



# Michigan Space Grant Consortium Fall Conference

**November 10, 2018**

University of Michigan  
Boeing Auditorium  
Francois-Xavier Bagnoud Building  
1320 Beal Ave, Ann Arbor, MI 48109

## Participant Packet

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## Presenter Instructions

### Speaker presenters

- Talks are scheduled 12 minutes apart. A 10-minute talk with 2 minutes Q&A and transition time is recommended.
- Do either one of the following:
  - Send your PowerPoint presentation to MSGC Program Manager ([bvyletel@umich.edu](mailto:bvyletel@umich.edu)) by Thursday, November 8. Put your name in the filename.
  - Arrive at FXB between 8:15am and 8:30am to ensure presentation compatibility with room system in the Boeing Auditorium (IT expert Dave McLean will be there to do this with you).

### Poster presenters

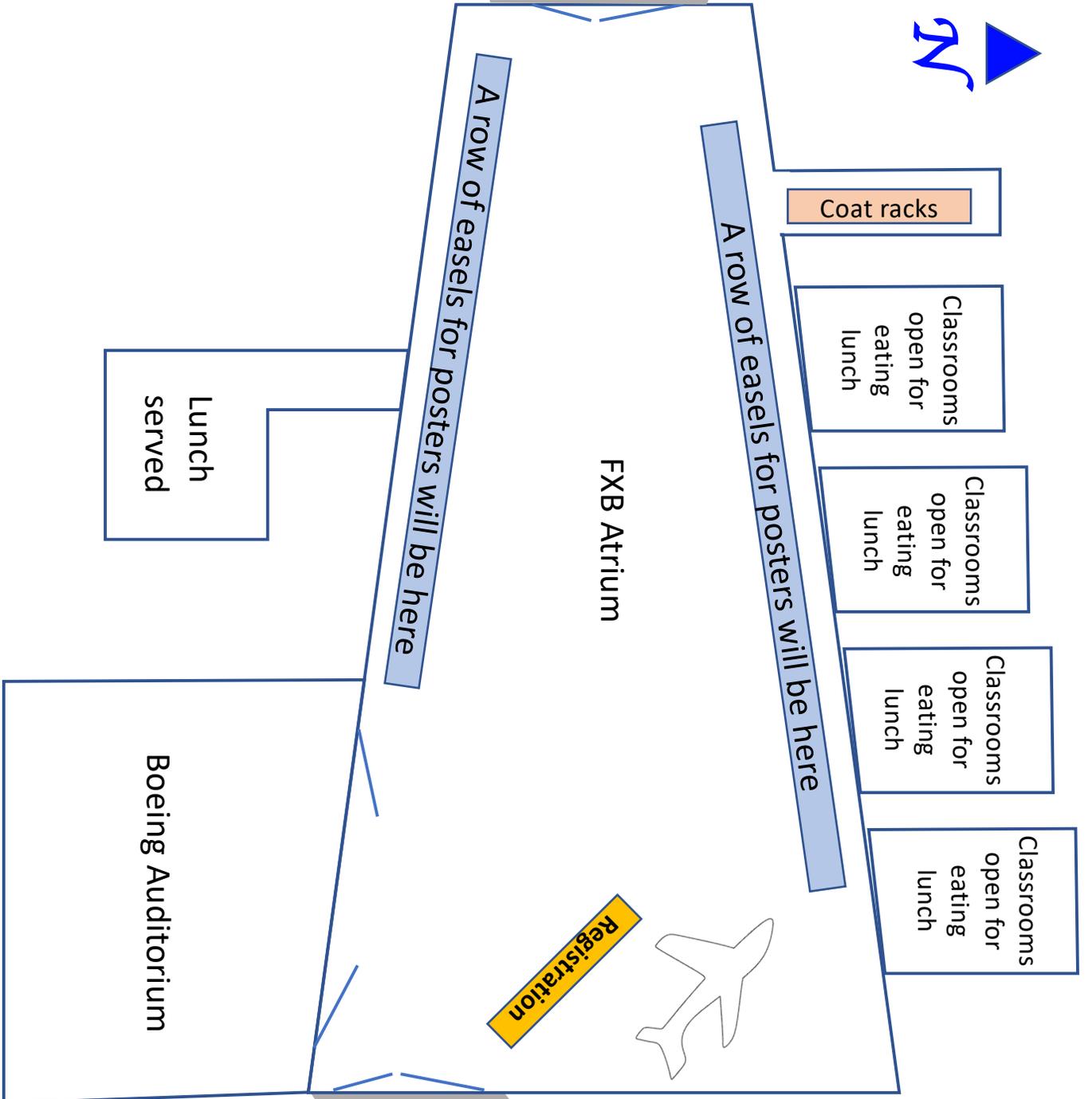
- Design the poster to fit a 32" x 40" foam core board - either portrait and landscape orientation.
- Easels will be selected on a first-come, first-served basis. FXB diagram shows easel locations
- Binder clips and/or tacks will be supplied for mounting the poster on the foam core board.
- Presenters must attend the duration of the Poster Session in which they are scheduled (see Poster Session List). Presenters are welcome to stand at their display during other poster sessions, **in addition** to when they are scheduled.
- Posters will remain displayed for the duration of the meeting.
- Posters must be removed either by 4:00 or within 15 minutes after the final presentation ends, whichever comes later. Posters display contents not removed after this time may be subject to damage or loss.

## Schedule at a Glance

8:00 am	FXB building opens
8:15 am	Breakfast
9:00 am	Conference begins with Keynote Session
10:30 am	Poster Session I
11:00 am	Second speaker session – Human Health in Space Exploration
12:00 pm	Lunch
12:45 pm	Poster Session II
1:15 pm	Third speaker session – Meteorites to Mass Shootings
2:15 pm	Poster Session III
2:45 pm	Fourth speaker session – Hands-On STEM Learning
3:35 pm	Adjourn

# Diagram of Francois-Xavier Bagnoud Building

Beal Ave.



*Note: Map  
not to scale*



## **2018 MSGC Fall Conference PROGRAM SCHEDULE**

University of Michigan  
Boeing Auditorium  
Francois-Xavier Bagnoud Building  
1320 Beal Ave, Ann Arbor, MI 48109



### **8:15 Breakfast**

### **9:00 Keynote Session**

#### **Welcome**

Prof. Mark Moldwin, Director MSGC

#### **CubeSats, and Balloons, and Students, Oh My!**

Prof. Kristina Lemmer, Western Michigan University (Keynote)

#### **Development of Lightweight CubeSat with Multifunctional Structural Battery System**

Breeanne Marshall, Wayne State University

#### **MASA and the Quest to Launch a Rocket to Space**

Geoff Parkes, University of Michigan

#### **Progress in Stages of Contact Binary Star Evolution**

Evan Cook, Calvin College

### **10:30 Poster Session I and Coffee Break**

### **11:00 Human Health in Space Exploration**

#### **Temperature Effects on Prefrontal Cortex Activation and Psychological Ratings during Water Immersion and a Fatiguing Task**

Kevin Phillips, Michigan Technological University

#### **NASA's Concern for Upper-Body Work Performance During Space Flight: What Impact Does Respiratory Muscle Fatigue Have?**

Thomas Bye, Michigan Technological University

#### **The Martian: An Accurate Depiction of Human Locomotion on Mars**

Alex Gabe, Michigan Technological University

#### **Stress-induced heat shock protein 40 and immune dysfunction in altered gravity**

Brooke Shepard, Oakland University

#### **Michigan Bioastronautics and Life Support Systems (BLISS)**

Rob Gitten, University of Michigan

**12:00 Lunch (through 1:15pm)**

**12:45 Poster Session II**

**1:15 Ecology, Engineering, Energy, and Extreme Events**

**The Hamburg (H4) Michigan Meteorite**

Prof. Michael Velbel, Michigan State University

**Bulk Metallic Glass Matrix Composites – Applications and opportunities in Aerospace Engineering**

Muhammad Musaddique Ali RAFIQUE – Wayne State University

**Hurricane Maria and Puerto Rican Epiphytes: A Case Study in Extreme Events and Plant Ecology**

Brendan Kosnik, Grand Valley State University

**Classifying Mass Shootings in the United States**

Tyler Gast, Hope College

**Thermal Osmosis Study in PEM Fuel Cells**

Nicholas Ingarra, Oakland University

**2:15 Poster Session III and Coffee Break**

**2:45 Hands-On STEM Learning**

**Energizing our World – Hands on Learning of Renewable Energy and Sustainability**

Dr. Kristofer Pachla, Grand Valley State University

**Roger That! Symposium on Space Exploration**

Prof. Karen Gipson, Grand Valley State University

**Hope College – Air Quality Monitoring in the Middle and High School Grades**

Susan Brown, Hope College

**Hope College Engineering the Future Academy**

Prof. Eric Mann, Hope College

**3:35 Adjourn**



## 2018 MSGC Fall Conference POSTER SESSIONS

University of Michigan  
Boeing Auditorium  
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1320 Beal Ave, Ann Arbor, MI 48109



Posters will be on display throughout the day.  
Presenters are asked to be at their posters during the time listed below  
and are welcome to be at their posters during additional sessions as well.

### POSTER SESSION I – BIOMEDICAL AND SPACE RESEARCH

10:30-11:00am

#### **Influence of Mass Transport on Energetic Ion Distributions at Saturn**

A. R. Azari<sup>1</sup>, M. W. Liemohn<sup>1</sup>, X. Jia<sup>1</sup>, A. M. Rymer<sup>2</sup>, N. Sergis<sup>3</sup>, D. G. Mitchell<sup>2</sup>, C. Paranicas<sup>2</sup>

<sup>1</sup>Climate and Space Sciences & Engr Dept, University of Michigan, Ann Arbor, Michigan

<sup>2</sup>Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland

<sup>3</sup>Academy of Athens and National Observatory of Athens, Athens, Greece

#### **The Apollo Number and Suit Dynamics**

J. Bigalke, H. Cunningham

Kinesiology and Integrative Physiology, Michigan Technological University, Houghton, Michigan

#### **Teaching Skeletal Muscle Contraction through Reverse Engineering**

Benjamin Cockfield<sup>1</sup>, Travis Wakeham<sup>2</sup>, Jessica Bruning<sup>1</sup>, Steven Stelly<sup>1</sup>, Steven Elmer<sup>1</sup>

<sup>1</sup>Dept of Kinesiology & Integrative Physiology, Michigan Technological Univ., Houghton, Michigan

<sup>2</sup>Department of Biological Sciences, Michigan Technological University, Houghton, MI

#### **A Nuclear Thermal Rocket Decay Heat Model with Implications**

Chad Denbrock

Nuclear Engineering and Radiological Sciences, University of Michigan, Ann Arbor, Michigan

#### **EEG Analysis of Physically and Electrically Activated Sensation**

Michael Dennis, Barry Bait

Biomedical Engineering, Hope College, Holland, Michigan

#### **Miniaturized Neuron Stimulator**

Lucas Essenburg, Robert Saltzman, Joshua White

Dept of Electrical & Computer Engineering, Western Michigan University, Kalamazoo, Michigan

#### **Department Wide Outreach Program in Kinesiology and Integrative Physiology**

Jana Hendrickson, Abby Sutherland, Tom Bye, Steven Elmer, Jason Carter, Kathryn Carter

Dept of Kinesiology & Integrative Physiology, Michigan Technological Univ, Houghton, Michigan

### **Micrometeoroid Population Inference on LISA Pathfinder Data**

Sophie Hourihane<sup>1</sup>, John Baker<sup>2</sup>, Tyson Littenberg<sup>3</sup>, Jacob Slutsky<sup>2</sup>, James Ira Thorpe<sup>2</sup>

<sup>1</sup> Department of Physics, University of Michigan, Ann Arbor, Michigan

<sup>2</sup>Gravitational Astrophysics Laboratory, NASA Goddard Space Flight Cntr, Greenbelt, Maryland

<sup>3</sup>NASA Marshall Space Flight Center, Huntsville, Alabama

### **Specialization by subsurface bacteria beneath a hyperarid Mars analogue system**

J. Robert Logan<sup>1</sup>, Heather Kittredge<sup>1</sup>, Peter Jacobson<sup>2</sup>, Jeff Muntifering<sup>3</sup>, Sarah Evans<sup>1</sup>

<sup>1</sup> Kellogg Biological Station & Department of Integrative Biology, Michigan State University, Hickory Corners, Michigan

<sup>2</sup> Department of Biology, Grinnell College, Grinnell, Iowa

<sup>3</sup> Save the Rhino Trust, Walvis Bay, Namibia

### **UV Shielding of *Bacillus pumilus* SAFR-032 Endospores by Martian Regolith Simulants**

Jordan M. McKaig<sup>1,2</sup>, Jonathan M. Galazka<sup>3</sup>, Jon C. Rask<sup>4</sup>, Camilla Urbaniak<sup>5</sup>, Samantha M. Waters<sup>6</sup>, Joseph Varelas<sup>6</sup>, Kasthuri J. Venkateswaran<sup>5</sup>, Patrick M. Nicoll<sup>7</sup>, David J. Smith<sup>3</sup>

<sup>1</sup>NASA Space Life Sciences Training Program, NASA Ames Research Center

<sup>2</sup>University of Michigan, Ann Arbor - Program in Biological Sciences

<sup>3</sup>NASA Space Biosciences Division, NASA Ames Research Center

<sup>4</sup>KBRwyle

<sup>5</sup>NASA Planetary Protection Division, NASA Jet Propulsion Laboratory

<sup>6</sup>Universities Space Research Association

<sup>7</sup>Blue Marble Space Institute of Science

### **Now-Casting Space Weather Events Using Heavy Ion Charge Distributions**

Alicia Petersen<sup>1</sup>, Susan Lepri<sup>1</sup>, Michael Liemohn<sup>1</sup>

