The Midstates Consortium for Math and Science presents

Undergraduate Research Symposium

Physical Sciences, Mathematics and Computer Science

November 9 & 10, 2018
Washington University in St. Louis

Beloit College - Carthage College - Colorado College - Grinnell College
Gustavus Adolphus College - Hope College - Knox College
Lawrence University - Luther College - Macalester College
St. Olaf College - University of Chicago
Washington University in St. Louis

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Program Schedule

Friday, November 9

1:00 pm – 6:15 pm	**Registration at Sheraton Clayton Plaza Hotel** **7730 Bonhomme Ave., Clayton, MO 63105** *(for late arrivals registration will be available outside the Banquet room during the program)*	**Clayton Plaza Lobby**
6:30 pm – 7:45 pm	**Welcome and Dinner Buffet** Michael Seymour, Director – Midstates Consortium for Math and Sciences	**Banquet Room**
7:45 pm – 8:00 pm	**Introductions and Comments** Professor John Bleeke, Symposium Organizer Washington University in St. Louis Michael Seymour, Director – Midstates Consortium for Math and Sciences Hope College	**Banquet Room**
8:00 pm – 9:00 pm	**Janet Anderson Lecture** **Dr. Joanne Stewart, Professor of Chemistry** **Hope College** ***Science, empathy, and the ethic of care***	**Banquet Room**
Following lecture	**Group Picture**	**Banquet Room**

Saturday, November 10

All Saturday events are at the Laboratory Sciences Building (LSB), Throop Drive, WUSTL campus

7:45 am – 8:00 am **Shuttle leaves at 8:00 am sharp – don't miss it**	**Load bus and vans – bus leaves at 8:00 am sharp** Those with vans or cars will drive to campus. Bring luggage if leaving Saturday. **There is a locked room for luggage and posters at the meeting site.**	**Clayton Plaza Lobby**

Saturday, November 10 (continued from previous page)

8:15 am – 9:00 am	**Continental breakfast on campus** Seating in LabSci 250 and LabSci 300 Check rooms for Session I Oral presentations	**Lobby LSB**
9:00 am -10:00 am	**Session I Oral Presentations of Student Papers** Session I.A: (4) Session I.B: (4)	**Lab Sciences Bldg** Room 250 Room 300
10:00 am – 10:15 am	**Break, set-up posters for Poster Session I** **Check rooms for Session II Oral presentations**	
10:15 am – 11:00 am	**Session 1 Poster Presentations** (20)	**Rettner Gallery & 3rd floor**
11:10 am – 11:55 am	**Session II Oral Presentations of Student Papers** Session II.C: (3) Session II.D: (3)	**Lab Sciences Bldg** Room 250 Room 300
12:00 pm – 1:30 pm	**Lunch and panel discussion** **Panel Discussion: *Life in Graduate School*** • *Gina Tran (Knox, Chemistry)* • *Tabbetha Bohac (U. of Chicago, Chemistry)* • *Lara Braverman (Knox, Chemistry)* • *Xiaochen Mao (St. Olaf, Earth & Planetary Science)*	**Holmes Lounge**
1:30 pm – 1:45 pm	**Set-up posters for session 2**	**Rettner Gallery & 3rd floor**
1:45 pm – 2:30 pm	**Session 2 Poster Presentations** (20)	**Rettner Gallery & 3rd floor**
2:30 pm – 2:45 pm	**Break, remove posters, check set-up for oral presentations in respective rooms**	
2:45 pm – 3:30 pm	**Session III Oral Presentations of Student Papers** Session III.E: (3) Session III.F: (3) Session III.G: (3)	**Lab Sciences Bldg** Room 300 Room 250 Room 301
3:30 pm – 3:45 pm	**Break, set-up for poster session 3**	
3:45 pm – 4:30 pm	**Session 3 Poster Presentations** (21)	**Rettner Gallery & 3rd floor**
4:30 pm – 4:45 pm	**Meeting Concludes** Remove posters Complete evaluations – available online Boxed dinners to go Shuttle pick up and return to the Clayton Plaza	**Lobby LSB**

2018 Janet Andersen Lecture
Science, empathy, and the ethic of care

Professor Joanne Stewart
Elmer E. Hartgerink Professor of Chemistry
Department of Chemistry
Hope College

Abstract: What is science? Is it emotionless, ruled only by logic and reason like *Star Trek's* Mr. Spock? Is it heroic, as in *Interstellar* and *The Martian*? Or is it connected and intuitive like Dian Fossey? Can we agree that the answer is yes! So where does that leave scientists who see injustice in the world and just want to make it a better place? Those heroes of science are all around you, and if you look, they are likely reaching out a hand for you to join them.

About Professor Stewart: Dr. Stewart's background in synthetic inorganic chemistry, her passion for supporting authentic student learning, and her innovative curricular approaches are evident in her work to establish *IONiC* and *VIPEr* (https://www.ionicviper.org). The *I*ntellectual *O*nline *N*etwork of *I*norganic *C*hemists is a vibrant virtual 'community of practice' for the collaborative development and dissemination of learning materials through the *V*irtual *I*norganic *P*edagogical *E*lectronic *R*esource website. During her 30 years at Hope Dr. Stewart has been eager to incorporate new pedagogies that more effectively engage students, such as group activities, case studies, and integrative learning, all with the goal of developing a community of learners who can relate their coursework to world issues, their lives and the community in which they live. Dr. Stewart has routinely involved students in her laboratory research and her studies in chemical education and the scholarship of teaching and learning, with students as co-authors in resulting publications. Through interactions with students in the classroom or laboratory, or as an advisor or a mentor, Dr. Stewart has provided a supportive, compassionate approach in helping all students learn about and explore career, calling and life.

Information about the Janet Andersen Lecture Award

Professor Janet Andersen was a beloved faculty member in the Hope College Mathematics Department and served enthusiastically as the Midstates Consortium Director for five years before her life ended tragically in an automobile accident in November 2005. As a teacher and scholar, Janet was devoted to providing creative, high quality learning experiences for her students, and she herself was always learning as she was teaching. As Consortium Director, she looked for ways to connect with and support natural science faculty, both new and experienced.

To honor Janet's work with students and faculty in her teaching, research and service to the Consortium, the Janet Andersen Lecture Award was established in 2008. Each year, two faculty nominees from Consortium institutions are selected by the Executive Committee to present the Janet Andersen Lecture at one or both of the fall Undergraduate Research Symposia on a topic of his or her expertise.

Janet Anderson Lecture Award Presentations

Year	Biological Sciences and Psychology Recipients	Physical Sciences, Mathematics and Computer Science Recipients
2008	David Hall, Biochemistry Lawrence University	Jeff Wilkerson, Astrophysics Luther College
2009	Ken Yasukawa, Biology Beloit College	Robert Jacobel, Physics St. Olaf College
2010	Sarah Elgin, Molecular Biology Washington University in St. Louis	Graham Peaslee, Nuclear Physics Hope College
2011	William Hammer, Paleo-geology Augustana College	George Lisenksy, Materials Chemistry Beloit College
2012	Eric Cole, Biology St. Olaf College	Tim Pennings, Mathematics Hope College
2013	Daniel Hornbach, Biology & Environmental Studies Macalester College	Bradley Chamberlain, Chemistry Luther College
2014	Phoebe Lostroh, Molecular Biology Colorado College	Kevin Crosby, Physics, Astronomy & Computer Science Carthage College
2015	Laura Listenberger, Biology and Chemistry, St. Olaf College	Julie Bartley, Geology Gustavus Adolphus College
2016	Maria Burnatowska-Hledin, Chemistry and Biology Hope College	Andrew Beveridge, Mathematics Macalester College
2017	Julie Legler, Mathematics, Statistics & Computer Science St. Olaf College	Thomas Varberg, Chemistry Macalester College
2018	Neena Grover, Chemistry and Biochemistry Colorado Collage	Joanne Stewart, Chemistry Hope College

Oral Session I Schedule

SESSION I.A: 9:00 am – 10:00 a.m. Room: LSB 250			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.A.1 (9:00)	Ross McFarland-Porter	Beloit College	Using graphene to study perovskite solar cells
I.A.2 (9:15)	Stephen Cropper	Grinnell College	Lessons from Single Crystal Growth in the RE-Co-Sb system.
I.A.3 (9:30)	Jillian Rix	Grinnell College	Effects of Spark Plasma Sintering on the Microstructure of Thermoelectric Materials
I.A.4 (9:45)	Mik Patel	Lawrence University	Exploring the potential of doublet state emission from a stable, luminescent, organic radical

SESSION I.B: 9:00 am – 10:00 a.m. Room: LSB 300			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.B.1 (9:00)	Espen Fredrick	Gustavus Adolphus College	Detection of Atmospheric Gravity Waves through Wavelet Analysis
I.B.2 (9:15)	Innes Maxwell	Lawrence University	An Exploration of Exoplanet Detection and Orbit Stability
I.B.3 (9:30)	Aldo Panfichi Sanborn	University of Chicago	Smoothed Particle Interference Analysis of DEM L71
I.B.4 (9:45)	Andrea Salazar	University of Chicago	Testing for Climate Limit Cycles on Tidally Locked Planets

Oral Session II Schedule

SESSION II.C: 11:10 – 11:55 a.m. Room: LSB 250			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.C.1 (11:10)	Cameron Kuchta	Beloit College	Comparing CNN Models Applied to Medical Imaging
II.C.2 (11:25)	Zachary Barnes	Knox College	Music Genre Classification using Deep Learning
II.C.3 (11:40)	Mattias McMullin	Lawrence University	Computationally Tracking Microtubules

SESSION II.D: 11:10 – 11:55 a.m. Room: LSB 300			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.D.1 (11:10)	Conner Corbridge	Colorado College	Comparing Tests for the Classification of Data by Tail-Heaviness
II.D.2 (11:25)	Jacob Erickson	University of Chicago	Intrinsic holonomy and curved cosets of Cartan geometries
II.D.3 (11:40)	Royce Dong	Washington University in St. Louis	Whispering-Gallery Devices for Sensing Applications

Oral Session III Schedule

SESSION III.E: 2:45 – 3:30 p.m. Room: LSB 300			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
~~III.E.1 (2:45)~~	Zach Martin CANCELLED	Luther College	~~Charm meson production from bottomonium decays~~
III.E.1 (2:45)	Aaron Swanson	St. Olaf College	(Delocalized) Baryons in Large Nc QCD with Heavy Quarks in d+1 dimensions
III.E.2 (3:00)	Sydney Jenkins	University of Chicago	New machine learning approaches at low latency for particle physics
III.E.3 (3:15)	Jacob Pierce	University of Chicago	Precision Calibration of Double-Sided Strip Detectors: Decoupling Source and Detector Losses

SESSION III.F: 2:45 – 3:30 p.m. Room: LSB 250			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
III.F.1 (2:45)	Kathryn Mehltretter	Grinnell College	Herbicide fate and transport in an agricultural watershed
III.F.2 (3:00)	Erik Schoonover	Hope College	Varied Approaches to Examine the Reaction Mechanism of a Rhodium-Catalyzed Decarbonylation of Pyridyl Ketones
~~III.F.3 (3:15)~~	Alessandra Leong CANCELLED	University of Chicago	~~Biophysical studies on α-Synuclein binding and its effects on inter-membrane interactions~~
III.F.3 (3:15)	Anusree Natraj	Washington University in St. Louis	Synthesis of Sequence-Defined Redox Responsive Polyviologens

SESSION III.G: 2:45 – 3:30 p.m. Room: LSB 301			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
III.G.1 (2:45)	Sam Kottler	Colorado College	Parameters of locally recoverable codes with multiple recovery sets
III.G.2 (3:00)	Charlie Moe	Gustavus Adolphus College	Smooth, non-singular, volume-preserving dynamical systems with uniformly bounded trajectories.
III.G.3 (3:15)	Will Asness	University of Chicago	An Overview of Alexandrov Spaces

Poster Session P1

10:15 a.m. – 11:00 a.m. Room: Rettner Gallery & 3rd floor hallway			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P1.01	Yana Astter, Grace Kozisek	Carthage College	Gold Nanoparticle Synthesis and Thin-Film Spin Coating
P1.02	Max Becher	Carthage College	Low-cost dropsonde development for multi-point measurement of thunderstorm electric fields
P1.03	Wes Brown, Karina Zikan	St. Olaf College	Quantifying two-meter near-surface inversions at sites across the Greenland Ice Sheet
P1.04	Yesheng Chen	Grinnell College	Language and Code: A Middle-School Digital Humanities Camp
P1.05	Christian Fares	Beloit College	The Sum of Proper Divisors Function and its Produced Graphs
P1.06	Hannah Gilbert	Macalester College	Computational Modeling of Isoprene Ozonolysis Reaction Intermediates Following 1,2 Addition
P1.07	Kaitlyn Gruber	Gustavus Adolphus College	Photodegradation of the Herbicide, Dicamba (3,6-Dichloro-2-methoxybenzoic acid), in Aqueous Solutions and on Plant Surfaces
P1.08	Diamond Jelani	Knox College	Toward the optimization of hydrosilylation reactions catalyzed by copper with BIAN ligands
P1.09	Yishen Li	Grinnell College	Characterization of Electrical and Magnetic Properties of Single Crystal GdNiPb
P1.10	Sophie Macfarland	University of Chicago	The Effects of Ligand Concentration on the Mechanical Properties of Nanoparticle Films
P1.11	Katheryn Menssen	Grinnell College	Properties of quadratic anticommutative hypercomplex numbers.
P1.12	Emily Morgan	Washington University in St. Louis	Synthesis and Characterization of Complexes of the PicTsN4 Ligand for Carbon Dioxide and Hydrogen Reduction
P1.13	Jonathan Palmer	Beloit College	Analysis of Omega-3 Fatty Acids in Fish Oil Dietary Supplements with ATR-FTIR Spectroscopy
P1.14	Saugat Pandey	Beloit College	Graphs from the Sum of Divisors Function
P1.15	Michael Regotti	Carthage College	Development of Undergraduate Organic Laboratories Using FastWoRX-M
P1.16	Morgan Reik	University of Chicago	The influence of fractional surface coverage on core-core separation in monolayers of thiol-ligated gold nanoparticles
P1.17	William Setterberg	Macalester College	Making and analyzing lead-halide Perovskite solar cells

