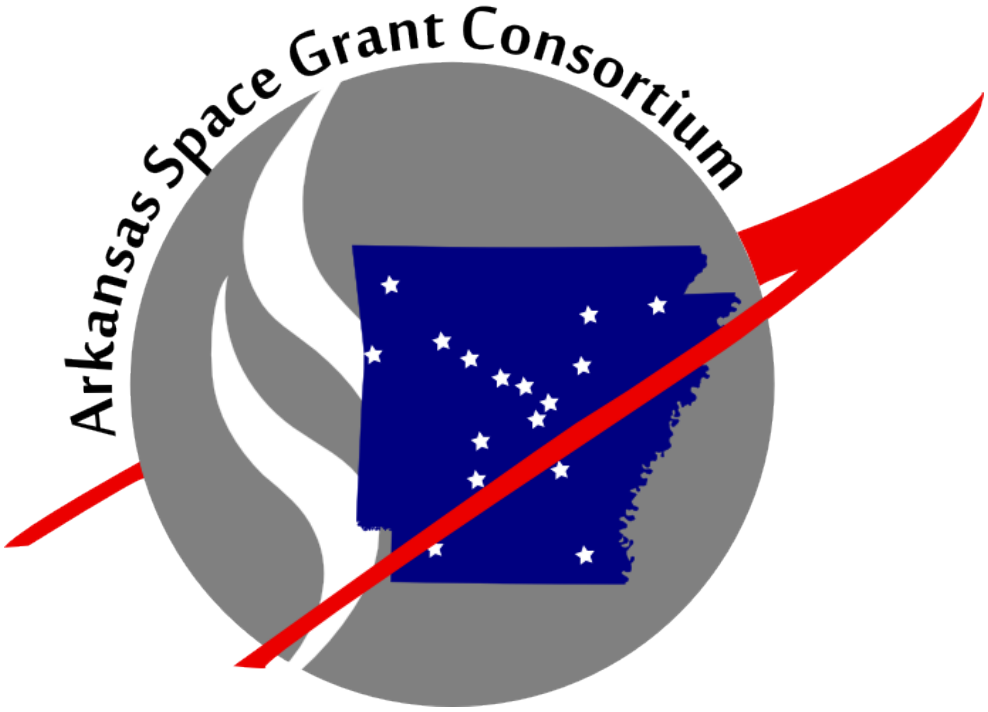
ABSTRACTS

Twenty-second Annual
Arkansas Space Grant Symposium



Monday, April 7, 2014

Hot Springs Convention Center
Hot Springs, Arkansas

A Note of
Special Appreciation
to the people who
worked to make
this Symposium a success.

Ms. Laura Holland, ASGC Staff
Ms. Kristi Wright, ASGC Staff
Ms. Schlyer Cannatella, ASGC Staff
and
The staff at Hot Springs Convention Center

DUANE G. "DIGGER" CAREY

(LIEUTENANT COLONEL, USAF RETIRED)
NASA ASTRONAUT (FORMER)

PERSONAL DATA: Born April 30, 1957 in St. Paul, Minnesota. Carey and his wife Cheryl have two children. He enjoys motorcycle travel, camping, and reading science fiction. His parents reside in Webb Lake, WI. Her mother resides in St. Paul Minnesota. Her father is deceased.

EDUCATION: Graduated from Highland Park High School, St. Paul, Minnesota in 1975; received a Bachelor of Science degree in Aerospace Engineering and Mechanics and a Master of Science degree in Aerospace Engineering from the University of Minnesota-Minneapolis in 1981 and 1982, respectively.

ORGANIZATIONS: American Motorcyclist Association

SPECIAL HONORS: The Distinguished Flying Cross with Valor Device and three Air Medals. The American Motorcyclist Association Hazel Kolb Brighter Image Award. Featured by the Associated Press as well as several magazines, including American Motorcyclist, Sport Rider, Road Trip, and Red Rider.

EXPERIENCE: Carey received his commission from the Reserve Officer Training Corps in 1981 and graduated from Undergraduate Pilot Training in 1983. He flew the A-10A during tours at England Air Force Base, Louisiana, and Suwon Air Base, Republic of Korea. He completed F-16 training in 1988 and was assigned to Torrejon Air Base, Spain. He flew over 30 combat sorties in Operation Desert Storm over Iraq. In 1991, he was selected to attend the United States Air Force Test Pilot School at Edwards Air Force Base, California. After graduation in 1992, he worked as an F-16 experimental test pilot and System Safety Officer at Edwards Air Force Base where he specialized in Performance and Flying Qualities testing of the F-16. He has logged over 4300 hours in more than 35 types of aircraft.

NASA EXPERIENCE: Carey was selected as an astronaut candidate by NASA in April 1996. He reported to the NASA Johnson Space Center in August 1996. Having completed two years of training and evaluation, he qualified for flight assignment as a pilot. Carey was initially assigned technical duties in the Astronaut Office Spacecraft Systems/Operations Branch and later on served as a Shuttle CAPCOM in Mission Control. In 2002 he served as pilot on STS-109. In completing his first space flight, Carey logged over 10 days in space. He left NASA in 2004 to pursue other interests.

SPACE FLIGHT EXPERIENCE: STS-109 *Columbia* (March 1-12, 2002). STS-109 was the fourth Hubble Space Telescope (HST) servicing mission. The crew of STS-109 successfully upgraded the Hubble Space Telescope, leaving it with a new power unit, a new camera and new solar arrays. HST servicing and upgrade was accomplished by four crewmembers during a total of 5 EVAs in 5 consecutive days. The space walkers were assisted by crewmates inside Space Shuttle *Columbia*. Carey also helped document the EVA activities with video and still images. STS-109 orbited the Earth 165 times, and covered 3.9 million miles in over 262 hours.

CURRENT ACTIVITES: Carey and his wife Cheryl are currently engaged in educating young people and other Americans about the importance of America's exploration and research programs. They also seek to inspire young people to pursue educations and careers in technical fields. They have traveled over 350,000 miles on motorcycles and have ridden through and camped in 53 states and provinces, Mexico, and the Republic of Korea. They hope to eventually travel around the world on their motorcycles.

Chemistry

Hydrogenase Models

Robert Bowman, Shakeena Johnson, Anwar Bhuiyan and Charles A. Mebi (PI)
Arkansas Tech University

This presentation is focused on the preparation and characterization of iron-based catalysts designed to model the structure and function of the active site of the efficient hydrogen producing [Fe-Fe] hydrogenase enzyme. We have prepared and characterized a series of diiron-carbonyl clusters coupled to polyaromatic thiolate ligands. The aryl groups are used to tune the proton reduction overpotentials of the clusters. These compounds have been structurally (X-ray crystallography) and spectroscopically (IR, UV-visible and NMR) characterized, and examined as catalysts for the electrochemical reduction of proton to hydrogen. Our catalysts generate hydrogen from acidic water at milder reduction potentials than similar complexes reported in the literature.

Development of Water Sampling Methods and Isotope Analysis

B. Miller and **K. Buckholz** (P.I.)
Department of Physics
Henderson State University
Arkadelphia, AR

Johnson Space Center
Houston, TX

Isotope analysis of water provides us with important information about the earth's hydrological, ecological, and climatic history and water cycle. Using these same techniques, we can gain similar knowledge about other planets and asteroids. The size of standard laboratory spectroscopy equipment makes isotope analysis on other planets impractical. However, we are currently testing a small, rugged spectroscopy device capable of achieving the accuracy needed for isotope analysis to be worthwhile. The next challenge is how to obtain a water sample from ice on mars or an asteroid. The design of the sampling device is intended to create a contained environment for the sample and to address the problems with the Mars Phoenix lander's scoop system. The result will be a system small enough to attach to the robotic arm of a rover or lander that can sample and analyze water isotopes in-situ without the sample being exposed to the atmosphere. A prototype ice drill was built as the first attempt at this, and the system was tested as a whole. Testing showed that the spectroscopy device had an adequate degree of accuracy, but the ice drill highlighted problems with sample preparation and containment. These problems were addressed in a new design for the acquisition instrument. This new design consisted of a probe containing a single, airtight chamber. After coming up with a realistic design, two versions of this new design were made. A simple prototype of one of these models was made to demonstrate the function of the device.

DEVELOPMENT OF A LECITHIN MODEL FOR MEASURING ABILITY OF CHEMICAL COMPOUNDS TO PREVENT LIPID PEROXIDATION

Kathryn Carter, Kyeshia Ward, Brittney McBride, Patrice Brown and Richard Walker, P.I.
Department of Chemistry and Physics, University of Arkansas at Pine Bluff, Pine Bluff, AR 71601

An in vitro model for measuring ability of chemical compounds to inhibit lipid peroxidation was developed. The lipid substrate used was soy lecithin. Peroxidation was generated by air oxidation catalyzed by the free radical initiator AAPH. Amount of lipid peroxides were measured using FOX reagent.

