Physics Department Newsletter 2016-2017

Letter from the Chair

Dear Friends,

We've had another good year here in the Department of Physics. If you've been keeping track, you'll notice that the Chairship has changed hands – Dr. George King III handed me the reins at the end of August 2015.

The intellectual life of the Department is vibrant due to the innovative teaching and vigorous research efforts involving our students. While research and teaching are sometimes be considered as being in conflict, particularly at an undergraduate institution like our Mary Washington, we would surely not attract the superb students we see without the intellectual excitement that come from bridging both excellent teaching of foundational physics knowledge and working on research projects that push its boundaries. I have talked to many prospective physics majors and their parents at multiple open house events over the last few years, and very much every single one has asked about our love for teaching and research opportunities for students -- and I've always been able to reassure them on these points.

This year we welcomed a new faculty member, Dr. Maia Magrakvelidze. She comes to us from the Kansas State University specializing in Atomic Molecular and Optical physics. She's shining in the classroom. She's leading the department effort in assessing effective teaching methods. Complementing her excellent teaching in the classroom, she has readily offered our students with multiple research opportunities outside the classroom.

We also welcomed a new adjunct professor, Dr. David Fallest, who's a research scientist at the Naval Surface Warfare Center in Dahlgren, VA. He's bringing with him expertise in teaching and research experience in Astrophysics. David is teaching our ever popular Astronomy courses. He's also a coach for the United States Physics Olympics Team.

For a school of our size, one would normally expect us to graduate about 4 to 5 physics majors per year as a national norm. This spring of 2017, we are graduating 10 seniors!!! Half of our graduating seniors have been accepted to graduate schools including Rochester University, George Washington University, Carnegie Mellon University, and The University of Hawaii. The rest are participating in internships and directly working for the government or for the Defense Industries along I-95 corridor. I look forward to the next newsletter to update you on the many exciting things going on in our department and I am also looking forward to hearing from you, our cherished alumni.

Dr. Hai Nguyen, Chair.
Department of Physics, UMW

Invited Talk

Brett DePaola – gave a talk on March 22 (JEPS 417, 5:00 pm) entitled "**A Scientist in the State Department: Mutual Enlightenment or a Lesson in Frustration?** "

Dr. DePaola is a Professor of Physics and Interim Department Head at Kansas State University. A specialist in Atomic, Molecular, and Optical Physics, he spent one full academic year (2010-2011) at the U.S. Department of State in Washington, DC as a Jefferson Science Fellow. There he officially worked as an analyst in the Bureau of Intelligence and Research, Office of Economics. Like all Jefferson Science Fellows, however, his additional duty was to provide general science input to anyone who needed it.

Departmental Updates

Dr. David Fallest joins the department as an adjunct professor. Dave earned his PhD in Astrophysics from North Carolina State University in August 2012. As an undergraduate, Dave earned B. A. degrees in Physics and Astronomy and Russian Language, along with a minor in Russian Studies at Beloit College in Beloit, WI. He has also been a coach for the U.S. Physics Team since 2008.

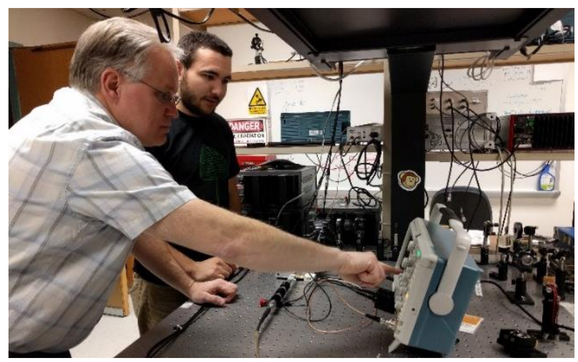
The Department of Physics is pleased to welcome Dr. Maia Magrakvelidze, who joins our department as a full-time assistant professor. Maia earned her Ph.D. in Atomic and Molecular Physics in November 2013 from Kansas State University, her first Master's degree in Condensed Matter Physics in May of 2005 from Tbilisi State University and her second Master's degree in Atomic and Molecular Physics in December 2009 at Kansas State University.