P1.18	Dmitry Shribak	University of Chicago	Development of Software Defined Radio Protocol for Acoustic Communication on Pipes
P1.19	Winifred Waters	Lawrence University	Design, Synthesis, and Characterization of Diarylquinoxalines
P1.20	Royce Yang	University of Chicago	DTRA: Computer Vision Data Generation with Weak Supervision
P1.21	Jason Ziwiski, Anthony Wendel, Chaudhry Muhammad Faiq Shafqat, Xingtong Wang	Beloit College	An Application to Find the Interesting Properties of Positive Integers

Poster Session P2

1:45 p.m. – 2:30 p.m. Room: Rettner Gallery & 3rd floor hallway

Poster #	Presenter Name	Institution	Title of Presentation
P2.01	Israel Ashiagbor	Colorado College	Nutritional Analysis of Croton Nuts to Determine Suitability for Animal Feed
P2.02	Rachel Bass	Grinnell College	Validation of the LNE51 AEGIS transfer line optics and electrostatic deflector
P2.03	Samuel Brunclik	St. Olaf College	Optimizing the synthesis of a new tetradentate mixed donor ligand
P2.04	Keegan Danielson	Luther College	Measuring material properties on the nanoscale using a mutlifrequency lockin amplifier
P2.05	Owen Ericksen	Grinnell College	Lessons from Single Crystal Growth of $REFe_{1-x}Sb_2$
P2.06	Eleanor Goblirsch	Lawrence University	Visualization of microtubule dynamics using STORM
P2.07	Allen Irvine	Knox College	Toward the synthesis of a 2-isopropylphenyl substituted bis(imino)acenapthene iron dibromide complex
P2.08	David Jin	Grinnell College	The Effects of Gaps on the Correlation Dimension of Nonlinear Systems
P2.09	Sarah Lipstone	Macalester College	Electromagnetic Waves with Parity Violation
P2.10	Khalid Mahmood	Washington University in St. Louis	Synthesis of a Fluorogenic Probe and its Application in Catalysis
P2.11	Jessica Metzger	University of Chicago	A neutrinosphere model for the photometry of kilonovae
P2.12	Henos Negash	Colorado College	Synthesis of dicarbonyl compounds and their reactivity with benzyne
P2.13	Celisha Oscar	Knox College	Synthesis and characterization of liquid crystalline properties for mixtures of heteroleptic copper (II) carboxylate dimers
P2.14	Dona Pantova	Macalester College	There's more than one way to cancel a regularized Stokeslet

P2.15	Reshma Rajan	Knox College	Computational analysis of iron dibromide precatalysts supported by bidentate alpha diimine and bis(imino)acenaphthene ligands
P2.16	Xi Ren	Beloit College	Characterization of Fatty Acids by ATR-FTIR spectroscopy and 2-D Correlation Analysis
P2.17	Thomas Shannon	Carthage College	Generative Design Using A Bi-directional Evolutionary Structural Optimization (BESO) Topology Method
P2.18	Vicky (Haowen) Su	Washington University in St. Louis	Nesquehonite Characterization Using NMR Crystallography
P2.19	Marie Wesson	University of Chicago	Optical collection enhancement from spin defects in silicon carbide using anti-reflective coatings
P2.20	Momin Zahid	Knox College	Developing a centralized resource on teaching computing to K-12 students and educators

Poster Session P3

4:00 p.m. – 4:45 p.m. Room: Rettner Gallery & 3rd floor hallway			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P3.01	Sam Armon	Macalester College	Transitioning between Young's representations of the symmetric group
P3.02	Adee Athiyaman	Knox College	Synthesis and characterization of heteroleptic copper dimers generated from tetrakis(3-phenylpropionate)dicopper(II) precursor.
P3.03	Christine Campisi	Washington University in St. Louis	Toward the Total Synthesis of Tabtoxinine-β-lactam Analogs
P3.04	Sydney Dybing	Washington University in St. Louis	Characteristics and Spatial Variability of Wind Noise on Near-Surface Broadband Seismometers
P3.05	Hyunji Eom	Grinnell College	SERS of Dyestuffs on Silver and Gold Monometallic and Bimetallic Nanoparticles
P3.06	Medha Goyal, Huayue Xue	University of Chicago	Dense Suspension Shear Jamming Depends on Particle Aspect Ratio
P3.07	Musaddiq Javed, Arsalan Bin Najeeb	Knox College	Dragonfly Task Mapping for Non-Square Jobs
P3.08	Benjamin Johnson, Thabiso Mabote	St. Olaf College	An Experimental System to Measure the Temperature Dependence of the Emission Spectrum of Toluene
P3.09	Lily Liu	University of Chicago	Antarctic ice geometry as possible explanation for upgoing cosmic ray showers detected by ANITA
P3.10	Macy Maraugha	Hope College	Characterization of surMOF thin film properties

P3.11	Jose Monge Castro	Colorado College	Computational Modelling of Closed-Cell Bipolar Electrochemistry based Heavy-Metal Water Sensor
P3.12	Marta Nowotka	Colorado College	Multiwavelength search for a low mass X-ray binary in the open cluster NGC 6819
P3.13	Madelyn Orndorff	Hope College	Morphological differences in electropolymerized EDOT films
P3.14	Maddie Klein, Kyla Pohl	St. Olaf College	Automorphism Orbits of some Metacyclic Groups
P3.15	Ellen Purdy	University of Chicago	Destruction of organophosphates via laser ablation
P3.16	Andrew Reuter	St. Olaf College	En route to the synthesis of a tetradentate ligand: optimization of the first step
P3.17	Zhiheng Sheng	Grinnell College	PyBoard lock-in amplifier for lake water optics
P3.18	Tiffany Suwatthee	University of Chicago	Probing the Sensitivity to Membrane Fluidity of the Binding of Milk Fat Globule EGF Factor 8
P3.19	Lu Xian	Macalester College	Using Order Parameters and Persistent Homology to Analyze Biological Aggregations
P3.20	Karina Zikan, Wesley P. Brown	St. Olaf College	Validating MODIS land surface temperatures using in-situ skin temperature data across Greenland

Abstracts for all Sessions
Physical Sciences, Mathematics and Computer Science
MCMS Undergraduate Research Symposium, Washington University in St. Louis
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All abstracts (poster and oral) are listed alphabetically by presenter last name. Abstracts with multiple presenters appear only once with first listed presenter. An alphabetical list of all meeting participants and their respective poster session or oral presentation number follows the abstracts.

Presenter(s): Sam Armon, Macalester College
Session: Poster P3.01
Title: Transitioning between Young's representations of the symmetric group
Advisor(s): Tom Halverson, MSCS, Macalester College

Abstract: The irreducible representations of the symmetric group S_n are indexed by integer partitions λ. The corresponding simple modules are denoted $\{S_n^\lambda \mid \lambda$ is an integer partition of $n\}$, and the dimension of S_n^λ equals the number of standard Young tableaux of shape λ. In the 1920s, A. Young defined two bases of S_n^λ -- the natural and seminormal bases -- by describing the action of permutations in S_n on vectors indexed by standard Young tableaux of shape λ. We give a formula for the entries in the transition matrix between the seminormal and natural bases, answering an open question in the representation theory of the symmetric group. Our method is to use a graph Γ_λ, which has vertices labeled by the standard tableaux of shape λ and colored edges corresponding to adjacent transpositions in S_n. This graph is the Hasse diagram of weak Bruhat order on standard tableaux, and the entries in the transition matrix are calculated using weights on walks on Γ_λ. We generalize our method to $G_{r,n}$, which is the wreath product of S_n and Z_r, and the Iwahori-Hecke algebra $H_n(q)$ of S_n.

Presenter(s): Israel Ashiagbor, Colorado College
Session: Poster P2.01
Title: Nutritional Analysis of Croton Nuts to Determine Suitability for Animal Feed
Advisor(s): Murphy Brasuel, Chemistry, Colorado College
Co-Author(s): Murphy Brasuel

Abstract: Nutritional analysis of Croton megalocarpus (Kenya) shows that it has significant potential as a new protein source from a nut already being utilized for its biofuel production. The Food and Agriculture Organization of the United Nations reported that, “Global demand for meat products will increase by 58 percent between 1995 and 2020. Consumption of meat will rise from 233 million tons in 2000 to a possible 300 million t by 2020; milk consumption will increase from 568 to 700 million t by 2020, and there will be an estimated 30 percent increase in egg production.” The croton meal is 47% protein with a high fraction of water and salt soluble proteins. The amino acid profile is rich in asparagine, glutamine, and arginine.

Presenter(s): Will Asness, University of Chicago
Session: Oral III.G.3 (3:15)
Title: An Overview of Alexandrov Spaces
Advisor(s): Colin Aitken, Mathematics, University of Chicago

Abstract: My research covers Alexandrov spaces, an interesting kind of topological space in which openness is preserved under arbitrary intersection. We will discuss how we can look at some of its topological properties as part of a preorder (such as how open sets are all initial segments of maximal chains), look at some interesting topological properties of Alexandrov spaces that distinguish them from an arbitrary topological space (like how connectedness and path connectedness are equivalent in this space), and finish up with a discussion of what paths look like in this space (and how they strengthen the intuitive connection between these spaces and preorders).

Presenter(s): Yana Astter, Grace Kozisek, Carthage College
Session: Poster P1.01
Title: Gold Nanoparticle Synthesis and Thin-Film Spin Coating
Advisor(s): John Kirk, Chemistry, Carthage College

Abstract: Nanotechnology has a variety of applications and is applicable to a wide range of fields including environmental monitoring, medical diagnostics, and detecting compounds in a laboratory setting. Sensors constructed out of nanoparticles are able to detect the presence of certain substances in an environment. This research presents the development of a sensor composed of gold and silica nanoparticles that will be used for detecting organic compounds in water. The gold and silica nanoparticle components of the sensor have different qualities that allow the sensor to function. Gold nanoparticles have unique optical properties that change depending on which environment they are in; the silica nanoparticles make up the majority of the sensor, provide strength to the structure, and stabilize the gold nanoparticles. We present our methods of synthesizing gold nanoparticles of a controlled size as well as the development of a crystalline structure composed of gold and silica nanoparticles that serves as the main component of the sensor.

Presenter(s): Adee Athiyaman, Knox College
Session: Poster P3.02
Title: Synthesis and characterization of heteroleptic copper dimers generated from tetrakis(3-phenylpropionate)dicopper(II) precursor.
Advisor(s): Thomas W. Clayton, Chemistry, Knox College

Abstract: Tetrakis(3-phenylpropionate)dicopper(II) was synthesized from copper (II) chloride dihydrate and sodium 3-phenylpropionate in water. Crystals were grown of the biscaprolactam adduct and the x-ray crystal structure determined. Surprisingly, the caprolactam adduct of the dimer exhibited liquid crystalline properties. The lability of the 3-phenylpropionate ligand (and carboxylate ligands in general) was utilized to synthesize novel heteroleptic copper (II) dimers. The effect of branching on the melting point and the range of thermal stability of potential liquid crystals was investigated. All products were characterized with FT-IR spectroscopy, melting point analysis, polarized optical microscopy, and differential scanning calorimetry. In addition, caprolactam adducts of the heteroleptic carboxylate dimers were examined.

Presenter(s): Zachary Barnes, Knox College
Session: Oral II.C.2 (11:25)
Title: Music Genre Classification using Deep Learning
Advisor(s): Dr. Jaime Spacco, Computer Science, Knox College

Abstract: The classification of music genre has become one of the most heavily researched areas in the field of Music Information Retrieval (MIR). In this report, a combination of approaches to recognize genres in the FMA and GTZAN datasets were tested. Music genre is a high-level feature, and because of this, using computer vision techniques on images has been shown to be effective. Each song clip was converted into mel-spectrogram representation. These images were then used as input into a convolutional neural network, which was implemented using the fast.ai framework, with PyTorch as the base library. By training on these inputs, the CNN's were able to learn common features that were shared by certain genres. Techniques such as data augmentation, batch normalization, and dropout were tested to improve the accuracy of each dataset. Future work on this topic will include combining traditional machine learning techniques on numerical features in tandem with image recognition neural networks.

Presenter(s): Rachel Bass, Grinnell College
Session: Poster P2.02
Title: Validation of the LNE51 AEGIS transfer line optics and electrostatic deflector
Advisor(s): Matthew Alexander Fraser, European Council for Nuclear Research (CERN)

Abstract: The Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy (AEGIS) at the European Organization for Nuclear Research will move from its current location to another area within the Antiproton Decelerator (AD) hall. Beam line LNE51 will provide AEGIS with 100 keV antiprotons from the Extra Low ENergy Antiproton (ELENA) decelerator ring. This beam line uses quadrupoles and electrostatic deflectors to guide and focus the antiproton beam from the decelerator to the experiment. The validation of the new 37.7 degree standalone electrostatic deflector design is described, and the element's transfer matrix is numerically determined.

Presenter(s): Max Becher, Carthage College
Session: Poster P1.02
Title: Low-cost dropsonde development for multi-point measurement of thunderstorm electric fields
Advisor(s): Brant Carlson, Physics, Carthage College
Co-Author(s): Brant Carlson

Abstract: Thunderstorms are often described as consisting of three charge layers: upper positive, central negative, and lower positive. This simple charge structure is inferred from balloon-borne electric field measurements, however, they typically only provide information from a single moving point. Realistic charge structures in thunderclouds are expected to be more complicated than this for a variety of reasons, including non-trivial updraft geometry, turbulence, and charge deposition by lightning. In order to more fully measure thunderstorm charge structures, we herein describe the development of an experiment composed of multiple low-cost electric field dropsondes. Each dropsonde consists of two pairs of electrodes. Each

pair has its electrodes on opposing sides of the device and connected to a differential charge amplifier. The enclosures for the dropsondes are designed so they spin as they fall which induces charge motion and allows us to measure electric field strength. This electric field data will be transmitted to a ground station in real time along with GPS coordinates. By keeping instrument and recovery costs low, we aim to launch a single balloon payload carrying several of these instruments to drop at intervals to provide a multi-point map of electric field and infer associated charge structures inside a thunderstorm.