Turbidity of solutions due to low solubility of mixture components often led to inconsistent data. These effects were lessened by use of triphenylphosphine in blanks and sonication and centrifugation of reaction mixtures. When these methods were used, a suitable standard curve for caffeic acid was obtained.

Studies of Transition Metal Complexes

M. Fuller and A. Bhuiyan (P.I.), Department of Physical Sciences, Arkansas Tech University, Russellville, AR 72801

Transition metal complexes have been investigated for use in biological electron transfer reactions such as artificial photosynthesis. Bipyridine complexes are the most investigated complexes because of favorable photophysical, photochemical, and redox properties. It was observed that forming complexes with cage ligands can alter inherent photophysical properties of the complexes in an advantageous manner. This talk deals with the synthesis and spectroscopic investigation of custom designed metal complexes containing hemi-cage hexadentate ligand. The ligand was prepared by the reaction of 1,3,5,-tris(bromomethyl)benzene and 5,5'-dimethylbipyridine in presence of diisopropylamine and n-butyllithium in dry THF at -78 ^{o}C. The product was recovered by extraction with dichloromethane and purified by column chromatography and recrystallization. Several transition metal complexes were synthesized with the hexadentate hemi-cage ligand. The complexes were characterized by absorption and emission spectroscopies, cyclic voltammetric method, and magnetic measurements.

Spectroscopy of Combustion of Hydrocarbons from 200 nm to 1650 nm

M. Greene and E. Wilson, PI
Harding University Department of Chemistry

The application of spectroscopy to the study of flames has provided valuable insights regarding combustion processes. Knowledge of these processes has helped to develop better analysis techniques. In this study, a dual system of StellarNet UV-Vis and NIR spectrometers was used to obtain emission spectra of propane and butane flames burned in air. The spectrometers were checked for wavelength accuracy by means of a low pressure mercury vapor lamp. Wavelength agreement between measured and published mercury lines averaged 0.2%. Inspection of the spectra obtained for both gases indicated the presence of OH (280-306nm), CH (386-440nm), C_2 (462-565nm), O_2 (760-775nm), H_2O (1320-1425nm) and CO_2 (1450-1600nm) in the flames. These spectra compared well with previously published spectra for these molecules. The location of each of these peaks not only determined the species present, but also the indicated the type of transition responsible for the emission.

COMPATIBILITY OF ANTIOXIDANT COMPOUNDS WITH FOX REAGENT

Kyeshia Ward, Saluta Banks, Shauna Grant and Richard Walker, P.I.
Department of Chemistry and Physics, University of Arkansas at Pine Bluff, Pine Bluff, AR 71601

The FOX reagent is commonly used in biochemical studies to measure the degree of lipid peroxidation in tissue. FOX reagent consists of a mixture of ferrous ammonium sulfate and xylenol orange dye in acidified methanol. Lipid hydroperoxides oxidize the ferrous iron in the FOX reagent to ferric iron. This produces an increase in absorbance at 560 nm which can be measured spectrophotometrically.

Antioxidant compounds are known to prevent lipid peroxidation. The aim of our study is to determine whether or not antioxidant compounds have any direct effect on the FOX reagent. If so, they would interfere with the lipid peroxidation assay and therefore could not be tested by this method.

We tested several compounds for the ability to significantly change the absorbance of either reduced FOX reagent (Fe^{+2}) or oxidized FOX reagent (Fe^{+3}) The compounds tested were quercetin, caffeic acid, vitamin C, cysteine, N-acetylcysteine, ribosylcysteine, captopril, penicillamine, zinc acetate and copper (II) chloride. We found that cysteine, penicillamine and copper (II) compounds were incompatible with the reagent. We believe that this is due to complexation with either the iron (II) or the xylenol orange dye used in the reagent. Quercetin had slight incompatibility with FOX reagent at high concentrations. It appeared that this was due to reduction of iron (III) to iron (II). All other compounds tested were compatible with the reagent.

Engineering

Remote Control of Mobile Robotic Vehicle Via Web-Interface

D. Bailey, J. Nesselrotte and E. Wilson, PI
Harding University Departments of Chemistry and Engineering and Physics

Our work designing and programming the hardware and software interface to control the Mars Mobile Spectrometer is presented. The goal is to use a Raspberry Pi microprocessor to interpret commands from a web-interface to control the movement of the Mars Mobile Spectrometer (Both Locomotion and Precise Motion to aim the Spectrometer). Using standard Wi-Fi (over an available LAN) to connect the robot to its controller (be it a laptop, tablet, or smartphone), the Raspberry Pi will send the commands to the various motor control modules on the robot itself. The motor controllers and Spectrometer control are installed in a National Instruments cDAQ which has a USB interface. USB control from the Raspberry Pi will be programmed in Python, keeping in mind the ARM architecture. The Raspberry Pi also has TTL communication that will be used directly off of the board. The design itself will use the TTL to command the stepper motors on the spectrometer, and the USB for Locomotion and Data acquisition, returning the data to the user on the selected control device in real-time. The Raspberry Pi has the computing strength to manage the locomotion functions, wireless network communication, and data transfer without taxing the hardware; with this in mind, we plan to use the Raspberry Pi for the future sensors and interface elements as we add them.

Optimization of Fuel Grain Geometries for Hybrid Rockets Using an Additive Manufacturing Process

R. Beeman and E. Wilson, PI
Harding University Departments of Chemistry and Engineering and Physics

Vehicles propelled by rocket motors are classified as being either liquid, solid or hybrid. Liquid rocket motors are exemplified by the main motors on the space shuttle; they are powerful and can be throttled, started and stopped. Solid rockets contain both the fuel and oxidizer combined together in a fuel grain. Once started, these very powerful motors cannot be stopped nor restarted. Hybrid rockets do not quite have the thrust of the previous two types and consist of an inert fuel grain, mainly hydroxy terminated polybutadiene (HTPB) and an oxidizer such as nitrous oxide. Hybrid rockets are very simply designed compared with liquid rockets and are much safer to operate than either liquid or solid rocket motors since the fuel and oxidizer are separated until they are mixed and ignited in the rocket motor during launch and flight. They can be throttled, stopped and restarted in flight. At the present time, civilian rocket manufacturers are using hybrid rockets exclusively in their programs. We are developing a test facility for hybrid rocket motor research using small scale hobby rocket motors. We will be studying the effect of different geometries on the thrust of these motors. Our method employs an additive manufacturing process (3D Printing). In addition we are designing better ways to add metallic aluminum to the fuel grains to improve their efficiencies. Our capabilities include measurement of thrust through strain gauges and recording of the spectra of exhaust plumes using a suite of spectral instruments.

Mars Rover 3-D Camera

A. Burns and E. Wilson, PI
Harding University Department of Chemistry

The 3d Camera System is a computer vision system designed for the Mars rover being developed by Harding University. It can be used either in the role of central control for the rover, or provide stereo imaging for a remote computer. As a central control unit, it can provide motor control through either external or internal H-bridge circuits for up to two DC motors and up to eight servos. As an imaging unit, the 3d camera system can send stereo computer vision to a remote computer system for further image processing.

A Zero Pressure At-launch Micro-Propulsion System

J. Lee and **A. Huang*** ** (P.I.)
University of Arkansas, Fayetteville, AR

A zero pressure at-launch micro-propulsion system is currently under development at the University of Arkansas, Fayetteville, for nano-satellites applications (on the order of 1-10 kilograms). Furthermore, the propellant is designed to be non-toxic and non-flammable due to its aqueous solution in humectant-based solvent. The goal of the present micro-propulsion system is to achieve 10 milli-Newton maximum thrust levels with 10s of micro-Newton second (μN-s) minimum impulse bits or better. The manufacturing technology used is a combination of precision-, micro-, and nano-fabrication techniques. All components of the propulsion system is passive, except for the miniature solenoid valves for throttling.

The Mars Rover Project (MRP)

Osman A. Martinez, Daniel Schwartz, and Kevin R. Lewelling

Department of Engineering, University of Arkansas – Fort Smith, Fort Smith, AR 72913

A joint research project to design and construct a Mars rover between the University of Arkansas – Fort Smith (UAFS) and Harding University started summer 2012 after receiving funding from the NASA Collaborative Research Program grant and both universities, respectively. This research project is unique due to the rover's capabilities of scanning large areas of the Martian terrain. A group of undergraduate students at Harding University has designed a suite of optical instruments to sense and measure atmospheric compositions, including biomarker gas presence on solid-surface solar system bodies such as Mars and Enceladus. UAFS Electrical Engineering students have designed and constructed an on-board power supply system based on a 12 V Lithium Ion (LI) battery pack, motor speed controllers, and programmed/implemented a HC912 microcontroller. A recent addition to the rover is a robotic arm that can lift and place weather stations, drill holes into the Martian surface, and help aid rover maneuverability in rough terrain causing immobility. This robotic arm will allow the collection of soil samples and placement of sensor arrays to measure temperature, moisture, and wind speed over a large area.