University of Michigan, Department of Climate and Space Sciences and Engineering

### **Implementing the FIDO model in a pulsar population synthesis**

Madeleine Rabitoy, Dr. Peter Gonthier

Department of Astrophysics, Hope College, Holland, MI

### **Inhibiting Pathogenesis of Tau Protein: Potential Biomarker of Physiological Changes Associated with Long-Term Space Travel**

Mina Sitto, Dr. Colin Wu, and Dr. Sanela Martić

Department of Chemistry, Oakland University, Rochester, Michigan

### **Distinguishing Stellar Populations within Milky Way Globular Star Clusters**

Jason Smolinski, Alex Van Kooten

Department of Physics and Astronomy, Calvin College, Grand Rapids, Michigan

### **Human Powered Locomotion on Mars**

Kelvyn Van Laarhoven, Derek Verbrigghe, Stephen Hook

Dept of Kinesiology & Integrative Physiology, Michigan Technological University, Houghton, MI

**Toxic effects of the biological pesticide, *Bacillus thuringiensis israelensis*, on North American frog larvae**

Eve Choi, Dr. Janet Vigna, and Dr. Jennifer Moore  
Biology Department, Grand Valley State University, Allendale, Michigan

**Implications of geochemical, petrographic and stratigraphic analyses of the upper Portage Lake Volcanics for the Keweenaw flood basalts**

William Ray Davis<sup>1</sup>, Mitchel Collins<sup>1</sup>, Andrew Lavigne<sup>1</sup>, Tyrone Rooney<sup>1</sup>, Susan Krans<sup>1</sup>, Eric Brown<sup>2</sup>, Seth Stein<sup>3</sup>, Carol Stein<sup>4</sup> and Rob Moucha<sup>5</sup>

<sup>1</sup>Earth and Environmental Sciences, Michigan State University, East Lansing, Michigan

<sup>2</sup>Department of Geoscience, Aarhus University, Aarhus, 8000, Denmark

<sup>3</sup>Earth & Planetary Sciences, Northwestern University, Evanston, Illinois

<sup>4</sup>Earth & Environmental Sciences, University of Illinois at Chicago, Chicago, Illinois

<sup>5</sup>Earth Sciences Dept., Syracuse University, 204 Heroy Geology Laboratory, Syracuse, New York

**Using remote sensing to study ecological changes associated with hydrologic fluctuations in a Great Lakes slack/interdunal wetland**

Alexandra Donaldson<sup>1</sup>, Suzanne J. DeVries-Zimmerman<sup>1</sup>, Jacob T. Stid<sup>1</sup>, Brian P. Yurk<sup>2</sup>

<sup>1</sup>Department of Geological and Environmental Sciences, Hope College, Holland, Michigan

<sup>2</sup>Department of Mathematics, Hope College, Holland, Michigan

**Farm to Lake: quantitative analysis of antibiotics, and metagenomic characterization of microflora in surface waters in livestock farm areas contiguous to Lake Michigan**

Dr. Babasola Fateye<sup>1</sup>, Ethan Wright<sup>2</sup>

<sup>1</sup>Biomedical Sciences, Grand Valley State University, Henry Hall 316, Allendale, Michigan

<sup>2</sup>Undergraduate Student, Grand Valley State University, Allendale, Michigan

**Magmatic Plumbing during the Terminus of the Keweenaw Large Igneous Province: Evidence from the Michipicoten Island Formation**

Kellen Martella<sup>1</sup>, Andrew LaVigne<sup>1</sup>, Christopher Svoboda<sup>1</sup>, Tyrone Rooney<sup>1</sup>, Guillaume Girard<sup>1</sup>, Robert Moucha<sup>2</sup>, Carol Stein<sup>3</sup>, Seth Stein<sup>4</sup>

<sup>1</sup>Earth and Environmental Sciences, Michigan State University, East Lansing, Michigan

<sup>2</sup>Earth Sciences, Syracuse University, 204 Heroy Geology Laboratory, Syracuse, New York

<sup>3</sup>Earth and Environmental Sciences, University of Illinois at Chicago, Chicago Illinois

<sup>4</sup>Earth and Planetary Sciences, Northwestern University, Evanston, Illinois

**Crustal Structure of the Mangystau Region, Western Kazakhstan**

Luis B. Martinetti, Kevin Mackey

Dept of Earth and Environmental Sciences, Michigan State University, East Lansing, Michigan

**The Cart Before the Redhorse: Examining Summer Habitat Use of the River Redhorse (*Moxostoma Carinatum*) to Guide Future Management**

Nicholas Preville

Biology Department, Grand Valley State University, Allendale, Michigan

## **Studying Vegetation Coverage and Dune Mobility with Drone-Acquired Multispectral Imagery**

Jacob Stid<sup>1</sup>, Ed Hansen<sup>1</sup>, Brian Yurk<sup>2</sup>, Paul Pearson<sup>2</sup>

<sup>1</sup>Geology Department, Hope College, Holland, Michigan

<sup>2</sup>Mathematics Department, Hope College, Holland, Michigan

## **Cenozoic Patagonian Magmatism**

Christopher Svoboda, Tyrone Rooney

Dept of Earth and Environmental Sciences, Michigan State University, East Lansing Michigan

**Developing a General Spin Dependent Compton Scattering Cross-Section in Strong Magnetic Fields**

Meredith Bomers, Peter Gonthier, PhD  
Department of Physics, Hope College, Holland, Michigan

**Thiol-yne reactions for incorporating longer wavelength azo dyes into polymeric photomechanical materials.**

Marcus A. Brinks<sup>1,2</sup>, Matthew L. Smith<sup>2</sup>, Jason G. Gillmore<sup>1</sup>  
Departments of Chemistry<sup>1</sup> and Engineering<sup>2</sup>, Hope College, Holland, Michigan

**Kinetics of Strontium Leaching from Doped Hydroxyapatite Nanoparticles**

Carmen Chamberlain, Karissa Libson, Anna Washburn and Dr. Amanda Eckermann  
Department of Chemistry, Hope College, Holland Michigan

**Mechanistic Exploration of Ketenimine Formation at Cobalt *Bis*(Alkoxide) Centers**

Nicholas Dewey<sup>1</sup>, Amanda Grass<sup>2</sup>, Stanislav Groysman<sup>2</sup>, Richard L. Lord<sup>1</sup>  
<sup>1</sup>Department of Chemistry, Grand Valley State University, Allendale, Michigan  
<sup>2</sup>Department of Chemistry, Wayne State University, Detroit, Michigan

**“Mission to Mars” at the Michigan Science Center**

Paulette Epstein, Charles Gibson  
Education and Engagement, Michigan Science Center, Detroit, Michigan

**Synthetic Design of a Salen Platform for Luminescent Heterobimetallic Lanthanide Complexes**

Jake M. Farnsworth<sup>1</sup>, Matthias Zeller<sup>2</sup>, and Evan R. Trivedi<sup>1</sup>  
<sup>1</sup>Oakland University, Rochester, Michigan  
<sup>2</sup>Purdue University, West Lafayette, Indiana

**Development of Organic Flow Cell Electrolytes for Terrestrial and Space Based Large-Scale Energy Storage**

Andrew Lantz, Sydney Shavalier  
Department of Chemistry, Grand Valley State University, Allendale, Michigan

**Energizing K-12 STEM Through Hands-On Experiences**

C.J. Kobus, M. Donoghue  
School of Engineering and Computer Science, Oakland University, Rochester, Michigan

**Targeting misconceptions and conceptual barriers about igneous rocks in college-level introductory courses: Design and evaluation of a new laboratory exercise linking rock classification to igneous processes**

S. R. Krans, M. A. Velbel  
Dept of Earth and Environmental Sciences, Michigan State University, East Lansing, Michigan

## **2018 STEPS Camp for Girls**

Sara L. Maas

Seymour and Esther Padnos College of Engineering and Computing Student Services,  
Grand Valley State University, Pew Campus, Grand Rapids, Michigan

## **Lab Activities to Connect Experiment & Theory in Physical Optics**

Christopher M. Nakamura<sup>1</sup>, Marie T. Cassar<sup>2</sup>, Morgan L. Bucko<sup>1</sup> and Nolan Taylor<sup>1</sup>

<sup>1</sup>Department of Physics, Saginaw Valley State University, University Center, Michigan

<sup>2</sup>Department of Psychology, Saginaw Valley State University, University Center, Michigan

## **Construction of a Plasma Chamber to Investigate Radio Wave Attenuation in Plasma Sheaths**

Mr. Jared Powell, Dr. Diane Jacobs

Physics and Astronomy, Eastern Michigan University, Ypsilanti, Michigan

## **Identification of Photo-Initializable Point Defects in Carbon Related Materials by Optically Detected Magnetic Resonance**

Brian C. Seper<sup>1</sup>, Ivan Lainez Aleman<sup>1</sup>, Forest Rulison<sup>2</sup>, Dr. Paul DeYoung<sup>2</sup>, Dr. Ryan Balili<sup>1</sup>

<sup>1</sup>Department of Physics and Astronomy, Calvin College, Grand Rapids, Michigan

<sup>2</sup>Department of Physics, Hope College, Holland, Michigan

<sup>2</sup>Department of Psychology, Saginaw Valley State University, University Center, Michigan



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**Speaker Presentation Abstracts**  
**(in presentation order)**

# CubeSats, and Balloons, and Students, Oh My!

Prof. Kristina Lemmer  
Western Michigan University

Keynote Address

Michigan Space Grant Consortium  
2018 Fall Conference

Boeing Auditorium  
Francois-Xavier Bagnoud Building  
November 10, 2018  
9:00am

Western Michigan University's Western Aerospace Launch Initiative (WALI) and the Aerospace Laboratory for Plasma Experiments (ALPE) are dynamic groups for undergraduate and graduate researchers. WALI is a student organization whose members are actively designing the Plasma Optical Spectroscopy CubeSat (POSC) mission. The goal of the initial satellite is to characterize an electric propulsion system in orbit using an off-the-shelf optical emission spectroscopy system. This will lead to the ultimate goal of designing and developing a CubeSat capable of electric propulsion system investigation from an inspector satellite. Research performed in ALPE includes plasma diagnostic development, laser diagnostics, alternative propellants for electric propulsion, Hall thruster oscillations, hollow cathodes, and the integration of electric propulsion systems with nanosatellites. Furthermore, ALPE students have collaborated with a microbial ecologist in the Department of Biological Sciences at WMU to design and develop a balloon-borne platform for collecting microbial communities in the atmosphere. This talk will focus on the research, and role of undergraduate and graduate researchers in the POSC mission and the development and implementation through a series of field experiments of the balloon-born microbial sampling system. Other research performed at ALPE will also be highlighted.

Kristina Lemmer is an associate professor in the Department of Mechanical and Aerospace Engineering at Western Michigan University where she has wide and varying research interests. Kristina received her undergraduate and graduate degrees from the University of Michigan in Aerospace Engineering. She researched the prevention of communications blackout during atmospheric re-entry of capsule-shaped reentry vehicles for her Ph.D. Her current interests include alternative propellants for electric propulsion systems, oscillations in magnetically shielded Hall thrusters, instant start and high powered hollow cathodes, integration of electric propulsion systems with nanosatellites, small satellite design and integration, plasma-assisted combustion, and diagnostic development for basic plasma research. Kristina has also collaborated with a biology professor to study the microbial diversity of the atmosphere through a balloon-based air sampling platform. Her research is supported by the Air Force Office of Scientific Research, NASA, the National Science Foundation, and MSGC.



## Development of Lightweight CubeSat with Multifunctional Structural Battery System

Breeanne Marshall<sup>1</sup>, Luke Roberson<sup>2</sup>

<sup>1</sup>Electrical and Computer Engineering Department, Wayne State University, Detroit, Michigan

<sup>2</sup>Exploration Research and Technology Directorate, NASA KPC, Cape Canaveral, Florida

**Abstract:** This effort proposes to develop a lightweight 1U CubeSat (10x10x10 *cm*) which utilizes improved and fully integrated structural battery materials for mission life extension of 200 to 300 percent, larger payload capability, and significantly reduced mass. The solid-state battery structure is envisioned to be a main structural mainframe for multiple structural elements. A solid-state battery has the promise to be more stable, contain more energy, and is much safer when compared to Li-ion batteries used throughout modern technologies. The high conductivity of the solid-state battery produces low power density, high energy density, and much lighter. Li-Ion batteries are a liquid electrolyte based battery that have been known to cause fires, may leak electrolyte, and may release hydrogen-derived gases. While working in the KSC labs, I enhanced my expertise in the development of a solid carbon fiber structural battery to create new technologies that will further exploration and discovery at NASA.

## **MASA and the Quest to Launch a Rocket to Space**

Geoff Parkes, Daniel Shafer, Cameron Buccellato, Katherine Shippers  
Aerospace Engineering Dept., University of Michigan, Ann Arbor

### **Abstract:**

Team Overview. The Michigan Aeronautical Science Association (MASA) is a student project team at the University of Michigan, which builds and launches high-powered experimental rockets each year. Members focus their work between the many rocket subsystems: liquid propulsion, avionics and telemetry, carbon fiber structures, and component machining. The team has a culture of in-house designing/manufacturing, diligent research and documentation, and pushing the boundary of experimental rocketry. During the last five years, MASA has competed in the annual Intercollegiate Rocket Engineering Competition (IREC). We have progressed from launching off-the-shelf solid rockets, to custom nitrous/paraffin hybrid rockets, to launching the first-ever bipropellant liquid rocket at IREC. Incoming members learn 3D design and simulation software, operate mills, lathes, and computer-guided machines, get their hands dirty with rocket assembly, and become a part of the MASA family.

