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NASA - MISSOURI SPACE GRANT CONSORTIUM
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COLLEGE AND NATIONAL SPACE GRANT FELLOWSHIP PROGRAM NASA

MISSOURI SPACE GRANT CONSORTIUM

MOSGC Missouri Space Grant Consortium

Preface

This 25th volume of our annual conference proceedings contains the abstracts of technical research reports that were written and presented by graduate, undergraduate, and high school students supported by the NASA-Missouri Space Grant Consortium. The complete reports can be found on the enclosed CD. The primary purpose of our program is to prepare students to contribute to nation's workforce in areas related to the design and development of complex aeronautical and aerospace related systems, as well as the in-depth study of terrestrial, planetary, astronomical, and cosmological sciences. This goal is being achieved by mentoring and training students to perform independent research, as well as supporting student-led engineering design team and scientific research group activities. This year's Silver Anniversary meeting was held at the Missouri University of Science and Technology on April 22-23, 2016.

The Missouri Consortium of the National Space Grant College and Fellowship Program is sponsored by the National Aeronautics and Astronautics Administration and is under the direction of Dr. Lenell Allen, National Program Manager. It is my pleasure to thank the Affiliate Directors of the Consortium: Dr. Frank Feng, University of Missouri-Columbia; Dr. Dan McIntosh, University of Missouri-Kansas City; Dr. Bruce Wilking, University of Missouri-St. Louis; Dr. Ramesh Agarwal, Washington University in St. Louis, Dr. Majed Dweik, Lincoln University of Missouri, and Dr. Mike Reed, Missouri State University, for their outstanding merit in directing and coordinating Space Grant activities at their respective institutions. I would also like to thank our Associate Directors: Dr. Vayujeet Gokhale, Truman State University, Ms. Tasmyn Front, Challenger Learning Center of St. Louis, and Dr. Mike Swartwout, Saint Louis University, for their contributions in coordinating, advising, and mentoring student research training at their institutions this past year. Finally, the student authors are to be commended for preparing and presenting their research reports with a high degree of quality and making this year's meeting a success.

I hope you find the wide variety of student research presented herein interesting and informative.

Sincerely,

Dr. S. N. Balakrishnan, Director
NASA-Missouri Space Grant Consortium
NASA-EPSCoR Missouri

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Student Research

Design Teams and Research Groups

Validation of the Wray-Agarwal Turbulence Model for Shock-Wave Boundary Layer Interaction Flows

Francis Acquaye
Department of Mechanical Engineering and Materials Science
Washington University in St. Louis
Advisor: Ramesh K. Agarwal

Abstract

In this paper, the recently developed one-equation Wray-Agarwal (WA) turbulence model is evaluated against the industry standard one-equation Spalart-Allmaras, and the two-equation Shear-Stress-Transport k-ω models. These eddy viscosity turbulence models are used to simulate four shock-wave/boundary layer interaction cases using OpenFOAM and ANSYS Fluent. The cases examined are a planar compression corner, an axisymmetric compression corner, a full body axisymmetric compression corner, and an impinging shock. OpenFOAM and Fluent results are compared to Wind-US solver results from the literature. Predicted heat transfer, surface pressure, skin friction coefficient, and velocity profiles are compared to the experimental data. Results of the WA model agree reasonably well with the experimental data

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Francis Acquaye is a M.S. student in the department of Mechanical Engineering and Materials Science at Washington University in St. Louis.

The Conceptual Design of a Satellite Communication Network for Supporting the Exploration, Colonization, and Early Development of Mars

Roy Allen
Department of Mechanical and Aerospace Engineering
University of Missouri – Columbia
Advisor: Craig Kluever

Abstract

The goal of this report aims to conceptually design a satellite communication network constellation capable of supporting the exploration, colonization and early development of Mars. Specifically, the communications architecture of the surface-to-space satellite communications network in collaboration with Earth-to-Mars satellite communications network design. Furthermore, the incorporation of a SmallSat, crosslink, constellation network for optimized total Mars surface coverage, designed and integrated into the existing communication structure. To do so, theoretical models of orbital mechanics, communications architecture design principles, link-budget design, user-defined and generated computational programs and commercially available software are utilized. Additionally taken into account were payload considerations, launch date optimization, and overall mission design requirements. By analyzing and optimizing the SmallSat constellation network for 25% to 100% Mars surface communication coverage area, and limiting the number of usable satellites based on launch vehicle analysis, it is possible to incorporate a reasonable SmallSat constellation network design orbiting about Mars for constant communication coverage which satisfies both surface-to-space and Earth-to-Mars communications.

Roy C. Allen IV came from modest beginnings growing up in Lees Summit Missouri, a Suburb of Kansas City. Named in honor of his grandfather, United States Navy veteran Roy C Allen Jr. and his great-grandfather, WWI veteran Roy C. Allen Sr. While attending high school Roy had the unique opportunity to truly appreciate mathematics, physics, and engineering and study under Dr. Paul Rutherford, descendent of Lord Ernest Rutherford, father of nuclear physics, at Summit Technology Academy in Lees Summit Missouri. He is currently a MSME candidate and aspires to continue his work at the University of Missouri – Columbia with plans to start dissertation research for his PhD in the Fall of 2016.

Designing and Instrumenting Shock Tube

Constantine G. Avgoustopoulos
Department of Mechanical and Aerospace Engineering
University of Missouri at Columbia
Advisor: Jacob A. McFarland

Abstract

The objective of this work is to discuss the design of an experimental facility within the Missouri Fluid Mixing and Shock Tube Laboratory. This experimental facility is a mechanically driven shock tube. The shock tube is used to study hydrodynamic instabilities, specifically, particle driven Richtmyer-Meshkov Instability (RMI). The experimental setup consists of three sections, the driver section, the driven section, and the test section. All sections are made out of carbon steel, this material was chosen for its high strength and low cost per unit. The driver is designed to withstand 2200 psi of pressure. It is made of 5 foot long, 10 inch diameter pipe with 1 inch thick walls. The driven and test sections are made of 7 inch square tube with ¾ inch thick walls. The square cross section allows for a normal planar shock to develop. The test section is the most crucial part of the Shock Tube since all of the data recorded in the experiments occurs at the test section. It is a 3 foot long section with the option of an additional 3 foot spacer to observe reshock. The effects of reshock are important to observe since it creates additional mixing in the fluid interface after initial shock interaction.

Constantine G. Avgoustopoulos is a first year graduate student at the University of Missouri at Columbia. He is currently pursuing a MS in mechanical engineering under the leadership of Dr. Jacob McFarland. He was born and raised in Atlanta, Georgia until he was 10. He then moved to Greece and spent his adolescence with his family. After high school, he returned to Atlanta to complete his undergraduate education. While he is still unsure in a specific career path, he aspires to pursue a career that will challenge him mentally and take him across the globe.

Optimization of Dissipative Elastic Metamaterials for Broadband Wave Absorption

Miles V. Barnhart
Department of Mechanical & Aerospace Engineering
University of Missouri, Columbia
Advisor: Guoliang Huang

Abstract

Elastic/Acoustic metamaterials comprise a new class of composite materials that possess unique effective material properties owing to their locally resonant substructures. Because of the locally resonant mechanism, elastic metamaterials have the ability to completely stop the propagation of elastic/acoustic waves over specific frequency regions (band gaps). However, the band gap regions of non-dissipative metamaterials are fixed, and therefore, broadband absorption is not possible. This draw back can be overcome by incorporating dissipative components into the metamaterials substructures. Furthermore, the elastic/acoustic wave absorption can be enhanced through optimization of the metamaterials structural topology and constituent material properties. In this study, a dissipative elastic metamaterial with a multi-resonator substructure capable of broadband acoustic/elastic wave absorption is studied. Analysis of the wave absorption properties over a broad frequency range is then carried out via dispersion relations obtained from the analytical model as well as numerical modeling using the finite element method. Then, a biological evolution inspired algorithm is employed in order to carry out optimization. By optimizing the dissipative metamaterials structural geometry and constitutive material properties, the absorption amplitude is significantly enhanced over a broad frequency range. Finally, a continuum design of the dissipative elastic metamaterial is proposed and numerical simulations are conducted where the absorption/attenuation of elastic stress waves is used as the measure of performance.

Miles Barnhart grew up in Springfield Missouri where he attended Greenwood Laboratory School for his elementary and secondary education. He was active in research during his time at Greenwood and participated on two occasions as a finalist in the Intel International Science and Engineering Fair (ISEF). Miles received his B.Sc. degree in mechanical engineering from the University of Missouri, Columbia in May 2014 and worked as an undergraduate research assistant during his senior year under Dr. J.K. Chen. He is currently a graduate student at the University of Missouri, Columbia studying mechanical & aerospace engineering. The main focus of Miles' research deals with the development of metamaterials that can be used for acoustic/elastic wave absorption.

The Effects of Evaporation on a Particle Driven Multiphase Hydrodynamic Instability

Wolfgang Justice Black
Department of Mechanical & Aerospace Engineering
University of Missouri, Columbia
Advisor: Jacob McFarland

Abstract

Multiphase systems have been of interest as early as the 1800s, starting with Stokes studying flow over a particle, and are still an important field with applications in various fields including propulsion design, astrophysics, refrigeration, fluid instabilities, as well as fusion. Many multiphase systems, especially those studied within the astrophysical community, experience complex accelerations, such as shock waves, which may drive shear dominated instabilities, increase or dampen mixing between phases, and even affect a phase change phenomena within the flow. Traditionally these multiphase systems have been simplified as multispecies single phase systems with mass averaged properties; however, in doing this potentially information is lost due to neglecting the effects of the different phases. This talk with present simulation work performed using a high energy high density hydrodynamic code FLAG. FLAG, mainly developed at Los Alamos National Laboratory, is an Arbitrary Lagrange Eulerian code which is nominally 2nd order. The simulations presented in this talk consider a shock tube environment, towards the goal of collecting information to help with the creation of a future laboratory facility and future experiments. The simulations examine three cases, dusty gas case; non-evaporating particles; and evaporating particles, which experience a multiple accelerations, in the form of a shock and reshock phenomena, as well as observations on the parameters important in evaporation.

Near-Infrared Spectroscopic Study of AA Tau

Logan Brown
University of Missouri – St. Louis
Dr. Erika Gibb

Abstract

To understand our own solar origins, we must investigate the composition of the protoplanetary disk from which the solar system formed. To infer this, we study analogs to the early solar system called T Tauri stars. These objects are low-mass, pre-main sequence stars surrounded by circumstellar disks of material from which planets are believed to form. We present high-resolution ($\lambda/\Delta\lambda$~25,000), near-infrared spectroscopic data from the T Tauri star AA Tau using NIRSPEC at the Keck II telescope, located on Mauna Kea, HI, taken in 2010. AA Tau has a close to edge-on geometry, with an inclination of $70^o \pm 10^o$ (Donati et al. 2010). Objects must have a nearly edge-on inclination for the disk to be sampled via absorption line spectroscopy. We observed strong absorption lines of both water and OH to which a spectroscopic model was fit in order for us to determine column density and rotational temperature.

Logan R. Brown is from southeast Wisconsin, where he did his undergraduate work at the University of Wisconsin – Milwaukee. He currently is a graduate student pursuing his PhD in Physics at the University of Missouri - St. Louis and should defend in the coming months. His research interests are in protoplanetary disk chemistry. You can find his first publication, Spectro-Astrometry of Water in DR Tauri, in Astrophysical Journal Letters. As he approaches the end of his education, he is looking forward to starting his new position at Boeing this Fall.

Multi-Disciplinary Satellite Design Optimization

Brynne Coleman
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Hank Pernicka

Abstract

This project presents a modular framework for satellite design optimization. Using the Missouri S&T Satellite Research Team's mission as a case study, the effects of geometry variations on differential drag are observed on a two-satellite trailing orbit formation. The results show that optimization is viable, and that the developed modules are returning useful data. Several opportunities to expand this work in the future for a more robust analysis are also identified.

Brynne Coleman received her B.S. in Aerospace Engineering at Missouri S&T in December 2014, and stayed in Rolla for graduate school. She hopes to graduate with her M.S. in Aerospace Engineering in December 2016.

