Proceedings of the 23rd Annual Meeting of the NASA - Missouri Space Grant Consortium

Missouri University of Science and Technology
April 25-26, 2014

Sponsored by

The National Aeronautics and Space Administration
National Space Grant College and Fellowship Program

NASA - MISSOURI SPACE GRANT CONSORTIUM
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MISSOURI SPACE GRANT

CONSORTIUM

Preface

This 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 and NASA-EPSCoR Missouri. 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 scientific research group and engineering design team activities. This year's meeting was held at the Missouri University of Science and Technology on April 25-26, 2014.

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. Mike Reed, Missouri State University; Drs. Frank Feng and Sudarshan Loyalka, University of Missouri-Columbia; Dr. Dan McIntosh, University of Missouri-Kansas City; Dr. Bruce Wilking, University of Missouri-St. Louis; Drs. William Smith and Ramesh Agarwal, Washington University in St. Louis, Mr. John Lakey, St. Louis Science Center, and Dr. Majed Dweik, Lincoln University of Missouri; 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. Mike Swartwout, Saint Louis University, Dr. Vayujeet Gokhale, Truman State University, and Ms. Tasmyn Front, Challenger Learning Center of St. Louis, for their contributions in coordinating, advising, and mentoring student research and 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. Dave Riggins, Director
NASA-Missouri Space Grant Consortium
NASA-EPSCoR Missouri

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NASA-Missouri Space Grant Consortium

NASA-EPSCoR Missouri

University of Missouri - St. Louis Planetarium Outreach Program

Anamaria Baluyut
University of Missouri- St. Louis
Advisor: Dr. Bruce Wilking

Abstract

The University of Missouri- St. Louis proudly offers 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 for fifth grade students and aims to stimulate critical thinking and encourage student interest in space, science, and engineering. It consists of a planetarium presentation and a classroom presentation with demonstrations and science related activities. Despite attempts to contact schools earlier in the academic year and the creation of a website, attendance numbers were low for this year's program. Restructuring of the program for a different target audience may be necessary.

Link to Full Paper

Anamaria Baluyut is a graduate student in the Department of Physics and Astronomy at the University of Missouri- St. Louis. She comes from O'Fallon, Missouri and plans to obtain her PhD in astrophysics.

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Katherine G. Becker
Washington University in St. Louis
Advisor: Dr. Jeffery G. Catalano

Abstract

Fe(III) oxide minerals are abundant in soil, sedimentary, and aquatic systems. Biogeochemical iron cycling creates conditions where aqueous Fe(II) and solid Fe(III) oxides coexist. These may undergo a series of secondary, abiotic reactions largely driven by electron transfer and atom exchange, which couple oxidative Fe(II) adsorption and reductive dissolution of Fe(III) at spatially separate surface sites. These reactions have been shown to cause the self-recrystallization of stable iron oxide minerals, during which trace metals may be incorporated into the iron oxide structure. Such processes may also fractionate stable isotopes of trace metals, which are considered potential biogeochemical tracers in modern and ancient systems. This study investigates factors affecting Zn adsorption and incorporation into Fe(III) oxide minerals during Fe(II)-catalyzed recrystallization (through XAFS spectroscopy) and identifies Zn isotopic fractionations associated with this partitioning (via MC-ICP-MS). After 28 days,Zn (enhanced byFe(II) presence)became incorporated into the goethite mineral structure, but Zn was not incorporated into hematite. Adsorption of Zn to both mineralsincreased from pH 7 to 8, but Fe(II) increased Zn sorption to goethite while decreasing Zn sorption to hematite. Additionally, Znsorbed to goethite was enriched isotopically light Zn, while Zn sorbed to hematite was enriched in isotopically heavy Zn. This study provides further evidence that Fe(II) and Fe(III) interactions at redox interfaces have the ability to affect trace metal cycling, bioavailibity, and contaminant fate through adsorption, incorporation, and release, and it draws attention to potential trace metal isotopic fractionations associated with adsorption and incorporation into Fe(III) oxide minerals.

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Near-Inrared Spectroscopic Study of AA TAU: Water Observation

Logan R. Brown
University of Missouri – St. Louis
Advisor: Erika L. 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 water to which a spectroscopic model was fit in order for us to determine column density and rotational temperature.

Logan R. Brown originally heralds 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. His research interests are in star formation, particularly in protoplanetary disk chemistry, and his work has been presented at a number of venues, most recently at Protostars and Planets VI in Heidelberg, Germany. Previous work in Spectro-Astrometry on molecular emission in DR Tau has won him recognition at the University of Missouri – St. Louis Graduate Research Fair. 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 pursuing a career in either academia or industry.

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Estimating Cutting Force Coefficients in High-Speed Low-Radial-Immersion Milling Processes

Josiah A. Bryan
University of Missouri
Advisor: Dr. Roger C. Fales

Abstract

A high-speed milling system is considered, which is prone to chatter vibration, a stability condition dependent on system parameters (e.g., cutting force coefficients). This work is motivated by the need for model parameters which can be used in stability analysis. An Extended Kalman Filter (EKF) is proposed to estimate cutting force coefficients for each tooth in a low-radial-immersion milling process to aid chatter stability prediction. The proposed EKF utilizes tool deflection measurements and no force measurements. The model used in the EKF is found to be observable, a quality required to achieve valid state estimations. Running the EKF with experimental tool deflection measurements produces estimates of cutting force coefficients that result in good correlation between simulation (using the estimated coefficients) and experiment. Such an EKF may help customize chatter stability analysis to any particular tool-workpiece system.

Josiah Bryan graduated in December 2011 with an MS in Mechanical & Aerospace Engineering from the University of Missouri in his hometown of Columbia, MO. He is now pursuing a Ph.D. there in the same discipline. His Ph.D. research under Dr. Roger Fales involves dynamics and controls for chatter prevention in milling processes. He plans to finish in May 2014.

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Investigating Compounds of Interest in Hydrogen Storage Applications using Residual Gas Analysis Mass Spectroscopy

Christopher L. Carr
Center for Nanoscience and Department of Physics and Astronomy
University of Missouri-St. Louis
Advisor: E.H. Majzoub

Abstract

We have used residual gas mass spectroscopy (RGA-MS) to analyze the temperature controlled decomposition of a nitrogen-doped nano-porous carbon (NNPC) framework infiltrated with $LiBH_4$. The decomposition pathways of bulk samples of $LiNH_2$ and $LiAlH_4$ were also studied using RGA-MS. The analysis of the $LiNH_2$ sample identified the correlated release of ammonia, nitrogen and H_2 gas. This suggests the further decomposition of NH_3 after the initial decomposition to ammonia and lithium imide (Li_2NH). The published decomposition pathway for $LiAlH_4$ was confirmed by our sample data. We observed a lowering in the onset temperature of H_2 desorption from 460 °C to 150 °C with respect to bulk $LiBH_4$ for $LiBH_4$ confined in NNPC. The presence of diborane (B_2H_6) and nitrogen gas was detected during the decomposition of the sample. The lowering of the onset desorption temperature for metal hydrides is required for incorporation in practical hydrogen storage systems.

Christopher Carr was born in Ware, Massachusetts. He lived in Massachusetts before attending Southern Illinois University in Edwardsville for his undergraduate studies in physics. Christopher is currently in his fourth semester of the graduate program at the University of Missouri St. Louis pursing his doctoral degree.

Planetary Science Summer School at the Jet Propulsion Laboratory: A Personal Experience

Ryan Clegg
Department of Earth and Planetary Sciences, Washington University
Advisor: Professor Bradley Jolliff

Abstract

The Jet Propulsion Laboratory in Pasadena, CA, in cooperation with NASA, produces a Planetary Sciences Summer School annually for graduate students and post-doctoral research associates. The purpose of the program is to give participants hands-on experience with the process for designing planetary exploration missions. This paper is a personal account of participating in the Summer 2013 program, by joining a team that designed a proposal for a robotic mission to the planet Neptune.

Imidazole-Based Ionic Liquid Ferrofluid Chemical Propellant Analysis

Brynne Coleman
Missouri S&T
Advisor: Dr. Joshua Rovey

Abstract

This project evaluated the potential of ionic liquids ferrofluids (ILFFs) as chemical propellants, since these liquids already indicate increased performance for electrospray thrusters. The NASA Chemical Equilibrium with Applications (CEA) code was used to predict specific impulses and combustion products of Bmim[NO3]-based and Emim[EtSO4]-based ionic liquids with varied amounts of iron oxide additions, assuming typical monopropellant spacecraft thruster values for the chamber pressure, 300 psi, and expansion ratio, 50. It was observed that as iron oxide was added to the mixtures, the specific impulses dropped significantly, proving to be an important consideration if the gains from hardware simplicity are not as significant as the propellant mass efficiency. However, the product species changed insignificantly, indicating that the iron oxide particles are not consumed in the reaction but act more as a catalyst, as predicted. Analysis of additional testing will be assessed further, pending results from the final experiments.

