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AL - 17-EPSCoRProp-0003

Micro-Magnetic Driven Design of Multi-Component Magnetic Alloys for Advanced Electric Propulsion

HEOMD, ARMD, STMD

Director: John Gregory

Sc-I: Claudia Mewes

Electric based propulsion has emerged as a strategic investment for NASA Aeronautics for the design and implementation of ultra-efficient aircraft to assist our nation in the transition to low-carbon propulsion. In electric motors, magnetic materials assist in the conversion of electrical energy to mechanical energy. During this conversion, alternating current energy losses occur which would be substantially reduced through the proposed development of a new class of (Fe,Co)-based amorphous and nanocrystalline magnetic composites. Such new materials will be a key requirement for NASA as it aims to improve the efficiency of electric motors that scale from the kilowatt to megawatt levels as outlined in NASA's next generation electrical and hybrid aircraft technical readiness plan. To provide a systematic development of these alloys, faculty at The University of Alabama (UA) will team with Glenn Research Center (GRC) scientists and engineers to create a synergistic partnership that leverages expertise and infrastructure at each institution. UA will lead a materials-by-design approach based on atomistic and micro-magnetic models that will predict the optimal phase distributions within these magnetic composites. Through the use of modern computational tools, we will be able to accelerate the experimental direction of processing of these alloys that will be done in partnership at the NASA facility. To assist NASA's processing control needed to achieve the modeled composite microstructures, UA will provided targeted phase transformation and kinetic studies of crystallization that will quantify the effects of annealing temperature and times on microstructural evolution. Furthermore, the analytical characterization of the materials will be forward fed back to our models to accurately capture the physics that gives rise to various magnetic attributes. Through joint UA-NASA magnetic characterization, we will verify, validate, and refine our models to the physically measured properties, with UA providing unique broadband thermomagnetic resonance studies that will reveal the loss performance in our alloys. This research positions UA-NASA as a formidable leader in nanocomposite magnetic material development through a closed loop interaction of modeling-processing-characterization. Through this research, the national workforce development in science and engineering will be strengthened by supporting the rising generation of STEM students as well as outreach programs that will inspire the next generation of scientists and engineers.

ND - 17-EPSCoRProp-0007

Derive phytoplankton size classes, detrital matter, particulaste organic matter and particulate inorganic matter from ocean color observation

SMD, STMD

Director: James Casler

Sc-I: Xiaodong Zhang

The Earth's oceans have absorbed nearly half of anthropogenic CO2 released into the atmosphere. One of the most important oceanic processes in sequestering atmospheric CO2 is net primary production by phytoplankton that fix inorganic carbon into organic matter in the sun-lit, surface ocean and its subsequent vertical transport to the ocean's interior. To better understand and quantify this biological pump requires detailed knowledge of spatial and temporal variations of phytoplankton community structure and other carbon pools. Ocean color remote sensing has revolutionized our understanding of global distribution of phytoplankton biomass and rates of primary production. However, significant uncertainty remains because (i) primary production varies among different phytoplankton species, which cannot be estimated adequately using a single measure of total biomass; (ii) other carbon pools, such as dissolved organic carbon, also play a role; and (iii) presence of mineral particles alters fluxes of organic carbon.

We propose to develop advanced inversion algorithms to infer global distributions of phytoplankton in three size classes (micro, nano, and pico), colored detrital matter, dissolved and particulate matter from remotely sensed ocean color data to support the studies of oceanic sequestration of atmospheric CO2. Dr. Xiaodong Zhang, a Professor with the Department of Earth System Science and Policy at the University of North Dakota will lead this effort as the Science-Investigator. His prior studies have led to the development of individual algorithms based on the field measurements that derive phytoplankton size classes and colored detrital matter from the spectral absorption coefficients and derive size and composition distribution of various biogeochemical stocks from the volume scattering functions. We will refine, revise and combine these individual algorithms into applications that can be used for satellite ocean color observation. Specifically, the developed algorithms will allow the retrieval of (i) phytoplankton concentrations in three size classes of micro (> 20 Âµm), nano (2 o 20 Âµm) and pico (< 2 Âµm) ranges; (ii) absorption at 410 nm and spectral slope of the colored detrital matter; (iii) backscattering by very small particles (of sizes < 0.2 Âµm); (iv) concentrations of particulate organic matter (POM) and particulate inorganic matter (PIM). The first two products will be estimate from ocean color o derived spectral absorption coefficient and the last two product from ocean color oderived spectral backscattering coefficient. We will test the developed algorithms over global ocean and estimate the associated uncertainty using collocated NASA ocean color observation and field measurements as well as additional field experiments.

