UNIVERSITY OF MARY WASHINGTON
where great minds get to work

Physics Department Newsletter 2018-2019

LETTER FROM THE ACTING CHAIR

It's been a great pleasure and challenge to handle the Physics administration in Dr. Hai's absence. It was a pleasure getting to know the students and faculty better, learning more about the awesome curriculum and activities in the department, and gaining a new perspective on the sciences at UMW. It was a challenge because it was a year of transition and change. With Dr. Hai on sabbatical, we welcomed Laura Dickinson as a visiting professor, and we hired a new tenure-track faculty member, Varun Makhija, to replace George King, who retires at the end of December, 2019. This was all in the midst of ongoing renovation and construction in Jepson, which required the faculty and students both to make do with temporary spaces and half-packed labs. Nonetheless, our students were able to conduct some great research through independent studies and internships, and we are very proud of them. Unfortunately for us, this spring our beloved Maia Magrakvelidze found a position near her husband in PA and will be leaving at the end of the summer. Soon we will be conducting another faculty search, but in the meantime we were lucky to find another great visiting professor, Will Dickinson, Laura's husband. Now, we look forward to the coming fall semester in our beautiful new facilities and a great year ahead!

Dr. Hai Nguyen Continues AAAS Policy Fellowship

Last spring, Dr. Nguyen was selected as a 2018-19 American Association for the Advancement of Science (AAAS) Fellow at the Pentagon and was awarded an extension to continue through the 2019-20 academic year. The Fellowship promotes and defends the integrity of science and its use in the Executive Branch of our government. It also seeks to provide a voice for science on societal issues and promote the responsible use of science in public policy. AAAS runs SCIENCE Journal and Science and Diplomacy.

Welcome to Dr. Varun Makhija

We are pleased to welcome Varun Makhija as a new tenure-track assistant professor. Dr. Makhija received his B.S. in physics from Drew University and his Ph.D. in experimental physics from Kansas State University. His research involves experimental and computational studies of rotational, vibrational, and electronic dynamics of excited molecules. This fall, he will teach University Physics and a course in Astrophysics. When he's not immersed in physics, Dr. Makhija studies classical Indian flute, relaxes with English literature (romantic poets, Shakespeare, novels) and Urdu/Persian poetry, and enjoys hiking and camping.

Dr. Maia Magrakvelidze Departs UMW

The department bids a fond but sad farewell to **Dr. Maia Magrakvelidze**, who is leaving to take a position at Cabrini University in PA, much, much closer to her husband! We have loved having her here for three years, and she will be sorely missed by her students and colleagues. We wish her the best of luck in her new position and her future family life.

Alumni Return as Visiting Faculty for 2019-20

Dr. Laura Dickinson will again join us as a Visiting Assistant Professor while Dr. Nguyen continues his fellowship. Dr. Dickinson her BS in Physics at UMW and her PhD in Applied Science from the College of William & Mary.

Dr. Will Dickinson (Laura's spouse) will join us as a Visiting Assistant Professor to step in for Dr. Magrakvelidze. Dr. W Dickinson received his BS in Physics at UMW and his PhD in Physics from the College of William & Mary.

Laura and Will live in Fredericksburg with their son, Elliot. We are pleased that such bright alumni are able to come back and teach at UMW!

Dr. Magrakvelidze Wins STEM Faculty Award

Dr. Maia Magrakvelidze was selected by the UMW student body for the UMW Kappa Sigma Chapter of Chi Beta Phi, STEM Honorary Faculty Award for the 2018-2019 academic school year. This award recognizes the students' choice for the most honored STEM faculty member. Shown here helping Dr. Maia celebrate her award are (L to R) AJ Rasure, Margaret Gregory, and Stephen Tivenan. Congratulations to Dr. Magrakvelidze on a well-deserved award!