Goals of the New Competition. MASA is tackling its biggest project yet: the [Base 11 Space Challenge](#). This competition tasks student-teams to launch a liquid-fueled rocket to the boundary of space, the Karman Line, at an altitude of 100 km. The timeline involves a design/prototyping phase for the first year; a testing, re-designing, and building phase for the second year; and the first launch window at the end of the second year. MASA will have a fueled 1000-lb rocket on the launch pad in May 2020, ready to make history. The team's approach to this project is "test early, test often", and we are setting major deadlines for ourselves. The ignition test of a more powerful liquid engine will take place this fall. New lightweight parachutes and reliable deployment mechanisms will be built and wind-tunnel tested. Tracking telemetry will be scaled-up to operate in the upper atmosphere. The first year of this project will be ended with a full-duration engine static fire in Mojave, California, a solid-rocket launch at Mojave to test avionics and parachutes, and a judging event where our rocket design is evaluated.

Our Work with Industry MASA has successfully partnered with industry as we developed solid, hybrid and liquid rockets. We have obtained sponsorships from the aerospace industry with companies, such as Boeing and Raytheon. MASA has organized design reviews with engineers at major space engineering companies, such as Blue Origin and SpaceX. MASA alumni have a strong presence in the industry, as employers realize the valuable skills that MASA members gain through our projects. We are excited to increase our engagement with industry as we compete in the Base11 Space Challenge.

## Progress in Stages of Contact Binary Star Evolution

Prof. Lawrence Molnar, Michaela Blain, Evan Cook, Sarah Whitten  
Department of Physics and Astronomy, Calvin College, Grand Rapids, Michigan

**Abstract:** The path of scientific inquiry is rarely a straight line. Our discovery in 2013 of a rapid decrease in the orbital period of the contact binary star KIC 9832227 led us to explore the possibility it was in a late stage of orbital evolution. At stake was the possibility of predicting the timing of the red nova outburst that can follow stellar merger. We published a specific prediction in 2017 after four years of additional data showed an acceleration that supported our idea. This September, however, we retracted this prediction following a reanalysis of the earliest archival data by Socia et al. At the same time, our recent work has identified a group of contact binary stars in an intermediate stage of orbital evolution. While these stars will not merge for some ten thousand years, their discovery deepens our understanding of the mechanisms that ultimately lead to the late stage and to merger. We will discuss a variety of implications of our interpretation for observable properties of these stars.

## Temperature Effects on Prefrontal Cortex Activation and Psychological Ratings during Water Immersion and a Fatiguing Task

Kevin Phillips<sup>1</sup>, Derek Verbrigghe<sup>1</sup>, Alex Gabe<sup>1</sup>, Brittany Jauquet<sup>1,2</sup>, Claire Eischer<sup>1,2</sup>, Tejin Yoon<sup>3</sup>, Steven Elmer<sup>1</sup>

<sup>1</sup>Dept of Kinesiology and Integrative Physiology, Michigan Tech. Univ., Houghton, Michigan

<sup>2</sup> Department of Physical Therapy, Central Michigan University, Mount Pleasant, Michigan

<sup>3</sup>Department of Physical Education, Kangwon National University, Chuncheon, South Korea

**Abstract:** Human space travel and exploration involves a number of scenarios in which thermoregulation may be challenged. This includes inflight exercise conditioning, extravehicular activity, and during an emergency egress. These scenarios may cause thermal discomfort and accelerate the development of fatigue in astronauts. The purpose of this study was to examine brain activation of the prefrontal cortex (PFC) and psychological ratings, during water immersion of the arm at different temperatures and during a fatiguing task.

**Methods:** Nineteen health physically active, adults volunteered to participate in three experimental sessions. Participants were positioned into a testing chair, where they performed maximum isometric elbow flexion contractions. Participants then submerged their right arm into one of the three water bath conditions for 15 minutes. Cold, neutral, and hot water temperatures were maintained at 8°, 33° and 44 °C, respectively. After the water immersion, participants performed a sustained isometric elbow flexion contraction, at 20% of the maximal elbow flexion torque recorded at baseline, for 5 minutes. Ratings of perceived exertion (RPE), on a scale from 0 – 10, were assessed every 30 seconds during the fatiguing task. Each participant reported their thermal sensation and discomfort at multiple time points throughout the experiment. The order of the experimental sessions were counterbalanced and randomized. Functional near-infrared spectroscopy was used to measure PFC activation. We calculated the blood-oxygenation response, determined as the difference between oxygenated and deoxygenated hemoglobin. Optodes 11 - 16, over the right PFC were averaged and used for analysis. Separate two way repeated measures ANOVA (time X temperature) were used to detect differences in thermal sensation, PFC activation, and RPE.

**Results:** There were main effects of time and temperature on ratings of thermal sensation and discomfort during the experiment. During the water immersion, there was no main effect of time, on PFC activation. However, there was a main effect of temperature ( $p < 0.01$ ). The cold and hot water immersion caused significantly greater PFC activation. During the fatiguing task, there was a main effect of time ( $p < 0.001$ ) and temperature ( $p < 0.05$ ) on PFC activation. Activation increased throughout the fatiguing task for all temperature conditions, and was significantly greater in the hot condition compared to the cold ( $p < 0.05$ ). There was a main effect of time and temperature on RPE. Participants RPE increased throughout the fatiguing task and was significantly lower during the cold compared to the neutral and hot conditions.

**Conclusion:** These results have important implications for the use of liquid cooling garments by astronauts.

## **NASA's Concern for Upper-Body Work Performance During Space Flight: What Impact Does Respiratory Muscle Fatigue Have?**

Thomas Bye, Steven Elmer

Department of Kinesiology and Integrative Physiology, Michigan Technological University,  
Houghton, Michigan

**Abstract:** In space, astronauts need to maintain a high level of work performance. However, muscular adaptations to microgravity decrease strength, endurance, and performance in the lower-body. Space flight and Extra-Vehicular Activity place considerable stress on an already weakened lower-body making upper-body strength, endurance, and performance even more important. Respiratory muscles have important respiratory, postural, and locomotor roles in the upper body. It is unclear if respiratory muscle fatigue affects upper-body exercise tolerance. The purpose of this study was to determine if inspiratory muscle fatigue occurs after high-intensity upper-body exercise and evaluate the effects of inspiratory muscle fatigue on upper-body exercise tolerance. We hypothesized that high intensity upper-body exercise would induce considerable ventilatory stress and reduce upper-body exercise tolerance in upper-body endurance trained men. Twelve male Division 1 National Collegiate Athletic Association (NCAA) cross-country skiers (age  $19.5 \pm 1.4$  yrs, height  $181.6 \pm 7.5$  cm, mass  $76.8 \pm 6.8$  kg, % body fat  $14.8 \pm 1.7$ ,  $VO_{2max}$   $68.2 \pm 3.8$  ml/kg/min, ventilation<sub>max</sub>  $175.6 \pm 16.8$  L/min) performed two upper-body exercise trials. Athletes performed arm-cranking at  $\sim 85\%$  of  $W_{peak}$  until their limit of tolerance for the control exercise trial (CON-EX). For the inspiratory muscle fatigue exercise trial (IMF-EX), athletes performed the same task with pre-existing fatigue in their inspiratory muscles ( $\sim 20\%$  reduction in maximal inspiratory pressure (MIP)) induced through a threshold resistance breathing device. Physiological responses and the limit of tolerance were compared between trials. After CON-EX, MIP decreased by  $10 \pm 8\%$  and remained reduced by  $7 \pm 7\%$  for 11 min ( $P < 0.05$ ). Compared to CON-EX, the IMF-EX limit of tolerance decreased by  $32 \pm 14\%$  ( $P < 0.01$ ). During IMF-EX, ventilation, breathing frequency, perceived exertion, and dyspnea increased whereas tidal volume decreased (all  $P < 0.05$ ). The data from these collegiate cross-country skiers' trials indicate that high-intensity arm-cranking impaired their inspiratory muscle function. Further, artificial induction of the inspiratory muscles decreased their limit of tolerance and increased perceptual stress. Collectively, our results demonstrate the functional consequences of inspiratory muscle fatigue on upper-body performances. Notably, our findings contrast with previous upper-body research testing untrained individuals. Thus, further research is needed to explore the mechanisms and the impact of respiratory muscle fatigue on upper-body performance in microgravity. This study was supported by the Michigan Space Grant Consortium, American Physiological Society, Portage Health Foundation, and PowerLung.

## The Martian: An Accurate Depiction of Human Locomotion on Mars

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**Abstract:** *The Martian* is a widely acclaimed science fiction film and *Golden Globe* winner for *Best Motion Picture*. It portrays how Mark Watney (Matt Damon's character) survives on Mars and eventually traverses 750 km across the Martian landscape to be rescued. We used this movie as an opportunity to consider how humans would theoretically move on Mars. Perhaps the most important environmental factor not accounted for by the filmmakers was the gravitational differences between Mars and Earth, Martian gravity is approximately 37% of Earth's gravity. Other factors that were accounted for include the Martian terrain and the additional load while wearing a spacesuit. Evidence suggests that gravity, terrain surface and slope, and load carriage influence the metabolic cost of transport (COT) which is the amount of energy expended to move the body a given distance (J/kg/m). However, it is currently unknown how all of these factors interact to impact human movement on Mars. The purpose of this educational class project was to examine the primary factors that influence one's COT on Mars, and to predict how humans will move most efficiently on Mars. We performed walking and running trials in our laboratory (n=5) to establish the relationship between COT and speed. Then, we gathered COT and space physiology literature to digitize more data. After, we processed our COT curves with the reduced gravity, increased load, increased gradient, and a Martian terrain data. Thus, weighting and combining these factors together and predicting how humans will move on Mars. We determined the most important factors that affect our choice of movement and COT are: gravity, load carriage, terrain, and slope. In Martian gravity humans would prefer to run, skip, or bound maintaining a constant COT across modalities. As the load carried increases, humans prefer to walk with an increased COT. Martian soil is soft and unstable, like sand, where humans prefer to walk slowly because of a linear increase in COT with speed. Similarly, while moving up a positive slope walking is preferred. However, a negative slope makes running preferential. Therefore, after combining the effects of all factors, we predict that Mark Watney was correct in walking on Mars while doing his daily chores, but should have run during his long-distance trek.

## Stress-induced heat shock protein 40 and immune dysfunction in altered gravity

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**Abstract:** In space, astronauts are more susceptible to pathogens, viral reactivation and immunosuppression, which poses limits to their health and the mission. Interestingly, during space flight, stress-inducible heat shock proteins (HSP) are robustly induced, and the overexpression of HSPs have been implicated in immune dysregulation, therefore HSPs may be critically involved in regulating immune homeostasis. HSP40/DNAJ1 plays a major role in proper protein translation and folding. Its loss of function has been implicated in susceptibility to microbial infection, while its overexpression has been implicated in autoimmunity, collectively suggesting its complicated, but necessary, role in maintaining immunological function. To determine the role of HSP40 during stress-induced altered gravity conditions, wild-type and Hsp40 mutant *Drosophila melanogaster* were exposed to ground-based chronic hypergravity conditions, followed by quantitative PCR (qPCR) analysis of immune gene expression. In addition, larval hemocytes were collected to determine the functional output in response to *E. coli* bioparticle phagocytosis. Preliminary data indicates a required role for Hsp40 in strengthening immune function during stress-induced spaceflight in flies. In short, a critical need to evaluate the relationship between HSPs and immune suppression during space flight is necessary. Since space travel may become available to the general public in the not too distant future, and for the possibility of long-term space missions, a more comprehensive evaluation of the molecules responsible for immune dysfunction observed during space flight is required.

[Supported by the Space Life Sciences Training Program (SLSTP)]

## Michigan Bioastronautics and Life Support Systems (BLiSS)

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**Abstract:** In 2015 a group of students at the University of Michigan came together with the purpose of developing the technology needed for an enduring human presence in space. This group came to call itself Michigan Bioastronautics and Life Support Systems (BLiSS). Over the past three years BLiSS has successfully won four awards under the NASA/National Space Grant eXploration Habitat Academic Innovation Challenge (X-HAB) program to conduct student led research in the areas of life support, space life sciences, and space habitats. In addition to its research work, BLiSS received notoriety by the entire UM community for taking third prize in the 2017 Bicentennial Campus of the Future contest. Uniting all BLiSS projects is a commitment to an interdisciplinary approach towards human spaceflight uniting students from a variety of departments, majors, and disciplines with researchers at NASA, industry, and academia. This presentation by BLiSS co-founder Rob Gitten and current BLiSS lead Cuilee Sha will cover the history of BLiSS and the projects it has done, the challenges the group faced along the way, and the value BLiSS brings to those who participate.

## The Hamburg (H4) Michigan Meteorite

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**Abstract:** We examined a thin section prepared from a 0.204 g slice from a 17 g sample recovered from the ice on Strawberry Lake, near Ann Arbor, Michigan. Before thin-sectioning, both surfaces of the 10 × 5 × 3 mm slice exposed cross-sections through intact chondrules up to 1 mm in diameter, and chondrule fragments, including one with recognizably radial-pyroxene texture. Metal was distributed irregularly throughout the matrix.

