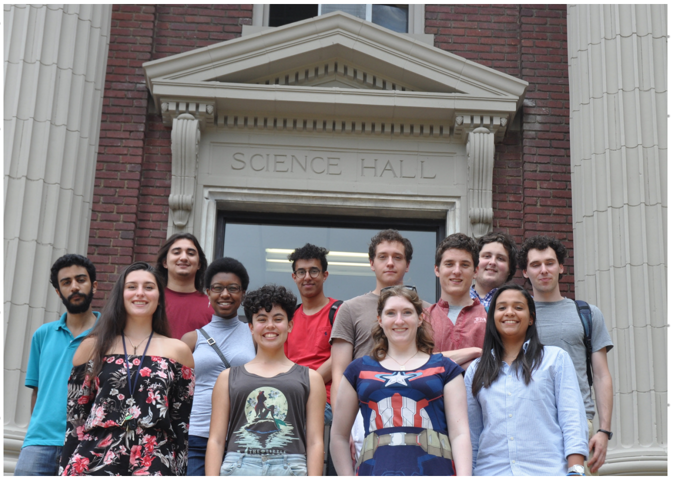
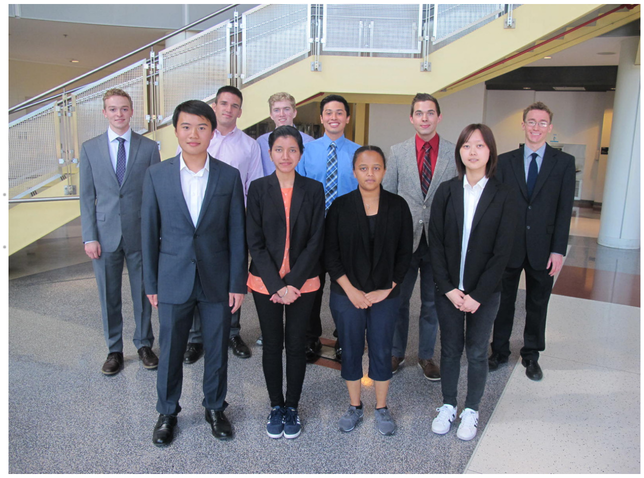
TREND, TE, & IRES FAIR

FRIDAY, AUGUST 10, 2018



Training and Research Experiences in Non-Linear Dynamics (TREND)



Research Experience for Undergraduates in Transportation Electrification (TE)

International Research Experience for Graduate and Undergraduate Students (IRES) in Electrified and Autonomous Transportation

Research Experience for Undergraduates (REU)

Cutting Edge, Team-Based Research
University of Maryland, College Park
Summer 2018

Partially funded by:
The National Science Foundation
Training and Research Experiences in Nonlinear Dynamics (TREND) Grant #PHY1756179
REU Program in Transportation Electrification Grant #EEC1263063
IRES in Electrified and Autonomous Transportation Grant #OISE1658602

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

COLLEGE OF COMPUTER, MATHEMATICAL, & NATURAL SCIENCES

IREAP INSTITUTE FOR RESEARCH IN ELECTRONICS & APPLIED PHYSICS

Training and Research Experiences in Nonlinear Dynamics (TREND)
Transportation Electrification (TE)
International Research Experience for Graduate and Undergraduate Students in Electrified and Autonomous Transportation (IRES)

FAIR

Friday, August 10, 2018
Kim Engineering Building
University of Maryland

8:30 a.m.
Breakfast, Kay Board Rooms

9:00 a.m.
Welcome, Zupnik Lecture Hall

9:15 a.m. – 9:45 a.m.
TREND Presentations Round I

9:50 a.m. – 10:20 a.m.
TE Presentations Round I

10:25 a.m. – 10:55 a.m.
IRES Presentations

10:55 a.m. - 11:05 a.m.
Break

11:05 a.m. – 11:35 a.m.
TREND Presentations Round II

11:40 a.m. - 12:10 p.m.
TE Presentations Round II

12:15 p.m. - 12:45 p.m.
Poster Presentations, Innovation Hall of Fame and Rotunda

12:50 p.m. - 1:45 p.m.
Judges meet

12:50 p.m.
Luncheon, Kim Building Rotunda

1:45 p.m.
Announcement of TE, TREND & IRES Winners, Zupnik Lecture Hall

TREND

The University of Maryland's Institute for Research in Electronics and Applied Physics, with support from the National Science Foundation, offers exciting research opportunities for undergraduate students in the broad area of nonlinear dynamics. Research projects in the Training and Research Experiences in Nonlinear Dynamics (TREND) program are theoretical, experimental or both. Research topics include experimental studies of nonlinear systems; magnetic reconnection and the dynamics of energetic particles; nonlinear dynamics in charged particle beam systems; nonlinear dynamics in optical systems; the dynamics of soft matter, granular matter, and biomaterials; theoretical and computational studies of chaos and nonlinear dynamics; the experimental study of nonlinear and chaotic microwave circuits; dynamics and control of motion coordination in groups; and dynamics of living cells.

Transportation Electrification

The University of Maryland's Department of Electrical and Computer Engineering, with support from the National Science Foundation, offers exciting research opportunities for undergraduate students in the broad area of transportation electrification. The Transportation Electrification program engages undergraduate students in basic research and provides laboratory experience in transportation electrification-related engineering projects performed with research mentors from University of Maryland at College Park (UMCP). The program is aimed at training students and promoting skills in them to become independent researchers by providing insights into research methodologies, self-discipline, team integration, and exposing them to the broader implications of their research.

IRES Electrified and Autonomous Transportation

The University of Maryland's Department of Electrical & Computer Engineering, with support from the National Science Foundation is offering exciting research opportunities for graduate and undergraduate students in the broad area of electrical engineering internationally. The Electrified and Autonomous Transportation program combines cutting-edge, team-based research with technical and educational seminars. This program annually recruits 5 talented students (2 graduate and 3 undergraduate students), trains them in basic research, and provides laboratory experience in challenging projects performed internationally with research mentors from Universidad Politecnica de Madrid in Spain and the University of Maryland at College Park (UMD).