Composition of Oxygen-Bearing Species in Comet C/2002 T7 (LINEAR)

Brigid M. Costello
University of Missouri – St. Louis
Advisor:. Erika Gibb

Abstract

Comet C/2002 T7 (LINEAR) was observed from 8 May, 2004 to 9 May, 2004, and 30 May, 2004 to 2 June, 2004 using CSHELL on the NASA Infrared Telescope Facility (IRTF) in Mauna Kea, Hawaii. From these observations, data were obtained to measure the chemical composition of the comet, along with the rotational temperatures and mixing ratios, relative to water. Five oxygen-bearing primary volatile species, including H_2O, CO, CH_3OH, H_2CO, and OCS, were sampled, along with a product species, OH. C/2007 T7 (LINEAR) displayed composition and properties similar to other Oort Cloud comets, with H_2CO displaying normal abundance, CO displaying depleted abundance, and CH_3OH and OCS displaying enriched abundances, in comparison to previously studied comets. In studying the properties of comets such as this, a taxonomy is being developed, with implications in understanding the role comets played in Earth's formation and origin.

Brigid M. Costello was born and raised in St. Louis, Missouri. She is in her final year as an undergraduate student in the Department of Physics and Astronomy at the University of Missouri – St. Louis. After graduation, she intends on attending graduate school to further her studies in physics and astronomy.

A Study of the Variability of Yellow Supergiant Stars

John Crooke
Department of Physics, Astronomy, and Materials Science
Missouri State University
Advisor: Robert S. Patterson

Abstract

From October 2015 until December 2015, 1 control pair and 7 sets of program yellow supergiant stars were observed at Missouri State University's Baker Observatory with a 0.36 meter Celestron Schmidt-Cassegrain hybrid telescope equipped with an Apogee Alta U77 CCD detector. Using IRAF, the images obtained were calibrated for differential aperture photometry. The Welch Stetson Index and standard deviations of average nightly delta magnitudes were used to determine candidates for variability. The selected candidates were then analyzed for periodicity. Two classical Cepheid stars were recovered. The rest of the stars were non-variable at the 1% precision level. Discussion of the location of these stars on the Cepheid instability strip is presented.

John Crooke is a sophomore at Missouri State University studying in the Physics, Astronomy, and Materials Science Department. His major field of study is Physics and he is pursuing the Astronomy/Astrophysics Track. After graduation he hopes to attend graduate school and earn a doctorate degree in astronomy with a focus in extragalactic astronomy.

The Massive and Distant Clusters of WISE Survey (MaDCoWS): Stellar mass fractions of an infrared-selected sample of high-redshift galaxy clusters

Bandon Decker
University of Missouri – Kansas City
Advisor: Mark Brodwin

Abstract

Galaxy clusters are the most massive gravitationally-bound objects in the universe and are excellent tools to study both cosmology and galaxy evolution. Whereas many cluster surveys look for signatures of the intracluster medium (ICM) in either X-ray or radio light, the complementary Massive and Distant Clusters of WISE Survey (MaDCoWS) uses infrared WISE data to find the most significant galaxy overdensities at $z \sim 1$. Using follow-up observations with the Combined Array for Research in Millimeter-wave Astronomy and the Spitzer space telescope, we have determined stellar mass fractions for ten of these infrared-selected clusters at $0.8 < z < 1.3$ with total masses ranging from 1.4-6 x 10^14 M_sun. We compare these fractions to those from a sample of ICM-selected clusters with similar masses and redshifts from the South Pole Telescope and the previous work at low redshifts.

Bandon Decker is a PhD candidate at the University of Missouri – Kansas City in the Astronomy and Physics Department who has thus far done nothing of note in nearly three years there. He aspires to continue to do research for the next several decades, but for progressively higher pay.

Polymeric Nanoparticles Bind Endotoxins

Mason L. Donnell
Department of Chemical and Biochemical Engineering
Missouri University of Science and Technology
Advisor: Katie Shannon

Abstract

Microgravity conditions in space lead to immunosuppression in astronauts. Space programs face new challenges in sanitation and infection prevention as new bacterial species are found in aerospace clean rooms. These bacteria contain endotoxins or lipopolysaccharides on their outer membranes and are essential to the body's immune response called sepsis. Endotoxins invade our bodies through aqueous solutions where bacteria undergo lysis and release their surface toxins. Current filtration methods of these solutions are insufficient, leading to our investigation of binding these molecules to polymeric nanoparticles as a water sanitation strategy to prevent infections in space. Using Polycaprolactone (PCL) we were able to engineer nanoparticles size 398.3 ± 95.13 nm. These PCL nanoparticles removed ~78.8±28.8% of endotoxins from an aqueous solution or a removal of 3.9×10^5 endotoxin units (EU) per ml. Presented are synthesis of polymeric nanoparticles, characterization of these nanoparticles, fluorescence assay analysis, and transmission electron microscopy (TEM) images showing sufficient endotoxin binding herein.

Mason Donnell grew up in rural Willard, MO before he made his journey to Missouri S&T. Being the creator of the school's first science club and volunteering at the local hospital for three years, his love for science and innovation was pronounced. He saw Missouri S&T as a good challenge for his academic abilities and decided to pursue a degree in Biological Sciences and Biomedical Engineering. Mason has received 1st place trophies at several poster symposiums including the 2015-16 OURE Engineering Competition, Center for Biomedical Science and Engineering Symposium, and the 2015 Mallinckrodt Pharmaceutical Intern Symposium. Mason also placed 3rd at the National American Institute for Chemical Engineers Conference Symposium in Materials Engineering. After graduation, he plans on perusing a PhD in Biomolecular Engineering.

Development of CO_2 Removal Systems for NASA's Advance Exploration System using Amine-Grafted Zeolite and MOF-Monoliths

Stephen Eastman and Harshul Thakkar
Department of Chemical and Biochemical Engineering
Missouri University of Science and Technology
Advisor: Fateme Rezaei

Abstract

In spacecraft cabins, carbon dioxide can create serious health risks at concentrations as low as 5000ppm. Due to this, the removal of CO_2 is a very important function of onboard life support systems. The current method uses a pressure swing adsorption system with zeolite 13x pellets. These pellets tend to break down into powder over time, filling up the filters and causing loss of usable adsorbent, necessitating periodic maintenance. The goal of this research is to investigate materials that would facilitate the construction of a compact and lightweight system to adsorb CO_2 requiring minimal maintenance during operation. To do this, novel materials with promising performance with regard to CO_2 capacity and stability were investigated. Material samples were prepared; structured adsorbent monoliths were produced from those using a 3D printer. then samples were characterized based upon surface area, pore volume, pore size distribution, and CO_2 capacity. Based on those tests, CO_2 capacity of an adsorbent is a function of pore size and surface area. Also, high loadings of zeolite were found to be possible, with CO_2 capacity increasing with adsorbent fraction.

Stephen Eastman is from Saint Peters, Missouri and is an undergraduate student at The Missouri University of Science and Technology. He is currently a junior in chemical engineering, with a GPA of 3.64. He is the safety officer for the Chem E car and worked extensively on the team and with the car. Stephen aspires to make a positive impact on the world and help in the transition to a environmentally sustainable economy. He hopes to become involved in research and development to further that goal.

Electrically Conductive Ink for Catalytic Nanoparticles

Ryland Forsythe
Department of Chemistry
Missouri University of Science and Technology
Advisor: Manashi Nath

Abstract

A water based, electrically conductive carbon ink has been formulated for use with catalytic nanoparticles. Rheological information has been gathered on various ink compositions, including viscosity and time dependence. A composition yielding viscosity near 1,000 centipoise has been found, and the ink has been shown to be dilatant. Voltammetry data shows an increase in overpotential compared to raw catalyst of 100 mV. Samples from the same ink show differing activity, which has been contributed to a partially discontinuous conducting layer.

Ryland Forsythe is from St. Louis, MO and is a graduating senior in Ceramic Engineering at Missouri S&T. He has been doing research for two years now and his previous project was on glass compositions for vitrifying radioactive waste. Ryland plans to go to graduate school in the fall, likely at UC Riverside for a PhD in Chemistry to investigate carbon nanotubes, specifically their growth mechanism, synthesis methods, and processing.

Shape Optimization of a Blunt Body in Hypersonic Reacting Flow for Reducing Both Drag and Heat Transfer

Samuel Gardner
Department of Mechanical Engineering and Materials Science
Washington University in St. Louis
Advisor: Ramesh Agarwal

Abstract

A large design concern for high-speed vehicles such as next generation launch vehicles or reusable spacecraft is the drag and heat transfer experienced at hypersonic velocities. In this paper, the optimized shapes for both minimum drag and minimum peak heat flux for an axisymmetric blunt body are developed using computational fluid dynamics (CFD) software in conjunction with a genetic algorithm (GA). For continuum flow field calculations, the commercial flow solver ANSYS FLUENT is employed to solve the unsteady compressible Reynolds Averaged Navier-Stokes (RANS) equations in conjunction with the Shear-Stress-Transport (SST) k-ω turbulence model. Park's six species finite rate chemistry model is employed to incorporate the effects of air dissociation at high temperatures. The computational results using this model compare favorably with the experimental results for a DLR model validating the computational model used in this study. The axisymmetric hypersonic blunt body shape is optimized using a multi-objective genetic algorithm (MOGA) to minimize both the drag and heat transfer. The MOGA creates a Pareto-optimal front for the optimized shapes obtained by weighting the two objectives of minimizing the drag as well as heat transfer. The computational results for the optimized shapes show a significant decrease in both the drag and heat transfer and exhibit the expected changes in the body profile.

Sam Gardner is a B.S/M.S. student in the department of Mechanical Engineering and Materials Science at Washington University in St. Louis. He will receive his B.S in May 2016 and then complete M.S in December 2016.

MICRONERVA: A Novel Approach to Large Aperture Astronomical Spectroscopy

Claire Geneser
Missouri State University
Advisor: Dr. Peter Plavchan

Abstract

The goal of MICRONERVA (MICRO Novel Exoplanet Radial Velocity Array) is to show that the combined light from multiple 8-inch telescopes is just as effective for taking spectroscopic radial velocity measurements as that of a larger telescope, at a reduced cost to the researcher. This paper analyzes the process of programming a single, 8-inch CPC Celestron telescope to actively guide on a target star within an accuracy of better than one arc second. A four telescope system will then be built to imitate the same light gathering power as a 16-inch telescope, such as the Cassegrain reflector housed at Baker Observatory. Our model tests the pricing to search for exoplanets using the array for discovery by the Doppler spectroscopy technique. All hardware is controlled using Python commands, along with ASCOM drivers. The results open possibilities to perform this research at a fraction of the former cost.

Claire Geneser is a student from the town of Mahomet, IL, currently enrolled in her senior year at Missouri State University. She is working on obtaining her Bachelors of Science in the Physics, Astronomy, and Material Science department. She plans to graduate with a Major in Physics, and Minors in both Astronomy and Mathematics. After graduation, she will continue her education in graduate school, in order to obtain a Doctorate of Physics.

MICRONERVA: Robotically Determining Telescope Orientation with an Arduino Board

Frank Giddens
Missouri State University
Advisor: Dr. Peter Plavchan

Abstract

The future of exoplanet discoveries with the radial velocity or Doppler technique requires the deployment of many automated, low cost telescope observatories. To achieve these goals, we are working on developing the MICRONERVA project, which is a prototype array of four eight-inch diameter, computer controlled telescopes. One key requirement of a telescope is to know accurately where it is pointed. For the telescopes in the MICRONERVA array, it is difficult to use the existing hardware to acquire this information. Thus, we have worked on a low cost Arduino board equipped with an accelerometer and magnetometer to derive a telescopes absolute pointing in altitude and azimuth. In this paper, we present our current progress in developing and controlling this sensor. We outline future efforts and how it will be incorporated into the robotic software for the MICRONERVA facility.

Frank Giddens is a current Junior level student at Missouri State University from the town of Bolivar, Missouri. He is in the Computer Science department working on his Bachelors of Science degree. Upon graduation he is planning to receive a Major in Computer Science and a minor in Astronomy.

Molecular Dynamics Simulation of Defects Generation and Doping via Ion Bombarding on Graphene Layer

Melinda Groves
Department of Mechanical and Aerospace Engineering
University of Missouri-Columbia
Advisors:Jian Lin and Yuan Dong

Abstract

Ion bombarding is a popular method to create holes, defects, and heteroatoms doping in graphene layers. The defective and doped graphene layers may have unique mechanical, thermal, and electrochemical properties. In this work, molecular dynamics simulations were performed with the reactive potential, ReaxFF, to study the process of ion bombarding on graphene layers. Both oxygen and nitrogen ions were investigated. The effects of ion density, system temperature, and energy flux on the defects formation and the geometric features of defects and dopants were illustrated. Results showed that the doping with N and O atoms occurs at different temperatures, and different doping sites were observed in each.

