Registration ID 1290862
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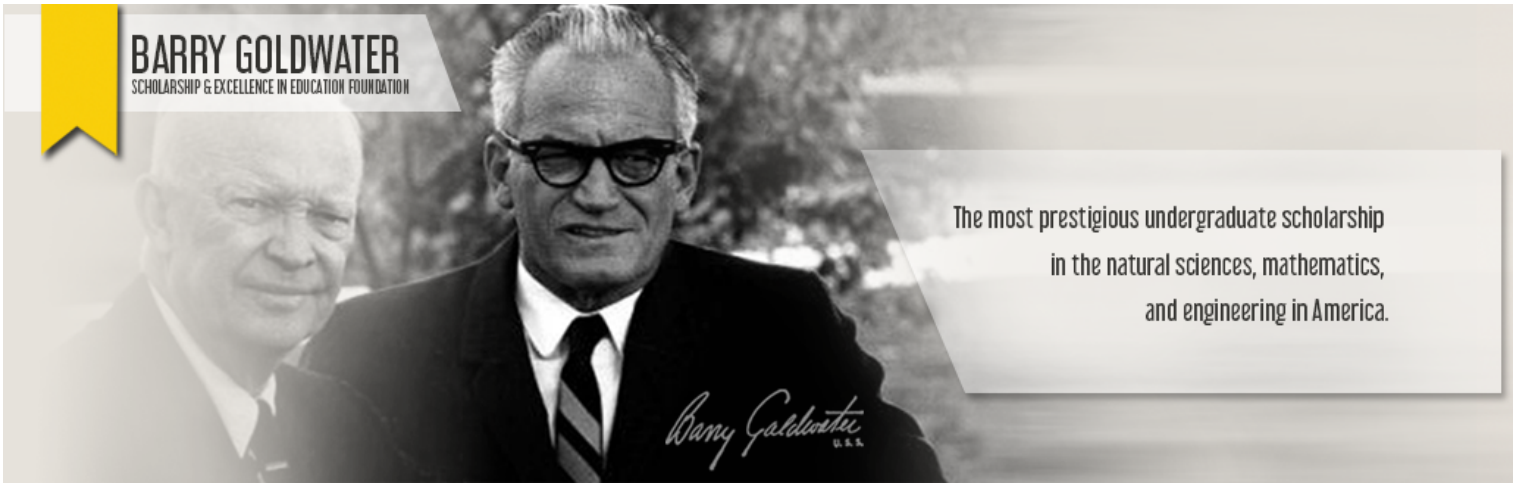

The Barry Goldwater Scholarship and Excellence in Education Foundation

Application Review

Registration ID 1290862

Registration ID 1290862
Your session will automatically time out at **11:19:38am** Central Time if no action is taken. Any action (saving information or choosing a new page) will reset this timer.

Your application data has been submitted. No changes to your application can be made, however, you can update profile information at any time from the Student Overview screen.

Recommenders

Recommenders

Actions	Name *	Email *	Action Date	Buttons
	Dr. Charles Kane		01/13/2022 12:23pm	
	Dr. George Clark		01/13/2022 10:03am	
	Dr. Jay Kikkawa		1/13/2022 10:03am	
	Dr. Danielle Bassett		01/13/2022 12:23pm	

The recommender's list is currently locked. The submission window is closed.

This application requires 3 recommendations.

Making a change to the list of recommenders: Student applicants cannot make changes to the list of recommenders. Changes to the list must be made by the Campus Representative. For guidance on how to remove and replace a recommender, please see FAQ questions **"How is a letter writer replaced?"**

Application Questions & Answers

Legal Residence Information

Question	Answer
* Citizenship	
* Legal Residence Address	
Address (line 2)	
* City	
* State	
* Zip Code	
* Your U.S. Congressional House District	

Career Goals/Professional Aspirations

Question	Answer
* What is the highest degree you plan to obtain?	Ph.D.
* In one or two sentences, describe your career goals and professional aspirations (see example below). This statement will be used in publications if you are selected as a scholar.	Ph.D. in physics, specializing in quantum gravity, primordial black holes, and cosmology. Conduct research in these areas and teach at the university level. I plan to earn a Ph.D. in physics, and then conduct research in the fields of quantum gravity and cosmology as a professor at a major research institution. To ensure I can achieve these goals, I am growing my knowledge base and skillset by means of coursework, research, and teaching. I am currently on track to simultaneously complete my bachelor's and master's degrees in physics and astronomy by May 2023. I am taking advantage of Penn's submatriculation program to challenge myself with graduate level courses and utilizing Penn's free

