The Midstates Consortium for Math and Science presents

Undergraduate Research Symposium

Physical Sciences, Mathematics and Computer Science

November 3 & 4, 2023
The University of Chicago

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

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Midstates Consortium for Math and Science

Undergraduate Research Symposium for the Physical Sciences, Mathematics and Computer Science

at The University of Chicago

Program Schedule

Friday, November 3

All times are Central Time

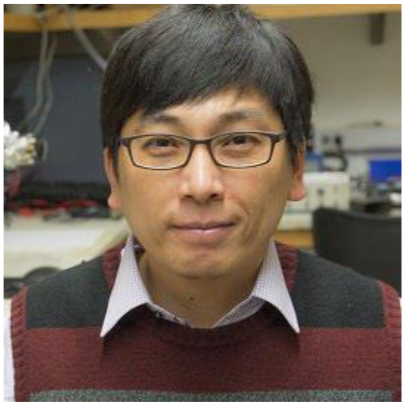
1:00 pm – 5:00 pm	Check-in & room keys at Hyatt Place Hotel	Hyatt Place Chicago South 5225 S. Harper Avenue
1:30 pm – 5:30 pm	Graduate School Exploration Seminar Registration at 1:30, sessions begin at 2:00 Reception with snacks 5:00-5:30 pm	Eckhardt Research Center (ERC) Lobby
5:30 pm – 5:40 pm	WELCOME Stuart Kurtz George and Elizabeth Yovovich Professor, Department of Computer Science and the College Master, Physical Sciences Collegiate Division University of Chicago Ed Hansen, Director Midstates Consortium for Math and Science Professor Emeritus, Geology & Environmental Science Hope College	Kent Lobby 1020 E. 58th St.
5:40 pm – 6:20 pm	Keynote Lecture Cheng Chen Professor, Department of Physics University of Chicago *"The Thrill of Discovery in a Science Lab"*	Kent 107 Lecture Hall
6:30 pm – 7:10 pm	Janet Anderson Lecture Amy Dounay Associate Professor of Chemistry and Biochemistry Colorado College "*New Drugs for Bad Bugs: Discovering Medicines for Neglected Diseas*es "	Kent 107 Lecture Hall
7:30 pm – 8:45 pm	Dinner Buffet	Gordon Center for Integrative Science (GCIS) Atrium 929 E. 57th St
Following dinner	Group Picture	GCIS Atrium
9:00pm	Shuttle & vans back to hotel UGo Shuttle at Regenstein Library	

Program Schedule
Saturday, November 4

All times are Central Time

Begins at 6:00 am	Breakfast	Hyatt Hotel Lobby
7:30, 7:45, 8:00 am	Check out of hotel Shuttles to campus depart Those with vans or cars will drive to campus, others will take the UGo shuttle. NOTE: There will be a room for storage of luggage and posters at the meeting site	Hyatt Hotel Lobby
8:00am – 8:30 am	Set-up for poster session 1 Check computer set-up for oral presentations	Gordon Center for Integrative Science (GCIS) Atrium
8:30 am – 9:30 am	Session 1 Poster Presentations	GCIS Atrium
9:30 am – 9:45am	Break, remove posters, check set-up for oral presentations in respective rooms	GCIS Atrium
9:45am -11:10 am	Session I Oral Presentations of Student Papers *15 min presentation, 2 min between talks*	Kersten
	Session I.A: (5) 9:45, 10:02, 10:19, 10:36, 10:53	Room 101
	Session I.B: (5)	Room 103
	Session I.C: (5l)	Room 105
	Session I.D: (5)	Hinds 107
11:10 pm – 12:45 pm	Lunch Buffet	Baker Dining Commons
11:10 am – 12:45 pm	Midstates Faculty meet & greet	Baker Dining Commons
12:30 pm – 12:45 pm	Set-up posters for session 2	GCIS Atrium
12:45pm- 1:45 pm	Session 2 Poster Presentations	GCIS Atrium
1:45 pm – 2:00 pm	Break, remove posters, check set-up for oral presentations in respective rooms	
2:00 pm – 3:25 pm	Session II Oral Presentations of Student Papers	Kersten
	Session II.E: () 2:00, 2:17, 2:34, 2:51, 3:08	Room 101
	Session II.F: ()	Room 103
	Session II.G: ()	Room 105
	Session II.H: ()	Hinds 107
3:25 pm -3:40 pm	Break, set-up for poster session 3	GCIS Atrium
3:40 pm – 4:40 pm	Session 3 Poster Presentations	GCIS Atrium
4:40 pm – 5:00 pm	Meeting Concludes**:** Remove posters**,** boxed dinners to go**,** shuttle pick up and complete online evaluations	GCIS Atrium
5:00 pm	Shuttle to Midway Airport	E. 57th Street at GCIS

2023 Keynote Lecture



Dr. Cheng Chen
Professor, Department of Physics
University of Chicago

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Title: ***The thrill of discovery in a science lab***

Abstract: What do you consider the most exciting discovery in science? Black holes? Superconductivity? Double helix structure of DNA? When asked this question in 1961, Physicist Richard Feynman answered, "Everything is made of atoms!"
Nowadays scientists are pushing all frontiers to spot new phenomena. So what are the best strategies to discover? In this talk, I will share a few stories of a few intriguing observations that occurred or are occurring in our laboratory at the University of Chicago.

2023 Janet Andersen Lecture

New Drugs for Bad Bugs:
Discovering Medicines for Neglected Diseases

Amy Dounay
Associate Professor of Chemistry and Biochemistry
Colorado College

Abstract: Over 1 billion people worldwide suffer from infectious diseases for which there are no adequate treatments or cures. Academic research teams play a key role in discovering new treatments for tropical diseases and antibiotic resistant infections, which have been largely neglected by big pharma and biotech companies. In the Dounay laboratory, undergraduate researchers design and synthesize new molecules with the potential to treat parasitic and bacterial infections. Our ongoing medicinal chemistry studies toward new treatments for Human African Trypanosomiasis (HAT) and *Pseudomonas aeruginosa* infection will be described. These studies illustrate a variety of strategies for engaging undergraduate students in multi-site collaborative research projects.

About Professor Dounay: The letter nominating Dr. Dounay for the award emphasized her teaching, research, and service to the larger professional community. According to her nomination letter "in the end one of the main reasons she is skilled and engaged as a teacher is that she really cares". This compassionate concern appears to characterize all aspects of her work. Before teaching she worked on drug design as a medicinal chemist at a large pharmaceutical company. In her academic research she has focused on the design and synthesis of new medicines for neglected tropical diseases or antibiotic-resistant infections, which many pharmaceutical companies do not find profitable enough to research. This aspect of her work is particularly attractive to both her undergraduate research students and students in her courses. She is known for implementing innovative initiatives in her courses including research-based laboratory projects focused on drug discovery and green chemistry. It is clear from the nomination letter and her CV that she is an exceptional mentor for undergraduate research students, a large proportion of whom go on to graduate school. Her CV has nearly a full page highlighting her diverse record of leadership and service to the chemistry professional community including her service as the Chair of the Gordon Research Seminar in Medicinal Chemistry.

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.

Oral Session I Schedule

SESSION I.A: Time: 9:45am Room Kersten 101 Moderator: Dhaya Anbajagane			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.A.1	Erin Coleman	Gustavus Adolphus College	Analyzing inflow in a lensed galaxy at z=2.45
I.A.2	Audrey Scott	University of Chicago	Hollow Cathode Discharge Instability Onset in Electric Thrusters
I.A.3	Sophia Smith	Gustavus Adolphus College	Installation of a Campus Radio Antenna Array for Radio Astronomy: Enhancing Exomoon Exploration Through Teamwork
I.A.4	Lily Johnston	Colorado College	Clouds and Precipitation Prediction within the GFDL SHiELD Model
I.A.5	Zeineb Mezghanni	Grinnell College	Shedding Light on Dark Matter Using Stellar Streams

SESSION I.B: Time: 9:45am Room Kersten 103 Moderator: Christian Cianfarani			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.B.1	Ridham Dholaria Pedro Lopez Vargas	Knox College	Distance Discrepancy in Dragonfly Arrangements
I.B.2	Lola Vescovo	Macalester College	Exact mixing times for random walks on trees of a fixed diameter
I.B.3	Xiao Hong	Washington University	Computational Aspect of Curvatures of Some Cayley Graphs
I.B.4	Xintan Xia	Macalester College	First Order Approximation on the Basilica Julia Set
I.B.5	Jessica Cao	University of Chicago	Volumes and Decompositions of Special Bruhat Interval Polytopes

SESSION I.C: Time: 9:45am Room Kersten 105 Moderator: Harry Fosbind-Elkins			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.C.1	Liam Keeley	Colorado College	Electrohydrodynamic Simulations of Pre-breakdown Electrons in a UV-Triggered Spark Gap
I.C.2	Rachel Kovach-Fuentes	University of Chicago	Smartpixels: Towards on-sensor inference of charged particle track parameters and uncertainties
I.C.3	Connor McMillin	Grinnell College	Geometrodynamics of a Quantum Mechanically Confined Particle on a 2D Curved Surface
I.C.4	Tate Flicker	University of Chicago	Upgrades for the High Luminosity LHC: testing pixel modules for the ATLAS Inner Tracker
I.C.5	Rishi Chebrolu	University of Chicago	Erbium-doped cerium oxide thin films on silicon as a host for quantum memory applications

SESSION I.D: Time: 9:45am Room Hinds 107 Moderator: Isak Jatoi			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.D.1	Soren Grant Sarah Carr	Gustavus Adolphus College	Method Optimization of Lipoprotein Separation using Anion Exchange Chromatography
I.D.2	Joshua Edwards	University of Chicago	Development of Infrared Capable Mixing Technology to Measure Microsecond Kinetics
I.D.3	Avery Greene	Lawrence University	Core Excited State Dynamics and Transition Dipole Moments with Ultrafast Laser Pulses at Xenon4,5-edge
I.D.4	Withdrawn		
I.D.5	Bethel Kifle	University of Chicago	Entanglement enhanced optical fiber sensor made of an efficient energy-time entangled photon-pair source and interferometer

Oral Session II Schedule

SESSION II.E: Time: 2:00pm Room Kersten 101 Moderator: Emily Simons			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.E.1	John Lê	Colorado College	Optimization of tip etching for scanning probe microscopy studies of semiconductor superlattices
II.E.2	Brett Bamfo	Lawrence University	Magnetic Levitation Using a Feedback System
II.E.3	Bianca Pol	University of Chicago	Charge Order in the Blume-Capel Model on a Triangular Lattice
II.E.4	Diangen Lin	University of Chicago	Single-Molecule Study of Disaggregation of Biomolecular Condensates by Heat Shock Proteins
II.E.5	Finn Braaten	University of Chicago	Explaining Granular Stress Drops in Partially Wetted Packings Using Tabletop Friction Measurements

SESSION II.F: Time: 2:00pm Room Kersten 103 Moderator: Shubhashree Pani			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.F.1	Eileen Limon	Lawrence University	Keeping up with your heart rate
II.F.2	Avery Antes	University of Chicago	Small Animal IMRT: How Targeting Hypoxic Regions can be Applied Clinically to Improve Radiation Treatment
II.F.3	John Georgiades	Washington University	Bifunctional antifolates targeting DHFR and the bacterial membrane

II.F.4	Jabr Abu-Halimah	University of Chicago	Use of AgNW Conductive Hydrogel for Increase in Signal-to-Noise Ratio in Biosensing Applications
II.F.5	Emily Oh	Washington University	Applying the singular value decomposition algorithm to quantum biological processes

SESSION II.G: Time: 2:00pm Room Kersten 105 **Moderator: Samuel Knight**			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.G.1	Jos Bhandari	Gustavus Adolphus College	Effect of buffer composition on retention of pharmaceutical analyses
II.G.2	Megan Morales	University of Chicago	Kinetic studies to establish reactivity trends of anomeric amides for nitrogen-deletion reactions
II.G.3	Katy Cash	Gustavus Adolphus College	Predicting Isocratic Retention Factors from Gradient Elution Conditions Using a Re-parameterized Neue-Kuss Model
II.G.4	Sarah Olsen	Washington University	Synthesis of self-complementary semicarbazone-based arrays
II.G.5	Kyle Hulle	University of Chicago	Mid-IR, Physical, and Optical Characterization of Polyaniline (PANI) for Electrochromic Purposes

SESSIONI II.H Time: 2:00pm Room Hinds 107 **Moderator: Stuart Kurtz**			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.H.1	Clarence Pan	Macalester College	Computational Mechanism Studies: ·OH Production in Gas-Phase α-Pinene Ozonolysis with Stereochemical Emphasis
II.H.2	Harry Gao	Washington University	SINCO: A Novel structural regularizer for image compression using implicit neural representations
II.H.3	Hanchen Li	University of Chicago	Optimizing Real-Time Video Experience with Data Scalable Codec
I.H.4	Xiangchen Li	University of Chicago	Study of branching ratio for KL to Pi0 e+e-e+e-

Poster Session P1

Time: 8:30am Room GCIS Atrium			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P1.01	Jen Tang	University of Chicago	Symmetries of the n-Body Problem
P1.02	Vu Anh Le	Beloit College	Monitoring Subsidence Trends of Underground Water Exploitation Areas Using InSAR Techniques
P1.03	Héctor Rauda	Carthage College	Topological Noise Differentiation
P1.04	Zhongyuan Zhang	University of Chicago	A hypothesis of how CEMP-r stars are formed with ejecta of Roche-lobe ov
P1.05	You Jung Ji	Colorado College	Test on Indoor Air Quality and Ventilation Rates of University Dormitories and Potential Solutions
P1.06	Allison Rabbani Rachel Rudacille	Grinnell College	Predicting the Sensitivity of LSPR Biosensors
P1.07	Raul Basilides Gomez del Estal Teixeira	University of Chicago	Characterizing redshift distributions in DELVE using self-organizing maps and Bayesian estimation for cosmic shear analysis
P1.08	Samara Goltz	Gustavus Adolphus	Degradation of Telomere-Related Gene mRNAs by the Nonsense Mediated Decay Pathway
P1.09	Sahana Giri	Knox College	Synthesis of low symmetry mixed ligand copper carboxylate liquid crystals
P1.10	Kaleb Funk Abbey Piatt Price	University of Chicago	Developing a Photothermally-Derived Carbon Dioxide Transport System
P1.11	Haley Siculan Trent Ediger Ava Beyers	Lawrence University	Using sUAS imagery to determine the effect of prescribed burns on C3 and C4 plant communities in a reclaimed Wisconsin prairie.
P1.12	Hongyi Liu	Macalester College	Estimates of the best constant for spherical restriction inequalities
P1.13	Yifan Zhao	University of Chicago	Exploring Machine Learning in Type Ia Supernova Standardization
P1.14	Murali Meyer	St. Olaf College	Mandelbrot Breadcrumbs
P1.16	Ezekiel Meulbroek	University of Chicago	Mechanical Validation and Optical Measurement of Ultra-High Frequency Feed-horn Arrays for Simons Observatory
P1.17	Daniel Godoy	Lawrence University	Synthesis of the Organic Luminescent Radical PyBDPA

Table 1 Continued			
P1.18	Avital Isakov	Washington University	Generalizing linear regression models for predicting neutral oxygen vacancy formation to design materials for STCH
P1.19	Rachel Quan	University of Chicago	Synthetic studies toward the cinncassiol diterpenoids
P1.20	Maya Ballard	St. Olaf College	Aerobic oxidative cleavage of indoles using electrochemical reductants
P1.21	Mohammad Tanzil Idrisi	Beloit College	Quantization optimization: Autoencoders and Lloyd-Max for data compression.
P1.22	Yoyo Ma	University of Chicago	Thermoresponsive Polymersomes for Vaccine Delivery
P1.23	Jingzhi Zhou	Grinnell College	3-projective hypergroups
P1.24	Enrique Hernandez Salcido	Colorado College	Optimization of a photochemically driven benzyne reaction
P1.25	Zoey Papka	University of Chicago	Resistance and Resilience in Lake Michigan Microbial Communities

Poster Session P2

Time: 12:45pm Room GCIS Atrium			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P2.01	Manuela Pinheiro	University of Chicago	Fabrication of polybenzoxazine-based porous carbons for globally-relevant separations
P2.02	Julie Lampert	Washington University	Density Matrix Renormalization Group Studies on Bond Dissociation Energies of Transition Metal Molecules
P2.03	Ionela Popa	St. Olaf College	Improving Software and Hardware of Atomic Layer Deposition
P2.04	Zewei Wu	University of Chicago	A Predictive Study on the Faint-End Luminosity Function of High-Redshift Dwarf Galaxies
P2.05	Hasif Ahmed	Lawrence University	Accelerating Diffusion Models in Particle Physics
P2.06	Naysha Jain	Knox College	BALANCE: Balloon Altitude Analysis of Cosmic Ray Flux Experiment
P2.07	Rohan Venkat	University of Chicago	Connecting Galaxy Morphology to Circumgalactic Gas Properties
P2.08	Joseph Fogt	Hope College	The effects of 600 keV proton irradiation on the Tc of YBCO based superconductors
P2.09	Zoya Akhtar	Gustavus Adolphus College	GC-MS analysis of Prunus americana extracts and their anti-proliferation and anti-migration activity on Glioblastoma multiforme
P2.10	Melody Leung	University of Chicago	Enhanced Collection Efficiency with Laser-Written Nitrogen-Vacancy Centers in Diamond Nanopillars
P2.11	Halvor Bratland	Grinnell College	Spherical Virtual Knots
P2.12	Destiny McLaws	Colorado College	Synthesis of Isoniazid-derived Metal Schiff Base Complexes
P2.13	Jennifer Spinoglio	University of Chicago	Investigating green space distribution in Chicago
P2.14	Kaashya Khandelwal Emelyce Bigirimana	St. Olaf College	How can we employ network methodologies to capture the dynamic evolution of mycorrhizal networks?
P2.15	Minwoo Son	Grinnell College	Sub-GeV Dark Matter Direct Detection Using Quantum Dots