Presenter(s): Wes Brown, Karina Zikan, St. Olaf College
Session: Poster P1.03
Title: Quantifying two-meter near-surface inversions at sites across the Greenland Ice Sheet
Advisor(s): Alden Adolph, Physics, St. Olaf College
Co-Author(s): Karina Zikan, Alden Adolph, Robert Fausto

Abstract: As our climate rapidly changes, close monitoring of temperature processes in the Arctic regions is critical to understand and predict ice loss and sea level rise. In Greenland, ice surface temperatures are often significantly lower than the atmosphere immediately above, a phenomenon known as an inversion. These inversions can limit vertical mixing between the ice surface and atmosphere, affecting the surface energy balance and hydrologic cycle. Our study investigates the frequency and strength of inversions across Greenland by comparing 2-meter air temperature and ice surface temperature data from 2015 obtained by a series of 20 automatic weather stations. We found inversions to be present 87% of the time with an average strength of 2.2°C ± 1.8°C (mean ± standard deviation). Our initial findings indicate incoming and outgoing longwave radiation and percentage of cloud cover to be the largest influencers on the strength of the inversion present. Understanding the processes controlling inversions can inform the interpretation of ice core temperature records and the modelling of the near-surface mass and energy exchange.

Presenter(s): Samuel Brunclik, St. Olaf College
Session: Poster P2.03
Title: Optimizing the synthesis of a new tetradentate mixed donor ligand
Advisor(s): Elodie Marlier, Chemistry, St. Olaf College
Co-Author(s): Andrew Reuter, Melanie Nevins, Chris Seong, Alexander Mench

Abstract: In order to stabilize low valent first-row transition metals, a new family of tetradentate ligands have been synthesized. These ligands utilize a β-diketiminate backbone with pendant phosphine donors to create a unique binding environment. The synthesis of these ligands has been characterized using electrospray ionization mass spectrometry (ESI-MS), ^{1}H and ^{31}P nuclear magnetic resonance spectroscopy (NMR) to study the effects of temperature, equivalencies, different moieties, and different addition methods on the overall reaction. Specifically, the second step of the synthesis will be discussed.

Presenter(s): Christine Campisi, Washington University in St. Louis
Session: Poster P3.03
Title: Toward the Total Synthesis of Tabtoxinine-β-lactam Analogs
Advisor(s): Timothy Wencewicz, Chemistry, Washington University in St. Louis

Abstract: Multi-drug resistant bacteria have been identified as a serious threat to global health. This has driven drug developers to come up with new classes of antibiotics designed to target specific mechanisms within bacterial cells predicted to avoid evolutionary pressures that beget resistance.

My target molecule, 2-amino-6-formamide-5-hydroxy-5-methylhexanoic acid, is an acyclic analog of Tabtoxinine-β-lactam, derived from Tabtoxin produced by plant pathogenic strains of Pseudomonas syringae, and improves upon its already demonstrated ability to inhibit activity of glutamine synthetase (GS). Bacterial GS is critical for nitrogen metabolism and biosynthesis of the cell wall, specifically that of Mycobacterium tuberculosis, making it a promising target for antibiotics.

The syntheses of precursors to 2-amino-6-formamide-5-hydroxy-5-methylhexanoic acid were completed. My synthetic route has the potential for streamlining library syntheses of this promising GS inhibitor scaffold. Determining the required structural components of Tabtoxinine-β-lactam through the synthesis and testing of analogs is necessary to optimize future GS inhibitors. The benefits of pursuing the synthesis of an acyclic structure, as opposed to a structure containing a four-membered ring, include synthetic flexibility and scalability, improved stability, and rapid diversification of the chiral C5-stereocenter to optimize parameters for mimicking the tetrahedral GS transition state to increase stability of the GS inhibition complex.

Presenter(s): Yesheng Chen, Seoyeon Lee, Grinnell College
Session: Poster P1.04
Title: Language and Code: A Middle-School Digital Humanities Camp
Advisor(s): Samuel A. Rebelsky, Sarah Dahlby-Albright, Computer Science, Grinnell College
Co-Author(s): Zhen Chen, Syamala Gumidialya, Annabella Koures, Seoyeon Lee, James Msekela, Halle Remash, Nolan Schoenle

Abstract: Over the past decade, community leaders have called for computing and computer science education opportunities to be made available earlier and earlier. Such calls have led to the creation of a wide variety of offerings including “summer camp” for students at middle-school and even elementary levels. Such camps often emphasize "fun" aspects of computing, such as games and robots. In contrast, research at the collegiate level suggests that meaningful applications of computing, such as computing for social good, are more successful at building and sustaining interest, particularly among traditionally underrepresented student groups. In response to this, we developed and offered a week-long summer camp that drew upon ideas and approaches from the digital humanities, which explores the use of algorithms and computation in support of broader humanistic inquiry, in the hopes of attracting students who might not otherwise consider computing. In this poster, we explain the rationale for the camp design, describe the camp curriculum. We also present preliminary data on the effects of the camp on students' self-efficacy and interest in computing.

Presenter(s): Conner Corbridge, Colorado College
Session: Oral II.D.1 (11:10)
Title: Comparing Tests for the Classification of Data by Tail-Heaviness
Advisor(s): Javier Rojo, Statistics, Oregon State University
Co-Author(s): Yetzaveli Cervantes, Meir Jablon

Abstract: Empirical evidence has shown that many real-world phenomena predictably display outliers. Thus, when selecting a statistical model for such data it is critical to properly account for the relative probability of seeing extreme values. It is common for statistical models to default to assumptions that characterize data with short or medium-tailed distributions. However, when the data is outlier prone the probability of observing extreme events will be severely underestimated. The three statistical tests presented here, Bryson's test, Rojo's test, and a modified form of Rojo's test, were specifically designed to determine when heavy-tailed distributions may be better suited for observed data then medium-tailed distributions. In this paper all three statistical tests are analyzed and compared to see which test demonstrates higher power and limited Type I error. By running simulations of each test and considering the impact that tail classifications have we are able to characterize the relative strength of each test in a variety of contexts and draw some conclusions about how to effectively test limited sample data for heavy-tailed distributions.

Presenter(s): Stephen Cropper, Grinnell College
Session: Oral I.A.2 (9:15)
Title: Lessons from Single Crystal Growth in the RE-Co-Sb system.
Advisor(s): Charles Cunningham, Physics, Grinnell College
Co-Author(s): Owen Ericksen, Yishen Li, Charles Cunningham

Abstract: Rare-earth, transition metal, intermetallic compounds have been of interest to the crystal growing community for some time. Often, compounds such as these will exhibit interesting magnetic properties and strong anisotropy. In this study, we developed a method for reliably growing single-crystal $RECoSb_2$ (RE=Ce,Pr,Nd) out of a self-flux. We then used the crystals grown to obtain preliminary magnetic and transport data. $RECoSb_2$ (RE=Ce,Pr,Nd) shows strong anisotropy, and ferromagnetism along its easy-magnetic axis with a Curie temperature of between 23 and 24.5 Kelvin. Resistance data shows that resistance appears to decrease with temperature. Future studies should verify the structure of our crystals and explore further their magnetic and transport properties.

Presenter(s): Keegan Danielson, Luther College
Session: Poster P2.04
Title: Measuring material properties on the nanoscale using a mutlifrequency lockin amplifier
Advisor(s): Erin Flater, Physics, Luther College
Co-Author(s): Saurabh Gupta, Ayra Mugda, Jesse Wilson, Bill Hudson, Jason Killgore, Erin Flater

Abstract: Scientists and engineers need to quantify the physical properties of materials to optimize the design of many different technologies. Specifically, knowing the stiffness and damping of a material are key. We can discover these properties at the nanoscale using the method of contact resonance on an Atomic Force Microscope (AFM). With the goal of obtaining accurate results through cost effective means, faculty and students at Luther College, along

with our collaborators in Colorado, have developed an eight lockin amplifier system that detects an oscillatory signal from the AFM. We then use these signals to find the resonance curve for a specific material, and which allows us to quantify the stiffness and damping of the material. Our research focuses on optimizing resonance curve fits to the eight frequency data points given by the eight lockin amplifiers. To characterize the behavior of the multi-lockin system, we started with a basic simulator and are progressing towards analyzing real experimental data. Once we have reached a good level of optimization with relatively simple curve fitting equations, then we will move on to more complex theories in the hopes of capturing key details in the data that would help us understand material properties more fully.

Presenter(s): Royce Dong, Washington University in St. Louis
Session: Oral II.D.3 (11:40)
Title: Whispering-Gallery Devices for Sensing Applications
Advisor(s): Lan Yang, Electrical & Systems Engineering, Washington University in St. Louis

Abstract: Whispering gallery modes (WGMs) are optical resonances where light is confined in a spherical cavity by repeated total internal reflection along the circular equator. The outer surfaces of WGM resonators are shaped by surface tension while the silica material is melted, resulting in a near atomic-level smoothness. This lends WGMs an ultra-high-quality factor ($>10^8$) such that a single photon can circulate within a cavity over a million times, enhancing light-matter interactions.

Sensing stimuli, e.g. particles adsorbing onto the resonator surface or temperature changes altering the spectral properties of the medium, can be measured via a number of transduction mechanisms. Perturbations in the local environment can be observed through wavelength shifts, linewidth broadening, or mode splitting in WGMs.

The sensing modalities and ultra-high-quality factors of WGM resonators allow for a myriad of applications such as photoacoustic, gas, and infrared radiation sensing. One particular WGM structure is the microbubble, which is formed by heating glass capillary tubing and applying internal air pressure to expand it into a spherical shape. The capillary-based technology uniquely combines optical and fluidic handling. Microbubbles reduce sample volume requirements and increase refractometric sensitivity, making it a promising platform for future optical sensing research.

Presenter(s): Sydney Dybing, Washington University in St. Louis
Session: Poster P3.04
Title: Characteristics and Spatial Variability of Wind Noise on Near-Surface Broadband Seismometers
Advisor(s): Adam T. Ringler, US Geological Survey - Albuquerque Seismological Laboratory
Co-Author(s): Adam T. Ringler, David C. Wilson, Robert E. Anthony

Abstract: Wind causes ground motion that appears on seismic records as noise across a wide bandwidth, which drowns out features such as small earthquakes and prevents observation of normal modes. As the wind field is heterogeneous at local scales due to structures, diurnal heating, and topography, wind-induced seismic noise can vary on seismometers installed just meters apart. We investigated the spatial variability of wind-induced noise using two weather sensors approximately 100 m apart, and collocated with several broadband seismometers. We

found that at longer periods (>5 s), increasing wind speed causes increases in noise on the horizontal components of seismometers. We also measured a very low coherence between the wind speed, wind direction, and the pressure recorded by our weather stations. We observed decreased coherence between the vertical components of our seismometers depending on the substrate surrounding the seismometer and found that this material could be amplifying the wind-generated noise. Additionally, the dominant source of high-frequency seismic noise at some sites could be anthropogenic rather than wind-induced. A more detailed understanding of the processes by which wind-induced noise is generated can inform sensor installation and the development of methods for mitigation of these effects, thus improving the quality of seismic data.

Presenter(s): Hyunji Eom, Grinnell College
Session: Poster P3.05
Title: SERS of Dyestuffs on Silver and Gold Monometallic and Bimetallic Nanoparticles
Advisor(s): Corasi Ortiz, Chemistry, Purdue University

Abstract: Surface-Enhanced Raman Spectroscopy (SERS) was utilized to identify organic colorants. SERS surfaces used include silver, gold as well as silver-covered gold, and gold-covered silver nanoparticles. As expected, silver produced the highest enhancement but core-shell Ag-Au colloids displayed comparable intensities while gold colloids showed the least intense signals. Aggregation agents were also researched, concluding that $Mg(NO_3)_2$ was the best choice for gold and silver surfaces, and KNO_3 for heterostructured ones. However, dyes such as lac, madder, cochineal, and kaempfitrin were unresponsive to non-silver surfaces regardless of activation agent used. Preliminary trials to immobilize colloidal particles onto glass were successful and seem promising as a SERS substrate for the analysis of these dyes. In addition, a Mexican textile was studied and subjected to various extraction methods. Attempts to identify the extracted dyes by comparing their spectra to our SERS library were unsuccessful.

Presenter(s): Owen Ericksen, Grinnell College
Session: Poster P2.05
Title: Lessons from Single Crystal Growth of $REFe_{1-x}Sb_2$
Advisor(s): Charles Cunningham, Physics, Grinnell College

Abstract: Single crystals of $REFe_{1-x}Sb_2$ (RE = Ce, Pr, Nd, Sm, Gd) were grown, or attempted to be grown, using flux growth methods. The structure of $REFe_{1-x}Sb_2$ has previously been analyzed as being part of the $ZrCuSi_2$ structure type, and of the P4/nmm symmetry group (no. 129). Our grown compounds show various types of magnetic properties, though all fairly weakly. From molar susceptibility we can give a basic assessment as to whether the given compound is antiferro-, ferro-, para-, or diamagnetic along a given axis. Measurements of magnetic susceptibility and temperature dependent resistivity were taken using a PPMS. In this paper we discuss the methods with which we grew our intended crystals and discuss at a cursory level the physical properties of our grown compounds.

Presenter(s): Jacob Erickson, University of Chicago
Session: Oral II.D.2 (11:25)
Title: Intrinsic holonomy and curved cosets of Cartan geometries
Advisor(s): Jacob W. Erickson, Math

Abstract: Cartan geometries provide a natural extension of Klein's Erlangen program to non-homogeneous geometries. We will discuss the basic intuition behind these mathematical objects and describe a simplification of the standard construction of curved orbits for a given holonomy reduction. New applications include a generalization of the de Rham decomposition theorem for Riemannian manifolds and a characterization of essential vector fields with fixed points for arbitrary parabolic geometries, including conformal geometries of mixed signature.

Presenter(s): Christian Fares, Beloit College
Session: Poster P1.05
Title: Sub-graphs of the graph of Aliquot sequences
Advisor(s): Darrah Chavey, Computer Science, Beloit College
Co-Author(s): Saugat Pandey and Darrah Chavey

Abstract: This research project explores sub-graphs of the graph of Aliquot sequences by asking the question if all graphs with 5, 6 or 7 edges can be found. The approach taken for answering this question involves fundamental ideas of object oriented programming, paired programming, concepts of graph theory and creating a front-end aspect as to show this work in a more interactive and visually appealing way. All graphs of with 2, 3 and 4 edges have been found and will be confirmed in this project, but because it is difficult to draw graphs with more than 4 edges, this project offers an automated program to do so.

