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20-ISS 2020-0002

Electrokinetic assembly of stable nanoparticle haloing suspensions

University Of Kentucky, Lexington

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Science PI: Dr. Stuart Joseph Williams

NASA MD: SMD

Kentucky s NASA EPSCoR jurisdiction solicited proposal responses from Kentucky university-led research teams to address the ISS flight opportunity listed in the FY2020 NASA EPSCoR International Space Station (ISS) Flight Opportunity announcement (NNH20ZHA002C). The NASA Kentucky EPSCoR program collaborated with responding faculty researchers to develop and submit a relevant proposal that will address NASA EPSCoR ISS objectives.

The goal of this proposed work by the University of Louisville research team is to utilize the microgravity environment on the International Space Station (ISS) and self-assemble, using electric fields, a bimodal colloidal solution containing both microparticles and nanoparticles. More specifically, we want to prove that nanoparticles are present within the microparticle interparticle spacing when the latter assembles into crystalline-like packing. In collaboration with NASA s Advanced Colloids Experiments (ACE) team, we will develop an automated platform for microscopic visualization and to apply the electric field to the colloidal samples. Our results can be applied towards the enhancement of quantum-dot synthesized solar cells (QDSS). Further, our work provides the foundation for future electrokinetic experiments by ACE (ACE-E).

20-ISS 2020-0003

NASA EPSCoR ISS: Assessing the Performance of Urease-Phospholipid Reactive Forward Osmosis Membranes for Water Reclamation Aboard the ISS

University Of Puerto Rico, San Juan

Director/PI: Dr. Gerardo Morell

Science PI: Dr. Eduardo L. Nicolau-Lopez

NASA MD: SMD

This proposal is a collaborative effort between the University of Puerto Rico and NASA Ames Research Center to advance the membrane-based technology for water reclamation in space. Water is one of the most massive components aboard spacecraft making it imperative to recycle wastewater. Moreover, the recovery of wastewater into potable water is critical for life support and environmental health of crewmembers, and is required to enable future long-term space exploration missions planned by NASA.

Previous research done at NASA Ames revealed that the conventional forward osmosis process leaves large quantities of total organic carbon dissolved in water. Under a NASA EPSCoR research project, we found that that these high levels of dissolved carbon are mainly due to the presence of urea and developed urea reactive forward osmosis membranes (UFOBs) technology as a proof-ofconcept to solve this problem.

In this NASA EPSCoR ISS project, we will evaluate the performance of UFOBs under microgravity conditions and correlate the diffusion of species compared to the results at 1g. The ground-based performance of UFOBs is promising, and their wetting dynamics and flux need to be evaluated in microgravity conditions to advance its technology readiness level. It is our hypothesis that due to the reactive nature of the UFOBs, they will achieve higher rejection rates and better water fluxes than conventional membranes under microgravity conditions, thereby paving the way for its use in future NASA missions.

20-ISS 2020-0004

In-Space Manufacturing of Assembled Lightweight Flexible Carbon-based Perovskite Thin Film Solar Cells with Radiation Stability in ISS

University Of Alabama, Huntsville

Director/PI: Dr. Dale Thomas

Science PI: Dr. Feng Yan

NASA MD: STMD

We propose in-space manufacturing of highly efficient and scalable carbon-based perovskite thin ilm solar cells and characterize its space radiation hardness in International Space Station (ISS). Long duration space missions require novel design and in-space manufacturing (ISM) to realize on-demand fabrication, repair, and recycling for the space application. In particular, the power of the entire ISS is provided by the solar panel which was manufactured on the earth. However, damage or break of the solar panel could generate severely power loss or accident for the ISS. Thus, it is desired to get fast repair and replace the solar panel through the ISM. The manufacturing process is very complicated and not suitable for the ISM due to the limited facilities, earth-independent, and microgravity conditions in the ISS. Therefore, to realize the ISM of the solar panel, an easy way to fit the limitation of the space working environment is needed. Particularly, a lightweight, stable, high efficient and flexible solar cell ISM is highly expected to repair or replace the broken or damaged solar panel in ISS.

Nowadays, the perovskite thin film solar cell becomes a new solar cell technology with high performance with power conversion efficiency >25%, and ultralow-cost per watt photovoltaic materials, and demonstrated radiation resistance. These advantages of perovskite solar cell technology promise the space application with affordable and sustainable solar energy during space exploration and ISS. However, conventional manufacturing of perovskite solar cells still suffers from the stabilities, degradation and short term durability. In this proposal, we employ the carbon-based perovskite solar cells for the space application by integrating the carbon electrode to prevent the space radiation and suitable for printing in space to demonstrate the in-space manufacturing of highly efficient and stable carbon-based perovskite for space application. If successful, this project will produce a new generation of solar cells that can be in-space manufacturing in demand and repair the solar panel in the satellite and ISS.