TABLE 2 Continued			
P2.16	Dang Nguyen	University of Chicago	Pragmatic Radiology Report Generation
P2.17	Elliot Triplett	Colorado College	Projection Operators for Protein Modeling
P2.18	Teagan Steineke, Jordan Wheeler, Justin Wheeler	Carthage College	Microgravity Ullage Detection (MUD)
P2.19	Madeline Busse	University of Chicago	The Importance of Fairness in Robot-Mediated Interactions Between Strangers
P2.20	Luka Mikek	Grinnell College	Silver and Platinum Nanoparticles as Artificial Peroxidase Mimics
P2.21	Sadeen Alsabbagh	Beloit College	Unlocking the Power of EHR System Logs to Improve Clinical Workflows with Process Mining
P2.22	Dillon Bass	University of Chicago	Validating the orbital periods of the coolest TESS planet candidates
P2.23	Andrew Valentini	Carthage College	Analyzing Causes of Gravitational Wave False Alarms
P2.24	Hind Flaih Maureen Bowen	St. Olaf College	A multiscale study of friction on diamond-like carbon films
P2.25	Sam Mamicha	Macalester College	Robust Aromatic DiHydrazides

Poster Session P3

Time: 3:40pm Room GCIS Atrium			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P3.01	Kate Powledge Julia Tuttle	University of Chicago	Support systems for the HELIX Ring Imaging CHerenkov (RICH) detector
P3.02	Takeshi Matsuda Tianlong Wang	Beloit College	Decentralized Machine Learning Approach on ICU Admission Prediction for Enhanced Patient Care Using COVID-19 Data
P3.03	Qianqian Wu	Grinnell College	Minimal Hypergroups with Non-normal Structure
P3.04	Michelle Hu	University of Chicago	Building Cateye Lasers for Chemical Enhancement of Strontium-Monofluoride (SrF) production and Magneto-Optical Trapping of Sr
P3.06	Maria Riek	Colorado College	Combating the antibiotic resistance of P. aeruginosa through synthesis of lectin targeted 4-fluorophenylalanine prodrug
P3.07	Evan Cook	University of Chicago	Considering interface concavity in spongy mesophyll segmentation
P3.08	Gabriella Stoudt	Gustavus Adolphus College	GC-MS analysis of Minnesota salvia essential oils and activity against proliferation and migration on glioblastoma multiforme
P3.09	Maureen Schmid	Knox College	Toward the synthesis and characterization of nonsymmetrical α-diimine ligands for iron-catalyzed hydrosilylation
P3.11	Sahil Kumar	Grinnell College	Experimental and Theoretical SSCC for Propane and Propyne
P3.12	Yousheng Tang	Colorado College	JS Surfaces over Hexagons
P3.13	Jian Park	University of Chicago	Learned decomposition for enhanced long-term time series forecasting
P3.14	Peter Wilson	St. Olaf College	Growth of solution processed crystalline organic semiconductors for future solar cell technology

Table 3 Continued			
P3.15	Adam Krekeler	Lawrence University	Unraveling how Microtubules Unravel: Experimentally Verifying a Model for Microtubule Depolymerization
P3.16	Holiday O'Bryan	Macalester College	Diagenesis of a Pyritized Contact in the Devonian Michigan Basin: Preliminary Findings
P3.17	Zisheng Luo	Washington University	Developing an Efficient Job-Scheduling Algorithm For Global Atmospheric Simulation
P3.18	Pravan Chakravarthy	University of Chicago	Spin-Lattice Times of Nitrogen-Vacancy Centers in Diamond
P3.19	Sona Baghiyan Liam Gallagher	St. Olaf College	Towards a Classification of Trialgebras
P3.20	Mark Krysan	Grinnell College	Analyzing changes in driving performance in individuals who use cannabis following acute use.
P3.21	Callista Tran	Colorado College	Development of greener protocols for solid-phase dipeptide synthesis for the Distributed Drug Discovery program
P3.22	Smayan Khanna	University of Chicago	Thermodynamics and kinetics of DNA and RNA dinucleotide hybridization to gaps and overhangs
P3.23	Houssam Ennoura	St. Olaf College	BUILDING SPID RAS RADIO TELESCOPE

Abstracts for all Sessions
Physical Sciences, Mathematics, and Computer Science
Midstates Undergraduate Research Symposium, University of Chicago
November 3-4, 2023

All abstracts (poster and oral) are listed alphabetically by presenter last name. Abstracts with multiple presenters appear only once with first listed presenter.

Presenter(s): Jabr Abu-Halimah
School: University of Chicago
Session: Oral: II.F.4
Title: Use of AgNW Conductive Hydrogel for Increase in Signal-to-Noise Ratio in Biosensing Applications
Advisor(s): Bozhi Tian, Chemistry, University of Chicago
Co-Author(s): Pengju Li
Abstract: Hydrogels have transformative applications to biomedical research. They are conformable, tissue-like materials with a multitude of uses and applications. Deformable bioelectronics, often using hydrogels, greatly improve biosensing and biomodulation due to the use of tissue-like materials, decreasing mechanical mismatch between the bioelectronics and target tissue. And previous research has shown that hydrogels increase the signal-to-noise ratio by causing the increased deformability of sensors to human skin. In this work, we create a novel hydrogel using a Silver Nanowire (AgNW) + phosphate buffer solution (PBS) + gelatin + starch + chitosan hydrogel composite to create a robust, deformable, and adhesive hydrogel for biosensing applications. Hydrogels of various AgNW-PBS concentrations, including a control with no nanowire were synthesized. Various mechanical tests were conducted to investigate the material's stiffness, conductivity, impedance, and ability to store elastic energy during deformation. Biosensing tests were thus conducted using sensors with and without this biocompatible hydrogel. Indeed, an increased signal-to-noise ratio for the sensors utilizing a hydrogel soft interface compared to the control that lacked it was observed. This research further strengthens the promise that deformable bioelectronics have on improving biosensing and biomodulation capabilities.

Presenter(s): Hasif Ahmed
School: Lawrence University
Session: Poster: P2.05
Title: Accelerating Diffusion Models in Particle Physics
Advisor(s): Vinicius Mikuni, NERSC, Lawrence Berkeley National Laboratory, ETH Zurich
Co-Author(s):
Abstract: Our research investigates the optimization of sampling techniques applied to particle physics datasets, focusing on numerical methods and comprehensive data analysis. The unique challenges encompassed by particle physics data, such as continuous coordinates, stochastic dimensionality, and permutation invariance, distinguish it from standard datasets. The prevalent deep generative models, mainly designed for image data, fall short for these datasets. Our approach centers on a novel neural network simulation called Fast Point Cloud Diffusion (FPCD). The core aim is to boost the efficiency and speed of diffusion models, assessed via minimized Wasserstein Distances between authentic and generated data distributions and reduced sampling time.

Presenter(s): Zoya Akhtar,
School: Gustavus Adolphus College
Session: Poster: P2.09
Title: GC-MS analysis of Prunus americana extracts and their anti-proliferation and anti-migration activity on

Glioblastoma multiforme
Advisor(s): Kennedy Nyongbela, Chemistry, Gustavus Adolphus College
Co-Author(s): Brian Castle, Catherine Vopat, David Odde
Abstract: Natural products from plants have been a bedrock of drug discovery for many decades and have provided more than half of all cancer medications. Paclitaxel (Taxol), a first-line treatment for various forms of cancer, is a glaring example. Invasive plants are known to alter biodiversity and ecosystem services, and one strategy in their management is to chemically investigate them as sources of potentially beneficial natural products. Native American wild plum, or Prunus americana is an invasive plant whose fruits are extensively consumed by Native Americans of the prairies either fresh or made into a sauce. In this study, the seed oil and extracts of the pulp of the plant were purified using column chromatography and analyzed with gas chromatography-mass spectroscopy. They were subsequently tested on U251 glioblastoma multiforme cell lines. Analyses revealed the presence of omega fatty acids in the seed oil for the first time, while the testing showed the oil to possess an unusual activity by tampering with cell proliferation and migration. These results have shown the plant as an alternative source of omega fatty acids and open a window for further investigation of P. americana seed oil as potential source of natural products to combat brain tumor.

Presenter(s): Sadeen Alsabbagh
School: Beloit College
Session: Poster: P2.21
Title: Unlocking the Power of EHR System Logs to Improve Clinical Workflows with Process Mining
Advisor(s): Mehmet Dik, Mathematics and Computer Science, Beloit College
Co-Author(s):
Abstract: Enhancing clinical workflows is a paramount objective for healthcare institutions aiming to optimize patient care and resource utilization. This research delves into harnessing the potential of Electronic Health Record (EHR) system logs through the application of process mining techniques. By analyzing the wealth of data contained within EHR logs, this study aims to uncover valuable insights into the actual execution of clinical processes. Through process discovery, conformance checking, and performance analysis, we seek to identify bottlenecks, deviations from established protocols, and opportunities for streamlining procedures. The proposed approach holds promise for facilitating evidence-based decision-making, reducing operational inefficiencies, and ultimately improving patient outcomes. The findings underscore the significance of leveraging EHR system logs as a means to gain comprehensive visibility into clinical workflows, fostering a data-driven culture of continuous process enhancement within healthcare settings.

Presenter(s): Avery Antes
School: University of Chicago
Session: Oral: II.F.2
Title: Small Animal IMRT: How Targeting Hypoxic Regions can be Applied Clinically to Improve Radiation Treatment
Advisor(s): Hania Al-Hallaq, Medical Physics, University of Chicago
Co-Author(s):
Abstract: The Small Animal IMRT lab researches how targeting hypoxic regions can be applied clinically to improve patient outcome. Hypoxia has been known for over sixty years to be resistant to radiation treatment and chemotherapy and is typically associated with a poorer outcome of the patient. To target these hypoxic region, we used EPR (Electron Paramagnetic Resonance). This research suggests that studying the biology of the tumor region can greatly improve patient diagnosis, treatment, and outcome. For forty-two cases, we used the XRAD225Cx to image and treat the patients (mice). In order to treat the tumors, I developed an original code to import speciality tumor masks into Micro Raystation. Furthermore, we 3D printed compensator blocks that isolated the tumor into antiboost or boost cases [boost: targeting the hypoxic region ; antiboost: targeting around the hypoxic region]. I found through the Dice Coefficient test that all compensators were more than 80% similar, thus proving that the 3D printed compensators are accurate to our planned apertures. We can

now safely deliver treatments to the mice given our compensators accuracy. This proves that this research provides reliable preclinical studies and suggests that observing tumor biology can improve radiation treatment.

Presenter(s): Sona Baghiyan, Liam Gallagher
School: St. Olaf College
Session: Poster: P3.19
Title: Towards a Classification of Trialgebras
Advisor(s): Erik Mainellis, Mathematics, St. Olaf College
Co-Author(s):
Abstract: The french mathematician, Jena-Louis Loday, worked throughout the 1990's and early 2000's to develop a system of mathematical objects now known as the algebras of Loday. The aim of the research is to investigate properties of a specific algebra of Loday: nilpotent triassociative algebras. We say an algebra is nilpotent when there exists some natural number n such that any n-product of elements in the nilpotent algebra is equal to zero. Thus, in the case of a triassociative algebra, there are three separate multiplications which may be nilpotent. The algebras we are concerned with, nilpotent triassociative algebras, are characterized by 3 different types of multiplications and 11 identities which define triassociativity. These triassociative algebras generalize associative and diassociative algebras; in particular, each multiplication forms an associative algebra. We explore the relations concerning nilpotency among these individual multiplication structures and the greater triassociative structure. A special type of extension called a central extension can be used to build the desired nilpotent algebras using linear mapping and direct sums. We use extension theory to classify these nilpotent algebras up to dimension 3. To simplify the computation we use Python code and calculate all possible multiplication results in the algebra.

Presenter(s): Maya Ballard
School: St. Olaf College
Session: Poster: P1.20
Title: Aerobic oxidative cleavage of indoles using electrochemical reductants
Advisor(s): Anna Brezny, Chemistry, St. Olaf College
Co-Author(s):
Abstract: Oxidative cleavage of alkenes is a valuable reaction in organic chemistry, as it transforms alkenes into useful carbonyl, containing compounds. Typically, oxidative cleavage requires dangerous reagents under specialized reaction conditions. Nature accomplishes this transformation with heme-containing enzymes and O2 to cleave the double bond in tryptophan. Our system mimics the biological process using metal porphyrins instead of enzymes to cleave indole and its derivatives. Our process seeks to understand how the chemical mechanism is different from the biological mechanism and to optimize the yields under chemical conditions. Our research has shown that oxidative cleavage of 3-methylindole is possible with appreciative yields under electrochemical reducing conditions and in the presence of chemical reductants. The optimized reaction found that in the presence of an axial ligand, specifically pyridine, increases the percent yield of the reaction. Additionally, side products of the reaction were identified and processes were designed to manipulate the voltage of the reaction to reduce the presence of these side products. Current efforts continue to optimize the reaction conditions and to expand the substrate scope beyond 3-methylindole.

Presenter(s): Brett Bamfo
School: Lawrence University
Session: Oral: II.E.2
Title: Magnetic Levitation Using a Feedback System
Advisor(s): Matthew Stoneking, Lawrence University
Co-Author(s):
Abstract: This summer I worked with Prof. Stoneking and the Lawrence Dept to construct a magnetic levitation

device using a feedback system. The goal in the beginning was to get the magnet to levitate for 10 seconds. My goal this summer was to bring the theory of magnetic levitation to life. Weeks into the research, I achieved levitation for 10 seconds. We then set off for a new goal of having stable levitation for 30 minutes or more. I set out to theoretically model the apparatus by measuring and finding the inverse scale length of the magnetic field and then finding the transfer functions of the components of the feedback system. Through a tremendous amount of mathematical theory and changes in the apparatus. I achieved stable levitation for 35 minutes, then 1 hour, then the next thing I knew the small magnetic disc was levitating for 3 hours plus. Overall, the results we achieved were that levitation is possible for long periods of time, with certain parameters being that the proportional gain respects the derivative gain in the PID circuit.

Presenter(s): Dillon Bass
School: University of Chicago
Session: Poster: P2.22
Title: Validating the orbital periods of the coolest TESS planet candidates
Advisor(s): Daniel Fabrycky, Astronomy and Astrophysics, University of Chicago
Co-Author(s):
Abstract: When an exoplanet passes in front of its host star, the resulting eclipse causes an observable decrease in stellar flux, and when multiple such transits are detected, the orbital period of the exoplanet can be determined. Over the past 5 years NASA's Transiting Exoplanet Survey Satellite (TESS) has discovered thousands of potential planets mostly with short orbital periods, although some have longer reported values over 100 days. These long orbital periods, however, are not easy to confirm due to frequent lengthy data gaps. Here we show that while the majority of these long period candidates likely have periods much shorter than reported, there are a sizable number of TESS candidates that can be confirmed as having long periods. Due to their long periods, these planets will have very cool equilibrium temperatures, and may be more likely to host exo-moons or rings. We present these candidates, along with a variety of small corrections to other TESS orbital periods and a number of planets with possible transit timing variations, with the goal of refining the TESS data set and enabling future research with respect to long period transiting planets.

Presenter(s): Jos Bhandari
School: Gustavus Adolphus College
Session: Oral: II.G.1
Title: Effect of buffer composition on retention of pharmaceutical analyses
Advisor(s): Dwight Stoll, Chemistry, Gustavus Adolphus College
Co-Author(s):
Abstract: Mobile phase composition is an important factor in determining the retention of pharmaceutical analytes. While ammonium phosphate is the most widely used buffer in chromatography, the WikiChrom project in Stoll laboratory utilizes a pH 3.2 ammonium formate buffer for retention gathering purposes. To figure out if the retention data with formate buffer could be replicated, a short-term reproducibility experiment was carried out. A total of 20 compounds were selected for analysis where the first and third batches utilized a pH 3.2 ammonium formate buffer, while the second batch consisted of a pH 3.2 Ammonium phosphate buffer. Even though certain basic compounds exhibited a change in retention, the experimental results led to the conclusion that the use of phosphate buffer did not hinder overall reproducibility.

Presenter(s): Finn Braaten
School: University of Chicago
Session: Oral: II.E.5
Title: Explaining Granular Stress Drops in Partially Wetted Packings Using Tabletop Friction Measurements
Advisor(s): Heinrich Jaeger, Physics, University of Chicago
Co-Author(s):

Abstract: The plastic deformation of granular materials, relieving stress through avalanche-like slipping between grains, is a complex process that highly depends on contact interactions between particles. For wetted granular materials, we observe a similarity when there is no liquid and when a lot of liquid is added to the material. However, upon adding microscopic amounts of liquid, we observe a dramatic increase in the magnitude and frequency of stress drops. Here, we present experiments studying how varying amounts of liquid between grain surfaces effects drops in frictional force due to surface sticking and sliding. We find that, for amounts of liquid covering the surfaces at a depth comparable to the height of surface asperities, there is an increase in the frequency and magnitude of frictional force drops when slipping. This correspondence of wetting depth to the size of surface features holds similarly for the amount of wetting for which stress drops increase in the bulk granular material. This leads us to suggest a mechanism by which microscopic amounts of liquid can strongly control the stress response of granular materials.

