Oral Presentations Session 1

Moderated by Professor Ed Cackett, Wayne State University

Liftoff for Michigan

Christine Brillhart, Educator, Science Department, Jefferson Middle School, Midland Public Schools, Midland, MI

Meeting an Apollo 13 astronaut, touching a moon rock, saving the world from an asteroid and making a comet. These experiences and more were part of the training I received at the Liftoff 2023 Summer Institute in Houston, Texas. Supported by Michigan Space Grant who work to defend our planet from near Earth objects, help train astronauts, research behind planning missions, hands-on applications, STEM resources and the history of NASA. In appreciation for MSGC,Äôs support, I would like to share a few takeaways and how this training has been used with students and teachers in the Midland community. As for a few key learnings my presentation will cover is 1) Failure of systems is practiced over and over at NASA; 2) Student awareness about the companies involved with the space program; 3) Relevance of the space program to student lives.

Computing camps for girls at EMU

Krish Narayanan, PhD, Professor, Department of Computer Science, Eastern Michigan University

The Bits & Bytes summer computing camp for middle school girls and the Gigabytes summer computing program for high school girls were a grand success at Eastern Michigan University! While Bits & Bytes has been offered for many years, it was the first year for Gigabytes. With the support of two MSGC grants, these programs served around thirty participants each in week-long sessions. The programs employed a near-peer mentoring model with the help of the Women in Computer Science club students at EMU. Participants were introduced computing and technology from theoretical concepts to applied projects. Coding was taught through educational software, robots, mobile apps, and drones. The programs included a career discovery event and a hackathon. EMU press releases about these programs can be found at https://today.emich.edu/story/story/12427 and https://today.emich.edu/story/story/12448. In this talk, we will share the curriculum and feedback from participants and parents.

The Effects of Contact Physics on the Formation of Planetesimals through Gravitational Collapse

Jackson Barnes, Department of Earth and Environmental Sciences, Michigan State University, East Lansing, MI
Stephen R. Schwartz, Planetary Science Institute, Tucson, AZ; Instituto de Fisica Aplicada a las Ciencias y la Tecnologias, Universidad de Alicante, San Vicent del Raspeig, Alicante, Spain;

Seth A. Jacobson, Department of Earth and Environmental Sciences, Michigan State University, East Lansing, MI

We have successfully applied a soft-sphere discrete element method (SSDEM) within the PKDGRAV N-body integrator to investigate the formation of planetesimal systems through the gravitational collapse of clouds of super-particles. Prior models demonstrated that gravitational collapse is effective at producing binary planetesimal systems but were limited by their use of a perfect-merger and inflated-radii super-particle approach, which inhibits analyses of planetesimal shapes and spins, produces unrealistically low-density planetesimals, and precludes the formation of tight binary orbits. With the SSDEM, super-particles rest upon each other through mutual surface penetration and by simulating contact forces to create planetesimals as aggregates. We can therefore track evolving planetesimal shapes, spins, and tight binary orbits. Yet, perfect-merger models perform better at the early stages of collapse when most collisions occur. Thus, we are constructing a novel hybrid N-body model through which we will combine the perfect-merger model at early times and the SSDEM at late times to more effectively model the innumerable collisions at the start of collapse while still recording planetesimal shapes and spins.

Lunabotics Astro-Huskies Automated Regolith Excavation System (ARES)

Christi LeCaptain, Project Manager, Mechanical Engineering, Michigan Technological University
Karson Linders, Assistant Project Manager, Mechanical Engineering & Robotics, Michigan Technological University
Seth Thurman, Lead Systems Engineer, Robotics Engineering, Michigan Technological University
Paul van Susante, Ph.D., M. ASCE, M. AIAA, M. ISTVS, Faculty Advisor for the Multiplanetary INnovation Enterprise (MINE), Mechanical Engineering ‚Äì Engineering Mechanics, Michigan Technological University

The Michigan Technological University (MTU) Multiplanetary Innovation Enterprise (MINE) Astro-Huskies have been participating in the NASA Lunabotics competition for 4 years. For our team, the second time in-person competition this time at the University of Alabama. With their robot, Automated Regolith Excavation System (ARES), the team was the first of only 10 Teams (out of 30) to complete the objective of traversing the simulated lunar terrain, excavating, and delivering simulated material to the collection point, this gaining awards for Automation & Innovative Engineering. The team will use this experience at the competition and in Systems Engineering and Project Management as they prepare for the 2023-24 Lunabotics Competition as well as during the rest of their careers for those who graduated. The talk will discuss the experience, lessons learned and path forward.