* What are your career goals and professional aspirations? Indicate which area(s) of mathematics, science, or engineering you are considering pursuing in your research career and specify how your current academic program and your overall educational plans will assist you in achieving your career goals and professional aspirations.	elective system to broaden my mathematical dexterity. Expanding my academic foundation has been vital to my continued improvement as a researcher. My research experiences over the past 4 years have allowed me to hone the skills necessary for effective scientific investigation. Through my work with the JHU Applied Physics Lab, I have both established computational and experimental competencies and built the communication skills necessary to write and publish in a peer-reviewed journal. Through my work in Dr. Kikkawa's lab at Penn, I have become proficient with mathematical and computational treatments of optical fields, methodologies I will apply to my future work with the matter and energy fields of quantum gravity. My teaching has also been instrumental in preparing me to become a professor. While I have always enjoyed being an informal tutor for friends and peers, I have recently formalized my teaching role as a calculus Teaching Assistant. As a TA I have received regular feedback about how to be a more effective teacher, which I will leverage for the benefit of my future students. I am excited to become a professor and share my work and passion for science with the next generation of researchers. After completing my BA/MS, I will attend graduate school for physics and conduct research in quantum gravity, exploring its implications for cosmology. More specifically, I am interested in studying quantum gravity's role in the creation of black holes and other compact objects, and what that can tell us about the origin of our universe: What are the conditions at the event horizon? What is the entropy of a black hole? How do these objects affect the expansion of the early universe? Following graduate school, I will pursue a postdoctoral position, and then finally a professorship. Quantum gravity research has developed exponentially over the past 20 years, most recently producing a formula for the gravity of a 2-dimensional quantum system, the Liouville QFT. This and other advancements are exciting to be sure, but there is still much work to be done. The goal of physical science, in my mind, is to understand what laws govern our universe, and quantum gravity is at the cutting edge of where our best guesses still fail. I am exhilarated by the opportunity this provides to push the boundary of human knowledge and contribute to a better understanding of our universe.
* Describe an activity or experience that has been important in helping shape or reinforce your desire to pursue a research career in science, mathematics or engineering.	Growing up, I always had a child-like awe for scientists. Unfortunately, this reverence led to feelings of disconnection and inadequacy. While I loved reading scientific papers, I did not believe I would ever be able to engage with the knowledge they held. As I began studying at Penn, these lingering assumptions led me to develop impostor syndrome. That all changed after my work in Dr. Kikkawa's lab. In summer 2021, I spearheaded a project studying how special kinds of laser beams (LG modes) with orbital angular momentum (OAM) propagate and interact with optical elements. As I conducted my experiments, I observed that beams created using established methods were breaking down upon propagation, causing information loss and limiting practical applicability. I scoured the literature, looking for a way to resolve this issue, and found a group that proposed a solution. Reading the abstract, my first thought was: "That shouldn't work." Following the outlined methodology, I was able to reproduce the published results, but in doing so, I identified one key difference—the light's phase distribution was misidentified. Because phase distribution is central to OAM, detecting this error was critical. I was elated. I finally felt as though I could contribute meaningfully to scientific discourse. I threw myself into developing and testing my own hypotheses to improve creation methods, and finally found a solution. While I knew I'd be a life-long learner, I no longer felt like an impostor.
* In what way did COVID-19 or other hardships over the past couple of years affect your research career plans and did those events alter your ability to pursue those plans? If you have had to make changes, in what way(s) did you adapt to the situation? If COVID-19 did not influence your plans, simply state that there was no impact. Please note that your application will not be looked at less favorably in any way if you have not been significantly impacted.	I am thankful to be able to say that COVID-19 has not had significant lasting effects on my research career plans. The hardships I faced were predominantly emotional rather than academic. My particular learning style was well-suited to the transitions back and forth between in-person and virtual classes. I did, however, lose the opportunity to work with Dr. Danielle Bassett over the summer of 2020. In spring 2020, I was enrolled in Dr. Bassett's network science class. We had many lively discussions about my research interests throughout the semester. As a result, she offered me a position in her lab working on applying network statistics to neuroscience, linguistics, and condensed matter. I accepted, hoping to use the experience in network topology as a building block towards understanding the quantum information approach to quantum gravity. Unfortunately, our plans were thrown into disarray by the pandemic. In a COVID-less world, I would have had the opportunity to gain these network science skills while simultaneously continuing my research at the JHU Applied Physics Lab. While that was no longer possible, my JHU mentors Dr. Clark and Dr. Kollmann were incredibly supportive and flexible as I worked with them virtually to publish my research on Saturnian charge exchange. Ultimately, this experience was extremely valuable, as I learned to navigate the authorship, peer review, and publication processes, despite surrounding COVID circumstances.
(Optional question, answering the question below will depend on your personal experience.) Goldwater Scholars will be representative of the diverse economic, ethnic and occupational backgrounds of families in the United States. Describe any social and/or economic impacts you have encountered that influenced your education - either positively or negatively - and how you have dealt with them.	I grew up in a suburb of Baltimore with one younger brother. My elementary school had only 30 students per grade, and no advanced track learning, so every day I sat in on the math class of the grade above mine. I felt isolated and intimidated, but I put my best foot forward. In eighth grade, I studied day in and day out for a standardized test that would allow me to attend a private high school. I was relieved when I scored well enough to earn a full scholarship, as my family would not have been able to afford tuition otherwise. Once there, I packed my schedule full of all the AP classes I could, even forgoing my lunch period so I could take AP Physics. My family had sacrificed a lot to get me to this point, and I had worked too hard to let them, or myself, down. I wanted to make the most of the educational opportunities I now had. I first applied for an internship with the JHU Applied Physics Lab my junior year. I was accepted and appointed project lead of my intern group. During this experience, I developed a passion for teaching. While I was responsible for sharing my Python expertise with the other members, I also recognized how much I was learning from my team. I realized that learning, teaching, and researching go hand-in-hand, allowing groups with varied skillsets to achieve what no single person could by themselves. Since then, I have sought to approach all my work from this perspective, leveraging the opportunities I've had for the benefit of my team and my peers.

