Ajeet Singh Gary

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Professional Summary

Will graduate from UMD with a dual degree in Mathematics and Computer Science and minors in Physics and Philosophy in Spring of 2019, and then pursue a PhD in Mathematics or Applied Mathematics. Specific research interests in string theory from a topological perspective, or gravitation and cosmology.

Education and Test Scores

University of Maryland College Park | College Park, Maryland

     Graduation date: May 2019

     Bachelor of Science in Mathematics

     Bachelor of Science in Computer Science

     Minors in Physics and Philosophy

     Completed cumulative credits to-date: 160

New York University Shanghai | Shanghai, China

     Time Enrolled: August 2014 – December 2014 (1 Semester)

     STEM Classes taken at NYUSH: Advanced Linear Algebra, Physics I, Chemistry I

GRE | Taken: Nov 12th, 2018   Verbal: 161 – 88th (percentile)   Quantitative: 168 – 96th   Writing: 6.0 – 99th

Research in Low Dimensional Topological Spaces (REU at Brown University Summer 2018)

Website: https://icerm.brown.edu/summerug/2018/

Part of two research projects, both of which are still ongoing via remote collaboration:

Character Varieties and Cubic Surfaces with Dr. William Goldman (University of Maryland)   Jun. 2018 - Present

     Visualizing and investigating the cubic surfaces of the $SL_2(\mathbb{C})$ character varieties associated with the Fricke spaces of hyperbolic metrics on orientable surfaces with two-generator fundamental groups.

     Other collaborators: Charles Daly, Jonghyun Lee

Origamis of Topological Surfaces with Dr. Tarik Aougab (Brown University)   Jul. 2018 - Present

     Investigating the action of $SL_2(\mathbb{Z})$ on Teichmüller spaces via the combinatorics of Minimally Intersecting Filling Pair Origamis (MIFPOs) on orientable topological surfaces without boundary. Utilizing HPC (High-Performance Computing) on Brown University's OSCAR cluster for relevant combinatorial questions.

     Other collaborators: Jenny Rustad, Paige Helms, Tasha Kim, Zichen Cui

Other Current Research

Self-Assembly of the Zika Virus Capsid with Dr. James Yorke (University of Maryland)   Sep. 2018 - Present

     Working to investigate the geometry of how the spherical shells (capsids) of the Zika virus self-assemble from three distinct proteins. Currently visualizing the structure and simulating the assembly using symmetries of the dodecahedron and the covering space of surfaces with Euler characteristic 0. Overall goals include formulating the set of all tilings of the sphere.

Correctness of Program Transformations   Oct. 2018 - Present

     Using LiquidHaskell to prove the correctness of certain code transformations used to improve runtime in Richard Bird's book "Pearls of Functional Algorithm Design".

     Collaborators: Shivam Agrawal, David Miller, and Andrew Witten in CMSC396H Honors Seminar

Conferences and Professional Presentations

- DYNAMICS AND MODULI OF GEOMETRIES ON SURFACES   Jan. 2019
  Groups, Geometries, and Spaces in honour of Alessandra Lozzi at ETH Zürich
    Dr. William Goldman will present his research on cubic moduli spaces and using the
    Mathematica models that were the main result of my work over the summer at ICERM.
    Abstract: https://www.math.ethz.ch/fim/conferences/groups-spaces-geometries-alessandra-iozzi/talks.html

- DYNAMICS ON THE CHARACTER VARIETY OF THE FRICKE SPACES OF SURFACES ON TWO GENERATORS
  Winter Enrichment Program (WEP) Undergraduate Poster Competition 2019 at   Jan. 2019
    King Abdullah University of Science and Technology (KAUST) in Thuwal, Saudi Arabia
    I competed in a poster competition to present my research.
    Same Abstract as the conference below (JMM).

- USING ORIGAMIS TO EXAMINE THE ACTION OF $SL_2(\mathbb{Z})$ ON QUADRATIC DIFFERENTIALS   Jan. 2019
  Joint Mathematics Meeting (JMM) - MAA Undergraduate Student Poster Session
    Poster presentation by my collaborator Paige Helms
    Abstract: Establish a lower bound for the number of orbits of the $SL_2(\mathbb{Z})$ action on the space of
    Quadratic Differentials, cotangent bundle to Teichmüller space. We accomplish this through an
    algebraic interpretation of a pair of minimally intersecting curves that fill a surface $\Sigma_{g,0}$ of genus g
    with no boundary components or punctures. Such a pair of curves can be visualized on a square-
    tiling of a surface S_g that also carries the structure of an origami, which gives us a way to examine
    the action of $SL_2(\mathbb{Z})$ on a given surface and calculate its monodromy group, giving us a lower
    bound for the number of orbits.