The proposed project aligns with the areas of interest of the Earth Science Division of the Science and Exploration Directorate at NASA Goddard Space Flight Center (GSFC). In particular, it is relevant to the focus of NASA's Ocean Biology and Biogeochemistry program and NASA's upcoming PACE satellite mission. Dr. Jeremy Werdell at NASA GSFC, the Project Scientist for the PACE mission, will collaborate with us. His research and knowledge on in-water bio-optical algorithm development and validation of remotely-sensed data products will provide well-need expertise on satellite algorithm development and testing with NASA's ocean color data.

MT - 17-EPSCoRProp-0013

Satellite-guided hydro-economic analysis for integrated management and prediction of the impact of droughts on agricultural regions

SMD

Director: Angela Des Jardins

Sc-I: Marco P Maneta

The management of water resources among competing uses presents a complex technical and policy challenge that is amplified by economic and population growth, and climate change. With current water sources across the western U.S. under increasing pressure or fully committed, future water management options will shift from developing new water supplies to improving management of existing resources. Integrated hydro-economic models capable of simulating the hydrologic system in irrigated and non-irrigated regions and the response of water users, especially farmers, to hydrologic constraints and economic and policy incentives, provide a framework to understand biophysical and socioeconomic implications of changing water availability.

Satellite earth observations provide critical information to advance understanding of the hydrologic cycle and the water supply system. Unfortunately, satellite-based methods to forecast agricultural water demands in response to variation in water supplies have been limited by a lack of calibrated models that can anticipate human behavior, particularly how farmers allocate land and water. In this proposal we provide solutions to these limitations and contribute to improving the socioeconomic dimensions of the NASA Earth Sciences Program by developing transformative decision support tools that integrate the effects of climate and farmer adaptive behavior in the study of regional water supply and demand systems. We will implement an integrated hydro-economic model of agricultural production driven by ground observations, multi-sensor satellite observations, outputs from regional climate models, and socioeconomic data. Our modeling approach overcomes the limitations of current decision support systems for agricultural water management, and provides policymakers and natural resource managers with satellite data-driven, state-wide, operational models capable of anticipating how farmers allocate water, land, and other resources when confronted with new climate, policy rules, or market signals. It also quantifies how farming decisions affect agricultural water demands, the water supply system, and other water users.

The backbone of our method is an economic model of agricultural production adapted to ingest satellite-based remote sensing estimates of crop acreage, yield and evapotranspiration in a continuous, operational manner. Biophysical constraints to production (e.g. water available for irrigation, precipitation, energy) are provided by an integrated hydrologic model and by regional and global climate datasets. We will apply these methods to quantify drought related impacts on agricultural practices and socioeconomic behavior across cropland areas in Montana, which are representative of the intermountain west. Although we will initially focus in this area, the developed methods are flexible and extendable to other agricultural regions.

Our proposal responds to the current NASA EPSCoR solicitation by making innovative use of NASA Earth science data and models to develop improved water management strategies that promote a secure and sustainable use of water supplies for agriculture in Montana. It will also establish a statewide cluster of researchers that will develop capacity from other NASA programs, and from other federal and state agencies, and regional stakeholders. Maximal NASA EPSCoR impact in Montana will be achieved by leveraging the outreach capacity developed by other EPSCoR initiatives such as the Montana Institute on Ecosystems and by the Montana Water Center to transfer research products to end users, and to provide science-based solutions to the challenges faced by water managers in the state of Montana.

WY - 17-EPSCoRProp-0016

Igniting a New Era of Planet Discovery with FHiRE: A Precision Spectrograph at the WIRO Telescope

SMD

Director: Shawna McBride

Sc-I: Hannah Jang-Condell

Nearly 3,500 planets are now confirmed in close to 3000 other planetary systems. For the vast majority of these systems only a single planet is known, and only a tiny minority have accurately measured masses. Astrophysical research teams formerly satisfied with exoplanet discovery are now beginning to ask deeper questions about planetary system architecture. Is our solar system structure typical? What processes shape the formation and evolution of planetary systems? These questions can be answered by measuring orbits and masses for multiple planets in many systems. The University of Wyoming's 2.3-meter WIRO (Wyoming Infrared Observatory) telescope is ideally suited to acquire the long-term, high-cadence observations that will be required to make progress in this frontier area of astrophysics. The field of exoplanet discovery is poised to grow rapidly, so much so that NASA has begun funding spectrographs at ground-based observatories, and JWST and WFIRST will spend much of their missions characterizing planets.

NASA's Transiting Exoplanet Survey Satellite (TESS) mission will launch in 2018 and discover at least 5000 nearby small exoplanet candidates around bright stars during its 2-year mission. Since TESS will only carry out photometry to detect brightness variations during a planet transit in front of a host star, a great deal of ground-based work will be needed to eliminate false positives and measure the masses of bona fide planets. Specifically, planet masses will be measured using high-resolution spectroscopy by detecting radial velocity (RV) signatures, or the Doppler â€œwobbleâ€� of the host star as it is pulled by its orbiting planet. NASA estimates that several hundred candidates will require intensive spectroscopic observations. Knowing exoplanet masses is necessary before astronomers, collaborating with geologists, atmospheric scientists, and exobiologists, can infer their densities, chemical compositions, and atmospheres. This is truly an interdisciplinary field, offering UWyo astronomers a golden opportunity to create collaborations with these other scientists both within UWyo and externally. We propose to build and install a new echelle spectrograph, the Fiber High Resolution Echelle spectrograph (FHiRE), at WIRO which stands to play a major role in the coming decades of planet spectroscopy.

