

# ELIZABETH G. CAMPOLONGO, PH.D.

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## EDUCATION

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**The Ohio State University**, Columbus, OH

*Doctor of Philosophy: Mathematics*

August 2022

- Thesis: Lattice Point Counting through Fractal Geometry and Stationary Phase for Surfaces with Vanishing Curvature
- Advisor: Krystal Taylor

*Master of Science: Mathematics*

May 2017

**New York University Gallatin School of Individualized Study**, New York, NY

May 2014

*Bachelor of Arts, Cum Laude in "The Language of Mathematics," Minor: Middle Eastern Studies*

## RESEARCH EXPERIENCE

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**Asymmetric Cloning to Eavesdrop on BB84 Protocol:**

*QuForce Innovation Fellow, 1<sup>st</sup> Place Demo (Mentor Alex Khan)*

April - August 2022

- Worked with another mathematician and a physicist to determine the theoretical optimal strategy for asymmetric cloning on a quantum channel (minimizing disturbance while maximizing information gain).
- Compared theoretical expectation to the experimental results from implementation of asymmetric phase-covariant cloning on IonQ's 11-qubit quantum computer (utilizing the Qiskit SDK).

*Independent Researcher, Mentor Alex Khan*

August - Present 2022

- Expanding our experimental investigation into the trade-off between information gain and detection when eavesdropping on quantum key distribution.
- Exploring the impact of noise on our base fidelity rates through implementation on IonQ using Native Gates directly.

**Lattice Points Close to the Heisenberg Norm**, OSU, Columbus, OH

September 2017 - May 2022

*Ph.D. Thesis Project*

- Worked with my advisor, Dr. Krystal Taylor, to answer questions at the intersection of harmonic analysis, number theory, and geometric measure theory.
- Adapted technique used by Iosevich and Taylor (2011) to count lattice points on and near smooth surfaces to instead count lattice points on and near surfaces with vanishing curvature.
  - Removed the non-vanishing Gaussian curvature condition for similarly homogeneous objects defined by norms. The limitation lies in the decay of the Fourier transform of the surface measure.
  - Leveraged the geometry of Heisenberg norm balls to attain results despite vanishing curvature. This work is generalizable to similar objects (those with less homogeneous dilations along one axis).
- Utilized method to estimate the number of lattice points in and near the intersection of two surfaces (described by the same or different norms).

**Topological Data Analysis Applied to Football**, Mined XAI, Dayton, OH

December 2021 - January 2022

*Intern, Continuing Fall Project*

- Analyzed remaining play-types: engineered predictive features for punts to cluster into different strategies with UMAP and HDBSCAN. Clustered on the 1-skeleton of alpha complexes for initial kickoff positions.
  - We expanded the SciPy Voronoi class to include points at infinity and compute Voronoi distance, then further extended this to an alpha complex class which constructs the 1-skeleton of an alpha complex.

**The Erdős Institute Boot Camp:**

*Topological Data Analysis Applied to Football A Fall 2021 Top Project*

September - December 2021

- Collaborated with two mathematicians and a research scientist on the NFL Big Data Bowl 2022 Kaggle Challenge.
- Engineered predictive features by play-type to cluster into different strategies with UMAP and HDBSCAN.
- Applied predictive modeling to each cluster to create a new metric for special teams play.

*Predicting COVID Spread*

September - December 2020

- Partnered with physics Ph.D. student to study COVID-19 spread at the county level in the United States as of December 2020 utilizing Random Forest and Nearest Neighbors Predictors (implemented in Python).

- Compared responses to the pandemic across states by considering factors such as mask use, poverty levels, median age of the population, and population density in each county.

**Statistics of Shapes Given by Point Clouds**, OSU, Columbus, OH

September 2018 - Present

*Computational Side-Project with Advisor*

- Utilizing an analog of the Fourier transform to develop a technique to find an "average shape," with the goal of describing a wide variety of surfaces with few parameters.
- Building off my thesis work of reducing reliance on smoothness of surfaces, we endeavor to avoid this condition, requiring only rotational invariance in the norm.
- Currently working to apply phase retrieval techniques, and determine their utility and the degree to which we can reliably retrieve information about a given shape after it has gone through this averaging process.