Brynne Coleman is a Senior in Aerospace Engineering at Missouri University of Science and Technology, and after graduating in December of 2014 with a minor in Mathematics, she will continue her studies as a graduate student at S&T.

Temperature-Dependent Battery Models for High-Power Lithium-Ion Batteries

Stephen Connor
University of Missouri-Columbia
Advisor: Dr. Zaichun "Frank" Feng

Abstract

In this research study, the comparison of two battery models for a high-power lithium ion (Li-Ion) cell for their use in hybrid electric vehicle simulations is explored. Saft America developed their high-power Li-Ion cell and the National Renewable Energy Laboratory (NREL) developed a resistive equivalent circuit battery model for comparison with the 2-capacitance battery model from Saft based on previous sets of experimental data. The primary goal of this project was to test and verify the Matlab translation of Saft's RC Model. In order to do this, the state space equations completely describing the model were put into a Matlab m.file, with all constant variables given. A plot of the output voltage versus time was also given in order to determine how closely the model results followed that of the experimental data. Furthermore, as check on the circuit via Matlab, these model projections were compared to the model results from Saft's P-Spice Model. It was found that for a single 18 second 200 A discharge, it exactly followed that of the P-spice Model. An initial voltage of 3.86 V was consistent for both and steady state voltage of 3.818 V was reached after 100 seconds. Therefore it was found that Matlab was an accurate platform in which to model the Saft Capacitance Li-Ion cell.

Stephen Connor hails from Dallas, TX and is currently a senior in Mechanical Engineering while pursuing minors in Mathematics and Aerospace Engineering at the University of Missouri-Columbia (Mizzou). He is working underneath Dr. Frank Feng and the Mechanical Engineering department of the College of Engineering on research titled, "Temperature-Dependent Battery Models for High-Power Lithium-Ion Batteries". At the university, Stephen is involved in Mizzou's College of Engineering Ambassadors, National Society of Black Engineers, Diversity in Engineering, and frequently tutors elementary and secondary school students at St. Luke's Methodist Church. He is also a Mizzou Diversity scholar and Diversity in Engineering scholar. This upcoming summer, he hopes of interning with either Sikorsky Aircraft (Enflite) in Georgetown, Texas or Lockheed Martin in San Antonio, Texas. After graduating from the University with his Bachelor's degree, he plans to attend graduate to school to further his education or immediately begin working in the Aerospace and Defense Industry.

Photometric Analysis of Seven Yellow Supergiant Stars

Philip E. Crouse
Department of Physics, Astronomy, and Materials Science
Missouri State University
Advisor: Dr. Robert S. Patterson

Abstract

From September to December 2013 a collection of yellow supergiant and bright giant stars was observed with the 14-in. telescope and Apogee Alta u77 CCD camera at the Missouri State University Baker Observatory near Marshfield, Missouri. The brightness of the program stars was obtained using differential photometry once the CCD images were calibrated. To be certain of any variability in program stars, double stars presumed to be constant in brightness of like spectral class, were observed concurrently.

Philip Crouse is from Columbia, Illinois. He is a junior student of physics, astronomy, and mathematics at Missouri State University.

RGB Analysis of Wedge Angles Around a Perforation in Silicon

Jamie Daugherty
Center for NanoScience & Dept. of Physics
University of Missouri- St. Louis
Advisor: Dr. Phil Fraundorf

Abstract

Because transmission electron microscope (TEM) observations are inherently two-dimensional, measuring the wedge angle and specimen thickness of small perforated TEM samples can be difficult. RGB analysis allows one to quantitatively analyze standard color images. Semiconductor silicon exhibits useful color changes in transmitted light as its thickness decreases below a few microns. Through a process of lighting a thinned silicon specimen from underneath, mitigating all other external light sources, analyzing the color transmission, and calculating the thickness and length of the area, a wedge angle can be determined. In this paper we calibrate RGB analysis applied to images of thin silicon with a standard thickness-fringe method for measuring a perforation's wedge-angle in the TEM, and show that the former allows for quantitative predictions of wedge-angle with lateral resolutions above a few microns.

Jamie Daugherty is a senior pursuing a bachelor's of science in general physics at the University of Missouri- Saint Louis and holds a bachelor's degree from the University of Wisconsin- Madison in International Relations. Upon graduation, she plans to continue her education in graduate school, eventually pursuing a career in material science and energy research. During her leisure time, she loves to learn new languages, travel, and dance.

Preparation of Quantum Fingerprint (Charge Based Transient Level Spectroscopy)-Ready Metal-Gallium Arsenide Interfaces for Molecular Characterization

Julian De Castro
University of Missouri - Columbia
Advisor Dr. Mark A. Prelas

Abstract

Quantum Fingerprint trace chemical detectors are desirable due to their high sensitivity, high selectivity, rapid acquisition and response rates, and robustness. These detectors are able to detect trace amounts of the target species (less than ppb). High sensitivity is a desired feature in the field; most situations call for foreign environments and samples of mixed species. The detector's ability to function, with minimum delays, calls for rapid sampling and data processing. Quantum Fingerprint detectors are promising due to its high operating life, low maintenance costs, and resilience to rugged environments. Undoped Gallium Arsenide is used as the base material for the Quantum Fingerprint sensor. This report elaborates on metallization, the features of Ohmic and Schottky contacts, and the preparation of metal-semiconductor interfaces. The interface is centered on a Gallium Arsenide (1 cm x 1 cm) square wafer. A (Nickel/ Germanium/ Gold/ Nickel/ Gold/ Nickel) deposition is place on one side of the Gallium Arsenide Wafer. The other side of the interface is undoped Gallium Arsenide. Signal was found when the interface was analyzed in an open-air environment in room temperature.

Julian Paulo Bugayong De Castro was born in Manila, Philippines on November 14, 1986. He attended the University of Missouri where he received his Bachelor of Science Degree in Biological Sciences on December 2009 and a Bachelor of Health Science Degree in Health Science, with a minor in Medical/ Health Physics, on May 2012. He is currently pursuing of Master of Science Degree in Nuclear Engineering (Health Physics) at the University of Missouri’s Nuclear Science and Engineering Institute.

He currently works as a Radiation Safety Graduate Assistant at the University of Missouri’s Environmental Health and Safety Office. He is currently serving as the Secretary of the Health Physics Society (University of Missouri- Subchapter), He is also a student member of the Mid-Missouri Subchapter Society of Nuclear Medicine.

Mathematical Models of Lithium Ion Batteries

Thomas Franklin
University of Columbia, Missouri
Advisor: Dr. Frank Feng

Abstract

Lithium ion batteries are light weight and very powerful. This makes them ideal for uses in hybrid vehicles, airplanes, space travel and many other situations. This study covers models of these batteries, and their instability problems such as thermal runaway. The first model studied is the Saft capacitance model found by deriving the equations. These results are then compared to equations obtained by the conference paper, *Temperature-Dependent Batter Models for High-Power Lithium-Ion Batteries*[1]. The voltages are also derived with respect to just capacitance and resistance. Next, the equations are derived for batteries in parallel. Future research with this model will deal with thermal runaway and the effects it has on the voltage the battery has after recharging. Batteries in parallel will also be looked at for this case.

Thomas Franklin grew up in St. Louis, Missouri, and is currently a junior at the University of Missouri, Columbia. He is completing a bachelor of science in both mechanical engineering and mathematics. Achievements include making the dean's list and multiple honor societies. His future goals are to go back to school for a masters, and possibly a PhD. He aspires to be a LEED certified engineer. Extracurricular activities of his include the University of Missouri Ice Hockey Team and the 3D print club.

