DISCRETE MECHANICS AND OPTIMAL CONTROL FOR MULTIBODY MECHANICAL SYSTEMS

David Allen, Virginia Tech
Ballroom C

This paper presents preliminary results for the application of DMOC to multibody systems. DMOC is a technique that produces optimal control histories for boundary value problems directly from a discretized Lagrange-D'Alembert principle, and therefore does not require the equations of motion to be explicitly known. This work will be used to develop a methodology for rapidly predicting the performance of a spacecraft with a chosen configuration of momentum exchange devices. By utilizing this methodology for many different configurations, it will be possible to develop a standard methodology for the evaluation of the performance of spacecraft attitude control systems with respect to the size, mass, and power requirements of the control system.

FREQUENCY-DEPENDENT THERMAL DIFFUSIVITY OF AMORPHOUS SILICON USING MOLECULAR DYNAMICS SIMULATION

Christopher H. Baker, University of Virginia
Cyber Lounge

Amorphous materials, or glasses, have applications in a host of technologies, including phase-change memory, insulation, and thermal barrier coatings. Yet, compared to their crystalline counterparts, understanding of thermal transport in amorphous materials is lacking. To this end, we present a simulation methodology to directly measure the frequency-dependent intrinsic thermal diffusivity of an amorphous material. In the case of amorphous silicon, our results corroborate the Allen-Feldman theory, correctly predicting the spike in diffusivity at about 8 THz. Providing empirical data, our method can be used to further refine the Allen-Feldman theory, and, ultimately, guide the development of an analytical theory to calculate the thermal properties of amorphous materials from the microstructure and acoustic properties.
REDUCTION OF JET NOISE USING ACTIVE CONTROL STRATEGIES

Jacob Bean, Virginia Tech

Ballroom C

Novel methods of active noise control (ANC) of jet noise are currently under investigation at NASA Langley Research Center (LaRC). These active control strategies involve introducing perturbations at or near the jet nozzle exit as to destructively interfere with noise generating mechanisms in the free jet. Perturbations such as fluid injection, acoustic excitation, and chevron excitation are being investigated. The addition of these perturbations at the nozzle lip has been shown to enhance turbulent mixing in the jet, thus suppressing the large scale coherent structures in the mixing layer which are the dominant noise generating mechanisms in a free jet. Experimental work has been conducted in the NASA LaRC small anechoic jet facility (SAJF) investigating the ability of actively controlled piezoelectrically-driven chevrons to reduce broadband jet noise. The noise emitted from a M=0.9 jet was examined for the cases of no chevron, a static chevron, and a piezoelectrically-driven chevron. The overall sound pressure level (OASPL) was measured in the sideline and downstream direction for open loop and closed loop control configurations. Due to the control architecture, the closed loop showed only small narrowband advantages over the open loop control.

PERFORMANCE METRICS AND COLLISION RISK MODELS FOR TIME-BASED AIR TRAFFIC MANAGEMENT

Alan Bell, Old Dominion University

Ballroom C

A finite supply of airspace and limited opportunities for expansion of physical infrastructure have led aviation authorities worldwide to commit substantial resources toward the development of new initiatives to accommodate rising demand in the global airspace system. The European Union is developing the Single European Sky, while a parallel program in the United States, the Next Generation Air Traffic Management System, or NextGen, is introducing systems and procedures that promise safer operations, increased efficiency, and environmental sustainability. This paper serves to present two enabling steps toward achievement of those objectives. The first is the establishment of a metric to express the time-based performance of aircraft operating in trajectory based operations environments. The second is a pair of stochastic models that provide a method by which the collision risk between these aircraft may be determined. Application is then demonstrated for the purpose of illustrating how future capacity requirements may be managed while maintaining an adequate margin of safety. The paper concludes by providing insight into the nature of required time performance that will be necessary to support forecasted levels of air traffic.
RIGOROUS RESULTS RELATED TO TURBULENT TRANSPORT IN GEOPHYSICAL FLUIDS

Zachary Bradshaw, University of Virginia

We examine the dynamical role played by inertial forces on the surface temperature (or buoyancy) variance in strongly rotating, stratified flows with uniform potential vorticity fields and fractional dissipation. In particular, using a dynamic, multi-scale averaging process, we identify a sufficient condition for the existence of a direct temperature variance cascade across an inertial range. While the result is consistent with the physical and numerical theories of SQG turbulence, the condition triggering the cascade is more exotic, a fact reflecting the non-locality introduced by fractional dissipation. A comment regarding the scale-locality of the temperature variance flux is also included.