Melinda Groves is a freshman attending the University of Missouri-Columbia College of Engineering, with plans to attain a degree in mechanical engineering with minors in aerospace engineering and mathematics. Melinda is the daughter of John Groves, DVM and Ingrid Haas, DVM of Barnett, Missouri and has one sister, Rachel, who is currently a junior at Mizzou. Melinda was raised on a beef cattle farm and attended Eldon High School, where she was very active in student council, volleyball, art club, and FFA. She was a member of the Eldon FFA Parliamentary Procedure Team that won 1st place in the nation at the 2014 FFA National Convention competition, as well as being selected the "Outstanding Secretary in the Nation" at this event. Melinda graduated 1st in her high school senior class and is a University of Missouri-Columbia Engineering Dean's Scholar. She is a member of the Newman Center.

An Investigation of Probabilistic Data Association Filters for Multi-Target Tracking

Matthew J. Gualdoni
Department of Mechanical and Aerospace Engineeing
Missouri University of Science and Technology
Adviser: Kyle J. DeMars

Abstract

Characterization based data association methods that actively apply labels to targets and attempt to maintain these associations create the vulnerability of miss-associating data, an event that can lead to filter divergence. Furthermore, these techniques are often used in filters that aim to minimize the mean square error of the target state estimates, a cost function that does not translate naturally to the multi-target domain. Probabilistic data association (PDA) eliminates this vulnerability by avoiding concrete associations altogether, maintaining all possible data association events and propagating their estimates to obtain a Gaussian mixture distribution for the target state estimate, which can be closely approximated with a single Gaussian. This prevents a loss of information due to committing to one data association event, and produces an estimate that minimizes the optimal sub-pattern assignment (OSPA) metric, a metric that is better suited to describing the performance of filters in the multi-target domain. This paper explains the vulnerabilities experienced by heuristic data association methods, and explains how PDA overcomes these vulnerabilities. The joint PDA (JPDA) method is also described, and simulation results are presented illustrating the performance of JPDA in estimating the state of multiple targets in the presence of data

Spacecraft Navigation using a Robust Multi-Sensor Fault Detection Scheme

Samuel J. Haberberger
Department of Mechanical and Aerospace Engineeing
Missouri University of Science and Technology
Advisor: Kyle Demars

Abstract

Redundant sensor networks of inertial measurement units (IMUs) provide inherent robustness and redundancy to a navigation solution obtained by dead reckoning the fused accelerations and angular velocities sensed by the IMU. However, IMUs have been known to experience faults risking catastrophic mission failure creating large financial setbacks and an increased risk of human safety. Robust on-board fault detection schemes are developed and analyzed for a multi-sensor distributed network specifically for IMUs. Simulations of a spacecraft are used to baseline several cases of sensor failure in a distributed network undergoing fusion to produce an accurate navigation solution. The presented results exhibit a robust fault identification scheme that successfully removes a failing sensor from the fusion process while maintaining accurate navigation solutions. In the event of a temporary sensor failure, the fault detection algorithm recognizes the sensors' return to nominal operating conditions and processes its sensor data accordingly.

Policy Based Security System

Jared Hall
Department of Physics, Astronomy, and Material Science
Missouri State University
Advisor: Mike Reed and. Lloyd Smith

Abstract

This document details the overall design of the Baker Observatory Security Management System, or BOSMS. In this document, we present all of the necessary descriptions and diagrams related to the project in order to clearly define how the system will be implemented. We discuss aspects of the system such as the motivation behind building such a system, the design details of each component, the functions of each component, and the overall flow of data between components. In this document, we also describe the restrictions and limitations involved with the system as well as how a user will interact with the system.

Jared Hall is a Junior Computer Science major at Missouri State University. His academic interests lie at the intersection of the following subjects: machine learning, cloud computing, distributed and parallel computing, and intelligent policy decisions. He is currently involved in two separate independent research projects: one on the a high performance cloud computing framework to generate Internet of Things policy and another on the use of convolutional deep belief networks to generate policy. Both of these projects will hopefully end in journal papers and provide him with an edge on the crowd in the graduate school application process. Jared has plans on attempting to enter a Ph.D. program in Computer Science after graduation, where he will perform further research in these areas. His end goal, should he be successful at in his endeavors, is to graduate from school spend a small amount of time in private science or working for himself and then to work as a professor at a research university, where he will continue his research in his chosen subjects.

MICRONERVA: Active Guiding Techniques for an Automated Telescope Array

Ryan Hall
Department of Physics, Astronomy, and Material Science
Missouri State University
Advisor: Peter Plavchan

Abstract

MICRONERVA (MICRO Novel Exoplanet Radial Velocity Array) is a project designed to measure spectroscopic radial velocities with a system of 8 inch CPC Celestron telescopes. Our goal is to show that MICRONERVA has the effective light gathering power of a single, larger telescope for a lower cost. Light from each telescope is centered and focused on the entrance of a single mode fiber. Then, multiple fibers from multiple telescopes are combined at the exits of the fibers and sent through to one spectrograph. Focusing on more specific aspects of my project, this paper discusses the various programs and techniques that will allow individual telescopes to actively guide on targets. Each telescope must constantly keep starlight centered on the entrance to its single mode fiber for the time needed to obtain the spectrum. This will maximize the amount of light coupled into the fiber and sent to the spectrograph. The process of active guiding will be done with the use of SBIG, ST-I guide cameras. The hardware is controlled using Python commands and the ASCOM and MaxIm DL drivers. The ability to actively guide on a target, with sufficient accuracy, is a crucial step that will determine the viability of the MICRONERVA project.

Ryan Hall is a current Junior level student at Missouri State University from the town of Rogersville, Missouri. He is in the Physics, Astronomy, and Material Science department working on his Bachelors of Science degree. Upon graduation he is planning to receive a Major in Physics with Minors in Astronomy, Math, and Computer Science. After this he would like to further his education by continuing on to a Masters or Doctoral program in Astrophysics.

A Study of Lithium-Ion Conducting Amorphous Ternary Phosphate Glass

Gavin Hester
Department of Physics, Astronomy, and Material Science
Missouri State University
Advisor: Saibal Mitra

Abstract

Lithium-ion batteries are currently one of the most prevalent energy storage devices available. However, these batteries often utilize liquid electrolytes that are corrosive, poisonous, and prone to developing dendritic shorts. A solid state electrolyte that conducts lithium well can mitigate these issues and provide additional benefits. The system xLi_2SO_4-$(1-x)(Li_2O$-$P_2O_5)$ is a promising candidate for a solid state electrolyte due to its high ionic conductivity and low electronic conductivity. The diffusion and structure of the system were studied via quasielastic and elastic neutron scattering, respectively. It is found that this compound conducts lithium using a jump diffusion mechanism that is promoted by vacancies in the compound. Ongoing work is also discussed to better understand this mechanism and how the electrolytes can be applied.

Gavin Hester was raised in Jefferson City, MO and currently attends Missouri State University. Gavin is a senior physics major with an emphasis in graduate preparation. Gavin will be going to Colorado State University this summer to obtain his PhD in condensed matter physics. He would then like to obtain a job as a professor of physics and join the ranks of academia.

Rigid MEMS Structures Formed by Lithographically Defined CNT Forest Composites

Ryan Hines
Department of Mechanical and Aerospace Engineeing
University of Missouri - Columbia
Advisor: Matt Maschmann

Abstract

Carbon nanotubes (CNTs) offer numerous material properties that exceed the performance of current commercially available materials. However, when grown in large populations known as CNT forests, many of the advantageous properties are severely diminished. As an illustrative example, an individual CNT has an elastic modulus of approximately 1 TPa, while a self-assembled CNT forest has an elastic modulus that can span from 100's of kPa to 100's of MPa, a gap of many orders of magnitude. The drastic decrease in mechanical stiffness has limited adoption of CNT forests in many MEMs-based applications including electrical contacts and structural gears. This research will develop new fabrication techniques to enable the use of natively soft CNT forest to synthesize rigid and conductive microscale devices. First, CNT forests will be synthesized from lithographically-defined catalyst layers to create the desired device structural form. The CNT forests will then be coated with alumina using atomic layer deposition or a polymer delivered in the gas phase. The resulting composite will be significantly more mechanically robust and may be used as a functional structure. The second phase of the research will be create selective CNT growth surfaces such that specific regions will selectively support CNT growth under specific synthesis conditions. This will facilitate the synthesis of 3-D CNT scaffolds with non-uniform heights.

Ryan Hines is from Chatham, Illinois, a smaller neighboring town of Springfield, Illinois. He graduated in the Fall of 2015 from The University of Missouri with a Bachelor's of Science in Mechanical Engineering and currently pursuing a Master's of Science in Mechanical Engineering. During his last year as an undergraduate he conducted undergraduate research with Dr. Maschmann. Ryan's research interests include the growth of carbon nanotubes and graphene, and their assembly into small-scale devices. One of his goals is to work in nanomaterial research or in the aerospace engineering field working with composites and materials.

Growth Response and Water-Use Efficiency of Radish Seedlings to Nutrient Solution Nitrogen Concentration in Hydroponic Culture

Lyric S. Howard
Lincoln University of Missouri
Advisors: Jonathan Egilla and Majed El-Dweik

Abstract

The National Aeronautic Space Administration (NASA) has demonstrated successfully for many decades the feasibility of using plants as a component a bioregenerative life support system (BLSS) to regenerate the atmosphere, purify water, and produce food for crews during long-duration space missions. Hydroponic plant production in Controlled Ecological Life-Support System (CELSS) can be a potential method to fulfill these needs. Limited nitrogen supply to plant root may induce phytohormone, particularly abscisic acid (ABA) regulation of shoot growth and the water relations of the plant. Conversely, excess nitrogen can reduce the quality of crop plants. Information about the optimum nitrogen for normalized plant growth in CELSS is limited. The objective is to determine the growth and yield response of radish (*Raphanus sativus* L.) to variable nitrogen (N) concentrations in hydroponic culture. Radish seedlings raised in 1.0-cm rockwool cubes were transferred into hydroponic culture at the second true-leaf stage and grown until maturity in a greenhouse (GH). The treatments comprised of Hoagland nutrient solution at 100% or 50% N, plus a control (commercial fertilizer at 200 mg N/ liter [equivalent to 100% Hoagland]). Fertilizer treatment had no statistically significant effect on stomatal conductance and leaf growth, but the fresh and dry weight of radish bulbs were highest at 50% N and at the lowest nutrient solution electrical conductivity (EC). It is anticipated that this research will enhance further understanding of how plant nutrient elements influence plant growth and water relations in CELSS, when this experiment is repeated under hyperbaric conditions.

Lyric Howard is a junior at Lincoln University of Missouri in Jefferson City, majoring in Agribusiness. She is actively involved in the Minorities in Agriculture, Natural Resources and Related Sciences (MANRRS) organization on campus and enjoys volunteering in her free time. Raised in Holts Summit, Missouri, she always had a passion for nature and the outdoors, and aspires to become a marketing director for an agricultural company or agency. She plans on furthering her education at the University of Michigan – Flint upon graduation.

Lifetime Analysis of Beryllium Reflector Used in Nuclear Reactors

Annemarie Hoyer
University of Missouri – Columbia
Advisor: Gary L. Solbrekken

Abstract

Used in the Advance Test Reactor (ATR), High Flux Isotope Reactor (HFIR), and University of Missouri Research Reactor (MURR), the beryllium reflector(s) is a structural component of great interest due to its cost and importance to reactor operation. The transmutation of the beryllium reflectors by the fast neutron flux combined with thermal stress due to gamma heating in the beryllium limits the reflector's lifetime in these reactors. The conversion from an HEU-based fuel to an LEU-based fuel in these reactors will be accompanied by a shift in neutron energy spectrum, leading to a reduction in gamma heating of the beryllium reflector per megawatt of core power as well as an increase in by-products of beryllium irradiation, helium and tritium gas production. Therefore, time at which components may fail should consequently shift. Detailed analyses, including neutronic, thermal, mechanical and hydraulic, are being carried out at the University of Missouri in order to assess the relative change in expected life span of beryllium reflectors. Historic life prediction for the beryllium reflector at MURR is based on the empirical observation of a single material failure coupled with a simple gamma-heating induced stress estimate. Numeric simulations based on operational assumptions and boundary conditions for both HEU and LEU cores will be used to estimate the relative life expectancy for the new LEU core. It is also not clear that the modeling strategy used by MURR is transferrable to other the other reactor sites that utilize beryllium as a reflector material. The objective of this study is to analyze the detailed thermal/structural behavior of the beryllium reflectors at MURR, HFIR, and ATR, and this is to be done for both the current HEU and the proposed LEU cores.