Barred olivine chondrules (BOC), porphyritic olivine (PO) chondrules, and porphyritic olivine-pyroxene (POP) chondrules were conspicuous in optical petrography. Backscattered-electron images (BEI) were acquired on the NMNH DMS FEI Nova NanoSEM 600 scanning electron microscope. Electron probe microanalysis (EPMA) used the NMNH DMS JXA-8530FPlus HyperProbe Electron Probe Microanalyzer. Chondrule silicates were analyzed for Si, Al, Fe, Mn, K, Ca, Ti, Mg, Na, and Cr.

Olivine is  $\text{Fa}_{17.0\pm 3.9}$  (N = 89). The average composition of Ca-poor px is  $\text{Fs}_{15.9\pm 2.6}\text{Wo}_{2.0\pm 2.2}$  (n = 96; the large Wo s.d. is caused mainly by a handful of large values –  $\text{Wo}_{8-16}$  – not large enough to be grouped with the high-Ca px). Common textures included BOC (n = 3), PO (n = 1), and POP (n = 4). Several less-common textures also occur. Microphenocrysts in some porphyritic chondrules have oriented skeletal outgrowths. Both porphyritic and barred olivine chondrules show textural and compositional evidence of disequilibrium during rapid cooling. Skeletal or hopper overgrowths /outgrowths on olivine phenocrysts indicate moderately rapid (disequilibrium) cooling at modest supercooling near the end of chondrule cooling. Olivine bars exhibiting elongated growth habit with centrally located glass inclusions occur sparsely but are widely distributed; they indicate faster cooling rates at higher degrees of supercooling).

Olivine bars in all barred olivine chondrules are compositionally uniform throughout. In all porphyritic chondrules in which olivine and pyroxene co-occur both olivine and low-Ca pyroxene microphenocrysts exhibit at least slight normal zoning (elevated Z-contrast) near their edges; the visible zoning is spatially associated with compositional. The outermost zones of olivine co-occurring with low-Ca pyroxene in such chondrules are substantially more iron-rich than the homogenous compositions of barred olivine. The outermost zones of low-Ca pyroxene all fall within a narrow range.

Mean compositions of the major silicates fall within the H-chondrite range, and the compositional ranges correspond to petrologic type 4.

## **Bulk Metallic Glass Matrix Composites – Applications and opportunities in Aerospace Engineering**

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Chemical Engineering and Materials Science, Wayne State University, Detroit, Michigan

Bulk metallic glasses have emerged as new material having superior properties of strength, hardness and elastic strain limit. However, they exhibit brittleness and lack fracture toughness. Efforts have been made to overcome this problem by promoting crystallinity in metal matrix thus making a composite. Upon achieving adequate toughness, they become suitable for varied applications. Their use has also been exploited for extreme aerospace applications. These include, gears of outer and deep space missions, whipple shields of space craft and international space station. In this talk, I aim to shed light on various aerospace applications of these materials and possibilities and opportunities to manufacture parts from it.

## Hurricane Maria and Puerto Rican Epiphytes: A Case Study in Extreme Events and Plant Ecology

Brendan Kosnik<sup>1</sup>, Gary Greer<sup>1</sup>

<sup>1</sup>Department of Biology, Grand Valley State University, Allendale, Michigan

**Abstract:** The structure of the lower-trunk (0-3m) epiphytic community of a mid-elevation (500-700m) forest in the Río Espíritu Santo drainage of El Yunque National Forest is a subject of research in the Greer lab that was first surveyed in May 2012. Hurricane Maria (category 4) devastated Puerto Rico's forests, including the study site, on September 24, 2017. The goals of our study were to document: (1) changes in forest structure; (2) changes in lower-trunk epiphyte community structure; (3) physical damage across size classes for dominant holoepiphyte species belonging to the fern genus *Elaphoglossum* (Dryopteridaceae) and bromeliad genera *Guzmania* and *Tillandsia*; (4) identify morphologies that increase survivorship during hurricane winds and the subsequent increase in exposure; and (5) establish a baseline for future studies tracking succession of the epiphytic community. During May and June 2018, we resurveyed the epiphytic community of the Río Espíritu Santo drainage using circular plots (10m radius) approximately 100m apart. All trees within two opposite quadrants of each plot and possessing DBH > 5cm were surveyed for epiphytes within the bottom 3m of their trunks. Hemispherical canopy photos were taken at midpoint and perimeter of each quadrant. Plant size was measured and damage from both wind and sun exposure was assessed for *Elaphoglossum*, *Guzmania*, and *Tillandsia*. Thus far, our analyses have revealed (1) a decrease in tree size (i.e., a disproportionate decrease in larger trees), (2) a decrease in epiphyte species richness, and (3) shifts in the species dominance. Additionally, although no linear relationship was found between tree DBH and epiphyte species richness in the 2012 survey, a positive linear relationship was observed in 2018. This change may be due to a vulnerability of epiphytes on smaller trees during hurricane force winds, particularly those with prior low abundance and frequency. Analyses seeking relationships between morphological traits that facilitate survivorship during severe storms (e.g., leaf size, leaf shape and stem width) as well as in the more exposed aftermath (e.g., specific leaf area, succulence and possession of scales or foliar trichomes) are ongoing.

## **Classifying Mass Shootings in the United States**

Tyler Gast, Yew Meng Koh, and John McMorris  
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**Abstract:** Mass shootings in the US appear to be random and unpredictable events. However, a closer examination of these events reveals certain trends and commonalities between them. In this study, we classify mass shootings using various statistical clustering algorithms. The implementation of these methods, their relative merits, and conclusions regarding similarities and distinct features between mass shooting incidents which arise from the different clusters of incidents are discussed.

## Thermal Osmosis Study in PEM Fuel Cells

Nicholas A. Ingarra, Dr. Xia Wang

Mechanical Engineering Department, Oakland University, Rochester, MI USA

**Abstract:** Heat and water management are essential for fuel cell operation. If the fuel cell membrane is too dry the resistance of the fuel cell will be too high and the performance will be reduced. If the cathode becomes flooding the  $O_2$  will terminate due to water preventing  $O_2$  from reaching the catalysts layer and the fuel cell shuts down. Presently there are two modes of water movement

EOD (Electric Osmosis Drag) and Back Diffusion. EOD goes from the anode to the cathode. Back Diffusion goes in the direction of cathode to anode. There is a third mode water movement that has not been understood. The phenomena is thermal osmosis. Thermal osmosis is the movement of water that is result of temperature gradient. Existing Testing shown water flow to go from hot to cold other testing has shown water flow to go in the direction cold to hot. The thermal osmosis testing consists of testing with heat and mass transfer and other testing has been completed with heat, mass and charge transfer. Another phenomenon exists to move water thru temperature gradient and this phenomenon is thermal osmosis. The research will involve determining a model for predicting thermal osmosis and understanding which variables influence the magnitude and direction and to determine how heat, mass and charge transfer effect the result. The plan is to model thermal osmosis thru COMSOL using three techniques. The first technique involves the use standard thermodynamics, the second technique involves modifying standard thermodynamics with thermal osmosis equations and the last technique involves using non-equilibrium thermodynamics to predict the thermal osmosis.

## Energizing our World – Hands on Learning of Renewable Energy and Sustainability

Kristofer Pachla, Chelsea Ridge, and Austin Phillips  
Grand Valley State University Regional Math and Science Center

**Abstract:** In June, 2018, 46 middle school aged students participated in the MSGC-supported *Energizing our World* (EOW) at Grand Valley State University (GVSU). This program was designed to engage students in a critical needs area: exploring renewable and sustainable energy generation in the era of climate change. In collaboration with GVSU science faculty, the GVSU Office of Sustainability Practices, and Consumers Energy, the goal of the camp was to spark an interest in students who may not otherwise have the opportunity to explore renewable energy.

Students in this camp participated in learning sessions with focus on introductions to energy, renewable sources such as wind and solar, energy storage and grids, and sustainability practices. Hands-on and field trip activities included visitation to the GVSU Sustainability Farm and the Kent County Recycling and Waste Management facilities. A culminating build event, a solar car race, allowed students to showcase their knowledge and participate in a purposeful event related to renewable sources.

New this year was the introduction of Design Thinking to link sessions together. By engaging in the Design Thinking process, participants found threads to weave concepts together to answer a bigger question: *How might we make our homes more sustainable?* This question guided the work throughout the week and culminated in the presentation of student visions for incorporating renewable energy and sustainable practices into a home plan or model. Student iterated their designs throughout the week and presented their designs to each other, experts in the field of renewable energy and sustainability, and their parents.

Participant demographics reflected a recruiting focus for equity of access, with 15% of participants from underrepresented populations in STEM (Hispanic and African American). Additionally, 35% of participants were female. On a test of content knowledge for sustainable and renewable energy practices, a statistically significant increase in knowledge was recorded ( $p < 0.001$ ) for the students opting into the testing. Student evaluations showed excitement for working with the wind turbines, and the hydrostatic pressure and hydroelectric power portions of the week. The project, sharing with experts, their peers, and family members was also highlighted as an exciting experience.

## The Roger That! Symposium on Space Exploration

Dr. Karen Gipson<sup>1</sup>, Dr. Samhita Rhodes<sup>2</sup>, Dr. Deana Weibel<sup>3</sup>,

<sup>1</sup>Grand Valley State University, Department of Physics

<sup>2</sup>Grand Valley State University, College of Engineering

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**Abstract:** *Roger That!* is a two-day public symposium on space exploration, named in honor of Roger B. Chaffee, a native Grand Rapidian who lost his life in the Apollo 1 fire; it is organized by faculty at Grand Valley State University (GVSU) in collaboration with staff at Grand Rapids Public Museum (GRPM). The symposium is held on a Friday and Saturday in mid-February, near Chaffee's birthday, and it literally offers something for everyone. On Friday, GVSU hosts an "academic conference" aimed at college students and the general public, with sessions given by experts from around Michigan and neighboring states on various aspects of space exploration, including both scientific and societal considerations. GVSU also holds a design challenge for 4<sup>th</sup> – 8<sup>th</sup> graders, which has been specifically formulated to address Michigan science standards. Meanwhile, GRPM offers field trips to K5 students including hands-on activities and planetarium shows, and selected presenters from the academic conference engage with students at the GRPM School. Friday culminates with a keynote presentation, to which local high schools and the general public are also invited. Saturday features family-friendly activities at GRPM, includes student clubs from GVSU, and culminates with a second keynote presentation. The keynote speakers are carefully selected to appeal to a diverse audience, and intentional efforts have been made to include women, ethnic minorities, and members of other underrepresented groups as presenters in order to demonstrate the diverse appeal of space exploration and more actively engage K12 students from underserved schools in the Grand Rapids area. For the past two years, there has been a growing emphasis on connections between space and the arts, truly transitioning the event from "STEM" to "STEAM". In 2018, Friday opened with a presentation on the NASA Art Program by a team of art professors from GVSU. The keynote speaker was retired NASA astronaut Dr. Guion "Guy" Bluford, the first African American to fly in space. His first presentation was entitled "An Astronaut's Journey," and the topic of being a minority in a STEM field was threaded throughout his remarks. Afterwards, Dr. Bluford signed autographs for audience members; children and adults alike were excited to receive personalized photographs and several people even brought items from home for him to autograph. Dr. Bluford's second presentation was "Flying in Space: The Space Shuttle and Beyond," in which he talked about the future of the space program. In 2019, Friday will open with a presentation by a local artist whose sculpture of Roger B. Chaffee was unveiled in downtown Grand Rapids in May 2018 to much acclaim. The keynote speaker will be retired NASA astronaut Nicole Stott, who has the distinction of having been the first to paint a watercolor in space, which she will discuss in her first presentation entitled, "eARTh from Space." She will speak about being a woman in the space program in her second presentation called "Space for Everyone." There will also be a special plenary session Friday afternoon featuring the directors of GRPM planetarium and the Alder planetarium in Chicago, Emily Hromi and Michelle Larson, respectively.

## Hope College – Air Quality Monitoring in the Middle and High School Grades

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<sup>2</sup>Community Partner, Hope College, Holland, Michigan

**Abstract:** Portable air quality monitors have shown to be an effective tool for inquiry-based learning in the middle and high school grades. Students are guided through creating their own research questions and testing protocols to collect relevant data. Program development has focused on exploring the most educationally effective construction and software for the monitors along with piloting curricular lessons and applications for the monitors for several math and science disciplines. As the monitoring project gains traction in local middle and high schools, the question of how the large amounts of monitoring data can be used to further support the students' learning needs to be addressed. Additionally, classroom teachers are aware of the potential learning value of that information but do not have a structure to use the data with their students. How do we train students to handle large data sets from scientific research? What formats and structures need to be in place to scaffold student learning around big data? How can large data sets inform inquiry learning for students? Starting from the classroom sets of data collected by our partner schools, we are initiating an exploration of how to best data mine and prepare data for use by the middle and high school grades. In partnership with local math and science teachers, the next phase of our project will develop and pilot new curricular units in environmental science and math that further explore the large sets of data continuing to be collected by the project. Use and maintenance of the monitors in local classrooms will continue. The project is managed by the Center for Exploratory Learning (ExploreHope) at Hope College, in partnership with the Holland-Hope College Sustainability Institute (Sustainability Institute), and local community members.