20-ISS 2020-0005

Evaluation of the Automated Small Format Nucleic Acid Extraction System for Use in MicroGravity Environments and on the International Space Station

University Of Vermont, Burlington

Director/PI: Dr. Bernard Cole

Science PI: Dr. Julie Dragon

NASA MD: SMD, STMD

NASA has made great strides in the last five years to develop a suite of instruments for the International Space Station (ISS) in order to perform molecular biology in space. However, a key piece of equipment that has been lacking is an instrument that can extract nucleic acids from an array of complex human and environmental samples with minimal astronaut interaction. Since all current earth-based automated DNA extraction instruments are designed of 1G gravity, they are not useful for applications on the ISS. The Omics in Space team, personnel from the University of Vermont Integrative Genomics Resource, and the Extreme Microbiome Project (XMP) have developed and tested the microTitan (simulated microgravity tested instrument for automated nucleic acid) system capable of automated, streamlined, nucleic acid extraction that is adapted for use under microgravity. The microTitan system has been evaluated using a whole cell microbial reference (WCMR) standard comprised of nine bacteria titrated at concentrations that would challenge the performance of the instrument as well as resolve detection limits for isolating DNA in the field.

The instrument is in an advanced prototype stage and has been tested in the field on samples collected at extreme environments including the hot springs at Yellowstone National Park and has proven to have extraction efficiencies equal to or greater than current earth-based instruments such as the Promega Maxwell system. It employs a novel reagent pack design compatible with microgravity and has been evaluate using Drop Tests experiments. The unit is a small format, low power consumption, capable of processing multiple samples (n=6) at the same time, and requires little astronaut interaction.

The object of this EPSCoR grant is 1) finalize the prototype design to be fully compatible with ISS operations, 2) deploy the device to the ISS, 3) perform six automated DNA extractions on the ISS using a "fixed" microbial whole cell reference samples developed by the Association of Biomolecular Resource Facilities metagenomic and microbiome research group (ABRF MMRG), and 4) establish performance results, and describe and characterize shortcomings of the instruments.

The benefits of this research in the area of microgravity are important on many levels. As humans drive deeper into space and microgravity environments, the need to perform DNA analysis become more critical for safety monitoring of food, air and water, but more importantly for astronaut and human.

20-ISS 2020-0006

High performance radiation hardened GaN high electron mobility transistors on silicon substrate for space applications

University Of Delaware

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NASA MD: SMD, STMD

NASA and general space missions for planetary exploration include acquiring information to understand environment, geology, volcanic activity, and seismic events. To complete these missions, long time operation of spacecraft with electronic systems to collect the information is indispensable. However, space is a harsh environment. Severe radiation and dramatic temperature variations can damage sensitive electronics. Thus, when selecting components for spacecraft electronic systems, we need to consider important parameters of the components such as radiation robustness and temperature tolerance. In addition, the cost, size and weight of the systems must be minimized. GaN high electron mobility transistor (HEMT) is one potential candidate for such applications due to its high switching speed, high breakdown voltage, and thermal and chemical stability.

Gallium-nitride transistors became available commercially in 2010, but they have not yet found their way into space instruments, despite their potential to reduce an instrument s size, weight, and power consumption. The radiation hardness of GaN transistors remains not well-explored and understanding of their radiation effects is still lacking.

This project will assess the radiation effects on GaN HEMTs. The specific objectives are: (1) to develop GaN HEMTs with innovative material design and fabrication process; (2) to examine the material properties and device performances of these transistors before/during/after space flight; and (3) to evaluate the effects of radiation on these GaN HEMTs and further enhance radiation hardness by optimizing the design.

This study will quantify radiation effects on GaN transistors, especially providing new radiation effect information for InAlN GaN-on-Si HEMTs. The success of this proposed work will enable GaN HEMTs to be applied in high temperature sustainable and radiation hard power amplifiers in satellites, low noise amplifier for RF satellite receivers, active electronically scanned arrays for increasing detection, navigation and earth observation capabilities. Ultimately, space systems with reduced size and weight, higher power efficiency, and greater resilience to radiation and temperature extremes will be delivered.