TREND Participants

Mentors

Professor Thomas Antonsen, *University of Maryland*
Professor Brian Beaudoin, *University of Maryland*
Professor James Drake, *University of Maryland*
Professor Michelle Girvan, *University of Maryland*
Professor Mohammad Hafezi, *University of Maryland*
Professor Daniel Lathrop, *University of Maryland*
Professor Wolfgang Losert, *University of Maryland*
Professor Thomas Murphy, *University of Maryland*
Professor Edward Ott, *University of Maryland*
Professor Derek Paley, *University of Maryland*
Professor Rajarshi Roy, *University of Maryland*
Dr. Marc Swisdak, *University of Maryland*

Students

Viktor Belay, *American University*
Daniel Belkin, *Swarthmore College*
Jessica Christian, *University of Maryland, Baltimore County*
Tatiana Davidson Bajandas, *University of Chicago*
William Fines-Kested, *Massachusetts College of Liberal Arts*
Kathleen Hamilton, *University of Maryland*
José Ortiz Tavárez, *University of Puerto Rico, Mayaguez*
Kyle Ritchie, *University of New Mexico*
Benjamin Ruben, *Rice University*
Shyline Santana, *University of Puerto Rico, Rio Piedras*
Ethan van Woerkom, *University of Edinburgh*
Helena Yoest, *Bucknell University*

GRAD-MAP Poster Participants

Students

Tessa Gonzalez, *University of Maryland*
Rishap Lamichhane, *Howard University*
DeOndre Kittrell, *Morgan State University*
Sara Negussie, *University of Maryland*

*Mentors ackowledged in the abstract section

Joint Quantum Institute (JQI) Poster Participants

Student

Kwasi Fahie, *Williams College*

*Mentors ackowledged in the abstract section

Transportation Electrification (TE) Participants

Mentors

Professor Behtash Babadi, *University of Maryland*
Professor Liangbing Hu, *University of Maryland*
Professor Alireza Khaligh, *University of Maryland*
Professor Patrick McCluskey, *University of Maryland*

Students

Felix Adams, *University of Maryland*
Christine Ahn, *Cornell University*
Firehiwot Gurara, *Cornell University*
Logan Johnson, *Liberty University*
Gurpreet Kaur*, College of Southern Maryland*
Juan Lopez*, University of Toledo*
Matthew Morin*, University of Maryland*
Jake O'Brien*, Ithaca College*
Zander Tedjo*, University of Texas at Austin*
Patrick Toplikar Jr.*, Missouri State University in cooperation with Missouri University of Science and Technology*

IRES Electrified and Autonomous Transportation Participants

Mentors

Professor Pedro Alou, *Universidad Politécnica de Madrid*
Professor José A. Cobos, *Universidad Politécnica de Madrid*
Alberto Delgado, *Universidad Politécnica de Madrid*
Rodrigo Marino, *Universidad Politécnica de Madrid*
Professor Miroslav Vasić*, Universidad Politécnica de Madrid*

Students

Alyssa Barth, *Texas A&M University, College Station*
Michael D'Antonio, *University of Maryland*
Joelle Dowling, *The George Washington University*
Jason Lim*, University of Nevada, Reno*
Daniel West*, University of New Haven*

Student Projects

TREND

Modeling the collective behavior of *Dictyostelium discoideum* under electrotaxis and nanotopographical guidance

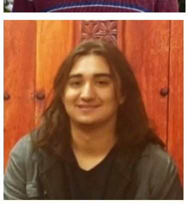
Viktor Belay, *American University*

Cellular migration is a function that is ubiquitous across a vast number of organisms. This phenomenon is observed in many biological functions such as embryogenesis, tissue regeneration, tumor metastasis, muscle contraction, and more. Cellular migration is influenced by many various factors; principally, by chemical, mechanical, and electrical cues. We utilize the model organism *Dictyostelium discoideum* to study the effects of nanotopographical guidance and electrostatic fields on the motion of cells. We develop a coarse-grain stochastic model of the influence of nanotopography, electrostatic fields, and signaling by the messenger chemical cyclic adenosine monophosphate on the motion of *D. discoideum* cells. Model simulations show that unidirectional guidance by nanoridges allows for consistent Dicty streaming and aggregation, while bidirectional nanotopography creates a cell bifurcation in which there is little to no streaming or aggregation. Dicty cells also exhibit directed collective motion when under the influence of a unidirectional electric field. Our results implicate that the random motion of *D. discoideum* cells is overtaken when cells undergo electrotaxis or chemotaxis, and when cells migrate on nanotopography.

Professor Wolfgang Losert, *University of Maryland*

Numerical and Thermodynamic Reversibility in Magnetic Reconnection

Daniel Belkin, *Swarthmore College*
Kyle Ritchie, *University of New Mexico*



Magnetic reconnection plays an important role in driving solar flares, coronal mass ejections, and the Northern Lights. Ubiquitous in astrophysical systems, it occurs when magnetic field lines align such that topological changes allow them to reduce their magnetic energy. This unstable configuration causes the field lines to break and reconnect, which results in an explosive release of kinetic energy. It is an open question whether magnetic reconnection is an irreversible process in some sense, and why. To investigate this question, we use particle-in-cell simulations to study the behavior of a two-dimensional collisionless reconnection configuration in reverse and observe particle trajectories near the x-line. We do not observe fully-developed or self-driving reverse reconnection. Early data suggest that the sensitivity of particle trajectories to phase differences in their Larmor orbits near the x-line contribute to the numerical irreversibility of reconnection. We show that the loss of phase information may be modeled by an effective collision operator. Finally, we suggest a model based on Zubarev's method for non-equilibrium statistical mechanics as an appropriate means of characterizing the entropic irreversibility of magnetic reconnection.