Evaluation of the Performance of Various Turbulence Models for Accurate Numerical Simulation of a 2D Slot Nozzle Ejector

Colin T. Graham
Department of Mechanical Engineering and Materials Science
Washington University in St. Louis, MO 6310
Advisor: Dr. Ramesh Agarwal

Abstract

With the development over last several decades, accurate Computational Fluid Dynamics (CFD) modeling has now become an essential part in the analysis and design of various industrial products where the fluid flow plays a key role. The goal of this paper is to apply the CFD technology to the analysis of a 2D slot nozzle ejector which has application in Short Take-off and Landing (STOL) aircraft and other future aerospace vehicles. In the nozzle-ejector configuration, the high speed air flow from the nozzle entrains the ambient air into a mixing chamber (ejector) as a means to create additional thrust for a STOL aircraft. In 1973, the effectiveness of a slot nozzle ejector configuration in generating additional thrust was evaluated experimentally by Gilbert and Hill of Dynatech under a NASA contract. In this research, the numerical simulations of this experimental configuration are performed and compared with the experimental data. An accurate computational model for simulations requires solving the appropriate governing equations of fluid dynamics using an accurate numerical algorithm on an appropriately clustered mesh in the computational domain. We employ the Reynolds-Averaged Navier-Stokes (RANS) equation to model the turbulent supersonic flow in the 2D slot nozzle ejector. These equations require the modeling of turbulent stresses which are modeled by using a turbulence model. The choice of a turbulence model can affect the accuracy of the solution because of their empirical nature. The goal of this research is to evaluate five turbulence models and determine the best possible model that can most accurately reproduce the experimental results. Five turbulence models employed are the one-equation Spalart-Allmaras model, two-equation standard k-ε and SST k-ω models, the four-equation Transition SST model, and the SAS SST k-ω model. The effectiveness of each turbulence model for simulating the ejector nozzle mixing flow is determined by comparing the computations with the experimental data and the best turbulence model is identified. For the computations, an unstructured mesh is generated using the ICEM CFD 14.5 software and the flow field is calculated using the commercial CFD solver ANSYS-Fluent.

Colin Graham is a M.S. student in the department of Mechanical Engineering and Materials Science at Washington University in St. Louis. He is currently working on his M.S. thesis under the guidance of Professor Ramesh K. Agarwal. He is expecting to graduate in May 2014.

Investigation of Efficient Aerodynamic Shape Optimization Techniques

Joe-Ray Gramanzini
Missouri University of Science and Technology
Advisor: Dr. Serhat Hosder

Abstract

The main scope of this project is efficient aerodynamic shape optimization in transonic flows with gradient-based and surrogate-based approaches. The techniques will be demonstrated on the aerodynamic shape optimization of airfoils and wings. This paper will focus on the implementation of the gradient-based optimization with adjoint-based sensitivities, which is performed using the FUN3D computational fluid dynamics (CFD) code of NASA Langley Research Center, and the Multidisciplinary Aerodynamic-Structural Shape Optimization using Deformation (MASSOUD) code, a shape parameterization and deformation tool. The aerodynamic shape optimization approach includes several key components, including the set up of a computational domain, creating a parameterization of the aerodynamic shape, and performing a sensitivity analysis. In order to study the selection of different approaches for these components, multiple test cases were selected from the AIAA Aerodynamic Design Optimization Discussion Group. This paper will focus on the presentation of the results for the optimization of a NACA0012 airfoil operating in a transonic inviscid flow regime for minimizing the drag under geometric constraints. The results show that, after a series of design cycles, an optimized airfoil geometry with a 63.16% drag reduction compared to the baseline can be obtained. The future studies will involve the implementation of the optimization techniques for the design of airfoils and wings in transonic, viscous, turbulent flows.

Joe-Ray Gramanzini, originally from Kansas City Missouri, is a Candidate for a Master's of Science in Aerospace Engineering at the Missouri University of Science and Technology. Were Joe-Ray is currently studying in the fields of Aerodynamics, Computational Fluid Dynamics, and Aerodynamics Shape Optimization. Joe-Ray Graduated Magna Cum Laude with a Bachelors degree in Aerospace Engineering from Missouri University of Science and Technology 2012. As a graduate student Joe-Ray was awarded the ASME Graduate teaching award in 2013. Joe-Ray is seeking a position as Aerodynamics Engineer with an aerospace company were Joe can work with an emphasis in aerodynamic design and analysis, CFD, propulsion, and thermofluids, while immersed in a completive environment where he can further develop his engineering skill set.

Searching for Interacting Early-Type Galaxies at Late Cosmic Times

Xiachang Her
Department of Physics
University of Missouri-Kansas City
Advisor: Daniel McIntosh

Abstract

Major gas-poor (dry) mergers between two comparably massive spheroidal galaxies are postulated to be the central mechanism responsible for the assembly of giant elliptical galaxies. Numerical simulations predict that these mergers may occur at late cosmic times and typically in dense environments. Previous work using the SDSS Galaxy Group Catalog provided a lower limit to the frequency of interacting early-type galaxies (ETGs) as a function of group mass. Yet, the tidal signatures of such interactions may be too faint to be clearly detected in shallow SDSS data. To improve constraints, we investigate a unique sample of major ETG-ETG pairs that are both close in projection and redshift, belong to common group hosts, and yet lack signs of interaction according to an SDSS analysis. We have obtained V-band imaging 1.5 times deeper than SDSS for 34 pairs with redshifts $z \leq 0.12$ and combined stellar masses $M_{star} \geq 10^{11}$ M_{sun}. Using a tidal interaction parameter derived from GALFIT image residuals we identify interaction signatures in 45% (17/38) of our sample. Our preliminary results indicate a higher frequency of interacting ellipticals at the centers of groups and clusters at late cosmic times.

Xiachang Her is a master student at the University of Missouri–Kansas City, majoring in physics. He have been working with Dr. McIntosh in his Galaxy Evolution Group since spring of 2010. Upon graduating in the summer of 2014, Xiachang would like to continue his education by pursuing a doctorate in astrophysics.

Microstructural Analysis of Shatter Cone Deformation in Optical Microscopy and Electron Backscatter Diffraction

Nils Kjos
Department of Earth and Planetary Sciences
Washington University in St. Louis
Advisors: Professor Bradley Jolliff and Doctoral Candidate Michael Zanetti

Abstract

The progress and future goals of a study on shatter cone formation processes is presented. Included is a general overview of the characteristics of shatter cones, as well as proposed shatter cone deformation mechanisms from recent literature. Shatter cone samples from the Kentland Crater in Indiana and the Charlevoix Crater in Quebechave been obtained. They will be used to examine shatter cones for the first time using electron backscatter diffraction in order to learn more about shatter cone deformation and shock effects recorded in shatter cones from different locales and formed in different rock types

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Nils Kjos is an undergraduate Junior attending Washington University in St. Louis, double majoring in Geophysics and English Literature. He has earned a spot on the Dean’s List at Washington University for all five of his attended semesters. After graduation, he hopes to receive a Fulbright grant to perform geological research in Tromsø, Norway before returning to the United States to apply for graduate school.

CFD Analysis of Open Rotor Engines Using an Actuator Disk Model

Michael Malick
Department of Mechanical Engineering and Material Science
Washington University in St. Louis
Advisor: Dr. Ramesh K. Agarwal

Abstract

In the world of transportation today, efficiency is essential and energy efficient systems are in high demand. Due to its high propulsive efficiency, an Open Rotor gas turbine engine has the potential to significantly minimize the specific fuel consumption and reduce CO_2 emissions in a new generation of transport aircraft. In mid-1980's GE invested significant effort in advanced turbo-prop technology (ATP) and un-ducted fan technology (UDF). However, in spite of its potential for 30% savings in fuel consumption over existing turbofan engines with comparable performance, for a variety of technical and business reasons, the advanced turboprop concept never quite got-off the ground. However, with current emphasis on "Green Aviation" NASA and aircraft engine industry (GE, Pratt-Whiney and Rolls-Royce) are investing significant resources in Open Rotor research and development. The goal of this study is to develop a numerical model to study the performance of counter rotating open rotors (CROR). Advanced CFD studies using the unsteady Reynolds – Averaged Navier-Stokes (URANS) equations are quite complex and computationally intensive. Therefore as a first step, we have developed a simplified model based on Froude's actuator disk method to replace the two spinning rotors with two rotating actuator disks on an axisymmetric model of the hub. The URANS computations for this model were performed using the CFD solver ANSYS- FLUENT. The results of computations have been compared using the wind tunnel data on F31/A31 CROR from NASA Glenn's Research Facility. It is shown that this simplified model has excellent agreement between the computed hub pressure distribution and the test data, while maintaining computational simplicity.

Michael Malick is an M.S. student in the department of Mechanical Engineering and Materials Science at Washington University in St. Louis. He is currently doing research on open rotor engines under the direction of Professor Ramesh K. Agarwal.