Annemarie Hoyer is from Columbia, MO and is currently pursuing her doctorate degree in Mechanical Engineering at the University of Missouri – Columbia, under Dr. Solbrekken. Her field of study is thermo-mechanical analysis and specifically current research deals with material lifetime prediction in radioactive surroundings such as those in a nuclear reactor. After graduation, she would like to pursue a career in consulting, utilizing skills learned in research and working at Oak Ridge National Laboratory in Oak Ridge, Tennessee. She has plans this summer to intern at Northrop Grumman, located near Baltimore, MD and hopes to graduate by December 2017.

Separating Dwarfs from Subgiants for the NASA TESS Mission using WISE Photometry

Joseph Huber
Missouri State University
Advisor:Peter Plavchan

Abstract

The goal of the Transiting Exoplanet Survey Satellite (TESS) mission is to find small transiting planets around bright main sequence stars. More specifically, this resaerch focused on the challenge of selecting the appropriate host stars – bright cool dwarfs – from the TESS transit Candidate Target List (tCTL). For example, a faraway giant star can appear to be similar to a nearby dwarf star of the same surface temperature, and it is impractical to find transiting planets around giant stars. Thus, it is difficult to reliably select host stars, so we have begun to explore the possibility of separating dwarfs from subgiants using WISE (Wide-field Infrared Survey Explorer) and 2MASS (Two Micron All Sky Survey) colors, thus disambiguating subgiants from dwarfs for G, K, and M spectral types. To accomplish this we are adapting code in IDL to automate the process of determining the spectral type and luminosity class of a sample of well-characterized stars.

Joseph Huber is a student from the town of Marshfield, MO, currently enrolled in his Junior Year at Missouri State University. He is working on obtaining his Bachelors of Science in the Physics, Astronomy, and Material Science department. He plans to graduate with a Major in Astronomy and Astrophysics, and a minor in Mathematics. After graduation, he will most likely continue to graduate school, in order to obtain a Masters in Astrophysics

Flow Visualization and Vortex Identification in Crossflow-Induced Boundary Layer Transition

Daniel Jamrozik
Department of Mechanical and Aerospace Engineeing
Missouri University of Science and Technology
Advisor: Lian Duan

Abstract

Fuel efficiency is a driving criterion for subsonic, swept-wing transport aircraft. A reduction in drag experienced on all aerodynamic surfaces of an aircraft leads to a savings in fuel. Recently, laminar flow control devices were designed to regulate the flow to favorable, low-drag conditions, by retaining laminar flow for as long as possible. The effectiveness of utilizing these mechanisms is widely questioned due to the uncertainty of laminar-turbulent transition flow. The nature of transition flow is complicated and has a vast number of scenarios. Experiments and high-fidelity simulations have resolved only a portion of these uncertainties. Direct Numerical Simulations (DNS) acts as a third contributor, and it may play a key role to revealing the underlying mechanisms of transition flow. This study investigated vortex identification methods by coupling DNS with flow visualization techniques for the aforementioned aircraft configuration. Specifically, the Q-method and swirling strength method were compared against one another to ascertain which was more suited to identify vortices in transition flow. Iso-surfaces were constructed in Tecplot 360 software that tracked the two criteria. It was found that the Q-method displayed the complete transition regime, from onset of laminar decay until full development of turbulent flow. The swirling strength approach demonstrated better capabilities to display finer vortices granularities. However, the Q-method was concluded to better illustrate crossflow vortex-induced transition due to its capability to quantify the DNS domain. The overall ambition of the research is to continue matching patterns with the utilized resources to better understand what drives transitional flow.

Daniel Thomas Jamrozik was born and raised in St. Louis, Missouri. Daniel grew up in a Polish family, and he represents the first generation individual born in America. Daniel graduated from Maplewood-Richmond Heights High School as the class valedictorian, and he chose a STEM field as his career pursuit, believing that he would thrive in a technical subject.

Daniel, now a senior studying Aerospace Engineering, attends Missouri University of Science and Technology in Rolla, Missouri. He expresses immense enthusiasm for the aerospace disciplines of aerodynamics and propulsion, and he is gearing for a career focused on the two specialties. Daniel has accumulated two internships, one being with the Naval Research Enterprise Internship Program and his second opportunity to start Summer 2016 within Rolls Royce. In his time of leisure, Daniel enjoys cycling, cooking, ice hockey, gaining knowledge of nutrition, and staying up-to-date with the news.

Kepler Observations of the Pulsating Subdwarf B Star KIC 2697388

Joshua W. Kern
Department of Physics, Astronomy, and Material Science
Missouri State University
Advisor: Michael Reed

Abstract

This research focuses on the analysis of three years of *Kepler* spacecraft short cadence data of the pulsating subdwarf B star KIC 2697388. The *Kepler* spacecraft observed ~150,000 stars over the course of its four year mission, of which 18 were discovered to be pulsating subdwarf B stars. For KIC 2697388, 238 periodicities; most with periods from 1 to 2.5 hours (which are associated with gravity-mode pulsations) were detected. Six periods were also detected in the short-period pressure-mode region. Standard seismic tools for mode identification including asymptotic overtone period spacings and rotationally-induced frequency multiplets were applied. As a result, 87% of the periodicities with mode identifications; most of low degree $\ell \leq 2$ have been classifed, but 21 are identified as $\ell = 4$. Frequency multiplets provide a rotation period for the star of ~42 days. A unique feature is seen in KIC 2697388's data; in all $\ell \geq 2$ multiplets the frequency splittings decrease over the course of the observations. If the trend continues, $\ell \geq 2$ multiplets would become singlets within a decade

Studies of the Mechanical and Extreme Hydrothermal Properties of Mesoporous Silica and Aluminosilica Materials

Dayton G. Kizzire
Physics, Astronomy, Materials Science Department
Missouri State University
Advisor: Robert Mayanovic

Abstract

Periodic mesoporous SBA-15 silica and Al-SBA-15 aluminosilica have potential for applications in the energy and chemical industries. The structural properties of periodic mesoporous silica SBA-15 and periodic mesoporous aluminosilica Al-SBA-15 are being investigated using small angle x-ray scattering (SAXS). The SAXS measurements were made at the Cornell High Energy Synchrotron Source (CHESS). The pressure-dependent SAXS measurements were made on mesoporous SBA-15 silica and Al-SBA-15 aluminosilica samples using a diamond anvil cell (DAC) to ~ 12 GPa in pressure. SAXS measurements were also made of the mesoporous SBA-15 silica and Al-SBA-15 aluminosilica under extreme hydrothermal conditions (to 250 °C and ~ 110 MPa) using the DAC. Both SBA-15 and Al-SBA-15 possess amorphous pore walls and have similar pore size distribution. Analyses of the pressure-dependent SAXS data show that the mesoporous Al-SBA-15 aluminosilica has greater mechanical stability than the mesoporous SBA-15 silica. Further analysis of the SAXS data from the extreme hydrothermal environment reveals that the Al-SBA-15 has greater hydrothermal stability than the SBA-15. Molecular dynamic simulations using LAMMPS and XSEDE are being conducted to understand the part the pore architecture plays in the stability of the mesoporous materials SBA-15 and Al-SBA-15.

Dayton Kizzire is from Ozark, Missouri. He obtained a Bachelor’s of Science in Physics at Missouri State University and he is currently pursuing his master’s degree in Materials Science at Missouri State University. He hopes to find a career in materials and device research and eventually continue his education towards a PhD.

Molecular Dynamics Simulation of Nitrogen Doping with Ammonia Gas in Defective Graphene Layer

Jenny Lam
University of Missouri-Columbia
Advisors: Jian Lin and Yuan Dong

Abstract

Nitrogen doping on graphene layers is believed to make very effective catalysts for a series of oxygen reduction or selective oxidization reactions. In this work, we perform molecular dynamics simulations with the reactive potential, ReaxFF, to study the process of nitrogen doping on graphene layers with ammonia gas. The effects of different hole sizes on graphene layers on the doping will be illustrated.

Jenny Lam is a freshman from the University of Missouri-Columbia who plans to attain a degree in mechanical and aerospace engineering with a minor in aerospace and mathematics. Her hometown is Quincy, Illinois. She is the daughter of Yung Lam and Hui Wu. Jenny attended Quincy Senior High School, where she was active as the Captain of the math team, treasurer of her chapter of the National Honor Society, Beta club, and key club. She is currently the programming chair for the Asian American Association at the University of Missouri-Columbia. Jenny hopes to further her career in research at the university

Auroral Occurrences In and Out of Solar Maximum

Cooper Lehr
Department of Mechanical and Aerospace Engineeing
Missouri University of Science and Technology

Advisors: Marilia Samara and Robert Michell
NASA Goddard Space Flight Center

Abstract

A ground based imager in Alaska has been used to measure the aurora borealis intensity during the night for the past four years. These data have been compiled into one graph to show the aurora intensity over a long period of time spanning from September of 2011, through May of 2015. This graph will be analyzed next to a plot representing the sunspot number in the same corresponding time frame. Since sunspots are an indication that the sun is more active, we should be able to find a possible relation between the two.

Cooper Lehr grew up in Weatherby Lake Missouri, and is currently a sophomore in Mechanical Engineering at the Missouri University of Science and Technology. He has been awarded with the Dean's List Award every semester he's been here. He is looking to graduate in 3 ½ years total with his Bachelor's in Mechanical Engineering, and a minor in Engineering Management. He will spend this summer working in Downtown Kansas City Missouri for a construction company, McCownGordon.

Comparison of Aluminide Diffusion Coatings on Various Steel Substrates Sythesized by Pack Cementation

Zach Leuty
Missouri State University
Department of Physics, Astronomy, and Material Science
Advisor: Ridwan Sakidja

Abstract

To increase the efficiency of steam power plants, operating temperatures must be raised above 650ºC. Even stainless steel corrodes very rapidly under these conditions. Aluminum diffusion coated steel is extremely corrosion resistant under these high-temp, high pressure, water vapor conditions. The aluminizing process is typically performed at 900º-1000ºC, which inevitably degrades the mechanical integrity of the steels structure. Recent advances in pack-cementation show that a low temperature (650ºC-750ºC) aluminizing is feasible using certain halide salt activators. In this study, the growth kinetics are examined to see how they are affected by selecting a different steel substrate (18-8 stainless steel, low chromium alloy steel, no chromium machine steel), halide salt activator (ammonium chloride, ammonium fluoride), growth time, and furnace temperature. It was found that chromium in the steel substrate can inhibit the growth process, therefore coatings on stainless steel are thinner. A higher iron content in the steel creates a thicker coating. Chloride based activators create a thicker coating than fluoride based activators. There is also a positive direct correlation with the temperature/time and the thickness of the diffusion coating. In the future, an oxidation test between these coated materials will be conducted to quantify which coating/substrate combination in more resistant to corrosion.

Zach Leuty is a junior at Missouri State University. His home town is Blue Springs, Missouri. He is currently working on his bachelor’s in physics from MSU with an emphasis in materials science and a minor in mathematics and is a Dean’s Scholarship recipient. Zach’s future plans are to obtain a master’s degree from Missouri State University in Materials science.

Recently Quenched Galaxies in the SDSS

Colton Luttrell
Department of Physics & Astronomy
University of Missouri-Kansas City
Advisor: Daniel McIntosh

Abstract

A study done by McIntosh et al. 2014 used the Sloan Digital Sky Survey (SDSS) to investigate the properties of massive elliptical galaxies in the present-day universe ($z < 0.08$) that have unusually blue optical colors. A unique subset of 172 non-star-forming ellipticals with blue colors and young average stellar ages ($t < 3$ Gyr) were found. These recently quenched ellipticals (RQEs) have properties that are consistent with a recent merger origin meaning they are new elliptical candidates that may play an important role in the observed buildup of massive dead galaxies in the present-day. Approximately 90% of these RQEs preferentially reside in the centers of small dark matter halos (< , within 10 times the halo mass of the Milky Way , and theoretically able to continue accreting new gas to fuel star-formation. Thus, a key unanswered question is what quenched these galaxies? We build on this study by not restricting to morphological type. Instead, we focus on all recently quenched galaxies (RQGs) that reside in the same environments as RQEs. We identify 515 of these RQGs (~ 3 times the sample of RQEs in McIntosh et al. 2014). Our focus is then to compare and contrast the properties of these new RQGs (~ 360) to the RQEs found in McIntosh et al. 2014.