Research Projects and Skills

Question	Answer
Research Project #1	Saturnian Charge Exchange
Starting Month	06
Starting Year	2019
Ongoing	No

Ending Month	05
Ending Year	2021
Average Hours/Week (Academic Year)	5
Average Hours/Week (Summer)	40
Name of Project Mentor	Dr. George Clark
Position of Project Mentor	Space Physicist
Affiliation of Project Mentor	Johns Hopkins University Applied Physics Lab
Name of Project Mentor	Dr. Peter Kollmann
Position of Project Mentor	Space Physicist
Affiliation of Project Mentor	Johns Hopkins University Applied Physics Lab
Name of Project Mentor	
Position of Project Mentor	
Affiliation of Project Mentor	
Institution where this research was performed	Johns Hopkins University Applied Physics Laboratory
Description of research, including your involvement in AND contribution to the project. A separate narrative box has been provided for you to describe the research skills you acquired while working on this project.	Saturn, much like the other gas giants in our solar system, has a strong magnetic field that traps charged particles coming in from the solar wind, creating a plasma-filled environment known as its magnetosphere. However, unlike the other gas giants, Saturn also has dense clouds of neutral gas in its magnetosphere, making it a unique case to study. I worked with Dr. Clark and Dr. Kollmann to explore what physical processes dominate the plasma-neutral interactions at Saturn. I conducted an analysis of ion intensity data measured by the Cassini spacecraft while it orbited Saturn. From this analysis, we theorized that a process known as "charge exchange" dominates plasma-neutral interactions in Saturn's magnetosphere. I then created a physical model of charge exchange, and its results matched the Cassini data, thus confirming our theory. This finding gives us a better understanding of similar plasma-neutral interactions in Earth's atmosphere, as well as in distant star-forming nebulae.
Research Skills (Briefly describe any research skill(s) you developed while working on this project that will be important going forward in your research career.)	I developed my ability to work through the processes of analysis, hypothesis, generation of theories, and development of experiments to test said theories. I also developed my computer science skills, becoming professionally adept with Python, including its common scientific and plotting packages.
Do you have Papers/Publications associated with this research project?	Yes
If yes, how many publications are associated with this work?	1
Citation	Sontag A, Clark G, and Kollmann P. 2021. Charge Exchange Ion Losses in Saturn's Magnetosphere. Journal of Geophysical Research, 126(10): 1-21.
Status	Published
How are you listed in the publication?	First author
Type of Publication	National Professional Society Journal
Do you have Presentations associated with this research project?	Yes
If yes, how many presentations are associated with this work?	2
Citation	Sontag A, Clark G, and Kollmann P. Charge Exchange Ion Losses in Saturn's Magnetosphere. Poster session presented at: Outer Planets Assessment Group; 2021 August 30 - September 1; Virtual.
Campus, Regional, National or International	National
Presentation type	Poster
How are you listed on the presentation?	Presenter
Citation	Sontag A, Clark G, and Kollmann P. Charge Exchange Ion Losses in Saturn's Magnetosphere. Poster session presented at: American Geophysical Union Fall Meeting; 2021 December 13-17; New Orleans, LA.
Campus, Regional, National or International	National
Presentation type	Poster
How are you listed on the presentation?	Presenter