Gallery

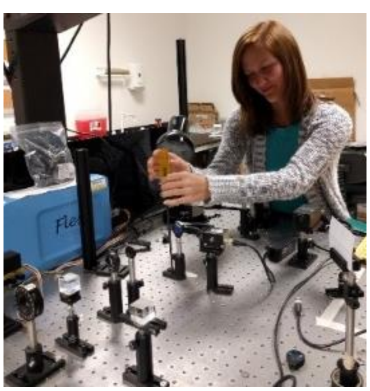
Student Research

Hannah Killian and Brandon Rozek – "Theoretical Calculations of Population Dynamics and Experimental Setup of Rb^{87} Coherent Excitation System". Our research focuses on the dynamics of population transfer in the two and three level atomic systems for ^{87}Rb. All atoms, including ^{87}Rb, have a quantum structure with discrete energy states. In order to change energy levels, the atom must absorb or emit a photon. The interaction of the atom's quantum system with light results in excitation of the atomic population. Theoretically we have proven that incoherent excitation leads to a third of the population transferred from the ground state to the upper most excited state. We then modeled the atomic interaction with coherent light and found conditions that would lead to nearly complete population transfer. In order to apply our theoretical results we began constructing a magneto optical trap (MOT), which uses a magnetic field and optical setup to capture atoms. Upon completion of the MOT this summer, we will be able to coherently excite ^{87}Rb atoms in order to observe and model the dynamics of population transfer between energy levels. (by Hannah and Brandon)

Ethan Ramirez and William Catoe – "Electro-magnetically induced transparency in a ^{87}Rb vapor cell". As we all know from grade school science class, all atoms have one or more electrons orbiting the nucleus. What most do not know, however, is that there are things called energy levels in which a given valence (outermost) electron may occupy. Within these energy levels exists "structures" or sub-states the electrons may exist in as long as the conditions are just right. In order to excite electrons into these states and sub-states, we must use a laser locked at a **very** specific frequency (or color) along with a second laser beam whose frequency is shifted by the frequency of the excited sub-state. Here lies the issue because the transitions we are after (F=1 → F'=2, and F=2 → F'=2) are separated by a frequency of ~6.835 GHz - that's 6.835 billion oscillations per second! The equipment usually used to generate and make use of a frequency this high is on the order of thousands to tens of thousands of dollars; however with the ever increasing availability of quality parts for reasonable prices, we have built a system in-house to generate and control the 6.835 GHz signal for only a few hundred dollars. We are currently assembling the optical set-up to make use of this signal and ultimately explore the Rubidium atom! (by Ethan)



Heather Hundley – "Mach-Zehnder Interferometer with Possible Heterodyne Setup". My research consists of a Mach-Zehnder interferometer in which a light source is split into two different beams by a polarized beam splitting prism. The two beams then follow different paths before being recombined by a second prism. Along each of these paths is an Acousto-Optic Modulator (AOM), which splits the beam into different orders. The setup then allows only the positive first order to continue through to be recombined. By connecting a signal generator to the AOMs, we can cause the positive first orders to pulse at different frequencies. Therefore, we are able to look at the interference pattern caused by the destructive and constructive interference of the two combined waves (typical Mach-Zehnder setup), or by adding frequency through the AOMs, we can look at the optical beat note of the two beams (heterodyne setup). These two different setups have many applications, such as studying the refractive properties of different materials. (by Heather)

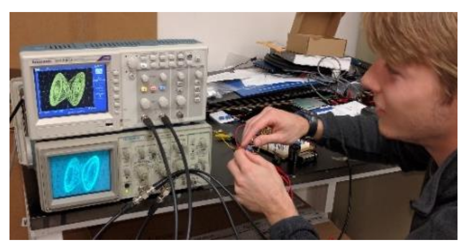


Pengcheng Zhang, Vidhya Cardozo, Kayla Frye –"Quantitative Efficiency Analysis of a Single Optically Trapped Up-converting Nanoparticle". New generation fluorophores, known as Up-converting Nanoparticles (UCNPs), when excited, have the ability to convert low energy near- infrared radiations (NIR) into 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 this 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. (by Vidhya)

Nicholas Gabriel – "Monte Carlo study of Alpha and Muon Sources for PROSPECT mass Calibration". Neutrino oscillation is one of the most well documented and intensely studied phenomena of Beyond the Standard Model physics, or physics not described by our best theories to date. Measurements of the electron anti-neutrino flux at the High Flux Isotope Reactor at Oak Ridge National Laboratory will be conducted as part of the Precision Oscillation and Spectrum (PROSPECT) short baseline neutrino oscillation experiment. The detector for this experiment is comprised of sub-modules that can be used to improve the sensitivity of the measurement if their relative masses are known, and ROSPECT collaborators at Brookhaven National Laboratory have considered two possible methods for determining this. By adding isotopes to the fluid that fills the detector and measuring the relative number of decays in each sub-module, the relative mass of these modules can be determined.