Professor James Drake, *University of Maryland*
Dr. Marc Swisdak, *University of Maryland*

Exploration of quantum, classical, and superposition optical state tomography

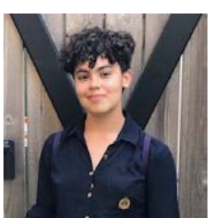
Jessica Christian, *University of Maryland, Baltimore County*

As a primary parameter of electromagnetic waves, optical polarization communicates the spatial orientation of incoming light waves and the degree to which an electromagnetic wave fits a certain profile. Polarization state can therefore conveniently be used to determine properties of light such as superposition or quantum entanglement, permitting further study of these unique phenomena. Within the field of optics, the ability to reliably create and identify optical states is foundational to experimental potential and is necessary to validate all further experiments performed: all optics laboratories must, in advance of any and all study, establish the legitimacy of their chosen state. In doing so ourselves, our lab demonstrates techniques to create a variety of optical states and to verify them by performing state tomography. We also provide a discussion of the optical states' superposition natures and the implications therein. Among those evaluated are classical and single-photon one-qubit states, as well as two-photon entangled states of alike and opposite polarizations, representing the majority of possible states among one- and two-photon configurations.

Professor Mohammad Hafezi, *University of Maryland*
Sunil Mittal, *Postdoctoral Researcher at University of Maryland*
Venkata Vikram Orre, *Graduate Student at University of Maryland*

Reservoir Computing: Observation and Prediction of Chaos

Tatiana Davidson Bajandas, *University of Chicago*



A vast number of systems can become chaotic in their dynamics in both nature and the man-made world, however until recently they remained difficult to model, characterize, and predict. The use of reservoir computing, a variation on artificial neural networks, has propelled our understanding of these systems forward with such capabilities as observation and prediction. In these tasks, input variables in the observation task and future output variables in the prediction task are projected with startling accuracy compared to the time scale of the system dynamics for an extended period of time. A tabletop experiment is compared to a reservoir computer implemented digitally on a laptop, wherein it is hoped that specific calculations will be faster than computations on a laptop. Observation and prediction tasks are conducted for the Lorenz chaotic system using a truncated sin2 nonlinearity function. Applications exist in a varied array of fields from meteorology to cell biology to economics where characterization of chaotic systems is becoming increasingly important.

Professor Thomas Murphy, *University of Maryland*
Professor Edward Ott, *University of Maryland*
Professor Rajarshi Roy, *University of Maryland*
Joseph Hart, *Graduate Student at University of Maryland*
Jaideep Pathak, *Graduate Student at University of Maryland*

Building Dynamic Models Using Reservoir Computing

William Fines-Kested, *Massachusetts College of Liberal Arts*

Prediction of chaotic dynamical systems has been difficult due to the sensitivity of the system to initial conditions in the system's state. Work has been done to build predictive models using numerical methods and simulated data, but little work has been done in this field using experimental data that includes noise. Recent work done in a machine learning field called "reservoir computing" demonstrates success in predicting dynamical systems. We test this reservoir computing technique on a time series data set containing the concentration of bromide ions in a Belousov-Zhabotinsky reaction. We find that we are able to obtain both short-term predictions with minimal error, as well as long-term predictions with error that oscillates and mimics the behavior of the original data that includes noise.

Professor Daniel Lathrop, *University of Maryland*
Sarah Burnett, *Graduate Student at University of Maryland*
Artur Perevalov, *Graduate Student at University of Maryland*
Ruben Rojas, *Graduate Student at University of Maryland*

Longitudinal RF Confinement in UMER

Kathleen Hamilton, *University of Maryland*

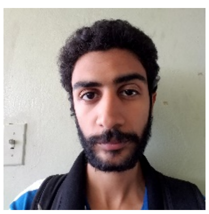
Conventionally, the longitudinal confinement on the University of Maryland Electron Ring (UMER) has employed barrier buckets. This method accelerates and decelerates particles at the outermost edges of the beam to maintain the rectangular longitudinal beam distribution without modifying the central region of a long 100ns bunch. While these barrier buckets have been successful for single bunch operations, multi-bunch mode can't be sustained using this scheme for confinement. We test an induction cell and radiofrequency (RF) amplifier experiment, applying sinusoidal wave bursts at the revolution frequency to confine a single-bunch, 60ns beam in the

linear slope regions of the wave. Future tests will involve higher frequencies to test multi-bunch confinement with the same system. Keeping the beams confined also entails avoiding particle loss. As in the RF cavities of other accelerators, there will be distinct regions of stability. We calculate the separatrices, which mark the boundaries of these areas and provide necessary information about beam cohesion, with a central synchronous particle. Although only single bunches have been tested so far, this work paves the way for multi-bunch confinement. This would advance the capabilities of the longitudinal confinement system, allowing UMER to increase its performance and modes of operation for different experiments.

Professor Brian Beaudoin, *University of Maryland*
Levon Dovlatyan, *Graduate Student at University of Maryland*
David Matthew, *Graduate Student at University of Maryland*

Herding Cats: Inducing Cooperation of Uncooperative Multi-Dimensional Agents

José Ortiz Tavárez, *University of Puerto Rico, Mayagüez*
Benjamin Ruben, *Rice University*



Systems of uncooperative or contrarian agents naturally tend toward disorder. Can a sufficiently strong leader overcome inter-agent uncooperativeness and force partial or complete cooperation within the population? Motivated by this question, we consider a multi-dimensional Kuramoto-like model consisting of repulsively coupled agents subjected to external periodic driving of constant magnitude. Using a generalization of the Ott-Antonsen method, we reduce the dynamics of the many-agent system to a low-dimensional system of differential equations. By varying the extent of the repulsive inter-agent coupling, we observe continuous and discontinuous transitions from partial coherence to full coherence ('cooperation'). Full system simulations agree well with our theoretical predictions of both time asymptotic steady states, as well as the transient time evolution toward them.