Colton Luttrell is currently a senior in physics (astronomy emphasis) at the University of Missouri-Kansas City, and works in the Galaxy Evolution Group under Dr. Daniel McIntosh. He is the main researcher on this project other than his advisor. After graduating UMKC Colton plans on attending graduate school to pursue a Ph.D. in astrophysics.

Ergonomic Development and Control Characterization of a Single Person Spacecraft Simulator

Ryan Mathewson, University of Missouri-Columbia
Dean Keithly, Cornell University
NASA Robotics Academy Research Associates, Human Factors
Mentor: H. Charles Dischinger
NASA Marshall Space Flight Center

Abstract

The FlexCraft is a single-person concept vehicle capable of remote or Teleoperated control to perform servicing at lower risk and cost than conventional spacesuit Extravehicular Activity (EVA) operations. The FlexCraft Simulator (FCS) is an evolving test vehicle for FlexCraft development in the Marshall Space Flight Center (MSFC) Flight Robotics Lab (FRL). Building upon the work of past FlexCraft teams, the FCS is undergoing comprehensive improvements to the human interface controller, situational awareness using star tracker simulators, and system documentation. Testing and analyzing the FCS motion yielded FlexCraft center of gravity, approximated mass, and thruster force through the dual StarGazer system. This allows further development of the FCS as a test bed for a single-person space vehicle.

Ryan Mathewson is a rising senior mechanical engineering student at the University of Missouri in Columbia, Missouri. Upon graduation, he will also earn a minor in Aerospace Engineering. Ryan is a member of MU Robotics, Sigma Phi Delta Engineering Fraternity, and a High Altitude Balloon Team. In addition, he also serves as a Student Coordinator for the MU Department of Residential Life and Freshman Interest Groups Program. Ryan worked on the FlexCraft - Single Person Spacecraft project while at NASA Marshall Space Flight Center in the summer of 2015. The FlexCraft team also consisted of Dean Keithly, Dominique McCraney, and Samantha White under the supervision of Charlie Dischinger.

Consider Analysis for Non-Gaussian Filtering

James S. McCabe
Department of Mechanical and Aerospace Engineeing
Missouri University of Science and Technology
Advisor: Kyle J. DeMars

Abstract

The consider Kalman filter, or Schmidt-Kalman filter, is a tool developed by S.F. Schmidt at NASA Ames in the 1960s to account for uncertain parameters or biases within the system and observational models of a tracking algorithm. Its novelty is in that it "considers" the effects of the uncertain parameters rather than other Kalman-filter-based approaches, which instead estimate these parameters directly. Avoiding this online estimation of parameters allows, in many cases, for a more computationally feasible algorithm to be acquired, making it amenable to real-time applications. The consider Kalman filter, however, is an approach that works solely with the mean and covariance of the posterior distribution. In many problems, mean and covariance are often insufficient statistical descriptions of the filtering state. This work presents a consider formulation that works with a Gaussian sum approximation of the true distribution, permitting the Gaussian mixture consider Kalman filter and enabling an operator to maintain a more complete description of the true posterior state density while still working within a consider framework.

Rapid and Sensitive Immunofluorescence Detection Method for Staphylococcus Enterotoxin A

Grace Mobley
Center of Nanotechnology
Lincoln University of Missouri
Advisors: Baskar Balakrishnan and Majed El-Dweik

Abstract

Staphylococcus aureus is an enterotoxin-producing bacteria responsible for a minimum of 241,000 cases of foodborne illness in the United States every year. The economic impact of these bacteria on the food industry and society as a whole is immense, with an estimated cost of $167,697,860 per year. There are a variety of methods of Staphylococcus aureus detection. The faster that the presence of these bacteria can be determined, the sooner the distribution of the contaminated food can be halted. For this reason, the efficiency of detection is directly tied to a reduction in affected populations. The objective of this study was to develop a novel detection method for the Staphylococcus Enterotoxin A (SEA). The pure toxin was labeled with fluorescent dye (FITC); then the labeled toxin was captured by a magnetic bead immobilized with the anti-SEA antibody. The bead used had a dual purpose: toxin purification and toxin detection. This process allowed the immuno-complex to observe with use of a fluorescent microscope.

Grace Mobley is currently a Graduate Student at Lincoln University in Jefferson City majoring Environmental Sciences.

Partial Volatile Composition of Comet C/2002 T7 (LINEAR)

Nicholas Moore
University of Missouri – St. Louis
Advisor: Dr. Erika Gibb

Abstract

C/2002 T7 is a dynamically new Oort Cloud comet. We observed six parent volatile compounds and two daughter volatile compounds using the CSHELL at IRTF on Mauna Kea. We report the volatile compound abundances of C_2H_6, CH_4, NH_3, NH_2, H_2O, C_2H_2, CH_3OH, HCN, and OH on May 8th and May 9th relative to water in the comet. Compared to other comets, T7 does not fit the current classification system in place for describing the composition of comets because it is neither "organically abundant", "depleted", nor "normal" with respect to its abundances. Motivating the need of a classification system is determining what role comets played in the beginning of life on Earth, as various studies have suggested that comets may have been a delivery mechanism for water and prebiotic molecules, possibly including amino acids, on Earth.

Nicholas D. Moore is an undergraduate student pursuing a Bachelor's degree in Physics along with a Bachelor's degree in Mathematics at the University of Missouri—Saint Louis. After completing his degrees he intends to go to graduate school for astrophysics to further work in the field.

Non-Invasive Fault Detection and Identification for Spacecraft Power Systems

Jacob A. Mueller
Department of Electrical and Computer Engineering
Missouri University of Science and Technology
Advisor: Jonathan W. Kimball

Abstract

In this project, a method of detailed system assessment has been developed using nonintrusive load monitoring algorithms. The method is designed to determine the activity of individual devices within a closed electrical system using only a single set of sensor measurements. The base nonintrusive load monitoring procedure has been modified to function as a real-time status assessment tool. This new method provides accurate profiles of device behavior in time, and indicates the probability of the observed behaviors based on stochastic models of healthy devices. In this way, behaviors indicative of device failure or malfunction may be detected and identified without the use of device-level sensor hardware.

Jacob A. Mueller is a doctoral candidate with the Department of Electrical and Computer Engineering at Missouri University of Science and Technology. He received the B.S. and M.S. degrees in 2012 and 2014, respectively, also at Missouri S&T. His research interests include modeling and control of power electronics, stochastic modeling of islanded power systems, and nonintrusive load monitoring. He hopes to continue to find interesting ways to apply these topics to spacecraft power systems, both during his remaining graduate school program and after.

Dust-Obscured Star Formation in Galaxy Clusters at High Redshift via a *Herschel* Stacking Analysis

Dave Nair
Department of Physics and Astrononmy
University of Missouri - Kansas City
Advisor: Mark Brodwin

Abstract

As the most massive collapsed structures, galaxy clusters provide an excellent laboratory in which to study galaxy evolution and cluster formation in rich environments. A large number of rare, distant candidate galaxy clusters have recently been discovered via their infrared galaxy overdensities in a new, wide-area (100 square-deg) survey centered on the *Spitzer*-South Pole Telescope Deep Field (SSDF). This extremely distant sample of 278 cluster candidates allows one to observe star formation and mass assembly in the first generation of galaxy clusters. Using a stacking analysis, imaging of these candidates with *Herschel* SPIRE bands can be fit to infrared luminosity (LIR) curves associated with dust-obscured star formation. After fitting to a specific LIR model, star formation rates (SFRs) for these cluster candidates can be calculated and are observed to be as high as many hundreds of solar masses per year.

Dave Nair is a graduate research intern working with Dr. Mark Brodwin at UMKC. He is currently completing his Physics Masters and thesis in star formation in distant galaxy clusters. Hailing from Kansas City, KS, Dave has always been a fond supporter of the arts and the pursuit to further understand the natural sciences.

Synthesis and Characterization of Alpha Amino Phosphonates

Nasruddeen Al-Awwal
Lincoln University of Missouri
Advisor: Majed El-Dweik

Abstract

A simple, efficient and general method has been developed for the synthesis of α-aminophosphonates through "one-pot" three-component condensation reaction of aryl aldehydes, primary aromatic amines and diethyl phosphite by Kabachnik-Fields (phospha-Mannich) reaction. This represents a good choice for the synthesis of alpha aminophosphonates. In this project work, various alpha amino phosphonates were obtained in high yields (70-80%) without use of any catalyst. Their chemical structures were established by FT-IR, 1H, 13C, 31P NMR spectroscopic analysis. All the compounds were found to exhibit anti-microbial activities.

Nasruddeen Al-Awwal was born on 23rd August, 1983 in Columbia, Missouri, USA. He graduated from Usmanu Danfodiyo University Sokoto, Nigeria where he obtained his B.Sc. in applied chemistry, 2005. He worked with CAS Kano, Nigeria as Lecturer I, Nasruddeen went to India on a full scholarship award from Kano State Government in order to advanced his studies where he obtained his MS Organic Chemistry from SRM University Kattankulathur, India. He is currently working on his second MS Environmental Science at Lincoln University, Missouri and planned to proceed ahead for his PhD. Nasruddeen plans to stay in the field of research and academics and contribute to society.

Enhancing Structural and Interaction Feature Contrast in SDSS Galaxies

Patrick Newman
Department of Physics and Astronomy
University of Missouri-Kansas City
Advisor: Daniel H. McIntosh

Abstract

The processes by which galaxies undergo quenching of star formation and morphological changes from disky to elliptical are still poorly constrained. We develop a software pipeline to generate residual images of galaxies (enhancing contrast and bringing out faint features by masking all nearby objects and subtracting a Sérsic profile of the galaxy), as well as calculate the Tidal Parameter that quantifies the strength of residual features. This pipeline is then used on 436 nearby ($0.01 < z \leq 0.08$) high mass ($>10^{10}$ $M_{\odot}$) blue and red 'spheroidal' galaxies (r-band concentration ≥ 2.6, and visually confirmed to lack an apparent disk) in the Sloan Digital Sky Survey at two different image depths. Initial and residual images of all galaxies within the pipeline are inspected. We find galaxies that show previously missed disky features, as well as tidal features that presumably indicate recent merger activity. Additionally, we find that the Tidal Parameter is a questionable discriminator of tidal from non-tidal features.

Patrick Newman is a Research Infrastructure Assistant at UMKC’s Physics and Astronomy department, and works in the Galaxy Evolution Group under Dr. McIntosh.

The Characterization and Assembly of Solar Cells on a Microsatellite

Jonathan D. Rasche
Department of Mechanical and Aerospace Engineering
Missouri University of Science & Technology
Advisor: Henry Pernicka

Abstract

The goal of this research is to design a process to efficiently construct solar panels for use on a microsatellite. Starting at the single cell level, it had to be decided what components were necessary for the intended mission. After trade studies were completed, it was decided that coverglass, diodes, and Kovar tabs were required for the assembly of the cells. To attach these components, several structures had to be designed and built to assemble large amounts of cells accurately. Then a structure for cell matching had to be designed. Cell matching allows for a more efficient layout of the solar cells on the solar panels. With the structures for assembly and testing completed, testing procedures and programs had to be completed. The program for cell matching still has minor issues, but is close to being finished. After the program is finished, cell matching and assembly can be completed. Then the cells will be ready for integration onto a solar panel which will be used to power and test a microsatellite. Eventually, several solar panels will be made and attached to a microsatellite that will hopefully be launched from the ISS.

Jonathan Rasche is originally from Decatur, Illinois where he met his wife, Beth Rasche. He is currently a junior in academic standing at Missouri University of Science & Technology where he will be getting his bachelor's degree in Aerospace Engineering. With his degree he hopes to work on microsatellite subsystems. His most notable achievement is launching a balloon satellite to near space and measuring how sound waves are affected in the reduced atmosphere.