## Hope College Engineering the Future Academy

Ms. Julia Hardy<sup>1</sup>, Ms. Erica Slenk<sup>2</sup>, Mr. Bill Boerman<sup>3</sup>, Ms. Susan Ipri Brown<sup>4</sup>, Dr. Eric Mann<sup>5</sup>

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<sup>4</sup>Engineering Department, Hope College, Holland, MI

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**Abstract:** Hope College's 2018 Engineering the Future Academy provided 63 local area at-risk and underserved students the opportunity to explore engineering design in a hands-on, problem solving context as well as professional development for in-service (4) and pre-service (2) teachers. Designed as a learning experience for students and a research and mentorship opportunity for undergraduate STEM and STEM education majors, this year's efforts centered around two one-week 30 hour on-campus design challenges exploring alternative energy sources. This year's challenges were developed collaboratively with the STEM teachers at Holland Public Schools with the on emphasis building units of instruction that are transferable to the classroom in the upcoming school year. Supplies and equipment purchased for the camp activities were transferred to the schools at the end of the summer. Fees, transportation and meals were provided for students to facilitate their participation. Throughout the academic year, the Holland Public School STEM teachers continue to receive curriculum support and new materials through regular interaction with the program staff. Additionally, new curriculum and supplies were provided to support the school's Advanced STEM class for 8th graders.



**2018**  
**Michigan Space Grant Consortium**  
**Fall Conference**

University of Michigan  
Boeing Auditorium  
Francois-Xavier Bagnoud Building  
1320 Beal Ave, Ann Arbor, MI 48109

**Poster Presentation Abstracts**  
**(in alphabetical order based on last name of first author)**

## Influence of Mass Transport on Energetic Ion Distributions at Saturn

A. R. Azari<sup>1</sup>, M. W. Liemohn<sup>1</sup>, X. Jia<sup>1</sup>, A. M. Rymer<sup>2</sup>, N. Sergis<sup>3</sup>, D. G. Mitchell<sup>2</sup>, & C. Paranicas<sup>2</sup>

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<sup>3</sup>Academy of Athens and National Observatory of Athens, Athens, Greece

**Abstract:** Interchange injection events are a primary radial transport mechanism at Saturn. These events rapidly delivering energetic ions (>3 keV) to the inner and middle magnetosphere but we ask here, how does the global distribution of interchange injection events influence the composition and dynamics of hot ion plasma in the middle magnetosphere? Interchange arises at Saturn due to a Rayleigh-Taylor like instability. The instability is caused by Saturn's rapid rotation that imparts a force outwards on the density gradient arising from Enceladus' outgassing of dense neutrals that become thermal plasma. We build off a previously developed event list detected with a trained and tested automation method developed using the CHarge Energy Mass Spectrometer (CHEMS) H<sup>+</sup> measurements. We review the pitch angle and composition data of interchange events between 3 – 220 keV and compare these to the global distribution of particles at Saturn.

## **Title: The Apollo Number and Suit Dynamics**

J. Bigalke and H. Cunningham

Kinesiology and Integrative Physiology, Michigan Technological University, Houghton, Michigan

**Abstract:** With the present goal of the United States to visit the surface of Mars by the year 2030, it has become increasingly vital to research ways to efficiently send astronauts with minimal risk to personal health. A major component of Mars exploration will revolve around the question, “How will we move once we’ve reached Mars?” Although there are numerous factors affecting how we will walk on Mars, including microgravity, terrain, and weight carriage, a critical focus should be placed on the dynamics of the space suit, specifically on the influence it may have on gait and speed selection. It is well established that previous suits cause a steep increase in the metabolic cost of transport, a decrease in mobility, and a slower preferred speed as well as walk-to-run transition. In order to analyze this, we have used a modified measurement of the Froude number developed by a research group at MIT, called the Apollo Number. This number takes into account the ratio of mass carried by the astronaut to the total mass moved. We hypothesize, using this formula, that certain modifications to the current space suit design may work to decrease the cost of transport, offer increased mobility, and potentially increase the walk-to-run transition speed. We have built a hypothetical modified space suit that works to alleviate the stressors added by additional weight, and allows functionality similar to that which would be seen with normal gait mechanics on Earth.

## Developing a General Spin Dependent Compton Scattering Cross-Section in Strong Magnetic Fields

Meredith Bomers, Peter Gonthier, PhD  
Department of Physics, Hope College, Holland, Michigan

**Abstract:** Various X-ray space telescopes have detected steady soft X-ray emission originating from highly magnetized neutron stars known as magnetars. Within the magnetospheres of these stars, accelerated electrons interact with X-ray thermal photons through inverse Compton upscattering, a quantum electrodynamic (QED) process in which electromagnetic photons are boosted to higher energies. This process is believed to be the source of the production of the high-energy tails in observed X-ray spectra from magnetars. Through the implementation of Sokolov & Ternov (S&T) spin states, there exist analytical expressions for the spin-dependent lifetimes of excited virtual states of charged particles in strong magnetic fields near the surface of magnetars. These lifetimes are required for determining the spin-dependent Compton scattering cross section. We propose the development of compact analytic expressions for spin-dependent Cyclotron lifetimes and Synchrotron emissions within magnetar magnetospheres. These correct, fully spin-dependent expressions will provide the necessary formulae and methods to be applied to the Compton cross section in strong magnetic fields. These will eventually be used in Monte Carlo simulations of magnetars' X-ray emission. With these expressions, we will be able to graphically analyze the specific effects spin states as well as the role that photon polarization plays in photon intensities. This will allow for more accurate and efficient modeling of magnetars using Monte Carlo techniques and may prove useful in understanding distinct features between highly magnetized pulsars and conventional gamma-ray pulsars, supporting future planned X-ray polarimeters such as NASA's IXPE<sup>1</sup>.

This research is made possible by the generous support of the Hope College Department of Physics and the Hope College Dean for Natural and Applied Sciences Office.

<sup>1</sup><https://ixpe.msfc.nasa.gov>

## Thiol-yne reactions for incorporating longer wavelength azo dyes into polymeric photomechanical materials.

Marcus A. Brinks<sup>1,2</sup>, Matthew L. Smith<sup>2</sup>, Jason G. Gillmore<sup>1</sup>  
Departments of Chemistry<sup>1</sup> and Engineering<sup>2</sup>, Hope College, Holland, Michigan

**Abstract:** The Smith research group in mechanical engineering at Hope College has an interest in photomechanical materials, which convert light to mechanical work in polymer or liquid crystalline networks through the photoisomerization of oriented azo dyes in the network.<sup>[1]</sup> The Gillmore research group in organic photochemistry has expertise in organic photochrome synthesis and isomerization. Together they are working to prepare polymerizable monomeric analogs of the BF<sub>2</sub>-coordinated azo dyes recently reported by Aprahamian and coworkers,<sup>[2],[3]</sup> so that these dyes which absorb at longer wavelengths (orange to near IR) than conventional (UV to green) azo dye may be incorporated into polymer networks. The use of longer wavelengths should minimize competitive absorption and photodegradation of materials and devices, and may allow future biocompatibility. Thiol-yne polymerizations<sup>[4]</sup> have good precedent in similar photoresponsive polymeric materials. In this present work I will report progress toward ethynyl and diethynyl substituted BF<sub>2</sub>-azo dyes, and model studies related to their incorporation into polymer networks.

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## Kinetics of Strontium Leaching from Doped Hydroxyapatite Nanoparticles

Carmen Chamberlain, Karissa Libson, Anna Washburn and Dr. Amanda Eckermann  
Department of Chemistry, Hope College, Holland Michigan

**Abstract:** Osteoporosis is a disease that affects millions of people worldwide and is thought to be characterized by an imbalance of osteoblast and osteoclast activity in bones. Strontium (Sr) has been shown to balance the activity of both of these cell types. Strontium-doped hydroxyapatite nanoparticles (Sr-nHAs) present a biocompatible method of strontium delivery to bones in affected individuals. Sr-nHAs were synthesized with various ratios of calcium to strontium and characterized by SEM, EDS, and P-XRD. Leaching studies were carried out in both phosphate buffer saline (PBS) and simulated bodily fluids (SBF) to determine the effect of ionic solutions on the leaching rate of strontium ions. SBF contains di-cations, including  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ , that can replace  $\text{Sr}^{2+}$  in the hydroxyapatite lattice. The rate of strontium leaching from the hydroxyapatite lattice was evaluated by ICP-OES. This study shows that the majority of strontium cations leached out of the lattice in the first 24 hours. Further, the leaching rates were dramatically decreased if the particles were sintered at 800 °C for two or more hours.

## **Toxic effects of the biological pesticide, *Bacillus thuringiensis israelensis*, on North American frog larvae**

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**Abstract:** The prevalence of mosquito-transmitted diseases has led to the demand for effective treatments to control mosquito populations, and the range of impact for mosquito-transmitted diseases are projected to expand in lieu of global climate change. We investigated the toxic effects that Bti, a biological mosquito larvicide, has on North America frog larvae. New protocols were developed to study the acute toxicity, genotoxicity (damage to the DNA), and cellular effects of Bti-based pesticides on leopard frog and wood frog tadpole development, using techniques for studying toxicity at the cellular and genetic level. Tadpole mortality was collected to estimate the LC50 (lethal concentration) of Bti. To evaluate genetic damage from sublethal Bti exposure, imaging flow cytometry was conducted on blood samples to determine cell-to-cell variation in DNA content and activity. Additionally, intestinal histology was used to identify cellular abnormalities in the intestine of Bti-treated tadpoles. The results from this study can be used to inform amphibian conservation efforts and to lay the foundation for further studies of Bti's impact in natural aquatic communities.

## Teaching Skeletal Muscle Contraction through Reverse Engineering

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**Abstract:** Skeletal muscles have many important functions including producing force for movement and breathing. Unfortunately, 50% of undergraduate exercise science students do not have a good understanding of the basic mechanisms responsible for muscle contraction. There are a number of challenges to consider when teaching skeletal muscle physiology. First, students often have difficulty visualizing the complex cellular and molecular mechanisms responsible for muscle contraction. Second, undergraduate physiology textbooks generally describe muscle contraction for only muscle shortening contractions even though muscles can also produce force when they lengthen. Finally, basic mechanisms of muscle contraction, often derived from isolated animal muscles, are not always translated to familiar human movements (e.g., walking, running, jumping). We developed and implemented an active learning activity that couples human stair climbing and descending exercise with a three dimensional physical model to facilitate better understanding of skeletal muscle contraction. Undergraduate human anatomy/physiology students (N=47) first performed a stair climbing and descending exercise while assessing changes in heart rate and perceived effort. Subsequently, students used a muscle contraction model to break down a muscle, identify key structures (e.g., layers of connective tissue, contractile proteins, regulatory proteins, sarcomere regions), and simulate energy use and force production during shortening and lengthening contractions. With this approach students were tasked with explaining from a muscular perspective why it was easier to go downstairs. To assess the effectiveness of the activity, students completed a brief questionnaire to obtain perceptions related to the laboratory format, level of engagement, and perceived learning. Nearly all the students ( $\geq 95\%$ ) “agreed” or “strongly agreed” that the activity: 1) provided a hands-on approach for learning about muscle contraction, 2) enhanced understanding of course material, and 3) connected the cellular mechanisms of muscle contraction to real world applications involving human movement. The vast majority of students (87%) reported that they enjoyed the lab activity and every student recommended that the activity be implemented again next year. Taken together, our results indicate that the activity was well received by students and that it enhanced their learning. The activity offered a unique “reverse engineering” approach for determining how the properties and mechanisms of muscles are responsible for whole-body human movement. This educational research project was supported by The Physiological Society.

## Implications of geochemical, petrographic and stratigraphic analyses of the upper Portage Lake Volcanics for the Keweenaw flood basalts

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**Abstract:** Continental flood basalt provinces (CFBPs) often involve emplacement of millions of cubic kilometers of magmatic material. Despite the large amount of mantle melting required for flood basalt generation, most magmas are not primary, and require some processing within the lithosphere before eruption. Flood basalt lavas represent one of the most effective probes of the evolving magma chamber conditions, and thus a well-preserved volcanic stratigraphic section is critical for investigating these processes. However CFBPs often suffer from poor preservation due to subsequent rifting and erosion. Although this problem is typically resolved by focusing on the youngest CFBPs, failed rifts can preserve significant stratigraphic sections. Here we focus on flood basalt flows from the 1.1 Ga Keweenaw CFBP that have been preserved within the failed Midcontinent Rift. We present geochemical, petrographic and stratigraphic analyses of the upper Portage Lake Volcanics erupted during the Keweenaw CFBP main stage volcanism. Basalts from this region are tholeiitic and unusually enriched in incompatible trace elements – an observation that cannot be accounted for by simple fractionation and assimilation. Furthermore, flow by flow analysis of these lavas reveals a seeming paradox where limited variation in MgO is combined with significant deviations in the concentrations of incompatible trace elements such as Ti, Nb and Zr. To investigate these inconsistencies, a recharge, evacuation, fractional crystallization and assimilation model was applied to the geochemical data and petrographic evidence. The model shows that the inconsistency in incompatible trace element concentrations can be resolved by a series of recharge events, and the complex interplay between fractionation, assimilation and magmatic recharge resulting in an evolving magma chamber. This interplay helps to explain why primary melts are not erupted at the surface even during periods of high magmatic flux. These results highlight the complex evolution of lavas in CFBP and demonstrate the need for the collection of stratigraphically controlled lavas to probe magma evolution.

## A Nuclear Thermal Rocket Decay Heat Model with Implications

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**Abstract:** A nuclear thermal rocket (NTR) is an example of the broader class of nuclear thermal propulsion (NTP) technologies. In the coming years, nuclear thermal rockets are a possible choice in propulsion for crewed missions to Mars and deep space science missions where increased power and efficiency are required. NASA is funding research projects to design the engine and core system of the proposed rockets. One of the major problems is how to cool the reactor during post-thrust operation while in transit between destinations. One solution is a power cycle attached to the reactor to convert previously wasted thermal energy into electricity for the crew or spacecraft. This method would reduce the need to use hydrogen propellant and reduce radiator mass. This project attempts to produce an accurate model in MATLAB for the time-dependent decay heat of the reactor to be used for the thermal analyses of the spacecraft power cycle/heat loss. Implications of the heat decay model are also given. These implications include: the amount of hydrogen propellant that can be saved with the introduction of a power cycle (about 15% decrease on average), as well as the reactivity control of the reactor for steady state operation of the power cycle after a high-power thrust. The reactivity control is derived and presented.