Presenter(s): Halvor Bratland
School: Grinnell College
Session: Poster: P2.11
Title: Spherical Virtual Knots
Advisor(s): Alan Royce Wolf, Mathematics, Grinnell College
Co-Author(s):
Abstract: Virtual knot theory extends the tools used to study ordinary knots to configurations which are geometrically impossible. This generalization bridges new connections between concrete knotted loops and more abstract algebraic structures. We examine a class of virtual knots called spherical virtual knots, which can be visualized as lying on a sphere. We use an invariant of virtual knots called odd writhe to prove the existence of virtual knots which are non-spherical.

Presenter(s): Madeline Busse
School: University of Chicago
Session: Poster: P2.19
Title: The Importance of Fairness in Robot-Mediated Interactions Between Strangers
A**dvisor(s):** Sarah Sebo, Computer Science, University of Chicago
Co-Author(s): Esha Mujumdar, Timmy Lin
Abstract: Previous HRI research and interactive robots such as the donkey at Universal Studios who insults guests waiting in line has suggested that there may be a positive purpose for negative robots. The Common Enemy project seeks to investigate whether a negative robot creates a stronger bond between strangers than a positive or bipolar robot. However, the more fascinating result that we found was that people have the most positive experience based not on the robot's absolute mood, but rather on its consistency in mood between participants. We designed an interactive circle-dragging diagram to measure closeness between the participants and the robot, with three circles: one for each person and one for the robot. The results of this measure indicated that the two participants felt closest to each other in the conditions when the robot treated them both with the same attitude--no matter whether this attitude was positive or negative. However, in the condition where the robot responded to one participant positively and the other negatively, there was almost no overlap between the two participants. Our experiment has significant results for integrating robots into human teamwork, and emphasizes the inherent psychological importance of fairness to human beings.

Presenter(s): Jessica Cao
School: University of Chicago
Session: Oral: I.B.5
Title: Volumes and Decompositions of Special Bruhat Interval Polytopes
Advisor(s): Mario Sanchez, Mathematics, Cornell Unviersity
Co-Author(s): Ruogu Zhang
Abstract: Let u and v be permutations on n letters, with u <= v in Bruhat order. A Bruhat interval polytope

Q_{u,v} is the convex hull of all permutation vectors z = (z(1), z(2),...,z(n)) with u <= z <= v. Bruhat interval polytopes have been studied recently in the context of lattice path matroid polytopes and the moment map of the flag variety. In this project, we study the volumes and decompositions of Bruhat interval polytopes through a combinatorial perspective to complement the previous algebraic geometry research on these varieties. Our research supports that these Bruhat interval polytopes subdivide into a special family of polytopes called the toric Bruhat interval polytopes, analogous to how lattice path matroid polytopes can be decomposed into border strip matroid polytopes. These toric Bruhat interval polytopes can be triangulated into simplices defined by maximal chains in the Bruhat order. Finally, we will provide a purely combinatorial formula for the volumes of these maximal chains.

Presenter(s): Kathryn Cash
School: Gustavus Adolphus College
Session: Oral: II.G.3
Title: Predicting Isocratic Retention Factors from Gradient Elution Conditions Using a Re-parameterized Neue-Kuss Model
Advisor(s): Dwight Stoll, Chemistry, Gustavus Adolphus College
Co-Author(s): Sarah Rutan
Abstract: The ability to predict isocratic retention factors from data acquired under gradient elution conditions may provide a more efficient path for establishing retention databases compared to the use of isocratic conditions alone. Such databases can be used to develop retention models and support simulations of separations, however past work has shown that isocratic retention factors predicted in this way are different from retention factors determined experimentally under isocratic conditions. In this presentation we will describe the use of a re-parameterized Neue-Kuss (NK) model, along with a Design of Experiments approach that aims to enable the accurate prediction of isocratic retention factors from experimental retention data acquired under gradient elution conditions. The results show that the fits of gradient data to the NK model yielded average (absolute value) prediction errors for model parameters in the range of 6 to 11%. However, the errors in isocratic retention factors predicted using this approach were much better with an average error of 1.59%, provided that the prediction does not involve an extrapolation to mobile phase conditions not used in the gradient elution experiments used to build the model. This is an important result that has the potential to simplify the acquisition of retention data for large database-building efforts.

Presenter(s): Pravan Chakravarthy
School: University of Chicago
Session: Poster: P3.18
Title: Spin-Lattice Times of Nitrogen-Vacancy Centers in Diamond
Advisor(s): Lee C. Bassett, Electrical and Systems Engineering, University of Pennsylvania
Co-Author(s): Rebecca Fishman
Abstract: The nitrogen-vacancy (NV) center is a point defect in diamond that has many applications in quantum computing, biomedicine, and other fields. Its chemical and physical properties enable it to function as a spin qubit for quantum information processing. NV centers can also be utilized in improving the quality of nanoscale medical imaging, particularly important to which is the spin-lattice relaxation time (T1) of a given quantum system. In this research, T1 measurements on nanodiamonds (NDs) are conducted and relaxation rates 1/T1 are analyzed as a function of ND size. An increase in size is found to correspond with a decrease in relaxation rate, and is compared to a previous study. The results shed some light into the optimal choice of size for computing and biosensing applications, but leave plenty of room for further research.

Presenter(s): Rishi Chebrolu
School: University of Chicago
Session: Oral: I.C.5
Title: Erbium-doped cerium oxide thin films on silicon as a host for quantum memory applications

Advisor(s): Supratik Guha, Pritzker School of Molecular Engineering, University of Chicago
Co-Author(s): Gregory Grant, Ignas Masiulionis
Abstract: Rare-earth ion dopants within solid-state hosts provide an attractive class of candidate materials for quantum communication technologies such as quantum memory systems. With a shielded 4f-4f transition in the telecommunication band (~1.5μm), predicted long-lived electron-spin coherence times, near-zero nuclear spin noise, and device fabrication techniques of the material in the solid-state, erbium-doped oxides are a promising class of materials for applications in fiber-based quantum network technologies. In particular, we investigate erbium-doped cerium oxide single-crystalline thin films on silicon using molecular beam epitaxy (MBE), controlling the doping concentration of erbium down to 2 parts per million (ppm). In characterizing this material, we conduct a microstructural and optical survey of the material's crystal structure, optical inhomogeneous linewidths, and optically excited state lifetimes at cryogenic temperatures. We also investigate the effects of doping concentrations and post-growth annealing conditions on these materials and optical characteristics. These results suggest erbium defects embedded in solid-state hosts as exciting material systems for quantum networks and communication applications.

Presenter(s): Erin Coleman
School: Gustavus Adolphus
Session: Oral: I.A.1
Title: Analyzing inflow in a lensed galaxy at z=2.45
Advisor(s): Tucker Jones, Department of Physics and Astronomy, University of California, Davis
Co-Author(s):
Abstract: Understanding the baryon cycle is crucial to forming an accurate picture of the evolution of galaxies, as gas inflows and outflows vary throughout a galaxy's lifetime and affect its star formation rate. At redshift z~2, it is highly unusual to observe star-forming galaxies with significant inflow but no outflow. We present spectroscopic analysis of a galaxy at redshift z=2.451 which exhibits signs of inflow in several ultraviolet ISM absorption lines, and no outflow. The absorption lines are redshifted by ~340 km with respect to the C IV nebular emission. This velocity is consistent with that of gas falling from the virial radius to the center of a galaxy of approximate halo mass 10^10 solar masses. Modeling stellar continuum features suggests this galaxy has a low metallicity and is primarily composed of very young stars. We conclude that this system is likely in the beginning of a cycle of bursty star formation, where inflow and star formation rates are high, but where supernovae and other feedback processes have yet to become sufficiently strong to produce strong outflow signatures. The rarity of observations of redshifted ISM gas absorption is likely due to the short time scale on which these conditions are present.

Presenter(s): Evan Cook
School: University of Chicago
Session: Poster: P3.07
Title: Considering interface concavity in spongy mesophyll segmentation
Advisor(s): Corey S. O'Hern, Department of Mechanical Engineering and Materials Science; Department of Applied Physics; Department of Physics, Yale University
Co-Author(s): Arthur K. MacKeith, Allison E. Culbert, Joy Pajarla, Craig R. Brodersen, Adam B. Roddy, Mark D. Shattuck
Abstract: MicroCT scans are a promising tool for biologists to observe leaf behavior on the cellular level. However, scans of spongy mesophyll can produce 'blobs' of cell matter, which requires additional effort to segment into individual cells. Past approaches apply a watershed transform and prune away proposed cells based on cell width. While generally effective, this approach leads to consistent undersegmentation in the final result. We propose a novel approach considering cell interface concavity in the pruning stage. Our new algorithm makes use of the watershed transform and cell width, but only for clear-cut cases – fringe cases are decided by examining border concavities of the candidate cells. Running on several complex datasets, our algorithm corrects the undersegmentation issue of the previous algorithm, while preserving its correct

segmentations. Running on a limited dataset with manual ground-truth segmentation, our algorithm produces a perfect segmentation with 99.7% average cell overlap.

Presenter(s): Ridham Dholaria, Pedro Lopez
School: Knox College
Session: Oral: I.B.1
Title: Distance Discrepancy in Dragonfly Arrangements
Advisor(s): David Bunde, Computer Science, Knox College
Co-Author(s): Suyash Chitrakar
Abstract: High-performance computing (HPC) systems are crucial for various scientific and engineering endeavors, their performance hinging on their specific network topologies. This research focused on exploring Dragonfly topologies through their distance discrepancy in systems. We dove into the scalability, robustness, and potential of these network topologies through graphs, using a tool we developed. Every graph representing Dragonfly topologies efficiently with the given parameters. Additionally, we compared these qualities among different Dragonfly arrangements, as there are many. While exploring these qualities, we discovered a discrepancy in the different distance paths in each arrangement. This unexpected difference indicates that the arrangements have different levels of efficiency, as each arrangement gives each processor different paths to every other processor. Our research asked the main question of why the discrepancy occurs. While we explored that question, we discovered equations to accurately find the distance paths in each dragonfly arrangement in any size. So although we did not answer the main question, these equations now allow us and any future researcher to compare the discrepancies of different Dragonfly arrangements of any size without having to run a multitude of costly simulations.

Presenter(s): Joshua Edwards
School: University of Chicago
Session: Oral: I.D.2
Title: Development of Infrared Capable Mixing Technology to Measure Microsecond Kinetics
Advisor(s): Andrei Tokmakoff, Chemistry. University of Chicago
Co-Author(s):
Abstract: We have developed a novel rapid microfluidic mixing device compatible with infrared spectroscopy. This innovation addresses a critical gap in probing nonequilibrium biological reactions occurring in the microsecond to millisecond range, where conventional mixing techniques fall short. Leveraging the sensitivity of IR spectroscopy in elucidating molecular vibrations and detecting subtle changes in the bonding environment of biological molecules, our microfluidic mixer facilitates real-time kinetics studies. We showcase this by examining the kinetics of ferricyanide reduction by ascorbic acid and measuring reaction rates as fast as 250 µs. Furthermore, we outline future directions, illustrating the potential of our system in unraveling intricate processes such as DNA hybridization.

Presenter(s): Houssam Ennoura
School: St. Olaf College
Session: Poster: P3.23
Title: Building SPID Radio Telescope
Advisor(s):
Co-Author(s): Ionela Popa
Abstract: This summer, I focused on building a radio telescope inspired by MIT Haystack Observatory's model, with the goal of developing an affordable radio telescope tailored for educational purposes for Saint Olaf College students. This project includes the creation of a compact radio telescope referred to as the 'SRT,' a miniature version known as the 'VSRT,' and an 11 GHz Ozone spectrometer. The SRT serves the purpose of observing the Sun and detecting the 21-cm hydrogen line. Additionally, a cost-effective USB 'dongle' originally designed for digital TV has been adapted for use as a software-defined radio. The data collected from the small

radio telescope will be processed using MIT-developed Linux-based software, streamlining the data collection process.

Presenter(s): Hind Flaih, Maureen Bowen
School: St. Olaf College
Session: Poster: P2.24
Title: Multi-Scale friction on Diamond-Like Carbon
Advisor(s): Brian Borovsky, Physics Department, St. Olaf College
Co-Author(s): Ana Colliton, Hind Flaih, Eskil Irgens, Lucas Kramarczuk, Griffin Rauber, Jordan Vickers, Seokhoon Jang, Zhenbin Gong, Junyan Zhang, Seong Han Kim
Abstract: We present results from a multi-scale study of friction on diamond-like carbon (DLC) coatings. DLC's ability to achieve "superlubricity" is an enticing prospect for applications, but this low friction behavior can depend on contact size and sliding distance, and it is very sensitive to interactions with the surrounding environment. Our work is a collaborative project with researchers at Pennsylvania State University under Dr. Seong Kim. We aim to understand the tribochemistry of DLC coatings across different size scales. At St. Olaf College, we measure sliding friction using an indenter probe and 5 MHz shear-mode quartz crystal microbalance (QCM) along with 20 Hz lateral sliding motions from a piezoelectric stage. The tips and substrates are analyzed using electron and optical microscopy, both before and after friction tests. We find that very low friction can be achieved at both macroscopic and microscopic contacts through a process of chemical and mechanical transformation at the sliding interface. For nanoscale contacts, the transformation may fail due to high pressures and unstable geometries. For microscale contacts, a threshold sliding distance near 20 nm is required to initiate the transition to low friction.

Presenter(s): Tate Flicker
School: University of Chicago
Session: Oral: I.C.4
Title: Upgrades for the High Luminosity LHC: testing pixel modules for the ATLAS Inner Tracker
Advisor(s): Karri Folan DiPetrillo, Department of Physics, University of Chicago
Co-Author(s):
Abstract: Upgrades to the ATLAS detector in preparation for the High Luminosity Large Hadron Collider (HL-LHC) will include the construction of a new, all-silicon Inner Tracker (ITk). ITk will be composed of nine layers, of which the innermost four are the Pixel Detector. The ATLAS Group at Argonne National Laboratory will be responsible for assembling approximately 1200 planar quad modules of active thickness 100µm for Layer 1 of the ITk Pixel Detector. An important pre-assembly step is the completion of IV scans on bare modules. Bare modules consist only of silicon sensors bump-bonded to frontend chips, whereas fully assembled modules also include a flexible PCB. During IV scans, we reverse bias the silicon sensor using voltages up to 200 V and probe the leakage current. Scans of the first bare modules received at Argonne show that four modules are functioning normally with no breakdown before 200 V, while one module shows early breakdown. Using these scans, we demonstrate a light-tight setup and the ability to complete scans as part of ANL's site qualification process. A discussion of IV scans will be placed in context with the full assembly process, and additional steps in the module assembly process will be summarized.

Presenter(s): Joey Fogt
School: Hope College
Session: Poster: P2.08
Title: The effects of 600 keV proton irradiation on the Tc of YBCO based superconductors
Advisor(s): Kyuil Cho, Physics, Hope College
Co-Author(s): Hope Weeda, Trevor Harrison
Abstract: We studied the effect of 600 keV proton irradiation on thin film Cuprate superconductors. A 500 nm thick YBCO-1237 sample was subjected to a series of proton irradiations with a total fluence of 7.2 x 10^16

p/cm^2. Upon irradiations, the superconducting critical temperature (T_c) was drastically decreased from 90 K towards zero Kelvin, and the normal state resistivity increased accordingly. The rate of T_c reduction to resistivity increase will be used to discuss the fundamental property of the superconductor.

Presenter(s): Kaleb Funk, Abbey Piatt Price
School: University of Chicago
Session: Poster: P1.10
Title: Developing a Photothermally-Derived Carbon Dioxide Transport System
Advisor(s): Aaron Esser-Kahn, Pritzker School of Molecular Engineering, University of Chicago
Co-Author(s): Katie Kloska
Abstract: To combat the global warming effects of carbon dioxide (CO2) and other greenhouse gases, advancements must be made in the technology of reducing carbon emissions and removing atmospheric CO2. Aqueous-amine based carbon capture involves a cycle where an amine binds to CO2 and is reheated to release the CO2 elsewhere, regenerating the amine solution. This regeneration process requires large thermal energy inputs to initiate CO2 release, limiting the efficiency of aqueous-amine systems. Previous work has shown that photothermal excitation of carbon-black nanoparticles initiates regeneration via localized heating around suspended nanoparticles, instead of bulk heating the capture solution. This photothermal phenomenon lowers the energy requirement of the regeneration process, increasing the efficiency of CO2 release with free solar energy instead of energy from fossil fuels. We propose to utilize this photothermal phenomenon in an apparatus with the ability to passively draw CO2 out of the atmosphere and continuously regenerate solvent and CO2 via solar energy. This apparatus has been demonstrated at bench-scale by suspending carbon-black nanoparticles in various capture solutions and implementing it in a passive-flow system using a semipermeable membrane. We aim to improve the apparatus's efficiency by altering properties such as membrane thickness, composition, solvent type, and apparatus architecture

Presenter(s): Harry Gao
School: Washington University in St. Louis
Session: Oral: II.H.2
Title: SINCO: A Novel structural regularizer for image compression using implicit neural representations
Advisor(s): Weijie Gan, CSE, Washington University in St. Louis
Co-Author(s): Zhixin Sun, Ulugbek Kamilov
Abstract: Implicit neural representations (INR) have been recently proposed as deep learning (DL) based solutions for image compression. An image can be compressed by training an INR model with fewer weights than the number of image pixels to map the coordinates of the image to corresponding pixel values. While traditional training approaches for INRs are based on enforcing pixel-wise image consistency, we propose to further improve image quality by using a new structural regularizer. We present structural regularization for INR compression (SINCO) as a novel INR method for image compression. SINCO imposes structural consistency of the compressed images to the ground truth by using a segmentation network to penalize the discrepancy of segmentation masks predicted from compressed images. We validate SINCO on brain MRI images by showing that it can achieve better performance than some recent INR methods.