The Investigation of Graphene and the Immobilization of Nanoparticles

Matthew Riehn
Department of Mechanical and Aerospace Engineering
University of Missouri - Columbia
Advisors: Matthew Maschmann and Shubhra Gangopadhyay

Abstract

Nanoenergetic materials are high energy densities and are made up of nanoscale fuel and oxidizer particles separated by small distances to promote rapid reaction. Graphene is a 2-D material, which acts to immobilize these nanoparticles and facilitate efficient composition. For the purposes of this project, we investigate the thermal transport of a graphene immobilized nanoenergetic system comprised of Al/Al_2O_3 core-shell nanoparticles that acts as a nanoscale fuel. We start by studying the key components of the nanoenergetic system in isolate. For example, we have synthesized multilayered layered graphene and exfoliated graphene flakes. The graphene acts as a support material and facilitates nanoenergetic particles immobilization. Further, a finite element COMSOL model has been developed to study the transient thermal response of the Al/Al_2O_3 nanoparticles.

Matthew Riehn is originally from Yokota Air Base, Japan, and came to the University of Missouri in Columbia in Fall 2012. In Fall 2015, graduated from the university with a Bachelors of Science degree in Mechanical Engineering. As of now, he is pursuing his Masters of Science degree in Mechanical Engineering at the University of Missouri in Columbia. After attaining his master’s degree, he hopes to work in the engineering industry and continue his education as well.

Molecular Dynamic Simulation of Layered Graphene Clusters Formation from Polyimides under Extreme Conditions

Sean C Rismiller
Department of Mechanical & Aerospace Engineering
University of Missouri, Columbia
Advisors: Jian Lin and Yuan Dong

Abstract

Graphene-based nanomaterials have great potential in catalysts and supercapacitors. In this paper the pyrolysis of polymers in a nanosecond time scale is studied with reactive molecular dynamics (MD) simulations using the ReaxFF potential. It is found that confined heating will produce graphene-like nanostructures out of two kinds of polymers: polyimide and polyether ether ketone. Pressure peaks above 3GPa with a processing temperature of 3000K. This indicates that the local high temperature and pressure can convert the polymers to graphene-based nanomaterials without metal catalysts, which may enable large scale production of high performance electrical devices and microreactors with laser scribing methods.

Sean Rismiller is an undergraduate research assistant from St. Louis at the Department of Mechanical and Aerospace Engineering, University of Missouri, Columbia, MO. He plans on completing his undergraduate degree and joining a research-oriented industry or continuing his education for a master’s degree in Electrical Engineering or Mechanical Engineering.

Study of a PRSEUS Multi-Bay Box for a Hybrid Wing Body Vehicle

Jerome Rivers
University of Missouri – Columbia
NASA Langley Research Center, Hampton, Virginia
Structural Mechanics and Concepts Branch

Abstract

A large composite structure incorporating stitching and carbon-epoxy panels was recently designed, analyzed, fabricated and tested up to the design ultimate loads (1.5 times the design limit load) and finally until catastrophic failure occurred. The 30 foot wide multi-bay box, representative of an 80% scaled center-section of a future hybrid wing body (HWB) aircraft, was manufactured using Boeing's pultruded-rod stitched efficient unitized (PRSEUS) concept. The testing done on the multi-bay box was part of NASA's Environmental Responsible Aviation (ERA) Project that investigated the viability of the PRSEUS concept as an option to develop non-conventional large aircraft transportation designs such as the HWB aircraft that aims to reduce fuel burn and emissions as a result of a lighter airframe and lower community noise while meeting the structural requirements set forth by the Federal Aviation Administration (FAA). At the conclusion of the pressure and load testing, the test article supported 101% of the design's ultimate load, which is the highest load expected to be encountered in flight, with a 24 inch long, 1 inch wide saw cut through the skin, flanges and center frame in the top of the box. The FAA requirement is to be able to carry 70% of the designed limit load with such significant damage, enough to land safely. The results of all tests conducted suggests that the PRSEUS concept prevents damage growth, is capable of carrying normal and higher than normal loads even with damage and is capable of reducing current aircraft design weight by at least 20%. These findings promote further investigation in to the development of an HWB aircraft.

Jerome Rivers is from St. Louis, MO, and is a 2nd year Master of Science candidate in mechanical engineering at the University of Missouri – Columbia under the advisement of Dr. Gary Solbrekken. Jerome hopes to graduate in December of 2016 and continue to work at the NASA Langley Research Center in the areas of mechanical and thermal designs/concepts through NASA's Pathways Intern Employment Program.

Exploring Oxygen Precipitate Cluster Distribution Variances in Cz Silicon

Jamie Roberts
Center for Nanoscience
Department Physics & Astronomy
University of Missouri – St Louis
Advisors: Phil Fraundorf

Abstract

Planar-section TEM specimens of the 12h-950°C Sun Edison industry annealed wafers were prepared. Precipitates were not found initially, and therefore the annealing times at 950°C were extended at UMSL's facilities. After another 12h at were found 950°C, oxygen-precipitate platelets in the seed end centers, but not in the opposite end centers. A closer look at the literature on oxygen cluster nucleation modeling following earlier work on precursor phase nucleation and growth helped us visualize what is happening in the specimens.[1] In that context, a set of qualitative Boltzmann-factor oxygen-cluster distribution models were assembled. These indicate that the 950°C anneals are indeed detecting larger as-grown oxygen clusters in the seed-end material, and that a short 800°C anneal might bring the opposite end material more into line with the seed end. The abundance of such as-grown clusters would be lessened by more rapid cooling (or a still faster pull rate), which can be performed to check if higher densities of such clusters are associated with a decrease in minority-carrier lifetime.

Jamie Roberts is a graduate pursuing a Masters in physics at the University of Missouri-Saint Louis and holds a bachelor's degree from the University of Wisconsin-Madison in International Relations and from the University of Missouri- Saint Louis in physics. She is pursuing a career in material science and energy research. During her leisure time, she loves to learn new languages, travel, and dance.

Aerodynamic Analysis with Uncertainty Quantification

Mario Santos
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Dr. Serhat Hosder

Abstract

Aerodynamic analysis of aerospace vehicles with uncertainty quantification is important to understand how a vehicle will perform in actual flight conditions. In this study, aerodynamic analysis with uncertainty quantification was performed on a low-speed aircraft wing, and a conical geometry at hypersonic flow. The low-speed wing geometry was analyzed using a combination of the vortex-lattice method, Monte Carlo analysis, and a sensitivity analysis. The high-speed conical geometry was analyzed using a combination of equilibrium shock analysis with real gas effects, Monte Carlo analysis, and a sensitivity analysis. For the low-speed wing geometry, the drag coefficient was found to be affected the most by uncertainties in flight conditions with a coefficient of variance of 12.57%. Uncertainty in the wing camber and wing incidence angle were found to affect performance the most with respective sensitivity coefficients of 52.050% and 24.856% for the lift coefficient, 51.768% and 24.675% for the drag coefficient, and 64.818% and 14.105% for the moment coefficient. For the high-speed conical geometry, the surface pressure was found to be affected most by uncertainties in flight conditions with a coefficient of variance of 15.21%. Uncertainty in the cone angle and Mach number were found to affect performance the most with respective sensitivity coefficients of 98.71430% and 1.19085% for the surface pressure, and 98.79860% and 1.19538% for the surface temperature. Thus for both cases it is important to reduce imperfections or deformations in the geometry to increase performance and reduce the chance of failure.

Mario Santos, whose home town is Boston Massachusetts, is currently an undergraduate senior at Missouri S&T where he also plans to continue his graduate career working with Dr. Serhat Hosder. He is a member of Sigma Gamma Tau, the national aerospace honor society, and is the aerodynamics group lead for the Missouri S&T Advanced Aero-Vehicle Group.

Design and Manufacture of a Photolithography System for Fabrication of Micro-Scale Devices

Chase Scanlan, Nick Snyder, Travis Tumlin
Department of Mechanical & Aerospace Engineering
University of Missouri-Columbia
Advisor:Jian Lin

Abstract

A design for a desktop mask alignment table for UV lithography was crafted based on a combination of published work and personal ideas, so that the system could be utilized for experimentation involving the applications of 2D materials. The design was done mostly by PhD student Travis Tumlin, but the actual construction was carried out by undergraduate students Chase Scanlan and Nick Snyder, who also made modifications to the design along the way. Upon completion of the system and testing that it was functional, Chase and Nick have now begun testing the system in order to determine the optimal conditions for its use by varying the exposure time, time in the developer, and intensity of the light exposure for the samples.

Chase Scanlan is a freshman and Research Assistant at Mizzou's Department of Mechanical and Aerospace Engineering from St. Louis, Missouri. He is majoring in mechanical engineering with plans to pursue a minor in aerospace engineering as well. Chase came to Mizzou as one of Mizzou's Engineering Dean's Scholars, a group of 20 incoming engineering students recognized for their exemplary academic performances in high school and potential as future engineers, he also qualified for the Dean's List last semester in engineering. He plans to pursue a career in the aviation side of aerospace engineering, starting with his position as a Software Engineering Intern in Rockwell Collin's Flight Control Department this summer, working on the Boeing 777X project.

Polynomial Chaos Applied to Orbital Uncertainties

Christine Schmid
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Adviser: Kyle J. DeMars

Abstract

An orbital application of polynomial chaos (PC) is presented and compared with Monte Carlo (MC) simulation. In the examples presented, uncertainty is restricted to the position and velocity of a satellite in Low Earth orbit, the first example using initial Gaussian distributions and the second using Gaussian Mixture distributions. For Gaussian distributions, the PC results (mean and standard deviation) prove valid against MC results. The validity of the results is used to show that making a distribution assumption after propagation (i.e. a GM remaining a GM) is invalid, an assumption not made by the PC framework.

Christine Schmid is a graduate student working under the mentorship of Dr. Kyle J. DeMars pursuing a doctorate in Aerospace Engineering at Missouri University of Science and Technology. She received her B.S. from the same university in the same field in 2014. Christine's current research topics include the application of polynomial chaos to the estimation of systems with undefined uncertainty distributions.

Growth and Characterization of Tungsten Diselenide Thin Films for Solar Energy Applications

Austin Shearin
Department of Physics, Astronomy, and Material Science
Missouri State University
Advisor: Kartik Ghosh

Abstract

Tungsten diselenide (WSe_2) thin films, a two-dimensional transition metal dichalcogenide, were synthesized using a pulsed laser deposition system. The films were characterized using a profilometer, ultraviolet-visible spectroscopy, x-ray diffractometry, and Raman spectroscopy. Profilometer results indicate films less than 30nm in thickness. XRD results indicate non-uniform films were obtained. Ultraviolet-visible spectroscopy indicates a blue shift for the tungsten diselenide films from 1eV to approximately 1.6eV. Raman spectroscopy does not give any indicative peaks for the WSe_2 structure.

Austin Major Shearin was born and raised in Springfield, MO. He attends Missouri State University and is about to graduate with his masters in materials science in the Physics, Astronomy, and Materials Science Department. He got his bachelors of science in physics at Missouri State University. He graduated Magna Cum Laude in his class from the honors college. Ever since Austin was a kid, he dreamed of going into scientific research as a career and has pursued that dream ever since.

Pump Health Monitoring of an Axial Piston Pump

Tyler Shinn
Department of Mechanical and Aerospace Engineering
University of Missouri – Columbia
Advisor: Dr. Roger Fales

Abstract

Hydraulic pump health monitoring can give early notice of a catastrophic failure occurring within the pump, saving time and money on repairs. This work focuses on developing a system to monitor an axial piston pump's volumetric efficiency, using state and parameter estimation techniques. A high order, nonlinear model has been utilized for the axial piston pump. Pressure measurements of the pump are used for a linear Kalman Filter as well as an Extended Kalman Filter to estimate the remaining states of pump model. Volumetric efficiency losses are tracked by the filters via estimation of two leakage coefficients, low Reynolds and high Reynolds leakage, which are allowed to vary within the model to track the changes. . In a separate analysis, a third parameter, a disturbance torque, was applied to the load and its estimation in a similar process to the leakage coefficients. Both filters are able to estimate a single leakage or load. However, the KF was unable to distinguish between two leakages. The EKF is able to distinguish between low and high Reynolds number flows since it takes into account the nonlinearities in the system including the leakage flow characteristics. The EKF shows promise in being able to estimate both leakages and a load disturbance simultaneously. Both types of filters were found to have fast run times suggesting that the filters could be implemented using typical microcontroller hardware found on industrial and mobile hydraulic machinery.

