**EPSCoR RID Minigrants: 7/6/2009 – 7/5/2012**

**2009-2010**

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| **P.I.** | **Institution** | **Research Area/Abstract** |
| John Armstrong | Weber State University | **HiSAM- High-Altitude Stratospheric Aerosol Monitoring Using the HARBOR Balloon Platform** – Enhance the scientific utility of HARBOR by: 1) Development two robust and inexpensive platforms for monitoring dust and aerosol properties over the Intermountain West. One platform will be operated by the Weber State University HARBOR Flight Team and another by the Utah State University HARBOR Flight Team. The platforms will be operated in geographically distinct areas to characterize the regional variation of atmospheric aerosois; and 2) Develop a set of robust, reusable vehicles for instrument design, space-flight instrument testing, and “guest observer” programs. The primary outcome of this work will be to “enhance the national competitiveness in aerospace” research by providing a new near-space platform for regional researchers and “promote statewise cooperative participation by research institutions” in aerospace-related research. |
| Shane Larson | Utah State University | **Low Frequency Gravitational-Wave Binaries** – Compact degenerate binaries in the Milky Way galaxy will be the most numerous sources detected by the Laser Interferometer Space Antenna (LISA). Theoretical studies and population synthesis models have predicted that the galaxy will contain tens of millions of evolved compact binaries where the individual components are combinations of white dwarfs, neutron stars and stellar mass black holes. The consequence of the existence of this source population is that in the low frequency gravitational wave band covered by LISA a significant signal from the galaxy will always be present in the data stream, and the signal will be confused for frequencies fc < 3mHz. Below this frequency, multiple overlapping binaries will contribute to the gravitational wave signal at every frequency, making it difficult or even impossible to resolve the data into the contributions from individual sources. The work presented here will explore how LISA observations enable direct probes of the underlying astrophysics that drives the evolution and character o the compact binaries. Furthermore, this work will also examine how LISA’s characterization of the compact binaries can be exploited to probe the stellar fossil record of the galaxy. This supports the astrophysics objectives of NASA’s current Science Plan. |
| Joseph Orr | University of Utah | **A Prototype Miniaturized Metabolic Gas Analysis System** – Man’s exploration of space has presented some challenging physiological problems, of these; bone loss is only partially reversible and cardiovascular deconditioning and muscular atrophy take a considerable length of time for recovery upon return to earth. It is hoped that cardiovascular or weightlessness decondition can be quantified and tracked by periodic exercise stress tests. We expect this project will result in: 1) A working prototype exercise metabolic gas analysis system that is small, light, efficient, and accurate; 2) Data demonstrating the prototype flow sensor to be accurate within 3%; 3) Bench test data showing the oxygen uptake measurement to be accurate within 5%; 4) Application to both industry and NASA for continued funding for this work. |

**2010-2011**

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| **P.I.** | **Institution** | **Research Area/Abstract** |
| John Colton | Brigham Young University | **Electrons in semiconductor quantum dots: spins and optics** - Quantum dots (QDs) are zero-dimensional nanostructures created by confining one or more electrons in all directions.  The PI proposes experiments (a) to study and control the electron spin states in semiconductor QDs, and (b) to assist in optically characterizing certain semiconductor QDs being designed by collaborators for potential infrared detector and solar cell applications. *Quantum dots in quantum computing*. Spin-based quantum computing is the idea to use quantum mechanical spin states (called “spins” hereafter for simplicity) in quantum dots as the “1”s and “0”s of a computer for storage and calculation. Quantum computers will be able to solve certain kinds of problems exponentially faster than classical computers. Examples of such problems include database searching,1 solving systems of linear equations,2 and the cryptography-related task of factoring large numbers into primes.3 Spin states of electrons in semiconductor quantum dots were first proposed as quantum-mechanical bits (qubits) of such a computer in 1998,4 and have been the subject of much research ever since. |
| Kyle Dawson | University of Utah | **Development of Remote Capabilities for the Willard L. Eccles Observatory and Characterization of the Site for Astronomical Observations** - The Department of Physics and Astronomy at the University of Utah has recently constructed a new astronomy research facility in southern Utah known as the Willard L. Eccles Observatory (WEO) at Frisco Peak. This new facility hosts a 32-inch optical telescope that was built using grants from the Willard L. Eccles Foundation and the E.R. Dumke & E.W. Dumke Foundation. We will use WEO for research of transient astronomical phenomena, undergraduate and graduate projects, and public outreach in Salt Lake City and rural Utah. We request funds to develop the observatory for remote observations from Salt Lake City and to characterize the quality of the site for astronomical observations. This effort will be used to justify upcoming proposals to equip the telescope with a new, custom, infrared imaging camera. |
| Ludger Scherliess | Utah State University | **Morphology and Causes of the Weddell Sea Anomaly** -Until recently, it appeared that the climatology of the ionosphere was well known and that its physics and chemistry was understood. However, the multitude of recent observations from satellites like NASA’s IMAGE and TIMED satellites, the TOPEX/Jason satellites, and from the six US-Taiwan joint project Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) satellites have given us an unprecedented global view of the ionosphere that has not been previously available. These observations have revealed that the 3-dimensional morphology, variability, physical causes and correlations within the ionosphere and the coupled ionosphere/thermosphere system are not fully understood and force us to reconsider our understanding of the climatology and the variability seen in the ionosphere. One of the most outstanding ionospheric structures is the Weddell Sea anomaly, which is a phenomenon in which the ionospheric electron densities are larger at night than in the daytime during southern hemisphere summer months. Figure 1 shows an example of the ratio of the nighttime to daytime peak electron densities observed by the COSMIC satellite. Clearly seen is the Weddell Sea anomaly as a large red spot between the southern tip of South America and  Antarctica. This density structure has large effects on GPS and HF communication systems. Although the anomaly was first reported many decades ago by *Bellchambers and Pigott* (1958)  using localized ionosonde measurements, its global extend has only recently been determined (Horvath, 2006). To date there is no clear explanation for the cause of this phenomenon and  global coupled Ionosphere/Thermosphere models fail to reproduce the structure (A. Burns, private communication). Furthermore, the 3-dimensional morphology that underlies this structure is currently not known. |