## EEG Analysis of Physically and Electrically Activated Sensation

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**Abstract:** Phantom limb pain, a pain or discomfort in a missing limb, affects 80% of amputees. This pain originates from incoherent signals coming from the amputated portion of the limb, likely causing changes in the somatosensory cortex. We hypothesize that by applying a non-painful sensation in the amputated limb, phantom limb pain may be reduced or eliminated. The long-term goal of this project is to develop a non-invasive therapy that consists of an electrically activated tapping sensation in the missing limb to promote neuroplasticity and changes in the somatosensory cortex. In this phase we investigated the differences in cortical activity between sensations evoked through electrical activation of the median nerve and physical tapping on the hand.

An electroencephalogram (EEG) was used to measure cortical activation in the somatosensory cortex during artificial and actual touch. A 64 electrode EEG cap was placed on the scalp to measure cortical signals. Cortical responses due to a variety of stimulus conditions were recorded under the following conditions: 1) Investigator tapping on each finger and the palm with a reflex hammer. 2) Electrical stimulation of the median nerve at the elbow to elicit a tapping-like sensation in the subject's hand. 3) Investigators tapping in the same location where stimulation was felt during electrical stimulation. The trials were grouped based on tapping conditions, and each group was averaged together to remove non-event related portions of the cortical activation.

The data was analyzed by comparing normalized peak voltages of cortical activation by time and voltage, and by calculating the correlation coefficients between the different conditions. Analysis was done on peak voltages at approximately 20 and 60ms post stimulus to quantify the brain's detection of stimulus, and peaks around 100ms to quantify perception. It was found that stronger cortical activation was elicited contralateral (opposite side) to physical and electrically activated sensation in all cases. Signal correlation, and timing varied between subjects. More trials and different analysis methods are needed to determine quantifiable differences between these two types of sensations.

## Mechanistic Exploration of Ketenimine Formation at Cobalt *Bis*(Alkoxide) Centers

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**Abstract:** Ketenimines are a useful synthetic starting point for making heterocycles in materials and pharmaceutical applications because they are high-energy species. The sustainable synthesis of high-energy species presents a chemical challenge if the reaction is to be done in an atom economical fashion (*i.e.* most reactant atoms end up in the products). Recent work has shown that the first isolable high-valent cobalt carbene can transfer its carbene moiety to isocyanide and form ketenimines. Unfortunately, the reaction only happens once and not in the desired catalytic (repeatable) fashion. This project sought to better understand this transformation and improve its design to become catalytic through computational modeling and density functional theory. This goal was partially achieved, as the reaction is not yet catalytic. However, significant progress was made towards understanding ketenimine synthesis and why the catalysis does not occur.

## Using remote sensing to study ecological changes associated with hydrologic fluctuations in a Great Lakes slack/interdunal wetland

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**Abstract:** We used historic infrared (2010, 2012, 2014, 2016) USDA National Agriculture Imagery Program (NAIP) photos and 3-band (visible green, visible red, infrared) drone images (2017, 2018) to examine ecological changes occurring in response to fluctuating lake levels in a secondary interdunal wetland or slack on Lake Michigan's eastern shore at Saugatuck Harbor Natural Area. Secondary slacks in Great Lakes coastal dunes are created where wind scours the sand to the water table within a dune. The studied slack is >1 ha in size with a subtle topography of ridges and pools creating a diverse vegetation mosaic. The slack's water table is tied to that of Lake Michigan which has quasi-periodic water level cycles of ~30 years. A 16-year period of below average lake levels occurred from 1998–2014. The 2010 photo, taken during this time, shows several pools (black) surrounded by bright red colors, indicating vigorously growing or wetland vegetation. In contrast dune vegetation is light pink in color. The highest monthly average lake level for 2010, 176.26m, was below the monthly average lake level of 176.43m. Pools are not noted in the 2012 photo. Areas previously shown in red are now light red to pink, suggesting a decrease in plant vigor and a shift to dune/upland vegetation. This shift corresponds to a .19m lake level drop from 2010 which dried the slack. Pools reappear in 2014 as lake levels rise from below average to average levels. The slack vegetation exhibits green, tan and pink to medium red colors, suggesting a mixture of plant vigor, density, and dune/upland and wetland vegetation in response to conditions changing from dry to wet. The 2016, 2017 photos show larger pool areas and dull to bright red colors dominating the slack, suggesting more vigorous or wetland plant growth in response to still rising water levels. The pools continue to expand with rising water levels in 2018. Vegetation shows dull red, indicating vigorous or wetland plant growth throughout the slack. Vegetation quadrat sampling in 2016–2018 confirmed dominant wetland vegetation throughout the slack with different species creating the red color variations. For example, *Cladium mariscoides*, beak rush, the dominant sedge throughout the wetland, is a lighter red than *Scirpus cyperinus*, wool grass, which grows in deeper ponds. Vegetation indices (2017, 2018 data) provide greater detail on ecological and species changes as the color changes between areas with different vegetation species are even more pronounced. Hence, these methods provide the means to evaluate past and to monitor current ecological changes due to fluctuating water levels.

## **“Mission to Mars” at the Michigan Science Center**

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**Abstract:** The Michigan Science Center’s (MiSci) 2017 Space Science focus: *Mission to Mars* was a network of dynamic programs including hands-on activities, Planetarium shows, speakers and the development of a new afterschool program, *Red Planet Pioneers*. Red Planet Pioneers (RPP) engaged students with space science projects. The after school program was designed with the intent to offer formal and informal educator training to implement the RPP program at multiple sites. Additionally, this project included public outreach efforts that incorporate a continuation of our annual Space Week, a 6 day celebration of Space Science, Space Travel, and the spirit of exploration. This project also included embedded special supports to engage girls and minorities Space, space exploration, and a mission to mars captures student and public imaginations. Institutions like the Science Center have the exciting job of creating experiences to engage the public with cutting edge science, new technology, and modern mysteries --- experiences that may just launch our future explorers, engineers and home-grown genius' to dedicate their lives to the challenges that need to be solved for a successful mission to Mars.

## Miniaturized Neuron Stimulator

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**Abstract:** The Western Michigan University Neurobiology Engineering Laboratory investigates optimization of intracellular neuron stimulation. This work involves application of pre-computed optimal current stimuli to leech neurons using an electrophysiology rig. The current electrophysiology rig relies on bulky rack-mounted equipment interfaced with a proprietary LabVIEW® computer-based program to control neuron stimulation [1].

A self-contained unit that embodies as much of the functionality of the current electrophysiology rig as possible was designed, developed, and successfully tested [2]. The unit interfaces with a rack-mounted DUO 773 electrometer to stimulate a neuron and measure the neuronal response. This is the only external equipment required. A TFT display provides a simple user interface to specify one-time or continuous stimulation of a neuron using a stored waveform and capture neuronal responses to a MicroSD card for later processing. The design centers on a ARM® Cortex®-based STM32F7 Microcontroller Discovery Board and is based on a design concept presented at the last MSGC conference [3].

**Acknowledgements:** The authors thank the MSGC for their support of Lucas Essenburg via undergraduate and graduate fellowships. The authors also thank the Neurobiology Engineering Laboratory, Dr. John Jellies for access to his lab, and Thomas Groves for performing a leech electrophysiology experiment that demonstrated unit functionality.

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## Synthetic Design of a Salen Platform for Luminescent Heterobimetallic Lanthanide Complexes

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**Abstract:** Schiff base complexes containing luminescent lanthanides have been studied as potential components of functional materials. Salen type heterobimetallic *3d-4f* complexes comprised of neodymium and ytterbium have yielded promising results as emitters in the near-infrared (NIR). Until now, complexes of this type have only shown NIR upon excitation in the UV. Herein, we report the synthesis and characterization of a heterobimetallic naphthalene bridged salen complex functioning as a sensitizer for NIR emitting lanthanides with visible excitation. The Zn(II) complex (**ZnL**), {6,6'-dimethoxy-2,2'-[naphthalene-2,3-diylbis(nitrilomethylidene)]diphenolato}a-pyridylzinc(II) was isolated before refluxing with **Ln(III)** nitrate (where **Ln**=La, Nd, Er, Yb) to yield the heterobimetallic complex {**ZnL[Ln(NO<sub>3</sub>)<sub>3</sub> · xH<sub>2</sub>O]**} (where x=0 or 1). Through vapor diffusion of THF into a pyridine solution of the complex, single crystals suitable for x-ray diffraction were grown. In this complex, the lanthanide ion adopts range of geometries from 9 to 11 coordinate and sits below the ligand plane, while the zinc atom adopts a distorted square pyramidal geometry and sits above the ligand plane. All compounds show an absorption in the visible ( $\lambda_{\text{max}}$ = 425nm in DMSO) and emission at 980nm (YbZnL), 1064nm (NdZnL), and 1525nm (ErZnL). The quantum yields for these complexes are on the highest order of magnitude expected for complexes of this type.

## **Farm to Lake: quantitative analysis of antibiotics, and metagenomic characterization of microflora in surface waters in livestock farm areas contiguous to Lake Michigan**

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**Abstract:** Microorganisms that are continuously exposed to low concentrations of antibiotics, in large part due to livestock farms, increases the risk of microbial resistance. Microbes subjected to an environment that is constantly exposed to low concentrations of antibiotics can either adapt or die. The adaptation confers resistance to succeeding generations of microbes, thus increasing the prevalence of resistant genes in microbes. However, the Veterinarian Feed Directive was implemented in December 2016 to curb agricultural use of medically relevant antibiotics. We hypothesize that the concentration of antibiotics in water samples will not be correlated with antibiotic resistance genes within microbes exposed in these waters.

## Department Wide Outreach Program in Kinesiology and Integrative Physiology

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**Abstract:** The Department of Kinesiology and Integrative Physiology at Michigan Technological University organized its first Health Sciences and STEM (H-STEM) event in 2016. Based on the success of this event we expanded our outreach efforts to engage more students and faculty in the department so that we could build stronger relationships with K-12 schools. Using a team approach (outreach coordinator, faculty, undergraduate and graduate students) we were able to participate in three major outreach events in 2017: PhUn Week (American Physiological Society), Physiology Friday (The Physiological Society), and National Biomechanics Day (American Society of Biomechanics). Our objectives were to: 1) increase understanding of how the human body works, 2) promote enthusiasm for careers in physiology and biomechanics, and 3) provide undergraduate and graduate students with service learning experience. To accomplish these objectives, faculty embedded service learning assignments into their undergraduate and graduate kinesiology courses. Undergraduate and graduate students formed small groups, selected a physiology or biomechanics topic, and implemented age-appropriate, hands-on activities. These outreach events were well received and impacted 641 total students in grades K-12 across 15 different schools in our rural area. Undergraduate and graduate students found value engaging with the community and communicating science to a public audience. The department continues to develop a culture of community outreach in order to better connect with local schools. This work was supported by the Michigan Space Grant Consortium.

## Micrometeoroid Population Inference on LISA Pathfinder Data

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**Abstract:** The LISA Pathfinder (LPF) was a joint ESA / NASA technology demonstration mission for the Laser Interferometer Space Antenna (LISA). LPF operated from December 2015 through July 2017. Designed to be the most sensitive accelerometer ever flown, the LPF surpassed its mission goals and proved sensitive enough for future gravitational wave detection with the LISA constellation. An ancillary benefit of the LPF's sensitivity was its response to perturbations like those from micrometeoroids impacts. Taking advantage of this, the LPF became the first in-situ micrometeoroid detector in the first Earth-Sun Lagrange point (L1). We use our catalog of 44 events to derive properties of the micrometeoroid environment around L1, estimate impact rates for future missions, and explain the process for similar analyses in the future.

## Energizing K-12 STEM Through Hands-On Experiences

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**Abstract:** A continuing comprehensive, hands-on, student-centered, activity-based outreach and education program is presented here to deliver substantive Earth system sciences training to three separate populations – K-12 students (through summer programming and school-year STEM field trips) focusing on underrepresented and underserved students, K-12 STEM teachers (best practices in teaching STEM, Next Generation Science Standards), and the broader community. The shorter workshops, STEM field day trips, and longer STEM camps in the summer are continuing activities. These efforts are STEM-centered, hands-on experiences where attendees learn fundamental knowledge and then apply this to active learning exercises. Promoting STEM to this generation and those younger is critical to enhance knowledge, education, and eventually economic growth with a sustainable mindset. Some results of this effort will be presented here, including breadth and depth of impact on eth local community.

## Targeting misconceptions and conceptual barriers about igneous rocks in college-level introductory courses: Design and evaluation of a new laboratory exercise linking rock classification to igneous processes

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**Abstract:** Igneous rocks are a major constituent of the terrestrial, lunar and Martian crust and provide physical and chemical insight about processes governing terrestrial and planetary bodies. The ability to classify igneous rocks is therefore fundamental to our interpretation of geologic processes, but to date lacks clarity and continuity in current introductory-level courses. Simplified classification exercises already exist and have been extensively modified for improvement over the years. However, the ability to link observations to processes continues to be impeded by the fact that chemical tracers of igneous processes are conceptually abstract. In addition, deeply rooted misconceptions about the physical state of earth's mantle and the origin of magma further inhibits a student's ability to connect observations about igneous rocks to geologic processes. In this study, an interactive laboratory lesson was designed and evaluated in terms of its ability to address common misconceptions and conceptual barriers regarding igneous rocks and processes. The lesson consists of three components designed to link observations of igneous rocks to geologic processes. Following a short interactive mini-lecture, students work in groups beginning with basic classification of common igneous rocks (granite, rhyolite, pumice, obsidian, gabbro, and basalt). The second component focuses on the mineralogy of Bowen's reaction series in hand sample and a simplified mathematical exercise in relative element abundances between mafic and felsic rocks. The last component asks students to interpret the origin of each rock classified on the basis of composition and texture combined.