- DYNAMICS ON THE CHARACTER VARIETY OF THE FRICKE SPACES OF SURFACES ON TWO GENERATORS
  Joint Mathematics Meeting (JMM) - AMS Special Sessions on Geometry Labs United   Jan. 2019
    I will be giving a 20 minute talk. Abstract: We are interested in the Fricke spaces of certain
    orientable surfaces with fundamental group rank two. They can be expressed using character
    varieties, representations as triples that comprise a certain family of cubic surfaces. We investigate
    the dynamics of the mapping class group action on the Fricke space as polynomial automorphisms
    of the surface, specifically ergodicity and a particularly interesting wandering domain.

- DYNAMICAL SYSTEMS ARISING FROM CLASSIFICATION OF GEOMETRIC STRUCTURES ON MANIFOLDS
  Texas Geometry and Topology Conference at Texas A&M University   Nov. 2018
    Dr. William Goldman presented his research on cubic moduli spaces and using the
    Mathematica models that were the main result of my work over the summer at ICERM.
    Abstract: The classification of locally homogeneous geometric structures on manifolds leads to
    interesting dynamical systems. This talk describes some examples of this classification (some with
    trivial dynamics and others with chaotic dynamics) and how this leads to questions about
    automorphism groups of affine cubic surfaces in 3-space.

- VISUALIZING MAPPING CLASS GROUP DYNAMICS ON THE FRICKE SPACE OF THE ONCE-PUNCTURED TORUS
  Celebrating 75 Years of Mathematics of Computation Symposium at ICERM   Nov. 2018
    Presented a poster on use of Mathematica to create visualizations of hyperbolic metrics and
    theorems about ergodicity on the Fricke spaces of the once-punctured torus, specifically on the
    utilization of parallel computing on the OSCAR supercluster to prepare smooth models for
    presentation.

- USING ORIGAMIS TO EXAMINE THE ACTION OF $SL_2(\mathbb{Z})$ ON QUADRATIC DIFFERENTIALS   Oct. 2018
  MAA Section Meeting at Scripps College
    Presentation by my collaborator Paige Helms.
    Abstract: The goal of this research is to establish a lower bound for the number of orbits of
    the $SL_2(\mathbb{Z})$ action on the space of quadratic differentials of a genus g surface, which can be
    identified with the cotangent bundle to the point in Teichmüller space T_g.

- VISUALIZING CUBIC MODULI SPACES   Oct. 2018
  SUMS Shenandoah Undergraduate Math and Statistics Conference at James Madison University
    - Gave a fifteen minute talk; abstract: $SL_2(\mathbb{C})$ character varieties allow us to represent hyperbolic metrics on topological surfaces on two generators as certain cubic surfaces. Investigating dynamics and ergodicity on these surfaces, as well as their other geometric properties.
- $SL_2(\mathbb{Z})$ ACTION ON SOME GENUS-G SURFACES   Sep. 2018
  NAM Undergraduate MathFest XXVII at Spelman College
    - Presentation by my collaborator Paige Helms.
    - Abstract: Investigating the action of $SL_2(\mathbb{Z})$ on the Teichmüller spaces of n-genus surfaces with and without punctures by investigating minimally intersecting filling pairs, specifically using an algebraic interpretation of these pairs and categorizing them into orbits under certain transformations.
    - My role was to use Mathematica to preform computations using HPC resources, test hypothesis, and generate graphics for presentations.
- DYNAMICS ON MODULI SPACES FOR TWO-GENERATOR HYPERBOLIC ISOMETRY GROUPS   Aug. 2018
  Geodesics on Real Hyperbolic Manifolds hosted by Connecticut College
    - Presented with Dr. William Goldman, talk focused on $SL_2(\mathbb{C})$ character varieties and specifically the dynamics on the moduli spaces for two-generator hyperbolic isometry groups and the nature of the Fricke spaces for surfaces with fundamental group rank two.
- MINIMALLY INTERSECTING FILLING PAIR ORIGAMIS   Aug. 2018
  Summer@ICERM 2018: Low Dimensional Topology and Geometry at Brown University
    - Presented research from the summer on investigating the Teichmüller spaces of arbitrary genus surfaces by investigating Minimally Intersecting Filling Pair Origamis or MIFPOs.
    - Collaborators: Dr. Tarik Aougab, Jenny Rustad, Paige Helms, Tasha Kim, Zichen Cui
- VISUALIZING CUBIC MODULI SPACES   Aug. 2018
  Summer@ICERM 2018: Low Dimensional Topology and Geometry at Brown University
    - Presented research from the summer on $SL_2(\mathbb{C})$ character varieties, mainly visualizing certain theorems about the dynamics and ergodicity on cubic surfaces representing $SL_2(\mathbb{C})$ characters.
    - Collaborators: Dr. William Goldman, Charles Daly, Jonghyun Lee
- VISUALIZING THE ACTION OF MÖBIUS TRANSFORMATIONS ON CHAINS IN THE COMPLEX PLANE (updated)
  University of Maryland Undergraduate Research Day   Apr. 2018
    - Continuation of project presented at the GLU conference with updates to the Mathematica visualizations and further exploration of the action of these Möbius transformations on both the complex plane and the Riemann sphere. Poster presentation.
- VISUALIZING THE ACTION OF MÖBIUS TRANSFORMATIONS ON CHAINS IN THE COMPLEX PLANE
  Geometry Labs United (GLU) Conference at Washington University   Aug. 2017
    - Mathematica visualizations of the action of Möbius transformations on the complex plane and Riemann sphere.