Professor Thomas Antonsen, *University of Maryland*
Professor Michelle Girvan, *University of Maryland*
Professor Edward Ott, *University of Maryland*
Sarthak Chandra, *Graduate Student at University of Maryland*

Global Bifurcation in a Simple Pendulum with Nonlinear Damping

Shyline Santana, *University of Puerto Rico, Rio Piedras*

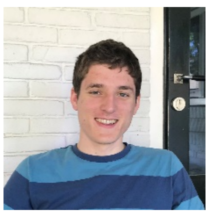
Swimming motion of a robotic fish driven by an internal reaction wheel has been shown to be analogous to the dynamics of a Chaplygin sleigh. We study a simple pendulum with nonlinear damping from a simplified form of Chaplygin sleigh motion under a feedback control law. Under certain values of the control gains the sleigh enters a limit cycle that produces forward motion. We conduct a bifurcation analysis for possible variations of the bifurcations and dynamics that

occur on the system as these control gains are varied. The basic dynamical properties are analyzed by phase portraits. For certain values of our controlled gains, a global bifurcation occurs that splits the desirable stable limit cycle into two undesirable limit cycles that results in unbounded spinning of the sleigh. Numerical simulations are carried out to optimize the forward sleigh motion or smooth swimming by obtaining our bifurcations parameters and knowing where our stable limit cycle lies.

Professor Derek Paley, *University of Maryland*
Brian Free, *Graduate Student at University of Maryland*

Zero-lag Synchronisation in a three-node Opto-electronic Oscillator Network

Ethan van Woerkom, *University of Edinburgh*



Isochronous synchronisation between nodes is investigated in a small network of coupled opto-electronic oscillators that includes both coupling and feedback time delays. Intermediate nodes act as either a relay, or a driver. We examine this behavior for different values of coupling. Synchronisation under these conditions was shown to be resistant to both parameter and time delay changes. Different coupling time delays induced phase lags in node dynamics.

Professor Thomas Murphy, *University of Maryland*
Professor Rajarshi Roy, *University of Maryland*
Joseph Hart, *Graduate Student at University of Maryland*

The Effect of External Magnetic Fields on the Hall Effect of a Dusty Plasma Tornado

Helena Yoest, *Bucknell University*

We present results from our experiment designed to characterize the way external magnetic fields influence the Hall Effect of a turbulent granular system. We agitated polystyrene particles in a vertical cylindrical annulus by applying wind against gravity, thus creating a model of a dusty plasma tornado. Because colliding particles lose or gain charge through the process of granular electrification, we can observe a resulting voltage difference between the concentric cylinders due to this agitation. We characterize the mean and RMS voltage between the cylinders due to the charge difference. The apparatus is placed inside of a vertical magnetic field of strength 0.62 T and aligned with the dipole. From here, we observe how the imposed magnetic field influences the voltage of the apparatus, and we find that there is a measurable difference as we vary the strength of the magnetic field.

Professor Daniel Lathrop, *University of Maryland*
Sarah Burnett, *Graduate Student at University of Maryland*

Transportation Electrification

Scalable manufacturing of supported nanoparticles through rapid thermal shock

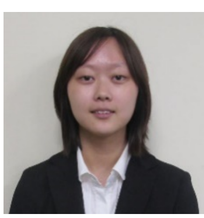
Felix Adams, *University of Maryland*

Carbothermal shock is a new technique for synthesizing uniformly distributed nanoparticles. A quick electrical pulse is applied to a carbon structure supporting a nanoparticle solution to rapidly heat it (2000K in 55ms). This method is much more time, energy, and material efficient than previous wet chemistry techniques. However, work still needs to be done to scale up this technique to mass production scale. I designed a system to scale up the rapid heating treatment portion of the carbothermal shock technique. The design has three major sections: the heating elements, the control circuit, and the support structure. The heating elements convert high amperage current into heat. A microcontroller controls the motion of the support material. All the mechanical components are mounted to an adjustable aluminum frame. As the design is constructed, I will incrementally test its reliability and safety.

Professor Liangbing Hu, *University of Maryland*
Yonggang Yao, *Graduate Student at University of Maryland*

Digital Control System using Dual-Core DSP for an AC-DC Converter

Christine Ahn, *Cornell University*



The push towards sustainable transportation has increased the focus on development of More Electric Aircrafts (MEAs) such as the Boeing 787. This creates the need for compact and efficient power electronic converters, such as the Regulated Transformer Rectifier Unit (RTRU) which interfaces the 235 V AC generator to the 28 V DC bus to power on-board auxiliary electric loads. I have designed and implemented a closed-loop digital control system for the RTRU prototype based on the Dual-Active Bridge topology, which regulates the transistor switching logic to achieve Power Factor Correction and maintain high conversion efficiency. The developed system optimally distributes the computation load on the dual-core architecture of the TI Delfino DSP to achieve a minimized execution time.

The designed z-domain PI controller regulates the phase-shift between various transistor gating pulses. The input to the controller is the output voltage sensed using the ADC and processed through the designed digital IIR lowpass filter. Using the dual-core architecture, CPU1 controls the primary-side transistors while CPU2 controls the secondary-side. The system was benchmarked for its execution time, and the control logic was verified on the hardware prototype. Using this optimized implementation, the execution times were reduced by more than 40% compared to a single-core implementation.

