THE IMPLICATION OF DENITRIFYING ANAEROBIC METHANE OXIDATION (DAMO) TO THE EVOLUTION OF AEROBIC METABOLISM AND EARLY EARTH ECOSYSTEMS

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Nitrite-dependent anaerobic methane oxidation (n-DAMO) has been recently reported to be catalyzed by “Candidatus Methyloirabilis oxyfera”, a bacterium associated with the NC10 phylum 13,4,2. Ca. M. oxyfera has a unique intra-aerobic pathway for the production of oxygen through the dismutation of nitric oxide into dinitrogen gas and oxygen 8. Since nitrogen oxides were present on early Earth, these findings could indicate that oxygen became available for microbial metabolism before the evolution of oxygenic photosynthesis 4,2, 10,8. In this study, we investigate the presence of DAMO bacteria in a Cape Cod aquifer and Ashmut pond sediments by detecting putative NO Dismutase genes (NOD) 3,4,5. PCR detection of NOD genes was conducted with the DNA samples extracted from groundwater and sediment where NO3- and NH4+ are discharged from the aquifer. The amplified products were sequenced and further analyzed through BLAST, CHROMAS, and MEGA. Pyrosequencing analyses of prokaryotic 16S rRNA genes were conducted using an Ion Torrent PGM. The RDP Pipeline was used to identify taxa to determine relative abundance of different microorganisms present on these sites. Phylogenetic analyses of NOD genes show the presence of similar communities in groundwater and NH4+ discharging sediments, though have yet to be conclusively linked to DAMO bacteria. Lower diversity of prokaryotic communities were observed in the NH4+ discharging site than the NO3- site. On the Phylum taxonomic level, Crenarchaeota and Acidobacteria were predominant in the NO3-, whilst in the NH4+ site, Crenarchaeota and Proteobacteria were predominant.

CORRELATIONAL STUDY OF OPEN CIRCUIT RESONANT (SANSEC) SENSOR'S ELECTRIC FIELD DISTRIBUTION ON LIGHTNING ATTACHMENT

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NASA Langley Research Center (LaRC) is conducting research to develop an open circuit SansEC (Sans Electric Connection) sensor to provide lightning strike protection (LSP) in conjunction with damage detection and diagnosis for composite aircraft. SansEC sensors are simplistic devices consisting of an open circuit conductive trace shaped in a planar geometric
spiral. The length and width of the conductive trace as well as the gap separation between adjacent turns determines the inductance, resistance and capacitance of the LRC circuit and its associated resonant response. When the sensor is placed on a composite substrate, the electric impedance of the substrate is reflected in the sensor’s resonant response thus enabling it to detect permittivity and conductivity changes associated with composite damage. SansEC sensors can be designed in various shapes and sizes depending on the application. For applications on exterior aircraft surfaces, the sensor must be designed to perform the required lightning strike protection in addition to damage detection and diagnosis.

Lightning-direct effect current tests were conducted on multiple SansEC sensor configurations to evaluate their ability to withstand the incident lightning energy and protect the underlying composite. Test results indicated several SansEC sensor geometric configurations demonstrated an intrinsic ability to steer the lightning current along the corner of the sensor. To investigate this phenomenology, electromagnetic computational simulations were conducted to calculate the electric field distribution on the SansEC sensor’s conductive trace to determine if the associated electromagnetic radiation preceding lightning attachment establishes modal structures on the conductive trace which predisposition the direction of the current flow. The simulations provide a means to visualize the trace’s modal structure and identify electric field regions residing on the sensor. This paper presents a correlational study of the SansEC sensor’s computed electric field distribution to the measured lightning propagation direction for various SansEC sensor configurations. The study suggests the direction of lightning propagation follows strong electric field regions resident on the conductive trace.

MATERIAL PREPARATION AND SPECTROSCOPIC STUDIES OF Ho3+ DOPED POTASSIUM LEAD HALIDES FOR 2 µM LASER APPLICATIONS

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There is significant current interest in the development of 2 µm lasers for applications such as medical surgery, optical communications, and laser remote sensing. The efficiency of current 2 µm solid-state lasers based on Ho3+ doped crystals is strongly dependent on the applied optical pumping method, lasing scheme, and overall heat loading in the laser gain medium. The trivalent Holmium ion (Ho3+) has a 2 µm transition between its 5I7 and 5I8 energy levels when incorporated into a solid-state host material. Due to the removal of electronic degeneracies in ground and excited state, the 5I7↔5I8 Ho3+ transition can operate as a quasi-three level system at room-temperature and a four level system at 77 K. The presented research in this work includes material purification, synthesis, crystal growth, and spectroscopic evaluation of Ho3+ doped into the low phonon hosts potassium lead chloride (KPb2Cl5) and potassium lead bromide (KPb2Br5). The spectroscopic evaluation included absorption, emission, and gain cross sections at different temperatures by using the F-L (Füchtbauer–Ladenburg) method. Comparative spectroscopic studies and cross-section calculations were also performed on a commercial Ho: YAG crystal. The results of this research will provide information on the possible lasing schemes and performance of the investigated Ho3+ doped crystals for 2 µm laser applications.
MECHANICAL DESIGN OF THE VIRGINIA TECH INSTRUMENTATION PAYLOAD ON THE LAICE 6U CUBESAT