Presenter(s): John Georgiades
School: Washington University in St. Louis
Session: Oral: II.F.3
Title: Bifunctional antifolates targeting DHFR and the bacterial membrane
Advisor(s): Timothy A. Wencwicz, Chemistry, Washington University in St. Louis
Co-Author(s): Angela R. Smith, Bruce A. Hathaway
Abstract: Antibiotic resistance poses one of the greatest challenges in human history. Treatments are failing in the clinic, leaving physicians without options, and patients with little hope. Bifunctional antibiotics have built a strong presence as viable strategy for treating bacterial infection. One recent innovation on this concept was

the development of dual action antifolates based on hydrophobic pyrroloquinazolinediamine compounds that target dihydrofolate reductase (DHFR) and membrane integrity and showed broad spectrum activity with undetectable resistance. We expanded on this work by designing cycloguanil derivatives with N-aryl and 6-alkyl hydrophobic substitutions on the 2,4-diamino-1,6-dihydro-1,3,5-triazine scaffold. These compounds show robust, broad-spectrum activity against many ESKAPE pathogens, including P. aeruginosa. Enzyme inhibition assays were performed with DHFR isoforms from E. coli and S. aureus which confirmed that these hydrophobic substitutions had little-to-no impact on biochemical potency. Fascinated by the possibility of a second mechanism of action, we performed SYTOX Green uptake experiments that revealed 6-nonyl and 6-undecyl substitutions provided strong membrane disruption, in contrast to the absence of signal by the parent compound, cycloguanil. We are currently working to design such molecules that are more potent in enzyme inhibition and less toxic to human cells via membrane disruption

Presenter(s): Sahana Giri
School: Knox College
Session: Poster: P1.09
Title: Synthesis of low symmetry mixed ligand copper carboxylate liquid crystals
Advisor(s): Thomas Clayton, Chemistry, Knox College
Co-Author(s):
Abstract: Long chain homoleptic copper(II) carboxylate dimers are often seen to exhibit liquid crystal mesophases at temperatures dependent upon the length and structure of the carboxylate chains. Previous work at Knox has shown that a reduction in m.p. is demonstrated when these dimers are substituted with carboxylates to yield heteroleptic dimers. The same substitution protocol, in the present work, was utilized to make mono ($Cu_2(O_2CR)_3(O_2CR')$), di (($Cu_2(O_2CR)_2(O_2CR')_2$), and tri-substituted ($Cu_2(O_2CR)_2(O_2CR')(O_2CR'')$) copper (II) dimers. The resulting products containing either of two branched ligands, 2-ethylhexanoate or 2-propyl valerate, were compared to those of the straight chain octanoate, and exhibited changes in m.p. and birefringent qualities. Previously, caprolactam adducts of heteroleptic dimers have been generated by direct addition of caprolactam to the dimers in toluene. These caprolactam adducts exhibited reduced m.p. by comparison with their parent compounds. In this work, we report the direct synthesis of the monosubstituted caprolactam adduct in toluene. This reaction apparently proceeds in toluene without donor solvent when caprolactam is present. Characterization of products was done using infrared spectroscopy (FT-IR), polarized optical microscopy (POM), and differential scanning calorimetry (DSC).

Presenter(s): Daniel Godoy
School: Lawrence University
Session: Poster: P1.17
Title: Synthesis of the Organic Luminescent Radical PyBDPA
Advisor(s): Graham T. Sazama, Chemistry, Lawrence University
Co-Author(s):
Abstract: Theory suggests that the efficiency of Organic Light-Emitting Diodes (OLEDs) would benefit from new materials based on stable luminescent radicals. This research project entails the synthesis of one potential luminescent radical, PyBDPA• . The synthesis and analysis of intermediates incorporating the chosen chromophore, pyrene, into the stable radical framework of 1,3-bisdiphenylene-2-phenylallyl (BDPA) are discussed. We also discuss how palladiumcatalyzed cross-coupling methods append the pyrene chromophore to the BDPA framework, with PyBDPA• as the desired product. Mass spectrometry results show successful synthesis of the nonradical version of the final product, PyBDPAH. However, the decision to append two pyrene groups to the framework was made to conduct a more thorough spectroscopy analysis. The results of the double substitution reaction remain under analysis, and a contrast between the monosubstituted versus the double-substituted PyBDPA• frameworks will be drawn. Further purification and analysis of this stable

radical will lead to a better understanding of doublet states, fluorescence, and how these molecules can improve the efficiency of OLEDs.

Presenter(s): Samara Goltz
School: Gustavus Adolphus
Session: Poster P1.08
Title: Degradation of Telomere-Related Gene mRNAs by the Nonsense Mediated Decay Pathway
Advisor(s): Jeffrey Dahlseid, Biochemistry & Molecular Biology, Gustavus Adolphus College
Co-Author(s):
Abstract: DNA is the biological molecule that holds the information dictating the structure and function of a cell. For a cell to convey, or express, this information, a cell utilizes DNA for the synthesis of messenger RNA (mRNA), a molecule which is then used to encode the synthesis of proteins. At any step, gene expression can be regulated. My research focuses on regulation through mRNA degradation. Saccharomyces cerevisiae (baker's yeast) is our model system of choice to study the Nonsense-Mediated Decay (NMD) pathway. NMD is a specialized pathway that rapidly degrades mRNA compared to the normal pathway. This is useful for degrading mutated mRNA that would code for compromised protein. Interestingly, NMD also targets mRNA that lacks mutations, like those for the six telomere-related genes that I study. Telomeres protect the DNA from losing essential information during DNA replication which is crucial for cell function. My project aims to understand if the mRNAs for certain genes are a target for the NMD pathway by measuring rates of mRNA degradation for yeast with and without the NMD pathway. I will present the results I have obtained so far for the mRNAs from EST3, SAS2, and TEN1.

Presenter(s): Soren Grant, Sarah Carr
School: Gustavus Adolphus College
Session: Oral: I.D1
Title: Method Optimization of Lipoprotein Separation using Anion Exchange Chromatography
Advisor(s): Dwight Stoll, Chemistry, Gustavus Adolphus College
Co-Author(s): Danni Li, Tina Dahlseid, Daniel Meston
Abstract: Lipoproteins are intricate biomolecules previously researched for their role in cholesterol transportation and coronary artery diseases. Recent research has revealed a potential link between lipoprotein levels and Alzheimer's Disease. There is a growing interest in establishing a separation technique capable of efficiently and robustly distinguishing the five primary classes of lipoproteins. These classes, HDL, LDL, IDL, VLDL, and Chylomicrons each contain a unique combination of triglycerides, cholesterol, and apolipoproteins. Prior methods of lipoprotein separation have included ultracentrifugation, electrophoresis, gel permeation chromatography, and anion exchange chromatography. Many of these previous methods fell short of delivering accurate measurements in a robust, time-efficient manner. Our research utilizes anion exchange chromatography to focus on two goals: increasing sample analysis time efficiency and decreasing inter-sample variability. Prior anion exchange chromatographic methods have required one hour to analyze a single plasma sample, a roadblock to large-scale data collection. Our objective was to complete the analysis of a single sample in fifteen minutes or less with low levels of inter-analysis variability, allowing for the accurate gathering of large amounts of data from a multitude of plasma samples in a time-efficient manner. By accomplishing these objectives, we hope to contribute to the understanding of the connection between lipoproteins and neurological diseases.

Presenter(s): Avery Greene
School: Lawrence University
Session: Oral: I.D3
Title: Core Excited State Dynamics and Transition Dipole Moments with Ultrafast Laser Pulses at Xenon4,5-edge
Advisor(s): Nicolette Puskar, Chemistry, University of California, Berkeley

Co-Author(s): Patrick Rupprecht, Daniel Neumark, Stephen Leone
Abstract: As ultrafast laser pulses have reached the timescale of core excited state dynamics, many spectroscopic techniques have grown in tandem. One such technique is four-wave-mixing (FWM) spectroscopy, which involves exciting a core electron to a dipole-allowed “bright state” with a pump pulse, then simultaneously coupling to nearby dipole-forbidden “dark states” with two probe pulses. Meeting the phase matching condition of these three “waves” causes changes in the polarization of the sample medium. This produces a fourth spatially isolated background-free resonant emission “wave.” This technique was employed in xenon using an XUV pump pulse and two NIR probe pulses in order to observe transitions from the 4d ground state to the 4d-16p and 4d-17p excited states. One result of the pump-pulse laser schematic is the presence of both attosecond transient absorption (ATA) signal from the probe and FWM emission signal. A computational model was derived to determine experimental transition dipole moments from both ATA and FWM signal. These results were compared while promising similarities were exhibited, there is much progress to be had in the development of modeling FWM emission integration. Experimental results were compared with previous theoretical calculations and found significant differences.

Presenter(s): Xiao Hong
School: Washington University in St. Louis
Session: Oral: I.B.3
Title: Computational Aspect of Curvatures of Some Cayley Graphs
Advisor(s): Renato Feres, Department of Mathematics, Washington University in St. Louis
Co-Author(s):
Abstract: The research let the readers make sense of curvature on geometric objects beyond classical Riemannian manifolds, specifically on Markov chains in metric spaces and on combinatorial graphs. We also examine compatibility of new definitions with classical ones and applicability of new definitions in terms of analogs of theories in different geometries. The research applies these definitions to a class of graphs, Cayley grpahs, and provide algorithmic improvement of computation of curvature of Cayley graph of certain groups. In particular, symmetric properties help us to improve the computational ability of general linear programming solver of optimization involved in the discrete curvature definition.

Presenter(s): Michelle Hu
School: University of Chicago
Session: Poster: P3.04
Title: Building Cateye Lasers for Chemical Enhancement of Strontium-Monofluoride (SrF) production and Magneto-Optical Trapping of Sr
Advisor(s): David DeMille, Department of Physics, University of Chicago
Co-Author(s):
Abstract: As part of DeMille Lab’s laser cooling and trapping of SrF molecules experiment, we produce SrF molecules using a cryogenic buffer gas beam source. We are interested in implementing an on-resonance 461 nm laser that will excite Sr atoms their excited state so we could potentially chemically enhance the production of SrF. Previous work done at the DeMille Lab has shown that the more common Littrow designed External Cavity Diode Laser (ECDL) at 461 nm is very unstable. In this work, we design and build Cateye designed ECDL at 461 nm, as its geometry makes it “self-aligning”, which leads to high feedback efficiency and narrow linewidth. Our work shows that that with the Cateye design, the 461 nm blue laser exhibits single peak and nice tunability (~ three free spectral ranges). With the stably lasing Cateye ECDL, we proceed to characterize the Sr atomic beam. From shining the laser both transverse and along the Sr beam, we obtain both the number of atoms present in the beam and its velocity profile. Lastly, we hope to turn on the 461 nm, 689 nm (Sr) and 663 nm (SrF) lasers and determine if the number of SrF molecules increases.

Presenter(s): Kyle Hulle
School: University of Chicago

Session: Oral: II.G.5
Title: Mid-IR, Physical, and Optical Characterization of Polyaniline (PANI) for Electrochromic Purposes
Advisor(s): Po-Chun Hsu, Pritzker Molecular Engineering, University of Chicago
Co-Author(s): Ting-Hsuan Chen
Abstract: While polyaniline (PANI) is an otherwise well-characterized semiconducting polymer (CP), its optical properties and related mechanisms are lesser known. Both within and outside the field of electrochromism - the phenomenon wherein a material's optical properties are modulated with an electrical potential - PANI literature has heavily focused on synthesis protocols for increasing conductivity and visible light modulation. However, much remains uncharacterized for mid-IR - a key region for heat management applications. As such, we created PANI thin-films with variable synthesis protocols, doping levels, and thin-film solvents, and tested their mid-IR electrochromic performance, mass change during voltage switching via Electrochemical Quartz Crystal Microbalance experiments (EQCM) and probed and modeled their optical properties with ellipsometry. We also repeated these measurements using PEDOT:PSS, a more commonly used mid-IR CP. We found that PANI thin-films had higher electrochromic performance in the mid-IR region than PEDOT:PSS films. Additionally, we speculate this originates from intrinsic differences in ionic diffusion and charge transport between PANI and PEDOT:PSS, based on EQCM and ellipsometry data. Overall, our data, beyond beginning a process to better characterize PANI in the mid-IR, also suggests PANI is more efficient, relative to PEDOT:PSS, as evidenced by higher electrochromic performance, which we suggest may be mechanically due to differences in ionic and electronic transport.

Presenter(s): Mohammad Tanzil Idrisi
School: Beloit College
Session: Poster: P1.21
Title: Quantization optimization: Autoencoders and Lloyd-Max for data compression
Advisor(s): Mehmet Dik, Mathematics and Computer Science, Beloit College
Co-Author(s):
Abstract: In the context of lossy compression, the rate-distortion function plays a crucial role in establishing the minimum required rate for reconstructing a source according to its distribution. This lower bound is well-defined for sources following a Gaussian distribution. We train and test an autoencoder with Gaussian inputs and aim to compress and reconstruct the source with distortion close to that defined by the rate-distortion function. We observe that autoencoders are far from optimal stand-alone compressors, but perform well when coupled with quantizers. Traditional image compression relies on handcrafted codecs that lack adaptability. Recently, researchers have been using deep neural networks (DNNs) to design compression systems. However, a common theme in these works is the use of primitive quantization schemes, such as rounding. In this project, we propose using the Lloyd-Max algorithm for quantization, which is proven to minimize the expected distortion. We show that utilizing the Lloyd-Max quantization leads to better reconstruction performance across all bit-rates compared to simply rounding.

Presenter(s): Avital Isakov
School: Washington University in St. Louis
Session: Poster: P1.18
Title: Generalizing linear regression models for predicting neutral oxygen vacancy formation to design materials for STCH
Advisor(s): Robert Wexler, Chemistry, Washington University in St. Louis
Co-Author(s): Ethan Nussinov
Abstract: Solar thermochemical hydrogen production (STCH) is a carbon-free means of producing hydrogen fuel, which is receiving increasing interest due to its ability to utilize the entire solar spectrum. Two-step STCH cycles produce hydrogen by thermally reducing a metal oxide at high temperatures (~1800K) using concentrated solar technologies, generating oxygen vacancies. The reduced metal oxide is then cooled (to

~1200K), and water vapor is passed over it. The metal oxide re-oxidizes, removing the oxygen from water, filling oxygen vacancies, and producing hydrogen.
For a standard reactor and operating conditions, the efficiency of two-step STCH is maximized when the metal oxide's oxygen vacancy formation enthalpy (ΔHv) is ~3.4-3.9 eV. While inexpensive, the state-of-the-art material, CeO_2, has too high a ΔHv (i.e., 4.4 eV) to be economically viable. To make two-step STCH more economical, metal oxides must be designed whose oxygen vacancy formation energies are within the optimal range. Regression models provide a route to high-throughput computational screening by predicting hard-to-calculate properties (e.g., ΔHv) from easily accessed features. We developed a linear regression model for ΔHv with sufficient accuracy over a wide range of metal oxides, generalizing the relationship between crystal features and ΔHv.

Presenter(s): Naysha Jain
School: Knox College
Session: Poster: P2.06
Title: BALANCE: Balloon Altitude Analysis of Cosmic Ray Flux Experiment
Advisor(s): Allison Jaynes, Physics and Astronomy, University of Iowa
Co-Author(s): Henry Krain, Klara Kjome Fischer, Meklit Shiferaw
Abstract: The BALANCE (Balloon Altitude Analysis of Cosmic Ray Flux Experiment) project aims to investigate the variation of cosmic ray flux with altitude, shedding light on the origins and fundamental physics of cosmic rays. It delved into the nature of cosmic rays, their interactions with Earth's atmosphere, and the principles of radiation detection.
To accomplish this, we employed three Geiger-Muller (GM) tube detectors to measure ionizing radiation, capturing secondary particles of cosmic rays and attached copper alloy shielding to hold the tubes with varying thickness for radiation measurement. Our payload included a housing for three high-voltage circuit boards, three 9V batteries, and an Arduino board. Data collection involved recording and counting Geiger counter voltage pulses and time-stamping the data to match altitude.
Analysis of the data revealed that cosmic ray counts decreased with increased shielding, consistent with prior research. The ratio of high to low energy particles does not change within altitude range. Notably, high-energy particles exhibited unexpected counts, possibly attributed to median energy selection.
This experiment was conducted as a part of the Edge of Space Academy at University of Iowa where I served as the Project Scientist. It was a 2 week project which included ideating, production, launch and analysis. We also collaborated with Iowa State University as our spacecraft provider.

Presenter(s): You Jung Ji
School: Colorado College
Session: P1.05
Title: Test on Indoor Air Quality and Ventilation Rates of University Dormitories and Potential Solutions
Advisor(s): Sally Meyer, Chemistry and Biochemistry, Colorado College
Co-Author(s): Cathy Xiao
Abstract: Although the average American spends 90% of their time indoors, many people are not aware of the importance of indoor air quality (IAQ). Since most dormitories are small and crowded, the impacts of indoor air pollution can be more severe. To improve IAQ in the dormitories, this study monitors particulate matter (PM2.5) and carbon dioxide (CO_2) and compares IAQ with or without plants and humidifiers. In the CO_2 case, the student living in the room is the source of the pollution. High concentrations of CO_2 and PM2.5 correlate with increased drowsiness and lower cognitive ability, and potential health concerns. This research uses low-cost portable sensors to measure CO_2 and PM2.5. Based on the results, Mathias double rooms with only one resident had both CO_2 and PM2.5 concentrations above health levels which are 1000ppm for CO_2 and 35

μg/m3 for PM2.5. Additionally, the use of humidifiers correlated with an increase in indoor PM2.5 levels above the maximum exposure limit. This research also shows that the presence of C3 or CAM plants can effectively lower nighttime CO2 concentrations, but they contribute to higher PM2.5 levels. With as many plants in the windows as there was space for the CO2 level still remained at an unhealthy level. These findings emphasize the need to explore alternatives to enhance overall IAQ within dormitory settings.