Resilience to Spaceflight Stressors: Validating Space Farming and Sweat Cortisol Biosensor Wearable as Means to Ensure Mission Health

Lisa S. Tsay, NASA Growing Beyond Earth Teacher Ambassador, Saginaw Valley State University
Margaret E. Hitt, President & Founder of Dow High Space Farmers, GeneLab for High Schools NASA Intern, H. H. Dow High School
Meha Shivakumar, H. H. Dow High School

With Artemis missions underway, extending the existing NASA mission health systems beyond low Earth orbit is critical. NASA utilizes the salad machine concept to grow fresh vegetables to balance crew members space diets and boost their morale. Recent studies in environmental psychology have shown that frequent immersion in nature significantly improves cognitive and emotional health. To test the effectiveness of space farming in ensuring mission health, we prototyped a sweat cortisol biosensor wearable and proposed using White LEDs supplemented with 1% Green light to grow NASA cultivars in long-duration space missions. The sweat cortisol biosensor wearable can help inform astronauts of potential issues with circadian phase, stress, and activation, thus assisting in individualized countermeasure regimens for spaceflight. Our space botany experiments investigated seven light treatments, including four moderate PAR ranges, two photoperiods, and two light colors, green and white. NASA cultivars fair best under higher light intensity with shorter photoperiods.

Oral Presentations Session 2

Moderated by Professor Bopaiah Biddanda, Grand Valley State University

Exploring the structural architecture, reactivation likelihood and seal-ability of faulted subsurface reservoirs in the northern Gulf of Mexico continental shelf: Implications for CO2 sequestration

Uzonna Anyiam, PhD in Geophysics, Dr., Geological and Environmental Sciences Department, Hope College.Madeleine O'Donnell, Undergraduate Student, Miss, Geological and Environmental Sciences Department, Hope College.
Emmanuel Uzuegbu, MSc in Geology, Mr., SLB, Stavanger, Norway.

The release of anthropogenic CO_2 into Earth's atmosphere has risen progressively and has resulted in and amplified climatic variations around the globe with unprecedented effect on humans. Geological sequestration of CO_2 via subsurface storage in reservoirs can significantly alleviate this effect but its mechanism is under explored. Therefore, it is imperative to understand the structural framework, possibility of reactivation, and sealing potential of faults of subsurface storage complexes in order to prevent migration of injected CO_2 outside the target storage strata. We utilized a suite of geological and geophysical data to characterize the structural architecture of reservoirs and overlying seals, evaluate fault-zone juxtapositions and seal properties, as well as perform detailed volumetric assessment of the different storage mechanisms characterized. We find huge potential for CO_2 storage in the northern Gulf of Mexico. This research aligns with NASA's goals, and the methods can be applied to explore sedimentary basins globally.

Using Airborne eDNA Detection Methods to Investigate Hemlock Woolly Adelgid Impacts on Communities in Michigan Mixedwood Forests

Keely Dunham, B.A., Graduate Research Assistant, Annis Water Resources Institute, Grand Valley University
Charlyn Partridge, Ph.D., Associate Professor, Annis Water Resources Institute, Grand Valley University, Jefferson Middle School, and Saginaw Valley State University

Hemlock woolly adelgid (HWA) is an invasive forest pest threatening Michigan's 176 million hemlock trees. This insect has caused the decline and death of hemlock stands in west Michigan, creating changes in the landscape that can alter biodiversity. An emerging, yet understudied monitoring technology is environmental DNA (eDNA), which is genetic material that is collected from the environment. I am using airborne eDNA as a tool to investigate HWA impacts on community composition in hemlock forests. I deployed airborne eDNA traps across sites with varying infestation levels to sample plant and insect taxa in west Michigan hemlock-dominant forests. I will evaluate how the introduction of this invasive pest impacts plant and arthropod diversity within hemlock ecosystems using an amplicon sequencing approach. This

project will expand our understanding of how invasive species drive changes in community composition within these critical landscapes.

