William Chuang   # Curriculum Vitae

Department of Mathematics   williamchuang@math.arizona.edu
University of Arizona
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EDUCATION

University of Arizona
  PhD Student in Mathematics, Fall 2022 – Present

San Francisco State University
  M.A., Mathematics, Spring 2022
  Thesis: The Hausdorff Dimension of Limit Sets of Well-distributed Schottky Groups
  Advisor: Dr. Chun-Kit Lai

University of San Francisco
  B.S., Mathematics, Fall 2018
  Major GPA: 3.88/4.00
  Minor in Computer Science
  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: The scaling factor of self-attention weights in transformers with Prof. Ning Hao, Fall 2023

San Francisco State University

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

San Francisco State University

Independent Study: A Study on Prime Geodesic Theorem and Limit Sets of Schottky groups, January 2021 – May 2021
Write a document summarizing the modern approach to prove the theorem with an emphasis on the growth rate based on the Hausdorff dimension of the limit set of the Schottky group.
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: A Study on Hom-Polytopes, September 2019 – December 2019
Combinatorics Project: A Study on Simplicial Complexes, January 2019 – May 2019
Advisor: Dr. Joseph Gubeladze

University of San Francisco

Independent Study: A Study on Prime Number Theorem, January 2018 – May 2018
Advisor: Dr. Paul Zeitz

Pennsylvania State University–University Park

Functional Analysis Project: A Study on Hardy's Proof on 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 $(9, 8, 4, 3, 7)$-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: Using Graph Theory to Implement a Search Engine in Inverted Index Data Structure, January 2018 – May 2018
Advisor: Dr. Chris Bryan

University of San Francisco

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

University of San Francisco

Research Assistant, August 2016 – May 2017
Worked on Lecture Notes for MSAN504 Review of Probability and Statistics
Advisor: Dr. Jeff Hamrick

University of San Francisco

Capstone Project: Implementing Applications of Dijkstra Algorithm, Spring 2016
Summer Research Project: Therapeutic Video Games for Disabled Patients, June 2016 – September 2016
The interpretability of deep neural networks, Fall 2016
  by trying to extract internal causal structures of deep neural networks and map it to a symbolic graph,
  by trying to construct a method to map human written symbolic code into sets of parameters to initialize deep neural networks, and
  reading causal inference papers written by Prof. David Galles and Judea Pearl
Advisor: Dr. David Galles

<center>Pre-Baccalaureate Independent Projects</center>

National Taiwan University

Research student at LeCosPA, September 2011 – May 2013
  – My old profile page: Tao-Mao Chuang
  – LeCosPA people at that time
Research topics that have partially presented in weekly group meetings, weekly journal club, weekly tea time meetings, and courses of cosmological physics and advanced research topics, including but not limited to the following:
  – computations on bremsstrahlung and Cherenkov radiation

- topological quantum field theory and quantum gravity in 2+1 dimensions using the Chern-Simons term
- cosmological constant problem, vacuum structure, and vacuum energy
- radiation from moving mirrors and black holes, Schwinger mechanism, Casimir effect, Hawking radiation, Unruh effect, and the existence of a mechanism for their reverse effects
- investigated if low-energy nuclear reactions might serve as the foundation for a potentially carbon-free energy source
- metamaterials and analog models of gravity
- instability of Anti-de Sitter Spacetime
- induced gravity–a revisit, Coleman-Weinberg–Witten theorem on Lorentz violation, and Ads/CFT correspondence
- quantum information
- holographic turbulence, AdS/CMT, and sonoluminescence
- holographic renormalization group flow and Ricci flow
- background-independent spin-foam models and Regge calculus

Advisor: Dr. Pisin Chen

National Taiwan University

Studied Kontsevich-Soibelmann wall crossing formula derivations and applications for mathematical quantum field theory, January 2012 – May 2012
Studied the method that solves 3D Ising model using the conformal bootstrap, 2011
Advisor: Dr. Heng-Yu Chen