Funding from this EPSCOR proposal would enable us to transform a basic echelle spectrograph having a velocity precision of about 100 m/s into a planet-hunting powerhouse with the 1 m/s precision required to detect Jupiter or Saturn analogs around Sun-like stars, or an Earth-mass planet in a 10-day orbit around a low-mass star. The key to achieving this high precision is the construction of a vacuum chamber for FHiRE to stabilize the spectrograph with a temperature-stabilized Thorium-Argon lamp for precise velocity calibration. Addition of a next-generation octagonal optical fiber will also help achieve this benchmark. With these upgrades, we can achieve 1 m/s RV precision, enabling us to find Solar System analogs and embark on a decades-long research program in support of NASA satellite missions.

The technologies involved are well-understood and in use currently on other planet-hunting spectrographs such as the European HARPS.

During the three-year grant period, our team will complete the FHiRE instrument, commission it, write the necessary data reduction software, and embark on a long-term exoplanet survey in collaboration with NASA centers and the TESS Follow-up Observing Program (TFOP). Specifically, we will join the Recon Spectroscopy and Precise Radial Velocity Work sub-groups. By working with the TFOP teams, we will coordinate our efforts with the TESS Science Team and other groups around the world.

NV - 17-EPSCoRProp-0024

Life in Salts: a Multidisciplinary Investigation of Microorganisms and Biosignatures in the Death Valley Salt Pan

SMD

Director: Lynn Fenstermaker

Sc-I: Henry J Sun

Recent data from Mars indicate seasonal flows of brine in hillslopes (i.e., recurring slope lineae), raising the possibility of extant life in the shallow subsurface. Questions postulated include the following: Could the concentration of salts, notably calcium perchlorate, be too high even for halophilic bacteria because of their chaotropic (toxic) properties? How do we find the most promising sites? What does an evaporite/salts-inhabiting microbial community look like? Would such biology leave mineral as well as organic biosignatures that could be detected by the instruments on current and proposed missions? This proposed project will characterize a high fidelity terrestrial analog in which these questions could be addressed. Specifically, we propose to characterize a recently discovered, layered, endo-evaporitic microbial community in the Badwater Basin (Death Valley) and its environment.

Objectives are to (1) identify the microorganisms and redox energy in the different layers; (2) determine their tolerance for Mars-relevant major cations and ions, including Ca and perchlorate; (3) study formation of the biogenic mineral rosickyite (gamma sulfur) and S isotopic fractionations associated with the sulfur biogeochemical cycle and look for other biogenic minerals; (4) develop a thermal-hydrological model for salinity in evaporite as a function of precipitation and evaporation; (5) test NASA life-detection instruments, including SHERLOC, a spectrometer for Mars 2020; and (6) engage Nevada school teachers so they can inspire their students to pursue careers in STEM disciplines.

The proposed project is interdisciplinary o including molecular, physiological, geochemical, and hydrological components. Astrobiologists at the Ames Research Center and Jet Propulsion Laboratory as well as planetary mission participants from other institutions will be engaged via two mechanisms: (1) the three students will be co-mentored by a NASA collaborator, including a visit to the collaborator's laboratory to perform experiments using mission-relevant technologies and (2) these technologies will be tested in year three during the field campaign. These substantive collaborations between Nevada's three research institutions and NASA centers will provide the basis for subsequent joint proposal submissions to a variety of programs at NASA and NSF. This proposed project addresses a stated strategic goal of NASA: to search for life on Mars, and a major goal of the Nevada Governor's economic plan: workforce development and teacher training, especially in STEM disciplines.

LA - 17-EPSCoRProp-0029

Production of Fuels and Other Life Support Products Using Wastewaters as a Feed into a Space-Based Biochemical Conversion System (BIOSYS)

STMD

Director: Gregory Guzik

Sc-I: Mark Zappi

Human exploration activities on celestial bodies, such as the Moon and Mars, will produce human life support-derived wastes and consume fuel, water, and oxygen. Key waste streams to be expected include (1) Black Water (toilet-derived); (2) Food Wastes (kitchen-derived); and, (3) Grey Water (aka. hygiene water). Further, water and oxygen will both need to be conserved and recycled. Therefore, to sustain human life during extended off-Earth excursions, recovery of the carbon, oxygen, and hydrogen along with the microchemicals making up the food, water, and air provided to the astronauts is needed to reduce the frequency of expensive makeup deliveries of these life support products. The technology used to recover resources must operate using compact, low weight designs; utilize minimal energy and oxygen footprints; be simple to operate with low maintenance; and, recover a high percentage of the life support resource chemicals that can placed back into beneficial use. The ideal system should also be flexible and contain built-in failsafe mechanisms that can adjust as unplanned events occur; yet, maintain operational capacity.