Presenter(s): Lily Johnston
School: Colorado College
Session: Oral: I.A.4
Title: Clouds and Precipitation Prediction within the GFDL SHiELD Model
Advisor(s): Allison Lawman and Linjiong Zhou. Environmental Science; Atmospheric & Oceanic Sciences, Colorado College, Princeton University
Co-Author(s): Linjiong Zhou
Abstract: Cloud and precipitation prediction poses considerable challenges in many numerical models. The System for High-resolution prediction on the Earth-to-Local Domains (SHiELD), developed at the Geophysical Fluid Dynamics Laboratory (GFDL), a Unified Forecast System UFS prototype atmospheric model, is used to evaluate the prediction accuracy of clouds and precipitation. In SHiELD, the complexities of cloud and precipitation prediction have resulted in noticeable biases in predicting the geographic distribution of precipitation, precipitation diurnal cycle, ice and liquid water path, and cloud fraction. We assessed the accuracy of the SHiELD model's predictions of clouds and precipitation and evaluated to what extent we could enhance the prediction accuracy by doubling the model's horizontal resolution from 13 km to 6.5 km. We found that the SHiELD prediction system exhibits the potential for improving cloud and precipitation prediction via higher horizontal resolutions. Significant tests help uncover and understand the true biases in the SHiELD system, with the goal of proposing solutions for improving cloud and precipitation prediction.

Presenter(s): Liam Keeley
School: Colorado College
Session: Oral: I.C.1
Title: Electrohydrodynamic Simulations of Pre-breakdown Electrons in a UV-Triggered Spark Gap
Advisor(s): Adam D. Light. Physics. Colorado College
Co-Author(s):
Abstract: By continuously charging and discharging a spark gap, it is possible to ¬achieve a high voltage pulse train of ~100ns pulses. However, many applications of spark gaps require a pulse stability which cannot be achieved by simply charging a spark gap and waiting for it to discharge: these applications need a trigger mechanism. We propose triggering a spark gap with a pulse of ultraviolet light, which has two effects: first, it provides a source of seed electrons. Additionally, because the photoelectric effect produces electrons but no ions, we create a negatively charged cloud around the cathode, which reinforces the applied electric field and can cause a spark gap held just below its breakdown voltage to discharge. In this poster, we discuss electrohydrodynamic simulations of the electron cloud prior to breakdown and present preliminary results describing regimes in which sufficient field reinforcement occurs so that a spark gap can be reliably triggered.

Presenter(s): Kaashya Khandelwal, Emelyce Bigirimana
School: St Olaf College
Session: Poster: P2.14
Title: How can we employ network methodologies to capture the dynamic evolution of mycorrhizal networks**?**
Advisor(s): Paula Mercurio, MSCS (Math Stats Computer Science), St. Olaf College
Co-Author(s):
Abstract: Having gained expert attention; mycorrhizal networks (MNs) as intricate systems of symbiotic relationships with complex dynamics are understood through the lens of graph theory. In order to model mycorrhizal networks; we employed both bipartite (BiNE, Loss Function) and non-bipartite methods (LE, N2V)

as well as random walk (BINE, N2V) and deterministic methods (LE, Loss function) to find our embeddings. These embeddings tell us the functional similarities between the trees and fungi, their associations and nutrient exchange. Link prediction is also used to assess lost connections and potential future links that could be formed. While all these methods were accurate a deterministic approach is more effective and preferred in modeling complex dynamics of MNs. The proposed mathematical modeling brings valuable insights into intricate dynamics governing MNs.

Presenter(s): Smayan Khanna
School: University of Chicago
Session: Poster: P3.22
Title: Thermodynamics and kinetics of DNA and RNA dinucleotide hybridization to gaps and overhangs
Advisor(s): Andrew Ferguson, Pritzker School of Molecular Engineering, University of Chicago
Co-Author(s): Brennan Ashwood, Michael S Jones, Aleksandar Radakovic, Smayan Khanna, Yumin Lee, Joseph R. Sachleben, Jack W. Szostak, Andrei Tokmakoff
Abstract: Hybridization of short nucleic acid segments (<4 nt) to single-strand templates occurs as a critical intermediate in processes such as nonenzymatic nucleic acid replication and toehold-mediated strand displacement. These templates often contain adjacent duplex segments that stabilize base pairing with single-strand gaps or overhangs, but the thermodynamics and kinetics of hybridization in such contexts are poorly understood because of the experimental challenges of probing weak binding and rapid structural dynamics. Here we develop an approach to directly measure the thermodynamics and kinetics of DNA and RNA dinucleotide dehybridization using steady-state and temperature-jump infrared spectroscopy. Our results suggest that dinucleotide binding is stabilized through coaxial stacking interactions with the adjacent duplex segments as well as from potential noncanonical base-pairing configurations and structural dynamics of gap and overhang templates revealed using molecular dynamics simulations. We measure timescales for dissociation ranging from 0.2–40 μs depending on the template and temperature. Dinucleotide hybridization and dehybridization involve a significant free energy barrier with characteristics resembling that of canonical oligonucleotides. Together, our work provides an initial step for predicting the stability and kinetics of hybridization between short nucleic acid segments and various templates**.**

Presenter(s): Bethel Kifle
School: University of Chicago
Session: Oral: I.D.5
Title: Entanglement enhanced optical fiber sensor made of an efficient energy-time entangled photon-pair source and interferometer
Advisor(s): Laurent Labonte, Collaboration: University of Chicago and Université Côte d'Azur
Co-Author(s):
Abstract: Optical phase measurement with interferometers is one of the most advanced techniques in classical metrology and most recently led to the detection of gravitational waves. On the other hand, quantum technologies have received substantial attention as a means to improve the resolution of metrological tasks by reducing statistical errors due to quantum noise. The optimal accuracy that can be achieved by measurements of an unknown phase by an interferometer with classical methods can be overcome by using quantum light. A canonical example relies on entanglement of N photons in an equal superposition of being in either one of the two modes of an interferometer, resulting in a shortened de-Broglie wavelength. This leads to an increase of the interferometric fringe pattern frequency by a factor of N (super-resolution) without changing the optical wavelength, allowing the latter to be chosen for optimized transmission through optical single-mode-fibers. The development of an entanglement-enhanced optical fiber sensor made of an efficient energy-time entangled photon-pair source working in the telecom range and interferometers is provided. In addition, a theoretical exploration of quantum resources and system architecture to envision the deployment of practical quantum fiber optic sensors exhibiting enhanced resolution is touched upon.

Presenter(s): Rachel Kovach-Fuentes
School: University of Chicago
Session: Oral: I.C.2
Title: Smartpixels: Towards on-sensor inference of charged particle track parameters and uncertainties
Advisor(s): Karri DiPetrillo, Physics, University of Chicago
Co-Author(s): Lindsey Gray, Jennet Dickinson, Morris Swartz, Giuseppe Di Guglielmo, Alice Bean, Doug Berry, Manuel Blanco Valentin, Karri DiPetrillo, Farah Fahim, James Hirschauer, Shruti R. Kulkarni, Ron Lipton, Petar Maksimovic, Corrinne Mills, Mark S. Neubauer, Benjamin Parpillon, Gauri Pradhan, Chinar Syal, Nhan Tran, Dahai Wen, Jieun Yoo, Aaron Young
Abstract: The combinatorics of track seeding has long been a computational bottleneck for triggering and offline computing in High Energy Physics (HEP), and remains so for the High-Luminosity Large Hadron Collider (HL-LHC) at CERN. Next-generation pixel sensors will be sufficiently fine-grained to determine angular information of the charged particle passing through from pixel-cluster properties. This detector technology immediately improves the situation for offline tracking, but any major improvements in physics reach are unrealized since they are dominated by level-one trigger acceptance. We will demonstrate track angle and hit position prediction, including errors, using a mixture density network within a single layer of silicon as well as the progress towards and status of implementing the neural network in hardware on both FPGAs and ASICs. Further, the importance of these results in a potential pixel track trigger will be demonstrated.

Presenter(s): Adam Krekeler
School: Lawrence University
Session: Poster: P3.15
Title: Unraveling how Microtubules Unravel: Experimentally Verifying a Model for Microtubule Depolymerization
Advisor(s): Douglas Martin, Physics, Lawrence University
Co-Author(s): Hilirie McLaughlin
Abstract: We collected experimental data to determine whether it supported either of two proposed models for microtubule shrinking. Microtubules are hollow, tubular proteins, and they form structures in cells called mitotic spindles; during cell division, the mitotic spindle of a cell unravels to pull chromosomes to opposing ends of a cell. The two proposed models for microtubule shrinking predict different widths for shrinking ends; the biased diffusion model predicts 25 nm, and the conformational wave model predicts 50 nm. We used super-resolution microscopy to image microtubules as they were shrinking (a special type of microscopy utilized because microtubules are smaller than the wavelength of light, and thus cannot be seen using a traditional light microscope). Our analysis (n=46) revealed an average shrinking end width of 16.0 nm, which more closely supports the biased diffusion model.

Presenter(s): Mark Krysan
School: Grinnell College
Session: Poster: P3.20
Title: Analyzing changes in driving performance in individuals who use cannabis following acute use.
Advisor(s): Jonathan Wells, Ryan Miller, Grinnell College
Co-Author(s):
Abstract: With the legalization of cannabis in many states, it is important to understand its impact on driving performance. Driving simulators have been used to run safe experiments on intoxicated driving. In most driving simulator studies, standard deviation of lateral position (SDLP) has been used as a measure of driving performance. However, this statistic is too reductive to analyze a variety of driving behavior differences. We instead use a third order autoregressive time series model with a signed error term to model driving lane position. In the AR model, logistic regression is used to parameterize a driver's tendency to return to their resting position. We use this parameter to compare driving performance across different drives. We apply this model to longitudinal data involving a baseline drive followed by acute cannabis dosing and three follow-up

drives spread across a two-hour timeframe. We then model the change in driving performance from the baseline to the dosed drives using mixed effects linear regression, where predictors such as use history, perceived readiness to drive, time after dose, and perceived feelings of intoxication are used to better understand each driver.

Presenter(s): Sahil Kumar
School: Grinnell College
Session: Poster: P3.11
Title: Experimental and Theoretical SSCC for Propane and Propyne
Advisor(s): T. Andrew Mobley, Chemistry, Grinnell College
Co-Author(s):
Abstract: Solute-solvent interactions play a pivotal role in various biological and industrial applications. Investigating their interactions is crucial in determining solubility, reactivity, and structure across various fields of physical and organic chemistry. The 3JHH, 2JCH, and 1JCH spin-spin coupling constants (SSCCs) of propane and propyne were measured experimentally and calculated using density functional theory (DFT). Experimental data was obtained using a 400 MHz Bruker Avance Instrument and geometry optimizations and coupling constant calculations were carried out using the Amsterdam Density Functional (ADF) software. The structures were first geometry optimized (B3LYP/QZ4P with COSMO as an implicit solvent model) and then to calculate the SSCCs a single point (PBEO/QZ4P-J with COSMO) was carried out. This paper will discuss our experimental and computational findings and discuss the applicability of DFT calculations for predicting solvent effects in small, organic molecules.

Presenter(s): Julie Lampert
School: Washington University in St. Louis
Session: Poster: P2.02
Title: Density Matrix Renormalization Group Studies on Bond Dissociation Energies of Transition Metal Molecules
Advisor(s): Kade Head-Marsden, Chemistry, Washington University in St. Louis
Co-Author(s): Anthony Schlimgen
Abstract: The bond dissociation energy (BDE) is not only a valuable metric for determining reaction enthalpies and molecular stability, but also a convenient tool for benchmarking levels of theory in electronic structure calculations. Information about transition metal compounds is of great interest due to their catalytic capabilities, yet they are notoriously difficult to model given their strong multi-reference character and large active spaces. We show that ab initio Density Matrix Renormalization Group (DMRG) calculations can reliably model bond dissociation processes in transition metal molecules and produce results that concur with previously reported experimental periodic trends in BDEs. Furthermore, we utilize orbital entanglement measures to quantify electron correlation, allowing for the assessment of orbital interactions throughout the dissociative process. Our findings establish the DMRG algorithm as a useful method for determining BDEs of transition metal compounds and provide insight into the mechanisms these dissociations from an electronic structure perspective.

Presenter(s): John Lê
School: Colorado College
Session: Oral: II.E.1
Title: Optimization of tip etching for scanning probe microscopy studies of semiconductor superlattices
Advisor(s): Zhigang Jiang, Phillip N. First, Physics, Georgia Institute of Technology
Co-Author(s): Alisha Vira, Harshavardhan Murali
Abstract: Semiconductors are powerful materials at the heart of our everyday technology and electronics. We are specifically motivated to study semiconductor superlattices, where two different semiconductor materials (either doped or undoped) are alternated in few-nanometer layers to create a new material, with electronic

properties tuned by the superlattice alternation period. To understand the properties of these superlattices, we characterize their atomic structure by Scanning Tunneling Microscopy (STM) and/or Atomic Force Microscopy (AFM). These techniques help us study quantities such as the bandgap and the energy spectrum. Scanning semiconductor surfaces at the atomic-level requires an atomically-sharp tip, which transmits either the tunneling current in STM or the force in AFM. To achieve atomic resolution in topographical scans, the tip apex should be comparable to the size of a single atom. This requires well-controlled electrochemical etching and further "tip preparation" within the STM/AFM instrument. We present an adaptable procedure for creating homebrew tips using electrochemical etching for tungsten and platinum-iridium wire, where certain conditions must be met to effectively shape the tip. We also present some of the data we acquired using the tips etched according to the procedure we developed.

Presenter(s): Vu Anh Lee
School: Beloit College
Session: Poster: P1.02
Title: Monitoring Subsidence Trends of Underground Water Exploitation Areas Using InSAR Techniques
Advisor(s): Mehmet Dik, Mathematics and Computer Science, Beloit College
Co-Author(s): Quoc-Hung Le
Abstract: Land subsidence is an escalating concern, particularly in urban centers like Ho Chi Minh City, Hanoi, and the Mekong Delta region. A 2019 report by the Copernicus EMS program highlights trends in ground subsidence, using InSAR technology. Subsidence rates vary spatially and in intensity, with hotspots in certain areas. Techniques like deep boreholes and traditional methods are employed to monitor subsidence in the Mekong Delta region. The project aims to delineate, assess, and monitor subsidence using InSAR technology in key regions. Results indicate diverse subsidence patterns from 2007 to 2010, with varying levels across different provinces. Notably, certain regions experience higher subsidence funnel centers. However, while the SBAS-INSAR technique ensures accurate monitoring, natural and human-induced factors must be considered during data acquisition, affecting actual subsidence rates. Despite challenges, this technique offers reliable insights into the complex phenomenon.

Presenter(s): Melody Leung
School: University of Chicago
Session: Poster: P2.10
Title: Enhanced Collection Efficiency with Laser-Written Nitrogen-Vacancy Centers in Diamond Nanopillars
Advisor(s): Alex High, Pritzker School of Molecular Engineering, University of Chicago
Co-Author(s): Anchita Addhya, Tanvi Deshmukh
Abstract: The nitrogen-vacancy (NV) center in diamond can detect a variety of physical quantities, such as magnetic fields, with unprecedented spatial resolution and sensitivity, which can enable powerful diagnostic capabilities in biological and condensed matter systems. However, its sensitivity is limited by the additional defects and strains introduced during NV creation that reduce coherence time, which need to be addressed via material developments and new sensing protocols to improve collection efficiency.
We aim to design and fabricate diamond nanopillars with sub-100 nm thick direct-bonded membranes on glass to enhance sensitivity and collection efficiency. Lumerical photonics simulations show more than 60% collection efficiency in the direct-bonded diamond nanopillars, a six-fold increase from the 10% collection efficiency demonstrated in bulk diamond. Testing surface etching techniques and atomic layer deposition of various dielectrics, we further extend NV coherence and improved charge state stability.
Using ultrafast laser pulses at 4K, we deterministically created NV centers in more than half of our nanopillar array by first creating vacancies then by driving vacancy diffusion to the nitrogen. Taking a photoluminescence spectra, we observed over a 5X increase in photoluminescence from the bare membrane to the nanopillars,

demonstrating increased collection efficiency through coupling to the nanopillar mode.