TOWARDS INTERFERENCE CORRECTIONS FOR THREE-DIMENSIONAL MODELS IN KEVLAR-WALLED ANECHOIC TEST SECTIONS

Kenneth Brown, Virginia Tech

As part of a continuing development effort on Kevlar-walled anechoic test sections, this paper addresses the aerodynamic corrections of such test sections for the case of three-dimensional flow over wings. The correction method employs a panel method to simulate the porous, flexible boundary conditions of the Kevlar walls. This paper extends the panel method which previously was only for use in two-dimensional flow situations to the case of three-dimensional flow. Subsequently, evaluation of the three-dimensional correction method is presented based on results obtained at the Japan Aerospace Exploration Agency (JAXA) including side-by-side tests of wings in both solid-wall and Kevlar-walled test sections. New measurements of test section wall pressure distributions and anechoic chamber pressures that validate the correction method are also included. Our goal is that with the increasing fidelity of aerodynamic corrections, Kevlar-walled test sections will become as useful for aerodynamic testing as they are for aeroacoustic testing.

PRESSURE WAVES IN A LOW-BOOM INLET

Sean Candon, University of Virginia

Data collected in the 8’x6’ supersonic wind tunnel at the NASA Glenn Research Center in 2010 of a low-boom supersonic inlet has been analyzed and compared to computational results generated using Detached Eddy Simulations (DES). The external compression, axisymmetric, low-boom concept inlet is modeled with a 3D structured grid and solved with the WIND-US code. Grid resolution and domain length effects are investigated using a short domain extending
only to the aerodynamic interface plane (AIP), compared with a long domain which extends further downstream to the mass flow plug. Off-design mass flow conditions are considered. Domain length is found to have a significant effect on the unsteady flow dynamics of the inlet flow. Centerbody surface pressure waves are captured only when using the long domain and are comparable to similar events seen by Kulite pressure taps from the wind tunnel tests. These pressure waves are investigated at several streamwise stations and found to originate downstream and propagate upstream to cause normal shock oscillations. Using the upstream running acoustic velocity in the subsonic diffuser, the observed pressure waves in experiments and DES appear to travel at acoustic speeds.

DOES DEVELOPMENT DICTATE VULNERABILITY? A GLOBAL STUDY OF INTERNATIONAL MIGRATION AND ENVIRONMENTAL CHANGE

Kyle F. Davis, University of Virginia
Cyber Lounge

Modern international human migration represents a powerful adaptive tool for diversifying a household’s income. While this phenomenon is largely driven by economics, environmental change can still play an important role in influencing the movement of people internationally. This may be particularly true for those countries whose economies place a greater reliance on agricultural output. Thus we seek here to examine the relationship of global international emigration to conditions of decadal-scale environmental changes and to explore whether it is the less developed countries whose emigration is most vulnerable to these changes. We find that globally countries with lower levels of development are more likely to have a significant relationship to adverse (typically drought-like) environmental changes. When considering regional effects, we also find that Africa is the most strongly affected with more than a third of African countries showing a relationship between emigration and environmental change during the past half century. Our findings therefore provide much needed global-scale evidence of environmentally induced migration and demonstrate that this effect is largely dependent on a country’s level of development.

RED BLOOD CELLS AS AN ULTRASOUND CONTRAST AGENT

Ali H. Dhanaliwala, University of Virginia
Cyber Lounge

Microbubbles, shell-stabilized micrometer-sized gas bubbles, are the most common ultrasound contrast agent. Microbubbles can both improve ultrasound image contrast as well as enhance drug delivery. Current microbubble formulations, however, have a limited half-life in vivo and a limited therapeutic carrying capacity. Red blood cells continue to be investigated as a drug delivery vehicle given their large carrying capacity and inherent biocompatibility. Red blood cells, however, cannot be tracked in vivo and drug release cannot be specifically triggered in space or time. In this paper, we propose a novel ultrasound contrast agent that combines the benefits of microbubbles with those of red blood cells. To achieve this, we investigate the loading of nanometer-sized microbubble precursors into red blood cells. Loading smaller microbubble precursors should improve red blood cell loading efficiency over micrometer sized
microbubbles. Once loaded, the microbubble precursors can be converted to gas to produce acoustically active red blood cells (aaRBCs). The acoustic properties and drug delivery potential of these particles are investigated.

**A CENSUS OF DIVERSE ENVIRONMENTS IN INFRARED DARK CLOUDS: WHERE DO MASSIVE STARS FORM?**

*William J. Dirienzo, University of Virginia*

**Theater**

Infrared Dark Clouds (IRDCs) harbor the earliest phases of massive star formation. Many of their compact cores of gas and dust host massive protostars, known from a variety of star formation indicators. We have used the Robert C. Byrd Green Bank Telescope (GBT) and the Very Large Array (VLA) to map the ammonia and CCS molecules in nine IRDCs to reveal the temperature, density, and velocity structures and explore chemical evolution in the dense cores. Ammonia is an ideal molecular tracer for these cold, dense environments, and by imaging CCS in these regions we test whether we can use the abundance ratios as "chemical clocks" to determine if the cores that do not show evidence of embedded protostars are indeed less evolved. We find evidence that the ammonia and CCS have different spatial distributions, however using only the 22 GHz CCS line to probe chemical evolution is insufficient as this line is typically weak and does not necessarily trace the full column of CCS. We further investigate the internal structure and kinematics of the IRDCs, revealing velocity gradients, filaments, and colliding sub-clouds that elucidate the formation process of these structures and their protostars. We find a wide variety of substructure including filaments and globules at distinct velocities, sometimes with velocity gradients and possibly colliding at sites of ingoing star formation. There is a tendency for protostars to form between dynamically distinct parts of IRDCs.