The next step in completing the rover's design is coordination of all individual sub-systems thus allowing rover autonomous guidance and data collection.

JBU Lunabotics

A. McIntyre, R. DaCosta, R. Dyck, A. Forret, J. Gaylord, E. Vega, W. Holmes (PI)

John Brown University

John Brown University (JBU) is sending a team of engineering students to the 5th annual Robotics Mining Competition at NASA's Kennedy Space Center (KSC). In 2010, NASA developed this competition to encourage universities to research and develop innovative new ways to excavate and transport lunar regolith (a simulated lunar soil). These ideas aid NASA in the development of technology that will actually be sent to the moon, an asteroid, or Mars in a future mission. The competition benefits all parties involved: NASA increases the scope of their ideas while university students gain valuable knowledge of the design process and development of a new product or idea. The team from John Brown University is competing in the May 2014 competition as part of their senior design project. The goal of this project is to design and construct a completely autonomous mining robot. The team will complete the design, construction, and testing prior to the competition at KSC on May 19, 2014.

As specified by NASA, the JBU team shall design, build, and test a robot to compete in the Robotics Mining Competition. This robot is designed to operate within the criteria and constraints given by NASA. As such, the robot will traverse an obstacle course, collect lunar regolith, and return the collected regolith to a bin at the other end of the arena. The competition uses a scoring matrix, which includes points for regolith excavated, robot mass, communication bandwidth, dust tolerance, and autonomous operation. In addition to the actual competition itself, the JBU team can earn points for writing a systems engineering paper, engaging in educational outreach opportunities in local communities, and presenting the design to a panel of judges at KSC in May. To earn the highest score possible, the JBU team will need to compete with excellence in all of these areas.

This presentation focuses on the design of the Lunabot and the features that will make it successful in the mining competition. These features include: an autonomous positioning and guidance system responsible for locating the Lunabot in the LunArena and controlling its actions, a communication system for starting the mining operation and monitoring the Lunabot health during the competition run, an excavation system to mine the regolith, an ejection system to deposit the regolith into the collection bin, a mobility system capable of navigating the rough terrain of the LunArena, and a power system that monitors the power consumed by all components during the competition run. Especially notable about this year's design is the autonomy system which, if successful, will mark the first time a JBU Lunabot team has been able to achieve autonomous operation during competition.

Battery Electric Vehicle Motor Drive Design

R.C. Murphree, O.A. Martinez, and K.R. Lewelling (P.I.)
University of Arkansas – Fort Smith 5210 N. Grand Avenue Fort Smith, AR 72913-3649

This presentation will review progress being made on designing and building a motor drive suited for Battery Electric Vehicles (BEV) using 3-phase induction motors. Commercially available motor drives used to control conveyor belts and air handlers do not respond well to abrupt changes encountered while driving an electric vehicle. The motor drive design best suited for our BEV will be powered by a 108 cell, 19 kW Lithium Ion (LI) battery with a nominal 360 V output. This motor drive will accept the DC battery output and produce 3-phase AC voltage which is proportional to the driver's accelerator pedal position. The first revision of this new motor drive design was completed May 2013 with some notable drawbacks. This first revision drive design utilized a DC-DC Buck converter to step down the 360 V battery output to 15 - 18 V which is used by the IGBTs to produce the 3-phase voltage needed to rotate the BEV's motor. The DC-DC Buck converter will be replaced with an inverter and step down transformer in the second revision of the motor drive design. This presentation will also discuss other drawbacks in the first revision and explain how the second revision will address these shortcomings.

General

Simulated Microgravity combined with Space-like Radiation Adversely affects Physiological parameters in Rats

P Chowdhury (P.I.) [1], D Gaddy[1], R Griffin [4], H Hendrickson[5] and M Dobretsov [2,3]

[1]Department of Physiology and Biophysics, [2]Department of Anesthesiology, [3]Department of Neurobiology and Developmental Sciences, [4] Department of Radiation Oncology, [5] Department of Pharmaceutical sciences, University of Arkansas for Medical Sciences, Little Rock, AR 72205, USA

This study examines acute and degenerative tissue responses to space-like radiation doses in a rodent model of simulated microgravity. Three groups of rats, control (CON), irradiated (IR) and irradiated plus suspended (IR+HLS) were maintained for two weeks. IR and IR+HLS groups were exposed to a total radiation dose of 10GY. Body weights, soleus muscle weights, malondialdehyde (MDA), insulin/glucose levels, pressure-pain threshold (PPT), grip force and heat pain were measured. CON gained weight faster than IR or IR+HLS. HLS but not IR resulted in soleus muscle atrophy. Bone mineral density in the proximal tibia was compromised by HLS and decreased by IR+HLS. Random plasma glucose levels were not affected by IR or IR+HLS. IR increased plasma insulin levels. PPT was increased in CON, remains unchanged in IR and decreased in (IR+HLS). MDA in plasma or in soleus muscle remain almost unchanged in CON, IR and (IR+HLS) rats. However, IR significantly increased soleus muscle Cyt / Arg ratio over CON. Grip force, and/or low back pain did not differ between CON, IR and IR+HLS groups. No effects of irradiation were seen in heat pain threshold measurements. IR eliminated "hypoalgesia" and (IR+HLS) produced hyperalgesia. Moreover, IR exacerbated the HLS-induced bone loss in the proximal tibia. These data suggest that radiation induces major physiological changes and these changes are exacerbated by exposure to HLS (supported by ASGC grant).

Nanotechnological Approach for Improvement of Plants Used in Space Exploration

Mohamed Lahiani and Mariya Khodakovskaya (P.I.)

University of Arkansas at Little Rock, Little Rock, AR, 72204

Advanced Life Support System is one of NASA biggest challenge for long-term missions. Scientists expect to grow plants in space for food provision or research purposes. Unfortunately, space condition provide stresses on plants that can limit their capacity to fulfill life support functions, such as combinations of microgravity, cosmic radiation, low atmospheric pressure, high CO_2 and temperature. Germination is plants' first stage of growth. Seeds of many valuable crops can be difficult to germinate in harsh environments of Space. Here, we are using a nanotechnology approach to improve crops most desirable traits by the application of multi-walled carbon nanotubes (MWCNTs). Exposure of valuable seeds crops (barley, soybean and corn) to MWCNTs in sterile media or by air-spray deposition resulted in the increase of rate of germination of all crops. The genetic analysis of exposed crop seeds showed an up-regulation of key genes involved in plant-water relations (aquaporins). The results of genomic study confirmed our previous reports on tomato seeds and demonstrated that MWCNTs can be a good candidate to enhance germination of seeds during Space Exploration.

What's Really Involved in Building a 3D Printer?

J. Nesselrotte and E. Wilson, PI
Harding University Departments of Chemistry and Engineering and Physics

There is a great deal of interest in 3D printing. It seems relatively simple to build a 3D printer and save a great deal of money. We will present an overview of 3D printers with an emphasis on fusion deposition modeling (FDM). Some of the design requirements and pitfalls to be avoided will be given.

Simulated Microgravity Perturbs Cytoskeletal Protein Expression in Mammalian Cells

B.K. Odeniyi, Z. Al-karakooly**,** D. Patel, Z. Javid, K. Hart, S. Kilaparty, Q. Al-Anbaky, J. Post, R. Mehta, M. Soulsby, P. Chowdhury and N. Ali (P.I.)

Department of Applied Science, College of Science, University of Arkansas at Little Rock

Profound physiological changes, such as fluid and organ shifts, occur in the human body after being exposed to microgravity conditions during space flight. Microgravity acts as a stressor to which cells respond and adapt through morphological and biochemical changes. To gain further knowledge about these cellular morphological and biochemical responses, mouse osteoblasts (MC3T3) cells were grown under normal and simulated microgravity conditions. Cells were initially cultured in flasks at normal gravity conditions to about 80 percent confluence. These cells were then separated for experimental and control conditions. Under control conditions, cells were grown in traditional cell culture flasks and kept at normal gravity condition. Under experimental conditions, cells were grown in a High Aspect Rotatory-wall Vessel (HARV) which simulates a low gravity environment. Morphological changes were observed; MC3T3 cells grown in the cultured flask grew in a monolayer while cells under experimental conditions grow in suspended spherical clusters. Changes in actin protein expression were observed in MC3T3 cells under experimental conditions during a 24 hour, 48 hour, and 72 hour time period. Currently data is being collected concerning the protein expression of different types of actin. The changes in cell signaling mechanisms under experimental conditions will be compared with those under control conditions. These results are relevant to the understanding of the cellular changes that occur in the human body as a result of low gravitational forces. This is essential for future NASA space flight.