Seventy-four participants in an intro-level geology course were given a pre-assessment and post-assessment quiz to gauge misconceptions and evaluate understanding of key concepts. Each question was followed by a Likert scale response to gauge an individual's confidence in a given response. Responses were binned according to academic major fields (geosciences, general STEM- non-geoscience, and other). The results show greater disparity in pre-assessment responses across majors than in post-assessment responses. Despite this initial disparity, students across all majors answered more questions correctly with higher confidence during the post-assessment than during the pre-assessment. While the outcome of this study may not be surprising, it highlights the importance of identifying misconceptions to target during instruction. In addition, it demonstrates that students with a range in majors and pre-existing notions can achieve an equal level of understanding in a single lesson.

## Development of Organic Flow Cell Electrolytes for Terrestrial and Space Based Large-Scale Energy Storage

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**Abstract:** Flow cell batteries which employ redox processes hold advantages over traditional setups such as lead-acid or lithium-ion batteries. They are able to store large amounts of energy more efficiently, and their use of organic materials poses less of an environmental hazard than batteries that rely on metals. While various organic materials have been explored for flow cell use, quinones are relatively inexpensive molecules which have shown promise in these systems. Quinones exhibit high reversibility, and they can be easily derivatized in order to exploit their electrochemical significance. Here, we present our findings using sulfonated derivatives of dihydroxyanthraquinone and 4,4'-biphenol in a redox flow cell. We include studies of important electrochemical values and flow cell measurements, and preliminary studies indicate that the sulfonated dihydroxyanthraquinone and 4,4'-biphenol redox couple shows promise. The current density for this system can reach approximately  $0.1 \frac{A}{m^2}$ .

## Specialization by subsurface bacteria beneath a hyperarid Mars analogue system

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**Abstract:** Analogue studies in extreme environments on Earth help us constrain our estimates of habitability on other planets by allowing us to study the traits that allow actual organisms to live in these environments. The Namib Desert in western Namibia is often studied as a Mars analogue system because of its hyperaridity, nutrient poor soils, and wind-driven geomorphology. Importantly, the region contains a network of groundwater springs that provide a window into the subsurface environment that may be an important refuge from the harsh conditions on the surface. To date though, no one has examined the bacterial community associated with the region's groundwater springs and the microbial traits that facilitate survival in this subsurface environment. As part of a long-term monitoring program, we analyzed the chemical composition of and isolated bacteria from water collected from 35 springs to characterize the microbial community of these springs and identify potential drivers of community assembly in Namib Desert groundwater. Springs ranged from fresh to hypersaline (0.3—190 mS/cm; mean seawater conductivity is 35 mS/cm), had neutral to mildly basic pH, and had a wide diversity of rare earth elements. All springs had viable bacteria, including one spring that contained more than 4x more sodium than that found in typical seawater. In two highly saline springs, we identified microbes that showed not just a *tolerance* but a *preference* (halophily) for high salt environments, suggesting adaptation to subsurface conditions. High-throughput amplicon and metagenomic sequencing will allow us to correlate environmental parameters with measures of the microbial community to identify other traits that may be important for surviving in this unique and chemically diverse environment, ultimately expanding our understanding of the limits of life in saline, subsurface ecosystems.

## 2018 STEPS Camp for Girls

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**Abstract:** The Science Technology & Engineering Preview Summer (STEPS) Camp for Girls is an all-girl day camp that provides an overview of engineering topics. STEPS is aviation-themed, with the central activities being the construction and flying of a radio-controlled airplane. Enrichment classes allow further exploration of topics in engineering that may include biomedical engineering, renewable energy and computer science/engineering. Off-campus fieldtrips allow for socialization and the opportunity to see professionals in a real working environment. An overarching theme to STEPS is empowering young women to find their true potential. Female role models and mentors have a leading role in this camp. STEPS draws a minimum of eighty campers from the west side of Michigan to participate, coming from as many as sixty different schools. These campers return to their schools with a great sense of accomplishment and confidence, hopefully having a synergistic effect with their peers who may not realize engineering is for girls, too.

## **Magmatic Plumbing during the Terminus of the Keweenawan Large Igneous Province: Evidence from the Michipicoten Island Formation**

Kellen Martella<sup>1</sup>, Andrew LaVigne<sup>1</sup>, Christopher Svoboda<sup>1</sup>, Tyrone Rooney<sup>1</sup>, Guillaume Girard<sup>1</sup>, Robert Moucha<sup>2</sup>, Carol Stein<sup>3</sup>, Seth Stein<sup>4</sup>

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**Abstract:** The volcanic products erupted during the terminal phases of large igneous provinces are rarely preserved, leaving ambiguity about the magmatic processes in operation during the shutdown of magmatism. Due to the failure of the North American Mid-Continent Rift, the majority of the 1.1 Ga Keweenawan large igneous province (LIP) is preserved, including the latest stages. Lavas observed at Michipicoten Island in Lake Superior provide a record of these processes during this late stage. Elsewhere in the Keweenawan LIP (e.g. Lake Shore Traps), volcanics from this terminal period show evidence for crustal contamination. Such contamination is largely absent at Michipicoten Island. This observation is unexpected and points to heterogeneity in the magmatic differentiation processes operational during the late stages of the Keweenawan LIP. To probe these magmatic processes in more detail, we present petrographic and laser ablation ICP-MS trace element data on mineral phases and cumulates from Michipicoten Island lavas. We report that Michipicoten Island volcanics show clinopyroxene-plagioclase-oxide cumulate glomerocrysts that are large and abundant in the lowest stratigraphic units and decrease in size and abundance in younger units. Within the upper flows cumulates are largely absent. We explore these petrographic results in the context of new in-situ mineral trace element data. These data will provide constraints as to the nature and number of magmas, and constraints as to where these magmas stalled within the crust. This contribution is more broadly applicable in aiding our understanding of magmatic processes that drive the terminal stages of LIPs.

## **Crustal Structure of the Mangystau Region, Western Kazakhstan**

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**Abstract:** The Mangystau Region, in southwestern Kazakhstan, was tectonically active during the Late Paleozoic through Early Triassic with multiple collisional events, and contains many features such as basins, plateaus, and mountain ranges. However, the tectonic history of this accretionary terrane has been controversial in the past since the Central Mangyshlak Uplift has a complex structure. The crustal and upper mantle structure was intensely studied with seismic methods during the 1960's, and several conflicting interpretations were produced on the structure, composition, and thickness of the crust. Since the region had never been instrumented with broadband seismometers, Michigan State University and the Institute of Geophysical Research of Kazakhstan installed 10 of these sensors throughout the region for about 20 days in the summer of 2016, with the purpose of studying seismic noise. With the data collected from this study, receiver functions were produced and inverted jointly with surface wave dispersion curves to create shear wave velocity models that estimate the crustal structure in the region. Since the volume of data collected is smaller than what is normally used for these methods, the receiver functions for each station were stacked to increase the signal to noise ratio. The region was divided into three major geomorphic areas (North Ust-yurt Basin, Central Mangyshlak Uplift, South Mangyshlak Basin) and some stations were strategically grouped together as they were installed in the same area. The interpreted results for crustal structure are similar to the previous studies, but the Moho transition is different than previously thought. Following historic Soviet nomenclature regarding the rock types within the crust, the crust of the North Ust-yurt Basin is interpreted to be composed of an 8 km thick upper sedimentary basin, a 12 km thick granitic mid crust, and a 20 km thick basaltic lower crust. The crust of the Central Mangyshlak Uplift is composed of a 3 km thick upper sedimentary basin, a 22 km thick granitic mid crust with ambiguities, and a 15 km thick basaltic lower crust. The crust of the South Mangyshlak Uplift is composed of a 10 km thick upper sedimentary basin, a 12 km granitic mid crust, and an 18 km thick basaltic lower crust. The Moho in the overall region is gradational and is about 38 to 40 km deep. Results do not show a crustal root from the collisions in this accretionary terrane. This has also been seen in the Appalachian Mountains, where there is no crustal root and there is a gradational Moho of about the same depth and has a similar age. This study applied a more modern method to understand the Mangyshlak Region of southwest Kazakhstan and provide new insights to the composition and structure of the crust.

## UV Shielding of *Bacillus pumilus* SAFR-032 Endospores by Martian Regolith Simulants

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**Abstract:** As exploration of the solar system advances with life detection missions on the horizon, the concern for planetary protection has grown considerably. When attempting to detect extraterrestrial life, the likelihood of false positives from terrestrial contamination must be minimized. The Exposing Microorganisms in the Stratosphere (E-MIST) balloon project aims to evaluate whether resilient terrestrial bacteria can survive stressors in a Mars-like environment. This is accomplished by sending *Bacillus pumilus* SAFR-032, an endospore-forming bacterial isolate from a spacecraft assembly facility, to the Earth's middle stratosphere (30-38 km), where low temperature & pressure and high radiation & dryness conditions are similar to the surface of Mars. Previous ground and flight tests showed that the vast majority of SAFR-032 spores (99.99%) were inactivated by direct sunlight due to ultraviolet (UV) radiation. This observation led us to explore the role of dust shielding in changing microbial survivorship outcomes. To determine the dust particle distributions and density for potentially shielding microbes from UV radiation, samples of a Martian dust simulant were mixed with SAFR-032 spores. The dry heat sterilized simulants used were JSC MARS-1, weathered volcanic ash from Hawaii, and JPL MRS-1, basalt from the Mojave Desert. These simulants display many chemical and physical properties similar to the Martian soil as characterized by landers and rovers, including reflectance spectrum, chemical composition, mineralogy, grain size, specific gravity, and magnetic properties. First, scanning electron microscopy was undertaken to visualize the aggregation of the spores with dust particles (i.e., shading effects), and samples of varying dust concentrations were subsequently irradiated with UVC light to test survivorship outcomes. After a relationship between dust concentration and spore survivorship is determined, a solar simulator capable of irradiating samples with a fuller UV spectrum (<280 - 400 nm) will be used to perform a more robust middle stratosphere simulation. Taken together, we will use results from the ground-based irradiation studies to feed into experimental designs for the next E-MIST ultra-long duration polar balloon flight launched by NASA.

## Lab Activities to Connect Experiment & Theory in Physical Optics

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**Abstract:** The development and testing of exploratory laboratory activities designed with the explicit goal of developing a strong, integrated understanding of optical theory along with the related laboratory applications will be reported. The activities were developed between Spring 2017 and Fall 2017 and implemented in Winter 2018. The activities were targeted at upper-division physics students. Optics is an applied science with numerous applications, and as such understanding both theory and application/experiment is particularly important in optics. The coursework design was informed by prior work in discipline-based education research (DBER) and differs from traditional upper-division physics instruction. A traditional upper-division physical optics lecture course was modified to highlight relationships between theory and application, which were then implemented in the laboratory activities. To begin to study the effects of our activities, we used a case-study interview design in which students were invited to participate in a study consisting of three interviews, at the beginning, middle and end of the semester. During the interviews students were asked to explain concepts and solve both experimental and theoretical tasks using the relevant optics concepts. Of seven enrolled students, six participated in the study and we collected 17 interviews. We are analyzing the data using qualitative coding of the students' responses, investigating future research efforts based on this work. We present our progress in this research.

## Now-Casting Space Weather Events Using Heavy Ion Charge Distributions

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**Abstract:** Space weather such as coronal mass ejections (CMEs) and solar energetic particles originate at the Sun and in addition to causing the Aurora Borealis can have damaging effects when they reach Earth. Space weather damages satellites, interferes with radio and GPS signals, and can induce currents which damage power grid infrastructure.

To improve forecasting of CMEs, this study uses measurements of high charge states of Iron, Oxygen and Carbon ions in the solar wind to now-cast CMEs. The presence of these ions in a CME is due to increased ionization attributed to enhanced heating as the CME forms in the solar corona near the surface of the Sun. The ratios of the ion charge state densities remain frozen as the CME travels outward from the Sun. This study analyzes six parameters based on these charge state ratios which we can measure as the CME approaches Earth. We present a study using data observed by the Solar Wind Ion Composition Spectrometer onboard NASA's Advanced Composition Explorer satellite, which is in orbit between the Sun and the Earth. We select the best thresholds to use for CME forecasting by creating a set of "now-casts" based on observational data from 1998-2011 and evaluating their accuracy compared to published CME databases.

## **Construction of a Plasma Chamber to Investigate Radio Wave Attenuation in Plasma Sheaths**

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**Abstract:** A communication blackout problem occurs when a vehicle reenters Earth's atmosphere from orbit. The high-speed collision of the vehicle with the atmospheric molecules ionizes the gas and causes a plasma sheath to form in front of the vehicle. This plasma sheath can attenuate signals from ground control and, in extreme cases, can lead to a total loss of communication. Multiple research teams have proposed theoretical solutions to this problem, such as using high-frequency waves or Raman scattering, but currently there have been very few experimental tests. We have constructed a special plasma chamber to experimentally determine if the proposed methods are truly effective. The primary focus of this project will be to measure how high-frequency radio waves affect the transmission efficiency of radio waves through a plasma sheath.