Presenter(s): Hanchen Li
School: University of Chicago
Session: Oral: II.H.3
Title: Optimizing Real-Time Video Experience with Data Scalable Codec
Advisor(s): Junchen Jiang
Co-Author(s): Yihua Cheng, Ziyi Zhang, Qizheng Zhang, Anton Arapin, Nick Feamster
Abstract: Real-time video communication is becoming more and more im- portant. However, packet loss is prevalent and resending packets, especially in long-latency networks, causes visual stalls. Previous solutions all perform suboptimally as they either add redundancy before sending the data, which reduces bitrate when no packet is lost, or fail to prevent video freeze when redundancy is not enough. User studies confirm that both bitrate decrease and video freeze significantly damage users' Quality of Experience (QoE). Through a user study comparing different artifacts during a quality drop period, we find that moderate quality drop is preferred over video freeze during packet loss. Inspired by this, we propose a new solu- tion that trains a neural network Autoencoder to optimize frame quality under different packet loss rates. Our insight is that such training produces a Data Scalable codec, whose quality increases with each new packet arrival and reaches highest quality when no packet is lost. Specifically, with the arrival of any x encoded bytes of a frame, the decoded quality is closer to the quality than if the whole frame were encoded with x bytes in the first place. Thus, unless all packets are lost, our approach causes a moderate quality drop instead of video freeze during packet loss. In the end, we identify the technical challenges remaining in this approach and point out future opportunities.

Presenter(s): Xiangchen Li
School: University of Chicago
Session: Oral: II.H.4
Title: Study of branching ratio for KL to Pi0 e+e-e+e-
Advisor(s): Yau W. Wah, Physics, University of Chicago
Co-Author(s):
Abstract: My goal is to measure the branching ratio of Klong decay into one neutral pion and two pairs of electron and positron (KL->pi0 e+e-e+e-). Klong, one type of kaon which are composed of one strange and one up or down quark, exhibits a variety of decay modes. The branching ratio is a crucial quantity that characterizes the probability of a given decay mode occurring, and measuring it is of huge importance for the understanding of this subatomic particle and also related to the asymmetry of our universe. Remarkably, this decay mode has never been measured experimentally due to its rareness. One theory article postulates that one similar decay (K+ ->pi0 e+e-e+e-) is at the order of 10^-11. However, I will take advantage of the high precision of our KOTO experiment. Through the study of simulation generated by a software called Geant4, we can develop a reconstruction algorithm and a system of physical cuts to discriminate background decays. With these methods, we can study the real physical data taken by our experiment in 2021 and measure the branching ratio.

Presenter(s): Eileen Limon
School: Lawrence University
Session: Oral: II.F.1
Title: Keeping up with your heart rate
Advisor(s): Margaret Koker, Physics, Lawrence University
Co-Author(s): Sophia Labrecque
Abstract: The use of MAX30102 with Adafriit CLED 128 × 32 in the Arduino board is used to measure and view heart rate. Using MAX30102 as a sensor and implementing code for the outputs results of the sensor into the OLED. By being able to create this on the audrino board and some knowledge of circuitry; we are able to keep

track of a person's health for everyday use. These everyday items can be found of the same components made in this experiment. A smart watch when running for example can keep track of a person's heart rate to medical examinations used by doctors in the ER. By exploring the code, Arduino Uno board we are able to get the reading and understanding how the heart rate monitor works. And understand how the MAX30102 is able to physically read from the sensor just by having a person placing their finger tip on the scanner.

Presenter(s): Diangen Lin
School: University of Chicago
Session: Oral: II.E.4
Title: Single-Molecule Study of Disaggregation of Biomolecular Condensates by Heat Shock Proteins
Advisor(s): Allison H. Squires, Pritzker School of Molecular Engineering, University of Chicago
Co-Author(s): Kyle M. Lin, D. Allan Drummond
Abstract: Heat shock and other cellular stresses cause the formation of protein aggregates, which are dispersed by stress-induced heat shock proteins (Hsps). Such aggregates are frequently assumed to form by toxic protein misfolding. However, mounting evidence shows that endogenous heat-induced protein aggregates form by adaptive processes of biomolecular condensation. One such protein, poly(A)-binding protein (Pab1) from yeast, forms condensates that are much more efficient substrates for yeast Hsps than misfolded protein aggregates. This discovery reopens fundamental questions about how non-misfolded, endogenous biomolecular condensates are dispersed by Hsps. Molecular-scale kinetics of condensate disaggregation is lacking. Here, we employ single-molecule total internal reflection fluorescence microscopy (TIRFM) to quantify the rate of disaggregation of Pab1 condensates. We directly image Pab1 condensates in the presence of condensate-dispersing Hsps, and measure condensates' change in fluorescence intensity at discrete intervals over time. To determine the effect of condensate size on the disaggregation rate, we further classify individual condensates based on their initial sizes, estimated by their initial fluorescence intensities and extrapolated intensities of single Pab1 molecules. Characterization of the kinetics of condensate disaggregation will inform future investigations of Hsp binding and stoichiometries and contribute to fundamental understanding of molecular-scale interactions between Hsps and biomolecular condensates.

Presenter(s): Hongyi Liu
School: Macalester College
Session: Poster: P1.12
Title: Estimates of the best constant for spherical restriction inequalities
Advisor(s): Taryn Flock**,** Macalester College
Co-Author(s):
Abstract: The restriction conjecture asks for a meaningful restriction of the Fourier transform of a function to a sufficiently curved lower dimensional manifold. It then conjectures certain size estimates for this restriction in terms of the size of the original function. It has been proven in 2 dimensions, but it is open in dimensions 3 and larger, and is an area of much recent active effort. In our study, instead of aiming to prove the restriction conjecture, we target understanding its worst-case scenarios within known estimates. Specifically, we investigate the extension operator applied to antipodally concentrating profiles, examining the ratio of the norms of these extensions. This involves understanding how the mass near the north pole compares to the mass near the south pole in terms of magnitude. Initial computational studies confirmed the established dichotomy between $p \geq 2$ and $1 \leq p < 2$. Based on these findings, we propose two conjectures: the first conjectures the function's monotonicity when $p > 2$, and the second shifts the study focus from the interval [0,1] to its endpoints. Our current focus is to evaluate the L-q norm of the ratio function to a more familiar form.

Presenter(s): Zisheng Luo
School: Washington University in St. Louis
Session: Poster: P3.17

Title: Developing an Efficient Job-Scheduling Algorithm For Global Atmospheric Simulation
Advisor(s): Kunal Agrawal, Computer Science, Washington University in St. Louis
Co-Author(s): Jordan Sun
Abstract: Global Atmospheric Simulation requires significant CPU resources and time, and the job-scheduling algorithm running on NASA's system, consisting of multiple computing resources, has room for improvement. Running atmospheric simulation involves computing large columns of data as well as communicating data between computers.
By leveraging the geographical nature of the data used in the simulation, we aim to maximize the potential of each computer by reducing the idleness of CPUs and the total time necessary to run atmospheric simulations. Since the overall speed of our simulation is limited by the processor with the heaviest workload, our version of the greedy algorithm aims to reduce inefficient communication between CPUs. Our strategy is to seek the locally best scheduling of CPUs that first minimizes the communication costs as long as the workload remains under a certain threshold, which is calculated based on the average of the total workload across all processors.

Presenter(s): Yoyo Ma
School: University of Chicago
Session: Poster: P1.22
Title: Thermoresponsive Polymersomes for Vaccine Delivery
Advisor(s): Stuart Rowan, Jeffrey Hubbell, Pritzker School for Molecular Engineering, The University of Chicago
Co-Author(s): Samir Hossainy
Abstract: Recent innovations in vaccines, which are safer and faster to develop than traditional vaccines, involve sensitive payloads that often fail to elicit robust immune responses; thus, research into novel vaccine delivery methods is needed. As an alternative to existing viral delivery systems, researchers have designed polymeric nanoparticles (polymersomes) that contain an aqueous cavity and encapsulate vaccine payloads. The polymer-based properties of polymersomes allow more stability and size tunability than the industry standard while maintaining a comparable payload loading efficiency. Here, we design temperature responsive polymersomes as a platform technology for enhancing payload delivery. The formulations here demonstrate easy assembly of near-monodisperse polymersomes without organic solvents through 1) room temperature-responsive polymersome assembly and 2) affinity-driven payload encapsulation. Our block copolymers are fully solubilized in buffered saline when kept refrigerated but homogenously self-assemble at room temperature into polymersomes. Our work focuses on using polymersomes to deliver protein payloads such as ovalbumin as a model for prophylactic vaccines, and are designed for versatile protein delivery, thus serving as a platform technology for a variety of parenteral formulations.

Presenter(s): Destiny McLaws
School: Colorado College
Session: Poster: P2.12
Title: Synthesis of Isoniazid-derived Metal Schiff Base Complexes
Advisor(s): Amanda Bowman, Colorado College, Chemistry and Biochemistry
Co-Author(s):
Abstract: Schiff bases are aldehyde or ketone like compounds where the carbonyl group is replaced by azomethine or imines, they are one of the most widely used organic compounds. Schiff bases are used as dyes, intermediates for organic synthesis or catalysts, and have wide applications in medical research, due to their antimicrobial activity and fighting of cancer cells. Research with other Schiff base ligands and synthesis of Schiff base metal complexes such as cobalt complexes, have found the antimicrobial activity is greater in metal Schiff base complexes when compared to the ligand alone.
This research focuses on the synthesis and characterization of isoniazid derived Schiff base ligands as well as the synthesis of cobalt and manganese complexes with the synthesized ligand and characterization of air stable metal complexes. Characterization was done using Infrared spectroscopy, 1H’NMR, Ultraviolet-visible, Raman and 13C’-NMR spectroscopies. 1H’-NMR and 13C’-NMR spectroscopies confirm successful synthesis of

isoniazid derived Schiff bases. 1H'-NMR of spectroscopy confirmed successful synthesis of the metal complexes, with spectra showing an expected number of peaks based on the symmetry of the complex. The Infrared spectroscopy of the ligands compared to complexes shows a shift in peaks and intensity that indicates a 1:2 metal complex formation.

Presenter(s): Connor McMillin
School: Grinnell College
Session: Oral: I.C.3
Title: Geometrodynamics of a Quantum Mechanically Confined Particle on a 2D Curved Surface
Advisor(s): Shanshan Rodriguez, Physics, Grinnell College
Co-Author(s): Leo Rodriguez, Ram Ram-Mohan
Abstract: We explore the geometrodynamic equation of motion of a quantum-confined particle on a two-dimensional curved surface of a semiconductor device (such as a graphene Buckyball). Building on the seminal work of de Costa/Mazharimousavi and motivated by the finite element method, we formulate a two-dimensional action principle of the quantum-constrained particle, which reproduces Schrodinger's equation on the curved surface. We then explore how to find the Einstein equation by varying the action with respect to the two-dimensional inverse metric. The geometrodynamical analysis is performed within a two-dimensional dilation gravity analog due to several computational advantages. This framework will be used to determine the perturbed geometry and ultimately to achieve shape optimization of the device.

Presenter(s): Sam Mamicha
School: Macalester College
Session: Poster: P2.25
Title: Robust Aromatic DiHydrazides
Advisor(s): Dennis D.Cao, Chemistry, Macalester College
Co-Author(s):
Abstract: Increased modernization and the need for robust, reliable dyes and polymers have led to aromatic diimides emerging as the industry staples in the synthesis of polymers, dyes, and pigments. The robustness and stability of the molecule are noted and provided by its benzene parent structure. Furthermore, side-chain engineering of the molecule makes it attractive in the synthesis of industrially relevant polymers that may observe pi-pi interactions(pi-symbol needed here). Nevertheless, the molecules' robustness is limited as the five-membered ring presents itself as a limiting factor. Due to the strain observed in the ring, the ring is prone to nucleophilic attacks from molecules such as water and other "hard" nucleophiles. With this observation, a research thrust was embarked on to synthesize and characterize an improved scaffold that possesses the desired qualities of Aromatic Diimides. More specifically, a research thrust was initiated to synthesize a scaffold that is lesser prone to degradation while retaining the attractive features of the industrially relevant dimiide.

Presenter(s): Takeshi Matsuda, Tianlong Wang
School: Beloit College
Session: Poster: P3.02
Title: Decentralized Machine Learning Approach on ICU Admission Prediction for Enhanced Patient Care Using COVID-19 Data
Advisor(s): Eyad Haj Said, Mathematics and Computer Science, Beloit College
Co-Author(s):
Abstract: The Intensive Care Unit (ICU) represents a constrained healthcare resource, involving invasive procedures and high costs, with significant psychological effects on both patients and their families. The traditional approach to ICU admissions relies on observable behavioral indicators like breathing patterns and consciousness levels, which may lead to delayed critical care due to deteriorating conditions. Therefore, in the ever-evolving landscape of healthcare, predicting whether patients will require admission to the ICU plays a

pivotal role in optimizing resource allocation, improving patient outcomes, and reducing healthcare costs. Essentially, in the context of the post Covid-19 pandemic, aside from many other diseases, this prediction not only forecasts the likelihood of ICU admission but also identifies patients at an earlier stage, allowing for timely interventions that can potentially mitigate the need for ICU care, thereby improving overall patient outcomes and healthcare resource utilization. However, this task usually requires a lot of diverse data from different healthcare institutions for a good predictive model, leading to concerns regarding sensitive data privacy. This paper aims to build a predictive model using deep learning techniques while maintaining data privacy among different institutions to address these challenges.

Presenter(s): Ezekiel Meulbroek
School: University of Chicago
Session: Poster: P1.16
Title: Mechanical Validation and Optical Measurement of Ultra-High Frequency Feed-horn Arrays for Simons Observatory
Advisor(s): Jeff McMahon, Astronomy & Astrophysics, University of Chicago
Co-Author(s): Thomas Alford, Erin Healy, Sara Simon
Abstract: The cosmic microwave background, a relic of when light decoupled from matter in the early universe, provides rich information about the origin and evolution of the universe. The Simons Observatory, a millimeter-wavelength experiment located in the Atacama Desert in Chile, will observe the temperature and polarization of the cosmic microwave background at unprecedented sensitivity, characterizing the primordial perturbations, enabling constraints on cosmic inflation, the growth of large-scale structure, neutrino mass, the duration of reionization, and many other cosmological and astrophysical questions. A vital component of the Simons Observatory camera is the feed horn array, designed to couple millimeter-wave signals to superconducting bolometer detectors. The feed-horn arrays, made of aluminum and machined with custom tooling, must be mechanically validated and electromagnetically tested with radio holography before being integrated into the cameras. We present the validation steps for the ultra-high frequency feed horn arrays designed for detectors with bands centered at 220 and 280 GHz. The feed-horn arrays, 15 fabricated for Simons Observatory, were demonstrated to meet the specifications necessary for the science goals of the experiment.

Presenter(s): Murali Meyer
School: St Olaf College
Session: Poster: P1.14
Title: Mandelbrot Breadcrumbs
Advisor(s): Daniel Stoertz, MSCS (Mathematics, Statistics, and Computer Science), St Olaf College
Co-Author(s): Mike Wang
Abstract: In this project we explore rational functions of the form f(z) = z^n + a/(z^d) + c where z is a complex number, a is a fixed real number, n and d are integers greater than 2, and c is a complex-valued parameter. We locate where, for a fixed above a specified lower bound, the c-parameter plane contains n+d homeomorphic copies of the Mandelbrot set. These baby Mandelbrot sets are distributed across (n+d)/gcd(n,d) distinct regions of the parameter plane. Our work generalizes the research done by Devaney; Jang, So, and Marotta; and Boyd, and Mitchell, each of which examined similar but simpler functions. Like this previous research, we take advantage of techniques first introduced by Douady and Hubbard to prove our results.

Presenter(s): Zeineb Mezghanni
School: Grinnell College
Session: Oral I.A.5
Title: Shedding Light on Dark Matter Using Stellar Streams
Advisor(s): Lina Necib, Physics Department, Massachusetts Institute of Technology (MIT)
Co-Author(s):

Abstract: Dark matter (DM) makes up about 84% of the matter budget in our universe. However, understanding its nature has been one of the most significant challenges in modern physics as it only interacts gravitationally with baryonic matter. DM effects influence the formation and evolution of cosmic structures, such as Stellar Streams. Stellar streams are remnants of disrupted star clusters or dwarf galaxies stretched out into elongated structures. They are remarkably sensitive to perturbations and their analysis provides valuable insights into the distribution and properties of DM in galaxies. In this work, we study the morphological differences of stellar streams under cold dark matter (CDM) and self-interacting dark matter (SIDM) models to understand the effect of DM on tidal disruption. Such DM models are well motivated, and might explain some of the discrepancies in observations. We use semi-analytical methods to generate galaxies with the GalIC code and run isolated simulations of mergers using Gizmo. Finally, we build a catalog of stellar streams under different DM assumptions. The resulting work can facilitate further analyses of the Milky Way's merger history and DM effects on structure formation.

Presenter(s): Luka Mikek
School: Grinnell College
Session: Poster: P2.20
Title: Silver and Platinum Nanoparticles as Artificial Peroxidase Mimics
Advisor(s): Corasi Ortiz, Chemistry, Grinnell College
Co-Author(s):
Abstract: Noble metal nanoparticles have been shown to have enzyme-like behavior and provide a viable alternative to natural enzymes. In this research, we present the successful synthesis of five different nanoparticle solutions, including two silver nanoparticle solutions, one platinum nanoparticle solution, and two silver@platinum core-shell nanoparticle solutions. These nanoparticles have been characterized by absorption spectroscopy (UV-vis) and transmission electron microscopy (TEM). Some of these nanoparticles are shown to have peroxidase-like activity, and the kinetic parameters for catalyzing oxidation of 3, 3’, 5, 5’ tetramethylbenzidine (TMB) by hydrogen peroxide are reported. Finally, two detection assays for measurement of hydrogen peroxide concentration in unknown solutions that make use of this reaction are explored, a colorimetric method and, the other, a Raman spectroscopy method.