Peter Marquis, Virginia Tech

The efficient use of space in a CubeSat is central to a mission’s scientific return because it directly affects the number of instruments that can be accommodated by the spacecraft. This report focuses on the mechanical design of Virginia Tech’s payload on the LAICE (Lower Atmosphere/ Ionosphere Coupling Experiment) 6U CubeSat, which is funded by the National Science Foundation (NSF). The LAICE CubeSat has been proposed to contain 8 separate sensors and is divided into two sections; one designed by the University of Illinois and the other by Virginia Tech. Virginia Tech’s payload includes a Retarding Potential Analyzer (RPA), a Bayard-Alpert Gauge (LINAS), a Cold Cathode Gauge (SNeuPI) and the associated electronics to run these instruments. The mechanical design presented in this paper addresses the challenges encountered when designing the VT payload. These challenges include:

- The number of electronics boards and their spacing,
- Vibration requirements and circuit board mounting techniques,
- The selection and placement of electrical connectors that meet size and vibration constraints,
- Determination of assembly procedures using Autodesk Inventor and 3D printed prototypes.

A CHANDRA X-RAY OBSERVATION OF THE GALAXY CLUSTER ABELL 3653: THE ORIGIN OF RAPIDLY MOVING BCG GALAXIES

Adrian Mead

The 44 ksec Chandra X-ray observation of the galaxy cluster Abell 3653 is analyzed. This cluster is notable for having a cD galaxy with a very large peculiar velocity. The cD is also a dumbbell galaxy. The Chandra image shows structures which suggest a recent or ongoing merger. There is a compact region of emission around the cD, which may be a small corona, although a contribution from the radio AGN in the cD cannot be ruled out. The central cluster X-ray emission is elongated from east to west around the cD, and on larger scales, a filamentary structure extends to the south. Along with existing observations of other clusters with rapidly moving cD galaxies, our observations confirm the link between high velocity cDs and cluster mergers. The X-ray structure and spectra of Abell 3653 suggests that the merger is occurring mainly along the line of sight.
FLEXIBLE MATRIX COMPOSITE ACTUATORS FOR VOLUME MANAGEMENT IN PROSTHETIC SOCKETS

Melina Mercier, Virginia Tech

For people with transfemoral or transtibial amputations, one challenge is that the residual limb changes volume throughout the day causing pain and discomfort. Often the wearer accommodates for the volume change by using multiple liners. The goal of this research is to explore volume changing flexible matrix composite actuators to accommodate for volume changes in the residual limb. The idea is that incorporating flexible matrix composite actuators into the prosthetic socket will provide for volume and stiffness adjustability throughout the day. In this research, flexible matrix composite actuators were fabricated into a spiral configuration (i.e. wafers) and evaluated at different pressures. A finite element model was created in Abaqus to begin comparing the physical data with mathematical modeling. Preliminary results shows that the active wafers can achieve changes in volume when pressurized. Further plans for the project include force and displacement evaluation at a range of pressures as well as improved finite element analysis.

OPTIMAL CONTROL IN 3D TIME-VARYING VELOCITY FIELDS USING ALPHA SHAPES

Nicholas Sharp, Virginia Tech

Vehicles in current fields, such as autonomous vehicles in underwater and atmospheric settings, present a difficult optimization problem in charting optimal paths from a given source to a given destination. The problem is especially challenging in the case of weakly propelled vehicles, where the current is stronger than the propulsion and the system is not fully controllable. Recent progress has been made on the general optimal control problem by using front propagation to track the boundary of a reachable set. This work presents a significant advancement on that technique by using alpha shapes to dynamically mesh a set boundary in three dimensional space. This process permits the solution of globally time-optimal trajectories in three dimensions. The method is presented mathematically and implemented for application to representative problems.

DESIGN AND TESTING OF A NANOSATELLITE DEORBIT DEVICE

Alexander Streit, Old Dominion University

Nanosatellites are satellites with small dimensions that are often used for educational missions by universities and other research organizations. At Old Dominion University a team of students and faculty in the Electrical and Computer Engineering (ECE) and Mechanical and Aerospace Engineering (MAE) departments is working on plans for such an opportunity in order to test a deorbit device that should reduce the orbital lifespan of nanosatellites and help them deorbit faster once their missions are complete, thus reducing the amount of new orbital debris generated. The planned deorbit device consists of a balloon filled with a sublimating powder such as Benzoic Acid, which will tend to sublimate at the low pressures of space, causing the balloon to inflate and act as an aerodynamic brake. In order to verify the operation of the deorbit
device the team needs to capture and recover some telemetry data. A wireless communication system is being developed to transmit temperature measurements as well as a video stream from the satellite to a base station on board the rocket that released the satellite. This system is being tested in a vacuum chamber setting to verify the operation and while launch opportunities are being sought.