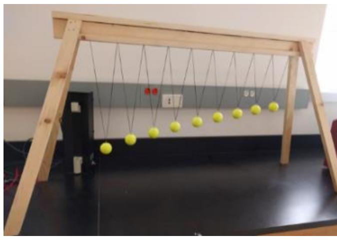
Over the summer I conducted research to understand how well this method works for determining the mass of the sub-modules. I used Monte Carlo simulation together with some pencil-and-paper calculations to determine this. Another way of going about this problem is using cosmic ray muons, which are produced primarily when high energy protons and helium nuclei from astronomical sources collide with the atmosphere of the Earth. I continued research on PROSPECT mass calibration in the fall semester with Dr. King, this time turning my attention to cosmic ray muons as a possible calibration source. I wrote Monte Carlo simulations in Python and C++ to determine the energy deposit and frequency of cosmic ray muons passing through the detector modules using experimental data of cosmic ray muon flux. (by Nicholas)

Ryan Barlow– "Hidden Strange Attractors in Chua's System". Recent examination of chaotic systems reveals a distinction between self-excited hidden attractors and Hidden Strange Attractors (HSO). The hidden oscillations occur where the basin of attraction does not intersect with local equilibrium points, and we will attempt to locate a hidden attractor experimentally within a modified Chua's Circuit.



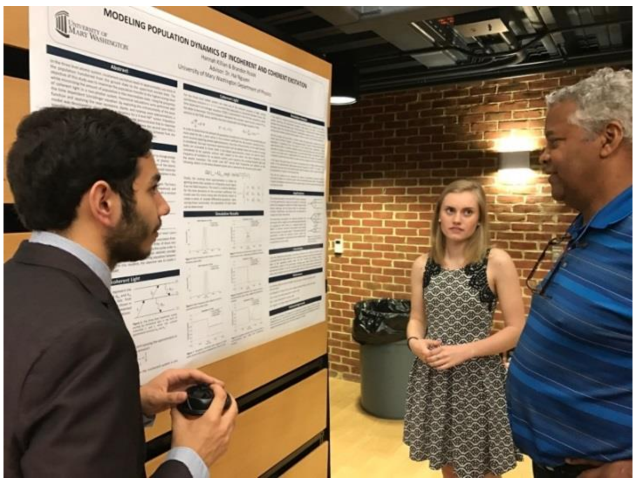
– "Fractal Image Compression (FIC) and GIS application". This research explores applications of Fractal Image Compression (FIC) through the FIASCO compression algorithm. FIC represents a divergence from established compression methods, and we compare the FIASCO algorithm to .jpg image compression. While both are lossy methods, the FIASCO readme claims to outperform .jpg compression. Additionally we discuss the image comparison method of subtracting pixel values using ArcGIS. The output image is a map detailing how well compression works topographically, as opposed to the PSNR image metric which simply outputs a number for associated image. (by Ryan)

Vincenzo Giambanco – "Pendulum Waves". The pendulum wave apparatus was built containing 9 equally spaced



pendulums with different lengths (and different periods) so that it creates the wave motion once set in motion. The goal of this experiment was to understand the theoretical framework behind the pendulum wave and to answer why the given pendulum wave patterns form. The length of pendula were chosen so that in the time - T_{max} the longest pendulum takes to go through some N -integer number of cycles, the next longest pendulum takes N+1 cycles to do so. The lengths of pendula were calculated using expression: $L(n) = (gT_{max}^2)/\big(2\pi(N+n+1)\big)^2$, where g = 9.8 m/s^2, $L(n)$ is the length of nth pendulum.

Research and Creativity Day Presentations

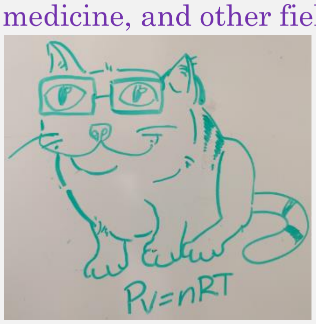


Hannah Killian and Brandon Rozek presented work on "*Modeling Population Dynamics of Incoherent and Coherent Excitation*" (Mentor: Hai Nguyen).

Zaire Sprowal Presented work on "*Fractal Image Compression (FIC) and possible applications to Physical Systems*" (Mentor: Hai Nguyen).