Presenter(s): Megan Morales
School: University of Chicago
Session: Oral: II.G.2
Title: Kinetic studies to establish reactivity trends of anomeric amides for nitrogen-deletion reactions
Advisor(s): Mark Levin, Organic Chemistry, University of Chicago
Co-Author(s): Julia L. Driscoll
Abstract: Anomeric amides are a class of compounds that can serve as electrophilic nitrogen sources, generating nitrenes for various synthetic applications. Our research group has developed a specific compound within this class, N-(benzyloxy)-N-(pivaloyloxy)-4-(trifluoromethyl)benzamide, that can be used to deaminate primary and secondary amines, forming a carbon-hydrogen bond or a carbon-carbon bond respectively. While this anomeric amide reagent exhibits good reactivity towards primary and secondary amines, including various bioactive compounds and natural products, it has limited reactivity towards sterically hindered amines. To facilitate the design of new anomeric amides, kinetic studies were conducted to probe the electronic and conformational properties of the reagent that promote reactivity towards amines. Quantitative NMR and computational methods were employed to validate the proposed mechanism and establish reactivity trends for anomeric amides with secondary amines. These findings can be used to determine the structural features that influence anomeric amide reactivity, enabling the creation of more effective anomeric amide reagents and broadening the scope of nitrogen deletion for various late-stage compounds.

Presenter(s): Dang Nguyen

School: University of Chicago
Session: Poster: P2.16
Title: Pragmatic Radiology Report Generation
Advisor(s): Chenhao Tan, Computer Science, University of Chicago
Co-Author(s): Chacha Chen, He He
Abstract: When pneumonia is not found on a chest X-ray, should the report describe this negative observation or omit it? We argue that this question cannot be answered from the Xray alone and requires a pragmatic perspective, which captures the communicative goal that radiology reports serve between radiologists and patients. However, the standard image-to-text formulation for radiology report generation fails to incorporate such pragmatic intents. Following this pragmatic perspective, we demonstrate that the indication, which describes why a patient comes for an X-ray, drives the mentions of negative observations and introduce indications as additional input to report generation. With respect to the output, we develop a framework to identify uninferable information from the image as a source of model hallucinations, and limit them by cleaning groundtruth reports. Finally, we use indications and cleaned groundtruth reports to develop pragmatic models, and show that they outperform existing methods not only in new pragmatics-inspired metrics (+4.3 Negative F1) but also in standard metrics (+6.3 Positive F1 and +11.0 BLEU-2).

Presenter(s): Holiday O'Bryan
School: Macalester College
Session: Poster: P3.16
Title: Diagenesis of a Pyritized Contact in the Devonian Michigan Basin: Preliminary Findings
Advisor(s): Kelly MacGregor, Geology, Macalester College
Co-Author(s):
Abstract: Petrographic analysis can reveal information about original depositional environments and subsequent diagenetic conditions. Here we examine a well-developed pyritized interval at the contact between the Traverse Limestone (a fossiliferous dolomitic packstone) and the “Squaw Bay Formation” in the Michigan Basin. Overlying the pyritized discontinuity, the “Squaw Bay Formation” is a calcareous, highly bioturbated shale, indicating Devonian sea level rise and/or basin subsidence. Little prior petrographic analysis has been done on these formations, and, given the stratigraphic consistency of the pyritized interval across geographically diverse cores, detailed petrographic study will elucidate the diagenetic history of each formation and the contact itself.
Ten thin sections were cut from three cores with samples taken at the contact and in both the underlying Traverse Limestone and overlying “Squaw Bay Formation”. Thin section petrography, SEM, and µXRF technologies are used to delineate diagenetic overprints and stratigraphic relationships. Preliminary data suggests extensive dolomitization of the Traverse Limestone and reveals diverse modes of fossilization preserved in the “Squaw Bay Formation”. The presence of chalcedony, glauconite, various forms of calcite, and several crystal morphologies of pyrite imply a complicated diagenetic history. Continued research will result in the development of a paragenetic sequence for this mineralized stratigraphic contact.

Presenter(s): Emily Oh
School: Washington University in St. Louis
Session: Oral: II.F.5
Title: Applying the singular value decomposition algorithm to quantum biological processes
Advisor(s): Kade Head-Marsden, Department of Chemistry, Washington University in St. Louis
Co-Author(s): Timothy J. Krogmeier, Anthony W. Schlimgen
Abstract: Current quantum computers are limited to implementing unitary gates. However, most realistic systems, particularly biological systems, have complex and irreversible interactions with their environments, meaning exact computational models are infeasible. Even with an open quantum systems treatment, which is often the closest model to reality, the dynamics are inherently non-unitary and unable to be directly implemented on quantum circuits. In order to circumvent this challenge, we use the singular value

decomposition (SVD) algorithm, a recently introduced quantum algorithm, applied to the Lindblad equation describing the system to implement open system dynamics on a quantum circuit. Using this method, we model the Fenna-Matthews-Olson complex and the radical pair mechanism for avian navigation both classically and in quantum simulation. The accurate long-time dynamics show the potential for using the SVD algorithm to model quantum processes as well as the relevance of quantum computation to the continued exploration of biological processes.

Presenter(s): Sarah Olsen
School: Washington University in St. Louis
Session: Oral: II.G.4
Title: Synthesis of self-complementary semicarbazone-based arrays
Advisor(s): Vladimir Birman, Chemistry, Washington University in St. Louis
Co-Author(s):
Abstract: Dynamic self-assembly of polymers can produce adaptable materials with intriguing properties. To combine both covalent and non-covalent reversible interactions, we have devised a new self-complementary hydrogen-bonded array that is composed of polymer chains containing repeated semicarbazone moieties. We have successfully synthesized the stable monomer precursor of Self-Complementary Semicarbazone-Based Arrays (SCSBAs) in moderate yields. Under acidic conditions, the precursor's semicarbazide functional group becomes deprotected, allowing the bifunctional monomer to polymerize in situ. The self-complementary arrangement of hydrogen bond donors and acceptors is expected to lead to spontaneous dimerization of these linear oligomers. Strategies to construct SCSBA polymers of controlled lengths are currently under investigation. This work represents significant progress in developing dynamic self-complementary arrays.

Presenter(s): Clarence L.Pan
School: Macalester College
Session: Oral: II.H.I
Title: Computational Mechanism Studies: ·OH Production in Gas-Phase α-Pinene Ozonolysis with Stereochemical Emphasis
Advisor(s): Keith T. Kuwata, Chemistry, Macalester College
Co-Author(s):
Abstract: Around 10^11 kilograms of terpenes (C5H8)n are released by vegetation into the troposphere yearly, around 35% of which are α-pinene, a structural isomer of monoterpene (C5H8)2. There is computational and experimental evidence that alkene ozonolysis leads to non-photochemical production of hydroxyl radical (OH). OH radical is an important tropospheric species, as it oxidizes hydrocarbons and indirectly produces ground-level ozone. Alkene, ozone, and hydroxyl radical engage with each other in a positive feedback cycle. α-Pinene is a bi-cyclo chiral molecule with an endo alkene site, which diversifies its ozonolysis reaction pathways regarding stereochemistry. It is challenging to study α-pinene ozonolysis experimentally due to the low activation barrier, unstable intermediates, and large exothermicity. The Kuwata Lab resorts to Density Functional Theory (DFT), coupled-cluster, and spin flip calculations to probe molecular thermodynamics in α-pinene ozonolysis, as well as master equations to simulate the product branching ratios.

Presenter(s): Zoey Papka
School: University of Chicago
Session: Poster: P1.25
Title: Resistance and Resilience in Microbial Communities of Lake Michigan
Advisor(s): Maureen Coleman, Department of Geophysical Science, University of Chicago
Co-Author(s):
Abstract: Understanding microbial communities is crucial in determining the long-term effects of environmental changes in aquatic systems. The Laurentian Great Lakes offer a unique and understudied system for studying these changes, with important implications for ecosystem services. This high-resolution

time series fills in gaps in current datasets of the microbial communities in Lake Michigan by assessing nearshore communities. The novel data set demonstrates community and physiological responses to temperature and disturbance events. Dissolved nutrient levels in Lake Michigan reflect microbial community productivity that can be observed through seasonal and short-term weather changes. The community's response demonstrates its resilience to stressors. Microbial community dynamics are critical for understanding the changing climate and its effects on these critical ecosystems.

Presenter(s): Jian Park
School: University of Chicago
Session: Poster: P3.13
Title: Learned decomposition for enhanced long-term time series forecasting
Advisor(s): Lara Kattan, Booth School of Business, University of Chicago
Co-Author(s):
Abstract: Univariate and multivariate time series forecasting is essential in fields like finance, medical sciences, and astronomy. Recent advancements have been made in the use of transformer-based models for long-term time series forecasting, but simple linear neural network models have also presented competitive results. These linear models traditionally use moving averages with a uniform kernel to decompose the input data, aiming to forecast trend and seasonal components separately.
This work expands upon existing linear models by introducing non-uniform kernels for the moving average decomposition. We employ a compact linear layer to generate distinct weights for the kernels at each timestamp. This more robust weighted moving average decomposition is able to better capture the trend and seasonal nuances of time series data, especially for input data with non-stationary variance. We demonstrate through implementation that our model improves upon the forecasting performance of existing linear models and more closely aligns with the accuracy of transformer-based models. Importantly, our model maintains similar size and runtime as other linear models while additionally reducing manual hyperparameter tuning.

Presenter(s): Manuela Pinheiro
School: University of Chicago
Session: Poster: P2.01
Title: Fabrication of polybenzoxazine-based porous carbons for globally-relevant separations
Advisor(s): Stuart Rowan, Pritzker School of Molecular Engineering, University of Chicago
Co-Author(s): Adarsh Suresh
Abstract: The continuous rise in carbon dioxide emissions highlights the dire need for additional research in the Carbon Sequestration and Storage (CSS) field. Porous carbons (PCs), a promising class of materials for CO2 sequestration, are lightweight and possess extraordinarily high surface areas. Furthermore, their scalable synthesis and remarkable thermomechanical stability make them suitable for demanding environments. Additionally, their hierarchical porosity helps optimize capacity and kinetics. While PCs have shown great potential, the fabrication of CO2-selective PCs derived from cost-efficient and sustainable starting materials and at industrially relevant quantities has remained a challenge. Using a template-coating pair design, this work demonstrates that PCs can be fabricated using a divinylbenzene-based Polymerized High Internal Phase Emulsion (Poly(HIPE)) as a template and polybenzoxazines, thermally stable, sustainably-derived polymers, as a coating. The carbons synthesized through this method exhibit excellent thermal and mechanical stability, having reached unprecedented atomic efficiency of 98.7%. Scanning Electron Microscopy (SEM) images confirmed the successful fabrication of this material, which can be enhanced for selectivity through the functionalization of nitrogen-rich molecules, enabling carbon capture at ambient conditions.

Presenter(s): Bianca Pol
School: University of Chicago
Session: Oral: II.E.3
Title: Charge Order in the Blume-Capel Model on a Triangular Lattice

Advisor(s): Richard Scalettar, Physics, University of California Davis
Co-Author(s): Matthew Nelson, Bianca Pol, Eduardo Ibarra García Padilla, Matthew Enjalran
Abstract: Strongly correlated materials exhibit charge and magnetic orderings, potentially affected by geometric frustration. These systems are described by fermionic Hamiltonians, which are very hard to study numerically, so determining a mechanism responsible for the observed charge and spin orders is difficult. Thus, we numerically study the classical Blume Capel (BC) model in a triangular lattice to capture the essential features of a charge and spin ordered system in a geometrically frustrated lattice. We use classical Monte Carlo methods to investigate both antiferromagnetic and charge order in the BC model and compare against a previously reported renormalization group (RG) calculation. We construct and utilize novel non-local order parameters that couple to the charge and spin degrees of freedom, which allows us to demonstrate the existence of an antiferromagnetically ordered and charge ordered phase in which spins occupy only a honeycomb sublattice of the full triangular lattice, whose bipartite structure avoids magnetic frustration. Although our results are consistent with RG regarding the location of the finite temperature second- and first-order phase boundaries from the paramagnetic to magnetic phase in the temperature vs chemical potential plane, we detect a richer phase diagram where charge and magnetic ordering occur at different critical temperatures.

Presenter(s): Ionela Popa
School: St. Olaf College
Session: Poster: P2.03
Title: Improving Software and Hardware of Atomic Layer Deposition
Advisor(s): John Nichol, Quantum Computing, University of Rochester, NY
Co-Author(s):,
Abstract: ALD is a technique that allows the growth of thin films on atomic precision with uniform thickness. ALD deposition of Aluminium Oxide (Al2O3) is achieved through a chemical reaction between water vapor and trimethylaluminum (TMA) gas, forming a uniform Al2O3 layer. Al2O3 is used as an insulator for quantum dots.Potential Current Leak kills quantum dots. The quality of this oxide layer can significantly affect quantum device performance. My job this summer was to improve the software and hardware fo ALD for a successful oxide film deposition.

Presenter(s): Kate Powledge, Julia Tuttle
School: University of Chicago
Session: Poster: P3.01
Title: Support systems for the HELIX Ring Imaging CHerenkov (RICH) detector
Advisor(s): Scott Wakely, Enrico Fermi Institute, University of Chicago
Co-Author(s):
Abstract: HELIX (High Energy Light Isotope eXperiment) is a balloon-borne experiment designed to measure the chemical and isotopic abundances of light cosmic-ray nuclei. Detailed measurements by HELIX, especially of 10Be from ∼0.2 GeV/n to beyond 3 GeV/n, will provide essential insights into the propagation processes of the cosmic rays. The experiment is set to launch from Kiruna, Sweden in Spring of 2024. HELIX features a Ring Imaging Cherenkov (RICH) detector designed to measure the velocity and charge of nuclei with energies greater than ∼1 GeV/n. The RICH detector consists of a radiator volume of high-transparency high index aerogel tiles imaged by a ∼1 m2 focal plane instrumented by 200 8×8 arrays of silicon photomultipliers (SiPMs). The metrology of the focal plane is determined through 3D scanning data created with the HandyScan laser scanner and VXElements software. The temperature of the RICH focal plane is controlled by a liquid cooling system, whose primary components are thermoelectric devices and a coolant pump. We present the analysis of the RICH focal plane metrology data and development of the thermal system and housekeeping software**.**

Presenter(s): Rachel Quan

School: University of Chicago
Session: Poster: P1.19
Title: Synthetic studies toward the cinncassiol diterpenoids
Advisor(s): Scott Snyder, University of Chicago
Co-Author(s):
Abstract: The total synthesis of natural products involves the construction of a complex molecule from readily available starting materials in ways that seek to develop new reagents, strategies, and tactics of broad applicability to synthetic chemistry while also providing material supplies for further investigations. The goal of this project is to develop a synthetic route for two cinncassiol diterpenoids. Various compounds in the Cinnamomum cassia family are reported to exhibit intriguing biological properties, with synthesis being necessary to explore their biochemical potential further. The target compound is synthetically challenging given its possession of a highly oxidized 5/6/5 core ring system with several quaternary centers.
Here we report our progress toward the synthesis of these targets, with success in forming several desired elements. These include an indium-mediated Conia-ene cyclization resulting in system rigidity and subsequent oxidative transformations. Current challenges include the cyclization of the left-hand cyclopentane ring. Another area of interest involves a biomimetic aldol reaction, which is projected to allow access to cinnamomol A from a late-stage intermediate of cinncassiol F.

Presenter(s): Allison Rabbani, Rachel Rudacille
School: Grinnell College
Session: Poster: P1.06
Title: Predicting the Sensitivity of LSPR Biosensors
Advisor(s): Keisuke Hasegawa, Physics, Grinnell College
Co-Author(s):
Abstract: The phenomenon of localized surface plasmon resonance (LSPR), which occurs in noble metal nanoparticles excited by the electric field of incident light, has many potential applications, particularly in biosensing. LSPR biosensors involve a metal nanoparticle modified with a receptor layer of a constant thickness and refractive index which attracts target molecules. The target molecules form an analyte layer, and changes in the concentration of target molecules in the analyte layer are reflected by a shift in this layer's refractive index. Miller and Lazarides (2005) derived an equation that elucidated a linear relationship between LSPR wavelength and sensitivity to changes in the bulk refractive index. We expand upon Miller's work to derive an equation which focuses on sensitivity to changes in the local refractive index—this is more applicable to biosensing technology. Like Miller, we found that our equation predicts the sensitivity of a nanoparticle without knowing its exact geometry. We confirmed the efficacy of this equation using the MATLAB package MNPBEM, with which we simulated gold nanospheres, nanocylinders, nanodisks, nanorods, and nanotriangles and their surrounding media. The simulations confirmed the accuracy of our theory, as the values predicted by our quasistatic approximations were within 15% of those produced by simulations.

Presenter(s): Héctor Rauda
School: Carthage College
Session: Poster: P1.03
Title: Topological Noise Differentiation
Advisor(s): Megan Stickler, Mathematics, Carthage College
Co-Author(s):
Abstract: Topological Data Analysis (TDA) is a dynamic field that harnesses mathematics and computing to decode data structures in various applications, from science and medicine to business, enabling the discovery of patterns and predictive insights that might otherwise remain hidden.
This study delves into the impact of noise on evolving data types, focusing on understanding the relationship between noisy data and "topological noise" – temporary data patterns sensitive to parameter changes. Traditionally, topological noise has been considered irrelevant, but recent research suggests it may have

significance, especially in chaotic systems. The aim is to develop methods to differentiate meaningful structural noise from random noise that does not mean anything.
This research enhances our grasp of data dynamics by investigating the complex interaction between evolving data and fleeting patterns. Such insights can potentially improve the utility of TDA in various fields, making predictions more accurate and revealing concealed insights within noisy datasets.

