**2023 Palmetto Academy Sites:**

**Dr. Qiushi Chen, Clemson University:**

**Toward bio-inspired energy-efficient drilling into lunar regolith**

Plants and animals and their burrowing mechanisms have become a source of inspiration for

novel terrestrial subterranean robots, which have great potential for in situ resource utilization

supporting NASA’s lunar exploration missions. This Palmetto Academy project will develop an

initial understanding of bio-inspired drilling and burrowing and explore their potential as an

innovative, energy-efficient technology for in situ characterization of lunar regolith.

**Dr. Kaelyn Leake, The Citadel:**

**Sub-millimeter sized patterning via laser modification of layer-by-layer ionic self-assembly**

**Process**

Advances in nano-scale fabrication techniques can lead to an increase in device design choices

and functionalities for scientists and engineers to address challenges associated with space

travel. Such advances in nanotechnology may lead to new approaches for sensors and

instruments, for example, which are critical to the mission of NASA. We will partner with the

student researcher to further develop our novel laser-based approach to layer-by-layer

fabrication to pattern at the sub-millimeter to few micron length scale.

**Dr. Sorinel Oprisan, College of Charleston:**

**Altered time perception under stress. The role of (micro)gravity stressor in time perception**

The perception of durations is essential for survival and adaptation and is critical for fundamental cognitive processes like decision-making, rate calculation, and planning of actions. Environmental stressors, such as (micro)gravity, modify the sensorimotor feedback loops and alter the brain's spatial and temporal perception. Our goal is to incorporate in a realistic neurobiologically neural network of the cortico-thalamic-striatal loops recent advances on the cellular-level effect of microgravity.

**Dr. Ana Oprisan, College of Charleston:**

**Universality laws in pure fluids and critical point experiments under density gradient**

The race for space exploration and, more recently, the Artemis Space mission requires reliable and efficient propellant management systems rooted in a more detailed understanding of the

thermophysical properties of liquid hydrogen and liquid oxygen (LHLO). The main objective of

this project is to investigate the universal power laws that govern the dynamics of LHLO near

critical points under magnetic levitation. Our established collaboration with Dr. Beysens’s

research team will allow us access to experimental data related to turbidity near the critical point from the HYdrogen DEvice Levitation (HYLDE) facility at the Commissariat à l’Energie

Atomique (CEA)-Grenoble (France), which magnetically compensates gravity to within a few

percents of Earth gravitational acceleration.

**Dr. Ramakrishna Podila, Clemson University:**

**Energy storage devices for operation in extended temperature range -60 to 600 C**

This project focuses upon sulfurized polymer-based Li-ion capacitors (LICs) to enable high

specific energy and operation in extended temperature ranges relevant for NASA missions. Two

undergraduate students will collaboratively work with graduate students in the Department of

Physics and Astronomy at Clemson to obtain hands-on experience in materials synthesis,

electrochemistry, thermal property measurements, and understand the underlying physics and

chemistry of batteries and capacitors. Student will also be introduced to new data visualization

tools (e.g., IGOR Pro) and python for data analysis. They will participate in journal clubs,

undergraduate research poster presentations, and use tools from Clemson Physics department’s career counseling and professional Development (CCPD 1400) course for undergraduates, students will gain deeper insights into their possible career paths including graduate school.

**Dr. Laura Redmond, Clemson University:**

**Dynamic Topology Optimization for Robust, Lightweight Origami Rovers**

Rigid-flex Printed Circuit Board (PCB) robots can be economically produced and compactly stored which could enable large droves of rigid-flex PCB robots to be sent to highrisk

lunar environments. However, one challenge with the architecture is enhancing the strength

of larger PCB panels for drops into Lunar pits, while not adding excessive mass or volume to the

structure. Ongoing work at Clemson University in partnership with JPL has suggested enhancing

the strength of larger PCB panels through topology-optimized exoskeletons using equivalent static loads. This Palmetto Academy will guide an undergraduate researcher through an initial

exploration of dynamic topology optimization for rigid-flex PCB robots, directly leveraging the

results of nonlinear dynamic analysis, and assess the influence of selected optimization parameters on the resulting design.