The proposed Biochemical Conversion System (BIOSYS) will effectively treat all human activity-derived waste (black water, grey water, and food waste streams) while producing beneficial by-products: fuels, recycled potable water, oxygen, protein cake, and machinery lube oils. The BIOSYS concept is based on a series of successful projects performed by the Project Team over the past 15 years that focused on converting wastewater into value-added products. The key development goals for the BIOSYS project are (a) be energy and oxygen use neutral; (b) have a compact process footprint and low payload weight; (c) be capable of treating water and air to reusable qualities; and, (d) be capable of producing co-products that can also be used for life support.

The primary BIOSYS concept design utilizes a series of treatment steps to convert wastewater constituents and cabin CO2 into recovered beneficial life support products. The design is composed of both anaerobic and aerobic bioreactor units; lipids extraction; a microalgae reactor; and an adsorption polishing step. This design results in the treatment of the contaminants in the water to essentially zero concentrations. Several products will be produced as system outputs: (1) Hydrogen - fuel for fuel cells; (2) Methane - also as fuel for fuel cells or potentially fed into the aerobic bioreactor for producing more protein and/or lipids; (3) Recovered O2 - recycled back into the cabin environment; (4) Lipids - Production of “green” lube oils or used as a nutraceutical; (5) Protein Cake (with or without lipids) - a food source; (6) Soil Amendments - fertilizer; and, (7) Recovered Water - recycled as potable water. One challenge could be oxygenating the aerobic unit which causes an oxygen sink that may be too costly. Hence, to reduce energy/oxygen use, a design option which eliminates the aerobic stage and replaces it with a passive solids separator will be considered.

The research plan involves evaluation of each unit operation performance via small reactor systems operated using a wide variation of feed rates and composition to test normal and stressed performance. Optimized individual units will be integrated into a bench system that will, in turn, be evaluated for its operational performance under stress. Mass and energy balances across the entire system and in between each unit operation will be used to optimize the performance of the bench system. A pilot system will be constructed based on the work done in the bench phase and its performance will be evaluated. Payloads and systems operation protocols will be evaluated and included as part of a comprehensive design evaluation. Publications including reports, peer-reviewed papers, and presentations will be key products along with outreach to recruit future STEM majors interested in space exploration.

LA - 17-EPSCoRProp-0030

Understanding and Quantifying Carbon Export to Coastal Oceans through Deltaic Systems

SMD

Director: T. Gregory Guzik

Sc-I: Zuo Xue

This project focuses on critical carbon processes at the interface of human-natural ecosystems, addresses the transport of carbon through the land-sea interface, and supports the NASA major strategic goal to advance understanding of Earth. Lateral export of carbon from delta-dominated systems to the coastal ocean is still largely unknown. This carbon export driven by river discharge is considered in global carbon budgets a â€œleakageâ€� from the biosphere-atmosphere interaction that eventually ends buried in marine sediments and stored over long timescales. We propose to investigate two contrasting coastal sites across one of the world's most dynamic systems o the Mississippi River Delta plain - to evaluate carbon cycle at different stages of delta evolution: 1) the Barataria Bay region where the coastline is experiencing significant subsidence and land loss, and 2) the Wax Lake Delta region where a fast prograding delta is expanding. These two sites are analogues of contrasting response to climate change, sea-level rise, and human activity. Understanding these two contrasting environment is critical to assess the role of delta systems in carbon export to the coastal oceans at a global scale.

The objectives of this project are to (1) Quantify different forms of carbon (dissolved vs. particular, organic vs. inorganic) and nitrogen fluxes from two deltaic sites to the coastal ocean; (2) Evaluate carbon transformation along salinity gradients; (3) Connect delta carbon and nutrient export to the coastal ecosystem using a coupled numerical modeling approach; (4) Improve satellite algorithms to couple remote sensing information with biogeochemical processes in land and oceanic environments; and (5) Use state-of-the-art remote sensing data to evaluate coastal wetland (above ground) biomass and carbon storage. We plan to achieve these objectives by combining remote sensing, oceanography, carbon cycling, and biogeochemistry to understand key biogeochemical processes regulating water and carbon cycling in subtropical deltaic/coastal systems and to project water and carbon cycle's response to climate change.