Presenter(s): Espen Fredrick, Gustavus Adolphus College
Session: Oral I.B.1 (9:00)
Title: Detection of Atmospheric Gravity Waves through Wavelet Analysis
Advisor(s): Darsa Donelan, Physics, Gustavus Adolphus College
Co-Author(s): Vatsala Adile

Abstract: This study investigated the use of Morlet wavelet analysis in the detection of gravity wave structure in the atmosphere of terrestrial bodies, primarily Mars, Venus, and Titan. Atmospheric profiles from data collected by planetary probes and satellites were processed to generate 2D images of wave structure in each analyzed atmosphere. The analysis shows a correlation between vertical wave structure at altitudes and wavelengths to those previously found using other methods such as comparing temperature gradient profiles to the dry adiabatic lapse rate. This suggests the use of Morlet wavelet analysis as a viable alternative to previously used methods for detection of small-scale variability.

Presenter(s): Hannah Gilbert, Macalester College
Session: Poster P1.06
Title: Computational Modeling of Isoprene Ozonolysis Reaction Intermediates Following 1,2 Addition
Advisor(s): Keith T. Kuwata, Department of Chemistry, Macalester College

Abstract: A computational approach was undertaken to model the process of isoprene ozonolysis, with the goal of constructing a mechanism and identifying reaction intermediates. Isoprene ozonolysis is the reactive process between ozone and isoprene – the most abundant alkene in the troposphere. This process generates many different products, a significant portion of which are known to be hazardous to human health and/or harmful to the environment. Using the Minnesota functionals M06L and UM06L and two different basis sets, 6-31+G(d,p) and def2TZVP, geometry optimization calculations were run through Gaussian 09. The resulting optimized transition structures and stable conformers were verified using intrinsic reaction coordinate (IRC) calculations, and only verified energies were reported. Results show that the initial formation and decomposition of the primary ozonide is a highly exothermic process, verifying the high reactive potential of isoprene and ozone. In comparison, there is a smaller energetic difference between the most stable conformer and other structures in the conformational interconversions following 1,2-addition. However, given the relatively small amount of energy lost to collisions in gas-phase work, there is enough energy in the system to facilitate the conformational interconversions and formation of vinyl hydroperoxides.

Presenter(s): Eleanor Goblirsch, Lawrence University
Session: Poster P2.06
Title: Visualization of microtubule dynamics using STORM
Advisor(s): Douglas Martin, Physics, Lawrence University

Abstract: Microtubules are essential to cell function, displaying a hallmark behavior of dynamic instability. The dynamic instability is essential to mitosis because of the microtubules' capture of kinetochores for chromosome segregation while the tip of the microtubule depolymerizes. In previous research, two models for the depolymerization and capture of kinetochores have been proposed: conformational wave and biased diffusion. Here we use a method of single-molecule fluorescence microscopy to visualize microtubules to confirm a model of depolymerization. We observed that the microtubule tip widens as depolymerization progresses, supporting the conformational wave model.

Presenter(s): Medha Goyal, Huayue Xue, University of Chicago
Session: Poster P3.06
Title: Dense Suspension Shear Jamming Depends on Particle Aspect Ratio
Advisor(s): Heinrich Jaeger, Department of Physics, University of Chicago
Co-Author(s): Huayue Xue, Nicole James, Heinrich Jaeger

Abstract: Dense suspension of particles in a Newtonian liquid can exhibit non-Newtonian behaviors such as shear thinning, shear thickening and shear jamming. Although recent studies show that friction between the particles and the particle surface chemistry plays an important role, little is known about how particle shape affects shear jamming characteristics. To address this, we present on experiments where we synthesize silica particles, designing the particle surface chemistry such that the particles exhibit strong shear jamming over

experimentally relevant packing fractions. Our synthetic approach enables us to synthesize particles with aspect ratios ranging from 1 (spheres) to 15 (slender rods). This allows us to isolate the effect of particle anisotropy on suspension thickening and jamming. The results uncover new physics about the rheological behavior of anisotropic particles and shed new light on how to rationally design shear jamming characteristics for protective material applications.

Presenter(s): Kaitlyn Gruber, Gustavus Adolphus College
Session: Poster P1.07
Title: Photodegradation of the Herbicide, Dicamba (3,6-Dichloro-2-methoxybenzoic acid), in Aqueous Solutions and on Plant Surfaces
Advisor(s): Amanda Nienow, Chemistry, Gustavus Adolphus College
Co-Author(s): Brittany Courteau

Abstract: Dicamba (3,6-Dichloro-2-methoxybenzoic acid), a broadleaf herbicide, was exposed to UV radiation in aqueous solutions and on surfaces of epicuticular waxes of corn and soybean leaves to observe the photochemical degradation. HPLC analysis of the dicamba samples was done to track degradation and calculate the rate constants for quantitative comparisons. The irradiation of aqueous solutions of dicamba under different conditions were compared to observe the effect of environmental factors on the photodegradation. Aqueous solution rate constants were significantly slower in increased acidic conditions and increased NOM concentrations, but excess and reduced oxygen concentrations did not affect the kinetics rate constant. In addition, faster rates of photodegradation were observed in the aqueous solutions than the wax surfaces. Mass spectrometry was used to analyze aqueous solution samples of irradiated dicamba to determine possible photoproducts.

Presenter(s): Allen Irvine, Knox College
Session: Poster P2.07
Title: Toward the synthesis of a 2-isopropylphenyl substituted bis(imino)acenapthene iron dibromide complex
Advisor(s): Helen M Hoyt, Chemistry, Knox College

Abstract: We recently reported that dppBIANFeBr$_2$ (dpp = 2,6-diisopropylphenyl, BIAN = bis(imino)acenaphthene) catalyzes the hydrosilylation of 1-hexene with phenylsilane in excellent yield (99%). However, we have found that dppBIANFeBr$_2$ gives only modest yields (41%) when disubstituted cyclohexene undergoes catalytic hydrosilylation with phenylsilane under similar conditions. We proposed to investigate whether analogous compounds to dppBIANFeBr$_2$ with a more sterically open iron active site could give a higher yield with more highly substituted substrates. Chien and coworkers have reported that the condensation of 2-isopropylaniline with acenaphthenequinone results in the formation of an alpha-diimine ligand 2iPrBIAN (2ipr = 2-isopropylphenyl), which supports the nickel-catalyzed polymerization of propylene. With the goal of preparing precatalyst 2iPrBIANFeBr$_2$, 2iPrBIAN was synthesized following this procedure, and 1H NMR at 400 MHz showed a mixture of isomers, which are proposed to be racemic and meso stereoisomers. Conditions have been explored to investigate ratios of isomer formation. Purification via recrystallizations in various solvents has had moderate success. Ongoing work focuses on optimization of synthesis and purification methods for characterization of the ligand, while future work will explore preparation of the precatalyst and its catalytic behavior.

Presenter(s): Musaddiq Javed, Arsalan Bin Najeeb, Knox College
Session: Poster P3.07
Title: Dragonfly Task Mapping for Non-Square Jobs
Advisor(s): David Bunde, Computer Science, Knox College

Abstract: Dragonfly topology is a scheme for high-performance computers that works to balance bandwidth present on the system and reduce latency. Task mapping for Dragonfly jobs includes assigning job tasks to a specific available computing resource. By doing this we can balance the bandwidth of a Dragonfly system and assure that the flow of information in a Dragonfly system is not disrupted.

Our Balanced Adjacency Coloring (BAC) scheme assigns colors to a group, where a group is a collection of multiple routers, the number of times pairs of colors are formed should be equal or within one of each other. The pairs of colors are also only adjacent if they share an edge with each other. In this paper we show how to create a Non-Square BAC (4 x K) on a 2-D stencil grid, for all K's and prove that it still holds true to the definition of a Balanced Adjacency Coloring.

Presenter(s): Diamond Jelani, Knox College
Session: Poster P1.08
Title: Toward the optimization of hydrosilylation reactions catalyzed by copper with BIAN ligands
Advisor(s): Helen M. Hoyt, Chemistry, Knox College

Abstract: Copper dihalide precatalysts with ArBIAN ligands (BIAN = bis(imino)acenaphthene; Ar = dpp or mes; dpp = diisopropylphenyl and mes = 2,4,6-trimethylphenyl) were prepared, following published procedures reported by Avilés and coworkers for $ArBIANCuCl_2$, and were preliminarily evaluated for the copper-catalyzed hydrosilylation of styrene with phenylsilane upon stepwise activation with NaHBEt3. Analogous in situ protocols utilizing dppBIAN and $Cu(OAc)_2$ to form the proposed catalyst have provided the highest conversion to a mixture of products with a catalyst loading of 10 mol% and a reaction temperature of 75 °C. With the future goal of attaching water-soluble biomolecules to the catalyst as a means of controlling outersphere selectivity, trials with the in situ formed copper catalysts have been investigated for water and oxygen sensitivity. The stepwise method also was investigated for water sensitivity, and preliminary analysis of the product mixture by 1H NMR spectroscopy shows evidence of the expected Markovnikov product observed under inert atmosphere conditions. Ongoing and future work focuses on identification of the species inside the product mixtures produced by the in-situ method.

Presenter(s): Sydney Jenkins, University of Chicago
Session: Oral III.E.2 (3:00)
Title: New machine learning approaches at low latency for particle physics
Advisor(s): Nhan Tran, LHC Physics Center, Fermi National Accelerator Laboratory

Abstract: Real time filtering and selection, known as triggering, is an important aspect of many particle physics experiments. The Large Hadron Collider upgrade will increase processing power and detector subsystem information, presenting an opportunity to improve the trigger capabilities of the Compact Muon Solenoid (CMS) experiment. This would benefit a wide variety of searches and measurements, including those related to supersymmetry, dark matter

physics, and the Higgs boson. Machine learning tools have advanced many fields, including particle physics. However, their usage in low latency (microsecond scale) trigger applications with specialized Field Programmable Gate Array (FPGA) hardware has only just begun. We study pattern recognition algorithms by considering novel graph-based neural network inference in FPGAs, a process that requires efficient design of the network architecture. We achieve this optimization by applying three techniques: hidden features reduction, geometric cuts and network compression. We evaluate these procedures on simulated TrackML data and on more representative CMS muon data. In combination, these methods reduce the number of necessary multiplications by a factor of 28 and make FPGA-based inference more feasible for the upgraded CMS Hardware Trigger with a slight degradation in performance.

Presenter(s): David Jin, Grinnell College
Session: Poster P2.08
Title: The Effects of Gaps on the Correlation Dimension of Nonlinear Systems
Advisor(s): Barbara Breen, Physics, Grinnell College
Co-Author(s): Ian Masson

Abstract: Due to a variety of factors, astronomical data is often collected containing gaps that can obscure the characteristics of the system. The purpose of this investigation is to examine the effects of gaps in nonlinear time series and to observe under which conditions the gaps cause a meaningful difference in analysis. To do this, we introduced gaps into two canonical nonlinear systems and gathered data on the conditions under which the correlation dimension of the gapped data diverged from the published value. We created the gaps by varying the mean and variance of Poisson distributions that determined how far apart the gaps were spaced and how large the gaps were. We were able to characterize the limits of reliability as a function of gap distribution and size.

Presenter(s): Benjamin Johnson, Thabiso Mabote, St. Olaf College
Session: Poster P3.08
Title: An Experimental System to Measure the Temperature Dependence of the Emission Spectrum of Toluene
Advisor(s): Rodrigo Sánchez-González, Chemistry, St. Olaf College
Co-Author(s): Ben Johnson, Thabiso Mabote, Rodrigo Sánchez-González

Abstract: The study of high-speed flows allows for the development of safe and reliable hypersonic transportation, military products, and space travel. Characterization of these flows requires reliable methodologies to measure velocities, temperatures, and species concentrations. Laser-induced fluorescence techniques offer the possibility of performing these measurements non-intrusively with high time and spatial resolution. However, accurate interpretation of fluorescence signals requires detailed understanding of the photophysical properties of the employed tracer molecule. This summer, we set up an experimental system that will allow us to study photophysical properties of toluene–to be used as a tracer molecule–to measure temperature in gaseous flows. Preliminary measurements of the toluene emission spectrum at room temperature and atmospheric pressure were performed and compared to literature spectra to demonstrate the functionality of the system. Future work will involve the measurement of emission spectra below room temperature.

Presenter(s): Sam Kottler, Colorado College
Session: Oral III.G.1 (2:45)
Title: Parameters of locally recoverable codes with multiple recovery sets
Advisor(s): Beth Malmskog, Math and Computer Science, Colorado College

Abstract: A code is a set of vectors, called codewords. Usually we look at codes that actually form vector spaces. Codes can be used for redundancy and error correction, when storing or transferring data. One way to do this is with locally recoverable codes (LRCs) in which any position of a codeword can be recovered from a fixed subset of other positions, called a recovery set. An interesting problem is called the availability problem, which addresses constructing LRCs with multiple disjoint recovery sets for each position. This project studied minimum distance and other parameters of families of such codes constructed from curves over finite fields.

Presenter(s): Cameron Kuchta, Beloit College
Session: Oral II.C.1 (11:10)
Title: Comparing CNN Models Applied to Medical Imaging
Advisor(s): Hong-Jun Yoon, Computational Sciences and Engineering, Oak Ridge National Laboratory
Co-Author(s): Folami Alamudun, Hong-Jun Yoon

Abstract: Convolutional Neural Networks (CNNs) have been popular tools for machine learning because of its ability to automatically represent features. To achieve high performance, we need to supply many training samples. For medical imaging, it is challenging to collect sufficient data samples for training and very costly. To counteract these problems, the current practice is to pre- train the network on ImageNet, a large natural image classification dataset, and fine tune it to the domain specific task.

We tested the feasibility of the current practice by testing multiple CNNs trained from scratch or from a pre-trained model. We trained each network either from randomized initializations of weights, pre-trained and only training the classifier, and pre-training with fine tuning of all weights.

We found that the different pre-training schemes had highly variable effects depending on the affected model. On average, randomized initialization performed far better than both schemes that included pre-training.