Eaglenaut Aerospace Club

B. Plank, A. Dearien, Z. Huffaker, W. Holmes (PI)

John Brown University

The John Brown University Eaglenaut Aerospace Club (EAC) is a student run organization that aims to provide students with hands-on project based experience outside of traditional coursework. The club allows students of any discipline to further their education through working with teams of other students on aerospace related projects. The club aspires to have a large repertoire of projects in the future. In order to accomplish these goals, some basic development of platforms and project understanding are required. Currently, the Eaglenaut Aerospace Club is developing technologies that can be applicable to numerous projects in the future. One such technology is a basic data acquisition device. The club is developing this device for a model rocket competition with local high school students.

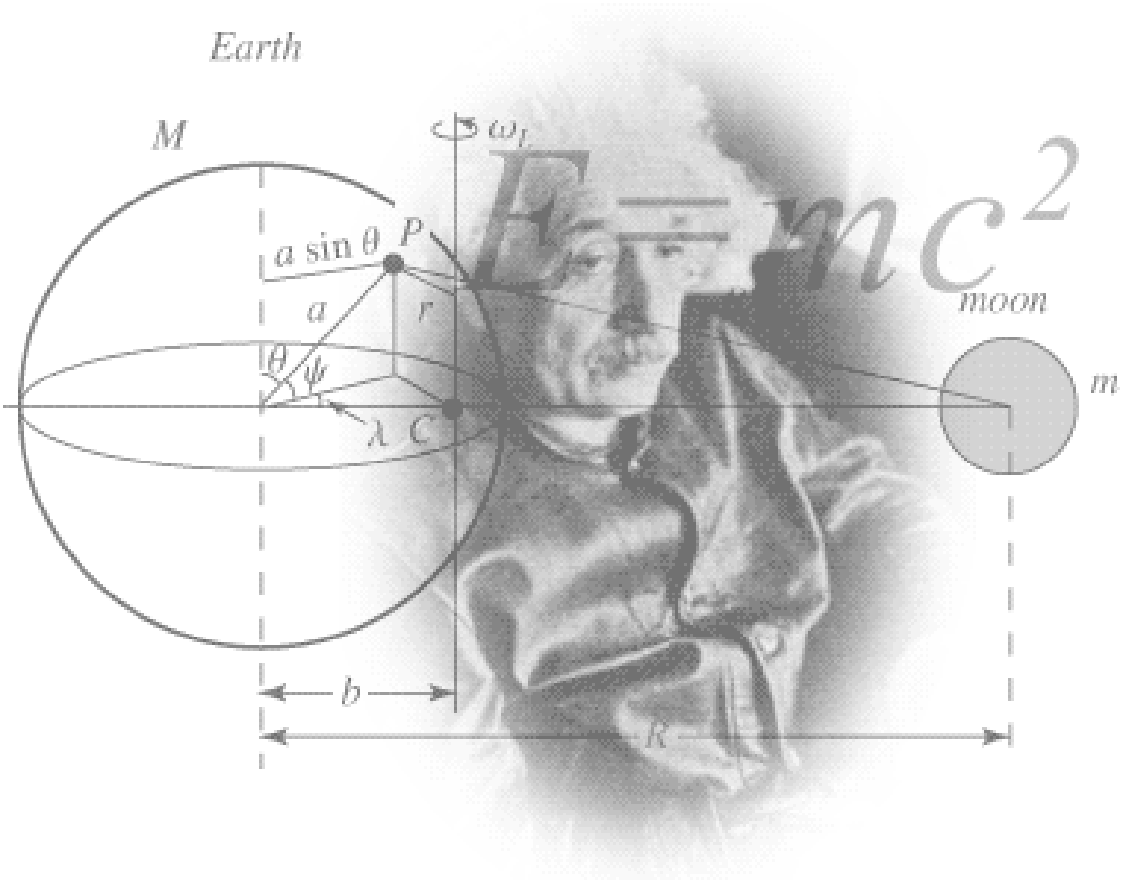
Robotic Educational Outreach for 6th Graders

C. Smith, A. Hoff, D. Geiger, W. Holmes (PI)

John Brown University

Associated with the John Brown University Lunabot program, a group of college students has been working with local 6th graders to encourage participation in STEM. This has taken place through weekly activities in which the college students assist a local teacher in implementing a robotic program in a 6th grade classroom using Mindstorm Robotics. The goals of this program are to encourage active engagement and enthusiasm about science and mathematics with the involved 6th graders.

Physics



Neutrinoless Double Beta Decay, estimation of background radiation

A Bachri [1], M P Hawron [2], P C Grant [3], and C B Martin [1]
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[2] *University of Connecticut, Storrs, CT 06269*
[3] *University of Arkansas, Fayetteville, AR 72701*

Neutrino Experiment with a Xenon TPC (NEXT) promises a novel detection method for the neutrino less double beta decay ($0\nu\beta\beta$). The planned instrument of detection is a 100 kg gaseous Xenon-136 high pressure Time Projection Chamber (TPC) to be installed in the Canfranc Underground Laboratory (LSC). The TPC will search for the rare $0\nu\beta\beta$ ionization signal of distinct topological signature with $Q_{\beta\beta}$ = 2.458 MeV. However, more frequent internal (within TPC) and external events are capable of depositing energy in the range of $Q_{\beta\beta}$ inside the chamber, thus mimicking $0\nu\beta\beta$, or interfering with its direct observation. In the following paper, assuming a basic cylindrical design for a titanium TPC capable of containing 100 kg of Xenon gas at 20 atm pressure, we estimate the background budget for NEXT – 100, analyze the most prominent problematic events. Gamma rays emitted from nuclei of ^{214}Bi and ^{208}Tl present in the outer shell titanium housing of the TPC are an example of such events for which we calculate probabilities of occurrences. We also study the effect of alpha-neutron (α-n) induced neutrons and calculate their rate. Alpha particles are created by the decay of naturally occurring uranium and thorium present in most materials, these particles can react with the nucleus of low Z elements, prompting the release neutrons and leading to thermal neutron capture. The calculations suggest that the anticipated PTFE coating of the chamber constitutes the primary material for neutron production, specifically, the fluorine component of Teflon proved to be much more likely to undergo an (α-n) reaction. From known contamination we calculate α-production rate from the highest purity titanium vessel when lined with Teflon to be 5.55×10^7 α/year, and using measurements of neutron flux from alpha bombardment we estimate the expected neutron flux from the materials. By identifying all gamma rays (prompt or delayed, of energies comparable to $Q_{\beta\beta}$) originating from thermal neutron capture with all stable elemental isotopes in NEXT proposed TPC, we show that, in order to limit the most probable reactions to a rate of one event per year or less, the neutron flux would have to be reduced to $(3 – 6) \times 10^{-10}$ cm^{-2}.s^{-}

Designing and Building a Low-Cost, Laminar Flow Wind Tunnel

S. Clardy, P.I.
Henderson State University, Arkadelphia, AR

While computer models of air flow and turbulence provide data for modern laminar flow studies, many parameters must be determined from an experimental environment. A laminar-flow wind tunnel provides the ability to observe both simple and complex aerodynamic phenomena. The purpose of this study was to design and build a "small scale" wind tunnel (net length is approx. 20 ft – test chamber length is 3 ft) in which experimenters can reliably determine the turbulent effects from the wing itself versus effects created by the wind tunnel design and the medium used to view the turbulent flow. Motivation for the wind tunnel includes valuable educational and experimental components in both design and use. Cost and facility size were the primary design constraints. The design parameters and building decisions are discussed herein.

Electron Fluid Dynamical Equations for Anti-force Current Bearing Waves

C. Clark, M. Hemmati, (P.I.)
Arkansas Tech University
Russellville, AR 72801

For analytical solution of breakdown waves with a significant current behind the wave front, we employ a one-dimensional, steady-state, three-fluid hydro-dynamical model with a shock front. Waves propagating in the opposite direction of the electric filed force on electrons (anti-force) are considered only, and the electron gas partial pressure is assumed to be the main element in driving the wave. Our set of equations consists of the equations of conservation of mass flux, momentum, and energy, plus Poisson's equation. The set of equations will be referred to as Electron Fluid Dynamical Equations (EFD). Following the shock front is a thin Debye layer in which the electric field starting with its maximum value at the shock front reduces to a negligible value at the trailing edge of the wave; while as one traverses through the sheath, the electrons slow down to speeds comparable to those of heavy particles at the end of the Debye layer.