**FREQUENCY DOMAIN ANALYSIS OF THE PHOTOACOUSTIC RESPONSE PRODUCED BY GOLD NANOROD COATED MICROBUBBLES**

*Adam Dixon, University of Virginia*

**Cyber Lounge**

We present the design of a multimodality contrast agent for photoacoustic and ultrasound imaging comprised of microbubbles coated with optically absorbing gold nanorods (AuNRMBs). Two populations of AuNRMBs with small (1.7 ± 1.2 µm) and large (3.0 ± 1.5 µm) diameters were studied in this work. Approximately 25,000 and 75,000 gold nanorods were associated with each microbubble in the small and large populations, respectively. Both populations of AuNRMBs produced photoacoustic waves with a 2 MHz center frequency in response to a 5 ns pulsed laser, while the center frequency of the photoacoustic wave produced by gold nanorods was approximately 1 MHz. Furthermore, the photoacoustic wave produced by AuNRMBs contained more high frequency content between 2.5 - 10 MHz when compared to the photoacoustic wave produced by AuNRs alone. These results demonstrate that the frequency content of the photoacoustic wave produced by AuNRMBs is fundamentally different from that of AuNRs alone, suggesting that the presence and location of AuNRMBs may be differentiated from nearby AuNRs based upon the frequency content of their photoacoustic response.
USE OF A COUPLED AERODYNAMIC-STRUCTURAL SIMULATION FOR THE DESIGN OF A MORPHING CONTROL SURFACE

E. Brady Doepke, Virginia Tech

Ballroom C

A process for the analysis of a morphing aileron using flexible matrix composite (FMC) actuators is developed. Design requirements were based on the use of a morphing aileron with an existing medium size commercial transport aircraft limiting the planform to the existing conventional aileron. The design uses two sets of contracting FMC actuators operating independently to actuate the deformable aileron in both trailing edge up and down cases while matching coefficient of lift values of a conventional aileron. The design space is examined by a series of response models which were then used to understand the sensitivity to material, geometric and loading design variables while minimizing required force from the FMC actuators.

DEEP SPACE STORM SHELTERS AND DISCRETE EVENT SIMULATION

Kathryn Dugan, The College of William and Mary

Theater

Missions outside of Earth’s magnetic field are impeded by the presence of radiation from galactic cosmic rays and solar particle events. To overcome this issue, NASA's Advanced Exploration Systems Radiation Works Storm Shelter Team (RadWorks) has been testing different radiation protective habitats to shield against the onset of solar particle event radiation. These habitats have the capability of protecting occupants by utilizing logistics such as food, water, brine, human waste, trash, and non-consumables to build short-term shelters. The goal of this research is to develop a discrete event simulation, modeling a solar particle event and the building of a protective shelter. Two different locations, the main hallway and the crew quarters, within a larger habitat that is similar to the layout of the International Space Station (ISS) are modeled and compared. The outputs from this model will yield three results: 1) provide the team with information on the amount of protection the crew members receive based on the two structures, 2) provide the amount of time for setting up the habitat during specific points in a mission given an event occurs, 3) and determine the total areas covered on the shelter by the different logistics.

ULTRACOLD ATOM MAGNETOMETER FOR SPACE-BASED MAGNETIC MAPPING

Charles Fancher, The College of William and Mary

Cyber Lounge

We present progress towards a proof of principle experiment using an atomic clock based method with ultracold atoms for magnetometry. We propose to combine the well-studied atomic clock method using magnetically sensitive atomic states to create an ultracold atom based magnetometer. This magnetometer would add science capacity to an atomic clock used for time keeping without significantly altering the weight or power requirements. By measuring the
frequency deviation of the atomic states from their zero magnetic field values we can calculate the magnetic field at the location of the atoms. Using two spatially separated atomic samples we can find the magnetic field gradient by \( B' = (B_1 - B_2) / \Delta x \). This gives more information about the magnetic field environment and can help to cancel out large fluctuating background magnetic fields. Our recent work has focused on loading an optical dipole trap with ultracold \(^{87}\text{Rb}\). We have loaded the trap with an atomic density of \(10^{11}\) atoms/cm\(^3\), which is sufficient to start running magnetometry experiments. We expect to have a magnetic field sensitivity of 10-100 pT, competitive with current approaches.