Professor Alireza Khaligh, *University of Maryland*
Akshay Singh, *Graduate Student at University of Maryland*

Development of Wi-Fi communication channel for wireless charging

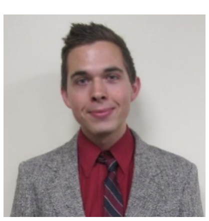
Firehiwot Gurara, *Cornell University*

Global electric vehicle (EV) market is increasing steadily aided by support from government policies, technological innovations and declining costs. EVs provide a cleaner means of transportation with increased fuel efficiency. In addition, the inherent advanced technologies and safety features present inside EVs make them ideal candidate for autonomous driving. One of the major challenges hindering the progress of the development of fully autonomous EVs is the absence of suitable charging technique. Wireless charging can be a primary solution for powering fully autonomous EVs. In wireless charging systems, power is transferred from an off-board transmitting pad on the ground to a receiving pad on a vehicle without using plugs. Therefore, a Wi-Fi communication channel is needed to transmit information from the vehicle to the off-board power interface. The goal of this project is to setup a Wi-Fi communication channel for assisting the control of wireless charging systems. A transmitter relays the voltage level of a battery to a receiver using Wi-Fi communication which is in turn serially transmitted to a digital signal processor (DSP) that controls the power flow. After initial setup and verification of the communication channel, a closed loop system evaluation is implemented on a laboratory prototype charger.

Professor Alireza Khaligh, *University of Maryland*
Arun Sankar U., *Graduate Student at University of Maryland*

Multi-Output DC-DC conversion using Flyback Topology

Logan Johnson, *Liberty University*



Plug-in electric vehicles utilize two batteries: a 250-400 V propulsion battery to supply the tractive system and an auxiliary 12/14 V lead-acid battery to supply the low-voltage electrical components of the vehicle. Doing so enables the battery powering the motors of the car to remain isolated from the battery powering less energy-intensive systems. Traditionally this requires that the two systems have two separate chargers. Integrating these two components would simplify charging the vehicle; the resulting charger would be smaller, cheaper, lighter, more efficient, and more reliable. However, such a system would require microcontrollers to provide closed loop control, PWM gate driving signals, and signal processing from electrical sensors. Each microcontroller must be powered with a steady 15 V supply drawn from the high-voltage battery; four such auxiliary supplies are required, each with separate current requirements. This necessitates a high-voltage DC-DC step down switched-mode power supply with five galvanically isolated output channels. This research showcases the design, simulation, and PCB layout of such a supply using a flyback converter with auxiliary windings for each of the channels.

Professor Alireza Khaligh, *University of Maryland*
Jiangheng Lu, *Graduate Student at University of Maryland*

η-ρ-σ Trade-off Quantification in More-Electric-Aircraft Power Electronic Systems

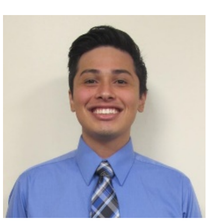
Gurpreet Kaur, *College of Southern Maryland*

In this research, we are analyzing the reliability or in other words, probability of success of critical and distinct components such as capacitors and power semiconductor devices (MOSFETS), where a real time estimation of remaining lifetime can be calculated. Additionally, the research will focus on the reliability analysis and evaluation at the system level for a non-modular single unit SiC MOSFET based auxiliary power supply unit (APU) for Boeing 787. Reliability has remained a significant obstacle suppressing the applications of power electronics; consequently, considerable amount of attention has been devoted to the reliability of power electronics. Hence, reliability evaluation is very crucial for design and operation management of the power electronic systems. Therefore, quantitative assessment of reliability at the component and system level is significant in verifying whether a particular design relates to specific parameters. Keeping this as a motivation, this study also focuses on studying and analyzing the inter-relation among reliability and other performance metrics such as power density, efficiency etc. The major metrics under consideration are failure in time (FIT), mean time to failure (MTTF denoted by σ), power density (ρ), efficiency (η) while keeping the focus only on capacitors and active power semiconductors.

Professor Alireza Khaligh, *University of Maryland*
Ayan Mallik, *Graduate Student at University of Maryland*

Estimation of Electric Vehicle Mode of Motion via Particle Filtering

Juan Lopez, *University of Toledo*



With the rise of electric vehicles, research involving the technology utilized for such vehicles has become critical. One area of interest focuses on the energy usage from an electric vehicle's available power sources, such as batteries and ultracapacitors. Such research is essential to increase an electric vehicle's energy efficiency, and this study aims to increase such efficiency by employing micron signal processing techniques. To this end, we propose to use state-space modeling and particle filtering in order to track and predict an electric vehicle's mode of motion.

These predictions can be utilized to further increase the car's energy efficiency by determining the appropriate sources of energy that best fit the energy demands. Since electric vehicles are exposed to both urban and rural roadways, determining which energy source to utilize is a significant step to increase the overall efficiency of an electric vehicle.

Professor Behtash Babadi, *University of Maryland*
Sina Miran, *Graduate Student at University of Maryland*

Thermal Management and Packaging

Matthew Morin, *University of Maryland*

The future of avionics will see the adoption of hybrid electric and all electric propulsion systems for aircraft. These systems will use large electric motors for propulsion and power electronics devices for regulating power distribution. The extremely high power demands of such systems necessitate the management of significant excess heat. In this paper, various thermal management methods are investigated in order to determine which will meet the cooling demands while minimizing weight and drag in order to maximize fuel efficiency. The thermal management methods investigated are cold plates, spray cooling, jet impingement, microchannel cooling, heat pipes, and phase change materials. After assessing the weight and drag of each method, the cost, reliability and availability of each cooling method is considered to find the best possible thermal management methods for the electric motors and power electronics.