For breakdown waves with significant current behind the shock front, the set of Electron Fluid Dynamical equations and also the electron temperature at the shock front need to be modified. We will present the modification of the EFD equations and also the electron temperature at the shock front, to describe anti-force waves with considerable current behind the shock front.

Current and Speed relationship in Lightning Return Strokes

R. Evans, M. Hemmati (P.I.)
Arkansas Tech University
Russellville, AR 72801

The electrical breakdown of a gas in a strong electric field is carried out by a wave with a strong discontinuity at the wave front, and traveling with speed comparable to speed of light. The electron gas pressure is considered to be a significant factor in sustaining the wave propagation. For theoretical investigation of electrical breakdown of a gas, we apply a one-dimensional, steady profile, constant velocity, three component fluid model, and assume the electrons to be the main element in the propagation of the wave. Our set of the Electron Fluid Dynamical equations consists of the equations of conservation of mass, momentum, and energy plus the Poisson's equation.

This study involves breakdown waves with a significant current behind the wave front propagating in the opposite direction as the direction of electric field force on electrons (lightning return strokes). As the wave speed decreases, solutions for the set of Electron Fluid Dynamical equations become possible only for relatively lower current values. We will present the wave profile for electric field, electron velocity, electron number density and electron temperature within the dynamical transition region of the wave.

Current Bearing Lightning Return Strokes with Low Wave Speeds

P. Galla, M. Hemmati (PI)
Arkansas Tech University
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For fluid dynamical analysis of breakdown waves with current behind the wave front, we employ a one-dimensional, three-component (electrons, ions and neutral particles) model to describe a steady-state, ionizing electron-fluid-dynamical wave propagating counter to strong electric fields (lightning return strokes). The electron gas temperature, and therefore the electron fluid pressure is assumed to be large enough to sustain the wave motion down the discharge tube. Such waves are referred to as anti-force waves. The complete set of equations describing such waves consists of the equations of conservation of mass, momentum and energy coupled with Poisson's equation.

Inclusion of the current behind the wave front alters the set of equations and the boundary condition on electron temperature. Using our modified set of equations, for several current values we have been able to integrate the set of Electron Fluid Dynamical (EFD) equations through the dynamical transition region of the wave. For low wave speeds, solutions for the set of EFD equations become possible only for comparatively low current values. We will present the method of integration of the set of EFD equations, and also the wave profile for electric field, electron velocity, electron temperature and electron number density within the dynamical transition region of the wave.

Self-Assembled Quantum Wires as Building Blocks for the Realization of Intermediate Band Solar Cells

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Intermediate band solar cells are one of the promising and innovative ways to improve solar cell efficiency. Most recent experimental and theoretical attempts to realize this technology were focused on the use of zero-dimensional quantum systems, such as semiconductor quantum dots as the basis of the intermediate band. In this work we propose as an alternative material system to use one-dimensional quantum wires as the intermediate band. To build such a system we have grown self-assembled InGaAs quantum wires by molecular beam epitaxy. Our experimental studies show that quantum wires possess a high optical absorption resulting in enhanced short circuit current and preserved open circuit voltage. This results in a realizable improvement in conversion efficiencies of the intermediate band quantum wire solar cell over the reference GaAs p-i-n single junction solar cell. We will discuss structural, optical, and transport characteristics of the proposed intermediate band and relate those to solar cell performance. Solar cell characteristics at variable temperatures will be presented and explained in regard to material electronic properties.

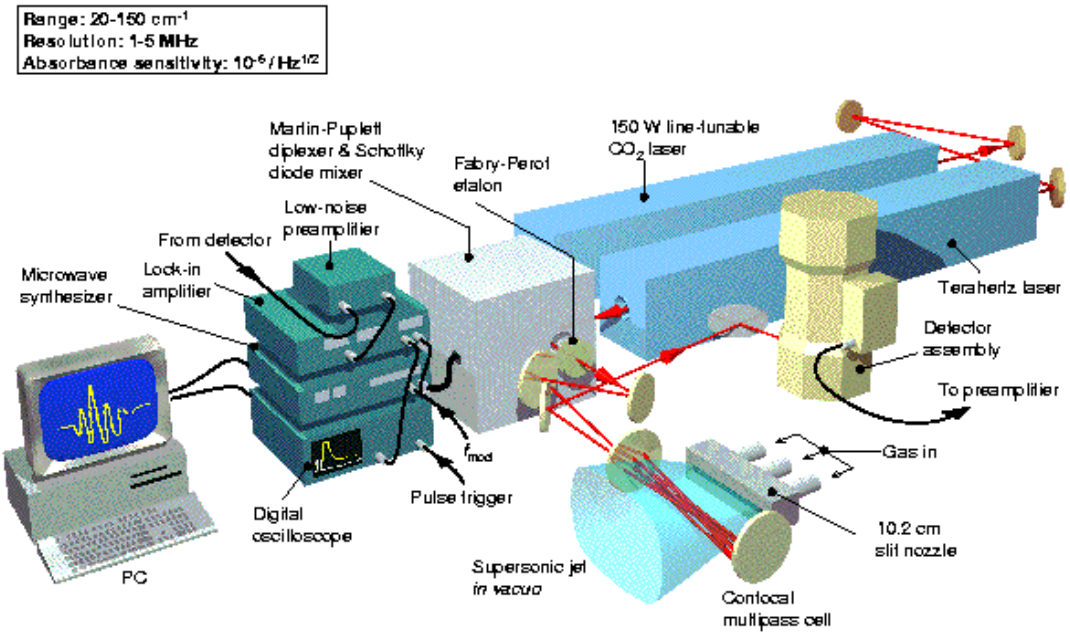
[1]Mansour Mortazavi – is the Principal Investigator of the project

Two-Wheeled Self Balancing Vehicle Design

R. McDaniel (PI), **J. White & Authur Paschke**
Henderson State University, Arkadelphia, AR

This project will undertake the construction and implementation of a two wheeled, self-balancing personal transportation device. The primary goal of the vehicle's electronics is to balance the vehicle. As the rider leans forward the motors turn in proportion to the angle of lean to try and keep the wheels under the center of gravity. This in turn will move the rider forward if the lean is sustained. The same process will work when the rider leans backward enabling the vehicle to go in reverse. Turns will be made by adjusting the speeds of the individual wheel motors. It will also be able to balance itself when a rider is not on it as well as shut down if the rider falls off. In practice this requires two sensors for balancing: a gyroscope and an accelerometer. The accelerometer and gyroscope is used determine the tilt of the vehicle. These measurements are feed back into the microprocessor where a PID control algorithm calculates the necessary voltage to supply to the motor to balance and drive the vehicle.

Spectroscopy



Designing a Sample Holder and Optics for Use in Raman Spectroscopy

T. Drury, M. Medrano and E. Wilson, PI
Harding University Departments of Chemistry and Engineering and Physics

Raman spectroscopy measures quantum mechanically forbidden transitions of a molecule when exposed to powerful radiation. In this technique, a laser beam is used to irradiate a sample and the light scattered by the sample at higher and lower wavelengths. This Stokes and anti-Stokes radiation, is recorded and measured. Since the intensity of the radiation is of very low intensity, it is important to capture every scattered photon and direct it into the monochromator for analysis. In our studies, we are examining several approaches of our own design of the sample compartment area in order to capture all the scattered light and maximize the signal to noise ratio of samples subjected to Raman analysis. Some of the designs being developed are reported.

Spectroscopy of Earth's Atmosphere and Solar Radiation in the Spectral Range of 400 nm to 1000 nm

S. Inabnet and E. Wilson, PI
Harding University Department of Chemistry

As preparation for the 2014 NSSSC (National Student Solar Spectrograph Competition) the spectrum obtained through Earth's atmosphere using available spectral data bases is examined. The spectrum that can be recorded by our competition high resolution spectrograph covers the range of 400 nm to 1000 nm. The spectrograph records all spectral signatures between the surface of the Earth at the geographical location where the measurements are made and from the surface of the Sun. Molecules that absorb radiation in this wavelength range and commonly found in Earth's atmosphere include ozone, oxygen and water vapor. Additionally, the Sun produces a plethora of spectral features of many different atoms and molecules. Most of the spectral features have been identified but not all. By creating a model spectrum from knowledge of available spectral databases makes it easier to interpret the spectra actually recorded at the place, time and environmental conditions when the measurements are obtained. Databases used include BAse de données Solaire Sol and HITRAN 2008.

