

# Ajeet Singh Gary

13056 Jerome Jay Drive  
Hunt Valley, MD 21030

agary@terpmail.umd.edu  
410-790-4936

U.S. Citizen

## Professional Summary

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Dual Bachelor of Science degrees in Mathematics and Computer Science from the University of Maryland (UMD), with minors in Physics and Computer Science. I have been engaged in research in low-dimensional topology with UMD's Dr. William Goldman's Experimental Geometry Lab for two years, and Brown University's Dr. Tarik Aougab for the past year since an REU at Brown University's Institute for Computational and Experimental Research in Mathematics (ICERM). I have presented our research at several conferences including the Joint Mathematics Meeting (JMM). In the Fall I will be starting an MS in Mathematics at New York University's Courant Institute of Mathematical Sciences. The backbone of my studies is Mathematics, although my minor in Physics and degree in Computer Science as well as first prize in UMD's 2019 Hackathon display my ability and interest in Physics and Computer Science. Throughout my undergraduate degree I worked as Head Teaching Assistant for various classes for several semesters, and created my own one-credit class on the technical computing language Mathematica. Ultimately, I aim to obtain a PhD in Applied Mathematics and work as a researcher and educator.

## Education and Test Scores

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**New York University - Courant Institute of Mathematical Sciences** | New York, New York

Master of Science in Mathematics (Currently Enrolled)

**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

**New York University Shanghai** | Shanghai, China

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

Vice President of NYUSH Math Club

Total Undergraduate credits: 206

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

## Awards

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- First place in Bitcamp 2019: The University of Maryland Hackathon Apr. 2019  
Project title: *Vector Calc Sandbox*  
Devpost page: <https://devpost.com/software/vector-calc-sandbox>  
Demo video: <https://www.youtube.com/watch?v=PjyebX9fSOg>
- Best STIC Facilitator – UMD Teaching Award Spring 2019  
Nominated as the best instructor/creator of a student-led one-credit course
- Second place in the KAUST WEP Undergraduate Poster Competition Jan. 2019  
Poster: <https://github.com/Eigenajeet/Moduli-Spaces-Research>  
Competition: <http://studentopportunities.kaust.edu.sa/WEP/>

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

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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 Past Research

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

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.

## Conferences and Professional Presentations

- LIVING ON A HYPERBOLIC DONUT Apr. 2019  
*2019 Regional Undergraduate Math Research Conference at Towson University*  
A 15-minute talk to an audience of students from various branches of math.  
Topology research from ICERM adapted for a public audience – goal is to touch on basic concepts in algebraic topology and hyperbolic geometry in a whimsical, intuitive framework, complete with visualizations made in Mathematica.
- DYNAMICS ON THE CHARACTER VARIETY OF THE FRICKE SPACES OF SURFACES ON TWO GENERATORS Jan. 2019  
*Winter Enrichment Program (WEP) Undergraduate Poster Competition 2019 at 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).
- DYNAMICS ON THE CHARACTER VARIETY OF THE FRICKE SPACES OF SURFACES ON TWO GENERATORS Jan. 2019  
*Joint Mathematics Meeting (JMM) - AMS Special Sessions on Geometry Labs United*  
I gave 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.  
Abstract: [http://jointmathematicsmeetings.org/amsmtgs/2217\\_abstracts/1145-51-843.pdf](http://jointmathematicsmeetings.org/amsmtgs/2217_abstracts/1145-51-843.pdf)
- VISUALIZING MAPPING CLASS GROUP DYNAMICS ON THE FRICKE SPACE OF THE ONCE-PUNCTURED TORUS Nov. 2018  
*Celebrating 75 Years of Mathematics of Computation Symposium at ICERM*  
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.
- VISUALIZING CUBIC MODULI SPACES Oct. 2018  
*SUMS Shenandoah Undergraduate Math and Statistics Conference at James Madison University*  
Gave a 15-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.
- DYNAMICS ON MODULI SPACES FOR TWO-GENERATOR HYPERBOLIC ISOMETRY GROUPS Aug. 2018  
*Geodesics on Real Hyperbolic Manifolds – GEAR Regional Workshop 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) Apr. 2018  
*University of Maryland Undergraduate Research Day*  
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 Aug. 2017  
*Geometry Labs United (GLU) Conference at University of Washington*  
Mathematica visualizations of the action of Möbius transformations on the complex plane and Riemann sphere.

