Decision</i>	2024 - Present

### Reviewer

<i>zbMATH Open</i>	2021 - Present
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### K-12 Outreach

Utah Math Olympiad Committee Member	2015 - Present
Activity Leader at Dartmouth Science Day (Games & Surreal Numbers)	April 8, 2023
Activity Leader at Lebanon Ward Pi Day (Trachtenberg Arithmetic & Random Walk)	March 25, 2023

Session Leader at Dartmouth Sonia Kovalevsky Day (Trachtenberg Arithmetic)	May 21, 2022
Activity Leader at Lebanon Ward Pi Day (Random Walk)	April 8, 2022
Exploring Mathematics Camp Leader (Graph Theory)	July 27-31, 2020
Exploring Mathematics Camp Leader (Cryptography)	July 13-17, 2020
Activity Leader at Lebanon Ward Pi Day (Random Walk)	March 7, 2020
Volunteer at Dartmouth Sonia Kovalevsky Day	May 11, 2019
Activity Leader at Dartmouth Science Day (Nim)	May 4, 2019
Math Circles Guest Speaker (Tropical Algebra)	February 24, 2018
Math Circles Guest Speaker (Continued Fractions)	October 21, 2017
Proofreader for Utah State Math Contest	February 2017
Math Circles Counselor	2013 - 2015

### **Dartmouth Graduate Student Council**

Ad Hoc Healthcare Committee Founder and Co-Chair	2022 - 2023
◦ <i>Budget Committee Member</i>	Summer 2022
Finance Officer	2021 - 2022
◦ <i>Budget Committee Member</i>	Summer 2021
Representative for Math Department	2020 - 2021
◦ <i>Service Committee Member</i>	2020 - 2021
◦ <i>Budget Committee Member</i>	Summer 2020

### **Dartmouth Directed Reading Program**

Mentor (Fuzzy Logic)	Winter 2023
Mentor (Decision Theory)	Spring 2022
Mentor (Fractional Calculus)	Winter 2022

### **Other**

LMFDB Contributor	2019 - 2023
Dartmouth Algebra and Number Theory Seminar Organizer	2019 - 2022
BYU Putnam Team Captain	2014 - 2016

## Other

### **Achievements and Honors**

3 <sup>rd</sup> Place in Virginia Tech Regional Math Competition	October 2016
2 <sup>nd</sup> Place in Search for High Rank Elliptic Curve at 2016 Connecticut Summer School in Number Theory	August 2016
Gold Palm Eagle Scout	December 2012
Black Belt (Taekwondo)	August 2012

### **Special Training**

Dartmouth Mathematics Teaching Seminar	Spring 2020
BYU Mathematics Teaching Seminar	Fall 2018

### **Academic Interests**

Analytic Number Theory • Arithmetic Geometry • Game Theory • Logic

### **Personal Interests**



Reading • Writing • Philosophy • Hiking

## Conferences and Workshops Attended

2024 <i>Simons Collaboration on Arithmetic Geometry, Number Theory, and Computation Annual Meeting</i> Virtual (Simons Foundation's Gerald D. Fischbach Auditorium, New York City)	January 11-12, 2024
<i>Big Data Conference 2023</i> Virtual (Harvard University, Cambridge)	August 31 - September 1, 2022
<i>Hilbert Modular Forms Infrastructure Week 4</i> Dartmouth College, Hanover	May 8-12, 2023
<i>Arizona Winter School 2023: Unlikely Intersections</i> University of Arizona, Tucson	March 4-8, 2023
2023 <i>Simons Collaboration on Arithmetic Geometry, Number Theory, and Computation Annual Meeting</i> Simons Foundation's Gerald D. Fischbach Auditorium, New York City	January 11-12, 2023
2023 <i>Joint Mathematics Meetings</i> Hynes Convention Center, Boston	January 4-7, 2023
<i>Hilbert Modular Forms Infrastructure Week 3</i> Dartmouth College, Hanover	December 12-16, 2022
<i>Modular Curves Workshop 2</i> MIT, Boston	November 5-9, 2022
<i>Big Data Conference 2022</i> Virtual (Harvard University, Cambridge)	August 26, 2022
<i>Explicit Methods for Modularity</i> Virtual (Simons Collaboration)	April 11-15, 2022
<i>Arizona Winter School 2022: Automorphic Forms Beyond <math>GL_2</math></i> Virtual (University of Arizona, Tucson)	March 5-9, 2022
<i>Hilbert Modular Forms Infrastructure Week 2</i> Dartmouth College, Hanover	February 21-25, 2022
2021 <i>Maine-Québec Number Theory Conference</i> Virtual (University of Maine, Orono)	October 2-3, 2021
<i>Spring 2021 Algebraic Geometry Northeastern Series</i> Virtual (Brown University, Providence)	May 4-5, 2021
21 <sup>st</sup> <i>Algebra, Geometry and Combinatorics Day</i> Virtual (University of Notre Dame, Notre Dame)	April 10, 2021
2021 <i>Joint Mathematics Meetings</i> Virtual (American Math Society, Mathematical Association of America)	January 6-9, 2021
<i>Fall 2020 Algebraic Geometry Northeastern Series</i> Virtual (Stony Brook University, Stony Brook)	October 23-25, 2020
2020 <i>Conférence de Théorie des Nombres Québec-Maine</i> Virtual (Université Laval, Québec)	September 26-27, 2020

14 <sup>th</sup> <i>Algorithmic Number Theory Symposium</i> Virtual (University of Auckland, Auckland)	June 29 - July 4, 2020
<i>UNCG Summer School in Computational Number Theory and Algebra: Ergodic Theory with Applications to Continued Fractions</i> Virtual (University of North Carolina, Greensboro)	May 18-22, 2020
2019 <i>Maine-Québec Number Theory Conference</i> University of Maine, Orono	October 5-6, 2019
<i>Fall 2019 Algebraic Geometry Northeastern Series</i> Boston College, Boston	September 20-22, 2019
33 <sup>rd</sup> <i>Automorphic Forms Workshop</i> Duquesne University, Pittsburgh	March 6-10, 2019
<i>Building Bridges: 4<sup>th</sup> EU/US Summer School + Workshop on Automorphic Forms and Related Topics</i> Alfréd Rényi Institute of Mathematics, Budapest	July 9-20, 2018
32 <sup>nd</sup> <i>Automorphic Forms Workshop</i> Tufts University, Medford	March 19-22, 2018
<i>Modular Forms are Everywhere</i> Max Planck Institute for Mathematics, Bonn	May 15-26, 2017
31 <sup>st</sup> <i>Automorphic Forms Workshop</i> East Tennessee State University, Johnson City	March 6-9, 2017
2017 <i>BYU Student Research Conference</i> Brigham Young University, Provo	March 4, 2017
2016 <i>Connecticut Summer School in Number Theory</i> University of Connecticut, Storrs	August 8-14, 2016
2015 <i>BYU Student Research Conference</i> Brigham Young University, Provo	March 21, 2015
2014 <i>BYU Student Research Conference</i> Brigham Young University, Provo	March 15, 2014