Designs for a Raman Spectrometer

M. Medrano, T. Drury and E. Wilson, PI
Harding University Departments of Chemistry and Engineering and Physics

Raman spectrometry has been increasingly employed by analysts in recent years due to the development of diode lasers capable of producing significantly powerful beams emitting radiation in the near infrared portion of the spectrum. The powerful visible and ultraviolet lasers used before the advent of near infrared diode lasers often produced fluorescence and, because of their higher power, degraded the samples to be analyzed. A distinct advantage of Raman spectrometry is the fact that the samples can be in an aqueous matrix allowing a broader range of samples to be analyzed. This means that biologicals samples as well as other samples can be studied without further sample preparation in their natural aqueous environment. In our studies, we are investigating ways of designing a versatile, robust Raman spectrometer using a variety of approaches that will be useful, have high resolution and be relatively inexpensive to construct.

Software & Hardware Design for a High Resolution Fiber-Fed Visible/Near Infrared Spectrograph

A. Shafer, J. Griffith, B. Thomason and E. Wilson, PI
Harding University Departments of Chemistry and Engineering and Physics

A high resolution fiber-fed solar spectrograph has been designed and built for the 2014 NSSSC (National Student Solar Spectrograph Competition). It is a Czerny-Turner type instrument with the grating mounted on a precision turntable. The grating is rotated by means of an Automation Direct Bipolar Stepper Motor, Model STP MTR 17040. The motor has a torque of 61 oz. in. and draws 1.7 amp. per phase at 12 VDC. It is housed in a NEMA 17 body. The motor rotates 1.8 degree per step. The motor has an Automation Direct Sure Step Stepping Motor Drive that greatly simplifies it's use. It can be programmed for micro stepping which provides an additional 2, 5, 10 or 50 micro steps per 1.8 degrees. The motor driver circuit also requires 12 VDC for operation. The only other device that needs programming is the SONY ILX511 Linear CCD array. This device requires 5 ma of current delivered at 5 VDC. To operate the detector, a series of timing profiles must be applied to the two clocks onboard the detector. The spectrum is recorded as an output of 2088 bytes of data presented sequentially on Pin 1 of the ILX511. The spectrum must then be saved onto a storage device for viewing and further manipulation. An Arduino UNO embedded controller using Arduino Software as provided with the integrated development environment - Arduino IDE 1.0.5. provides the computing hardware and software environment necessary to operate the grating stepper motor and the ILX511 detector. A Secure Digital Card (SD disk) is attached by means of a Radio Shack Arduino SD Shield in order to store the spectra and other vital information required. The algorithm created provides the integration of wavelength selection and spectra recording and storage in a seamless environment.

Design of CCD Array Detector for a Czerny-Turner Spectrograph

B. Thomason, T. Reed and E. Wilson, PI
Harding University Departments of Chemistry and Engineering and Physics

Designing and building a high resolution solar spectrograph requires that each part of the instrument be robust, of the highest utility and simple to employ. The detector chosen for our Czerny-Turner spectrograph meets these requirements to a reasonable degree. It is a 2048 pixel SONY ILX511 CCD linear array. This is the charge coupled device (CCD) used in most barcode readers and has become a standard detector by designers of spectrographs. The spectral sensitivity of this device peaks at 450 nm and it is useful in the wavelength range of 400 nm to 1000 nm. Power requirements are minimal. It needs only 5 mA of current delivered at 5 VDC for operation. It is operated by two clock signals, a φCLK (clock) and φROG (readout gate). To produce a spectrum, the output of each pixel is read sequentially at the output pin. For the 2014 NSSSC (National Student Solar Spectrograph Competition) a detector has been designed and built around the SONY ILX511 that captures and reports excellent spectra when used as an integral part of the Harding NSSSC Spectrograph. A buffer amplifier is used to match the impedances of the sensor with the data capturing electronics. A voltage amplifier is designed to be used whenever higher signal intensity is needed.

Designing a High Resolution Fiber-Fed Spectrograph for Solar Observations

E. Wilson, PI, B. Thomason, S. Inabnet and T. Reed
Harding University Departments of Chemistry and Engineering and Physics

Harding University students have been competing in the National Student Solar Spectrograph Competition for three years. Lessons learned from these experiences show it is possible to build a high resolution spectrograph in a simple and straight forward manner. An interactive Microsoft Excel® Spreadsheet has been developed that is useful for designing a Czerny-Turner Spectrograph. With the use of this aid, it is possible to choose the proper optics needed to maximize the light throughput for the monochromator part of the instrument. An over view of the process used to construct the 2014 NSSSC competition spectrograph will be given.

Poster

Cartographic and Biological Surveys of Sandtown Cave (Independence County, AR)

Kayla Floyd, Natalie McFarland, Anna Mickler, Daniel Trinh, and David J. Thomas (P.I.).
Lyon College, Science Division, Batesville, Arkansas 72501, USA.

During the period of September 2010 through June 2013, 20 trips were made to Sandtown Cave in Independence County, AR. During these trips, we surveyed and mapped the cave, counted animals, and collected water and soil samples. Heterotrophic and autotrophic microorganisms were cultured from the samples. Animals were photographed and identified using commercial field guides and online resources. No animals were taken from the cave. A complete map of the cave was produced during summer 2013.

Unlike most other caves in the region, Sandtown Cave formed in a sandstone deposit. With the exception of one small region of flowstone, calcite-based speleothems are nonexistent. The cave's soils have high sand content. Characterization of the soil and its microbial biomass is in progress. Animal inventories are ongoing. Notable vertebrate animal species within the cave included cave salamanders (*Eurycea lucifuga*), dark-sided salamanders (*Eurycea longicauda melanopleura*), grotto salamanders (*Eurycea spelea*), pickerel frogs (*Rana palustris*), tri-colored bats (*Perimyotis subflavus*), northern long-eared bats (*Myotis septentrionalis*) and big brown bats (*Eptesicus fuscus*). Invertebrate animals include: camel crickets (*Ceuthophilus* sp.), several varieties of millipedes (class Diplopoda) and spiders (order Araneae), mosquitoes (family Culicidae), and daddy longlegs (family Sclerosomatidae). No aquatic invertebrates were found. Water flows rapidly from the surface through the cave ceiling during rainy weather. The floor of the cave is also very porous; pools of water occur throughout the cave, but all are very transient.

Parts of the cave have been marked with graffiti, but all marks are over 30 years old. We found very little trash in the cave, and aside from our visits, there seems to be little recent human activity. Members of the Little Rock and COBRA Grottos of the National Speleological Society, and Upward Bound Math/Science students assisted during cave expeditions. This research is funded by the Arkansas Space Grant Consortium.

Differences Between Invertebrate Communities Associated with Native Macrophytes and the Invasive Macrophyte *Alternanthera philoxeroides* in Arkansas Wetlands

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Aquatic macrophytes provide habitat for invertebrates and fishes and are a source of food and provide nursery habitat for biota. *Alternanthera philoxeroides* (Alligator weed) is an invasive aquatic plant that is widespread throughout the United States and is problematic because it can displace native macrophytes and alter ecosystem function. Three wetland sites in Arkansas were selected for a study of aquatic invertebrate communities associated with native and invasive aquatic macrophytes during the summer of 2013. Two of the wetland sites were recently constructed stormwater treatment wetlands (Site 1 and 2) and the third was a reference wetland (Site 3). Replicate samples of macrophytes were collected in July, August, and October. In October, average taxa richness of Site 2 was 12.7 compared to 10.3 at Site 3. Shannon's Diversity was highest in invertebrate communities from stormwater treatment wetlands then from the reference wetland, 2.48 vs. 1.89, respectively. Trophic structure was more complex at constructed wetland sites than at Site 3 as evidenced by the presence of predatory taxa such as Tanypodinae (Order Diptera) and Acariformes (Order Hydracarina) at Sites 1 and 2 and their absence at Site 3. At the end of the study, Site 3 had become dominated by *A. philoxeroides* and was characterized by lower biological diversity. With predicted increases in drought severity and intensity and human pertrubations, *A. philoxeroides* populations are predicted to gain a competitive advantage in disturbed wetland habitats. Knowledge of aquatic invertebrates associated with *A. philoxeroides* can aid the selection of biocontrol agents and inform management of wetlands to support biological diversity.