Professor Patrick McCluskey, *University of Maryland*
Yonatan Saadon, *Graduate Student at University of Maryland*
Zhaoxi Yao, *Graduate Student at University of Maryland*

Design of Driving Power Supply for an AC/DC Converter

Jake O'Brien, *Ithaca College*

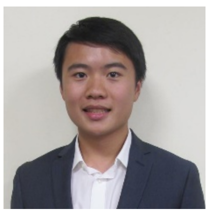
This project aims at designing an auxiliary DC voltage source for driving an AC/DC converter circuit. Plenty of converter topologies have been suggested for applications of the DC power source, and each topology has obvious strengths and weaknesses. For example, resonant converters have excellent performance in terms of power efficiency, while flyback converters maintain low design complexity and high cost effectiveness [4]. The target power range to drive the AC/DC converter circuit is 30-50W. Flyback converters are widely used for lower power applications, typically less than 100 W [1]. The flyback converter has a low cost because of the minimal components needed. In addition, it has good transient response and galvanic isolation between the input and output sides [2]. Furthermore, the flyback converter is less sensitive to the transformer tolerance, so that the topology enables a robust and reliable power supply [3]. Because of these factors, a Silicon MOSFET based flyback converter topology is employed for this project.

During the REU program, the operating principle, detailed design methodologies focused on performance optimization, and implementation considerations will be presented. Based on the contents, an AC/DC converter that converts the voltage from single-phase 230 Vrms to 12 Vdc will be implemented, and simulation results will be demonstrated

Professor Alireza Khaligh, *University of Maryland*
Yongwan Park, *Graduate Student at University of Maryland*

3D-Printing of Solid-State Lithium-ion Batteries

Zander Tedjo, *University of Texas at Austin*



As technology continues to advance, there is an increasing need for better energy storage devices to power portable electronics, from pacemakers to smartphones to electric vehicles. Consequently, there is strong interest in developing lithium ion batteries that have higher gravimetric density, volumetric density, and capacity, with faster charging and discharging rates. However, the energy density and power density of current battery designs are limited due to the opposition between ion diffusion distance and thickness of active materials. Therefore, solid-state 3D-printed designs will be implemented to improve lithium ion batteries and overcome the challenges of 2D designs. Interdigitated 3D-printed battery designs have the advantage of greater surface area contact and thickness while maintaining a constant ion diffusion distance. Moreover, solid-state electrolyte is safer than traditional electrolyte. In order to maximize the potential of 3D-printed batteries, we will focus on printability, manufacturing, and structural design. This involves determining the optimal viscosity, printing parameters, and cross-sectional shape. The capacity, retention, and internal resistance of the battery will then be measured and analyzed during cycles of charging and discharging. By developing 3D-printed batteries, we hope to further the field of battery technology and improve the electronic devices dependent upon them.

Professor Liangbing Hu, *University of Maryland*
Boyang Liu, *Graduate Student at University of Maryland*

IGBT Power Module Reliability Assessment

Patrick Toplikar Jr., *Missouri State University in cooperation with Missouri University of Science and Technology*

Power modules are an important part of hybrid electric vehicles; they are used in critical areas such as powertrain electronics. Usage and environmental conditions can lead power modules to fail overtime; accelerated testing helps determine and characterize device performance and reliability faster. In this project, thermal cycling is induced to multiple power modules simultaneously, in order to assess the effect of thermal cycling on the devices' response to a power test; data comes from in-situ monitoring of temperature and voltage. The temperature variation of the system due to power testing can indicate whether there is any potential damage in the die, die attach, wire bonds, or other components. If the response changes significantly as the number of applied thermal cycles and power tests increases, then the device has incurred some damage; however, if the response stays consistent as the number of power cycles increases, then the device remains reliable. Data analysis and device imaging and characterization are performed to assess failure modes and mechanisms within the power module. The project also proposes a new circuit that enables at least four IGBT modules to undergo power cycle testing simultaneously, as well as additional changes to potentially improve future research.

Professor Patrick McCluskey, *University of Maryland*
Erick Gutierrez, *Graduate Student at University of Maryland*

IRES Electrified and Autonomous Transportation

Development of QR PCA Algorithm for Use on an FPGA

Alyssa Barth, *Texas A&M University, College Station*

In the creation of quality wine, it is important to monitor the percentages of the wine's chemical compounds throughout production. During the process, the environment and composition of the wine constantly change, and the analytical method used to evaluate the wine must be updated accordingly. Currently, photochemical sensors in embedded systems are used to accomplish such, which provide a huge amount of data per measurement. Since the algorithms currently in place are limited by resource utilization and system latency, they only consider a predetermined portion of the data. This can potentially lead to a loss of system accuracy. Other approaches might improve system accuracy by applying machine learning techniques, such as feature extraction. A well-known feature extraction technique is Principal Component Analysis, of which one of the faster methods is QR PCA. The goal of this research is to implement QR PCA on an FPGA as a prototype for industry, since it may provide a more accurate reading of the wine's data, while still being able to adjust in real time. First, QR PCA was implemented at a higher level in MATLAB to verify that the algorithm was functioning accordingly. It was then implemented in C, so that later, Verilog's high-level synthesis tool could be used to program the FPGA.

Rodrigo Marino, *Graduate Student at Universidad Politécnica de Madrid*

High Power-Density, High Efficiency, 6.6kW On-Board Charger for Electric Vehicles

Michael D'Antonio, *University of Maryland*

This work focuses on the design of a 6.6kW on-board charger (OBC) for electric vehicles (EVs). The OBC is designed to be compatible with a universal single-phase AC input voltage from 85Vrms-265Vrms. A traditional two-stage approach with an AC-DC PFC, DC link, and isolated DC-DC converter is utilized. First, a bridgeless totem-pole interleaved boost PFC is designed, with variable DC link voltage control. Second, half- and full-bridge derived three-level LLC resonant DC-DC converters are analyzed, designed and compared. The EV battery charging profile is controlled by the variable DC link voltage and the LLC converter, which operates with either half- or full-input-voltage near the resonant frequency. The two primary areas of interest are power density and efficiency, of which the targets are 5kW/L and 96%, respectively. To achieve both simultaneously, wide-bandgap (WBG) semiconductor components, including Silicon Carbide (SiC) and Gallium Nitride (GaN), are considered at high switching frequency. Furthermore, an integrated transformer is designed, which incorporates the circuit's resonant inductance as the leakage inductance. Finally, attention is placed on the particular components that inhibit high power-density achievement, and how their volumetric contributions could be reduced in future designs.

