William Chuang — Curriculum Vitae

Department of Mathematics
University of Arizona
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Education

University of Arizona
M.S. in Mathematics (Expected) Spring 2025
(Graduate-level coursework completed under Ph.D. classification)

San Francisco State University
M.A. in Mathematics Spring 2022
Thesis: *The Hausdorff Dimension of Limit Sets of Well-Distributed Schottky Groups*
Link: `https://scholarworks.calstate.edu/downloads/xd07h079g`
Advisor: Dr. Chun-Kit Lai

University of San Francisco
B.S. in Mathematics, Minor in Computer Science Fall 2018
Major GPA: 3.88/4.00
Graduated with Honors

Research Interests

I am broadly interested in the interplay between mathematical physics, geometry, and the topology of data. My recent work focuses on:

- Analyzing the intrinsic factors and topological structures underlying self-attention architectures, aiming to understand how geometry and topology inform algorithmic design.
- Developing theoretical frameworks in geometric data analysis, notably through an abstract definition of curvature for novel data representations.
- Applying hyperbolic geometry and Kleinian groups to enhance neural network performance and security—specifically:
  (1) Introducing global symmetries into networks (especially autoencoders and transformers),
  (2) Strengthening data encryption and decryption,
  (3) Devising new approaches for deriving neural networks that can be composed or edited mathematically based on previously trained models,
  (4) Dynamically modifying energy landscapes on a global scale to reduce computational costs during training by sequentially mapping model parameters to configurations that systematically decrease the loss function's output.

- Investigating linear combinations, cyclic groups, and orbifolds of feedforward neural networks with restricted codomains, leveraging autoencoders composed of feedforward networks and their inverses to achieve deeper model interpretability.
- Constructing a rigorous interaction theory by integrating:
  (1) The Callan–Symanzik equation and stochastically motivated measures,
  (2) Motives and Hopf algebras within a renormalization group (RG) framework,
  to advance the mathematical understanding of deep neural networks.

Other Independent Projects

University of Arizona

- **Independent Study: Real and Complex Analysis, and Applications of Hyperbolic Geometry**
  With Prof. David Glickenstein, Fall 2023

University of Arizona

- **RTG Project: Scaling Factors of Self-Attention Weights in Transformers**
  With Prof. Ning Hao, Fall 2023

San Francisco State University

- **Computation of the Hausdorff Dimension of Limit Sets of Schottky Groups**
  With Dr. Chun-Kit Lai, June 2021 – May 2022

San Francisco State University

- **Independent Study: Prime Geodesic Theorem and Limit Sets of Schottky Groups**
  January 2021 – May 2021
  Wrote a summary of the modern proof with an emphasis on growth rates based on the Hausdorff dimension of the associated limit set.
  Advisor: Dr. Chun-Kit Lai

San Francisco State University

- **Topology Project: A Study on Fundamental Groups**
  September 2020 – December 2020
  Advisor: Dr. Emily Clader

San Francisco State University

- **Independent Study: Hom-Polytopes**
  September 2019 – December 2019
- **Combinatorics Project: Simplicial Complexes**
  January 2019 – May 2019
  Advisor: Dr. Joseph Gubeladze

University of San Francisco

- **Independent Study: Prime Number Theorem**
  January 2018 – May 2018
  Advisor: Dr. Paul Zeitz

Pennsylvania State University–University Park

- **Functional Analysis Project: Hardy's Proof of Uniform Distribution**
  January 2018 – May 2018
- **Independent Study: Reading "Lecture Notes on Functional Analysis: With Applications to Linear Partial Differential Equations"**
  January 2018 – May 2018
  Advisors: Dr. Sergei Tabachnikov and Dr. Moisey Guysinsky

Pennsylvania State University–University Park

- **Topology Project: Solving the $(9, 8, 4, 3, 7)$-Linkage Problem**
  January 2018 – May 2018
- **Topology Final Project: Conway's Basic Theorem**
  September 2017 – December 2017
  Advisor: Dr. Sergei Tabachnikov