20-ISS 2020-0007

Acoustic Tractor Beams to Manipulate Fluids in Reduced Gravity

University Of Mississippi

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Science PI: Dr. Likun Zhang

NASA MD: SMD, STMD

Acoustic standing waves were used by NASA in the past two decades for non-contact control of fluids. The need for a reflector or a container to generate the standing waves limited the flexibility of that technique. This limitation inspires us to develop non-contact techniques using the recently developed acoustic travelling tractor beams, which have the flexibility for non-contact control of fluids in free space. The objective of the proposal is to demonstrate fluid collection using ultrasound beams as an acoustic tractor beam to collect and manipulate fluids in a microgravity environment.

Long-term microgravity exposure to the experiment provides a unique benefit of being able to study the acoustic interactions with the fluids without the interference that gravity provides. The operation process will be over a time scale longer than what is provided in parabolic flight. In the first phase of the project, the experimental apparatus will be developed and tested in ground experiments, including transducer design, fluid operation, and acoustic characterization, before deployment to the ISS. Data on ISS will be collected as videos to demonstrate the manipulation of fluid droplets in a microgravity environment and for later analysis. We expect to observe trapping and pulling of larger and multiple droplets by means of an acoustic beam. We will also compare the beam s trapping capability in reduced gravity to what is possible on Earth.

Fluid control by non-contact techniques is an important area of research for the International Space Station and relevant to NASA s strategic research and technology development priorities in fluid management technologies. Our investigation of fluid control using the recently developed travelling sound beams will open up a new flexibility for fluid control - particularly in a reduced gravity environment.

20-ISS 2020-0008

Efficient microgravity heat and mass transfer with no moving parts

New Mexico State University

Director/PI: Dr. Paulo Oemig

Science PI: Dr. Peter Vorobieff

NASA MD: SMD, STMD

We propose to demonstrate an efficient, noncontact method of transporting heat in microgravity. This new method does not employ any moving parts and requires only a modest power supply to drive low-impedance Helmholtz coils. This method has been extensively tested on Earth and there is strong evidence that it should work even better in microgravity environments.

In Earth s gravity field, heat and mass transfer in liquids occurs via convection, provided a destabilizing thermal gradient exists. In the microgravity environments of space, artificial convection must be used, which is generally accomplished by driving the fluid with mechanical action, and that requires motors, other moving parts and seals, raising reliability and maintenance concerns. To address these concerns, much attention has been focused on non-contact methods of inducing fluid flow. Magnetic fields are the focus of many proposed techniques, because it is easy to generate fields having large energy densities over significant volumes. Recent discoveries reveal that dynamic magnetic fields of very modest strength (order of milliTesla) can create vigorous, organized flows in dilute magnetic particle suspensions.

We propose to show that these discoveries isothermal magnetic advection (IMA) and vortex fluid formation with symmetry-breaking and rational fields can create highly efficient heat/mass transfer in space applications. IMA occurs when a uniform biaxial magnetic field whose frequency ratio is a simple rational number (e.g. 1:2) is applied to a 1-2 vol.% suspension of magnetic particles (platelets) in fluid. The flow rate increases as the square of the field magnitude. With triaxial magnetic field, vortex flow can form in the fluid, producing strong mixing and heat and mass transfer in complex, confined geometries and the flow direction can be controlled externally and with no moving parts. We shall find if a high degree of control of fluid heat transfer can be achieved in microgravity with triaxial magnetic fields. These studies will employ an enclosed cell filled with water and seeded with a small volume fraction of magnetic platelets. Heat transfer will be quantified using off-the-shelf point diagnostics. One part of the cell will be heated. In the absence of natural or artificial convection, heat transfer will occur only through diffusion and radiation, so any local heating will lead to a quick temperature rise. In a strongly mixed fluid the rate of heating will be much slower. The magnetic field will be comprised of two ac components and a small permanent field. Each ac component will require ~30 mW of power per milliliter of liquid at the 50 Gauss field that produced essentially maximum heat transfer on Earth. Each experiment would be less than 1 minute in duration, with the maximum power consumption not to exceed 30 W. We expect that in space the required field strength will be lower, since gravity-driven particle sedimentation will not occur. At 25 Gauss the power requirement would drop to ~7.5 mW/ml. Visualization of the flow patterns can further elucidate the physics of the flow. Results of microgravity and ground tests will be compared.

Our goal is to quantify control over heat/mass transfer as a function of the magnetic field parameters as an important first step to the implementation of this new technology in future space systems. The ISS is the perfect platform to explore the efficacy of this new approach in microgravity, where the ability to facilitate and control heat and mass transfer with no moving parts and very low power requirements may be indispensable.