The work will leverage and bolster existing NASA investments in observations and modeling of physical and biogeochemical ocean processes. In particular, we address Earth Science objectives 3 (â€œDetecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycleâ€�) and 4 (â€œEnabling better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate changeâ€�) under the NASA Strategic Goal to â€œAdvance understanding of Earthâ€� as identified in the NASA 2014 Science Plan. This work is also aligned with the area of interests of several NASA centers including the Goddard Space Flight Center and Jet Propulsion Laboratory. Project outcomes will contribute to the development of systematic approaches for exploiting next-generation remote sensing missions with higher spatial, temporal, and waveband resolution. The project will forge collaborative partnerships between Louisiana State University, the â€œflagshipâ€ university of Louisiana, and Southern University - Baton Rouge, lead institution for the largest Historically Black Colleges and Universities (HBCU) system in the nation. This project emphasizes students and faculty exchange, benefit teaching and research effectiveness, promotes diversity, and enhances scientific and technological understanding on the United States coast that is most vulnerable to the changing climate.

NE - 17-EPSCoRProp-0034

MORS: Modular Robotic Suit as an Exercise System for Maintenance of Muscle Strength of Astronauts during Long-Term Space Missions

HEOMD, STMD

Director: Scott Tarry

Sc-I: Jose Baca

The project described in this proposal targets the Human Health Countermeasures element, particularly, the Risk of Impaired Performance Due to Reduced Muscle Mass, Strength & Endurance. It targets gap M9: Identify and validate exploration countermeasure hardware for the maintenance of muscle function, and gap M7: Develop the most efficient and effective exercise program for the maintenance of muscle function. The Human Exploration and Operations (HEO) and Space Technology Mission directorates' goals and the Human Research Program's (HRP's) goals closely align with the objectives of this project, i.e., Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions. The HRP is dedicated to discovering the best methods and technologies to support safe and productive space travel. HRP's goal is to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration. The desired center will be JSC within the Human Adaptation and Countermeasures Division headed by Dr. Bloomberg.

KS - 17-EPSCoRProp-0037

Efficient and Compact Thermal and Water Management Systems using Novel Capillary Structure for Space Technology

HEOMD

Director: Leonard Miller

Sc-I: Gisuk Hwang

NASA requires next-generation spacecraft technologies, including efficient and compact thermal and water management systems, to extend human presence in space. NASA has employed liquid-vapor, phase-change-based thermal and water management systems, but limited performance per surface area (i.e., low heat flux) requires bulky systems and additional control systems. This results in complex and expensive spacecraft, CubeSat, spacesuit, and habitat designs. Improving evaporator and condenser performance using capillary forces would create lightweight thermal and water management systems that would function in space. Similar scientific and engineering challenges occur in sustainable energy, environmental, and industrial systems on Earth, including efficient electricity production, water boilers, water desalination, smart buildings, electronics packing, and food production. To solve these compelling research problems and address societal needs, research infrastructure will be established by five Assistant Professors with joint expertise at three Kansas (KS) research Universities [Wichita State University (WSU), Kansas State University (KSU), and University of Kansas (KU)], along partners at two NASA centers [Jet Propulsion Lab (JPL), Glenn Research Center (GRC)], two KS industries (WireCo, and Cargill, Inc.), and education centers (Cosmosphere, a NASA science museum in KS, and outreach centers at WSU/KSU/KU). This new research infrastructure in KS will stimulate research activities and empower a future Science, Technology, Engineering, Mathematics (STEM) workforce to solve research challenges for NASA over the next 30 years.

The proposed research will develop innovative evaporators and condensers using bimodal wick structures that enable (a) very high heat flux removal (1 kW/cm2) with extremely low thermal resistances (0.01 K/[W/cm2]) at large scales (>100 cm2), and (b) waste water recycling and humidity control. These research objectives directly address NASA's technological needs, including Heat Pipe Capillary-Based Loops (TA 14.2.2.5), Two-Phase Pumped Loop System Develop (TA 14.2.3.2), Micro- and Nano-Scale Heat Transfer Surface (TA 14.2.2.10), and Water Recovery and Management (TA 6.1.2), and Habitation (TA 6.1.4). Enhanced performance will reduce the weight and size of thermal and water management systems for successful future NASA missions and sustainable economic growth in KS.

Innovative evaporator and condenser designs require the combination of expertise in thermofluid sciences, advanced manufacturing, and image-based diagnostics. The proposed approach includes bimodal wicks to sustain liquid films for evaporation and remove condensed liquid in condensation. Bimodal wicks include micro-scale particles combined into larger, millimeter-scale structures for capillary wicking in space and on Earth. This work is enabled by laser-based, additive manufacturing to quickly prototype bimodal wicks, and X-ray-microtomography-based, 3D nondestructive analysis methods to characterize pores. The team will work together to fundamentally understand and create wicking structures with superior thermal performance that can be economically manufactured in space or on Earth. This work will train five graduate and five undergraduate students in an inter-university partnership combining experimental and theoretical approaches. The team has experience recruiting underrepresented students and will continue their successful strategies. The proposed education program will highlight this NASA research to hundreds of undergraduate students through coursework and several NASA student summer internships. Outreach programs in thermal science, manufacturing, and image-based diagnostics will be implemented in summer camps at the Cosmosphere and all three universities. The combination of research-based outreach and educational programs will create a pipeline to ensure a strong KS STEM workforce.