**GALLIUM ARSINIDE BASED SOLAR CELLS GROWN ON SILICON SUBSTRATES**

*Patrick Goley, Virginia Tech*

Cyber Lounge

This work presents recent progress by the authors to integrate a gallium arsenide (GaAs) based solar cell onto a silicon (Si) substrate using a GaAs buffer layer the molecular beam epitaxy growth method. It is highly desirable to replace the germanium substrates used in today’s state-of-the-art multijunction space solar cells with Si in order to gain advantages in cost, weight, mechanical strength, heat dissipation, and manufacturing scalability. However, the large lattice parameter mismatch between GaAs and Si leads to a high density of threading dislocations in thin crystalline films of GaAs grown on Si. These threading dislocations severely degrade minority carrier lifetime in the absorbing layers of the solar cell, leading to poor cell efficiency. In this work, a GaAs-on-Si cell and GaAs-on-GaAs control sample demonstrated efficiencies of 4.82% and 13.8%, respectively, under the AM1.5G solar spectrum. These values represent the performance before etching the top GaAs contact layer and before applying an anti-reflection coating. The large difference in performance is attributed to a high threading dislocation density (TDD) in the GaAs-on-Si sample. Continued optimization of the material growth phase of the solar cell development is needed to close the gap between GaAs-on-Si and control sample solar cell performance.

**AN ASSESSMENT OF DFT METHODS AND BASIS SETS TO INVESTIGATE THE DECOMPOSITION OF NOVEL HEDMS AND THEIR PRESSURE DEPENDENCE**

*Lenora K. Harper, Old Dominion University*

Cyber Lounge

Density functional theory (DFT) was used to understand the shock sensitivity on the properties of high energy density materials (HEDMs) using 1-(2-nitro-2-azapropyl)-5H-tetrazole as a test molecule due to its small size and similar explosive properties to more common explosive compounds such as hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraazocine (HMX). Levels of theory and basis sets were investigated in order to determine accurate bond distances and IR frequencies. Shock sensitivity studies of ammonium nitrate also were implemented to determine decomposition pathways of energetic materials by describing their structural properties (i.e. phase change, packing, orientation) under pressure.
AMINE- AND SULFIDE-SENSING COPPER(I) IODIDE FILMS IN ENCLOSED SPACES

Kylie M. Henline, The College of William and Mary

Cyber Lounge

Volatile organic compounds (VOCs), detrimental to human health, are present in many household environments, necessitating novel methods of detection. Copper(I) iodide (CuI) is an inexpensive, commercial, air-stable salt that spontaneously reacts with a variety of VOCs to produce luminescent adducts, making CuI a good prospective detector material. Microcrystalline films of CuI have been cast from solution onto glass. As cast, the films show almost no visible emission; however, upon exposure to VOC amines and sulfides, the films form surface adducts that display a variety of visible emission colors. Chemically related VOCs produce remarkably different CuI-adduct emission colors in some cases. The films are reusable due to facile removal of the VOC. The surface of CuI films have been characterized using optical microscopy, scanning electron microscopy with energy dispersive spectroscopy, and powder X-ray diffraction. Limits of detection have been studied for specific VOCs by exposing CuI films and measuring their emission using an LED/fiber-optic fluorimeter. Tetrahydrothiophene (THT) produced a variety of luminescent adducts with CuI films. As a result, the CuI-THT system was studied more closely. Five new CuI-THT phases, four of which are luminescent, were structurally characterized using X-ray diffraction. These phases were further characterized using thermogravimetric and chemical analysis.

UNMANNED AERIAL VEHICLE TARGET HANDOFF IN MULTI-TARGET, MULTI-UAV COMPLEX ENVIRONMENT

Julie Hoven, Old Dominion University

Ballroom C

Target handoff in a 3D UAV environment requires a sound framework between at least two sensors and one target. In this project, the ultimate goal is to develop a robust algorithm that can determine the appropriate time to initiate handoff of target tracking responsibilities from one sensor with a target in view to another sensor with that same target in view. In this paper, we will describe the variables necessitated for and the process by which a main trigger criterion equation can be used to notify the system of a handoff request and to execute it. Many variables are needed in such a calculation, including the target’s global 3D coordinates and its velocity, any nearby sensor’s 3D coordinates and resolution, and system characteristics that determine the sensor’s fields of view and resolution capabilities. With these values in hand, thresholds due to the sensor’s field of view (FOV) and maximum resolution can be calculated. The thresholds are the minimum indicators that are required to successfully handoff the target to the adjacent sensor based on the properties of the sensors, system, and the target.
AN INVESTIGATION OF A SCRAMJET CAVITY FLAMEHOLDER USING STEREOSCOPIC PARTICLE IMAGE VELOCIMETRY

Justin Kirik, University of Virginia

Ballroom C

Progress in a particle image velocimetry (PIV) investigation of a scramjet combustor with a cavity flameholder is described. Such measurements will characterize a critical component of a propulsion system offering a revolutionary change in aerospace performance. Experiments to date have addressed the issue of fouling of flowpath windows by PIV seed particles, an issue which these results indicate has been solved by the use of graphite seed particles. Further work is needed to refine the seed particle delivery system before final data are taken. Planned measurements will examine cross-sections of the cavity flameholder and the main duct of the flowpath, and the resulting data will both enhance the fundamental understanding of scramjet flows as well as provide benchmark data for the validation of numerical models.

