

## **New Mexico NASA EPSCoR**

### **Researcher:**

Nikolai Kalugin

**Research Title:** Sensitive Fast Selective Tunable High Temperature photodetectors for Space Research, Human Health and Structural Monitoring of Aerospace Structures.

### **Project Description:**

We propose to address NASA needs for sensitive fast tunable infrared photodetectors for 1) infrared aerospace spectroscopy (SAFIR, SPIRIT, ESPRIT, CALLISTO, SOFIA, and other projects, 2) for Far-Infrared tomography health control systems for astronauts, and 3) for infrared structures health monitoring systems (SHM) of aerospace structures (damage accumulation and gradual degradation of material properties is the fundamental problem in operation of aerospace structures). Our work will be coordinated with partners in the NASA JPL. The proposed project will benefit the State-funded aerospace engineering (both undergraduate and graduate) programs in New Mexico. The cross-disciplinary nature of the project will allow NMT students to better understand fundamentals of GaAs and carbon-based materials for aerospace applications, and gain skills required in contemporary job market. The proposed project will support the PI's efforts to set up the Nano-Optoelectronic Materials and Device Laboratory at the Materials and Metallurgical Engineering Department of New Mexico Tech. The project will definitely boost the development of NASA-oriented research program in the New Mexico Tech. It will help increase the number of MATE graduates from NMT, familiar with/oriented on research important for NASA.

## **New Mexico NASA EPSCoR**

**Researcher:**

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**Research Title:** Concept Study of using a Passive Mechanism to Simulate Walking on the Moon

**Project Description:**

The goal of this small EPSCoR project is to conduct a preliminary study of an innovative technology of using passive mechanism to compensate the gravity force for training astronauts walking on the Moon or another reduced-gravity environment. The technology is based on static balancing of gravity forces using spring enforced parallel mechanisms. In the project, a simplified prototype mechanism will be designed, built, and tested. The test will help: 1) better understand the theory and explore potential issues unforeseeable from the theory; 2) investigate several known influential issues such as spring design, dynamic loading, and joint friction; and 3) improve the design concept to make it practically feasible. The new technology will provide a low-cost, very reliable, and easy-to-use alternative means to meet the increasing need of EVA training for NASA's future manned planetary exploration missions.

## **New Mexico NASA EPSCoR**

### **Researcher:**

Peter Hofner and Michelle Creech-Eakman

**Research Title:** A Multiwavelength Investigation of Massive Protostars

### **Project Description:**

Despite the important role which massive stars ( $M > 8 M_{\text{sol}}$ ) play in essentially all research areas of Astronomy, their formation mechanism is poorly understood. Observational and theoretical work of the last few years resulted in a database of massive protostellar candidates and several competing theories attempting to explain how the massive star is assembled within a dense molecular core. The recent surveys performed by NASA's SPITZER infrared telescope allow a systematic investigation of the massive star formation process. Here we propose to carry out this investigation using multiwavelength techniques which bring together information from the radio, infrared and X-ray wavelength bands. Based on the SPITZER data we will use the data archive of NASA's X-ray mission CHANDRA, as well as radio archives provided by NRAO to compile a large multiwavelength catalog of massive protostars. For a small sample we will carry out a detailed investigation combining the multiwavelength data with the goal of critically testing existing theories of massive star formation. In the future, we will continue this research for a larger sample. The proposed project is thus necessary as a proof of concept, and at the same time will allow to build the necessary expertise to carry out this research. We will seek future funding from NASA and NSF for a large scale continuation of this project, and the results produced in this pilot study will strongly increase our chances of success.

## **New Mexico NASA EPSCoR**

### **Researcher:**

Rafiqul A. Tarefder

**Research Title:** Predicting Failure Behavior of Polymeric Composites in Space Vehicles Using a Unified Constitutive Model