Selected Coursework at UMD:

Math240 - Linear Algebra	Cmsc131 - Object Oriented Programming I
Math241 - Multivariate Calculus	Cmsc132 - Object Oriented Programming II
Math246 - Differential Equations	Cmsc250 - Discrete Structures
Math310 - Introduction to Mathematical Proof	Cmsc216 - Introduction to Computer Systems
Math403 - Abstract Algebra	Cmsc330 - Organization of Programming Languages
Math405 - Linear Algebra	Cmsc389e - Digital Logic Design
Math410 - Real Analysis I	Cmsc351 - Algorithms I
Math411 - Real Analysis II	Cmsc420 - Data Structures
Math430 - Euclidian and Non-Euclidian Geometries	Cmsc451 - Algorithms II
Math432 - Introduction to Topology	Phys272 - Fields/Electricity and Magnetism
Math452 - Chaos and Dynamics	Phys273 - Waves

Math462 - Partial Differential Equations	Phys371 - Modern Physics
Math858r - Ramsey Theory	Phys401 - Quantum Physics I
Stat410 - Probability and Statistics	Phys410 - Classical Mechanics
Phil170 - Introduction to logic	Astr120 - Solar Systems
Phil370 - Modal Logic	Astr398b - Black Holes

Enrolled in this semester (Spring 2019):

Math466 - Numerical Analysis	Cmsc422 - Machine Learning
Phys457 - Quantum Computing	Cmsc389u - Virtual Reality
Phil470 - Gödel's Incompleteness Theorem	

UMD Independent Study and Research Experience

- ➢ Member of Dr. William Goldman's Experimental Geometry Lab   Spring 2017 - Present
  Current project: Geometry research on Visualizing Plücker Coordinates and Investigating Lines on Cubic and Quadric surfaces in Projective 3-Space
- ➢ Studying Differential Forms with the UMD Math Department's Directed Reading Program   Fall 2017
  (DRP) – producing a Math Department final presentation titled *Understanding the Generalized Stokes' Theorem Using Differential Forms* presented at UMD's twice-annual DRP talk
- ➢ Geometry research (with stipend) focusing on Hermitian Matrices, Möbius Transformations,   Spring 2017
  and Tiling the Punctured Torus with Dr. William Goldman's Experimental Geometry Lab
- ➢ Studied Lorentzian Geometry and Special Relativity with the UMD Math Department's
  Directed Reading Program – Independent study mentored by a graduate student, producing   Spring 2017
  a Math Department final presentation titled *Making Sense of Special Relativity* presented at
  UMD's twice-annual DRP talk

UMD Teaching Experience (Paid Positions)