Coordinatization Effects on Non-Gaussian Uncertainty for Track Initialization and Refinement

James S. McCabe
Missouri University of Science and Technology
Advisor: Kyle J. DeMars

Abstract

A comparison between common coordinate systems used for state representation in orbital mechanics is presented for track initialization in orbit determination and follow-on tracking utilizing optical angles-only measurements. A Gaussian mixture parameterized probability density function representing uniform uncertainty across all possible Earth-bound constrained orbits is constructed. This distribution is mapped into each coordinate system, propagatedforward in time, and refined via a Bayesian filter. Performance measures related to uncertainty characterization are applied to judge the efficacy of the method in each coordinate system.

James McCabe is an undergraduate at the Missouri University of Science and Technology, and he will be graduating in May 2014 to remain and begin work on his PhD. He has previously interned at NASAs Marshall Space Flight Center for the Guidance, Navigation, and Mission Analysis Branch and his research interests include initial orbit determination, astrodynamics, and estimation theory.

Investigation of Metal Hydrides and Other Electrode Materials in Lithium-ion Batteries: Improving Capacity and Cycling Performance

Alyssa M. McFarlane, Dongxue Zhao, Waruni Jayawardana, Henry Hamper
Center for Nanoscience
Department of Physics and Astronomy
University of Missouri, Saint Louis
Advisor: E.H. Majzoub

Abstract

Lithium-ion batteries (LIB's) are in high demand for applications requiring high-powered energy sources such as hybrid and electric vehicles (HEV's and EV's), although limitations on cycling life and energy density remain. Recent studies show that utilizing conversion reactions leads to greater capacities, and nano-porous carbons (NPCs) impregnated by materials such as metal oxides have yielded high reversible lithium storage capacities and favorable morphologies. A capacity of 600 mAh/g has been previously achieved using TiO2 spell out particles formed inside NPCs and lithium foil as a counter electrode. The sample was cycled at a constant current between .1 V to 4 V. Ordered mesoporous carbon-TiO2 (OMCT65) was prepared by a basic polymerization method. Light metal hydrides are attractive as conversion materials and may improve these results. NPC's infiltrated with LiBH4 were synthesized and cycled at a constant current, and exhibit improved cycling life. One very important factor relating to the preservation of electrode morphology is control of the Surface Electrolyte Interface (SEI). The formation of the SEI is distinct and can be controlled to produce favorable morphology with the use of electrolyte additives. NPC's infiltrated with light metal-hydrides will be cycled with Vinyl Acetate, a polymerizable electrolyte additive, with results pending.

Optical Emission Spectroscopy of Plasma Formation in a Xenon Theta-Pinch

Warner C. Meeks
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Joshua L. Rovey

Abstract

Analyses of xenon spectral emission data in the IR range from excited neutral xenon transitions and estimations of electron temperature are performed on a theta pinch test article. Estimations are based on a collisional-radiative model originally written for Hall-effect thrusters by Karabadzhak *et al.* utilizing apparent collisional cross-sections. Tests performed on a pulsed xenon plasma at an energy of 80 joules, neutral back-fill pressures of 10 to 100 mTorr, and vacuum discharge frequency of 462 kHz yield time-averaged electron temperatures of 6.4 to 11.2 eV for spectra integrated over the entire 20 µs. Time-resolved T_e estimations are done using CCD gate widths of 0.25 µs and yield estimates of up to 68 eV during peak spectral activity. Results show that back-fill pressures of 30 and 50 mTorr appear to generate plasma earlier and remain cooler than 10 and 100 mTorr. Poor signal-to-noise ratios produce substantial fluctuation in time-resolved intensities and thus estimation errors, while not quantified here, are assumed high for the time-resolved studies. Additionally, spectra acquired in the UV band verify; 1.) the presence of 2^{nd} order diffraction in the near-IR band from singly ionized xenon transitions, and 2.) the absence of air (contaminant) spectra.

Using MatCont for Bifurcation Analysis of Nonlinear Differential Equations

Andrew Noble
University of Missouri - Columbia
Advisor: Frank Feng

Abstract

Cells within a lithium ion battery are sensitive to small perturbations that can lead to a break in symmetry resulting in thermal runway. Differential equations that model the dynamic responses of batteries during charging and discharging have been developed. These models include the coupling between the thermal effects and the electrochemical effects. The resulting differential equations are highly nonlinear and the dynamic responses can only be studied though numerical methods. Numerical integration methods have been widely used to study nonlinear differential equations. The work is tedious since the bifurcation and even chaos are possible outcomes in many of these equations. In particular, the occurrence of bifurcations is associated with a loss of stability in a battery's operation, which is of most importance to its safe operation. A very complicated tool for the bifurcation analysis of nonlinear differential equations known as MatCont has been developed. This tool is uniquely suited for the bifurcation analysis of the nonlinear differential equations governing the dynamics of the batteries during charging and discharging. This paper summarizes the efforts spent learning how to use the tool and how to adapt it for specific applications.

Andrew Noble is from Rocheport, Missouri and is pursuing his undergraduate BS in Mechanical and Aerospace Engineering at the University of Missouri, Columbia. Noble has worked for two semesters as a teaching assistant for the department's "Programming and Software Tools" course under Dr. Steven Neal. Currently a junior, Noble is working on undergraduate research involving MATLAB and numerical continuation while being apart of Tau Beta Pi and the University of Missouri Engineering Ambassadors. After graduating, Noble aspires to gain experience working as an engineer before later pursuing a Master's degree.

Analyzing Density of Damage Layer in Silicon Using the Fork Method, Color Thickness Analysis and Thickness Fringe Measurements

Stephen Ordway
University of Missouri - St. Louis
Advisor: Dr. Phil Fraundorf

Abstract

In order to determine size, depth and surface density of Helium implanted silicon wafers, the fork method was modified to create stabilized cross-sectional TEM specimens. By mounting two pieces of wafer with the SOI in the middle, more area of interest could be found from each specimen. Digitizing TEM images and using ImageJ's distance tool allowed for distance analysis. In order to find the thickness of the sample at the area of interest, which was necessary to find the surface density from a top down view, two methods were used. First, a transmitted light image was taken of a perforation and by using the corresponding RGB values of the digital images, the thickness could be measured. The second method used thickness fringes and the corresponding lattice orientation to determine thickness change. Both allowed for a wedge angle to be created, the thickness of the sample to be calculated, and the resulting surface density of the implanted voids to be recorded. These two methods confirmed one another giving very similar wedge angles.

Stephen Ordway is from Jefferson City. He received his Bachelors Degree in General Physics from the University of Missouri – St. Louis (UMSL) in 2013. He has stayed in the department and is currently working on his Masters. Stephen hopes to continue his studies at UMSL and attain his Ph.D.

A Basic Monte Carlo Model of Initiated Chemical Vapor Deposition using Kinetic Theory

Hayley R. Osman
Missouri State University
Advisor: Saibal Mitra

Abstract

Initiated Chemical Vapor Deposition (iCVD) is a well-known method for depositing polymers used in chemical, biological, and electrical applications. It is a variation of hot filament deposition and can used to produce conformal coatings of polymer films at relatively low reaction temperatures. It is also a solventless technique in which thin polymeric films are deposited by introducing controlled ratios of monomer and initiator gasses into the reaction chamber. Low temperatures in the reaction chamber allow the deposition of polymer films on a wide variety of substrates that include biological substrates.

Hayley R. Osman is from Festus, Missouri, and is a Junior Physics major with minors in Spanish and Mathematics.

Active--Passive Networked Multi-Agent Systems

John Daniel Peterson
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Assistant Professor Tansel Yucelen

Abstract

An active--passive networked multiagent system framework, which consists of agents subject to exogenous inputs (active agents) and agents without any inputs (passive- agents) has been studied. An integral action-based distributed control approach and analyze its transient time and steady state performance characteristics using results from graph theory, matrix mathematics, Lyapunov stability, and *L* stability is proposed. Apart from the existing relevant literature, where either none of the agents are subject to exogenous inputs (i.e., average consensus problem) or all agents are subject to these inputs (i.e., dynamic average consensus problem), the key feature of our approach is that the states of all agents converge to the average of the exogenous inputs applied only to the active agents, where these inputs may or may not overlap within the active agents. Tthe conditions when the performance of the proposed distributed controller specializes to the performance of standard distributed controllers used for average consensus or dynamic average consensus of leaderless networks is discussed and the connections between pinning control and containment control of leader--follower networks are drawn.