Determining Black Hole Mass of Active Galactic Nuclei Using FWHM of the Hβ Emission Line and Luminosity Relations

J. Jacobs, S. Clark and D.L. Burris (P.I.)
University of Central Arkansas, Conway,AR

The Narrow Line Emission from an Active Galactic Nuclei contains the Balmer Hβ emission line. These lines are believed to come from material further from the central black hole. The Hβ line can be used to determine the velocity of the gas. The luminosity of the black hole can be determined by applying the extinction correction to the spectral files. The extinction correction accounts for the amount of light that our own galaxy absorbs, giving the true luminosity of the AGN. With both the velocity of the gas and the luminosity, the mass of the black hole can be determined. We have recently began a project using IRAF to measure the FWHM of the Hβ line for a group of AGN selected by the research group of J. Kennefick at the University of Arkansas. This will provide an independent mass determination for use as they seek a correlation with spiral galaxy pitch angle and black hole mass.

Photovoltaic Generation of Hydrogen

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We are generating hydrogen and oxygen gases without using any exotic or expensive equipment or materials. This involves the electrolysis of water molecules into hydrogen and oxygen by applying an external direct current potential. Water is oxidized (loss of electrons) at the anode to form oxygen gas. Hydrogen ions are reduced (gain of electrons) at the cathode to form hydrogen gas. Currently, we use a 12 V lead acid adsorbed glass mat battery charged by a photovoltaic panel as an energy source. The anode and the cathode stainless steel electrodes are placed in separate enclosed tubes connected by a bridge, immersed in an electrolyte solution. A direct current is supplied to the electrolyzer with a voltage exceeding 3.0 V. Twice as much hydrogen gas is produced at the cathode as oxygen gas is produced at the anode. We are currently fabricating a larger electrolyzer with the help of a grant from the Arkansas Space Grant Consortium Science Technology Engineering and Mathematics program.

Success Rates of STEM Majors

Kelsey Ledbetter KL (P.I.)
Patricia Buford
Tom Limperis
Arkansas Tech University

Institutions of Higher Education like Arkansas Tech have certain placement qualifications to meet before a student is accepted into the university. This study reviews the placement qualifications for students entering Calculus 1. The present requirements for incoming freshmen are 24 on the ACT or a C or better in either College Trigonometry or Pre-Calculus. The research information starts with the incoming freshmen of 2007 and follows their success rates throughout the STEM program chosen. Then using the data collected I will make mathematical models presenting the results. The purpose of this project is to investigate requirements for placement and make recommendations for our future entering freshmen with STEM majors.

Iron-Carbon Bond Length – Bond Valence Relationship

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A bond length – bond valence correlation is a simple way of checking and evaluating molecular structures and is of great interest in chemistry, biology, geology, and material science. Pauling (1947) first determined an "empirical" logarithmic dependence of bond order (s, valence) to bond length *R* as $s = exp[(R_o-R)/b]$, where R_o is the bond length of unit valence and "*b*" is an empirical fitting parameter. Since then, "b" values were experimentally found to range from as low as 0.25 and as high as 0.9. A common practice is to consider the "b" parameter a universal constant equal to 0.37 and allow the bond length of unit valence R_o to be the floating parameter.

Based on quantum mechanical arguments, a theoretical expression for the "b" parameter has recently been found by our research group. In the present study, experimentally determined Fe-C bond lengths (literature data) were used to determine and "best-fit" b fitting parameter for Fe-C bonds, and to optimize the orbital exponents of iron and carbon (based on a single exponential, hydrogen-like wavefunction).

Cartographic and Biological Surveys of Bat Cave (Independence County, AR)

Natalie McFarland, Anna Mickler, and David J. Thomas (P.I.).
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During the period of July 2008 through July 2013, 22 trips were made to Bat Cave in Independence County, AR. Of those trips, 11 were made during summer 2013. Unlike most of the other caves that we study, Bat Cave is closed to us during late fall and late spring as the owners use the land for hunting. During these trips, we counted animals and collected water and soil samples. Heterotrophic and autotrophic microorganisms were cultured from the samples, and identified by ribosomal gene sequence analysis. Animals were photographed and identified using assorted field guides. No animals were taken from the cave.

A crude map of the cave was produced in 1979 by the now-defunct Eastern Arkansas Grotto based at Arkansas State University. We started surveying Bat Cave in June 2013 to make a more detailed map. Currently, we have mapped 50-60% of the cave's length.

Bat Cave is geologically diverse. Part of the cave formed in sandstone, while the rest of the cave formed in limestone. Cave formations include speleogens (erosional) and speleothems (depositional), many of which show signs of secondary erosion. Most of the cave's floor is covered by large breakdown, which form convoluted, and often deep, secondary passages. The cave's soils have high sand content. Characterization of the soil and its microbial biomass is in progress. Many of the cave's surfaces are damp—often with trickling water. The sounds of dripping and trickling water can be heard throughout the cave, but we have not found any significant streams. The cave has one known persistent pool of water. Bat Cave is likely connected to Buzzard Cave – a small cave approximately 200 m southwest – but the connection is too small for human exploration.

Animal inventories are ongoing. The cave's namesakes – bats – are only present in large numbers during hibernation. Very few bats were found during the spring and summer. Notable vertebrate animal species within the cave included cave salamanders (*Eurycea lucifuga*), long-tailed salamanders (*Eurycea longicauda*), dark-sided salamanders (*Eurycea longicauda melanopleura*), tri-colored bats (*Perimyotis subflavus*), and Rafinesque's long-eared bats (*Plecotus rafinesquii*). Invertebrate animals include: camel crickets (*Ceuthophilus* sp.), cave diplurans (*Litocampa* sp.), several varieties of millipedes (class Diplopoda) and spiders (order Araneae), mosquitoes (family Culicidae), flies (family Muscidae), and daddy longlegs (family Sclerosomatidae). No aquatic invertebrates were found.

Parts of the cave have been marked with graffiti, but all marks are over 30 years old. During our initial visits in 2008, we found (and removed) old trash in the cave. However, aside from our visits, there seems to be little recent human activity (although we have been told of some recent visits by other responsible cavers). Members of the Little Rock and COBRA Grottos of the National Speleological Society assisted during cave expeditions. This research is funded by the Arkansas Space Grant Consortium.

Comparing Water Adsorption Properties of Montmorillonite Clay Minerals

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Hendrix College, Conway, AR

The study of water adsorption on clay minerals is fundamental to soil science and important for understanding climate effects of mineral dust aerosol in the earth's atmosphere. We have studied water adsorption as a function of relative humidity (RH) on three montmorillonite clays originating from different sources, including Texas (STx-1b), Arizona (SAz-1) and Wyoming (SWy-2). The montmorillonite samples have been characterized by BET surface area analysis and scanning electron microscopy. Water adsorption was monitored and quantified using horizontal attenuated total reflectance Fourier transform infrared (HATR-FTIR) spectroscopy equipped with a flow cell. Water content was determined using Beer's law and optical constants for bulk water. Experimental results indicate that, of the three tested clays, STx-1b contains the highest percent by mass of adsorbed water (~60% water by mass at 80% RH). It was also determined that, while higher BET surface area is consistent with higher adsorbed water contents, the primary exchangeable cation also appears to be an important factor. Upon normalizing the water contents to the BET surface area, we found that the two clays with the same primary exchangeable cation (Ca^{2+}) had similar water contents but the clay with the more hydratable exchangeable cation (Na^{+}) had higher water contents at RH values greater than 50%. At these RH values, the water had already formed a complete interior later and had access to exchangeable cations.

Anion Composition of Aerosols

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Aerosols affect Earth's ecosystem by changing the global reflectance properties of the atmosphere. This reflective property depends on their chemical composition. They may also cause adverse health effects when their concentrations increase due to increase in activities such as urban traffic congestion and/or enhanced farming practices like foliage burning. All these activities result in an increase in aerosol concentration, and consequently an increase in pollution. This study was performed to try and characterize the chemical composition of aerosols found in an urban town, Jonesboro AR, which is also surrounded by farming areas. Aerosol samples were collected in using a mini-particle collector and analyzed using ion chromatography. It was found that the majority of the aerosols contained chloride, nitrate, and sulfate components at different concentration levels. Further studies are being conducted to determine the origin of the collected aerosols and their distribution around Jonesboro AR.

An Optical NanoSat Detection and Ranging System (SADARS)

M. Orona, A. Couch and E. Wilson, PI
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Because of the expense of placing research instruments in orbit around the Earth or other Solar System bodies, many investigators are interested in NanoSat satellites for use as vehicles to take their instrumentation and technology into orbit. A collaboration between investigators at three Arkansas universities, UAF, UALR and Harding, has been created to develop critical technologies for successful NanoSat deployment: micro propulsion systems (MPS) and satellite detection and ranging systems (SADARS). SADARS is being developed at Harding and UALR while MPS is developed at UAF. The NanoSat design parameters for these studies have been defined by partners at Marshall Space Flight Center who are developing a 6U satellite bus measuring 10 cm high by 20 cm wide and 30 cm deep. The MPS will require one-third of the space, the avionics, communications and power supply will occupy another one-third leaving approximately one-third of the satellite volume for the SADARS system. Our SADARS approach involves the use of LEDs and diode lasers and their sensors for establishment of an optical detection and ranging system. High definition video cameras will also be investigated as a tool to locate and identify the NanoSats used for a mission.