### **Project Description:**

Understanding and prediction of the failure (i.e. damage and cracks) behavior of polymeric composites play vital roles in the design and safety of space vehicles such as aircrafts, spacecrafts, missiles, satellites, and launch-system. The traditional finite element fracture models require defining crack location or crack zone in the model geometry and parameters. The research proposed herein is a unified modeling approach, which allows to model elastic, plastic, and creep strains, micro-cracking, and fracture leading to damage in a single framework without requiring to define a crack location or zone. Thus the proposed unified modeling approach has advantages over the traditional fracture mechanics approach. In the proposed study, principles of mechanics and physics will be invoked to derive a simple unified constitutive model, which will be implemented in a numerical scheme (i.e. finite element) to predict failure behavior of composites. In particular, the proposed research will involve numerical modeling of damage and crack growth in simple panels made of IM-7/977-2 composite, which is space qualified. The proposed model will be validated using laboratory tests and data from literature. It is hoped that the validated model will be used to study design life of space vehicles and complex aerospace components such as turbine vanes, blades, disks, rocket nozzle liners, etc subjected to complex service loadings. The proposed research may lead to the development of tools for designing durable aircrafts and spacecrafts for safe satellite missions, which is the current focus of NASA's Aeronautic Research Mission Directorate.

## **New Mexico NASA EPSoR**

**Researcher:**

Robert A. Paz

**Research Title:** Simulating Reduced Gravity in Space Flight Training Using an Exoskeleton

**Project Description:**

The overall goal of this project is to develop and demonstrate one of the most critical enabling technologies required for developing space flight motion simulators. These next-generation, end-to-end (from launch to landing), 6-degree-of-freedom (6-DOF) simulators will provide the realistic motion and visual cues for training space travelers. They will also support the future of personal space flight. The technology to be developed uses computer controlled exoskeletons to allow a human limb to move freely as if in a zerogravity or reduced-gravity environment.

## **New Mexico NASA EPSCoR**

### **Researcher:**

Sayavur I. Bakhtiyarov

**Research Title:** High Performance Turbojet Engine Nano-Lubricant

### **Project Description:**

Development of new class lubricants for turbojet engines is one of NASA's high priority research and developments areas. It necessary to design high-quality lubricants based on low-viscosity oils and special high-performance additives. Application of common chemically active additives does not provide solution to the problem as in the environment of low-viscosity petroleum oils they can not prevent the fatigue failure (pitting) of sliding surfaces. Our recent investigations showed that the amorphous fine carbon (AFC) additives, obtained, for example, via oxidizing pyrolysis of methane during production of acetylene, improves the resistance to mechanical, chemical and abrasive scuffing and fret. In the proposed research project we will perform the comparative SEM, TEM and Auger-spectroscopic investigations of structure of friction surfaces of several objects (rollers, bearings, racers, small balls, gears, and model test pieces working in the environment of oils with the AFC additives and the commercial oils) carried out on micro and sub-micron level showed a simultaneous presence of different structural states of carbon on the rubbing surfaces. After tribo-activated conversion of the AFC a specific, secondary, hetero-phase structure formed on the rubbing surfaces will be analyzed. Based on the obtained results we will develop a method for surface film formation on the rubbing parts of mechanisms made of steel, cast iron and other iron alloys, in order to increase the resistance to wear and reduce friction. The new transmission motor oils could provide increase of the automotives lifetime for 20% and the transmission efficiency at the temperatures up to -500C.

## **New Mexico NASA EPSCoR**

### **Researcher:**

Shuguang Deng

**Research Title:** Hydrogen Storage in Metal-Doped Ordered Mesoporous Carbons for Fuel Cell Applications

### **Project Description:**

A research project focused on the development of a novel adsorbent for hydrogen storage is proposed. Based on our previous research we proposed to apply the ordered mesoporous carbon (OMC) for removing organic sulfurs from hydrocarbon fuels by selective sulfur adsorption. This adsorbent has the advantage of extremely large specific surface area (~6000 m<sup>2</sup>/g), high accessible pore volume (0.87 cm<sup>3</sup>/g) and uniform pore size distribution with average pore diameter of 6 nm and very fast kinetics if hydrogen adsorption. If this material is doped with a metal that has a strong affinity for hydrogen with a suitable technique, it could give rise to very high hydrogen uptake through the spillover mechanism even at ambient conditions. NMSU will synthesize the ordered mesoporous carbon adsorbents, dope it with palladium and platinum, make all possible materials characterization of SEM/TEM imaging and XRD pattern, evaluate adsorption equilibrium and kinetics, generate heat of adsorption curve and provide five adsorbent samples for NASA White Sands Test Facility to validate the adsorbent developed in this project. The ultimate goal of this project is to develop a cost-effective and safe on-board hydrogen storing process using physisorption.