Professor Miroslav Vasić, *Universidad Politécnica de Madrid*

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700 W DC-DC Synchronous Buck Converter using GaN Semiconductors for Satellite Applications

Joelle Dowling, *The George Washington University*

The weight and volume of a satellite directly affect its cost; therefore, it is the goal of engineers working on the next generation of satellites to reduce the size of the satellite's on-board components while maintaining their performance. DC-DC step-down converters are necessary in satellite applications to convert solar power to usable power for the satellite´s loads, thus it is crucial that the converter size is minimized. New technologies in the field of semiconductors allow this goal to be realized, specifically by replacing Silicon (Si) with Gallium Nitride (GaN) power semiconductors.

This presentation will address the solutions associated with decreasing the size of a DC-DC synchronous buck converter while maintaining an efficiency over 97%. Decreasing the converter volume is primarily accomplished by increasing the switching frequency, which is possible using GaN power semiconductors, with limited impact to the converter efficiency. In this project, the rate of change of the high-side drain-source voltage over time was analyzed, and soft-switching techniques were implemented to minimize switching-related losses. Furthermore, the thermal management approach was optimized, despite limitations associated with the space application.

Professor Pedro Alou, *Universidad Politécnica de Madrid*
Nicolás Alonso, *Graduate Student at Universidad Politécnica de Madrid*

Design and Optimization of Ground Assembly for Wireless Power Transfer Systems for Electric Vehicles

Jason Lim, *University of Nevada, Reno*

Due to increasing concerns of harmful environmental effects caused by the use of fossil fuels, electric vehicles are becoming ever more prevalent in today´s society. The success of electric vehicles depends greatly on designing cheap and efficient charging methods. While several charging methods currently exist and many more are being researched, this paper focuses on a specific method called inductive charging, which utilizes inductive power transfer to charge a stationary vehicle wirelessly. This wireless power transfer system acts as a gapped transformer, where the primary coil, contained in the Ground Assembly (GA), is implemented separately from the secondary coil, contained in the Vehicle Assembly (VA). While the complete GA and VA system must also include relevant power electronic circuits, this paper focuses primarily on the inductive coils themselves. Starting with the standard GA design proposed by the Society of Automotive Engineers, Finite Element Simulation techniques are used to optimize efficiency and cost by tuning the dimensions of the coil, reducing the amount of ferrite core, and/or adding new cheaper materials that maintain or improve the magnetic behavior of the system. Finally, a prototype based these optimizations is built and tested to validate the simulation results.

Professor Miroslav Vasić, *Universidad Politécnica de Madrid*
Alberto Delgado, *Graduate Student at Universidad Politécnica de Madrid*

Hard-Switching versus Soft-Switching in GaN MOSFETs: What Are the Penalties of Using Hard-Switching?

Daniel West, *University of New Haven*

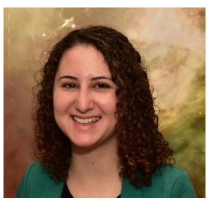
In this work we explored power losses in gallium nitride (GaN) MOSFETs with respect to soft-switching versus hard-switching. As conventional MOSFETs have been pushed to their theoretical limits, relatively newer materials such as GaN and silicon carbide (SiC) continue to be investigated and replace conventional semiconductors such as silicon due to the demand for higher performance of modern electrical systems. The circuit used in this work was the buck converter circuit of the GS66508T-EVBHB evaluation board (EVB), which is designed to demonstrate the performance of GaN Systems' 650V devices. LTSpice was used to model and simulate the circuit. Theoretical calculations regarding conduction, switching, and driving losses were used to analyze trends with respect to switching frequency. Advantages and costs of soft-switching versus hard-switching were analyzed and verified experimentally. With switching frequency held at 100 kHz, 99.28% efficiency with soft-switching and 99.14% efficiency with hard-switching was achieved for 1 kW with a 400-V input and 340-V output. The most notable disadvantages for hard-switching were the significantly higher temperatures, voltage spikes, noise, and ringing.

Professor José A. Cobos, *Universidad Politécnica de Madrid*
Diego Serrano, *Graduate Student at Universidad Politécnica de Madrid*

GRAD-MAP

The Search for Changing Look Quasars in iPTF: Quantifying Real Variability

Tessa Gonzalez, *University of Maryland*



Quasars or active galactic nuclei (AGN) are extremely luminous supermassive black holes accumulating matter in the center of galaxies. Changing look quasars are extremely variable quasars that change spectral type. There is a proposed unification scheme for AGN that states that the presence of broad and narrow spectral lines are due to a different viewing angle of the AGN with respect to an obscuring torus. This model is challenged by observations of AGN that change spectral class over a short time span. Our goal is to efficiently select a large sample of candidate "changing look" AGN, so we can probe the physical mechanism causing their spectral transformation. This selection is based on the calculation of several statistics describing the variability such as reduced chi squared or the ratio of detections above and below the mean brightness, along with metrics that aim to tell us if the detection is real. Once we have a list of variable quasars, we can follow up by taking their spectrum and quantifying their characteristics. We calculated these statistics that selected 39 highly variable sources from a catalog of 95 variable sources, cutting out 59% of the sources. We successfully created a pipeline that combs through a catalog of variable objects and selects the highly variable AGN, thereby making the processes of follow up more efficient.