NH - 17-EPSCoRProp-0041

Application of antifreeze proteins and mimetic peptides in anti-icing surface coating

ARMD, STMD

Director: Antoinette Galvin

Sc-I: Krisztina Varga

Uncontrolled icing of surfaces can cause catastrophic impacts on ground and air transportation, utility networks, and communication transmissions throughout civilian and military sectors. The proposed project aims to achieve more profound understanding and control of the icing process via development of new protein-conjugated hybrid materials. The proposed research is highly multidisciplinary and will benefit from the synergy of investigators. Antifreeze proteins (AFPs) are ice-binding proteins produced in certain fish, insects, bacteria, and plants that live in cold climates and contribute to their freeze resistance. AFPs irreversibly bind to the surface of ice crystals preventing their growth and inhibiting ice recrystallization during temperature fluctuations (i.e. restructuring of small crystals into large lattices). AFPs have the unique property of depressing the freezing point of water without significantly altering the melting point, known as thermal hysteresis. AFPs retain their function when conjugated to polymers or surfaces, and we hypothesize that the incorporation of AFPs and antifreeze peptides onto a solid matrix (glass or polymer) will enhance antifreeze activity and protein stability. The results of this study will contribute to a better fundamental understanding of ice-binding and ice-growth inhibition by hybrid materials and lead to the future rational design of new cryo-functional materials.

The multidisciplinary team is uniquely qualified to carry out the proposed research due to their expertise in structural biology, biochemistry, polymer and peptide synthesis, surface chemistry, spectroscopy, microscopy, as well as their long research interest in studying the freezing process, ice nucleation, antifreeze activity, and the interaction of water with small molecules or macromolecules. AFPs will be produced using molecular biology techniques while short peptides and functionalized polymers will be synthesized by reaction engineering techniques. AFP and polymer structure will be characterized by NMR spectroscopy. Functionalized tailor-made polymers with multiple copies of grafted AFPs and peptides will be characterized by differential scanning calorimetry for thermal hysteresis activity of AFP-polymer conjugates and the interaction of water with AFPs. The antifreeze properties of the same AFPs and peptides anchored to glass and metal surfaces will also be measured and contrasted to their performance un-anchored in solution. Low temperature microscopy, ice nucleation studies, and ice adhesion measurements to the hybrid AFP or peptide conjugates will be measured in the Ice Adhesion Facility at CRREL, allowing us to gain insight into field performance of these AFP based hybrid materials both in space and terrestrial applications. We propose to characterize two AFPs (e.g. desert beetle and a plant), which most likely act by a different mechanism, which we anticipate will lead to a better fundamental understanding of the underlying mechanism of antifreeze activity.

The proposed research is well in line with the missions of NASA's Aeronautics Research Mission Directorate (ARMD), the Space Technology Mission Directorate (STMD), Human Exploration and

Operations Mission Directorate (HEOMD), and the Glenn Research Center (GRC). The project will make significant and direct contributions to the development of anti-icing technology with applicability in ground transportation and aviation, planetary exploration, and maintenance of instrumentation on the space station. Broader potential applications of AFPs include cryoprotection for improving the quality of freeze-dried (or frozen) foods, medications, biological materials (e.g. blood), and low temperature preservation of humans during long space travels. Microscopic and higher organisms genetically engineered with AFPs become cold resistant, which would optimize their survival in harsh conditions (e.g. ice caps of Mars) if humans were to colonize another planet.

VT - 17-EPSCoRProp-0042

Critical Gas-Surface Interaction Problems for Atmospheric Entry

HEOMD, STMD

Director: Darren Hitt

Sc-I: Jason Meyers

The scale of current planetary exploration missions is limited by existing Entry, Descent and Landing (EDL) technology to payloads on the order of the recent Mars Science Laboratory Rover. Future efforts require that new EDL systems, such as inflatable decelerators, be developed now so that the technology will be mature in time for implementation on planned missions. However, all current and proposed EDL systems are inherently limited by a lack of knowledge of fundamental gas-surface interactions. Many surface reaction rates driven by hot plasma gases remain largely uncertain, owing to the difficulty of measuring such rates in ground test facilities at conditions that are relevant to the flight environment. The 30 kW Inductively Coupled Plasma (ICP) Torch Facility at UVM is designed to allow such measurements. Using laser-spectroscopic measurement techniques, the facility has produced quantified reaction rates for a number of critical reactions. We propose to study oxygen and nitrogen recombination on such surfaces in Mars atmosphere plasma tests. This activity will address the apparent "super-catalytic" behavior of surfaces by isolating and quantifying the different surface reaction mechanisms at such conditions. A second experimental effort will assess nitrogen recombination on common heat shield materials, including PICA char and Fiber-form. The experimental results will then be integrated into a finite rate, surface chemistry kinetics framework within the existing UVM NGA/ARTS code. This numerical effort also will be used to study gas-surface interaction chemistry with multiple, competing reactions paths and to explore surface energy accommodation.