## **New Mexico NASA EPSCoR**

### **Researcher:**

Zayd Chad Leseman and Jonathon Phillips

**Research Title:** Growth of Carbonaceous Materials for Enhanced Material Properties

### **Project Description:**

This proposal encompasses a technology that leads to the growth of carbonaceous materials that have the potential of having enhanced materials properties and the ability to enhance other materials through creation of composites. Thus far, the PI has been able to grow graphite and carbon filaments at significantly lower temperatures, < 750K, than any other existing technique for growth of carbonaceous materials. Moreover, the carbonaceous materials *only* grow on a catalytic template, which allows for targeted growth of said carbonaceous materials. These materials are of high interest to many missions of NASA. Specifically, these materials can be used to make molecular electronics, increase thermal management, and create materials with higher stiffnesses and strengths. Thin sheets of graphite (graphene) are believed to be the ideal candidate for molecular electronics. Though, this advancement itself will not contribute significantly to decreasing of payload, it will enable lower energy consumption, which will impact battery size and the overall size of the payload. Interwoven carbon filaments and/or graphite used in its bulk form can be used to create materials with higher thermal conductivities, stiffnesses, and strengths. This can be accomplished by using the bulk materials or adding them to a matrix material and forming a composite. Improvement of these thermal and mechanical properties will allow for decreasing of the payload size as well.

## **New Mexico NASA EPSCoR**

### **Researcher:**

John Wilson

### **Research Title:**

Carbonate dissolution in mixed waters due to ocean acidification and sea-level rise

### **Project Description:**

Much of the anthropogenically released atmospheric carbon dioxide has been stored in the ocean, causing a 0.1 decrease in ocean surface pH, with models predicting that by 2100 the surface ocean pH will be 0.5 below pre-industrial levels. In mixed ocean water – fresh water environments (e.g. estuaries, coastal aquifers, and edges of ice sheets), the decreased ocean pH couples with the mixed water chemistry to make water more undersaturated with respect to calcium carbonate than ocean acidification alone. Mixed-water calcite dissolution may be one of the first directly observable effects of ocean acidification, as the ocean water and the fresh water can both be saturated with respect to calcium carbonate while their mixture will be undersaturated. While the mixed-water effect is widely applicable, this proposal focuses on implications for coastal and island aquifers, and the potential for an increased rate of mixed water speleogenesis and porosity/permeability development. The proposal also accounts the indirect effects of rising sea level and a growing coastal population on these processes. The product will be a basic quantitative model that can predict mixed water dissolution in coastal freshwater aquifers, using temporally changing sea level, ocean pH, precipitation, acidity of precipitation, and groundwater pumping. Applications will be to coastal areas such as the unconfined Floridan aquifer of the United States or the Yucatan Peninsula of Mexico.

## New Mexico NASA EPSCoR

**Researcher:**

Steve Stochaj  
Laura Boucheron  
Tom Harrison

**Research Title:**

Automated Image Analysis of Calorimeter Data for Determination of Particle Identity and Energy

**Project Description:**

Apply newly developed automated image processing techniques to analysis of imaging calorimeter data taken with instruments for high-energy, particle astrophysics. The nature of dark matter is the most fundamental question currently at the forefront of physics, astronomy, and cosmology. The use of imaging calorimeters for particle astrophysics was pioneered at NMSU with a series of balloon flights starting in 1989. Over the past 20 years these instruments have been improved and are widely used on balloons and space-based missions for astrophysics. However, developments in the analysis techniques have progressed more slowly. This project will focus on developing an improved methodology for determining energy and identity of particle from their signals in imaging calorimeters. The state-of-the-art in particle identification produces a separation between electron events and proton events of  $10^5$ . This means that 1 in every  $10^5$  is misidentified as an electron. This work applies some of the newest image processing techniques from electrical engineering to the analysis of imaging calorimeter data with the goal of improving the separation of electron and proton events by an order of magnitude ( $10^6$ ). If successful, the algorithms developed through this work could find widespread use throughout the worldwide astrophysics community. This work will strengthen NMSU's contribution to the collaboration and will put the university in an excellent position to have a major role in NASA's Orbiting Astrophysical Spectrometer in Space (OASIS) mission.