ULTRACOLD MAGNETIC MOLECULES

Elana Urbach, The College of William and Mary

Ultracold atomic clocks have the potential to provide extremely accurate measurements of the position and velocity of spacecrafts through NASA’s Deep Sea Network (DSN). The Ultracold Atomic, Molecular, and Optics Physics Lab at the College of William and Mary is currently working on developing a new generation of chip-based atomic clocks with an eye towards such an application. Notably, with very little increase in the payload, the ultracold atomic clock can also be operated as a magnetic sensor. Magnetic sensing has several potential applications, including mapping the magnetic fields of planets, which can help to determine their properties and history. Furthermore, the sensitivity of the magnetometer can be improved by replacing the ultracold atoms with molecules, which have the advantage of having larger magnetic moments. This project proposed to implement a magnetic sensor enhanced with ultracold molecules, which can be used in conjunction with an atomic clock. An apparatus including a magneto-optical trap, magnetic trap, and dual laser dipole trap has been modified for studies of the 155 G Feshbach resonance and associated production of ultracold Rubidium-85 molecules. Modifications include changes in optical pumping technique to successfully spin-polarize Rubidium-85 molecules.

INVESTIGATION OF COUNTERFLOW FLAME NOZZLE GEOMETRIES USING A TWO-DIMENSIONAL AXISYMMETRIC REACTING FLOW MODEL

Alexander VanDine, University of Virginia

The objective of this research is to explore the impact of differing geometric configurations on the quasi one-dimensional assumptions commonly utilized in the study of counterflow flames. The applicability of experimental data using these quasi one-dimensional models with small diameter nozzles (D) and short nozzle separation distances (L) has been questioned by some research although a full multidimensional investigation has not been completed. The computational package OpenFOAM was used for the axisymmetric numerical analysis of a computational domain with the convergent sections of the opposed nozzles as well as the co-flow inert annular flow. For computational efficiency, the fuel considered in this investigation was diluted hydrogen versus air in a non-premixed flame configuration, with detailed chemical kinetic and transport properties and neglected Soret effects. The results presented here demonstrate the effects of using several L/D ratios and their impact on the extinction strain rate curve. Additionally, a comparison between the two-dimensional results and traditional quasi one-dimensional results are presented to show that at large separation distances and small diameters, the self-similar velocity field assumption in the quasi one-dimensional model becomes invalid.
CHARACTERIZING THE EFFICIENCY OF DYE-SENSITIZED SOLAR CELLS USING SINGLE MOLECULE SPECTROSCOPY

Natalie Wong, College of William and Mary

Single-molecule fluorescence (SMF) is used to create false-colored images of single rhodamine 6G (R6G) dye molecules on single crystal rutile TiO2. Qualitative comparisons of fluorescent spot density and emission intensity are made to the R6G/glass and R6G/colloidal anatase TiO2 systems. The low signal-to-noise ratio preventing CPD analysis of blinking dynamics motivates consideration of the implications of time-averaged experiments. Complete characterization of dye/semiconductor systems with efficient ET requires sub-10-ms time resolution to ensure capture of short photophysical events and accurate mathematical fitting for ET rates.

HIERARCHICAL FORMATION IN ACTION: CHARACTERIZING ACCELERATED GALAXY EVOLUTION IN COMPACT GROUPS

Catherine Zucker

Compact groups provide an ideal environment in which to study galaxy evolution and the build-up of massive early-type galaxies. With their dense galaxy concentrations and relatively low velocity dispersions, compact groups mimic the conditions of hierarchical galaxy assembly, thus providing a window to the evolution of galaxies in earlier stages of the universe. Compact group galaxies show a canyon in Spitzer IRAC colorspace: galaxies are either quiescent with low specific star formation rates, or are booming with star formation--galaxies with moderate levels of specific star formation are rare. Previous Spitzer IRAC studies identifying this canyon have been limited to small number statistics due to telescope capabilities. These small sample sizes yield few galaxies located within the canyon region, a problem when one seeks to understand the properties of these unique galaxies and their implications for galaxy evolution. We utilize newly available all-sky WISE data to study the entire sample of Hickson Compact Groups, thereby including more galaxies with intermediate MIR colors indicating moderate levels of specific star formation. Using the largest sample of compact groups to date, our results confirm the existence of a canyon in MIR colorspace and shed light on the processes that lead to accelerated galaxy evolution in compact groups.