J. D. Peterson is a Graduate Research Assistant of the Mechanical and Aerospace Engineering Department and a member of the Advanced Systems Research Laboratory at the Missouri University of Science and Technology

Spectral Mapping of Phyllosilicates in Mawrth Vallis using Along-Track Oversampled CRISM Imagery

Kathryn E. Powell
Department of Earth & Planetary Sciences
Washington University in St. Louis
Advisor: Raymond E. Arvidson

Abstract

The detection of phyllosilicates on the Martian surface has been important in the understanding of the planet's aqueous history. CRISM and OMEGA hyperspectral imagery have been used to detect phyllosilicates in widespread Noachian terrains. Mawrth Vallis is one of the areas with the richest spectra signatures of phyllosilicates. The along-rack oversampled (ATO) CRISM mode allows for better spatial resolution than previously possible with hyperspectral imagery. This study uses ATO imagery to map an area of Mawrth Vallis that was previously considered as a landing site. Smectites are indeed present and can be placed in stratigraphy using a combination of the ATO andHiRISE high-resolution imagery. Future work includes determination of specific smectite species and relative proportions and evaluation of possible formation mechanisms.

Kathryn Powell is originally from Columbia, Maryland and earned her B.S. in Astrophysics from Rice University in Houston, Texas. She is a first-year graduate student in the Department of Earth & Planetary Sciences at Washington University in St. Louis. Her research uses remote sensing to reconstruct past environments on Mars.

Asteroseismology of KIC10001893

Breanna Quick
Missouri State University
Advisor: Dr. Michael Reed

Abstract

NASA's Kepler spacecraft observed the same portion of the sky from March 2010 until April 2013. It only stopped for one day per month to transmit data back to Earth, providing a nearly uninterrupted stream of data for over 150,000 stars for nearly three years. Many of the stars in the field are pulsating stars and their brightness changes in a periodic manner in accord with their properties, mainly density. This paper reports the analysis of a compact pulsating star, KIC10001893, which shows variability with periods between 2 minutes and 5.3 hours. 127 periods were detected with maximum amplitudes of 5.6 parts-per-thousand. These periodicities were inspected for rotational multiplets, from which a spin period of 104+/-15 days is determined for the star. A second mode identification method is applied which searched for, and found, asymptotic overtone spacings. Using the properties we discovered, models can be constructed to infer the internal structure of this star.

Breanna Quick is a student at Missouri State University. She is from a tiny, rural town called Lowry City, Missouri. Breanna went to school at Lakeland, which is in Deepwater, Missouri. Only about 10 students from her class of 27 students attended college. In the future, Breanna plans to attend graduate school, earn her Doctorate degree, become a professor, and conduct her own research.

Evolutionary Trends of Massive Spheroidal Galaxies from 0.6<z<2.5 in the CANDELS UDS Field

Zachary Rizer, Daniel H. McIntosh and the CANDELS Collaboration
University of Missouri - Kansas City
Advisor: Dr. Daniel McIntosh

Abstract:

Spheroidal galaxies are linked to the buildup of massive non-star-forming (quiescent) galaxies. Yet, it remains unclear whether spheroid formation or star formation quenching came first. Does the process of galactic quenching always produce a spheroid, or does the production of a spheroid lead to the galaxy being quenched? Using a new comprehensive catalog of visual classifications based on the HST/WFC3 imaging from the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS), we study the population of visually classified pure-spheroid (elliptical and bulge-dominated) galaxies with Mstar > 10^10 Msun over a wide redshift range (0.6 < z < 2.5) in the Ultra Deep Survey (UDS) field. CANDELS offers the best statistics on rest-frame visual morphologies of z>1 galaxies compared to previous studies based on rest-frame UV. Through UVJ color analysis we find a clear buildup of quiescent spheroidal systems among massive galaxies with decreasing redshift, accompanied by a non-evolving low fraction (10-20%) of star-forming systems. These results are consistent with the steady production of new spheroids that are subsequently quenched. We find quantitatively similar results using spheroidal samples based solely or jointly on automatic (Sersic n>2) selection. Whatever mechanisms are responsible for the buildup of the massive quiescent population, they preferentially add spheroidal systems.

Zachary Rizer is from Lenexa Kansas and is a non-tradition junior/senior student at the University of Missouri - Kansas City. Zachary is a non-traditional because this is his second bachelors degree. He has a previous degree in philosophy. Currently he is on his way to attaining a degree in Physics with an emphasis in Astrophysics. He has made the Dean's List multiple years in a row and has been awarded the honor of attaining various scholarships each semester. Zachary presented a poster of his research at the 2014 American Astronomical Society meeting and has also given an oral presentation of his work at the 2014 MidAmerican Regional Astrophysics Conference. Zachary has not completely narrowed down exactly what his career goals are quite yet, but he is definitely enjoying the learning process along the way.

Study of OH Absorption in AA Tau

Nathan Roth
University of Missouri – St. Louis
Advisor: Dr. Erika Gibb

Abstract

Understanding how young stellar systems are populated with organic molecules and water is integral to the understanding of our own solar system and the formation of life here. By studying the chemical composition of the protoplanetary disks that will evolve into planetary systems, it is possible to learn more about our own stellar origins. The objects of study are low-mass, pre-main sequence stars known as T-Tauri stars, which are analogs of the early solar system. Presented are near-infrared, high resolution ($\lambda/\Delta\lambda \sim 25{,}000$), spectroscopic data of the T-Tauri star AA Tau gathered in 2010 using NIRSPEC at the Keck II telescope on Mauna Kea, HI. AA Tau has a nearly edge-on geometry,[1] which permits its study via absorption line spectroscopy. Presented are spectra of strong OH absorption lines and fits of spectroscopic models to the data, from which rotational temperatures are determined.

Nathan Roth is a senior undergraduate student at the University of Missouri – St. Louis in St. Louis, Missouri, seeking a B.S. in Physics from the Department of Physics & Astronomy. He intends pursue graduate studies and earn a Ph.D. in Physics. After earning his Ph.D., it is Nathan's dream to become a Professor of Physics and split his time between teaching and research in astrophysics and cosmology.

Shape Optimization of Blunt Bodies for Drag Reduction in Hypersonic Flow using a Genetic Algorithm

Christopher Seager
Department of Mechanical Engineering and Materials Science
Washington University in St. Louis

Abstract

With current emphasis on access to space, there is resurgence of interest in NASA and US Air Force on the analysis and design of reusable space vehicles. The challenge in the design of these vehicles is to reduce both the drag of the vehicle and heat transfer to the surface of the vehicle. Recently Yumusak and Sinan performed a study of shape optimization of an axisymmetric blunt body in hypersonic flow for minimum drag using the inviscid compressible Euler equations. Their study did not account for the viscous effects due to transitional and turbulent flow. Accounting for transitional/turbulent flow effects is important for calculation of drag as well as heat transfer. The goal of this research is to minimize the drag as well as heating of a blunt body in transitional/turbulent flow at high speeds at high altitude by optimizing its shape. For flow field calculation, the commercial flow solver ANSYS-FLUENT is employed to solve the Reynolds-Averaged Navier-Stokes (RANS) equations in conjunction with several turbulence models, namely the Spalart-Allmaras (SA), k-ω SST and k-kl-ω models. For shape optimization, a multi-objective genetic algorithm is employed with two objectives, one to minimize the total drag and the other to minimize the heat transfer to the body. Some results are presented for shape optimization of a blunt body employed in the 'Aerothermodynamic Shape Optimization of Hypersonic Blunt Bodies' by Yumusak and Sinan. The results agree with those for the optimized shape with reduced drag using the compressible Euler equations with a genetic algorithm. In addition, the inviscid results with those obtained by employing the RANS equations with several turbulence models are compared. The work is currently continuing for shape optimization of a bicone shape body with two objectives – minimization of drag and heat transfer.

Chris Seager is a B.S./M.S. student in the department of Mechanical Engineering and Materials Science at Washington University in St. Louis. He is currently a junior working on this research under the guidance of Professor Ramesh K. Agarwal. He is expecting to graduate with a B.S in May 2015 and M.S. in May 2016.

Proper Motions in a Young Stellar Cluster

Timothy Sullivan
University of Missouri-St. Louis
Advisors: Bruce A. Wilking (UMSL)
and Frederick J. Vrba (U. S. Naval Observatory, Flagstaff Station)

Abstract

The basics of star formation and why velocity dispersion is an important characteristic of embedded clusters is discussed. The relative proper motions of objects within the Rho Ophiuchi star-forming region are the subject of this study. The relative and absolute velocity dispersions in the X (RA) and Y (Dec) directions for each of the 4 fields that were observed are calculated. These do not match up which leads to the conclusion that there is a problem either in the proper motion calculations, or in the identification of field stars. Since YSOs often show variability in the infrared, a Chi^2 value for each object based on differential photometry is calculated. Suspect field stars are investigated in an attempt to see if they are actually cluster members, and the variability results to a survey of the area are compared.