Seismic Amplitude-based Lahar Tracking

Brendan Harville, BS Applied Geophysics, Undergraduate Student, GMES, Michigan Technological University
Gregory Waite, BS Mathematics, MS Geophysics, PhD Geophysics, GMES, Michigan Technological University

Lahars are strong debris flows or mudflows that swiftly transport small and large sediments, rocks, and even trees in their path, which can cause considerable damage. These hazards occur on the flanks of volcanoes either due to volcanic activity or heavy, sustained rainfall. The latter is a main trigger for lahars on the frequently active Volcan de Fuego in Guatemala. The initial aim of this study was to use data from a seismometer network on the southern side of Fuego in order to locate and track lahars for hazard risk mitigation purposes. We have extended the study to better understand why some locations along the channel consistently produce the strongest seismic waves. The correlation of lahar stream sinuosity, changes in channel gradient, and locations of dominant seismic sources is used to test the significance of channel morphology on seismic signal generation.

Sea Ice Leads as a Source of Arctic Sea Spray Aerosol: A Combined In-situ Measurement and Remote Sensing Study

Judy Wu, M.S., Graduate Student, Dept. of Chemistry, University of Michigan
Jun Liu, Ph.D., Postdoctoral Researcher, Dept. of Chemistry, University of Michigan
Jamy Y. Lee, Ph.D., Graduate Student, Dept. of Chemistry, University of Michigan
Son V. Nghiem, Ph.D., Senior Research Scientist, NASA Jet Propulsion Laboratory, California Institute of Technology
Kerri A. Pratt, Ph.D., Professor of Chemistry, Dept. of Chemistry, University of Michigan

The Arctic is warming faster than the global average, resulting in reduced summer sea ice and delayed fall ice freeze-up. With increased open water, sea spray aerosol (SSA) emissions are expected to be rising, impacting climate through solar radiation scattering (direct effect) and cloud formation (indirect effect). Knowledge of Arctic SSA emissions from leads (sea ice cracks) during fall-winter is limited. Therefore, an aerosol time-of-flight mass spectrometer (ATOFMS) was deployed from Nov.- Dec. 2018 near Utqiaƒ°vik, Alaska to measure the size and chemical composition of individual atmospheric aerosol particles. SSA was found to contribute significantly to the particle population. Both freshly-emitted and partially-aged SSA were observed and examined in relation to local open water and sea ice leads using satellite-based remote sensing of the sea ice surface. These results will improve the assessment of increased SSA impacts on aerosols, clouds, and climate in the rapidly-changing Arctic.

EXPLAINABILITY IN MULTIVARIATE TIME SERIES CLASSIFICATION MACHINE LEARNING MODELS

Emanuel Sanchez (Undergraduate student, Computer Science department, Hope College)
Giovanni Battaglia (Undergraduate student, Computer Science department, Hope College)
Brooke Odle (Ph.D., Assistant Professor, Engineering, Hope College)
Omofolakunmi Olagbemi (Ph.D., Assistant Professor, Computer Science, Hope College)

Explainability within models is a crucial part of machine learning (ML) models because it promotes trust in the models by providing insights into how their predictions were determined. Our study applies the classification model XCM's explain ability component in identifying the critical features leading to classification decisions on data collected while participants performed patient-handling tasks on manikins. Studies show that nurses sustain musculoskeletal injuries early in their career, attributable to some extent to posture adopted during patient-handling tasks. The ML models classify posture adopted during tasks as ‘good’, ‘poor’, or, in some cases, ‘neutral’, where good posture minimizes the risk of musculoskeletal injuries (especially low back pain) in the participants. Features deemed important by XCM (e.g., lumbar rotation, hip flexion) aligned with expectations from a biomechanical standpoint. Training another ML model using only those features improved model accuracy. Further analysis will assist with determining metrics indicative of good posture.

Digital Phantoms for Quantitative Ultrasound and Photoacoustic Imaging of Thrombosis

Sullivan Lauderdale, BS, Graduate Research Assistant, Department of Electrical and Computer Engineering, Oakland University
Alycen Wiacek, PhD, Assistant Professor, Department of Electrical and Computer Engineering and Department of Bioengineering, Oakland University

Thrombosis or blood clots in the human body can be fatal, particularly if they are not identified and treated quickly. Diagnosing thrombosis in astronauts presents a unique challenge due to the limited resources available for imaging. Current methods to diagnose thrombosis are invasive, not quantitative, or require hardware not available at the point-of-care. Therefore, this work proposes quantitative ultrasound and photoacoustic imaging to non-invasively diagnose thrombosis and focuses on the development of a digital phantom to study new quantitative algorithms. A 3D tissue model of a blood clot embedded within a vessel in tissue was created and imaged with a 5 mm-diameter light source and a linear array transducer. Ultrasound and photoacoustic images were simulated using a combination of Monte Carlo and k-Wave to simulate light transport and acoustic wave propagation, respectively. The results demonstrate the promise of digital thrombosis phantoms to evaluate ultrasound and photoacoustic imaging approaches to diagnose thrombosis.