**Autonomy Technology Research Center**, Wright State University, Dayton, OH

May - August 2018

*Graduate Researcher*

- Collaborated with Dr. Trevor Bihl from Air Force Research Lab (AFRL) on an applied math problem in Detecting and Analyzing Anomalies with Topological Data Analysis.
- Improved community understanding of how topological data analysis (TDA) could be used for detecting and analyzing anomalies in large data sets—specifically those describing visual data.
- Compared the efficacy of analyzing the MNIST dataset through TDA to an analysis with diffusion maps by running topological models through the Ayasdi platform and applying diffusion maps in MATLAB.

**Elm Encryption/Decryption Program**, OSU, Columbus, OH

January - May 2018

*Cryptography Coding Project*

- Using the Elm programming language, developed a program to encrypt and decrypt messages in the ADFGVX cipher used by the Germans in World War I.
- Extended this program to implement the alterations to the cipher I developed in my undergraduate thesis.
- Inspired to use Elm and guided in learning to implement Elm code by Dr. Jim Carlson.

**Linguistics and Mathematics in Cryptology**, NYU, New York, NY

January - April 2014

*Undergraduate Thesis Project*

- Researched the effect on linguistic structures of various crypto-systems and techniques surveyed in previous study, The Evolution of Cryptology (listed below).
- Performed a comprehensive analysis--mathematical and linguistic--of both an original field cipher from World War I (the ADFGVX cipher) and my modified version.
- Focused on the mathematical representations of the ciphers' attributes and their effects on the linguistic structure of the plaintext message as compared to the patterns and structures evident after encryption.
- Culminated in a 49-page analytical paper proposing meaningful alterations to the cipher, which were further supported by cryptanalytic techniques attempted against them and distinct differences in the patterns of original and encrypted messages.

**REU: Algorithmic Combinatorics on Words**, UNC Greensboro, NC

June - July 2013

*Undergraduate Researcher*

- Wrote programs in Java to calculate distinct non-trivial abelian circular squares and fifth powers in binary partial words.
- Used data from the programs to extrapolate patterns describing the number of distinct non-trivial abelian circular squares in binary partial words conforming to different patterns and containing at most two holes.

**The Evolution of Cryptology**, NYU, New York, NY

September - December 2012

*Undergraduate Independent Study/Research Project in Cryptology*

- Using a combined mathematical and historical analysis, focused on the development of cryptanalytic techniques from ancient times and how these techniques and their application evolved into new ciphers and cryptographic methods through the First World War.
- Culminated in a research paper analyzing a German field cipher from World War I (the ADFGVX cipher), its cryptanalysis, and a modification of the cipher that I developed.

## **RESEARCH AND PERFORMANCE AWARDS**

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*Research Projects*

- 1<sup>st</sup> Place: QuForce Demo Day (2022)
- Top Project: Erdős Institute Fall Boot Camp (2021)

### ***The Ohio State University***

- Graduate Associate Performance Award (2021)
- Rhodus Graduate Fellowship (Autumn 2018 and 2019)
- Math Department Fellowship (2016)
- University Fellowship (2015)

### ***New York University Gallatin***

- Honors on Senior Thesis Project: Linguistics and Mathematics in Cryptology
- Founder's Day Award
- Dean's List
- National Merit Scholarship

## **TEACHING EXPERIENCE**

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### **The Erdős Institute Boot Camp**

May, September 2022

#### *Teaching Assistant*

- Assisted students during group problem sessions, answering questions regarding technical and theoretical practices.
- Ensured groups progressed at a reasonable rate, providing hints as necessary.

### **BAMM: Beyond the Classroom Summer Camp, OSU, Columbus, OH**

June 2021

#### *Teaching Associate*

- Evaluated middle and high school students' submissions as they discovered the math behind magic tricks.
- Assisted students in Zoom help sessions and led afternoon discussions.