Tyler Shinn, grew up in Quincy, Illinois. He chose to attend University of Missouri – Columbia early on, following in the footsteps of his mother and sister. He graduated with a Bachelor of Science in Mechanical Engineering in May of 2013, and then a Masters of Science in Mechanical Engineering, also from the University of Missouri – Columbia, in August of 2015. He is currently pursuing his Doctorate in Mechanical Engineering.

A Study on Surface Enhanced Substrates for Raman Spectroscopy

Daniel Soden
Department of Physics, Astronomy, and Material Science
Missouri State University
Advisor: Kartik Ghosh

Abstract

Surface enhanced Raman spectroscopy builds upon one of the most powerful analysis tools of the twenty-first century to enable ultrasensitive detection of analyte particulates. Currently, analysis techniques, while effective, require both a high degree of expertise and a reasonable amount of time. This study utilized sputtering physical vapor deposition as a means to functionalize substrates with noble metal nanoparticles, achieving a localized plasmon resonance effect (LSPR). Nanoparticle morphology and optical properties were studied to determine optimal growth characteristics for surface enhanced Raman spectroscopy. Future testing will be conducted to determine the actual inelastically scattered signal boost associated with the substrates.

Daniel Soden is from Springfield, Missouri, and has attended Missouri State University for both his undergraduate program in physics as well as his graduate degree in materials science. He is currently in his last semester of his graduate program and has accepted a position as a product engineer at Eagle Picher Technologies, LLC.

An Investigation of Mercury's Exosphere using MESSENGER MDIS Images

Amanda Stadermann
Department of Earth and Planetary Sciences
Washington University in St. Louis
The Johns Hopkins University – Applied Physics Laboratory
Advisor: Nancy Chabot

Abstract

The MESSENGER mission to Mercury launched in 2004, flew by Earth once, Venus twice, and Mercury thrice before orbital insertion in 2011. From orbital insertion, it was in a highly elliptical, polar orbit until the mission ended in April 2015. Throughout its four years in orbit around Mercury, the MESSENGER spacecraft mapped the entire surface and made uncountable scientific discoveries. The Mercury Dual Imaging System (MDIS) has two cameras: the Narrow Angle Camera (NAC) and the Wide Angle Camera (WAC). The WAC has a broader field of view than the NAC, but is restricted to lower spatial resolutions. In this study, we use WAC images to investigate the exosphere of Mercury.

Uncertainty Quantification of Turbulence Model Coefficients for Mildly Separated Flows

Kimon Stephanopoulos
Department of Mechanical Engineering and Materials Science
Washington University in St. Louis
Advisor: Ramesh K. Agarwal

Abstract

In this paper detailed uncertainty quantification studies focusing on the closure coefficients of eddy-viscosity turbulence models for several flows and for two CFD solvers are performed. Three eddy viscosity turbulence models are considered: the one-equation Spalart-Allmaras model, the two-equation Shear Stress Transport k-ω model, and the one-equation Wray-Agarwal model. OpenFOAM and ANSYS Fluent are used as flow solvers. Uncertainty quantification analyses are performed for subsonic flow over a flat plate, subsonic flow over the NASA wall-mounted hump, and transonic flow over an axisymmetric bump at zero angle of attack. In the case of the flat plate, coefficients of pressure, lift, drag, and skin friction are considered to be the output quantities of interest. In the case of the NASA hump and transonic bump, these quantities are considered along with the separation bubble size. Uncertainty quantification is conducted with DAKOTA code using stochastic expansions based on non-intrusive polynomial chaos. The influence of the closure coefficients on output quantities is assessed using global sensitivity analysis based on variance decomposition. This yields Sobol indices which are used to rank the contributions of each constant. A comparison of the Sobol indices among the turbulence models, flow cases, and flow solvers is conducted. Closure coefficients of interest are identified in the hope of aiding modelers in improving the accuracy of these turbulence models.

Kimon Stephanopoulos is a B.S./M.S student in the Department of Mechanical Engineering and Materials Science at Washington University in St. Louis. He will graduate with B.S in May 2016 and then complete M.S in May 2017.

Report on Atomistic Modeling of Bonding in Carbon-Based Nanostructures

Timothy Stillings
Department of Physics, Astronomy and Materials Science
Missouri State University
Advisor: Ridwan Sakidja

Abstract

In this study, modern DFT calculations are compared with classical molecular dynamics calculations using Tersoff and AIREBO potentials to assess their accuracy as a means to model carbon structures, specifically C70. Further assessment models interactions between two C70 molecules. It was found that the DFT calculations provided the most accurate results, but calculations done with AIREBO potentials correlate well with the DFT calculations. Tersoff potentials, on the other hand did not perform well and overestimated the bond lengths. An observation of the charge redistribution as a result of inter-molecule interaction between C70's was made revealing an interaction which may be originated from the formation of pi bond.

Timothy Stillings is a senior from Missouri State University where he is seeking a degree in Physics from the Department of Physics, Astronomy and Materials Science. Tim is originally from Ava Missouri but currently resides in Springfield. After graduation, Tim plans on seeking a Master's degree from Missouri State University

Novel Fluorescence Spectroscopy Based Detection Method for Foodborne *Listeria monocytogenes*

Ayriana Taylor
Center of Nanotechnology
Lincoln University of Missouri
Advisors: Majed El-Dweik and Baskar Balakrishnan

Abstract

Listeria monocytogenes is a Gram-positive facultative anaerobic pathogenic foodborne bacteria, which causes listeriosis. This bacterium is typically found in both raw and processed foods. *L. monocytogenes* are capable of growing in a wide range of pH, temperature, oxygenic, and osmolality conditions. This adaptable characteristic means that the detection process of this bacterium must be a continuous practice along with the entire process of food preparation and supply stages. The present study involved in developing a rapid and reliable detection method for this bacterium can be used at any point in food processing and supply stages. The method includes a quick purification of bacteria from the food sample using an immunomagnetic separation technique. The purified bacteria were inoculated into Brain Heart Infusion broth for a short-term enrichment to achieve a detectable quantity. After enrichment, the bacterium was labeled with a Fluorescent dye (TRITC). The labeled bacteria were then captured with immunomagnetic beads that were immobilized with a specific antibody. This immune complex was evaluated using a spectrofluorometer. The entire detection process was completed in just 1 hr, while the traditional culture-based methods require five to seven days for detection.

Ayriana Taylor is currently a senior at Lincoln University in Jefferson City majoring in Animal Science.

Rapid and Highly Specific Immunofluorescence Detection Method for Foodborne *Shigella*

Kayla Turner
Center of Nanotechnology
Lincoln University of Missouri
Advisors: Majed El-Dweik and Baskar Balakrishnan

Abstract

Shigella is Gram-negative and facultative anaerobic bacteria closely related to the genus *Salmonella*. *Shigella* is a major foodborne bacterial pathogen, which is the cause of shigellosis. Some serotypes can produce an enterotoxin called the *Shiga* toxin, which is responsible for Hemolytic Uremic Syndrome. The source of contamination is through humans, especially in cases of poor hygiene. Detection process of this bacteria remains a concern, due to lack of specific culture methods of this bacteria, which leads to a high level of cross contamination with *Salmonella* species. In the present study, the bacteria were separated from the enriched food sample. The separated mixed bacterial sample subjected to fluorescent dye labeling using FITC dye. The labeled bacterial sample subjected to the isolation of targeted *Shigella* bacteria. For this, a specific antibody immobilized Protein-A coated magnetic bead was used. The purified fluorescently labeled bacteria visualized under fluorescence microscopy. The presence of fluorescent proved the purification and detection of *Shigella*. This method turned out to be highly specific to *Shigella*.

Kyala Turner is currently a senior at Lincoln University in Jefferson City.

Direct Numerical Simulation for Turbulent Drag Reduction using Riblets

David Varner
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Lian Duan

Abstract

Current research has shown that reducing drag on aircraft can result in major reductions in fuel usage. One method of reducing drag involves changing the surface geometry from flat to textured. This study focuses on sawtooth riblets as the optimal geometry to reduce drag. Direct Numerical Simulation (DNS) of these riblets will show which height and length ratios best facilitate drag reduction. Currently, results for a flat plate simulation are being obtained. Creating a 3D mesh in order to test the riblets has proven much more troublesome. Creating these meshes are the next step in moving forward with this research.

David Varner hails from Platte City, Missouri. He is a graduating senior in Mechanical Engineering and studies at the Missouri University of Science and Technology. After returning from his coop in Nebraska, he is seeking employment in the mechanical design field.

Determination of Characteristics in an Argon Theta-Pinch Plasma

Mitchell Wainwright
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Dr. Joshua Rovey

Abstract

Pulse induced plasmas are of interest for use in high powered space craft propulsion and nuclear fusion. A gap remains in current understanding of how energy conversion occurs early on in inductively driven plasma, and in order to characterize this, time resolved data is required. Usages of spectroscopic and triple probe measurements are options to obtain these time resolved values. The usage of both of these techniques and possible future research topics for better characterization of early on plasma formation and energy conversion will hence be discussed.

Mitchell Wainwright hails from Clifton, IL, and is a graduating senior in aerospace engineering with a minor in computer science at Missouri University of Science and Technology, and plans on continuing on in the graduate program there. Mitchell has been involved in many activities as an undergraduate including college athletics, design teams, volunteer work, and research (including co-authorship on a conference paper).

Uncertainty Mapping in Probabilistic Delineation of Angles Only Initial Orbit Determination

Kari C. Ward
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Kyle J. DeMars

Abstract

The application of the transformation of variables technique is presented for angles-only orbit determination. This method provides an analysis for the effect of a nonlinear transformation on the probability density function from an input domain to the output domain. The set of possible orbit solutions is refined using admissible region constraints for isotropic and anisotropic intervals between optical measurements of the satellite. The transformation of variables technique provides a relative probability to each solution within the set of previously equiprobable possibilities delineated by the admissible region approach to orbit determination.

RotCFD: UNS2D Airfoils Report

Shannah N. (Withrow) Maser, Missouri University of Science & Technology
Nikolaus L. Thorell, Georgia Institute of Technology
Alexandre M. Poux, Georgia Institute of Technology
Mohammad A. Syed, Pennsylvania State University
Rotorcraft Aeromechanics Branch
NASA Ames Research Center, Moffett Field, CA 94035
Mentors: William Warmbrodt and Gloria Yamauchi

Abstract

Studying flows in two-dimensional computational domains is beneficial for understanding 3-dimensional geometries. For example, flow past long cylinders, boxes, or wings can be simplified to two dimensions. A new package to Sukra-Helitek's Rotorcraft CFD (RotCFD) called UNS2D is a two-dimensional solver. The UNS2D code is still in development and is being verified against experimental data. The objective of this project was to validate UNS2D results for the NACA 0012, NACA 64-208, Eppler 387, and AGRC1506 airfoils. The equivalence of rotating flow around an airfoil verses rotating a body within a flow was also investigated to determine if the solutions depended on geometry orientation in the grid

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Shannah (Withrow) Maser is a senior in Aerospace Engineering at the Missouri University of Science and Technology (Missouri S&T) from Odessa, Missouri. Shannah has interned at Ames Research Center in the Rotorcraft Aeromechanics Branch during the summers of 2014 and 2015 where she performed software analysis of RotCFD software, studied applications of stall delay and tip loss of an AW609 rotor, and analyzed flow patterns during flight testing of the V-22 Osprey as a project lead. She has also been active on campus in the Aerospace Engineering department as the president of the microgravity research team, Miners in Space, from 2013-2015 and, currently, as the University Nanosat 9 Program Manager for the Missouri Satellite Research Team (M-SAT). In December 2016, she plans to begin an Aerospace Engineering master's thesis project at Missouri S&T under Dr. Hank Pernicka in the position of Program Manager with an emphasis in Systems Engineering. After graduation, Shannah would like to continue to work in leadership in the Aerospace Engineering field.