University of San Francisco

- **Capstone Project: Graph Theory for an Inverted-Index-Based Search Engine**
  January 2018 – May 2018
  Advisor: Dr. Chris Bryan

University of San Francisco

- **Capstone Project: Applying the Method of Steepest Descent and Cauchy Contour Integrals to the Fisher Exact Test**
  January 2018 – May 2018
  Advisor: Dr. Xuemei Chen

University of San Francisco

- **Research Assistant**
  August 2016 – May 2017
  Assisted with lecture notes for MSAN 504 (Review of Probability and Statistics).
  Advisor: Dr. Jeff Hamrick

University of San Francisco

- **Capstone Project: Implementing Dijkstra's Algorithm Applications**
  Spring 2016
- **Summer Research Project: Therapeutic Video Games for Patients with Disabilities**
  June 2016 – September 2016
- **Interpreting Deep Neural Networks**
  Fall 2016
  Explored causal structures within deep networks to map them onto symbolic graphs, and investigated methods to initialize models from human-written code.

Read causal inference research by Prof. David Galles and Judea Pearl.
Advisor: Dr. David Galles

Pre-Baccalaureate Independent Projects

National Taiwan University

- **Research Student at LeCosPA**
  September 2011 – May 2013
  Presented various topics in weekly meetings and seminars, including:
  - Bremsstrahlung and Cherenkov radiation
  - Topological quantum field theory and 2+1D quantum gravity via Chern-Simons terms
  - Cosmological constant, vacuum structure, and vacuum energy
  - Radiation from moving mirrors and black holes (Schwinger mechanism, Casimir effect, Hawking/Unruh effects)
  - Potential carbon-free energy sources via low-energy nuclear reactions
  - Metamaterials and analog models of gravity
  - Instability of Anti-de Sitter space
  - Induced gravity, Coleman-Weinberg–Witten theorem on Lorentz violation, AdS/CFT correspondence
  - Quantum information, holographic turbulence, AdS/CMT, sonoluminescence
  - Holographic renormalization group flow and Ricci flow
  - Background-independent spin foam models and Regge calculus

  Advisor: Dr. Pisin Chen

National Taiwan University

- **Kontsevich–Soibelmann Wall-Crossing Formula for Mathematical QFT**
  January 2012 – May 2012
- **Conformal Bootstrap Methods for the 3D Ising Model**
  2011
  Advisor: Dr. Heng-Yu Chen

National Taiwan University

- **A Study on the Lee–Yang Theorem and Riemann Zeta Function in Statistical Mechanics**
  January 2012 – May 2012
  Advisor: Dr. Ning-Ning Pang

National Taiwan University

- **Dark Energy Problem via Modified Gravity**
  September 2010 – May 2011
  Focused on the equivalence of Einstein frames and conformal mappings in scalar-tensor theory.
  Advisor: Dr. Je-An Gu

Work Experience (Teaching & Research)

University of Arizona

- Graduate Teaching Assistant, MATH 112 (College Algebra), Section 33 – Fall 2022
- Graduate Teaching Assistant, MATH 112 (College Algebra), Sections 12 & 18 – Spring 2023
- Graduate Teaching Assistant, MATH 112 (College Algebra), Section 13 – Fall 2023
- Grader, MATH 112 (College Algebra), Sections 9, 13 & 20 – Fall 2023
- Tutor, MATH 129 (Calculus II) – Fall 2023
- Grader, MATH 129 (Calculus II) Final Exam – Fall 2023
- Grader, MATH 122B/125 (Calculus I) Common Final Exam – Fall 2023
- Graduate Teaching Assistant, MATH 112 (College Algebra), Sections 101, 102, 201, 202, 401 & 402 – Spring 2024
- Graduate Teaching Assistant, MATH 125 (Calculus I), Section 001 – Fall 2024
- Graduate Teaching Assistant, MATH 112 (College Algebra), Sections 103 & 203 – Spring 2025
- **Teaching Mentors & Advisors:** Mitchell Wilson, Tina Deemer, Catherine Yslas, Oussama Ben Said, Tynan Lazarus, and Prof. David Glickenstein