- ➢ Co-Instructor for the 1-credit class CMSC389E – *Digital Logic Design through Minecraft*   Spring 2019
  - Description: This course uses Minecraft Redstone to teach the inner workings of a computer, building the logical structure from the ground up. We start with building logic gates and progress to adders, an ALU, and eventually all of the parts necessary for a full, Turing-complete computer that can run Assembly-style code.
  - Responsibilities: Creating course materials, weekly lectures, grading, office hours.
  - Advised by Professor Jason Filippou, expected enrollment of 30 students.
- ➢ Instructor and creator of the 1-credit class MATH299M – *Visualization through Mathematica*   Fall 2018
  - Description: A comprehensive course on Mathematica, starting with basics   – Present
    including plotting, computation, 3D modeling, and interactive output. The last several weeks focus on advanced topics including parallelization, evaluation control, precomputation, and advanced dynamic functionality. Course culminates in personalized final projects on a topic of each student's choice.
  - Responsibilities: Creating course materials, weekly lectures, grading, office hours.
  - GitHub: https://github.com/Eigenajeet/MathematicaPortfolio.git
  - Cross listed as the CS course CMSC389W.
  - Advised by Dr. William Goldman. Class of 30 students from the Math, Physics and CS departments.
- ➢ Head TA for CMSC250 - *Discrete Structures*   Spring 2018 – Fall 2018
  - 3 Instructors, 26 TAs, 550+ students. Main sequence course for the Comp Sci major.
  - Responsible for leading TA meetings, creating grading rubrics, generally managing all TAs, working directly with instructors on course content, being the main point of contact between the students and teaching staff, and leading two discussion sections a week.
  - Covered a lecture on injectivity and surjectivity for Professor Jason Filippou and covered a lecture on modular arithmetic for Dr. Clyde Kruskal.
- ➢ TA Coordinator for MATH131 – oversight over all MATH131 TAs   Fall 2017

- ➢ TA for MATH131 – *Calculus II for Life Sciences*   Fall 2017
- ➢ Tutoring MATH140 – *Calculus I* 4 hours a week with the UMD Math Department   Fall 2017
- ➢ TA for MATH131 – *Calculus II for Life Sciences*   Spring 2017
- ➢ Tutoring MATH141 – *Calculus II* 4 hours a week with the UMD Math Department   Spring 2017
- ➢ Tutoring MATH140 – *Calculus I* 10 hours a week with the UMD Math Department   Fall 2016

Sylvan Work Experience

Organization: Sylvan Learning
Location: Sylvan Learning of Bel Air – 5 Bel Air S Pkwy #1515, Bel Air, MD 2015
Job title: Summer STEM Program Coordinator
Position held: Summer 2016 and Summer 2017
Job description: Overseeing various STEM projects such as bridge building and Lego machines, as well teaching basic coding using Tynker, and basic physics to children of various ages, primarily 1st-5th grade.

Attended Conferences

- ➢ *KAUST Winter Enrichment Program (WEP)* in Thuwal, Saudi Arabia   2019
- ➢ *Joint Mathematics Meeting (JMM)* in Baltimore, Maryland   2019
- ➢ *Celebrating 75 Years of Mathematics of Computation* at ICERM   2018
- ➢ *SUMS Conference* at James Madison University   2018
- ➢ *GEAR Regional Workshop* at Connecticut College   2018
- ➢ *February Fourier Talks* at the University of Maryland   2018
- ➢ *Geometry Labs United* at Washington University   2017

Club and Organization Involvement

- ➢ Member of the Computer Science Departmental Honors program
- ➢ Member of the UMD XR Club – programming Virtual Reality and Augmented Reality using Unity
- ➢ Class facilitator with STICs – the Student-Initiated Course Program
- ➢ Smith Investment Fund Quantitative Team member – designing and back-testing trading algorithms, will be building a strategy and taking it to the market in the next few months
- ➢ UMD Math Club member

Awards

- ➢ Second place in the KAUST WEP Undergraduate Poster Competition   2019
  http://studentopportunities.kaust.edu.sa/WEP/

Coding Events

- ➢ Second place in the *Dante Challenge Bowl I* coding challenge   2017

Community

- ➢ Feature on the blog *Computational Complexity*, the most-read Computer Science Theory blog globally 2018
  https://blog.computationalcomplexity.org/2018/10/practical-consequences-of-rh.html
- ➢ Organizer of event *Which CS STIC Should I Take?* for undergraduate STEM majors   2018

Selected Technical Skills

- ➢ Skilled in Mathematica, Sage, CoCalc, Geogebra, MATLAB, Desmos and LaTeX
- ➢ Experienced in High-Performance Computing (HPC) on supercomputing clusters as well as cloud computing
- ➢ Fluent in coding languages Java, C, C#, Python, Ruby, OCaml, Fortran, Prolog, Haskell, and LiquidHaskell
- ➢ Proficient in the virtual and augmented reality software Unity
- ➢ Active user of collaborative software Slack, Piazza, Canvas, Panopto, Gradescope, Trello, and Dropbox