#### Conferences and Professional Presentations given by my Collaborators

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- AUTOMORPHISMS OF AFFINE CUBIC SURFACES May 2019  
*University of Maryland Algebra-Number Theory Seminar*  
Dr. William Goldman presenting the software I created over the summer at ICERM.  
Abstract: [http://www-math.umd.edu/gcal\\_rss.php?seminar\\_key=AN&year=2019&html](http://www-math.umd.edu/gcal_rss.php?seminar_key=AN&year=2019&html)
  - DYNAMICS AND THE CLEBSCH DIAGONAL CUBIC SURFACE Feb. 2019  
*George Mason University Topology, Arithmetic, and Dynamics Seminar (TADS)*  
Dr. William Goldman presenting the software I created over the summer at ICERM.  
Abstract: <http://math.gmu.edu/~slawton3/TADSAbstracts/Spring2019/goldman19.pdf>
  - 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>
  - 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.  
Abstract: <https://www.maa.org/sites/default/files/Programs/%28Final%29%20JMM%202019%20Student%20Poster%20Booklet.pdf>

- 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.
- 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  $T_g$ .
- $SL_2(\mathbb{Z})$  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 perform computations using HPC resources, test hypothesis, and generate graphics for presentations.

#### UMD Teaching Experience (Paid Positions)

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- 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 33 students.
  - Instructor and creator of the 1-credit class MATH299M – *Visualization through Mathematica* Fall 2018  
 Description: A comprehensive course on Mathematica, starting with basics – Spring 2019 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 35 students from Math, Physics, CS, Engineering, and Finance.
  - 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

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| ➤ Tutoring MATH140 – <i>Calculus I</i> 4 hours a week with the UMD Math Department  | Fall 2017   |
| ➤ TA for MATH131 – <i>Calculus II for Life Sciences</i>                             | Spring 2017 |
| ➤ Tutoring MATH141 – <i>Calculus II</i> 4 hours a week with the UMD Math Department | Spring 2017 |
| ➤ Tutoring MATH140 – <i>Calculus I</i> 10 hours a week with the UMD Math Department | Fall 2016   |

## Sylvan Work Experience

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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 1<sup>st</sup>-5<sup>th</sup> grade.

## Publications

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“Visualizing Cubic Moduli Spaces” by Ajeet Gary and Jonghyun Lee

Will be published in the University of Maryland Undergraduate journal *Scientific Terrapin* in August 2019

## Selected Coursework at UMD

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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	Cmsc389u - Augmented Reality
Math411 - Real Analysis II	Cmsc351 - Algorithms I
Math430 - Euclidian and Non-Euclidian Geometries	Cmsc420 - Data Structures
Math432 - Introduction to Topology	Cmsc422 - Machine Learning
Math452 - Chaos and Dynamics	Cmsc451 - Algorithms II
Math462 - Partial Differential Equations	Phys272 - Fields/Electricity and Magnetism
Math466 - Numerical Analysis	Phys273 - Waves
Math848g - Dynamics on Moduli Spaces	Phys371 - Modern Physics
Math858r - Ramsey Theory	Phys401 - Quantum Physics I
Stat410 - Probability and Statistics	Phys410 - Classical Mechanics
Phil170 - Introduction to logic	Phys457 - Quantum Computing
Phil370 - Modal Logic	Astr120 - Solar Systems
Phil470 - Logical Theory	Astr398b - Black Holes

## UMD Independent Study and Research Experience

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| ➤ 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 (DRP) – producing a Math Department final presentation titled <i>Understanding the Generalized Stokes' Theorem Using Differential Forms</i> presented at UMD's twice-annual DRP talk | Fall 2017             |
| ➤ Geometry research (with stipend) focusing on Hermitian Matrices, Möbius Transformations, and Tiling the Punctured Torus with Dr. William Goldman's Experimental Geometry Lab   | Spring 2017           |
| ➤ 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

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#### Other Attended Conferences (no presentation)

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| ➤ <i>Innovate Maryland 2019</i>                               | Apr. 2019 |
| ➤ <i>February Fourier Talks</i> at the University of Maryland | Feb. 2018 |

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#### UMD Club and Organization Involvement

- 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

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#### Coding Events

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| ➤ Host of UMD Bitcamp Hackathon's Mathematica workshop               | Apr. 2019 |
| ➤ UMD Bitcamp Hackathon 2019 Participant                             | Apr. 2019 |
| ➤ Second place in the <i>Dante Challenge Bowl I</i> coding challenge | 2017      |

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#### Volunteering

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| ➤ Volunteer with Girls Excelling in Math and Sciences (GEMS)   | 2019 |
| GEMS holds STEM events for middle school girls guided by volunteer undergraduate students. The goal is to inspire interest and confidence in STEM for young girls. |      |
| <a href="https://gemspg.wordpress.com/">https://gemspg.wordpress.com/</a>  |      |

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#### Community

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| ➤ Feature on the blog <i>Computational Complexity</i> , the most-read Computer Science Theory blog globally   | 2018 |
| <a href="https://blog.computationalcomplexity.org/2018/10/practical-consequences-of-rh.html">https://blog.computationalcomplexity.org/2018/10/practical-consequences-of-rh.html</a> |      |
| ➤ Organizer of event <i>Which CS STIC Should I Take?</i> for undergraduate STEM majors  | 2018 |

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#### Selected Technical Skills

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