Timothy Sullivan was born in Kansas City, Missouri and lived there before attending Truman State University for his undergraduate degree. He is currently in his fourth semester in the graduate program at the University of Missouri - St. Louis. Timothy hopes to earn his PhD in physics while doing astronomy and astrophysics research at UMSL.

Modeling and Characterization of Fused Deposition Modeling Tooling for Composite Process

Gregory Taylor

Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Advisor: Dr. K. Chandrashekhara

Abstract

Fused Deposition Modeling (FDM) or Additive Manufacturing is a manufacturing process that allows flexible design and rapid creation of tooling at significant time and cost savings. Vacuum assisted resin transfer molding (VARTM) is emerging as a viable method for the manufacturing of complex high-quality aerospace composite parts. In VARTM, the fiber reinforcement is placed into a mold and vacuum is then applied to the outlet of the mold and the resin is drawn into the mold. In the current study, ULTEM 9085 FDM tools were analyzed for composite manufacturing. Solid and sparse-build coupon testing was completed at room and elevated temperatures. VARTM tooling was evaluated for performance at elevated temperatures and for several cycles to check damage assessment over the lifetime of the tool.

The Nature of Earth's Building Blocks as Revealed by Calcium Isotopes

Maria C. Valdes
Department of Earth and Planetary Sciences, Washington University in St. Louis
Advisor: Frédéric Moynier

Abstract

Because calcium is a refractory, lithophile element which does not partition into planetary cores, the calcium isotopic composition of the mantle represents bulk Earth and calcium isotopes have the potential to reveal genetic links between Earth and meteorites. However, whether calcium exhibits significant mass-dependent variations among Earth and the various chondrite groups, and the magnitude of these variations, is still contentious. Here we have developed a new method to analyze calcium isotope ratios with high precision using multiple-collector inductively-coupled-plasma mass-spectrometry. The method has been applied to a range of terrestrial and meteoritic samples. We find that the Earth, the Moon, and the aubrite parent body are indistinguishable from enstatite, ordinary, and CO chondritic meteorites. Therefore, enstatite chondrites cannot be excluded as components of Earth's building blocks based on calcium isotopes, as has been proposed previously. In contrast, CI, CV, CM and CR carbonaceous chondrites are largely enriched in lighter calcium isotopes compared to Earth, and overall, exhibit a wide range in calcium isotopic composition. Calcium is the only major element, along with oxygen, for which isotopic variations are observed among carbonaceous chondrite groups. These calcium isotope variations cannot be attributed to volatility effects, and it is difficult to ascribe them to the abundance of isotopically light refractory inclusions. On the basis of calcium isotopes, carbonaceous chondrites (with the exception of CO) are not representative of the fraction of condensable material that accreted to form the terrestrial planets and can be excluded as unique contenders for the building blocks of Earth

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Maria Valdes, originally of Long Island, New York, is a second-year graduate student in the Department of Earth and Planetary Sciences at Washington University in St. Louis. She earned her bachelor's degree in Geophysical Sciences from the University of Chicago in 2011. A gap year was spent working as a laboratory technician in the Noble Gas Geochemistry Laboratory at the University of Illinois-Chicago (supervisor: Reika Yokochi), in the Laboratory for High-Pressure Mineral Physics at the University of Chicago (supervisor: Andrew Campbell), and as the Robert A. Pritzker Center for Meteoritics and Polar Studies intern at the Field Museum of Natural History in Chicago (Supervisor: Philipp Heck). Her graduate studies began in August of 2012, working with Frédéric Moynier developing the calcium isotopic system for MC-ICP-MS. Maria presented her first year's work at the 2013 AGU conference in San Francisco, which she won a Student Travel Grant Award to attend. Most recently, she successfully defended her Master's work and will receive her A.M. degree in Earth and Planetary Sciences from Washington University, with an emphasis on geo- and cosmochemistry, in May of 2014. She looks forward to continuing her PhD studies in isotope cosmochemistry with Frédéric Moynier (now at IPGP Paris) and Bradley Jolliff.

Efficient Uncertainty Quantification of Hypersonic Reentry Flows

Thomas K. West IV
Missouri University of Science and Technology
Advisor: Dr. Serhat Hosder

Abstract

The objective of this study was to demonstrate the use of a combined sparse sampling and stochastic expansion approach for efficient and accurate uncertainty quantification of highfidelity, hypersonic reentry flow simulations, which may contain large numbers of aleatory and epistemic uncertainties. Stochastic expansion coefficients were obtained using the pointcollocation non-intrusive polynomial chaos technique under sparse sampling conditions, utilizing a number of samples less than the minimum number required for a total order expansion. This study introduced two methods of measuring the accuracy of the expansion coefficients as well as their convergence with iteratively increasing sample size. The sparse sampling solution technique and accuracy and convergence measures were demonstrated on a stochastic, high-fidelity, computational fluid dynamics model for radiative heat flux on a Hypersonic Inflatable Aerodynamic Decelerator during Mars entry. The model consisted of 93 uncertain parameters, coming from both flow field and radiation modeling. Results indicated that an accurate surrogate model could be obtained with only about 15% of the number of samples required for a total order expansion when compared to previous work.

Thomas Kelsey West IV was born in Lake St. Louis Missouri. After graduating from Troy Buchanan High School in Troy, MO in 2006, he began his undergraduate education at the Missouri University of Science and Technology. Over the course of his undergraduate education, Tom participated in the NASA Undergraduate Student Research Program at NASAs Jet Propulsion Laboratory in 2008. In 2010, Thomas graduated Summa Cum Laude earning Bachelor of Science degrees in both Aerospace Engineering and Mechanical Engineering as well as an undergraduate minor in Applied Mathematics. He then earned a Master of Science degree in Aerospace Engineering from the Missouri University of Science and Technology in 2012 and is currently in pursuit of a Ph.D in Aerospace Engineering while having multiple internships at the NASA Langley Research Center during this time.

Simulink Implementation of a Coupled Cross-Flow/In-Line Vortex Induced Vibrations Model

Lawrence M. Williams

Department of Mechanical and Aerospace Engineering
University of Missouri - Columbia
Advisor: Dr. Frank Feng

Abstract

Recently, a low-order mathematical model of vortex-induced vibration (VIV) with two-degrees-of freedom (2-DOF) have been developed using double Duffing and van der Pol oscillators. This study utilizes MATLAB/Simulink to simulate a coupled cross-flow/in-line VIV model to better predict fluid behavior. To promote software reusability of VIV models, development of a graphical user interface (GUI) incorporating VIV dynamics models may also be deemed useful.

Lawrence M. Williams is a senior chemical engineering major at the University of Missouri, in Columbia, MO. He is interested in developing computational tools to aid engineers and scientists.

A New Low Reynolds Number One-Equation Turbulence Model Based on a Rigorous *k-ε* Closure

Timothy J. Wray
Washington University in St. Louis, St. Louis
Advisor: Ramesh K. Agarwal

Abstract

Accurate turbulence modeling remains a critical problem in the prediction capability of many flows using computational fluid dynamics. In this paper a new one equation eddy viscosity model is derived from k-ε closure. The ε-equation used in this derivation is the exact ε-equation so that all budget terms are accounted for in the new model. The new model is used to simulate the flow of several canonical separated flow cases. The open source software OpenFOAM is used for the flow field calculations. It is shown that the new model increases the accuracy of flow simulations compared to the commonly used Spalart-Allmaras (SA) and Shear-Stress-Transport (SST) *k-ω* models, especially for flows with small regions of separation. Several cases of flows with small regions of separation are computed using the present model and are compared with computations using SA and SST *k-ω* model and experimental data. The present model is not only more accurate but is also computationally more efficient.

Tim Wray is a PhD student in the department of Mechanical Engineering and Materials Science at Washington University in St. Louis. He is currently working on his doctoral dissertation under the guidance of Professor Ramesh K. Agarwal. He is expecting to graduate in December 2014.