Presenter(s): Alessandra Leong, University of Chicago
Session: ~~Oral III.F.3 (3:15)~~ CANCELLED
Title: Biophysical studies on α-Synuclein binding and its effects on inter-membrane interactions
Advisor(s): Ka Yee Lee, Chemistry, University of Chicago
Co-Author(s): Peter Chung and Luke Hwang

Abstract: α-Synuclein is implicated in numerous neurodegenerative disorders, most notably Parkinson's disease, but much of its physiological functions remain unknown. Due to its abundance within the presynaptic terminal, localization around synaptic vesicles, and purported role in synaptic vesicle fusion, it is critical to elucidate how α-Synuclein modulates

interactions between membranes. To this end, we created a robust model system, spherical-nanoparticle supported lipid bilayers (SSLBs), that mimics the biophysical characteristics of synaptic vesicles and allows for previously unrealizable measurements that characterize the protein's effects on inter-membrane interactions. SSLBs were formed by osmotically shocking vesicles onto silica nanoparticles, providing a platform for (1) the strong binding of α-Synuclein to lipid membranes and (2) sufficient monodispersity and scattering length density for synchrotron X-ray methods. Small angle X-ray scattering and X-ray photon correlation spectroscopy gave insight into how α-Synuclein alters higher-order colloidal structure and diffusion dynamics of SSLBs. We found SSLBs formed micro-aggregates, which were subsequently disrupted by the addition of α-Synuclein. This indicates that α-Synuclein exerts a repulsive potential between membranes potentially inhibiting interactions between synaptic vesicles and other membranes. Our findings present significant implications for α-Synuclein's role in synaptic vesicle recycling and its sequestration to synaptic vesicles in neuronal reserve pools.

Presenter(s): Yishen Li, Grinnell College
Session: Poster P1.09
Title: Characterization of Electrical and Magnetic Properties of Single Crystal GdNiPb
Advisor(s): Charles Cunningham, Physics, Grinnell College

Abstract: We have synthesized the intermetallic ternary compound GdNiPb in single crystal form by the flux growth method. We determined the crystal structure through x-ray diffraction and studied the temperature dependence of magnetization and resistivity from 1.8K to 350K. Our magnetization results show GdNiPb is antiferromagnetic with Néel temperature 15K, but resistivity shows loss of spin disorder scattering at a much lower temperature 3.75K.

Presenter(s): Sarah Lipstone, Macalester College
Session: Poster P2.09
Title: Electromagnetic Waves with Parity Violation
Advisor(s): Tonnis ter Veldhuis, Physics, Macalester College
Co-Author(s): Tonnis ter Veldhuis

Abstract: Axion particles have been postulated to resolve the strong CP problem in Quantum chromodynamics. The axion field may double as the inflaton field that produces cosmic inflation. In this project, we use a combination of analytical and numerical analysis to study how axion-induced parity symmetry violation affects the dynamics of electromagnetic waves.

Presenter(s): Lily Liu, University of Chicago
Session: Poster P3.09
Title: Antarctic ice geometry as possible explanation for upgoing cosmic ray showers detected by ANITA
Advisor(s): Abigail Vieregg, Department of Physics, University of Chicago

Abstract: Neutrinos are small, electrically neutral particles, so their paths can be traced back to their sources. We are interested in ultrahigh-energy neutrinos because they provide clues about ultrahigh-energy sources and their cosmological evolution. The ANtarctic Impulsive Transient Antenna (ANITA) is a balloon experiment searching for radiation showers induced when neutrinos interact in the ice. More often though, ANITA sees showers induced by cosmic

rays, whose paths cannot be traced back to their sources, that reflect off the ice and are detected as pulses with inverted polarity. On several flights of ANITA, some pulses with non-inverted polarity were observed, which could mean that these radio showers had not reflected and that particles on upgoing paths (as opposed to the downgoing paths of cosmic rays) were detected. There are several theories that attempt to explain these anomalous events, including tau-lepton decay and sterile neutrinos. However, these hypotheses contradict current EeV diffuse neutrino flux limits and neutrino-matter interaction models. Here we show that these upgoing events could have resulted from geographic irregularities, such as ice bridges and sastrugi. Using finite-difference time-domain simulation, we found that ice configurations can cause a downgoing signal to appear upgoing, providing a possible explanation for these mysterious events.

Presenter(s): Sophie Macfarland, University of Chicago
Session: Poster P1.10
Title: The Effects of Ligand Concentration on the Mechanical Properties of Nanoparticle Films
Advisor(s): Stuart Rice and Binhua Lin, Chemistry and Physics, University of Chicago
Co-Author(s): Morgan Reik, Melanie Calabro

Abstract: When dodecanethiol-ligaged gold nanopartlices are deposited on an air-water interface, they self-assemble into Langmuir films which previous experiments have shown are mechanically resilient. Their mechanical properties have been elucidated through experiments in which the films are compressed uniaxially. In these experiments, as the ligand concentration decreases the ligand-ligand and ligand-core interactions are altered such that the 2-dimensional compressive and shear moduli of the films increases. However, these experiments were largely done upon films while they were still at an air-water interface – this study focuses on films which are removed from an air-water interface and are dried. This is important, since many potential applications of these films are in electronic devices as sensors utilizing their optical and mechanical properties, but this would require the films to operate in a dry environment. This study examines how variations in the concentrations of ligands in a gold nanoparticle solution and by extension the concentration of ligands on the surface of the gold nanoparticles, impacts the mechanical properties of a dried monolayer films composed of those nanoparticles. Specifically, the Young's Moduli of the films are measured through contact-mode Atomic Force Microscopy (AFM), which demonstrates that lower thiol concentrations are conducive to higher young's moduli.

Presenter(s): Khalid Mahmood, Washington University in St. Louis
Session: Poster P2.10
Title: Synthesis of a Fluorogenic Probe and its Application in Catalysis
Advisor(s): Bryce Sadtler, Chemistry, Washington University in St. Louis

Abstract: We present a method to image variations in the activity of metal oxide photocatalysts using a fluorogenic probe. This technique enables us ultimately to measure which facets of the photocatalytic nanocrystals are most active. We employ a concise, four-step synthesis to produce the fluorogenic probe, a dinitro-boron-dipyrromethene fluorophore. As the initial product is only soluble in methanol and other polar organic solvents, a fifth step at the end can make the probe water-soluble. The advantage of the water-soluble molecule is that it has a

higher quantum yield and can more easily be used for single-particle imaging. Both versions of the fluorogenic probe can undergo a 4 proton, 4 electron reduction, whereby one of its aromatic nitro groups is reduced to a hydroxylamino group when exposed to light in the presence of a photocatalyst and methanol as a hole scavenger. By turning an electron-withdrawing group into an electron-donating group, the molecule goes from non-fluorescent to highly fluorescent. This is advantageous because we can then use the fluorogenic probe to perform single particle imaging of photocatalytic nanocrystals and analyze which facets can most easily catalyze the reduction reaction.

Presenter(s): Macy J. Maraugha, Hope College
Session: Poster P3.10
Title: Characterization of surMOF thin film properties
Advisor(s): Mary E. Anderson, Chemistry, Furman University; Elizabeth Sanford, Chemistry, Hope College
Co-Author(s): Alyssa J. VanZanten, Alexander J. Osterbaan, Ashley E. Trojniak, Mary E. Anderson

Abstract: Metal organic frameworks (MOFs) are nano-porous, crystalline materials made up of organic linkers coordinated to metal ion nodes arranged in a scaffold-like structure. The atomic architecture of MOFs enables gas storage, chemical sensing, and energy storage with potential for direct integration into devices. This research studies a range of copper-paddlewheel MOF systems fabricated using a sequential, solution-phase deposition method to form surface-anchored MOFs. A solution of organic ligands and a solution of copper ions are alternatingly exposed in rounds of deposition cycles to a gold substrate functionalized with a carboxylic acid terminated self-assembled monolayer. The optical thickness of these films was characterized by ellipsometry. To determine the physical thickness of the surMOFs, films were patterned and etched for quantitative imaging by atomic force microscopy. This involved a solvent stability study to determine the optimal etchant procedure. Nanoscale control of film thickness is obtained based on the number of deposition cycles producing films with controllable thicknesses from 4 to 40 nm. These surMOF films were found to be highly conformal with the underlying substrate. Understanding the physical properties of surMOFs is essential for incorporating these promising materials into real-world applications.

Presenter(s): Zach Martin, Luther College
Session: ~~Oral III.E.1 (2:45)~~ CANCELLED
Title: Charm meson production from bottomonium decays
Advisor(s): Todd K. Pedlar, Physics, Luther College

Abstract: Centered in Tsukuba, Japan, the Belle experiment collected a great deal of data using the KEKB particle accelerator. With access to this data, a number of interesting studies of bottomonium, in which a bottom quark is bound by the strong force to an anti-bottom quark, may be conducted. Through analysis of official continuum Monte Carlo samples at the Y(2S) energy level, and our own samples associated with the decay chain $Y(2S)\rightarrow\gamma\chi bj(1P)\rightarrow D+X$ (X any other particle) we have characterized the yield of these D mesons from the various decays of the $\chi bj(1P)$ states as a function of the energy of the photon emitted by the Y(2S). Refinement of this analysis method is integral to future analyses as we carry out an identical analysis on the true data collected by the Belle detector in an effort to better understand the strong force.

Presenter(s): Innes Maxwell, Lawrence University
Session: Oral I.B.2 (9:15)
Title: An Exploration of Exoplanet Detection and Orbit Stability
Advisor(s): Megan Pickett, Physics, Lawrence University

Abstract: Exoplanets, planets that orbit stars outside of our own solar system, are discovered frequently using a variety of methods. This project aims to measure the radial velocity of stars using specific orbital parameters in order to determine the gravitational influence of their orbiting planets. This is done using original code written in Python, which can take data for almost any system and process it to generate a radial velocity diagram. Once the planets of a system have been confirmed to exist and located, we simulate their orbits over extended periods of time to test their stability and assess the system's longevity and potential to host life. Through this research we have found a reliable way to generate accurate radial velocity graphs of stars due to their planets, as well as verified the stability and potential habitability of systems like TRAPPIST1.

Presenter(s): Ross McFarland-Porter, Beloit College
Session: Oral I.A.1 (9:00)
Title: Using graphene to study perovskite solar cells
Advisor(s): Yongli Gao, physics, University of Rochester

Abstract: The hybrid organic-inorganic perovskite material has been a subject of intense research over the past few years, as the material has been shown to have optoelectronic properties that make it a promising candidate for the active layer in a next generational solar cell. However, there are serious concerns regarding the long-term stability of this material; often times, it is difficult to discern the underlying degradation mechanisms in a device as adjacent layers encapsulate the perovskite. In order to investigate these issues, a method to transfer graphene to the perovskite layer was adapted to overcome the perovskite's reactivity. Graphene is a conductive monolayer and a strong diffusion barrier, making it possible to simulate an interface while preventing environmental exposure to perovskite. Graphene has been successfully transferred to target substrates with the adapted method including perovskite layers. However, further refinements need to be made to reduce damage to the perovskite layer before this method can be implemented for a biased interface or environmental exposure study. This project was supported by NSF award PHY-1757062 and GR528162.

Presenter(s): Mattias McMullin, Lawrence University
Session: Oral II.C.3 (11:40)
Title: Computationally Tracking Microtubules
Advisor(s): Douglas Martin, Physics, Lawrence University

Abstract: Microtubules are important for both the structure and function of cells, and one of their attributes of interest is their stiffness. This is measured by observing their fluctuations under a microscope as they are propelled by motor proteins. In order to obtain low uncertainty measurements of stiffness, a microtubule must be observed for several minutes continuously. Here we present the integration of a machine learning based microtubule tracking system with microscope hardware to track microtubules for arbitrarily long periods of time.

Presenter(s): Kathryn Mehltretter, Grinnell College
Session: Oral III.F.1 (2:45)
Title: Herbicide fate and transport in an agricultural watershed
Advisor(s): Andrew Graham, Elaine Marzluff, Chemistry, Grinnell College
Co-Author(s): Andrew Graham, Elaine Marzluff

Abstract: This study aimed to quantify atrazine and metabolite concentrations in an agricultural watershed. Atrazine, an endocrine disruptor and widely used herbicide in corn production, enters waterways through surface run-off and groundwater contamination. At the Grinnell College Conard Environmental Research Area near Kellogg, Iowa, sampling for atrazine and three of its metabolites occurred at the two water bodies, Willow Creek, which drains about 0.5 km2 of primarily agricultural land, and downstream Perry Pond. From these samples, the loads of atrazine and its metabolites entering the water bodies during June 2018 were determined. Atrazine and two of its metabolites, hydroxyatrazine (HA) and deethylatrazine (DEA), were detected in all samples with detection limits of approximately 1 ng/L. High-resolution sampling during storm events observed increases in atrazine and metabolite concentrations, with the highest increases in concentrations associated with the earliest storm events in Willow Creek in June. Atrazine concentrations declined in Perry Pond throughout the study period. The DEA to atrazine ratio increased over time, with decreases associated with high flow events. Stormwater retention ponds and engineered wetlands have been suggested as strategies for reducing nutrient run-off; the present study provides a better understanding of the fate and transports of pesticides in such systems.

Presenter(s): Katheryn Menssen, Grinnell College
Session: Poster P1.11
Title: Properties of quadratic anticommutative hypercomplex numbers.
Advisor(s): Karen Shuman, Mathematics, Grinnell College

Abstract: In this paper, I describe various properties of what I call quadratic anticommutative hypercomplex number systems. Roughly defined, hypercomplex numbers are numbers of the form $x_1 + i_1x_2 + \ldots + i_nx_{n+1}$ such that $x_1 + i_1x_2 + \ldots + i_nx_{n+1} = y_1 + i_1y_2 + \ldots + i_ny_{n+1}$ if and only if $x_j = y_j$ for all j in {1,2,…,n}. I define a quadratic anticommutative hypercomplex number system as a set of hypercomplex numbers such that $i_j^{\,2} = p_j$ for all j in {1,2,…,n} (where p_j is a real number) and $i_ki_j = - i_ji_k$ for all k and j in {1,2,…,n}, k not equal to j. These numbers have some interesting properties. In particular, in this paper I derive a coordinate system for these numbers which allows me to prove a generalized form of the Demoivre's formula for these numbers, which I use to prove a result about the roots of these numbers. In the second part of this paper, I prove some interesting results relating to differentiation on these numbers.

Presenter(s): Jessica Metzger, University of Chicago
Session: Poster P2.11
Title: A neutrinosphere model for the photometry of kilonovae
Advisor(s): James Annis, Dark Energy Survey, Fermi National Accelerator Laboratory
Co-Author(s): James Annis

Abstract: We present a unified, physically motivated model for a binary neutron star merger and the associated electromagnetic transient (the "kilonova"). First, we do an inventory of the ejecta components predicted in simulations. From this, we devise a two-component model for constructing observables. We develop a neutrinosphere model for the ejecta composition, and account for ejecta anisotropy and viewing angle effects in producing the observed lightcurves. We use this to fit the optical and infrared photometry of GW170817. In the Appendix, we also fit blackbodies to the early-time optical photometry, accounting for the blueshift of the expanding ejecta. Our temperature and velocity fits are colder and slower, respectively, than previous estimates.