Oral Presentations Session 3

Moderated by Professor Massood Z. Atashbar, Western Michigan University

Development of Highly Sensitive Pressure Sensors with Hybrid Structure for E-Skin and Soft-Robotic Applications

Sergei Akhmatdinov, Undergraduate Computer Engineering Student, Department of Electrical and Computer Engineering, Western Michigan University

The human sensory system comprises five senses: vision, hearing, smell, taste, and touch. Despite the skin being the body's largest receptor, the sense of touch has received less scientific attention compared to vision and hearing. Our research fills this gap in tele-robotic systems, where prior work focused on improving commercial haptic feedback devices for human-machine interfaces. We propose an innovative haptic system with advanced force-sensing capabilities, mimicking human touch perception. It measures forces exerted by a robot arm during manipulation and provides tactile feedback.

To replicate human skin's sensitivity, we optimize pressure sensors with PDMS-based cones and porous structures, suitable for both gentle touches and high-pressure interactions. Our experiments show that as the robot's gripper pressure rises from 0 to 375 kPa, the voltage delivered to the microcontroller from a Sallen-key readout module decreases from 3V to 1.1V, causing an increased tactile vibration frequency from 10 Hz to 300 Hz.

Printed and Micro-structured Graphite Electrodes for High Capacity and Fast Charging Lithium-Ion Batteries
Himanaga Emani, Ph.D. Student, Dept. of Electrical and Computer Engineering, Western Michigan University

Enabling safe and high capacity (ability to store more energy) lithium-ion batteries (LIBs) that can charge in less than 30 minutes would accelerate the public acceptance of electric vehicles (EVs). Today’s EVs comprise of thick electrodes inside the LIBs which require more than 120 minutes for charging and exhibit safety concerns such as aging, exploding, catching fire etc. The major source of these hazards is due to high tortuosity (path travelled by lithium-ions (Li+) inside the batteries) and lithium-plating (formation of metallic lithium around anode while charging) which occurs on surface of the electrodes resulting in rapid capacity fading of the LIBs. In this work, we implemented additive printing process such as screen printing for fabricating flexible, lightweight electrodes for LIBs. In addition, we have introduced micro-structured secondary pore networks (SPNs) which can significantly reduce the tortuosity of the electrode and can counter the formation of lithium plating on anode surface resulting in a significant improvement in capacity retention of ~95% in comparison to ~60% for conventional LIBs after 100 cycles of testing. Screen-printed electrodes with SPNs were also able to successfully arrest the formation of lithium plating on anode surface due to free channels available for transportation of Li+.

Simulation and Modeling of the Settling Behavior of Polydisperse Gas-Solid Flows With Application to Pyroclastic Density Currents
Emily Foster, bachelor's and master's degrees in mechanical engineering & E.I.T certification & Ph.D. candidate, Oakland University department of mechanical engineering

Pyroclastic density currents (PDCs) are fast-moving, highly destructive volcanic phenomena resulting from the collapse of an ejected volcanic column. PDCs travel up to several hundred kilometers per hour and can cause extensive damage to human settlements, infrastructure, and ecosystems. PDCs are inherently complex due to their multiphase nature and the wide range of length and time scales present. Because of these complexities, developing accurate models that are accurate across multiple length and time scales remains challenging. In this talk, I present a set of high-fidelity Euler Lagrange data for polydisperse settling, informed by real-world ejecta characteristics (e.g. particle diameters). This data is then used to inform a new settling model that captures both clustering in the particle phase as well as polydispersity in particle diameter. These models can then be integrated into existing coarse-grained solvers to improve the accuracy of PDC hazard modeling.