Student Scholarships and Senior Awards

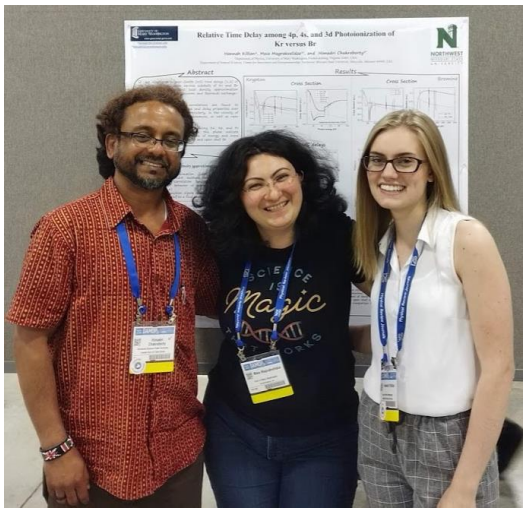
The department was pleased this year to award the **Peggy Ellis Gill '53 Scholarship in Science** to physics major, **Stephen Tivenan**

Each year we have the honor of awarding the **Bulent I. Atalay Scholarship in Physics** to an outstanding rising junior or senior major. This year's recipient was **Hannah Killian**

Hannah Killian also received the **Einstein Prize**, which goes to a graduating physics major for outstanding performance, academic excellence, leadership and overall contributions to the physics program.

Our other outstanding senior award, the **Physics Faculty Award**, which recognizes outstanding academic accomplishment in the physics program was awarded to **Emily MacIndoe**

Faculty and Student Research Presented at APS Conference



Hannah Killian and Dr. Magrakvelidze presented the results of their research at the 49th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics in June, 2018 in Fort Lauderdale, Florida. The presentation in the Time-Resolved Electron Dynamics and Attosecond Spectroscopy session, was entitled "Relative Delay among Br and Kr 4p, 4s, and 3d Photoionization." These results will hopefully help current experiments for investigating the time delay in photoionization processes of different systems.

Dr. Himadri Chakraborty, Dr. Magrakvelidze and Hannah Killian at DAMOP

Hannah Killian Earns Departmental Honors

Supervised by Dr. King and working in conjunction with scientists at Dahlgren, Hannah Completed an Honors Thesis on **"Nanoparticle-polymer composites".** Nanoparticle-polymer composites (NPC's) consist of an insulating polymer containing nanoparticles. For NPC's containing metallic particles, the composite becomes conductive at a specific volume fraction, known as the percolation threshold. Previous studies found NPC's to be conductive when the particles were not in contact, suggesting that electrons may be tunneling through the matrix. Additionally, all metallic particles have an inherent oxide shell. Since oxides are semiconductors, this increases the electrical complexity of the nanocomposite. Hannah's research evaluated the effect of the oxide layer on particles in a NPC through treatment of percolation and quantum tunneling theories to explore the conductive behavior in RF fields. Quantum mechanics was used to evaluate the probability of an electron tunneling between two Cu or CuO particles in an insulating matrix. The transmission probability for an electron to tunnel from one Cu nanoparticle to another in a PMMA matrix with an electric potential of 60 V was found to be very high, with tunneling 95% probable until 200 nm particle separation. After the incorporation of an oxide shell, the tunneling distance at 95% probability increased to 300 nm. A percolation model was constructed in MATLAB, where the tunneling distances for Cu and CuO particles were incorporated to estimate the volume fraction of a NPC. The addition of the oxide layer increased the tunneling distance between particles and decreased the percolation threshold needed to obtain a conductive NPC.

Other Student Research Projects

Sterling Heyns – "**The Virtual Solenoid Project**" – A normal electromagnet consists of charges flowing through metal coils, which creates a magnetic field whose strength is proportional to the current and number of coils. This project was created to subvert the normal current cost of electromagnets, creating a stronger magnet with less current cost. The idea is that two wire solenoids, creating magnetic fields orthogonal to each other and an electron's velocity, will cause that electron to rotate in a circle while traveling in a straight line, resulting in a solenoid formation and producing a magnetic field. An electron gun will provide a steady stream of electrons, creating a solenoid without the use of metal. This semester we created computer simulations of the Virtual Solenoid apparatus to test whether or not it is possible for it to produce a magnetic field stronger than the two real solenoids attached to it combined.

continued below

Other Student Research Projects (continued)