USING A SONIC NET TO DETER PEST BIRD SPECIES- EXCLUDING EUROPEAN STARLINGS FROM FOOD SOURCES BY DISRUPTING THEIR ACOUSTIC ENVIRONMENT

Ghazi Mahjoub, The College of William and Mary

Cyber Lounge

Pest avian wildlife is responsible for substantial economic damage every year in the United States. In this study we focused on altering the foraging behavior of the European starling (*Sturnus vulgaris*), a pest bird that poses significant risk for bird-aircraft strikes. The goal of our project was to develop an effective system to limit starlings’ access to food patches. Previous technologies used to deter starlings have generally failed as birds quickly habituate to startle regimes. Using non-linear ultrasonic parametric arrays, we broadcast a directional sound that overlapped in frequency with starling vocalizations and was contained in a specific area creating a “net”. We hypothesized that the “sonic net” would disturb acoustic communication for starlings, causing them to leave and feed elsewhere. The sonic treatment decreased starlings’ presence at the treated food patches, on average by 46%. Additionally, we assessed whether the sonic net disrupted the birds’ response to an alarm call. When under the sonic net, starlings did not respond to the alarm call, suggesting that the sonic net disrupted acoustic communication. The sonic net is a promising new method of decreasing foraging activity by pest bird species, which has important implications for deterring birds from sensitive areas of airports.

PHASE CHANGES AND IRRADIATION EFFECTS OF OUTER SOLAR SYSTEM AND INTERSTELLAR WATER ICES

Emily H. Mitchell, University of Virginia

Cyber Lounge

We address unknowns about the physical state of astronomical water ices at relevant temperatures, to contribute to the understanding of the processes that have shaped the evolution
of extraterrestrial bodies over time. Here, results are presented on the temperature and morphology dependence of the crystallization kinetics of water ices, which can be extrapolated to astronomical timescales. Additionally, we discuss irradiation effects of amorphous water ices that have been saturated with methane, relevant to Transneptunian objects and Centaurs. We observe that ion bombardment increases the gas adsorption capacity of methane-laden ice as well as the production of new radiolytic molecules. Finally, we report a contrasting process using ice saturated in ambient hydrogen, the most abundant gas in the interstellar medium, in which the H$_2$ retention of irradiated ice is reduced and the production of radiolytic H$_2$O$_2$ is suppressed.

SMART REFLECTANCE EDITING IN PHOTOGRAPHS

*Kathleen D. Moore, The College of William and Mary

Photographers seeking certain post-processing effects in their photographs often have to turn towards artistic interpretation to achieve realistic edits. Given the variety of image-editing tools in software today, users are gaining increased control on their final results. There are cases when the user wishes to change the geometry of an object in a photographed scene. How can the user have fine-grained control over the geometry while keeping the object's reflectance physically consistent?

Our image-editing tool enables a user to perform an edit to the underlying geometry of an object while it computes the updated reflectance information on the back end. Though it is a largely under-constrained problem to determine missing reflectance information, we seek simple user-guided input that can aid in the computation and confine the final result to a physically-based solution.

STILBENE-CONTAINING THERMOTROPIC LIQUID CRYSTALLINE POLYESTERS FOR AEROSPACE APPLICATIONS

*Ashley M. Nelson, Virginia Tech

The ability of a copolymer to integrate properties of both liquid crystalline and elastomeric systems enables a variety of emerging applications. Often a multitude of synthetic steps are required to achieve such diversity in a copolymer, specifically when desiring the material properties obtained from main chain mesogenic sequences. This work describes the one-pot synthesis and characterization of biphenyl-containing segmented copolyesters with varying methylene spacers and oligomeric diols. A thorough investigation of the thermal and thermomechanical properties as a function of methylene spacer length demonstrates the distinct relationship between melting temperature and even/odd spacers; the regularity of a methylene spacer with an even number of carbons allows packing to occur more readily resulting in enhanced thermal properties. Similarly, the effect of hard segment (HS) structure on the thermal, thermomechanical, and tensile properties was explored, showing an increase in the thermal transitions with increasing HS content. Finally, the ability of these copolyesters to retain a liquid crystalline morphology despite the incorporation of a flexible oligomeric polyether was
investigated. This synergy will enable superior processing of intricate devices while ensuring mechanical durability.

DEVELOPMENT OF ADAPTED CAPACITANCE MANOMETER FOR THERMOSPHERIC APPLICATIONS

Cameron Orr, Virginia Tech

An adapted capacitance manometer is a capacitor with one fixed plate and one movable plate that is able to make accurate pressure measurements in low pressure environment. By using detection circuitry, a change in capacitance can be measured and directly related to a differential pressure experienced in the environment. First, a high sensitivity manometer will be produced to experience a measurable change in capacitance in a low pressure space environment. Second, an accurate and precise detection circuitry will be developed to measure the change in capacitance. Both parts of the instrument will need to be tested to confirm accurate measurements when experiencing small pressure differentials. Validation of the system as a viable option for space flight pressure measurements will enable low power pressure measurements in future small satellite missions.