Synergistic Approach for Computational Analysis of Geomagnetically Induced Currents in Power Grids
Adebola Oke, Electrical Engineer, WMU alumnus, Electrical and Computer Engineering, Western Michigan University
Pablo Gomez, PhD in Electrical Engineering, Associate Professor, Electrical and Computer Engineering, Western Michigan University

Geomagnetically induced currents (GICs) can be highly disruptive to power grid operations. Despite the study of geomagnetic disturbances (GMDs) since the 1940s, comprehensive methods for accurate and precise analysis of their impact, especially in individual grid components, remain limited. This work describes a method based on the synergistic use of different computational tools for detailed simulation of GMDs in power grids. The proposed methodology allows the effective integration between three main aspects required for accurate determination of GICs and their effects on power systems: (1) location-specific estimation of Earth's magnetic fields at ground level, (2) detailed physics-based ground impedance modeling considering specific geological environment, and (3) power grid modeling considering detailed network and grounding topology. The goal is to generate an end-to-end methodology for GIC calculation in power grids from the magnetic field environment during a geomagnetic event, the soil conductivity profile at the site of interest, and the grid topology data.

Charging the Future: Solid-State Lithium Ion Batteries in Electric Aviation

Valliammai Palaniappan, PhD Student, Electrical and Computer Engineering Department, Western Michigan University
Massood Atashbar, Professor, electrical and Computer Engineering Department, Western Michigan University

Electric aviation missions would require a significant increase in specific energy of energy storage devices beyond 400 Wh/kg. Lithium-ion batteries (LIB) have shown considerable promise as power sources for electric vehicles. However, using volatile organic liquid electrolytes directly causes major safety issues, including the risk of fire and explosion posing a significant barrier to large-scale LIB applications. Solid-state electrolytes can address the safety issue associated with LIBs because they do not include flammable liquid chemicals. Solid-state electrolytes based on inorganic Li+ conductors, on the other hand, typically have limited ionic conductivity. To boost ionic conductivity, or to accelerate Li+ intercalation, it is necessary to manage the porous structure so that the Li+ can readily travel between the anode and cathode during the charging and discharging process. In this work, different methods of creating porous architectures for potential use as solid-state electrolytes will be discussed.

Thermal Equation of State of Transition-Metal-Bearing Davemaoite and Implications for Large Low Shear Velocity Provinces (LLSVPs)

Allison Pease (MS, PhD candidate), Michigan State University, Department of Earth and Environmental Science
Mario Cueva Calderon (PhD), Michigan State University, Department of Chemical Engineering and Materials Science
Stella Chariton (PhD), Center for Advanced Radiation Sources, The University of Chicago
Vitali Prakapenka (PhD), Center for Advanced Radiation Sources, The University of Chicago
Susannah Dorfman (PhD), Michigan State University, Department of Earth and Environmental Science

Davemaoite ($CaSiO_3$) is proposed to be a major mineral phase in Earth's lower mantle. Although previous studies have focused largely on the pure $CaSiO_3$ end-member, the only natural davemaoite sample identified in a diamond inclusion demonstrates that davemaoite in the mantle may be a solid solution with as little as 43 mol% $CaSiO_3$ component mixed with other components, including 11 mol% $FeSiO_3$. The thermoelastic behavior of such Fe-bearing (and other transition metals) davemaoite has not been measured and may represent the physical properties of subducted basalt in the lower mantle. In this study, we synthesized homogeneous (Ca, Fe, Mn)SiO_3 starting materials from oxide powders in a vacuum-sealed glass ampule.

Samples were loaded into a diamond anvil cell and transformed to the cubic or tetragonal perovskite structure above 35 GPa and 1500 K. To constrain the thermal equation of state of these compositions, in situ X-ray diffraction data were obtained at GSECARS, the Advanced Photon Source, Argonne National Lab at pressures and temperatures up to 80 GPa and 2500 K. High-temperature volume data were fit to a Mie-Gruneisen equation of state. The 300 K equation of state was determined based on a third-order Birch-Murnaghan equation of state. We observe that $Ca_{0.82}Mn_{0.18}SiO_3$ and $Ca_{0.69}Mn_{0.16}Fe_{0.15}SiO_3$ have 1-3% lower unit cell volumes than $CaSiO_3$. When K' is fixed to 4, the bulk modulus increases by 5-10% compared to $CaSiO_3$ and up to 5% compared to the $MnSiO_3$ end member. For natural Fe, Mn-bearing davemaoite, the incompressibility is higher relative to pure $CaSiO_3$. Variation of the thermal equation of state with increasing transition metal content will be used to provide insight into the thermal gradient and heat storage within the lower mantle's large low shear velocity provinces (LLSVPs). LLSVPs have recently been proposed to be enriched in davemaoite and Fe content relative to the surrounding mantle. These constraints provide critical insight into the stability of the tetragonal-cubic crystal structure, bulk modulus, and thermal expansion with composition of this major lower mantle mineral.