**2011-2012**

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| **P.I.** | **Institution** | **Research Area/Abstract** |
| Heng Ban | Utah State University | **Novel Nanoscale Characterization of Advanced Thermoelectric Materials** - We propose to develop a new measurement technique that can probe the local thermoelectric power of semiconductor nanostructures. The novel method will be based on the use of a dualprobe Atomic Force Microscope (AFM), which is being purchased by the PI under a separate federal equipment grant. The high-vacuum AFM system can heat the probe tip and measure the tip temperature as the tip contacts a surface, and is planned to be used to determine local thermal properties at 10-100 nm scale. This project will further develop the system to measure the electromotive force (EMF), i.e., Seebeck coefficient. Such a measurement technique will be the first of its kind in the world. The nanoscale capability will be able to reveal the thermoelectric power change across a p-n junction and provide information on band structure and carrier concentration of semiconductor junctions at nanometer resolutions, which could significantly advance the development of thermoelectric, electronic, and optoelectronic devices. This project will characterize newly developed thermoelectric materials in collaboration with NASA Marshal Space Flight Center (MSFC). The project will support a graduate student and an undergraduate student will also be involved in the laboratory research. |
| Brad Bundy | Brigham Young University | **Engineering Controlled Covalent Protein Immobilization for Planetary Exploration with Next Generation Lab-on-a-Chip Technology** - We propose the development of a technology to attach proteins to surfaces in a covalent, site-specific and minimally invasive manner. The work would have direct application to NASA’s current Lab-on-a-Chip Applications Development division (LOCAD). The successful development of our technology would impact the development of next-generation Chips by: 1) Increasing the number of molecules which could be tested on a single Chip; 2) Increasing the reliability, stability and reusability of Chips; and 3) Decreasing the weight of Chips and thus the cost of transport. Specifically, we propose to apply recently developed technology to incorporate an unnatural amino acid (unAA) in a controlled unique location **(Figure 1A)**. This unAA will serve as a unique chemical moiety to enable the covalent attachment of a protein directly to a surface. For this purpose, the highly selective, reactive, and biocompatible Copper-catalyzed Azide Alkyne Cycloaddition (CuAAC) will be used **(Figure 1B)**. The attached protein will be assessed for increased reliability, stability, and reusability and optimized for attachment density. This will have a transformative impact on Lab-on-a-Chip technology **(Figure 1C)**  being developed for chemical assays during planetary exploration (e.g. NASA/ESA ExoMars Mission) as current protein-surface attachment technology is non-covalent (unstable under non-biological conditions), non-specific, and/or damaging to the protein. |
| Shane Larson | Utah State University | **Wide-field Variability Search Strategies for Multi-Messenger Astronomy** - Gravitational-wave astronomy is an emerging observational discipline that utilizes propagating gravitational disturbances, rather than light, as a probe of astrophysical systems. The modern landscape of gravitational wave astronomy is dominated by *laser interferometric observatories*, most notably the NASA Laser Interferometer Space Antenna (LISA)[1], and the American LIGO (the largest experiment ever funded by the National Science Foundation)[2]. In today’s era where tight budgetary constraints are an important aspect of experimental design and mission evaluation, maximizing the science returns of any mission is crucial to its success. The LISA project is currently undergoing design study reviews to evaluate how cost-saving alterations to the mission infrastructure (such as shorter interferometric armlengths, or alternative orbital configurations) impact the science returns [3]1. This is not a new endeavour, as many alternative space-based mission designs have been considered in the past, such as OMEGA [4], GEM [5], and DECIGO [6]. Every design for a gravitational wave detector has strengths and weaknesses, but one way to *always* increase the science return of the instrument is to utilize complementary observational information from other instruments. Observations of astrophysical systems in gravitational waves provide data streams that are highly complementary to traditional electromagnetic observations, encoding information that is difficult to obtain by any other means: precise maps of the dynamical distribute on and motion of masses, accurate luminosity distances, and detection of systems that are electromagnetically dim or dark. By contrast electromagnetic observations generally yield spectra which encode information about composition and relative motion with respect to the observer. The science returns, for both traditional electromagnetic  telescopes (EMTs) and gravitational wave interferometers (GWIs), are significantly amplified by coincident observation across different spectra – what is colloquially known as *multi-messenger astronomy*. |