**Dr. Kasra Sardashti, Clemson University:**

**Quantum Sensing of Solar Flares using Superconducting Detectors**

These students will join in a research effort aimed at the development of new,

quantum-based sensing techniques for the highly charged components of the solar wind

using superconducting strip detectors. This will be a collaborative effort between the

Laboratory for Band-engineered Quantum Systems (LaBEQ) and the Clemson University

Electron Beam Ion Trap Facility (CUEBIT) that supports NASA’s physical science and

science mission directorates while promoting the development of new space technologies. This collaborative project has a goal of sensing solar activity at a fidelity and speed that far exceeds that used in traditional ion detection. It will leverage the capabilities of LaBEQ and the CUEBIT facility to engineer the required superconducting materials for new sensors while producing the required atomic species present in the solar to test them. The students participating in the Palmetto Academy program will have the opportunity to design, implement, and test candidate sensor technologies in a state-of-the art laboratory astrophysics setting. In the process, they will learn several key skills, such as how to generate high temperature plasmas in magnetically compressed high current electron beams, how to cryogenically cool targets for ultrahigh vacuum, and how to detect and characterization the effects of radiation on a target. The project will teach the students the methods of proper experimental design and how to analyze and interpret scientific data. The educational goals are to familiarize the undergraduate student with the common experimental and computational techniques that are important to many fields of interest

for NASA.

**Dr. Ya-Ping Sun, Clemson University:**

**Student Participation in Developing Nanomaterials-Derived Technologies for Space Applications**

Antimicrobial technology is critical to space missions such as human mission to Mars;

Traditional agents/approaches are insufficient for the challenging needs;

Carbon quantum dots coupled with human-friendly light are highly effective for the needs;

The targeted technology addresses both decontamination and protection challenges.

**Dr. Ralph White, University of South Carolina:**

**Structural Batteries Demonstrators for Aerospace Applications**

The project aims to recruit two graduate students with interest in Chemical Engineering,

Electrochemistry and Structural Mechanics that will spend ten weeks at the UofSC in Prof. Ralph E. White’s battery modeling group. The students will work on paving the way to the development of structural batteries, which have the potential to revolutionize electric vehicles in the aerospace field. One student will work on the development of demonstrators for structural testing of structural batteries, together with the team at the McNair Aerospace Center and another will work on developing optimized fiber coating methods. Ultimately, the students will be exposed to interdisciplinary work, which will make them gain unique skills. Both students will learn how to use electrochemical instruments and structural testing instruments for structural batteries and will get the chance to work together with other colleagues, learning experimental methods. This project will help the students gain valuable experience and skills and be part of a project that has the potential to advance the development of the aerospace industry of the future.

The project is of high relevance to NASA, which is already working on developing electric vehicles – Maxwell X-57 – and to South Carolina, which is home to hundreds of aerospace companies, such a Boeing, who is also building structures out of carbon fibers. At the end of the project, the students will be evaluated by the PIs of the project and through the peer-reviewing process of an article submitted to the Journal of Electrochemical Society.

**Dr. Ming Yang, Clemson University:**

**Electrochemical Recovery and Conversion of Captured In-Space CO2 to Methane Fuel**

In-situ resource utilization (ISRU) is at the heart of space exploration as NASA launches a

new phase of missions to low Earth orbit (e.g., space station), Mars, and beyond. Solely relying

on fuel resources from Earth not only leads to high operational costs for sustainable space

exploration but also adds an additional burden to the fragile energy and environmental system of our home planet. Our research site at Clemson University proposes electrochemical-related

research to empower self-sustained and long-duration space explorations. The proposed work falls under NASA’s Mission Directorate of Space Technology (STMD) and Human Exploration and Operations (HEOMD). Specifically, we aim to invite three summer students to participate in the guided research of recovering and converting alkaline-solution captured CO2, an abundant natural resource that can be found on Mars and a hazardous gas generated by crew members in the space station, into renewable CH4 propulsion fuel.