Research Projects and Skills

Question	Answer
Research Project #2	Orbital Angular Momentum
Starting Month	06
Starting Year	2021
Ongoing	Yes
Average Hours/Week (Academic Year)	5
Average Hours/Week (Summer)	50
Name of Project Mentor	Dr. Jay Kikkawa
Position of Project Mentor	Professor of Physics
Affiliation of Project Mentor	University of Pennsylvania
Name of Project Mentor	
Position of Project Mentor	
Affiliation of Project Mentor	
Name of Project Mentor	
Position of Project Mentor	
Affiliation of Project Mentor	
Institution where this research was performed	University of Pennsylvania
Description of research, including your involvement in AND contribution to the project. A separate narrative box has been provided for you to describe the research skills you acquired while working on this project.	Analogous to how common objects can display angular motion either by rotating or by orbiting some coordinate center, specially created "Laguerre-Gaussian" (LG) modes of a laser beam can carry angular momentum in either "spin" (SAM) or "orbital" (OAM) forms. Light carrying OAM can be used to efficiently transfer information and is a prime candidate for use in quantum computers, so good methods of creating and manipulating such beams will be critical. I am working with Dr. Kikkawa to probe how LG modes are created and how they propagate through optical devices.

	I first adapted a program written by a recent doctoral candidate to simulate how beams with OAM could be created via diffraction, focused by a converging lens, and displayed on a screen. I then identified beam traits that cause wave packets to break down upon propagation, and discovered a new kind of diffractive element that can resolve the issue. We plan to submit these results for publication in the Optica journal by July 2022.
Research Skills Briefly describe any research skill(s) you developed while working on this project that will be important going forward in your research career.	I honed my ability to develop novel approaches and hypothesize new solutions to problems that have not been previously studied in detail. I also developed my scientific communication skills in both providing and receiving propositions and feedback with my mentor and lab partner.
Do you have Papers/Publications associated with this research project?	No
Do you have Presentations associated with this research project?	Yes
If yes, how many presentations are associated with this work?	1
Citation	Sontag, A and Conefrey-Shinozaki, C. Orbital Angular Momentum: Huygens-Fresnel GPU Simulation. Poster session presented at: Interdisciplinary Research Group Meeting; 2021 October 22; Philadelphia, PA.
Campus, Regional, National or International	Campus
Presentation type	Oral
How are you listed on the presentation?	Presenter

Mentor Recognition Information

Question	Answer
Mentor Name	George Clark
Title	Dr.
Mentor Name	Jay Kikkawa
Title	Professor
Mentor Name	Charles Kane
Title	Professor

Letter Writer Information

Question	Answer
* Name of Letter Writer	Dr. Jay Kikkawa
* Letter Writer's Institution	University of Pennsylvania
* Title of Letter Writer	Professor of Physics
* Relation of the Letter Writer to the student	Taught my quantum class and mentored my research

Letter Writer Information

Question	Answer
* Name of Letter Writer	Dr. George Clark
* Letter Writer's Institution	Johns Hopkins Applied Physics Lab
* Title of Letter Writer	Space Physicist
* Relation of the Letter Writer to the student	Mentored my summer research for the past 4 summers

Letter Writer Information

Question	Answer
* Name of Letter Writer	Dr. Charles Kane
* Letter Writer's Institution	University of Pennsylvania
* Title of Letter Writer	Christopher H. Browne Distinguished Prof. of Phys.
* Relation of the Letter Writer to the student	Taught my intro E&M class and my grad QM classes

Other Activities and Accomplishments

Question	Answer
Activity/Accomplishment	Teaching Math
Organization (if applicable)	Penn Math Department
Scope of Activity/Accomplishment	College/University
Role/Involvement	I have worked for 2 semesters as a Teaching Assistant for Penn's undergraduate math classes. Potential TAs apply with references, and less than half of applicants are offered a position.
Leadership Position	Teaching Assistant
Length of Involvement	Academic Year