Kathleen Smith – "**Wave Packet Dynamics of Diatomic Molecules**"– Exploring wave propagations within the potential curves of diatomic molecules allows for theoretical calculation of the position, internuclear distance, of the molecules after ionization. Identifying the position of the molecules gives insight into the nature of chemical reactions, the characteristics of matter, and the vibrational levels within atomic energy states. The motion of the diatomic molecules H_2 in the excited state and O_2 in both the $a^4\Pi_u$ and $A^2\Pi_u$ excited states was studied. Solving the time-dependent Schrödinger equation using the Crank Nicholson method produces a wave function that describes the dynamics of the molecular ions. Substituting values for time into the correct form of the wave function gives the internuclear distance of the molecules at that time after ionization. For hydrogen, time steps of .001 femtosecond (10^{-15} s) were used to determine the position from 0 to 350 femtoseconds after ionization. A time step of .005 fs was used to determine the position of oxygen from 0 to 2,000 fs after ionization.

Shivani Gupta– **"Optical Trapping of Nanoparticles"** – New generation fluorophores, known as Up-converting Nanoparticles (UCNPs), when excited, have the ability to convert low energy near- infrared radiations (NIR) into visible high energy wavelengths through non-linear optical processes. The UCNPs can be exploited in a way so they can be integrated into various biological and medical research, such as single molecule spectroscopy, colloidal dynamics, protein isolation, and can also be used as bio-detection assays in both in vitro and in vivo applications. The purpose of my research is to study and compare the up-conversion and detection of nanoparticles, namely $NaYF_4$ with infrared laser beams of wavelengths 915 nm and 980 nm. The advantage of using a 915 nm laser includes lower water absorption and deeper tissue penetration, which is ideal for medical applications. This is ongoing research, and the eventual goal is to prepare equipment for the optical trapping of nanoparticles, develop more advanced computer programs for data analysis, and finally use mice as our models for UCNP application. The tracking of drugs through the blood-brain barrier when receptors are present for the nanoparticles is also one of the many applications of studying UCNPs.

Interdisciplinary Projects

☼ Physics and Computer Science

Stefano Coronado – "**Beowulf Cluster for Research and Education**"— A Beowulf Cluster is a group of computers, individually known as nodes that communicate with one other. One computer serves as the center of this cluster as a master node. The master node sends instructions to the others over a Local Area Network (LAN) to complete a given task. We have built a working cluster from surplused Dell OptiPlex 990 models that can distribute the load of MPI scripts across the group of computers before revealing the output to the master computer. We are now looking at adding extra graphics processors to expand potential applications of the cluster.

☼ Physics and Music

Rebecca Callaway (Double major in Physics and Music) and Mary Dye (music major) – "**Laser Harp: Restoring a Classic Instrument with Modern Technology" –** Working in conjunction with the music department, we are using our knowledge in physics as well as music technology to create a digital synthesizer that utilizes lasers and photo-resistors as an interface instead of a keyboard. An injured harp was graciously donated by Dr. Brooks Kuykendall and the music department. With repair and refurbishing, we input almost two full octaves worth of lasers, photo-resistors, and the required circuitry. When a laser is blocked, the frequency that is assigned to the given laser/photo-resistor pair is then played through the attached speaker.

Student Internships

This past fall, Vidhya Cardozo, AJ Rasure, and Stephen Tivenan worked with Dr. Alan Camp from Polaris Alpha to develop a database of unmanned aerial vehicle acoustic signatures and other external noise. They gathered signatures fromYouTube and other online sources to create the sample library. From there, a selection of ideal signals was created with reduced noise. Ideal signals were used to create two algorithms to assemble data into an acoustic fingerprint and compare fingerprints. Dr. Camp provided weekly lectures on topics relevant to programming, modeling, data management, experimental data analysis and other topics.

Summer Science Institute (SSI) Presentations

Two of our physics students presented their work at SSI this year:

Stephen Tivenan — **"**The Entropy and Elasticity Constant of Rubber Bands". Advisor: Maia Magrakvelidze

Margaret Gregory—"Wave Packet Dynamics in Diatomic Molecules". Advisor: Maia Magrakvelidze

The faculty and students were impressed with their work, and we continue to encourage students to participate in the summer science institute in the future. It's a great way to get introduced to important skills and techniques as to practice doing science and sharing results with general audiences.