## **The Cart Before the Redhorse: Examining Summer Habitat Use of the River Redhorse (*Moxostoma Carinatum*) to Guide Future Management**

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**Abstract:** The resiliency of our aquatic ecosystems hinges on our ability to protect the native species that reside there. The River Redhorse (*Moxostoma carinatum*) is one such example and populations have become low enough to warrant listing by the State of Michigan. Causes of decline include overfishing, habitat alteration, and lack of knowledge of basic life-history attributes including the use of non-spawning habitat. In order to aid its recovery, we implanted 15 individuals with radio transmitters and tracked their locations over the course of a summer. Tagged River Redhorse were found to move as far as 50 km down river following spawning and establish themselves in small home ranges. Substrates in these home ranges were dominated by gravel which represented 59 percent of samples. Little preference for depth or velocity was shown among the tracked fish. However, general habitat use was dominated by runs and riffles which represented 58 and 27 percent of tracked locations respectively. Presence of mussels and snails, the River Redhorse's preferred food source, appeared to be the best predictor for the River Redhorse's use of an area as they were found at 79 percent of all tracked locations. The recovery of the River Redhorse will likely depend on our ability to protect these newly discovered feeding areas as well as any known spawning sites. Future management should therefore focus on the protection of native mussels and snails and should attempt to maintain connectivity between spawning and summer habitats.

## Implementing the FIDO model in a pulsar population synthesis

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**Abstract:** Recent advances by our NASA Goddard colleagues in pulsar modeling utilize a new model known as Force-free Inside, Dissipative Outside (FIDO) to model the electrodynamics in the magnetospheres of pulsars, in which the magnetosphere within the light cylinder has infinite conductivity  $\sigma$  inside and finite conductivity  $\sigma$  outside. This more realistic model has the potential to describe the electric field distribution in pulsar magnetospheres more accurately than previous models, such as the pair-starved, polar cap and slot gap models, by assuming the dissipative regions of the magnetic field exist only outside the cylinder. The population synthesis code will seed the galaxy with neutron stars evolving them from their birth to the present time within the galactic potential and spinning them down to their present-day period and period derivative as a result of the magnetic field at birth. The Monte Carlo code will provide pulsars with particular set of characteristics such as period, magnetic field, viewing geometry - inclination angle  $\alpha$  and viewing angle  $\zeta$  with respect to the rotational axis, with the conductivity  $\sigma$  and  $\gamma$ -ray luminosity determined by the predicted trends of the FIDO model. In order to obtain the  $\gamma$ -flux, the phase averaged profile is obtained from the FIDO sky maps, requiring a standard method of a 5D interpolation computer routine. My research took the first step towards the implementation the FIDO model into our population synthesis code by using the sky maps of the gamma-ray intensity in the sky as seen from a viewing geometry from simulation of the high-energy emission of a particular neutron star. I implemented a standard 5D interpolation method to create arbitrary maps from arbitrary simulation data with values of  $\alpha$  and  $\zeta$ , the pulsar period, the period derivative, the assumed conductivity  $\sigma$  outside the pulsar light cylinder, and polar surface magnetic  $B$ .

## Identification of Photo-Initializable Point Defects in Carbon Related Materials by Optically Detected Magnetic Resonance

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**Abstract:** NASA's demonstration of a prolonged operation of integrated circuits made from silicon carbide (SiC) at high-temperature and high-pressure opened the possibility of long-duration landing missions in harsh environments. In addition, point defects in carbon related materials, such as diamond and SiC, has recently caught the interest of a rapidly growing field of carbon-based technology and nanoscale biological sensing applications because of the defect center's unique combination of properties which includes high temperature operation, stability and sensitivity to magnetic or electric fields. This feature further widens the potential applications of SiC technology especially in extreme environments. To probe defect centers of various materials, we built an Optically Detected Magnetic Resonance (ODMR) setup to initialize, manipulate and investigate the photo-spin characteristics of various defect centers. Magnetic fields were used to shift the energy levels of the spin states and microwaves were applied to flip the electron populations between the states. Here, we first present important physical phenomena that occur on nitrogen-vacancy point defects (NV centers) in nanodiamond, such as the Zeeman effect, photo-initialization of spin states, optically detected electron spin resonance, and Rabi oscillations to illustrate the NMR-like capabilities of point defects. The data on our nanodiamond NV centers show electron spin resonance at 2.875 GHz at a zero magnetic field environment. Well-known results of diamond NV centers, such as its spin resonance, were used to optimize our ODMR setup and to calibrate our measurements on the various defects we have created in other materials such as silicon carbide. Preliminary data on silicon-vacancy-type defects on silicon carbide (6H-SiC) samples irradiated with ionized hydrogen and helium (H<sup>+</sup>, Alpha 1+) through our Calvin-Hope College collaboration will be presented. The irradiation energy, fluence, and irradiation particles (H<sup>+</sup>, Alpha 1+) were systematically varied to arrive at an optimum setting for creating single defects, di-vacancies, or defect clusters on various silicon carbide polytypes (6H, 4H, 3C). We continue to identify and characterize SiC point defects using our ODMR setup in search for NMR-like features that are on par or better than NV center point defects. Enabling an NMR-like feature in SiC devices for exploration in harsh environments will expand the scope of possible scientific inquiries of NASA's future landing missions.

## **Inhibiting Pathogenesis of Tau Protein: Potential Biomarker of Physiological Changes Associated with Long-Term Space Travel**

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**Abstract:** In space, astronauts are exposed to a substantial amount of space radiation, leading to physiological changes associated with the central nervous system. When the radiation strikes the retina, it triggers a signal to the brain as light flashes, promoting eye degeneration and presenting early onset cataracts.<sup>1</sup> Visual changes also have been observed in early stages of neurodegenerative diseases, such as Alzheimer's Disease (AD).<sup>2</sup> The accumulation of cytotoxic protein aggregates is a pathological hallmark of degeneration of the brain and the eye. Hence, inhibiting eye and brain degeneration is a viable strategy towards reducing health risks associated with long-term space exploration and travel. One of the key features of this process is the presence of abnormal tau protein. In the brain, tau protein binds microtubules and promotes their stability which is regulated by multiple post-translational modifications, in particular by phosphorylation. Phosphorylation at certain amino acid sites alters the structure and function of tau. Specifically, phosphorylation of tau promotes cytotoxicity by inhibiting tau affinity for microtubules and promoting tau aggregation. Given the biological relevance of hyperphosphorylation and aggregation of tau, this research aims to 1) detect tau aggregation *in vitro*, 2) phosphorylate tau with protein kinase Fyn, and 3) inhibit phosphorylation by using anti-tau antibodies. SDS-PAGE and fluorescence aggregation assay were utilized to characterize tau aggregation. Additionally, Western blot was used to confirm the Fyn protein kinase-catalyzed tau phosphorylation at Tyr residues. The inhibition of tau phosphorylation was also evaluated in the presence of inhibitory anti-tau antibodies including D-8, Ser262, A-10, and K280 antibodies, all of which target various tau epitopes. Data indicates that targeting tau phosphorylation and aggregation with antibodies may be a potential therapeutic avenue against neurodegeneration.

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<sup>1</sup> Budinger, TF; Lyman, JT; Tobias, CA; Visual perception of accelerated nitrogen nuclei interacting with the human retina. *Nature*, 1972, 239: 209-1.

<sup>2</sup> Katz, B; Rimmer, S; Iragui, V; Katzman, R; Abnormal pattern electroretinogram in Alzheimer's disease: evidence for retinal ganglion cell degeneration? *Ann Neurol*. 1989, 26: 221-5.

## Distinguishing Stellar Populations within Milky Way Globular Star Clusters

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**Abstract:** Once thought to host a single stellar population, nearly all globular star clusters are now believed to harbor multiple stellar populations, distinguishable most often by multiple sequences on the red giant branch (RGB) of a color-magnitude diagram. The nature of these subgroups can provide insight into the formation history of globular clusters and how they have contributed to the growth of the Milky Way. Such distinct sequences of stars are not often visible to the eye on these diagrams, but with sufficiently precise photometry they can be distinguished statistically. We present our procedure to distinguish multiple populations using ground-based data from the Calvin-Rehoboth Observatory. To verify the procedure, we apply the procedure to the globular cluster Messier 13 and the evolved open cluster NGC 6791. The results of our procedure for these clusters match previously published results, giving us confidence in our procedure. We also present evidence that the somewhat arbitrary parameters used in our procedure do not introduce bias into our results. Finally, we apply our procedure to the poorly studied cluster M56 to look for multiple populations.

## Studying Vegetation Coverage and Dune Mobility with Drone-Acquired Multispectral Imagery

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**Abstract:** Sand dunes migrate when covered with bare sand, but are but are immobile when vegetated. Migrating dunes can destroy human infrastructure and in the past coastal dune management focused on planting vegetation to stabilize dunes. We now realize that some mobility is required for maintaining ecological diversity of coastal dune conditions and the focus is shifting towards preventing over stabilization. Aerial photographic surveys have been used to determine regional long term trends in dune mobility. We are developing techniques to use drone-acquired remote sensing data to study dune mobility over shorter time periods on a local scale using the 70 ha dune preserve at Saugatuck Harbor Natural Area (SHNA) as the test area. We collected multispectral (red, green, near-infrared) data with a resolution of 0.75 cm<sup>2</sup> per pixel. The NDVI value  $((NIR - Red) / (NIR + Red))$  was used to characterize each pixel as predominantly vegetated or predominantly bare sand. From this information we calculated proportions of vegetation in larger areas. Drone-acquired imagery was used to make a detailed topographic map of the area. The next step was to combine this information to create a map showing sensitivity to dune mobility for various sub regions. We calculated relative values for five indices which affect dune mobility. Two indices depend on vegetation density: the extent of vegetation surrounding a patch of ground and the extent of vegetation upwind from that patch. The wind shadow index is based on the assumption that a dune creates a barrier inhibiting aeolian deflation in the lee of the dune. The elevation index takes into account the effect of topographic acceleration in enhancing the ability of wind to transport sand. The slope orientation index is based on the orientation of the slope with respect to wind direction. For a given wind direction maps showing the relative values of each of these indices were calculated, using the R statistical software (<http://www.R-project.org/>). No model yet exists on how these separate indices should be combined to form a map of overall sensitivity to dune mobility. As a first step, we combined the indices using a simple model in which the various indices were weighed according to their relative importance. Separate maps were created for all 16 directions of the compass rose. Weather station data were used to calculate the relative sand drift potential in each direction. The dune mobility potentials were combined in proportion to the sand drift potential in each direction to create a map of overall sensitivity to dune mobility. In the future we plan to use drone acquired images to test the mobility predictions from these maps.

## Cenozoic Patagonian Magmatism

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**Abstract:** The origin of magmatism in continental back arc settings remains poorly constrained due to the confounding effects of subduction, extension, and the continental lithospheric mantle. Further complexities may result from possible slab windows and other unusual tectonic conditions. Given the central role of subduction zones within the plate tectonic cycle, constraining the flux of materials through such settings is an important goal in modern studies of subduction systems. Southeastern Patagonia represents an important venue in which to study this intersection between tectonics and magmatism. Here, a 40-50 Ma record of magmatism has been attributed to a plume rising through a slab window. However, the volume and timing of magmatism is not well constrained. Here we explore the distribution of these rocks, preliminary geochemical data that helps cluster these events, and plans for subsequent geochronological analysis that will form the basis of this research. Our preliminary work has that revealed four magmatic groups that are all extremely alkaline in character, including a series of basanites. These basanites carried a series of xenoliths from a locality that has never been previously documented.

## Human Powered Locomotion on Mars

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**Abstract:** Given the current initiatives of both private space exploration organizations and government mandates for space exploration agencies, human exploration of Mars is inevitable. Finding metabolically energy efficient means of transportation will be fundamental to the success of Martian explorers. Although the efficiency of unfueled mechanical transportation tools on Earth warrants their consideration to enhance human powered transport of the Martian explorer, to our knowledge this topic has not been explored to any formal extent. The use of motorized means of transportation may be limited due to fuel or weight constraints, and thus the purpose of this investigation was to conceptually explore the possibility of human powered locomotion devices as an alternative to motorized or unaugmented transport on Mars. Proper investigation of this concept involves consideration not only of metabolic cost of transport, but also of the inhospitable environment and terrain on Mars. This includes soil composition, micro terrain, grade, and atmospheric conditions. To uncover efficient human powered modes of transportation Mars, literature was reviewed, data was reproduced, and results were combined in order to translate information from Earth to its use on Mars. The bicycle is by far the most efficient mode of human-powered locomotion in Earth's environment. A more compact solution to mechanical augmentation could be a spring loaded exoskeleton. Taking existing knowledge regarding metabolic cost of transport (Kcal/kg/km) for devices on Earth has led us to believe that different human powered locomotion tools may be useful in different scenarios on Mars. In addition to those covered here, there remains several uninvestigated modes of human powered locomotion, including hiking poles and human towed sleds or carts that were predicted to be helpful to efficiency on Mars, but to a lesser degree than what was observed in this study.

## MSGC Logo Entries

1.



2.



3.



4.



5.



6.



7.



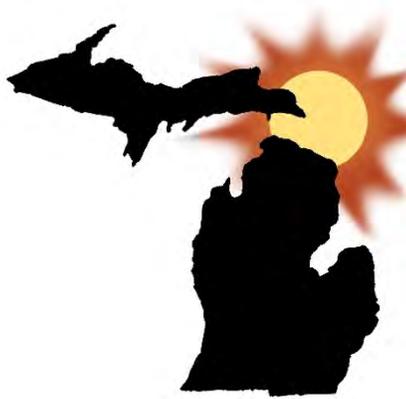
8.



9.



10.



11.



12.



13.



14.



15.



16.



17.



18.



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