### **Recitation Instructor, Tutor, and Grader, OSU, Columbus, OH**

August 2016 - May 2022

#### *Graduate Teaching Associate*

- Graded Intro Analysis I & II, Analysis Overview, honors and regular sections of Foundations of Higher Mathematics (proof writing course), and Linear Algebra.
- Contributed to creation of content for college pre-calculus Ximera textbook.
- Taught recitation sections of Calculus I.
- Tutored Calculus I & II, Calculus for Engineers, Business Calculus, and College Algebra.

### **Tutoring Undergraduate Level, New York, NY**

September 2013 - May 2014

#### *Undergraduate Tutor*

- Tutored college student in discrete mathematics, linear algebra, and programming (C++).
- Two to three days a week in three-hour sessions.

### **HCSSiM, Hampshire College, Amherst, MA**

June - August 2012

#### *Junior Faculty*

- Taught algebraic topics such as modular arithmetic and basic group theory in first main course; taught lessons on fractals and random walks (eg., absorbing Markov chains) in chaos theory course.
- Taught two "minis" (seven day, hour-long) on cryptology: pen and paper ciphers, then modern cryptology.
- Gave an hour-long, program-wide lecture on cracking the Enigma.
- Assisted students with assigned problems and course material during daily three-hour problem sessions.

## **OHIO STATE VOLUNTEER AND LEADERSHIP EXPERIENCE**

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### **SIAM, OSU Chapter Math Modeling Contest Judge**

November 2017, 2018, and 2019

- Graded undergraduate teams' reports based on the merits of their mathematical models, analysis of their results, thoroughness of their conclusions, and the overall creativity and readability of their solutions.

### **AWM, OSU Chapter President (Formerly Vice President, Outreach Chair)**

Academic Years 2019-2022

- Created new chapter website with pages to highlight resources and opportunities for undergrads through post-docs.

### **OSU Math Department Peer Mentor**

Academic Years 2016-2018 and 2019-2021

## **PAPERS**

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- *Lattice Point Counting through Fractal Geometry and Stationary Phase for Surfaces with Vanishing Curvature* ([Dissertation](#)).
- *Lattice Points Close to the Heisenberg Spheres*, with K. Taylor, OSU ([arXiv](#)).
- *A Tutorial on Topological Data Analysis for Big Data Analytics*, with T. Bihl, AFRL (Preprint).

## CONFERENCES

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- miniMAGNTS Poster Presentation: *Lattice Point Counting: From Gauss Circle Problem to Heisenberg Norms* (August 2021).
- SIAM Annual Meeting, AWM Workshop Poster Presentation: *Lattice Point Counting: From Gauss Circle Problem to Heisenberg Norms* (July 2021).
- 3M RISE Symposium (June 2021).
- Hausdorff Trimester Program at The Hausdorff Center for Mathematics, Universität Bonn:
  - Seminar Series: Harmonic Analysis From the Edge & Arithmetic Applications of Fourier Analysis (May-August 2021).
  - The Polynomial Method, Summer School (June 2021).
  - The Circle Method: Entering its Second Century, Summer School (June 2020--Postponed to May 2021).
- (Upcoming) Young Women in Geometric Analysis Presentation: *Lattice Point Counting: From Gauss Circle Problem to Heisenberg Norms*, The Hausdorff Center for Mathematics (April 2020--Postponed to 2021).
- IEEE NAECON Presentation: *A Tutorial on Topological Data Analysis for Big Data Analytics* (July 2019).
- First Midwest Graduate Student Conference: Geometry and Topology meet Data Analysis and Machine Learning Poster Presentation: *Performing Topological Data Analysis through the Ayasdi Platform* (June 2019).
- INFORMS Symposium Presentation: *Big Data Analysis with Topological Data Analysis* (October 2018).

## SKILLS

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- **Data Analytics and Machine Learning:** Python (Pandas, NumPy, Scikit-learn, Matplotlib), Ayasdi (TDA).
- **Computer Languages:** Python, LaTeX, Java, basic Elm and Bash programming.
- **Tools/Platforms:** Jupyter Notebook, GitHub, Microsoft Office Suite, iWork, Zoom, Linux, Macs, and PCs.
- **Foreign Languages:** Functionally proficient in Spanish and Italian. Arabic (beginner), French (reading).
- **Public Speaking:** Twelve years of theatre performance and training, including Off-Broadway.