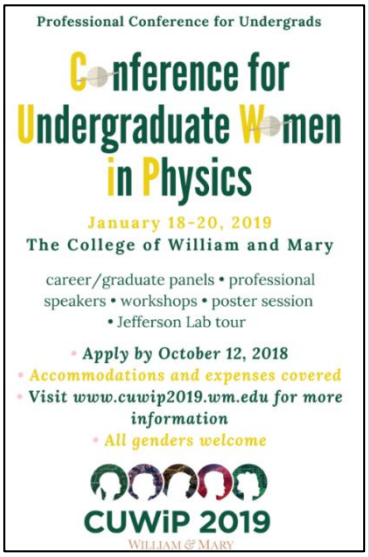
Interested in participating in the future? Speak with a faculty member about getting involved in research!

Abi Wigboldy Participates in CUWiP

Senior major, **Abigail Wigboldy** received funding to attend the Conference for Undergraduate Women in Physics (CUWiP), which was held at the College of William & Mary this year.

The primary goal of CUWiP is to help undergraduate women in physics by providing the opportunity to experience a professional conference, information about graduate school and professions in physics, and access to other women in physics of all ages with whom they can share experiences, advice, and ideas.

"The meeting was enjoyable, helpful and very informative," Abi said.



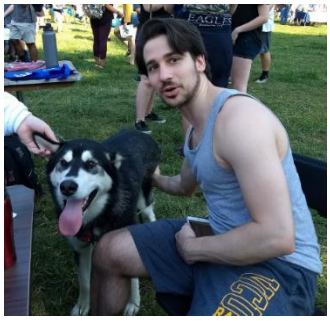
SPS CLUB (ΣΠΣ) The Society of Physics Students (SPS) is a professional association explicitly designed for students. Membership in this club is open to anyone interested in physics. Besides physics majors, our members include majors in chemistry, computer science, engineering, geology, mathematics, medicine, and other fields.

The SPS club at UMW helps students become contributing members of the professional community. Courses in the major develop one range of skills, but an active SPS member learns other skills such as effective communication and personal interactions, leadership, networking, outreach, and more.

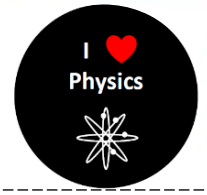
If you are interested in joining SPS, contact

- AJ Raure (email: arasure@mail.umw.edu),
- Henry Mills (email: wmills@mail.umw.edu)
- Margaret Gregory (email: mgegor3@umw.edu)

SPS at Club Carnival



SPS Game Night



Standard Gravity Day

SPS Outreach

SPS met with **Bob Bumgarner '16**) who visited us to explore coordinating events with the Commonwealth Governor's School and UMW physics majors.

Join us on Facebook

https://www.facebook.com/UMW-Physics-Department-526840247437584/

SPS "BBQ" Party

Welcome to Our Newest Majors

1. **Joshua Taylor**
2. **Henry W. Mills**
3. **John Wood**
4. **Jordan Reiser**

Congratulations to the Class of 2019!

Paul Breene (PJ), Vidhya Cardozo, William Catoe, Shivani Gupta, Hannah Killian, Emily MacIndoe, Philip Sadighian, Kathleen Smith

Updates from our Alumni

Jessica Hewitt Dwyer and Dr. King

Eric Raterman '18: Software Developer at Central Square Technologies.

Terence McPhillips '18: Coast Guard OSC

Ryan Barlow '17: Electro-Optical Engineer, Manufacturing Techniques, Inc. (MTEQ)

Wesley Roberts '13: Research Director, Cabot Consultants

Ryan Barlow and Dr. Maia

Jessica Hewitt Dwyer '04: Lieutenant Colonel in the United States Air Force and Assistant Professor of Physics at the United States Air Force Academy in Colorado Springs, CO. Jessica also serves as the Advisor in Charge for the Department of Physics and the Director of the Academy's Center for Physical Education Research.

Come back and visit! We always enjoy our alumni!

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GIVING DAY

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