Presenter(s): Charlie Moe, Gustavus Adolphus College
Session: Oral III.G.2 (3:00)
Title: Smooth, non-singular, volume-preserving dynamical systems with uniformly bounded trajectories.
Advisor(s): Jeff Ford, Mathematics, Gustavus Adolphus College

Abstract: Inspired by Greg Kuperberg's question "Does there exist a non-singular, volume preserving dynamical system on R^3 with uniformly bounded trajectories." We sought out to find such a dynamical system. Krystyna Kuperberg and Coke Reed constructed a dynamical system on R^3 with uniformly bounded trajectories, but does not preserve volume. Jeff Ford later constructed a dynamical system on R^3 that does preserve volume, but has trajectories with bounds that are not uniform. The original question remains open and it seems unlikely that modifying these constructions will give us the conditions that we need on R^3. However, these constructions can be extended into higher dimensions to give us the dynamical system that we seek. In this talk, we present our construction of a smooth, non-singular, volume preserving dynamical systems with uniformly bounded trajectories.

Presenter(s): Jose Monge Castro, Colorado College
Session: Poster P3.11
Title: Computational Modelling of Closed-Cell Bipolar Electrochemistry based Heavy-Metal Water Sensor
Advisor(s): Eli Fahrenkrug, Chemistry, Colorado College

Abstract: Bipolar Electrochemistry is an emerging and increasingly popular area of research with many potential applications. A promising technique uses what is known as "Closed-Cell" Bipolar-Electrochemistry (BPE), in which two sets of electrochemical processes are physically isolated from each other, having only an electrode allowing current flow in between. Many crucial aspects of this technique have not been studied, and further understanding of underlying aspects of Closed-Cell BPEs are needed to optimize designs and maximize usefulness of applications. Using COMSOL Multiphysics®, aspects of our heavy-metal in water

sensing prototype were modeled and studied. Current density at both BPE and electrolytes were determined, as well as the potential drop (versus adjacent reference) across parts of the system. Additionally, electrode surface change (given the deposition of a species of interest) and some of its effects were modeled. Geometrical considerations (size/shape) were also studied. Chemical processes of dilute species were additionally incorporated in the model and its impact on the design and functioning was assessed. Determinants of the position of the line of zero potential (lzp) were determined, such as relative conductivity of electrolytes and relative exposed BPE area. The model, although limited, sheds light on the main considerations when working with closed-cell BPEs.

Presenter(s): Emily Morgan, Washington University in St. Louis
Session: Poster P1.12
Title: Synthesis and Characterization of Complexes of the PicTsN4 Ligand for Carbon Dioxide and Hydrogen Reduction
Advisor(s): Liviu Mirica, Chemistry, Washington University in St. Louis
Co-Author(s): Nigam Rath, Liviu Mirica

Abstract: The electrochemical reduction of protons or carbon dioxide to produce fuels and other chemicals in a sustainable manner has been an area of intense focus in inorganic chemistry for several years, but further research is required to produce catalysts that can perform these reactions efficiently. Our group has synthesized and characterized new transition metal complexes of the ligand PicTsN4 (N-(tosyl)-N'-(2-methylpyridine)-2,11-diaza[3,3](2,6) pyridinophane). The structural and electrochemical properties of these metal complexes have been studied via techniques such as NMR, EPR, X-ray crystallography, and cyclic voltammetry in order to determine their potential for carbon dioxide and proton reduction. Complexes of Ni(II), Pd(II), and Cu(II) show the most promise for the reduction of carbon dioxide or protons, and future investigations will include an examination of the products and efficiency of these processes.

Presenter(s): Anusree Natraj, Washington University in St. Louis
Session: Oral III.F.3 (3:15)
Title: Synthesis of Sequence-Defined Redox Responsive Polyviologens
Advisor(s): Jonathan Barnes, Chemistry, Washington University in St. Louis

Abstract: Viologens are electroactive 1,1′-dialkyl-4,4′-bipyridiniums that can exist in three oxidation states. When multiple viologen units are chemically linked, a polyviologen, i.e. a polymer of viologen units, is formed. Polyviologens are useful in engineering artificial molecular muscles, which range from nanometer-sized to larger systems, and can be controlled by external stimuli such as light or chemical oxidation / reduction. Previously, our group used polar, hydrophilic hexaethylene glycol subunits to chemically link the viologen subunits. The goal of my project is to instead use aliphatic hexamethylene linkers to investigate structure-property-performance relationships in the sequence-defined polyviologens since they will be more crystalline. Extensive screening has allowed the reaction conditions to be optimized for the first three steps of the polyviologen synthesis. These reaction conditions will then be applied to the

remaining steps. The end goal is to scale the synthesis, introduce branching in the polyviologen chains (using aryl linkers), and finally incorporate the polyviologens into hydrogel or organogel systems to study their thermal properties and performance as actuators and potential artificial molecular muscles.

Presenter(s): Henos Negash, Colorado College
Session: Poster P2.12
Title: Synthesis of dicarbonyl compounds and their reactivity with benzyne
Advisor(s): Jessica Kisunzu, Chemistry and Biochemistry, Colorado College
Co-Author(s): Simone D. Hall, Katie M. Thompson & Jessica Kisunzu

Abstract: O-benzynes have been used as a synthetic source of carbons due to their highly reactive nature caused by their bond strains. In past research, o-benzynes have been used as a starting material along with a variety of substituted dicarbonyl compounds to yield substituted aromatics. Taking advantage of o-benzyne's reactivity, this research sought to determine whether various sulfur and nitrogen-containing dicarbonyl compounds will react with a benzyne precursor to form the expected products via an elimination-addition reaction under mild conditions. We present preliminary data that quantitatively investigates the conditions needed for this reaction to produce the expected products. The analytical analysis supports that we synthesized three new products, but more analytical analysis will need to be conducted for further characterization.

Presenter(s): Marta Nowotka, Colorado College
Session: Poster P3.12
Title: Multiwavelength search for a low mass X-ray binary in the open cluster NGC 6819
Advisor(s): Natalie Gosnell, Physics, Colorado College
Co-Author(s): Thom Ory, Rory Lowe, Natalie Gosnell

Abstract: The focus of this study is a low mass X-ray binary (LMXB) candidate in the open cluster NGC 6819. LMXBs are binary systems of a low-mass star and a neutron star supernova remnant, luminous in X-rays due to the transfer of mass between the objects. LMXBs are found in excess in globular clusters, where the cluster is massive enough to retain neutron stars despite their high velocities due to its supernova explosion. Theoretical models prohibit the existence of LMXBs in the sparse stellar environments of open clusters, as the neutron star velocities are expected to exceed the escape velocities of open clusters. The presence of an LMXB in an open cluster can provide an observational evidence for alternative supernovae formation scenarios characterized by smaller velocities of the remnants, such as electron-capture supernova, accretion induced collapse, or the merger of two massive white dwarfs. This study aims to confirm the presence of an LMXB in NGC 6819 through determining its optical counterpart, achieved by cross-matching neighboring X-ray sources with optical sources and therefore improving the positional uncertainty of the LMXB candidate. We present photometric and H-alpha analysis of the cluster, the first step toward accurate source cross-correlation.

Presenter(s): Madelyn Orndorff, Hope College
Session: Poster P3.13
Title: Morphological differences in electropolymerized EDOT films
Advisor(s): Elizabeth M. Sanford, Chemistry, Hope College
Co-Author(s): Elizabeth M. Sanford, Mary E. Anderson, Kenneth L. Brown

Abstract: Polyethylenedioxythiophene (PEDOT) can be formed from the electropolymerization of ethylene dioxythiophene (EDOT) to form films with good mechanical stability, and excellent electronic and optical properties for a variety of applications including electrochemical sensors. A study was designed to examine how the properties of a functionalized EDOT monomer affect the morphology of a electrochemically formed film. Five EDOT monomers were prepared for this study and then electrochemically polymerized using cyclic voltammetry (CV) on indium tin oxide (ITO) glass. The surface morphology of the resulting films was analyzed using scanning electron microscopy (SEM) and compared to PEDOT films. The effects of differing the number of polymerization cycles, the potential window for CV, and solvent on surface morphology were studied as well. Significant differences in film morphology were observed for all variables.

Presenter(s): Celisha Oscar, Knox College
Session: Poster P2.13
Title: Synthesis and characterization of liquid crystalline properties for mixtures of heteroleptic copper (II) carboxylate dimers
Advisor(s): Thomas Clayton, Chemistry, Knox College
Co-Author(s): Thomas Clayton

Abstract: Previous work in the Clayton group has utilized ligand exchange of labile carboxylate ligands to produce heteroleptic (mixed ligand) carboxylate complexes of copper (II) dimers. Notably, both monosubstituted ($Cu(O_2CR)(O_2CR')_3$), and disubstituted ($Cu_2(O_2CR)_2(O_2CR')_2$) complexes have been synthesized and characterized by elemental analysis. Generally, heteroleptic copper (II) carboxylate complexes exhibit enhanced liquid crystalline properties such as lower melting points and larger ranges of thermal stability by comparison with related homoleptic dimers ($Cu_2(O_2CR)_4$). In this project we report the use of stoichiometry to intentionally produce mixtures containing both monosubstituted and disubstituted copper (II) carboxylate dimers. All products were characterized by FT-IR spectroscopy, melting point, polarized optical microscopy (POM), differential scanning calorimetry (DSC), and elemental analysis.

Presenter(s): Jonathan Palmer, Beloit College
Session: Poster P1.13
Title: Analysis of Omega-3 Fatty Acids in Fish Oil Dietary Supplements with ATR-FTIR Spectroscopy
Advisor(s): Rongping Deng, Chemistry Department, Beloit College
Co-Author(s): Xi Ren

Abstract: The current method of quality assessment surrounding the ever-growing dietary fish oil market, gas chromatography (GC), requires large amounts of time, money, and expertise, all the while generating waste. Using infrared (IR) spectroscopy and quantum chemistry, we can attempt to predict the quality of fish oils and offer an alternative quality assessment tool that is a rapid-response, non-destructive, cost-friendly, and easy to operate. Quality controls

for the dietary fish oil market regulate the amount of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), two omega-3 fatty acids (FAs) beneficial to cardiovascular health. These two FAs are identifiable by their chain length and degree of unsaturation and generate unique IR spectral features. These characteristics and their corresponding IR signatures can be exploited to develop a relationship between the spectral feature and the molecular structure. Identifying and assigning the key IR bands from fatty acid standards of varying chain length and degree of unsaturation allows us to create a model with which to predict the content of more complex mixtures of fatty acids. In turn, this model can be used to find the content of EPA and DHA, and to an extent, serve as an alternative quality assessment.

Presenter(s): Saugat Pandey, Beloit College
Session: Poster P1.14
Title: Graphs from the Sum of Divisors Function
Advisor(s): Darrah Chavey, Computer Science, Beloit College
Co-Author(s): Darrah Chavey, Christian Fares

Abstract: The project investigates what happens when we construct a graph from one number to the sum of its proper divisor. For example, the number 10 is connected to 8, the sum of its proper divisors (excluding the number itself); 8 then has an edge to 7; 7 is connected to 1. If we look into the range of numbers from 1 to 10, this would give various disconnected graphs, including the path 10 → 8 → 7→ 1 of edge 3. Our research was about finding the small directed graphs as this 'sum of proper divisors' (aliquot graph) for various ranges of numbers. I worked on creating a graphical user interface to show graphs of various edges based on the ranges inputted by the users. Along the way, we were able to find 18 graphs with 5 edges out of 21. If we had kept the system running for a longer period of time, we would have been able to find all the 21 graphs with 5 edges.

Presenter(s): Aldo Panfichi Sanborn, University of Chicago
Session: Oral I.B.3 (9:30)
Title: Smoothed Particle Interference Analysis of DEM L71
Advisor(s): Vikram Dwarkadas, Astronomy and Astrophysics, University of Chicago
Co-Author(s): Kari Frank, Vikram Dwarkadas, Ryan Crum, David N. Burrows

Abstract: Supernova remnants (SNRs) are complex, 3D objects; properly accounting for this complexity when modeling the resulting X-ray emission presents quite a challenge and makes it difficult to accurately characterize the properties of the full SNR volume. We have developed a novel analysis method, Smoothed Particle Inference, that can be used to study and characterize the structure, dynamics, morphology, kinematics, and abundances within the remnant. In this poster we apply the method to the Type Ia supernova remnant DEM L71. We present histograms and maps showing various global properties of the remnant, such as temperature, elemental abundances, and ionization age. Our analysis confirms the high abundance of Fe within the ejecta of the supernova, which has led to it being typed as a Ia. We find that despite its regular appearance, the temperature and other parameter maps exhibit highly irregular substructure which is not captured with typical X-ray analysis methods.

Presenter(s): Dona Pantova, Macalester College
Session: Poster P2.14
Title: There's more than one way to cancel a regularized Stokeslet
Advisor(s): William Mitchell, Mathematics, Statistics and Computer Science, Macalester College

Abstract: Flows in highly viscous fluids, or on very small scales, are governed by the Stokes limit of the Navier-Stokes system of partial differential equations. The linearity of the Stokes system permits the use of Green's functions such as the Stokeslet, which is an idealization of the flow induced by the motion of a very small, very fast bubble. We obtain regularized versions of the Stokeslet as well as the point source, rotlet, and stresslet in a semi-infinite fluid bounded by a rigid planar barrier. We do this by using the method of images following a reflection formula first given by H.A. Lorentz more than a century ago. Our formulas are not identical to those given by Ainley and Cortez, so we compare the two versions by integrating the PDE errors over the half-space fluid domain. For both versions the error is small when the regularized delta function is highly concentrated around the location of the singularity, but for more spread-out delta functions our formulas have smaller error. Our new regularized Stokes systems may be useful in developing more efficient computational methods for micro-scale flows, e.g. in boundary integral or immersed boundary solvers.

Presenter(s): Mik Patel, Lawrence University
Session: Oral I.A.4 (9:45)
Title: Exploring the potential of doublet state emission from a stable, luminescent, organic radical
Advisor(s): Graham Sazama, Chemistry, Lawrence University

Abstract: BDPA, α,γ-bisdiphenylene-β-phenylallyl. is a stable, radical and anthracene is a luminescent molecule. These two molecules are being combined to create a stable, luminescent, radical called BDAA, α,γ-bisdiphenylene-β-anthracenylallyl, in order to study ground-state, doublet, photophysics. Research in this field could lead to the possibility of creating more efficient and more powerful OLED devices.