National Taiwan University

A Study on Lee-Yang Theorem and the application of Riemann zeta function in Statistical Mechanics, January 2012 – May 2012
Advisor: Dr. Ning-Ning Pang

National Taiwan University

Studied dark energy problem using modified gravity, particularly the equivalence of Einstein frame and its images of conformal mappings in scalar-tensor theory, Sept 2010 – May 2011
Advisor: Dr. Je-An Gu

WORK EXPERIENCE

University of Arizona

Graduate Teaching Assistant of MATH 112 College Algebra, section 33, Fall 2022
Graduate Teaching Assistant of MATH 112 College Algebra, sections 12 and 18, Spring 2023
Graduate Teaching Assistant of MATH 112 College Algebra, sections 13, Fall 2023
Grader of Math 112 college algebra, sections 9, 13, and 20, Fall 2023
Tutor of MATH 129 Calculus II, Fall 2023

Grader of Math 129 Calculus II final exam, Fall 2023
Grader of Math 122B/125 Calculus I common final exam, Fall 2023
Graduate Teaching Assistant of MATH 112 College Algebra, sections 101, 102, 201, 202, 401, and 402, Spring 2024
Graduate Teaching Assistant of MATH 125 FA24 001 Calculus 1
Teaching Mentors and Advisors: Mitchell Wilson, Tina Deemer, Catherine Yslas, Oussama Ben Said, Tynan Lazarus, and Prof. David Glickenstein

San Francisco State University

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

San Francisco State University

Graduate Teaching Assistant of 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

Undergrad Research Assistant, Spring 2010
Hired and advised by Prof. Cheng-Pang Liu

National Dong Hwa University

Tutor of Calculus and General Physics, August 2008 – December 2009
Hired by NDHU Department of Physics

Awards and Honors

- Nominated for MSRI Summer Graduate School on Metric Geometry and Geometric Analysis at University of Oxford, UK, Fall 2021
- Dean's Honor Roll, University of San Francisco, Spring 2018
- Mathematics Advanced Study Scholarship and Internal Scholarship (from MASS program) for covering the tuition and fees, The Pennsylvania State University–University Park, Fall 2017
- Dean's Honor Roll, University of San Francisco, Spring 2015, Fall 2016, and Spring 2017
- Pi Mu Epsilon Honor Society at University of San Francisco
- Admitted to Summer School on Symmetry in Mathematics and Physics, National Taiwan University, Summer 2012
- Admitted to Prof. Anthony Zee's Quantum Field Theory Course at Institute of Physics, Academia Sinica, February 2012

- Admitted to the first LeCosPA Symposium–Towards Ultimate Understanding of the Universe, National Taiwan University University, February 2012
- Admitted to the 2nd International Workshop on Dark Matter, Dark Energy Matter-antimatter Asymmetry, National Tsing Hua University, 2010 Winter
- 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, Dec 8, 2023
- Information Security Awareness Certification, The University of Arizona, Employee Development, Growth and Engagement, Aug 27, 2023
- MASS Program, achieved all requirements of the 2017 Mathematics Advanced Study Semesters program at The Pennsylvania State University
- ACM Special Interest Group on Management of Data, SIGMOD 2016, recognition of service award
- Tackling the Challenges of Big Data, an online program developed by the faculty of the MIT Computer Science and Artificial Intelligence Laboratory, Feb 3–March 17, 2015

Skills

- Problem Solving; Can learn new skills quickly.
- Programming Languages: C/C++, Python, R, Java, Lisp, Shell Script, Sed, Awk, LaTex, Mathematica
- Packages and Libraries: PyTorch, Lightening, Numpy, Pandas, Scikit, Matplotlib, Orge3D
- Recently, learning Haskell and Lean
- Designing algorithms to construct examples for studying theoretical research in math, physics, statistics, and computer science