SD - 17-EPSCoRProp-0045

Wireless Body Area Network in Space: Development of Wireless Health Monitoring System with Flexible and Wearable Sensors

HEOMD, STMD

Director: Edward Duke

Sc-I: Yanxiao Zhao

The goal of this project is to develop a wireless body area network combined with flexible and wearable sensors that will comprise a health monitoring system for spacesuits. The project is directly related to priorities in the Human Exploration and Operations Mission Directorate and the Space Technology Mission Directorate of NASA. To address our goal, we have assembled a multi-institution and multidisciplinary research team from South Dakota School of Mines and Technology (SDSM&T), South Dakota State University (SDSU), and University of South Dakota (USD), along with collaborators at four NASA research centers (Johnson Space Center, Glenn Research Center, Ames Research Center, and Langley Research Center) and three industry partners (ILC Dover, L3 Communication Systems-West, and Nanopareil LLC). This collaboration is well positioned to address the grand challenges in technology and science of wireless communication, sensor development, nanomaterials, and occupational health for a next-generation health monitoring system relevant to NASA missions.

This project proposes an integrated research plan to (1) design and implement a robust, efficient, and secure wireless body area network of sensors for collection and transmission of real-time and multi-dimensional physiological data of human bodies; (2) develop prototype wireless sensor nodes of wearable biomedical and strain sensors that are lightweight, conformable, ï¬,exible, and stretchable; (3) integrate innovative wearable sensor nodes into the wireless body area network and evaluate the performance of network; and (4) build new research infrastructure and capability for wireless sensing systems and ï¬,exible sensor development in South Dakota. In addition to the research goals, the other objectives of the project are (1) to provide high-quality research and education for K-12, undergraduate and graduate students; (2) to strengthen the science, engineering and healthcare programs at SDSM&T, SDSU and USD; (3) to foster close partnership with NASA research centers, industry, and academia; and (4) to initiate new technology commercialization and promote economic development in South Dakota.

The outcome of the project will enable a wireless network system for real-time and multi-dimensional monitoring of the physiological parameters of the human body, which will provide key technologies for evaluation of health impacts of the space environment on astronauts. Additionally, this project will contribute significantly to the research and education infrastructure of South Dakota, further strengthen the relationship with NASA by creating recruitment opportunities for NASA research centers, and promote economic development in the state. These outcomes are directly relevant to NASA's Technology Roadmap area TA 6: Human Health, Life Support and Habitation Systems; as well as other areas including TA 4: Robotics and Autonomous Systems; TA: 8 Science Instruments, Observatories, and Sensor Systems; and TA: 12 Materials, Structures, Mechanical Systems, and Manufacturing. This project is also directly related to research foci of the "2020 Vision: The South Dakota Science and Innovation

Strategy" in Human Health and Nutrition, Materials and Advanced Manufacturing, and Information Technology and Cyber Security.

OK - 17-EPSCoRProp-0048

Space-borne Antennas & Circuits for Condensed Radars and STEM (SPACERS)

SMD, HEOMD

Director: Andrew Arena

Sc-I: Hjalti H Sigmarsson

The University of Oklahoma (OU) team's partners at the NASA Goddard Space Flight Center (GSFC) are currently designing EcoSAR, a new polarimetric, interferrometric, synthetic aperture radar (SAR) system that will provide unprecedented two- and three-dimensional fine scale measurements of terrestrial ecosystem structure and biomass. The design of this radar was conceived in approximately 2010, with a vision that a terrestrial radar would be developed first, which would pave the way for the design of a space-borne radar in the future. A recent partnership between members of the OU team and GSFC resulted in the development of advanced digital radar techniques for EcoSAR. These techniques have enabled a new class of radar operations that improved science, enhanced system performance, facilitated a path for space-borne implementation, and pushed technology beyond the current state-of-the-art, while keeping the costs low.

The goal of the proposed effort is to combine the recently developed digital radar techniques with new and innovative, adaptive radar hardware to help NASA move towards space-borne applications of new radar systems like EcoSAR. This will be achieved by splitting the effort into five tasks: 1) Transmit/receive module development. The transition from terrestrial to space-borne necessitates higher transmitter power levels, which will result in signal degradation due to non-linear behavior of the electronics as well as increased power consumption. These issues will be addressed by designing a new high-efficiency power amplifier with improved linearity from using digital predistortion. 2) Radar fairing design, flight experiments, and data collection. NASA's Digital Beamforming Synthetic Aperture Radar (DBSAR-2) will be used to test engineering ideas and collect high quality radar datasets. In order to achieve that, DBSAR-2 needs to be prepared for flight. A fairing will be designed and flight experiments performed. 3) Space-borne antenna design. For any antenna to be deployed in space, its size and weight are major concerns. A new miniaturized antenna design will be pursued and an adaptive matching network will be designed and integrated. The purpose of the matching network is to increase the angular scanning capabilities of the radar. Scientifically, this will allow the radar to create imagery at wider angles. 4) Waveform optimization. The quality of the waveform used in the SAR algorithms will be analyzed and optimized. Mathematical optimization methods will be utilized to determine what kind of waveform is best-suited for optimal system performance. 5) Meteorological sciences. In this task, previously collected terrestrial data from surface, airborne, and current NASA space-borne remote sensing platforms will be analyzed. A key component of the work will serve to bridge the critical design elements and engineering requirements of the hardware design with the encompassing needs of the scientific community focused on ecosystem dynamics in relation to critical drivers including weather, climate, and available water resources.