Suvi Gezari, *Assistant Professor at University of Maryland*
Sara Frederick, *Graduate Student at University of Maryland*

Observational Strategies for James Webb Space Telescope in Detecting Kilonovae

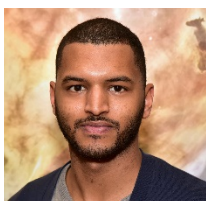
Rishap Lamichhane, *Howard University*

A kilonova occurs when two neutron stars merge into each other. The neutron-rich ejecta from the merger undergoes a rapid (r-process) nucleosynthesis which leads to formation of heavy elements such as gold. The radioactive decay of the unstable nuclei powers the kilonova emission in optical and near-infrared spectrum which peaks at longer wavelengths. Short duration Gamma-ray bursts (sGRBs) are thought to be caused by this merger along with the gravitational waves. Thus, the kilonova emission is a promising electromagnetic counterpart for the future gravitational wave detection from binary neutron star mergers. James Webb Space Telescope (JWST) is equipped with Near Infrared Camera (NIRCam) and Mid Infrared (MIRI), which can be used to get crucial information on kilonova and the synthesis of heavy elements. In this project, we create a distribution of kilonova models and their host galaxies based on published observational data/models and design optimal observation configurations using the JWST Exposure Time Calculator (ETC). We will calculate the exposure times to achieve required signal to noise ratio (SNR) for these configurations. The results will be used to investigate the observation strategies for the future kilonova studies using the JWST to unravel the origins of heavy elements in the universe.

Dr. Leo Singer, *NASA Goddard Space Flight Center*
Pradip Gatkine, *Graduate Student at University of Maryland*

Designing Kilonovae Observations for the James Webb Space Telescope

DeOndre Kittrell, *Morgan State University*



Since the detection of GW170817, a substantial amount of research has been conducted on the electromagnetic counterpart of the binary neutron star merger. The kilonova that results from these mergers has peak emission at infrared frequencies due to the lanthanide rich composition of the ejecta. We seek to create formidable kilonovae observation strategy for the James Webb Space Telescope (JWST), which will debut new instruments like NIRcam and MIRI, designed for observing in the infrared range of the spectrum. We begin by producing a population of multi-component kilonova models using MOSFIT, accounting for key merger parameters such as ejecta mass, ejecta velocity, and ejecta opacity. We then create a separate population of potential host galaxies based on properties such as, redshift, stellar age, and star formation rate. The two groups are synthesized to create simulated scenes that can be implemented in the JWST Exposure Time Calculator (ETC) via Pandeia. We explore these simulated scenes to determine which observing configurations are most efficient in revealing the kilonova science, by minimizing exposure times while maximizing the capabilities of JWST.

Dr. Leo Singer, *NASA Goddard Space Flight Center*
Pradip Gatkine, *Graduate Student at University of Maryland*

Optimizing Configurations for the Next Generation Very Large Array

Sara Negussie, *University of Maryland*

Radio telescopes, such as the Very Large Array (VLA), which is made up of 27 dishes, are instruments used to study a celestial object, such as a star or galaxy. The angular resolution of these telescopes and interferometer is ~ λ/d or λ/D, where d is the diameter of a single dish and D is the diameter of the largest separation between dishes. Radio interferometry is the process of forming an image made by measurements from pairs of dishes. The number of pairs of dishes is equal to N(N-1)/2, where N is the number of dishes. The higher the number of dishes, the more measurements that can be added together to form a more correct image. Currently, there is a proposal that is projected to build more dishes around the VLA. This project will be the next generation Very Large Array (ngVLA), and it will be able to answer questions that no current instrument can, such as: How did the solar system form? How did the universe evolve? How did supermassive black holes form? It can answer these questions because the angular resolution of the ngVLA will be very small. The dish (d) results in a field of view with a resolution determined by the array size (D). Putting together many smaller dishes (D) can emulate a large single radio telescope (d). However, because there is separation between dishes, there will be gaps in the data collected from the uv plane. The uv plane is 2D cut out of the sky that the radio telescopes point at. To alleviate this issue of gaps of missing data, we are searching for the best dish size for an additional radio telescope to add to the current proposed ngVLA model. We are using a computer package called the Common Astronomy Software Application (CASA) to simulate the ngVLA and the extra telescope. We measure how well the data has improved by comparing the fidelity verses the dish size. The fidelity is a measure of the quality of the image and acts like a signal to noise ratio. It is increasing with the amount of pointings made and the diameter of the dish size. In my poster, I will expand on my findings.

Professor Alberto Bolatto, *University of Maryland*
Peter Teuben, *Principal Research Scientist at University of Maryland*

JQI

Possible improvements in four-wave mixing: Eskma top-hat beam shaping lens

Kwasi Fahie, *Williams College*

In our lab, we study exotic states of light by four-wave mixing (FWM) Gaussian waves in a Rb-cell. Across the length of the cell, Gaussian intensities vary in strength and size, causing distortions in the observed output. A potential improvement to these experiments is replacing the Gaussian intensity beam with a uniform-intensity beam. Optics meant for this are commercially available, and we have studied such a lens for potential use.The Eskma top-hat converter is a beam shaping lens which - when paired with a focusing lens - takes Gaussian intensity light and produces near-uniform intensity at focal length. This experiment analyses the wave profile at a working distance (WD) near focal length (500 mm) and examines phase aberrations and amplitude interference induced by the lens. Light input came from a fiber optic, coupled with an aspherical lens and resized through a series of Kepler beam expander. Using a translating stage and beam profiler, we observed changes in the top-hat profile shape for WDs above and below the focal length. We then observed phase interference with a modified Mach-Zehnder interferometer; high-contrast fringes occurred at focal length, suggesting unexpected phase shifts caused by the lens. We will consider these changes in intensity and phase before implementing the beam shaping lens in a FWM process.

Nicholas Brewer, *Postdoctoral Researcher at University of Maryland*
Donald Fahey, *Postdoctoral Researcher at University of Maryland*
Prasoon Gupta, *Graduate Student at University of Maryland*
Kevin Jones, *Research Associate at University of Maryland*
Rory Speirs, *Postdoctoral Researcher at University of Maryland*