San Francisco State University

- Graduate Teaching Assistant, Calculus – Spring 2022
- Grader, MATH 227 [05] (Calculus II)
- Instructor, MATH 226 [38] (Calculus I) – Fourth-hour component of MATH 226 [37]
- Instructor, MATH 227 [06] (Calculus II) – Fourth-hour component of MATH 227 [05]
- Instructor, MATH 227 [36] (Calculus II) – Fourth-hour component of MATH 227 [35]
- **Advisors:** Prof. Kim Seashore, Prof. Shandy Hauk, and Prof. Eric Hsu

Other Academic Experience

San Francisco State University

- Graduate Teaching Assistant, Pre-Calculus – Fall 2019
- Advisor: Prof. Kim Seashore

University of San Francisco

- San Francisco Math Circle – Fall 2016
- Advisor: Prof. Paul Zeitz

National Dong Hwa University

- Undergraduate Research Assistant – Spring 2010 Hired and advised by Prof. Cheng-Pang Liu
- Tutor of Calculus and General Physics – August 2008 to December 2009 Hired by the NDHU Department of Physics

Awards and Honors

- **Nominated for MSRI Summer Graduate School on Metric Geometry and Geometric Analysis**
  University of Oxford (UK), Fall 2021
- **Dean's Honor Roll**
  University of San Francisco, Spring 2018
- **Mathematics Advanced Study Scholarship and Internal Scholarship (MASS Program)**
  The Pennsylvania State University–University Park, Fall 2017
  (Covered tuition and fees)
- **Dean's Honor Roll**
  University of San Francisco, Spring 2015, Fall 2016, and Spring 2017
- **Pi Mu Epsilon Honor Society**
  University of San Francisco
- **Admitted to the Summer School on Symmetry in Mathematics and Physics**
  National Taiwan University, Summer 2012
- **Admitted to Prof. Anthony Zee's Quantum Field Theory Course**
  Institute of Physics, Academia Sinica, February 2012
- **Admitted to the 1st LeCosPA Symposium: Towards Ultimate Understanding of the Universe**
  National Taiwan University, February 2012
  [Link]
- **Admitted to the 2nd International Workshop on Dark Matter, Dark Energy, and Matter-Antimatter Asymmetry**
  National Tsing Hua University, Winter 2010
  [Link]
- **Admitted to the Summer School for Theoretical Physics**
  National Tsing Hua University, Summer 2009
- **President's List**
  National Dong Hwa University, March 2008, November 2008, March 2009, March 2010

Certificates

- **Safety Preparedness Training**
  The University of Arizona, Employee Development, Growth, and Engagement
  December 8, 2023
- **Information Security Awareness Certification**
  The University of Arizona, Employee Development, Growth, and Engagement
  August 27, 2023
- **MASS Program Completion**
  Completed all requirements for the 2017 Mathematics Advanced Study Semesters program at The Pennsylvania State University

- **Recognition of Service Award**
  ACM Special Interest Group on Management of Data (SIGMOD) – 2016
- **Tackling the Challenges of Big Data**
  Online program developed by the faculty of the MIT Computer Science and Artificial Intelligence Laboratory
  February 3 – March 17, 2015

Skills

- **Problem Solving and Adaptability:** Demonstrated ability to learn new skills quickly.
- **Programming Languages:** C/C++, Python, R, Java, Lisp, Shell Script, Sed, Awk, LaTeX, Mathematica
- **Libraries and Packages:** PyTorch, Lightning, NumPy, Pandas, scikit-learn, Matplotlib, Ogre3D
- Designing algorithms to generate examples for theoretical research in mathematics, physics, statistics, and computer science