Enhancing the Multidisciplinary Astrobiology Research Community at Truman State University

Nicholas Barabolak, Tyler Gardner, Trevor Leighton, William Melvin, Nathan Scott, and Neal Thompson
Truman State University
Advisors: Dr. Laura Fielden and Dr. Vauyjeet 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. Three teams composed of one faculty and two undergraduate students pursued astrobiology research projects and participated in weekly community-building events. This project supported the activities of the astrobiology research program at Truman, strengthened the new Center for Astrobiology, and inspired students from a range of science disciplines to consider careers in astrobiology. A total of six students and two faculty members from Biology, Chemistry, and Physics participated in activities sponsored by this project.

Nick Barabolak is a sophomore at Truman State University. He grew up in Elmhurst, IL, approximately 16 miles SW of Chicago. He recently switched from a Physics Major to a Double major in Mathematics and Philosophy and continued researching astrobiology out of interest. This is his first year working in the astrobiology program under the direction of Dr. Vayujeet Gokhale.

Tyler Gardner is a sophomore at Truman State University. He is pursuing a Physics degree with minors in Mathematics and Astronomy. This is his first semester doing research with Dr. Vayujeeet Gokhale in the Astrobiology program, and he is eager to continue doing more work in this field.

Trevor Leighton is a sophomore Chemistry major at Truman State University. He is considering a double major with Biology. He was born in Elkhart, IN and grew up in St. Louis, MO. This is his first year working in the Astrobiology program under the direction of Dr. Laura Fielden. He learned of this opportunity through his attendance of a biology seminar at which students presented their research.

William Melvin is junior Biology major at Truman State University. He grew up in northern Minnesota and Montana and now lives in northeastern Missouri. This is his second year in Truman's astrobiology program working under the direction of Dr. Vayujeet Gokhale.

Nathan Scott is a freshman at Truman State University. He grew up in Chapel Hill North Carolina. He is a Biology Major with a minor in Chemistry. This is his first year working in the astrobiology program under the direction of Dr. Vayujeet Gokhale and Dr. Laura Fielden. He learned about the opportunity through his freshman level biology class.

Neal Thompson is a freshman at Truman State University. He is a physics and chemistry double major. He plans to continue with astrobiology/astronomy research in the future.

Testing of Active Compression Decompression Cardiopulmonary Resuscitation in a Microgravity Environment

Pavel Galchenko, Kevin King, Shannah Withrow
Missouri University of Science and Technology
Advisor: Dr. Henry Pernicka

Abstract

Miners in Space is a student design team at the Missouri University of Science and Technology that works in collaboration with NASA's Microgravity Flight Program to develop and fabricate experiments to be tested in a microgravity environment. Over the last three years, Miners in Space has focused on testing a method of cardiopulmonary resuscitation (CPR) called Active-Compression-Decompression cardiopulmonary resuscitation (ACD-CPR) and comparing its efficiency compared to NASA's current CPR procedure in a microgravity setting. Miners in Space aimed to achieve this with an ACD-CPR device in two separate experiments. The first step involved in assessing the feasibility of this technique in microgravity was to perform compressions with the ACD-CPR device, to determine if the average person is able to perform CPR in this way. The second experiment involves a more complicated model of the human chest designed to test the relative flow rates of fluid in the heart during CPR in microgravity, and to compare those flow rates to traditional CPR methods in the same environment. The results of this experiment indicate strong support of the hypothesis that ACD-CPR is mechanically feasible in microgravity, and that the fluids model of the heart will not be significantly different in 0g than it is in 1g. Because preparation time is significantly shorter using the ACD-CPR, behind-the-back method and the suction cup allows for greater efficiency, these results also support the conclusion that ACD-CPR is more efficient in microgravity than current NASA procedures.

Shannah Withrow, president of Miners in Space, is a sophomore at the Missouri University of Science and Technology studying aerospace engineering. She has been a part of the Miners and Space team for two years and was given the privilege to travel to Houston to participate in NASA's Microgravity Flight Program as a ground grew member in 2013. She plans to return to Houston again during the summer of 2014 to participate in the Microgravity Flight Program as a flyer and team lead. Shannah is also involved with Christian Campus Fellowship and the Boeing mentorship Program.

Harrison Moenster is the vice president of Miners in Space and has been on the team for over three years. He is a senior in mechanical engineering and will be graduating this coming May. Harrison is also an active member of KMNR, Missouri University of Science and Technology's student-run radio station.

Jaykob Maser is a senior studying physics at the Missouri University of Science and Technology. He holds an associate's degree in math and science from Northwest Missouri State University and is the treasurer of Miners in Space. Jaykob also works as a teaching assistant in the physics department, overseeing a section of the Kinematics and Energy Lab. He will be going to graduate school soon, seeking a master's degree at Missouri S&T before proceeding to work on a doctorate elsewhere. His fields of interest are plasma and nuclear physics.

Jennifer Nickel is currently a freshman at Missouri University of Science and Technology. She plans to graduate in December 2017 with a dual major in Architectural and Civil Engineering. She has been on the Miners in Space team for a semester and a half, and she has held the position of secretary for half a semester. Jennifer has also been actively involved in Missouri S&T's Solar House design team as part of the Architecture subgroup for about a semester.

Missouri S&T Satellite Research Team

Christine Schmid, Keith Legrand, William Schatz, Edward Nickel
Missouri University of Science & Technology
Advisor: Dr. Henry Pernicka

Abstract

The Missouri University of Science and Technology (Missouri S&T) satellite research team (M-SAT), in conjunction with a number of AFRL/NASA/industry mentors, is working toward the design, construction, and launch of its first mission. The M-SAT mission consists of two microsatellites, named MR SAT (Missouri–Rolla Satellite) and MRS SAT (Missouri–Rolla Second Satellite), performing proximity operations. MR SAT will act as an inspector satellite while MRS SAT will simulate an uncooperative resident space object (RSO). The goals of M-SAT are to test new technologies in support of missions involving proximity operations, including the study of an R-134a-based cold gas propulsion system for use in formation flying applications and the development of a stereoscopic imager sensor used to determine the real-time relative position/velocity vectors between the satellite pair. Data obtained during the close formation flight phase will be evaluated for the benefit of future missions. As a result of the modest budget that accompanies a university level project; M-SAT has required the use of innovative, low-cost solutions to meet the stated objectives.

Christine Schmid, Program Manager, is from Mokane, Missouri and is a senior in the Aerospace Engineering department at the Missouri University of Science and Technology. Her emphasis includes satellite guidance and control and is an active member of the GN&C subsystem on the M-SAT team. After graduation, Christine plans to receive her Masters degree in aerospace engineering from Missouri S&T.

Keith LeGrand, Chief Engineer, is currently an undergraduate student in Aerospace Engineering at the Missouri University of Science and Technology. His research interests are focused in the areas of astrodynamics, estimation, and spacecraft embedded systems. Past internships have included positions at the Air Force Research Laboratory, Garmin International, and Sandia National Laboratories. Keith has accepted an invitation to participate in Sandia's Critical Skills Master's Program, in which he will earn his Master's in Aerospace Engineering before beginning full-time employment at Sandia National Laboratories in Albuquerque, New Mexico.

William Schatz is currently a senior in the Department of Mechanical and Aerospace Engineering at Missouri University of Science & Technology, majoring in Aerospace Engineering. He is from Sullivan, Missouri. William will graduate in December, 2014, and intends to begin working in the aerospace industry.

Edward Nickel is a senior in aerospace and mechanical engineering at Missouri S&T. As a member of Missouri S&T's Miners in Space team he was a coauthor on a student paper which outlined the team's outreach program, which won first place in the Outreach division at the 2014 AIAA International Student Paper Conference. He was also coauthor of a poster on ACD-CPR in microgravity, which won second place in the enabling technology category of the student poster competition at the 2013 ASGSR national conference.

Impermeable Membranes Using Transparent Graphene Composites

Garrett Beaver
Missouri State University
Advisor: David Cornelison

Abstract:

Graphene has been shown to be theoretically impermeable to all gases, making it a promising gas barrier material. In order to test its performance, polymer membranes were surfaced coated using graphene nanoplatlets in order to reduce the helium permeability. Various coating techniques were tested using graphene dispersed in methanol and isopropanol. Optimal platelet size and quality were determined using Raman, TGA, and SEM. Finally, the permeation rate of the membranes was determined using a custom permeation test apparatus.

Garrett Beaver is working on his Master's degree at Missouri State University studying Material Science and Engineering. He is currently researching the characteristics of devices made from 2D materials such as Molybdenum Disulfide. Garrett hopes to attend the microelectronics program at University of Arkansas.