Presenter(s): Jacob Pierce, University of Chicago
Session: Oral III.E.3 (3:15)
Title: Precision Calibration of Double-Sided Strip Detectors: Decoupling Source and Detector Losses
Advisor(s): Guy Savard, Physics, University of Chicago
Co-Author(s): Mary Burkey, Louis Varriano, Guy Savard

Abstract: Precision calibration of silicon detectors for energy measurement of alpha particles requires correction for a number of interactions experienced by the incident particles prior to charge collection. These losses include two effects dependent on the penetration angle of incoming particles: losses due to calibration source thickness (~5 keV for precision sources), as well as losses in the detector front contact known as the "detector dead-layer" (~15 keV for a 100 nm dead-layer at typical alpha decay energies). These effects are critical to consider if radioactive sources are used to calibrate energy of decaying trapped ions because the latter

experience the dead-layer loss but not the source loss. In this work, we demonstrate a self-consistent approach to decoupling the source and detector losses for double-sided silicon strip detectors (DSSDs) which, once estimated, may be used in future calibrations using the same sources and detectors.

Presenter(s): Maddie Klein, Kyla Pohl, St. Olaf College
Session: Poster P3.14
Title: Automorphism Orbits of some Metacyclic Groups
Advisor(s): Jill Dietz, Mathematics, Statistics, and Computer Science, St. Olaf College
Co-Author(s): Jill Dietz, Sam Nycklemoe

Abstract: The automorphism group, Aut(G), of a group G acts naturally on the group as do subgroups of Aut(G). We study these actions for a particular family of metacyclic p-groups, P_m, where p is prime. We determine the members of each orbit of P_m under the action of Aut(P_m), and count the number of distinct orbits. Each orbit partitions into n orbits under the action of the unique p-Sylow subgroup of Aut(P_m), where n divides the index of Syl_p(Aut(P_m)) in Aut(P_m). Finally, we not only compute n in each case, but determine the members of each “Sylow orbit.”

Presenter(s): Ellen Purdy, University of Chicago
Session: Poster P3.15
Title: Destruction of organophosphates via laser ablation
Advisor(s): Steven Sibener, Chemistry, University of Chicago

Abstract: This research explores the destruction of organophosphates via rapid laser heating under atmospheric conditions. Some organophosphate compounds are representative simulants of the nerve gases Soman and Sarin, and an understanding of their reactivity is relevant to the destruction of chemical warfare agents. Simulants including diisopropyl methylphosphate (DIMP), tributyl phosphate (TBP), and trioctyl phosphate (TOP) were deposited on a graphite crystal and ablated at surface temperatures ranging from 1600 to 3100 K using an Nd:YAG infrared laser. Gaseous products present after ablation were analyzed using fourier-transform infrared spectroscopy (FTIR). The results of this analysis indicate breakage and fragmentation of the alkyl chains; alkenes, alkynes, carbon monoxide, and carbon dioxide were observed. Oxygenated products were not observed. This suggests that decomposition proceeds by cleavage of the O-C bond followed by further fragmentation and substitution of carbon chains, particularly at higher surface temperatures. The distribution of products was found to be highly dependent on alkyl chain size and surface temperature. This research adds to the understanding of reactivity and decomposition pathways, with important applications in destruction of nerve agents by combustion and pyrolysis.

Presenter(s): Reshma Rajan, Knox College
Session: Poster P2.15
Title: Computational analysis of iron dibromide precatalysts supported by bidentate alpha diimine and bis(imino)acenaphthene ligands
Advisor(s): Helen M. Hoyt, Chemistry, Knox College

Abstract: Recently, we reported that in situ reduction of dppBIANFeBr_2 and dppDIFeBr_2 (dpp = 2,6-diisopropylphenyl; BIAN = bis(imino)acenaphthene; DI = N=C(Me)-(Me)C=N) demonstrated nearly quantitative yields for the catalytic hydrosilylation of 1-hexene, while other substituted BIAN and DI ligand backbones provided lower yields. To investigate the factors responsible for reactivity trends, density functional theory (DFT) calculations were performed at the B3LYP level of theory on an expanded series of iron dibromide precatalysts. Geometry optimization, Mössbauer spectroscopy, and numerical frequency computations have been performed for select precatalysts. Where possible, computed values were compared to experimental values, such as Mössbauer isomer shifts or parameters determined by X-ray crystallography. Previous calculations have shown that high spin Fe(II) supported by a redox-innocent ligand is the best electronic structure description for these compounds. Generally, trends show that racemic isomers have higher computed isomer shifts than their corresponding meso isomers. In addition, for compounds with analogous aryl substitution, those with a BIAN backbone tend to have higher computed isomer shifts than those with a DI backbone. Ongoing work includes exploring different basis sets in order to give insight on better computational methods for those computational results that do not yet explain experimental data with current methods.

Presenter(s): Michael Regotti, Carthage College
Session: Poster P1.15
Title: Development of Undergraduate Organic Laboratories Using FastWoRX-M
Advisor(s): David Brownholland, Chemistry,
Co-Author(s): David Brownholland

Abstract: FastWoRX-M was used in place of liquid extraction for the reduction of 9-fluorenone to 9-fluorenol, a classic second-semester introductory organic chemistry experiment. FastWoRX-M is an absorption powder made by coating a magnetic, inert substrate with a hydrophobic polymer. This polymer coating offers a non-specific affinity for absorbing organic molecules, allowing extraction of organic reagents after aqueous work-up. FastWoRX-M accelerates the reaction work-up and reduces solvent use. Percent yields ranging from 23-75% and melting points matching literature values of the product, 9-fluorenol, achieved from this modified reduction reaction demonstrates that FastWoRX-M is a valid alternative to traditional liquid extractions and may facilitate more efficient experiments in organic chemistry laboratories. Furthermore, FastWoRX-M was successfully recycled up to 10 times with good results. This experiment will be piloted by Carthage College organic chemistry laboratories in the spring of 2019 and the results of the students using FastWoRX-M will be compared to those using traditional liquid-liquid extraction. Student's understanding of extractions, polarity, solubility, and miscibility will be assessed between the two groups. FastWoRX-M is proposed as an alternative method of extraction in undergraduate organic labs in order to use laboratory time more efficiently and enable more chemistry or more discussion in the lab course.

Presenter(s): Morgan Reik, University of Chicago
Session: Poster P1.16
Title: The influence of fractional surface coverage on core-core separation in monolayers of thiol-ligated gold nanoparticles
Advisor(s): Stuart Rice, Binhua Lin, Department of Chemistry, Department of Physics (respectively), The University of Chicago
Co-Author(s): Sophie Macfarland, Melanie Calabro

Abstract: The way in which thiol-ligated gold nanoparticles self-assemble into long-range ordered two-dimensional Langmuir monolayers when deposited on a liquid or solid surface is contingent on the length of the thiol chain and its concentration in solution. Several studies of the influence of ligand length and composition on the nanoparticle-nanoparticle pair interaction and on the properties of nanoparticle films have been reported. However, the understanding of the molecular and structural origins of these properties is incomplete, particularly when it comes to examining the number of thiol molecules on the nanoparticle surface. It has been conventional to assume that the concentration of ligands in solution, within the range typical for nanoparticle syntheses, always generates the maximum possible surface packing on the nanoparticle core. We demonstrate through Grazing Incidence X-Ray Diffraction (GIXD) and Transmission Electron Microscopy (TEM) that the nanoparticle-nanoparticle separation and correlation length of these films increases linearly with thiol concentration in the parent solution, indicating that the bulk thiol is in equilibrium with the thiol on the core surface. Our findings thereby challenge the assumption that the free energy of binding of an alkanethiol to a gold nanoparticle is so large that its surface is consistently saturated with ligands.

Presenter(s): Xi Ren, Beloit College
Session: Poster P2.16
Title: Characterization of Fatty Acids by ATR-FTIR spectroscopy and 2-D Correlation Analysis
Advisor(s): Rongping Deng (PhD), Chemistry and Physics Department, Beloit College

Abstract: FTIR spectroscopy is a convenient analytical method for quantitative and qualitative chemical analysis. This method has a test procedure of non-sample destruction, fast process, no extra chemical waste and less labor intensive. The method can be easily used by many people in chemical analysis. However, the instrument resolution limit makes it difficult to characterize samples with certain chemical mixtures. In this research, I am interested in using 2-dimensional correlation analysis to improve the spectral resolution and develop a method to characterize the unsaturated fatty acids in dietary fish oil supplements.

Presenter(s): Andrew Reuter, St. Olaf College
Session: Poster P3.16
Title: En route to the synthesis of a tetradentate ligand: optimization of the first step
Advisor(s): Elodie Marlier, Chemistry, St Olaf College
Co-Author(s): Samuel Brunclik, Alexander Mench, Chris Seong, Melanie Nevins

Abstract: In an effort to develop new catalysts for industrial purposes, a new family of tetradentate ligands has been designed with a β-diketiminate backbone and pendant phosphine donors. The ligand synthesis is a two-step process where each step must be optimized to maximize yields and purity. In the first step, two equivalences of a 2-bromoaniline derivative are condensed onto 2-(4-tolyl)-malondialdehyde to afford the dibromo ligand

precursor. The products of the reaction have been characterized using electrospray ionization mass spectrometry (ESI-MS), 1H and 13C nuclear magnetic resonance spectroscopy (NMR). Optimization studies for the first step have focused on the impact of changing the R group on the bromoaniline, the addition of an acid catalyst, the use of a dean stark trap and the length of the reaction time.

Presenter(s): Jillian Rix, Grinnell College
Session: Oral I.A.3 (9:30)
Title: Effects of Spark Plasma Sintering on the Microstructure of Thermoelectric Materials
Advisor(s): Vinayak Dravid, Materials Science and Engineering, Northwestern University

Abstract: Thermoelectric devices represent a promising method of generating renewable electricity by recruiting heat that might otherwise be wasted. To this end, spark plasma sintering (SPS) is a popular method of fabricating stable, dense materials from a powder, and is effective in producing robust thermoelectric materials on a short time scale. We employ scanning electron microscopy, energy dispersive spectroscopy and secondary ion mass spectrometry to analyze PbTe-based thermoelectric samples produced with varying SPS parameters to understand how material microstructure changes during the SPS process. We find that although SPS increases material density and durability, the process also produces definite microstructure morphology changes with the potential to significantly alter thermoelectric properties.

Presenter(s): Andrea Salazar, University of Chicago
Session: Oral I.B.4 (9:45)
Title: Testing for Climate Limit Cycles on Tidally Locked Planets
Advisor(s): Dorian Abbot, Department of Geophysical Sciences, University of Chicago

Abstract: In the search for potentially habitable exoplanets, M-dwarf systems are particularly promising due to their abundance in the galaxy. Planets orbiting these stars are likely tidally locked in 1:1 spin orbit states. This paper will examine the effects of negative carbon-silicate feedback on the climate of these tidally locked planets. Recent work has shown that Earth-like planets in the outer regions of the habitable zone may experience unstable climates that enter limit cycles between temperate and glaciated states. Concurrently, it has been shown that tidally locked planets are unlikely to experience a bifurcation as they transition from a temperate to a glaciated state, which could inhibit these limit cycles. In this paper we run PlaSim, an intermediate-complexity global climate model (GCM), coupled to a carbon cycle model for tidally locked planets. We test for limit cycles at various levels of insolation and CO2 outgassing flux. This work is important because climate limit cycles would likely limit a planet's potential for complex life.

Presenter(s): Erik Schoonover, Hope College
Session: Oral III.F.2 (3:00)
Title: Varied Approaches to Examine the Reaction Mechanism of a Rhodium-Catalyzed Decarbonylation of Pyridyl Ketones
Advisor(s): Jeffrey Johnson, Chemistry, Hope College
Co-Author(s): Greg J. Campbell, Cole J. Wagner, Eric P. Weeda, Jacob H. Jansen, Katherine M. Reed

Abstract: Reaction pathways can be complicated and difficult to understand in transition metal catalysis reactions. An understanding of reaction intermediates and pathways can provide information allowing one to functionalize molecules for more efficient synthesis. Previous work has shown that pyridyl ketones undergo rhodium-catalyzed carbon-carbon bond activation and decarbonylation. In the hope of avoiding decarbonylation and to allow for alternative functionalization across the carbon-carbon bond, work is underway to examine the mechanism of this reaction. Current methods to understand the mechanism include rate analysis utilizing nuclear magnetic resonance (NMR) spectroscopy, in situ Fourier transform infrared (FTIR) spectroscopy, and competition reactions between various substituted pyridyl ketones. A variety of pyridyl ketones and reaction conditions are also currently being explored to optimize the decarbonylation reaction.

Presenter(s): William Setterberg, Macalester College
Session: Poster P1.17
Title: Making and analyzing lead-halide Perovskite solar cells
Advisor(s): James Heyman, Physics, Macalester

Abstract: Lead-halide Perovskite solar cells are a relatively new solar technology with great potential. The cells can be manufactured quickly and inexpensively and for the most part in an air environment; they have exhibited power conversion efficiencies of above 20%. In this project, we manufactured methylammonium lead triiodide/chloride Perovskite cells in an inverted ITO/PEDOT:PSS/Perovskite/PCBM/CaAl structure. We utilized spin coating to deposit the organic layers, and a single-solution deposition technique for the Perovskite layer. We used a high-vacuum evaporator to deposit the metal contacts. We achieved a maximum efficiency of 8% measured under a tungsten halogen lamp (I = 1440 W/m^2). Additionally, we measured our working cells under a solar simulator of unknown intensity using a voltage sweep apparatus, wherein the working cells exhibited good diode characteristics. Our working cell yield was about 20%, and we hypothesize the density and relative size of Perovskite crystallites has an impact on solar cell performance and functionality. We were able to control the Perovskite crystallite density for some cells by ensuring the uniformity of the PEDOT:PSS hole-transport layer; these cells performed better than previous cells even with the rest of the process unchanged.

Presenter(s): Thomas Shannon, Carthage College
Session: Poster P2.17
Title: Generative Design Using A Bi-directional Evolutionary Structural Optimization (BESO) Topology Method
Advisor(s): Brant Carlson, Physics, Carthage College

Abstract: Topology optimization is a mathematical method that optimizes material layout within a given design space, for a set of loads, boundary conditions and constraints with the goal of maximizing performance of the system. Advancements in topology optimization methodologies, such as the bi-directional evolutionary structural optimization (BESO) method make it possible for 3D CAD designs to be optimized for structural and thermal purposes based on initial user specification. In order to make topology optimization available to the future engineers of tomorrow, we describe the development of improvements to an open source topology optimization framework, including but not limited to: a BESO method, graphical visualization of structural and thermal loads, design domain animations, and a smoothing method that makes designs suitable for additive manufacturing.