The students, who will be under the guidance of the OU team and the NASA mentors, are the common link between NASA and university education mission. By training students in the classroom and lab, they will learn about new technologies and go on internships at the GSFC. These internships are crucial to the success of this effort, as they are one of the primary mechanisms by which knowledge from OU is directly transferred to the labs at NASA. This directly supports the NASA 2014 Strategic Plan's focus on the development of science, technology, engineering and mathematics (STEM) disciplines.

The OU team is diverse, consisting of a mixture of assistant professors and full professors from three universities across the state of Oklahoma. World class facilities are available to the team both at the Advanced Radar Research Center in Norman, and the Unmanned Systems Research Institute in Stillwater.

SC - 17-EPSCoRProp-0050

Nanomaterials-based hybrid energy storage devices and systems for space applications

HEOMD, STMD

Director: Cassandra Runyon

Sc-I: Apparao M. Rao

Project Outline: Energy storage systems are critical for all robotic and crewed missions which comprise up to ~30% of a spacecraft's mass. Many state-of-the-art (SOA) energy storage systems are limited by their low efficiency, heavy components, and a high degree of sensitivity to extreme environments, however. Most SOA energy storage technologies need improvement in specific energy, safety, reliability, and durability (Hill et al. NASA Technology Roadmaps: Technology Area 3; May 2015). This project will address these limitations through the development and integration of nanomaterial-based hybrid energy storage devices with energy generation technologies for efficient power management.

Alignment with NASA and SC EPSCoR priorities: This project is well aligned with the following NASA Space Technology Mission Directorate (STMD) priorities: (1) Space Power and Energy Storage Roadmap, Technology Area (TA) 3, (2) Nanotechnology (TA 10), and (3) Thermal Management Systems Roadmap, TA 14; and the SC Science and Technology Strategic Plan Vision 2025 (R&D, Education and Outreach, and Economic Development).

Project Objectives: (1) To establish a strong and sustaining research and development program that builds upon our existing strengths and collaborations with NASA, specifically in energy storage devices for space applications. The project objectives will be achieved through the integration of: (a) multiple project elements ranging from materials development to device or component level demonstration performed jointly by the team, our NASA and industrial (Cornell Dubilier, Inc.) partners; and (b) educational energy programs developed at Clemson and Orangeburg-Calhoun Technical College (OCTech) with hands-on technology transfer through our industrial collaborators (such as Cornell Dubilier, Inc.) to promote human resource development within SC. (2) Our most challenging goal entails sustaining the program beyond EPSCoR support, which we will achieve through the establishment of a NASA funded energy center between the Clemson Nanomaterials Institute, the Clemson University International Center for Automotive Research, and the OCTech robotics and automated manufacturing division.

Method of Approach: The fundamental limitation of today's batteries is the lack of lightweight recyclable electrode materials that can store and rapidly deliver high amounts of charge safely for at least a thousand cycles without degradation. We will addresses these challenges through the development of: 1) high-capacity nanostructured cathodes (e.g., NMC) and anodes (e.g., Si) for Li-ion batteries, 2) engineered current collector-active material interfaces (CCAMI), 3) boron nitride-based thermal management nanomaterials to prevent localized hot spots and evenly distribute the heat within a battery pack, and 4) battery thermal management systems for real-time monitoring, estimation and control, with the ultimate goal to significantly downsize the battery pack while ensuring the same performance and safety.

Expected Outcomes: This project will establish a self-sustaining research cluster on energy and power storage for applications relevant to NASA and other federal agencies. We will leverage our existing partnerships with NASA scientists, local industrial partners, and national lab collaborations (Oak Ridge and Savanna River) for sustaining this program through a federally funded research center. We expect that this project will lead to blueprints for batteries with a longer lifecycle and higher energy and power density. Importantly, this project will improve both cathodes and anodes to achieve safer and high-energy density Li-ion batteries. Nanomaterials-based novel thermal management systems for battery packs will be developed with enhanced capability to monitor and optimize battery pack usage. Lastly, this project will establish new energy certification programs to train underrepresented minorities and promote a 21st century energy workforce.