Evaluation of Six Turbulence Models for Accurate Numerical Simulation of a 2D Slot Nozzle Ejector

Isaac Witte
Department of Mechanical Engineering and Materials Science
Washington University in St. Louis
Advisor: Ramesh K. Agarwal

Abstract

Accurate numerical simulation of high speed ejector flow is critical for design and optimization of nozzle ejector systems. Computational Fluid Dynamics (CFD) modeling of the turbulent mixing of a high speed jet with subsonic flow requires a turbulence model that can predict the flow field with an acceptable accuracy. In this paper, we consider six turbulence models – one equation Spalart-Allmaras (SA) model, one-equation Wray-Agarwal model, two-equation k-ε and Shear Stress Transport (SST) k-ω models, four equation Transition SST k-ω turbulence model and Scale Adaptive Simulation (SAS) - SST k-ω model. The accuracy of these models is evaluated by comparing the CFD predictions against the experimental data available from NASA for a 2D slot nozzle ejector in a variable area mixing section. In addition the effect of two boundary conditions at the nozzle inlet – the pressure condition and the mass flow rate condition, on solution accuracy is investigated. It is shown that the Wray-Agarwal, SST k-ω and the Transition SST k-ω turbulence models give the best overall agreement with the experimental data.

Isaac Witte is a B.S. /M.S student in the department of Mechanical Engineering and Materials Science at Washington University in St. Louis. He will graduate with B.S in May 2016 and complete M.S in May 2017.

Missouri S&T Satellite Research Team

Thomas Knight and Garrett French
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Henry Pernicka

Abstract

The Missouri University of Science and Technology Satellite Research team (M-SAT) is working with a number of AFRL/NASA/industry mentors in designing, constructing, and launching nanosatellites and microsatellites. M-SAT's Nanosat 8 endeavor consists of two microsatellites, named MR SAT (Missouri-Rolla Satellite) and MRS SAT (Missouri-Rolla Second Satellite). MR SAT and MRS SAT will simulate an inspector satellite and an uncooperative resident space object respectively. The two will perform proximity operations during flight. In addition to proximity operations and stereoscopic imaging, MR SAT is being used to study cold gas propulsion. MR SAT and MRS SAT placed first January 2015 at the University Nanosatellite Program (UNP) competition.

M-SAT is now competing in Nanosat 9. APEX (Advanced Propulsion Experiment) will demonstrate a multi-mode thruster that is being developed at the Aerospace Plasma Lab at Missouri S&T. The thruster shall utilize an ionic liquid monopropellant for both chemical and electric burns. M-SAT also participated in the first two Ground Tournaments for NASA's Centennial Challenge Cube Quest. Lunar CubeQuestador was used as a study of a medium thrust, cold gas propulsion system.

The associated Balloon Satellite (B-SAT) program is designed to help students develop payloads that fly to high altitudes via balloons. Students learn about developing mission goals and mission planning, integrating components, soldering, using microcontrollers, programing, and data acquisition and instrumentation. A space balloon summer camp for high school students was offered the summers of 2014 and 2015.

Thomas O. Knight is a second semester senior, pursuing a BS degree in Aerospace Engineering. Since 2015 he has contributed the Missouri S&T Satellite team through his involvement on the power and propulsion subsystems

Garrett L. French is a second semester freshmen in Aerospace Engineering at the Missouri University of Science and Technology. He is an active member of M-SAT.

Enhancing the Multidisciplinary Astrobiology Research Community at Truman State University

Colby Cook, Physics
Tyler Gardner, Physics/Mathematics
Trevor Leighton, Chemistry
Charlyn Ortmann, Physics
Nathan Scott, Biology/Chemistry/Astronomy
Truman State University
Advisors: Dr. Laura Fielden and Dr. Vayujeet Gokhale.

Abstract

Faculty and undergraduate students at Truman State University continued the activities of the Multidisciplinary Astrobiology Research Community and introduced new interdisciplinary educational opportunities for Truman students. We continued our collaboration with Dr Neil Sargentini at ATSU, Kirksville in an attempt to include other local institutions in our astrobiology related activities. We were joined by Dr. Carolina Sempertegui-Sosa, a Biology faculty member at Truman State University in our weekly seminar class. We discussed astrobiology themed review papers during the seminar class, and devoted a significant amount of time discussing the introduction of an ‘Astrobiology Minor’ at Truman State University. These projects supported the activities of the astrobiology research program at Truman, strengthened the Center for Astrobiology, and inspired students from a range of science disciplines to consider careers in astrobiology. A total of five students and three faculty members from Biology, Chemistry, and Physics participated in activities sponsored by this project.

Student Biographies

Colby Cook is a freshman physics major at Truman state university. He grew up in Kansas City, Missouri and now lives in Kirksville. This is his first year in Truman's astrobiology program working under Dr. Vayujeet Gokhale. Colby likes to play lacrosse and basketball in his free time.

Tyler Gardner is a senior at Truman State University. He is pursuing a Physics degree with a minor in Mathematics. This is his third year doing research with Dr. Vayujeeet Gokhale in the Astrobiology program. Tyler will graduate at the end of this semester and is deciding on which graduate-school offer he will accept.

Trevor Leighton is senior chemistry major at Truman State University. He grew up in St. Louis, Missouri and now lives in Kirksville, Missouri. This is his third year in Truman's astrobiology program working under the direction of A.T. Still University's Dr. Neil Sargentini. Trevor enjoys learning new languages, recreational swimming, and winemaking.

Charlyn Ortmann is a sophomore Physics majors at Truman State University. She grew up in a small town in southern Missouri and now lives in northeastern Missouri. This is her second year in Truman's astrobiology program working under the direction of Dr. Vayujeet Gokhale. Charlyn loves camping, hiking, and spending time with her family.

Nathan Scott is a Junior at Truman State University. He grew up in Chapel Hill, NC. and moved to MO in 2009. He is pursuing a Bachelors degree in Biology as well as minoring in both Chemistry and Astronomy. This is his third year working in the astrobiology program under the direction of Drs.Vayujeet Gokale, Laura Fielden, and Carolina Sempertegui-Sosa.

Faculty Biographies

Laura Fielden is a professor in biology at Truman state university. She earned her Ph.D. in Zoology from the University of Natal, South Africa. Her research interests center on the ecophysiology of ectoparasitic arthropods, in particular ticks and fleas. Laura Fielden and her research group are currently investigating the physiological basis of long term survival in ticks.

Vayujeet Gokhale is an assistant professor of physics at Truman State University. He earned his BSc. in physics ('96) and MSc. in nuclear physics ('98) from the University of Bombay, followed by a PhD in astronomy from Louisiana State University. The Gokhale group is interested in identifying and observing exoplanets in transiting systems, and studying habitable zones around low mass stars.

Light Pollution in Kirksville

Celene Fuchs, Eric Hilker, Steven Pankey, Ingrid Roettgen
Truman State University
Advisor: Dr. Vayujeet Gokhale

Kaila Lorenzen
Moberly Area Community College
Advisor: David Caples

Abstract

Faculty and undergraduate students at Truman State University and the Moberly Area Community College (MACC) participated in activities related to quantifying the light pollution in and around the Kirksville area in northeast Missouri. Students used light sensors to track the amount of light projected towards the sky at various locations on campus, the University farm, and at Thousand Hills State Park (about 5 miles W/NW of Kirksville). In addition, students used DSLR cameras to qualitatively capture the amount of light pollution by capturing long exposure tracked and untracked images of the night sky. The students have designed an outreach program to be tied in with the weekend shows at the *Del and Norma Robison Planetarium* at Truman State University, which includes handing out light pollution related brochures, a 6-minute '*Losing the Dark*' planetarium documentary produced by the *International Dark Skies Association*, and Q&A sessions with the audience. Additionally, students have reached out to school administrators, the local power company (*Ameren*), and published opinion pieces in the local newspaper regarding light pollution and possible solutions.

Student Biographies

Celene Fuchs is a sophomore Romance Language major at Truman State University, currently studying French, Spanish, and Italian; she is also working towards a minor in French and Translation and a minor in art history. She lives in St. Charles, Missouri, and is quite disappointed in the lack of stars visible. Her interests include reading, singing, and history.

Eric Hilker is a junior Biology major at Truman State University. He grew up in Eureka, Missouri almost all of his life. This is his first semester working in Truman's Light Pollution Project under the direction of Dr. Vayujeet Gokhale. Eric enjoys the outdoors with his yellow labs, and to go on adventures with his family and friends. One of Eric's hobbies includes weight lifting/Crossfit. He is also a DJ for Truman State's radio station.

Kaila Lorenzen is a freshmen Pre-engineering major at Moberly Area Community College. She grew up in Western Illinois and now is a resident of Northern Missouri. This is her first year working with Truman's Light Pollution Research team, under the direction of Dr. Vayujeet Gokhale and Prof. David Caples. Kaila loves anything to do with the outdoors. She really enjoys hiking with her two dogs, equestrian riding, and kayaking.

Steven Pankey is sophomore Phyics major at Truman State University. He grew up in the suburbs of Saint Louis and now lives in northeastern Missouri. This is his first semester in Truman's photometry program working under the direction of Dr. Vayujeet Gokhale. Steven enjoys the outdoors, movies, and a dark skies.

Ingrid Roettgen is a Communication major at Truman State University. She joined the research team after taking Dr. Vayujeet Gokhale's 'Introduction to Astronomy' class and subsequently becoming fascinated with the night sky. She assists the research team as an amateur photographer, capturing images of light pollution around the Kirksville area. In her "spare" time, Ingrid likes to take her dog on long walks, play video games, and read clickbait on the internet.

Faculty Biographies

David Caples is an Assistant Professor of Mathematics at Moberly Area Community College. He has a masters degree in mathematics from the University of South Dakota with an emphasis in computational mathematics. Prior to his seven years of teaching, he worked as a computer consultant in St. Louis for ten years completing projects at AT&T, Union Pacific, and Monsanto. When away from the classroom, he enjoys backpacking, camping and reading.

Vayujeet Gokhale is an assistant professor of physics at Truman State University. He earned his BSc. in physics ('96) and MSc. in nuclear physics ('98) from the University of Bombay, followed by a PhD in astronomy from Louisiana State University. Dr. Gokhale loves the night sky and National Parks, and dreams of becoming an astronomy park ranger at the Arches National Park in Utah.

A Bridge to the Stars Scholarship and Mentoring Program (FY2015)

Derrick Jennings (Spring 2016 Bridge Mentor)
Linda Pham (Spring 2016 Bridge Mentor)
Department of Physics & Astronomy
University of Missouri – Kansas City
Supervisor: Prof. Daniel McIntosh

Abstract

This report primarily covers the results of the Spring 2015 semester (FY2014) Bridge to the Stars scholarship and mentoring program set up by Prof. Daniel McIntosh at the University of Missouri – Kansas City. Results from Spring 2015 (FY2014) semester are compared to all semesters of the Bridge program including Spring 2016, which will end in May 2016. The purpose of the program was to provide underrepresented minority high school students a chance to take a college level astronomy course, and gain an understanding of basic physics/astronomy principles, while also being introduced to college life. The demographics of the six students who participated in the program varied widely. Two males, one Asian American and one African American as well as three female students, one Hispanic American, one African American, and one Caucasian, including one trans student, Caucasian, participated in the A Bridge to the Stars program. Two students attended East High School; one attended Lincoln College Preparatory Academy, one attended Central Academy, one attended African Centered College Preparatory Academy, and one was homeschooled. The mission of these high schools is to provide a high quality, individualized, values-based college preparatory education, which is consistent with their participation in programs like this. Prof. Daniel McIntosh was assisted by two undergraduate interns at the University of Missouri – Kansas City. For the 2015 Spring (FY2014) semester, Prof. Daniel McIntosh hired interns Derrick Jennings and Abby Shelburne to peer mentor the high school students. The interns were to attend class with the students, as well as meet outside for at least one hour each week. The weekly meetings outside of class would begin with questions from the students, followed by review of lecture slides and class materials.

University of Missouri- St. Louis Astronomy Outreach Program

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Abstract

The University of Missouri- St. Louis is proud to offer the Planetarium Outreach Program through the Department of Physics and Astronomy, with funding provided by the NASA-Missouri Space Grant Consortium. The program is geared towards third through fifth grade students and aims to stimulate critical thinking and encourage student's interest in space, astronomy, and engineering. It consists of a planetarium presentation and a classroom presentation with demonstrations and science related activities. The planetarium was proud to receive various upgrades in the summer of 2015, among them new seating and a full color high definition projector. The new projector runs on Starry Night 7 and various other programs, allowing for endless customization of planetarium presentations. The program was proud to partner with the Challenger Learning Center this year as well, providing simulated space missions in addition to the planetarium and classroom demonstrations. The program hosted a total of twelve groups, comprised of nineteen planetarium presentations, and seventeen classroom demonstrations. The twelve groups totaled 454 students. With our new partnerships and recent upgrades, the program has the opportunity to further develop several alternative shows in an attempt to widen our available audience.

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