ELEMENTARY WIDEBAND TIMING OF RADIO PULSARS

Timothy Pennucci, University of Virginia

We present an algorithm for the simultaneous measurement of a pulse time-of-arrival (TOA) and dispersion measure (DM) from wideband pulsar data. The algorithm was presented in an earlier VSGC manuscript; due to space limitations, we present here only a portion of the results from a demonstration of our new technique on three years of wideband data from the bright millisecond pulsar M28A. We experiment with pulse modeling by using a Gaussian-component scheme that allows for independent component evolution with frequency, a "fiducial component", and the inclusion of scattering. We find improved TOA and DM precisions by factors of a few. Measurements from our algorithm will yield precisions at least as good as those from traditional techniques, but is prone to fewer systematic effects and is without ad hoc parameters. A broad application of this new method for DM correction with modern large-bandwidth observing systems should improve the timing residuals for pulsar timing array experiments, like the North American Nanohertz Observatory for Gravitational Waves. The full paper has been refereed by The Astrophysical Journal and can be found on the arXiv (1402.1672). Our publicly available code can be found at github.com/pennucci/PulsePortraiture.
NEW TEST CAPABILITIES FOR THE 0.3-METER TRANSONIC CRYOGENIC WIND TUNNEL

Ben D. Phillips, Old Dominion University
Ballroom C

The small-scale, cryogenic, and high pressure characteristics of the 0.3-Meter Transonic Cryogenic Tunnel provide a unique, high-Reynolds number research capability. However, the facility is currently restricted by its reliance on a two-dimensional adaptive wall test section coupled with an inadequate facility control system. Access to the test section is restricted, the walls require excess time for convergence and are mechanically constrained by a wall jacking system that degrades under cyclic cryogenic operations, and the tunnel requires excessive time to reach the set point, particularly at low Mach numbers. As a result, productivity and operational efficiency are limited, leading to expensive testing. Research is currently being conducted into new design concepts for a modular transonic test section with passive ventilated walls. The new test section will be adaptable so as to simulate the behavior of a variety of transonic facilities, initially the NTF and the Ames 11ft transonic tunnel. The ability to simulate other transonic facilities allows researchers to pursue risk reduction experiments, improve test planning and address fundamental flow problems such as the study of wall interference correction techniques and application of modern fluid dynamic measurement techniques under transonic high Reynolds number conditions.

FINITE VOLUME SOLUTION RECONSTRUCTION METHODS FOR TRUNCATION ERROR ESTIMATION

Tyrone S. Phillips, Virginia Tech
Ballroom C

The numerical solution to differential equations results in a discrete solution space for the finite volume and finite difference discretization methods. For various reasons, it can be necessary to prolong the solution from a discrete space to a continuous space. The prolongation to a continuous space can be done using various curve-fitting methods which adds an additional level of approximation to the solution. The allowable error of a prolongation operation depends on the specific task required by the user. In this paper we investigate various prolongation methods and identify the minimal requirements specifically for the purpose of truncation error estimation (the difference between the discrete and integral governing equations) for finite volume methods. The reconstruction methods investigated will include k-exact and ENO methods. Truncation error estimation for 1D Burgers’ equation and the k-exact method suggest that the minimum polynomial order is dependent on the highest derivatives in the truncation error expression and, therefore, the discretization scheme. The effect of different reconstruction methods on truncation error estimation is investigated and the minimum polynomial order for accurate truncation error estimation is identified for the Euler equations and is found to be second-order for the weak formulation and third-order for the strong formulation.
STUDY OF INSULATOR METAL TRANSITION OF VO₂ THIN FILMS

Elizabeth Radue, The College of William and Mary

VO₂ is a paradigm of a highly correlated material that undergoes a phase transition, changing from an insulator phase to a metallic one upon when heated, VO₂ has drawn interest because the insulator-metal transition (MIT) occurs just above room temperature at 154°F (68°C) enabling interesting technological applications. It has been shown that VO₂ thin films can also undergo MIT when stimulated by an ultrafast optical pulse. Thin films often exhibit different properties than bulk materials due to microstructure defects, strain, etc. Thus, we have been studying the MIT of VO₂ thin films grown on different substrates using a strong 100fs pulse to induce the transition, while changing the arrival time of a weaker pulse to probe the changes of the film over time. By studying films grown on different substrates and observing differences in the dynamics of the MIT we aim to better understand the mechanisms of the light induced transition. We have found noticeable differences in the threshold fluence needed to optically induce the MIT in films on different substrates, as well as the longevity of the metallic state. I will be discussing the implications of these differences regarding the mechanisms responsible for the optically induced phase transition.