Presenter(s): Zhiheng Sheng, Grinnell College
Session: Poster P3.17
Title: PyBoard lock-in amplifier for lake water optics
Advisor(s): Joshua Weber, Physics, Grinnell College
Co-Author(s): Calvin Tang, Andreas Velten, Joshua Weber

Abstract: As a part of the development of a remote algae detection system, our project aims to construct a measurement device for optical properties of lake water. We utilize a digital lock-in amplifier (LIA) programmed on a PyBoard microcontroller to achieve higher signal-to-noise ratios than simple amplifiers. A modulated LED is placed underwater and a photodiode is placed above water to detect the signal, which is then analyzed by the PyBoard LIA. Our device is a low-cost and portable alternative to the commercially available LIA, while the results are still comparable to the commercial version. Preliminary testing shows that the PyBoard LIA has a bandwidth of 20Hz when modulated at 1000Hz and can still reliably detect a signal at our target distance of 15m in air.

Presenter(s): Dmitry Shribak, University of Chicago
Session: Poster P1.18
Title: Development of Software Defined Radio Protocol for Acoustic Communication on Pipes
Advisor(s): Alexander Heiftez, Nuclear Engineering, Argonne National Lab (Phd from Northwestern)
Co-Author(s): Xin Huang, Alexander Heifetz

Abstract: Nuclear Engineering Division at Argonne has been developing a novel method of transmitting information via acoustic waves on pipes in a nuclear facility. This method provides the capability to communicate information from within the containment building under the conditions of total power outage following a severe accident. Transmission of images is most challenging because corruption of the header string might render the reconstructed image unreadable.

We used the Software Defined Radio tool GNURadio, which allowed us to build a communication protocol with different modulation and front error correction techniques. The

goal of this task was to successfully transmit the header file of a .ppm (Portable Pixel Map) image because any corruption in this data destroys the image.

Our results show that passing the square wave through the communication channel leads to higher noise around the DC offset as well as a more jagged frequency response from the square wave. In order to further improve the system, we would have to lock the phase after the information is received from the Red Pitaya, as well as develop a system that helps reduce the number of samples the system needs to pass through the active gain loop before becoming decodable.

Presenter(s): Vicky (Haowen) Su, Washington University in St. Louis
Session: Poster P2.18
Title: Nesquehonite Characterization Using NMR Crystallography
Advisor(s): Sophia Hayes, Chemistry, Washington University in St. Louis

Abstract: Carbon dioxide (CO_2) emission has been one of the most concerning issues over the century. It has been blamed as the cause of various environmental problems including global warming and acidification of the oceans. Three main strategies are available to control the amount of CO_2 emission: replacement of fossil fuels with renewable energy source, improvement of energy efficiency and CO_2 sequestration. As one product of sequestration of CO_2 in nature, the understanding of chemical formula and crystal structure of nesquehonite is crucial for the thermodynamics and investigation of CO_2 sequestration process for future study in the field of energy and environment. Over the past century, the arguments about chemical formulas between [$MgCO_3$•$3H_2O$] and [$Mg(OH)(HCO_3)$•$2H_2O$] has been in suspense due to the lack of precise measurement and innovative techniques. In our study, a combination of X-ray diffraction, Nuclear Magnetic Resonance (Rotation-Echo Double-Resonance), and Density Functional Theory computation, was applied in this research to confirm the chemical formula of nesquehonite as [$MgCO_3$•$3H_2O$]. Furthermore, the accurate evaluation of the positions of multiple protons in nesquehonite demonstrates the potential of applying this research methodology in similar studies of minerals.

Presenter(s): Tiffany Suwatthee, University of Chicago
Session: Poster P3.18
Title: Probing the Sensitivity to Membrane Fluidity of the Binding of Milk Fat Globule EGF Factor 8
Advisor(s): Ka Yee C. Lee, Chemistry, University of Chicago

Abstract: Milk fat globule EGF factor 8 (MFG-E8) belongs to a class of proteins that identify and bind phosphatidylserine (PS) containing membranes. These proteins detect membrane dysregulation, which is implicated in exposed PS in apoptosis and malignant cells. MFG-E8 is involved in several cellular functions including blood coagulation, cell fusion, and clearance of apoptotic cells by targeting exposed PS on membranes. In order to study PS binding, we used a model system of a series of large unilamellar vesicles of di-unsaturated and monounsaturated lipids to identify the sensitivity of the binding affinity of MFG-E8 to changes in membrane fluidity using a tryptophan fluorescence spectral shift assay. MFG-E8's interactions with lipid membranes under different conditions offer insight into the mechanism of MFG-E8's sensitivity to electrostatics and packing properties of lipid membranes. We find that MFG-E8 has a

stronger binding affinity with tightly packed membranes with monounsaturated lipids rather than di-unsaturated lipids. However, typical degenerative cells have fluid membranes such as those with di-unsaturated lipids rather than monounsaturated lipids, and therefore, MFG-E8 may uniquely prefer PS-exposing non-apoptotic-like membranes. This understanding allows the creation of similar membrane binding proteins that target specific membrane fluidity, which can be used in drug delivery or other processes.

Presenter(s): Aaron Swanson, St. Olaf College
Session: Oral III.E.1 (2:45)
Title: (Delocalized) Baryons in Large Nc QCD with Heavy Quarks in d+1 dimensions
Advisor(s): Prabal Adhikari, Physics, St. Olaf College

Abstract: We study baryons with heavy quarks in the ‘t Hooft large Nc limit in arbitrary d+1 dimensions. The limit allows for Witten’s mean-field picture, where each quark interacts in a mean-field potential (due to the Nc – 1 other quarks), which is a color Coulomb potential. Surprisingly, the characteristic size diverges for 4+1 dimensions, meaning that the Coulomb potentials in four spatial dimensions is not strong enough to localize the Nc quarks into a single baryon. However, in all other dimensions, baryons are localized with a width that decreases with the quark mass and the strong coupling constant. We characterize the nature of the potential in d+1 dimensions, with a particular focus on the 2+1 dimensional theory since non-abelian gauge theories (relevant for gluons) have a richer gauge structure. This additional gauge structure is known as Chern-Simons and modifies the 2+1 color Coulomb potential such that it becomes a 2+1 dimension Yukawa-type potential. As an aside, we find that in even dimensions the Yukawa potential, which in 3+1 dimensions is a 1/r times an exponential, is actually a Bessel function of the second kind in even spatial dimensions.

Presenter(s): Winifred Waters, Lawrence University
Session: Poster P1.19
Title: Design, Synthesis, and Characterization of Diarylquinoxalines
Advisor(s): Stefan L. Debbert, Chemistry, Lawrence University

Abstract: Schistosoma mansoni is a parasitic worm that is transmitted to humans through infected bodies of water. Currently, there is only one drug, praziquantel, that is being used to treat schistosomiasis, which causes concerns about drug resistance.

This research is focused on the design new diarylquinoxaline compounds that may have anti-schistosomiasis activity. To make these compounds, Buchwald-Hartwig conditions, using a palladium source and a sterically demanding ligand in an air-free environment, have been adapted. This protocol has succeeded to produce one diarylquinoxaline analog, and the reaction conditions are currently being optimized to improve the yield of the reaction.

Presenter(s): Marie Wesson, University of Chicago
Session: Poster P2.19
Title: Optical collection enhancement from spin defects in silicon carbide using anti-reflective coatings
Advisor(s): David Awschalom, Institute for Molecular Engineering, University of Chicago

Abstract: Silicon carbide is becoming an increasingly important material host in the fields of quantum sensing and quantum information science with defect spins. Optically-active point defects in SiC, such as the silicon vacancy and divacancy, contain ground state electron spins with long spin coherence times. It has been shown that the divacancy contains a high-fidelity spin-photon interface, compatible with remote entanglement protocols. Due to a large index of refraction mismatch between SiC (~2.6) and air, the majority of photons emitted from the point-defects are lost due to total internal reflection and Fresnel reflection. Here, we show the fabrication and characterization of anti-reflection coatings on SiC for enhancing the optical readout of single divacancy defects. By growing thin film dielectrics using plasma enhanced chemical vapor deposition (PECVD) on the surface of SiC, we can reduce the reflectance to < 1% in a 400 nm wide band surrounding the wavelengths for divacancy optical transitions. Additionally, using computational techniques including particle swarm optimization, we can design customizable optical bandstop filters also with thin film dielectrics grown by PECVD. These techniques can eventually be combined with solid immersion lenses to provide further optical enhancements and low noise optical filtering of divacancy defects directly on-chip.

Presenter(s): Lu Xian, Macalester College
Session: Poster P3.19
Title: Using Order Parameters and Persistent Homology to Analyze Biological Aggregations
Advisor(s): Lori Ziegelmeier, Math, Computer Science, and Statistics Department, Macalester College
Co-Author(s): Maitrayee Deka

Abstract: In this project, we explore the dynamics of biological aggregations which are groups of organisms, such as fish schools, bird flocks, and insect swarms, formed through social interaction and coordinated behaviors like attraction, repulsion, and/or alignment. We aim to classify by parameter numerical simulations generated from the highly-cited Vicsek model using both topology and the classic alignment order parameter. The topology approach computes the persistent homology at all time values of a simulation and summarizes this information as a crocker plot. The order parameter approach computes the normalized average of the velocity (that is, the alignment), producing a time series of the simulation. The outputs of both approaches for every simulation are input as feature vectors to machine learning clustering algorithms. We show that clustering with topology yields better results than clustering with order parameter and therefore, topology can be used as a reasonable means for parameter identification.

Presenter(s): Royce Yang, University of Chicago
Session: Poster P1.20
Title: DTRA: Computer Vision Data Generation with Weak Supervision
Advisor(s): Xiuzhong Wang, Midea Group RAC Research and Development

Abstract: At the heart of all computer vision research and development today lies a core, ubiquitous problem: the lack of a specialized training database that meet the standards of modern-day quality and quantity. Amazon Mechanical Turk arises as an economical solution, utilizing cheap labor via crowdsourcing. However, it still relies upon intensive labor and requires long turnaround. This project proposes a method named DTRA (Detection, Tracking, Reverse Tracking, and Augmentation) to reduce the need for user intervention by making use of continuity in video data. By integrating state-of-the-art methods, DTRA is able to auto-generate data suitable for the demands of modern R&D. The flowchart is as follows: Initially, DTRA makes use of Darknet's YOLOv3 for object detection and initialization. These detections then serve as checkpoints for background aware correlation filter (BACF) object tracking, which considers changes both in the foreground and background over time. Considering challenging scenarios, DTRA introduces merged-data reverse tracking to retrace object paths in reverse. Lastly, DTRA utilizes data augmentation methods to generate data with desired variability in respect to brightness, color, and angle, leading to much richer training data. Our experiments show that DTRA compares favorably against state-of-the-art data generation methods, producing low-cost yet competitive results.

Presenter(s): Momin Zahid, Knox College
Session: Poster P2.20
Title: Developing a centralized resource on teaching computing to K-12 students and educators
Advisor(s): Monica McGill, Computer Science, Knox College

Abstract: Computer Science Education Research (CSED) is a centralized repository which provides access to research backed activities for teaching Computer Science to learners in Kindergarten-12th Grade, and for the professional development of teachers. The website, http://csedresearch.org, is designed to also allow educators and researchers to explore the effectiveness of different CS-related activities. This can be done with research articles and evaluation instruments.

For research articles, a search box is provided for someone looking for something very specific, and a filter is provided to sort results based on numerous identifiers such as focus area, student and instructor demographics and activity and research information. Similarly, for evaluation instruments, a filter is provided to sift through the repository and narrow down the results based on a criteria set by identifiers such as type, demographics, cognitive concepts, non-cognitive concepts, year, assessment, length and cost to access. The website also allows authors and researchers to submit their own works for inclusion into the repository, although that will require them to classify their submission on all of the above said identifiers.

Presenter(s): Karina Zikan, Wesley P. Brown, St. Olaf College
Session: Poster P3.20
Title: Validating MODIS land surface temperatures using in-situ skin temperature data across Greenland
Advisor(s): Alden C. Adolph, Physics, St Olaf College
Co-Author(s): Wesley P. Brown, Alden C. Adolph, Robert Fausto

Abstract: Given potential for global sea level rise caused by increasing ice melt from the Greenland Ice Sheet (GIS), accurate land surface temperature (LST) measurements are invaluable to climate change research. Remotely-sensed LST measurements calculated using the Moderate Resolution Imaging Spectroradiometer (MODIS) provide information from vast polar regions where ground-based measurements are difficult to obtain. MODIS LST data must be validated using ground-based measurements in order to ensure the accuracy of the MODIS LST algorithms. While previous validation projects have found a cold bias in the MODIS LST data over Greenland compared to in-situ 2-meter air temperature measurements, MODIS LST data should be validated by ice surface (skin) temperature measurements when possible due to ice surface processes. To investigate potential cold biases, we compare MODIS LST data and skin temperature measurements from 20 automatic weather stations across the GIS. Our initial results indicate the presence of a mean cold bias of 2.1°C ± 5.2°C (mean bias ± standard deviation) in the MODIS LST data that becomes more pronounced at lower temperatures and higher specific humidity.

Presenter(s): Jason Ziwiski, Anthony Wendel, Chaudhry Muhammad Faiq Shafqat, Xingtong Wang, Beloit College
Session: Poster P1.21
Title: An Application to Find the Interesting Properties of Positive Integers
Advisor(s): Darrah Chavey, Math/Computer Science, Beloit College
Co-Author(s): Anthony Wendel, Chaudhry Muhammad Faiq Shafqat, Xingtong Wang, Darrah Chavey

Abstract: The field of mathematics is full of various interesting properties that apply to numbers, but there are few programs that allow you to find them by inputting a number of your choice. Those that exist are restricted to an upper cap on how large the number can be due to restrictions in how computers store them. By bypassing these restrictions, we have created a Java application that can operate without this limitation. Our program thus is able to output a list of interesting facts about any positive integer, drawing from of a collection of over 200 possible properties. This program will be useful for math teachers as an interesting in-class activity and to mathematicians as a curiosity and a utility.

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