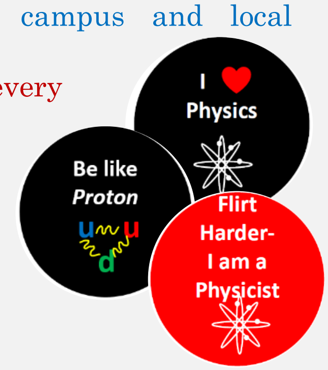
Ryan Barlow presented *two* papers on "*Fractal Image Compression and GIS Application*" (Adviser: Suzanne Sumner) and on "*Chaos: Hidden Attractors in Chua's Circuit*" (Mentor: George King, III)

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 exists to help students transform themselves into contributing members of the professional community. Course work in the major develops only one range of skills, however, an active SPS member acquires other skills such as effective communication and personal interactions, leadership experience, establishing a personal network of contacts, presenting scholarly work at professional meetings and outreach services to the campus and local communities.

Members of the SPS at UMW meet once in every two weeks (every alternate Wednesday at 5:00 p.m.). At these meetings, the club officers discuss about the upcoming events (research talks, fundraising, telescope nights and so on) held by the club or by the Physics Department, and design T-shirts/buttons. This club also provides students an opportunity to have effective and fun conversations with their professors and fellow-classmates.



If you are interested in joining SPS, please contact Vidhya Cardozo (email: vcardozo@umw.edu) or Kayla Frye (email: kfrye3@mail.umw.edu)

Alumni

Join us on Facebook

Laura (Rickard) Dickinson — UMW Physics 2010 graduate defended her PhD on "Characterization of Interfacial Interactions by Functionalized atomic force microscopy (AFM) Probes" from William &Mary.

Ryan Bodenstein — UMW Physics 2004 graduate

Figure: Ryan in the damping ring at the Accelerator Test Facility 2 at KEK in Tsukuba, Japan.

Ryan defended his PhD from UVA in 2012 on research performed at Jefferson Lab. His dissertation was titled, "A Procedure for Beamline Characterization and Tuning in Open-ended Beamlines." After working on the design of a new rare-isotope accelerator in South Korea for two years, Ryan now works at the John Adams Institute for Accelerator Science at the University of Oxford. He is currently involved in beamline simulations of the Compact Linear Collider (CLIC) and International Linear Collider (ILC), investigating the luminosity recovery achieved by the use of nanosecond timescale feedback systems in the interaction regions of CLIC and the ILC. Additionally, Ryan collaborates with colleagues at CERN on single and two-beam tuning of the CLIC beam delivery system.

Special THANKS to our recent program donors: Karen and Nathan Baillie, and Dr. Ellen Brown, who extended their generosity toward our department by donating gracefully.

Thanks to Ellen's dog Gowkie for visiting us and allowing us to pet him.
We do appreciate it.

New Students

This year we had some new students declaring the physics major:

Paul Breene —
Logan Cass —
Sterling Heyns —
Elizabeth Kaiser—
Kyle Miner —
Grace Percival —
Ellen Poole —
Kathleen Smith —
Abigail Wigboldy—

Welcome!

Congratulations Class of 2017!

Ryan Barlow	— works for MTEQ, INC.
Heather Hundley	— going to graduate school at East Carolina University to receive her Master's Degree in Medical Physics.
Macey Sandford	— Research assistant at University of Hawaii at Manoa – working with Dr. Shiv Sharma on NASA's Mars 2020 mission and ONR related projects on telescopic Raman and fluorescence instruments for detecting minerals, organic and fluorescent biological materials.
Zaire Sprowal	— going to University of Rochester to pursue a Ph. D. in plasma physics.
Nicholas Gabriel	— going to graduate school at George Washington University.
Alex Polka	— going to graduate school at Virginia Commonwealth University.
Matthew Froelich	— joined NSWC Dahlgren Division.
Vincenzo Giambanco	— hired in Fauquier County to teach Physics (AP 1 and AP 2).
Pengcheng Zhang	— job at Vitatech Electromagnetics, LLC
James Taylor	— intern at Dahlgren.

Zaire Sprowal received the Prince Woodard Outstanding Leader Award, given to a graduating senior who has made a substantial impact on campus and beyond, while exemplifying the values of honor, leadership and service. Sprowal received an award of $1,000. Congratulations to Zaire!

UNIVERSITY OF MARY WASHINGTON
where great minds get to work

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Einstein Prize Award an award presented to a graduating physics major for outstanding performance, qualities adjudged as academic excellence, leadership and overall contributions to the physics program. This award was established in 1995 and funded initially by Dr. Bulent Atalay.

This year's recipient is: **Zaire Sprowal** for his tremendous input to Physics Department and for drawing attention from academic leadership to our department.

Physics Faculty award– established in 2002 by the physics faculty, this award recognizes a senior for outstanding academic accomplishment in the physics program.

This year's recipient is: **Pengcheng Zhang** for his high academic performance. Pencheng is double major in Physics and Math.