Collaborative Mobile-Cloud Computing for Disaster Scene Inspection

Jianfei Chen
University of Missouri – Kansas City
Advisor: Zhiqiang Chen

Abstract

Optical imaging techniques have been commonly used in Civil Engineering practice for aiding the archival of damage scenes and more recently for image-based damage analysis. However, an evident limitation in the current practice is the lacking of real-time imaging, computing and analytics capability for team-based visual inspection in a complex built environment. This paper explores a new computing paradigm, called collaborative mobile-cloud computing (CMCC), and proposes a CMCC framework for conducting intelligent condition inspection in a disaster-attacked scene. Through software design, this framework synthesizes advanced mobile and cloud computing technologies with three innovative features: (i) context-enabled image collection, (ii) interactive imaging and processing, and (iii) real-time on-demand image analysis and condition analytics. Through field experiments and computational performance evaluation, this paper demonstrates the feasibility of the proposed CMCC framework, which includes verification of real-time imaging, analytics, and particularly, the mobile-cloud computational solution to two representative damage analysis problems considering complex imagery scenes

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Jianfei Chen was born on 1987, Chongqing, China. He attended Beijing University of Posts and Telecommunications and received his Bachelor degree in Electrical and Information Engineering in 2010, Beijing, China. In 2013, he received his Master of Science degree in Electrical and Computer Engineering department at University of Missouri Kansas City, Kansas City, MO, USA, and continuing his Ph.D. program in Electrical and Computer Engineering department at University of Missouri Kansas City. His area of interest is image processing and system integration.

Observations of Earth-like Exoplanets

Kent Mastroianni and Shannon Dulz
Missouri State University
Advisor: Michael Reed

Abstract

We are studying the atmospheres of extrasolar planets. One of our goals is to determine the feasibility of measurements of hot, rocky planets using ground-based telescopes such as Baker Observatory. Using images collected at Baker Observatory, we compare results to expectations from models. The goal of our ground-based observing is to determine optimal techniques for gathering data (or even if one exists) for extrasolar planet measurements. After routine image processing, we produce lightcurves which may reveal information about the atmospheres of these planets. In our poster, we present work on two of our target planets: GJ1214b, and Kepler 50.

Earth-like exoplanets were first discovered in 2009, and are expected to account for ~38% of all detected exoplanets (Table 6 Borucki et al., 2011). Many of these planets orbit extremely close to their parent stars with periods under a week. Because of this close proximity, the surfaces of these terrestrial planets are heated to temperatures in excess of 1000K. Under such extreme conditions, it is likely that these terrestrial planets have lava-like surfaces and atmospheres produced as a byproduct of vaporization. It is our goal to discern the light that comes from these hot, rocky planets in order to characterize surface compositions, atmospheric conditions, and under what conditions they are formed.

Shannon Dulz is a freshman at Missouri State University with a physics major concentration in Astronomy and Astrophysics. She is from Saint Louis, Missouri and hope to pursue graduate school after her undergraduate studies.

Kent Mastroianni is a sophomore at Missouri State University double-majoring in Astrophysics and Applied Mathematics. He is from Jefferson City, Missouri and also hopes to pursue graduate school in the future.

Impermeable Graphene Sheets

Steven Harrellson
Missouri State University
Advisors: David Cornelison and Edward Sosa

Abstract

Polyurethane sheets were coated with graphene platelets in an attempt to reduce the permeation of helium through their surface. A number of graphene coated polyurethane membranes were manufactured and characterized using UV-VIS spectroscopy and permeability testing. Preliminary results showed no significant reduction of helium permeation as a result of graphene coating processes, but further research must be done to provide any significant conclusions.

Steven Harrellson is a junior physics major at Missouri State University. He was raised in Dexter, Missouri, a small town in southeastern Missouri where his family still lives today. In his undergraduate career he has had the privilege of being able to participate in a variety of research opportunities. During the academic year he works in the lab of Dr. Robert Mayanovic doing physical chemistry. Steven has also had research internships through a computational and biophysics REU at the University of North Carolina at Chapel Hill in the summer of 2013 and a materials science internship funded by the EBSCOR grant at the Johnson Space Center in fall of 2013. He was recently accepted into a REU program at Columbia University where he will spend nine weeks this summer working with Dr. Alan Bigelow at the Radiological Research Accelerator Facility (RARAF). Upon graduation Steven hopes to obtain a PhD in either biophysics or materials science and combine his passion for research and teaching by becoming a professor.

Design of System for the Spectroscopic Study
Of Refractory Materials of Astrophysical Interest

Nolan Ingersoll and Yarden Bosch
Missouri State University
Advisor: David M. Cornelison

Abstract

The Kepler spacecraft is discovering hundreds of rocky, terrestrial planets. Many of these planets are very close to their parent stars with orbital periods below one week. At such close distances, the surfaces will be heated to over 1000K, several above 2000K. Under these conditions, most light gases will evaporate into space, many rocky materials will melt and some will vaporize. The goal of this project is to understand what those places are like. To achieve this goal, we intend to produce those atmospheres in the lab to make measurements that would confirm or deny their presence when compared to observations by telescope of the planets themselves. Some work has been done, including the spectroscopic study of an SiO2 atmosphere at 1700K, and much more work of interest remains to be done.

Yarden Bosch is a materials science graduate student at Missouri State University, and **Nolan Ingersoll** is a physics undergraduate. They carried out this research under the direction of Dr. David Cornelison.

Synthesis of Quality Graphene from Graphite via Ultrasonication with the Addition of Various Surfactants at a Constant Rate

Daniel Soden, Jincheng Bai, and Ying Deng
Department of Physics, Astronomy, and Materials Science, Missouri State University
Advisor: Dr. Lifeng Dong

Abstract

Over the last several years, graphene has emerged as one of the most interesting and potentially useful materials of the 21st century. The material's unusual physical and photovoltaic properties make it incredibly useful in a variety of different applications that could revolutionize modern technology. However, the much sought after monolayer graphene has proven to be difficult to produce in sufficient quantities, with most processes outputting high layer or even defect ridden graphene instead. This experiment aims to correct some of these problems, concerning itself with the synthesis of high quality graphene through continuous sonication with different surfactants added throughout, as well as the issue of graphene quality as a function of sonication time. This was accomplished through the creation and addition of Triton X-100 surfactant solution to a graphite suspension during sonication experiments lasting for 50 minutes, 80 minutes, 110 minutes, 140 minutes, 170 minutes, and 200 minutes respectively. The resulting graphene suspension was then filtrated to separate out the graphene, before being tested for quality through Raman spectroscopy, X-Ray Diffraction, and scanning electron microscopy. An identical sonication experiment was performed with an isopropyl alcohol solution to provide a side-by-side comparison with the Triton X-100. Doping of created graphene will also be explored via another sonication method. This completely physical method of graphene synthesis and doping provides a much simpler and more environmentally safe way to achieve the highly desired few layer graphene, and will hopefully allow for greater use of the substance in industry and its implementation into new technology.

Daniel Soden is a senior level physics major at Missouri State University originally hailing from Lee's Summit, Missouri. He has participated in a variety of different conferences, most notably the Argonne Undergraduate Symposium and the annual spring meeting of the American Physical Society in Denver, Colorado. After his graduation this spring, He will continue to achieve his Master's degree in Materials Science.

Hot Planets Around Other Stars

Amanda Winans
Missouri State University
Advisor: Dr. Mike Reed

Abstract

This project's goal is to study the atmospheres of hot, rocky exoplanets. These planets reside very close to their host stars and thus have very short orbital periods (on the order of a few days); such close proximity means that the planets' atmospheres may be made of vaporized rock. Ground-based observations of both small and large exoplanets are used to study the light reflected off of these planets during their different orbital phases. Multiple filters are used to determine wavelength dependent reflection. The focus of this paper is the gas giant exoplanet CoRoT-1b. Not only is this planet interesting in its own right, but it can be used to test observing strategies and analysis techniques with the goal of achieving sufficient precision to study smaller rocky exoplanets

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Amanda Winans is a senior pursuing a Bachelor of Science in Physics with an emphasis in astronomy at Missouri State University (MSU). During the summer of 2012 she was awarded an NSF REU position at Purdue University where she programmed for the LSST Image Simulator. Her junior year research concerned variable stars including the continuing search for M dwarf pulsators using NASA's Kepler spacecraft. She is currently part of an EPSCoR funded project to study the atmospheres of hot exoplanets. Currently, Amanda has been accepted to at least one graduate program in astronomy and will make a decision soon. She also plays violin in the MSU symphony and her hometown is Kansas City, Missouri.