Nitrate can be Reduced to Nitrite in Celery during Storage

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The dynamics of nitrate (NO_3^-) and nitrite (NO_2^-) contents in celery were investigated at room temperature and at a refrigerated 4^oC. Nitrate concentration was determined by the electrochemical method with a nitrate ion selective electrode, while nitrite concentration was determined by a Griess assay. Our results showed that nitrate contents in fresh celery were 2.161 ± 1.045 mg/g (fresh weight), while the nitrite contents were below the detection limit (~0.0002 mg/g) on the day the samples were prepared. The nitrate contents in fresh homogenized celery decreased 50.1%, while nitrite content increased more than a 1,700 fold during storage at room temperature for three days. If homogenized celery was stored in a refrigerator at 4^oC, nitrate contents decreasing and nitrite contents increasing were much slower. However, when homogenized celery was boiled for 10 minutes or treated with antibacterial mouthwash on the day when the sample was prepared, no change in nitrate and nitrite levels were observed during storage either in the refrigerator at 4^oC or at room temperature.

These interesting results strongly suggest that celery may contain nitrate reductase (NaR), the enzyme that catalyzes the reduction of nitrate to nitrite. When this enzyme was inactivated by boiling 10 minutes or by treatment with antibacterial mouthwash, then no nitrate was reduced to nitrite. Nitrate is more stable when vegetable is stored at a lower temperature.

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Acoustic Properties of NASA Flight-Approved Materials and other Testable Samples

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Minimizing excess noise aboard manned space vehicles continues to be an active concern for NASA's Johnson Space Center. Excess noise, especially within a confined space, can affect work productivity, clarity of communication, as well as resting habits. One means of changing a location's acoustic properties, whether it is a space vehicle or a classroom, is by the use of sound absorbing materials. Understanding the acoustic properties of such materials can lead a better acoustic environment. In relation to many provided acoustic foams and felts, this project seeks to quantify three frequency dependent quantities; namely, the absorption coefficient, acoustic impedance, and complex wave number values. These are obtained by utilizing an impedance tube in which two microphones simultaneously measure the forward and backward components of generated plane waves within the tube. Data analysis of the complex microphone response measurements is conducted in two ways; one which follows a featured procedure in an ASTM International standard and another which is derived to accommodate for a one inch air gap in the experimental setup. In order to aid in the analysis of these complex quantities, Python code templates are created to read in test data, generate acoustic plots, and also validate prior work with past samples in which the data was evaluated using various formatted equations within Microsoft Excel. Organizing these results can lead into the discussion of how to specifically arrange and utilize the materials to both maximize their acoustic performance based upon a material's density and minimize excess ambient noise on manned space vehicles.

Determination of Fatty Acid Content in native Arkansas Algae

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School of Mathematical and Natural Sciences

Characterization of algae for their fatty acid content is one of a variety of tests done to determine the applicability of the algae. Applications include use as nutrients for aquaculture, in human consumption, or potential ability as biofuels. A number of freshwater eustigmatophyceae have been tested to determine if there are any differences in fatty acid concentration between species. While there are a number of algaes that have been described in this same manner, we want to compare a native species to these others. In order to do so, modification of previous sample preparation methods have been required, and will be described. Fatty acid content was then determined through GC-MS analysis. Current results show that the fatty acids analyzed compromise 0.7239-1.2217% of the total mass of the dry algae, with additional samples to be analyzed.

A Biological Inventory of Cave Point Cave (Stone County, AR)

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During the period of March 2009 through January 2014, 30 trips were made to Cave Point Cave in Stone County, AR. During these trips, we counted animals and collected water samples. Heterotrophic and autotrophic microorganisms were cultured from the samples, and identified by ribosomal gene sequence analysis. Animals were photographed and identified using common field guides and online resources. No animals were taken from the cave.

Cave Point Cave is approximately 415 meters long, and most of the human-accessible portions of the cave follow an underground stream. The stream dries to a muddy passage during extended dry periods on the surface. The cave mouth is approximately 3 m wide by 7 m high. Two other openings likely connect the cave with the outside, but are too small for human entry. The cave is privately owned, and the owners live on the same property (but not in close proximity to the cave). The owners prefer to keep irresponsible visitors out of the cave, but are not always successful. Cave Point Cave has been used by the local populace for over 100 years, and is moderately vandalized. It contains relatively few depositional formations, but most are intact. Graffiti has been scratched into the walls and occasionally spray-painted. Macroscopic life is found throughout the cave.

Presumptive fecal coliform bacteria were found in water samples throughout the cave. A variety of macroscopic fungi have been observed on animal droppings. Compared to other caves of its size in the region, Cave Point Cave houses a diverse animal community. Notable vertebrate animal species within the cave included: cave salamanders (*Eurycea lucifuga*), dark-sided salamanders (*Eurycea longicauda melanopleura*), western slimy salamanders (*Plethodon albagula*), Ozark zig-zag salamanders (*Plethodon angusticlavius*), Ozark redback salamanders (*Plethodon serratus*), pickerel frogs (*Rana palustris*), Blanchard's cricket frogs (*Acris crepitans blanchardi*), tri-colored bats (*Perimyotis subflavus*), Rafinesque's big-eared bats (*Plecotus rafinesquii*), big brown bats (*Eptesicus fuscus*), raccoons (*Procyon lotor*), woodchucks (*Marmota monax*), and wood rats (*Neotoma* sp.). Common invertebrates include camel crickets (*Ceuthophilus* sp.), several varieties of millipedes (class Diplopoda) and spiders (order Araneae), heleomyzid flies (family Heleomyzidae), small beetles (order Coleoptera), mosquitoes (family Culicidae), springtails (order Collembola), bristletails (*Litocampa* sp.), amphipods (*Stygobromus* sp.), webworms (*Macrocera nobilis* larvae), and pseudoscorpions (order Pseudoscorpionida).

Occasional unauthorized visitors continue to litter and damage the cave. During our most recent cave trips, we found extensive, recent damage to formations and clay infiltrates. The cave mouth is small enough to be gated at moderate expense. However, the distance from utilities to the cave might make welding operations difficult. Members of the COBRA Grotto of the National Speleological Society assisted during cave expeditions. This research is funded by the Arkansas Space Grant Consortium.

Measurement of Elasticity of Rat Bones under Simulated effects of Hind-Limb Suspension (HLS) and Radiation†

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Studies have shown that exposure to microgravity results in the loss of bone mass. This study aims to determine the variations in elastic modulus of rat femurs under microgravity conditions and radiation exposure. Microgravity was simulated by hind limb suspension of the rats via the tail for two weeks. Radiation exposure occurred during the same time as suspension with dose 10 grays given over the same time period. The animals were then sacrificed and the femurs were surgically extracted and cleaned of the adhering soft tissue. The experimental technique used to attain elasticity began with the design and development of an apparatus for securing the bones at one or both ends. Two methodologies were used: i) a 3-point bending technique and ii) classical bending where bending is accomplished keeping one end fixed. Three point bending method used a captive actuator controlled by a programmable IDEA drive. This allowed incremental steps of 0.047mm for which the force is measured. The data is used to calculate the stress and the strain. In the second method a mirror attached to the free end of the bone allowed a reflected laser beam spot to be tracked. This provided the displacement measurement as stress levels changed. Analysis of stress vs. strain graph together with solution of Euler-Bernoulli equation for a cantilever beam allowed determination of the elastic modulus of the leg bone for (i) control samples, (ii) HLS samples and (iii) HLS samples with radiation effects. Earlier research results on elemental compositions when combined with mechanical properties (elastic modulus and lattice structure) indicated weakening of the bones under space-like conditions of microgravity and radiation.

NanoSat Spectrometer

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Formation flight of a squadron of NanoSats provides exciting possibilities for space missions around Earth and other Solar system bodies. A design for a miniature spectrometer is presented that would be used to map important data about solar system atmospheres within a spatial and temporal framework. For a squadron of five NanoSats, atmospheric composition would be sampled periodically on a global scale at reasonably short times in both the horizontal and vertical directions with short cycle periods. The instrument would be built around a prism with a high refractive index using a CCD linear array detector. In this way, instrument volume could be kept to a minimum and no moving parts would be needed. An initial test will be conducted using high altitude balloons as the test vehicles. The balloons flights would be provided by the Arkansas BalloonSat project.