Other Activities and Accomplishments

Question	Answer
Activity/Accomplishment	Music Mentoring
Organization (if applicable)	Penn Music Mentoring Program (PMMP)
Scope of Activity/Accomplishment	Community
	I am the coordinator for PMMP's relationship with the local community "Play on Philly" program. I organize 10-

Role/Involvement	15 Penn students teaching music classes for 3 hours per week to nearly 100 underserved Philadelphia youth. I also teach one class myself.
Leadership Position	Site Coordinator
Length of Involvement	More than one academic year

Other Activities and Accomplishments

Question	Answer
Activity/Accomplishment	Coordinating Lectors
Organization (if applicable)	St. Agatha-St. James Parish
Scope of Activity/Accomplishment	Community
Role/Involvement	I coordinate the lectoring ministry at my local Catholic church. I train new lectors, coordinate their scheduling for 4 weekly masses, and act as liaison between the lectors and the parish administration, adding up to roughly 4 hours per week.
Leadership Position	Lector Coordinator
Length of Involvement	More than one academic year

Other Activities and Accomplishments

Question	Answer
Activity/Accomplishment	Playing Music
Organization (if applicable)	Penn Wind Ensemble
Scope of Activity/Accomplishment	College/University
Role/Involvement	I am the lead percussionist in the Penn Wind Ensemble, which rehearses weekly and puts on two concerts per academic year. We play pieces from a wide variety of eras, composers, and styles, and center each concert around a common theme.
Leadership Position	Percussionist
Length of Involvement	More than one academic year

Recognitions

Question	Answer
Recognition	Benjamin Franklin Scholar
Type	
Award Description	The Benjamin Franklin Scholars are "a vibrant community of students at Penn who share a passion for broad intellectual exploration." I was awarded this scholarship for having a wide range of interests and for being in the top 5% of Penn applicants.
Award Year	2019

Current College/University

Question	Answer
* Institution type:	4-year institution
* I am currently enrolled	Full-time
* Are you a transfer student (i.e., Did you transfer from another academic institution to the institution that is nominating you for a Goldwater scholarship?)	No
* Field of study	Physics and Astronomy
Physics and Astronomy areas of specialization	Astronomy and Astrophysics
Period through the end of which you will be reporting your GPA	Fall 2021
* Official cumulative unweighted GPA through the period reported above	4.00
* How many credit hours does your school require for graduation?	36
* How many credit hours will you achieve as of January 1, 2022?	32.5
* How many credit hours do you plan to achieve for graduation?	49
* Expected baccalaureate graduation month	05
* Expected baccalaureate graduation year	2023
* According to the definition provided above, indicate whether you are a sophomore or junior.	Junior
* Matriculation status at the institution you will be attending during the 2022-2023 academic year	Currently Enrolled
* Have you been involved in or do you plan to Study Abroad?	No

Coursework

Question	Answer
Current Course 1	Quantum Physics II
Course Level	Graduate
Current Course 2	Particle Physics
Course Level	Graduate
Current Course 3	Modern Physics Laboratory
Course Level	Undergraduate
Current Course 4	Astrophysics Laboratory
Course Level	Undergraduate

Current Course 5	Quantum Computing and Information
Course Level	Undergraduate
Current Course 6	
Course Level	
Future Course 1	Quantum Field Theory I, II
Course Level	Graduate
Future Course 2	Relativistic Quantum Field Theory
Course Level	Graduate
Future Course 3	Cosmology
Course Level	Graduate
Future Course 4	Statistical Mechanics
Course Level	Graduate
Future Course 5	Electromagnetic Phenomena
Course Level	Graduate
Future Course 6	Life and Death of Stars
Course Level	Undergraduate
Course outside of Major 1	Abstract Algebra
Course Level	Graduate
Course outside of Major 2	Differential Geometry
Course Level	Graduate
Course outside of Major 3	Topology
Course Level	Graduate
Course outside of Major 4	
Course Level	
Course outside of Major 5	
Course Level	
Course outside of Major 6	
Course Level	

Previous Schools attended

Question	Answer
School Name	
City	
State	
Institution type:	
Dates attended	
Unweighted GPA on a 4.00 scale	
Will you be providing a transcript from this school to your Goldwater Campus Representative?	

Future Academic plans

Question	Answer
* Is the institution you will be attending for the 2022-2023 academic year the same as your current academic institution?	Yes

Certification and Release

Question	Answer
* Applicant's Signature	Andrew Sontag

Supporting Documentation

File Type / Description	Description
Essay	Research Essay