DEPOSITION AND MICROSTRUCTURE OF AIR PLASMA SPRAYED (APS) YTTERBIUM MONOSILICATE FOR ENVIRONMENTAL BARRIER COATINGS (EBCS)

Bradley Richards, University of Virginia

Environmental Barrier Coatings (EBCs) have been studied since the late 1980’s for use as prime-reliant coatings to protect silicon-based ceramics from volatilization in the hot section of gas turbine engines. EBCs are typically deposited using an Air Plasma Spray (APS) process that is economical, has been in use for over 60 years, and is widely available. Despite such prolific use, there have been no published studies on APS processing of EBC materials, even though more than 30 variables may affect coating structure or chemistry and thereby significantly impact performance. Due to this lack of processing science, we have endeavored to study the processing space of APS deposition of ytterbium monosilicate powder that is relevant to EBC systems. We have carried out APS depositions on a Praxair-TAFA APS system utilizing an SG-100 APS torch, and report microstructures and chemistries of coatings for seven unique combinations of spray parameters selected to determine the effects of primary APS factors. We report coating microstructure and the formation mechanism of a chemically modified coating as well as the useful spray parameter space and response to APS processing of ytterbium monosilicate.
MEASURING PLANETARY ATMOSPHERES USING ORBITING RADIATION PRESSURE BAROMETER SPHERE (ORBS) SWARMS

Robert Robertson, Virginia Tech

Ballroom C

The mission concept presented here uses the relative motion of groups, or swarms, of very small, spherical satellites to measure planetary atmospheres. We call these satellites orbiting radiation pressure barometer spheres, or ORBS. A swarm of ORBS will be released together in orbit with identical inertial and magnetic properties, but with different optical coatings. This variation in optical properties alone will produce relative motion among the members of a given swarm which is a function of only radiation pressure forces. By cleverly assigning ORBS optical properties and implementing detailed solar radiation pressure models, ORBS relative motion data can be used to estimate important atmospheric quantities. A feasibility study is underway to assess the viability of the ORBS concept. This study involves three primary components. First, force modeling and orbit propagation tools are needed to simulate ORBS relative motion. Second, a systems engineering and instrumentation design process is needed to assess the viability of ORBS as a relatively inexpensive, simple mission concept. Finally, estimation tools are needed to yield valuable science data from simulated ORBS measurements. The first two components of this ORBS feasibility study are presented here.

REGIONAL-SCALE VARIATION OF DISSOLVED ORGANIC CARBON CONCENTRATIONS IN SWEDISH LAKES

David A Seekell, University of Virginia

Cyber Lounge

We assessed spatial variability in dissolved organic carbon (DOC) concentrations measured in nearly 2000 Swedish lakes. Inter-lake variance peaked at two different scales, representing within-region and between-region variability. The variation between regions was greater than the variation between lakes within regions. We tested relationships between DOC and runoff, drainage ratio and altitude for spatial heterogeneity using geographically weighted regression. Relationships varied geographically, but cluster analysis delineated two contiguous regions of similar relationships. Altitude had a significant inverse relationship with DOC in the mountainous regions whereas drainage ratio had a significant positive relationship with DOC in the flatter regions. These heterogeneous relationships explained regional patterns in DOC concentrations. We conclude that regions are a key characteristic scale of spatial variability for DOC concentrations. This scale of variability reflects the intersection of environmental gradients with spatially heterogeneous relationships. Regional scale structure in limnological patterns indicates that individual lakes are not independent from one another, but are groups where DOC concentrations are a function of similar environmental patterns and processes.
AN OBJECT-CENTERED VIBROTACTILE DISPLAY FOR SPATIAL LOCALIZATION IN AEROSPACE SYSTEMS

Adam D. Sitz, Old Dominion University
Ballroom C

Vibrotactile displays are capable of conveying extrapersonal spatial information to users navigating or operating within a three-dimensional environment (e.g., aircraft pilots and astronauts). Although vibrotactile displays are greatly customizable in terms of bodily contact points, recent studies have focused on torso-based displays designed to egocentrically orient users towards distal targets; however, these displays may be poorly suited to convey elevation cues because of the generally cylindrical shape of the human torso. The present study evaluated the relative position and dispersion of participants’ extrapersonal localizations using a spherically-shaped handheld vibrotactile display versus an analogously configured torso-based display. It was hypothesized that participants would project a non-bodily-centered egocenter onto the handheld display in order to correctly interpret spatial cues. However, data suggest participants may rely on a bodily egocenter even when presented with object-centered vibrotactile cues. Additional research directions are discussed.

EMERGING SUPER STAR CLUSTERS WITH WOLF-RAYET STARS

Kimberly R. Sokal, University of Virginia
Theater

We have discovered a massive star cluster in NGC 4449 that may complete, for the first time, a continuum of massive cluster evolution, as it is undergoing a critical and brief phase when enshrouding natal material is being drastically altered by a massive star population. Evolved massive stars are likely driving a complete removal of the natal material, which was thought to disperse before the massive stars are revealed. I have estimated the massive star populations in the cluster to be ~150 and have characterized the surrounding dust, finding that the dust is being destroyed near the cluster center.

To expand the sample of known objects in this evolutionary stage, I am conducting a multi-wavelength survey of young, massive clusters in star forming galaxies. These objects have never been systematically studied, and I have obtained optical spectra and am utilizing archival data from Hubble, Spitzer, and Herschel space telescopes to identify WR populations and characterize the physical environment in ~50 clusters through a panchromatic analysis. With this study, I am examining the role of WR stars and their intense feedback in clearing out obscuring natal material and driving the early evolution of massive clusters.
MODELING LOBLOLLY PINE NUTRIENTS WITH HYPERSPECTRAL REMOTE SENSING

Beth R. Stein, Virginia Tech
Cyber Lounge

Given the importance of loblolly pine (*Pinus taeda*) in intensive forest management in the southeastern US, there is a need to assess macronutrients with remote sensing. Reflectance-based nutrient models were developed across a natural nutrient gradient across the species’ range. Fascicles were collected from 237 samples of 3 flushes at 18 sites. Spectroradiometer and nutrient measurements were taken on samples. Partial least squares regression performed well at the regional scale, with R² values for N, P, K, Ca, and Mg of 0.81, 0.70, 0.68, 0.42, and 0.51, respectively. These results corroborate models of previous studies on other species.

MULTI-INSTRUMENT, HIGH-RESOLUTION IMAGING OF POLAR CAP PLASMA

Evan G. Thomas, Virginia Tech
Theater

Many critical technologies relied upon by both commercial and military users around the world are directly impacted by events occurring in the Earth’s ionosphere. Strong geomagnetic storms are responsible for causing ionospheric clutter in over-the-horizon radar systems; scintillations and their associated errors in GPS signals; and induced electrical currents in power distribution networks. Here we present a multi-instrument study of polar cap patches during a geomagnetic storm on 22 January 212 which was caused by a coronal mass ejection from the sun. We focus on a 2-hour interval when a continuous stream of patches was observed travelling from their dayside source (plume of storm enhanced density) across the polar cap to the nightside auroral oval. These ionospheric density patches are a common source of errors in satellite navigation systems used by commercial shipping and aircraft along transpolar routes, and are an important feature of space weather.

ELECTRONIC PROPERTIES OF GRAPHENE-TOPOLOGICAL INSULATOR HETEROSTRUCTURES

Christopher Triola, The College of William and Mary
Theater

The unique electronic properties of graphene and topological insulators have gathered a great deal of attention in recent years. Graphene, a one-atom-thick sheet of carbon, possesses the highest room-temperature mobility of any known material and its electronic states are endowed with a pseudospin quantum number that is locked with the direction of the momentum. Topological insulators are materials which are insulating in the bulk but conduct topologically protected mid-gap states on their surfaces. One of the most interesting properties of these electronic surface states is that the direction of the electron spin is locked with the direction of the electron's momentum. We formulate a continuum model to study the low-energy electronic structure of heterostructures formed by graphene on a strong three-dimensional topological
insulator (TI) both for the case of commensurate and incommensurate stacking of the graphene lattice relative to the TI surface lattice. For both the commensurate and the incommensurate case we find that the graphene's proximity to a TI induces splitting of the spin-degenerate bands of isolated graphene and the appearance of non-trivial spin textures.

**TOWARDS AUTONOMOUS OPERATION OF UNMANNED AERIAL VEHICLES WITH LIMITED SENSING**

*Samantha E. Wright, Old Dominion University*

Quadrocopters, which are unmanned four rotor helicopters, are a popular class of aerial vehicles that are suitable for experimentation. Hence, the classical inverted-pendulum on a cart problem has been extended to a controlled inverted-pendulum system on a quadrocopter and it has been successfully demonstrated in an indoor facility with a camera sensing system. Towards the facilitation of autonomous operation, the nonlinear mathematical model for a published inverted-pendulum on a quadrocopter has been used to determine a minimum on-board sensor suite to regulate the position of the inverted-pendulum while changing the position of the quadrocopter. Using the determined minimum set of measurements, regulation of the inverted-pendulum and tracking of the quadrocopter’s position has been demonstrated with linear and nonlinear simulations.

**DEVELOPMENT OF QUANTUM GASES FOR APPLICATIONS WITH MICROWAVE AND RF POTENTIALS**

*Austin Ziltz, The College of William and Mary*

We present progress on an experiment to manipulate and trap ultracold atoms with microwave and RF (μ/RF) AC Zeeman potentials produced with an atom chip. These μ/RF potentials are well suited for atom interferometry and spin-dependent trapping for 1D many-body physics studies due to their ability to operate in conjunction with magnetic Feshbach resonances to tune interactions. Calculations show that μ/RF potentials will significantly suppress the inherent atom chip roughness associated with DC magnetic potentials. We have assembled a dual species, dual chamber apparatus that produces ultracold $^{39}$K samples and $^{87}$Rb Bose-Einstein condensates on an rf-capable atom chip, with access to other isotopes. On-chip $^{39}$K will be sympathetically cooled through the microwave evaporation of rubidium, and transferred to a co-located dipole trap for a series of spatial manipulation experiments to study the capabilities and performance of μ/RF potentials.