Presenter(s): Maria Riek
School: Colorado College
Session: Poster: P3.06
Title: Combating the antibiotic resistance of P. aeruginosa through synthesis of lectin targeted 4-fluorophenylalanine prodrug
Advisor(s): Amy Dounay, Chemistry and Biochemistry, Colorado College
Co-Author(s): Ty Kruger
Abstract: Pseudomonas aeruginosa, a deadly bacteria common among those living with cystic fibrosis, is known for its strong antibiotic resistance. Chronic P. aeruginosa infections are characterized by biofilm formation, increasing the challenges of treatment. Two carbohydrate-binding proteins, LecA and LecB, have been identified as structural components of the P. aeruginosa biofilm that can be useful for targeted drug delivery. The compound 4-fluoro-L-phenylalanine (4-FPhe) exhibits antibacterial properties but also high cytotoxicity against mammalian cells and therefore would benefit from a prodrug approach. The prodrug design includes a LecA probe that can be attached to the 4-FPhe compound using a tetrapeptide linker. P. aeruginosa peptidases will then cleave the linker following the accumulation of the drug at the infection site allowing for full antimicrobial activity of 4-FPhe. Progress towards the effective synthesis of the prodrug compound will be reported.

Presenter(s): Enrique Hernandez Salcido
School: Colorado College
Session: Poster: P1.24
Title: Optimization of a photochemically driven benzyne reaction
Advisor(s): Jessica Kisunzu, Chemistry and Biochmistry, Colorado College
Co-Author(s): Benjamin Sokol, William L. Abbey
Abstract: The reactivity that comes from arynes' unstable strain has made it a molecule that is highly sought out to use and intentionally apply. Currently, one of the more widespread methods for benzyne formation is the use of 2-(trimethylsilyl) phenyltrifluoromethanesulfonate (silyl-triflate) with a fluoride source such as CsF. There is still a need for a new complementary benzyne generation method that is more time efficient. An early appearance of a photochemically produced benzyne was reported in 1975 by Y. Maki and coworkers through the utilization of a high-pressure mercury lamp where they discovered that 2-(3-acetyl-3-methyltriaz-1-en-1-yl) benzoic acid (AMTBA) can be a useful benzyne precursor. Upon irradiation of AMTBA with a UV light, it can produce benzynes which react with substrates at a highly reduced time frame compared to other methods. Previous work in our group shows the successful synthesis of AMTBA and the replication of known benzyne reactions under photochemical conditions. Through the use and practice of solvent sparging, a new photoreactor design, creating stock solutions, and utilizing quartz glassware for the reaction, we are able to report the successful optimization of insertion reactions, cycloadditions, and nucleophilic additions using AMTBA.

Presenter(s): Maureen Schmid
School: Knox College
Session: Poster: P3.09
Title: Toward the synthesis and characterization of nonsymmetrical α-diimine ligands for iron-catalyzed

hydrosilylation
Advisor(s): Helen Hoyt, Chemistry, Knox College
Co-Author(s):
Abstract: Recently, reduced iron complexes bearing symmetrical bidentate α-diimine ligands ArN=C(Me)-(Me)C=NAr (ArDI) and ArBIAN ligands (BIAN = bis(imino)acenaphthene; Ar = dpp and Mes; dpp = 2,6-diisopropylphenyl; Mes = 2,4,6-trimethylphenyl) have been shown to promote the catalytic hydrosilylation of 1-hexene in high yield. However, more sterically hindered alkenes have provided lower yields. The goal was to produce nonsymmetrical diimine ligands to study whether this would allow for the catalysis of more sterically demanding alkenes. Thus, a series of synthesis reactions were performed to optimize the conditions with different ligand backbones, side groups, reaction times, solvents, catalysts, and equivalents. Flash column chromatography and recrystallization were utilized to purify desired products. α-Ketoimines were synthesized in small amounts from 2,3-butanedione and acenaphthenequinone with anilines, and adjusting reaction times and adding formic acid as a catalyst improved the ratio of the desired products to byproducts. Nonsymmetrical dpp,4-t-BuBIAN (where 4-t-Bu = 4-tert-butylphenyl) was successfully synthesized and characterized by 1H, 13C, and 2D NMR. Future work will focus on increasing the yield of these purified ligands and applying them toward iron-catalyzed hydrosilylation of larger substrates.

Presenter(s): Audrey Scott
School: University of Chicago
Session: Oral: I.A.2
Title: Hollow Cathode Discharge Instability Onset in Electric Thrusters
Advisor(s): Dan M. Goebel, NASA JPL
Co-Author(s):
Abstract: Hollow cathodes are an integral part of ion and Hall thrusters used for electric propulsion in deep space missions and in commercial communications satellites. Hollow cathodes are known to operate in a quiescent “spot-mode” and in a noisy “plume-mode” in which plasma instabilities generate erosive energetic ions. The onset of plume mode in hollow cathodes has been defined historically as when the keeper voltage oscillation values exceed 5 Vp-p (peak-to-peak). Using a LaB6 hollow cathode in a vacuum chamber setup that simulates ion and Hall thrusters, a set of emissive and Langmuir probes have been used to investigate the plasma properties associated with plume mode onset as a function of discharge current and gas flow rate. We find that plume mode onset occurs at keeper voltages of 2 Vp-p, and starts at higher gas flow rates and lower values of higher discharge currents than expected from the traditional metric. Mode competition between three different instabilities observed in the near-cathode plume affects the overall plasma oscillation levels correlated to energetic ion production. We find that the plasma oscillation levels measured by in situ plasma diagnostics are more indicative of the presence of oscillations and energetic ion generation than keeper voltage.

Presenter(s): Haley Siculan, Trent Ediger, Ava Beyers
School: Lawrence University
Session: Poster: P1.11
Title: Using sUAS multispectral imagery to determine the effect of prescribed burns on C3 and C4 plant communities in a reclaimed Wisconsin prairie
Advisor(s): Jeffrey Clark, Geosciences, Lawrence University
Co-Author(s): Ava Beyers, Kat McClain
Abstract: We examine the effect of prescribed burns on C3 and C4 plant communities in a reclaimed Wisconsin prairie ecosystem. Our research builds off previous work to discriminate between C3 and C4 plants and further determine the effects of prescribed burns on the area using sUAS imagery. We find that the area most recently burned (2023) is more vegetated overall with warmer and drier soil, and that C4 plants are more common than C3 plants throughout the entire study site. This aligns with previous research which shows that C4 plants thrive in warmer and drier environments cultivated by burning. Our findings illuminate ecosystem dynamics after

fire; this will become increasingly important as we see a rise in wildfires and droughts due to climate change. As these climate effects become more prevalent, it is imperative to understand how ecosystems respond so that prairie managers can more effectively cultivate biodiversity and abundant plant communities.

Presenter(s): Sophia Smith
School: Gustavus Adolphus College
Session: Oral: I.A.3
Title: Installation of a Campus Radio Antenna Array for Radio Astronomy: Enhancing Exomoon Exploration Through Teamwork
Advisor(s): Darsa Donelan, Physics, Gustavus Adolphus, College
Co-Author(s):
Abstract: This presentation highlights two narratives: both the captivating realm of celestial signals and the collaborative effort involved in establishing a sturdy radio antenna array on our college campus. Motivated by the curiosity to study cosmic mysteries and distant exomoons using radio signals, our goal took shape through a collaboration involving our campus's facilities, grounds crew, electricians, and technology services. This synergy played a crucial role in translating our scientific vision into reality. The facilities crew was able to help and ensure optimal placement, while the grounds' crew efforts preserved the natural surroundings without excessive disruption. The skillful work of electricians and technology services' aided in wiring, power supply, and network integration, culminating in a continuous, autonomous data collection setup. Beyond the basic mechanics, this endeavor accentuates the essential overlap between theoretical principles and practical execution. It represents the potential of interdisciplinary cooperation in expanding innovation knowledge boundaries. As the antenna array reaches skyward, it symbolizes not only our journey to unravel cosmic mysteries but also the unified spirit of our campus community. This presentation encapsulates the profound impact of teamwork, shaping the realm of radio astronomy and advancing exomoon exploration into a promising frontier.

Presenter(s): Minwoo Son
School: Grinnell College
Session: Poster: P2.15
Title: Sub-GeV Dark Matter Direct Detection Using Quantum Dots
Advisor(s): Lindley Winslow, Department of Physics, Massachusetts Institute of Technology
Co-Author(s): Deniz Erdag, Nora Hoch
Abstract: This study investigates the possibilities of direct detection of Sub-GeV dark matter (DM) with quantum dots (QD). QDs are nanoscopic crystals of semiconducting material and low-threshold scintillating targets apt for detecting interactions in small energy scales. During a DM-QD interaction, an exciton is formed. Given the initial exciton carries energy that exceeds double the energy of a QD, multiple excitons are created during relaxation, emitting multiple photons.
In the experimental prototype, a cubical container of a 40ml QD solvent in polycarbonate is placed between a 2-PMT setup where the two PMTs are attached to opposite sides of the container. Simulation using Geant4 was conducted to produce photons with energies from 1.77 eV to 3 eV, mimicking DM-QD interaction. Number of photons detected and their energy were measured.
Results show that 4.4% of photons generated are detected by the PMT. The energy detected does not show a significant difference. The decrease in the number of photons is because of the short absorbance length of polycarbonate and the low quantum efficiency of the PMTs. Improvement will require a new material with a longer absorbance length as a solvent such as toluene and a new type of detector such as SNSPD.

Presenter(s): Jennifer Spinoglio
School: University of Chicago
Session: Poster: P2.13
Title: Investigating green space distribution in Chicago

Advisor(s): Sabina Shaikh, Committee on Environment, Geography and Urbanization, University of Chicago
Co-Author(s): Sammy Thiagarajan, Diya Gandhi, Kevin Lin, Ethan Jiang, Matthew Rubenstein, Xander Deanhardt, Alex Viviano, Emily Nigro, Anna Warsaw
Abstract: The Environmental Research Group conducted a multi-faceted research project on green space distribution in Chicago during the 2021-2022 academic year. Given the well-known benefits of green space, including air pollution reduction and positive physical and mental health impacts, Chicago's poor green space quality and inequity is a major cause for concern. We conducted our research along three channels. Our Outreach Team connected with local environmental organizations and city representatives to learn about Chicago green space and environmental justice issues directly from those who experience them and are working to find solutions. The team conducted interviews with three organizations that work with green space distribution and accessibility in Chicago and culminated the findings in a final report. Our Policy Team looked into policy proposals to overcome the green space inequity of Chicago. They investigated the impact and feasibility of green roof incentives, based on the success of Toronto's 2009 bylaw. Finally, our Data Analysis Team worked to establish and visualize a variety of correlations to investigate causes of Chicago's green space inequity, and green space benefits. This included quantifying the effects of property sales, land surface temperatures, and the impact of park access in Chicago, and mapping them with geospatial data.

Presenter(s): Teagan Steineke, Jordan Wheeler, Justin Wheeler
School: Carthage College
Session: Poster: P2.18
Title: Microgravity Ullage Detection (MUD)
Advisor(s): Kevin Crosby, Physics and Astronomy, Carthage College
Co-Author(s): Justin, Wheeler, Sikiel Graves, Jill Forgac
Abstract: Non-invasive Detection of Liquid Propellant Location During Microgravity Transfer

Presenter(s): Gabriella Stoudt
School: Gustavus Adolphus College
Session: Poster: P3.08
Title: GC-MS analysis of Minnesota salvia essential oils and activity against proliferation and migration on glioblastoma multiforme
Advisor(s): Kennedy D. Nyongbela, Chemistry, Gustavus Adolphus College
Co-Author(s): Catherine Vopat, David Odde
Abstract: There are growing concerns on the effectiveness of cancer drugs such as a rise in resistance by cancer cells to current medications. New forms of cancer drugs are currently being discovered, with one potential solution being natural products derived from plants. In this project, three Minnesota salvia species, notably Salvia officinalis, Salvia nemorosa, and Salvia pratensis, volatile extracts were obtained by hydro distillation and analyzed by GC-MS. The oils along with commercially available (-) thujone, eucalyptol, and camphor were tested on U251 Glioblastoma multiforme (GBM) brain tumor cells and monitored for 24 and 72 hours. Eugenol was identified in all three oils, being the first report of its presence in Salvia species. Eucalyptol, camphor, caryophyllene and other compounds were identified as well. The anticancer testing showed that S. officinalis, S. pratensis, and (-) thujone exhibited activity at 20mM against the proliferation and migration of GBM cells in a 24-hour time-lapse microscopic monitoring of a 24-well plate that contained GBM cells at three concentrations. The results show these Salvia plants to have antiproliferative and antimigratory activity against GBM, opening a window for their further investigation as potential sources of new anticancer agents to combat brain tumors.

Presenter(s): Jen Tang
School: University of Chicago
Session: Poster: P1.01

Title: Symmetries of the n-Body Problem
Advisor(s): Jeff Xia, Keith Burns, Mathematics, Northwestern University
Co-Author(s): Josh Fleckner, Evan Huang, Brennan Jackson,
Abstract: In the following report, we explore two dynamical systems questions inspired by the n-body problem. In the first section, we provide an alternative proof of the non-integrability of the planar 3-body problem by examining the relationship between the number of first integrals of a Hamiltonian system and the geometric multiplicity of the eigenvalue of 1 in the monodromy matrix of a periodic solution of the system. In the second section, we develop an analogue of Floquet theory for quasi-periodic linear differential equations systems.

Presenter(s): Raul Basilides Gomez del Estal Teixeira
School: University of Chicago
Session: Poster: P1.07
Title: Characterizing redshift distributions in DELVE using self-organizing maps and Bayesian estimation for cosmic shear analysis
Advisor(s): Chihway Chang, Astronomy & Astrophysics, Kavli Institute for Cosmological Physics, University of Chicago
Co-Author(s): Alex Alarcon, Dhayaa Anbajagane, Chihway Chang
Abstract: Photometric redshifts (photo-z) estimate the redshift distribution of a large sample of galaxies more cheaply, albeit less precisely than time and resource-demanding spectroscopic redshifts (spec-z). Photo-z leverages photometric measurements of objects to estimate redshifts, in contrast to spectroscopy. There are two primary methodological categories for photo-z estimation techniques: template fitting and machine learning methods. Template fitting methods employ physically motivated models of spectral energy distribution, providing a broader redshift range at the expense of precision. Conversely, machine learning methods are data-driven and offer higher precision, albeit confined within the redshift range of the training dataset. In this work, we present redshift distributions and photo-z analyses for 47 million galaxies in the Dark Energy Camera Local Volume Exploration (DELVE) survey coadd catalog for cosmic shear analysis, a cosmological probe examining the large-scale structure of the Universe. These redshift distributions were obtained using both template-fitting, specifically Bayesian Photometric Redshifts, and machine learning methods utilizing Self-Organizing Maps. To calibrate our photo-z estimates, we employ a combination of a survey transfer function named Balrog, constructed using galaxies from the Dark Energy Survey (DES) Deep Fields, and a collection of high-quality multi-band photo-z and spec-z catalogs acquired from COSMOS, PAUS, and the DES Portal.

Presenter(s): Yousheng Tang
School: Colorado College
Session: Poster: P3.12
Title: JS Surfaces over Hexagons
Advisor(s): Jane McDougall, Mathematics, Colorado College
Co-Author(s): Zhiqi Yao
Abstract: A minimal surface that locally minimizes its area, and can alternatively be defined as a surface with a mean curvature of zero. A Jenkins-Serrin (JS) surface is a specific type of minimal surface with a polygonal base and with unbounded height over the polygonal boundary - positive on some edges and negative on others. One famous JS surface is the doubly-periodic Scherk surface, discovered by Heinrich Ferdinand Scherk in 1834 and which has a square base. Using Sheil-Small Theory, we considered harmonic mappings onto hexagonal regions, thereby obtaining more general JS surfaces. We created a harmonic mapping onto a particular hexagon that appears to be a square. To construct it we start with a piece-wise constant boundary function that maps six arcs of the unit circle onto the vertices of the hexagon, and the Poisson integral formula extends it to a harmonic function of the unit disk onto the hexagon. We use a dilatation with four factors. By changing arc sizes and the location of dilatation zeros, we obtain a mapping onto a hexagon with prescribed interior

angles, two of which are 180 degrees and four of which are 90 degrees. The side lengths are shown to form a square, and we obtain a new minimal surface that we call the "Hexasquare Minimal Surface." This JS surface differs from the Scherk surface by changing boundary heights more frequently, but shares many symmetries of the Scherk surface.

Presenter(s): Callista Tran
School: Colorado College
Session: Poster: P3.21
Title: Development of greener protocols for solid-phase dipeptide synthesis for the Distributed Drug Discovery program
Advisor(s): Amy Dounay, Chemistry and Biochemistry, Colorado College
Co-Author(s):
Abstract: The Distributed Drug Discovery (D3) program seeks to engage students in undergraduate organic chemistry laboratory courses in the design and synthesis of new drug leads for neglected diseases. D3 laboratory protocols are designed to be robust and accessible so that students in instructional laboratories around the world can reproducibly synthesize potential drug leads using readily available reagents and equipment. At Colorado College , ongoing D3 synthesis projects target non-natural, fluorinated dipeptides that inhibit biofilm formation of Pseudomonas aeruginosa (Pa), a source of deadly infections in cystic fibrosis patients. To improve the sustainability and accessibility of the program, our research has focused on developing greener solid-phase peptide synthesis (SPPS) methods for implementation in the research and instructional lab settings. Notable opportunities for improvement include selection of greener solvents and coupling reagents and reduction in solvent volumes and reagent excesses. Recent progress toward development of greener protocols in the research lab and their implementation in instructional labs will be reported.

Presenter(s): Elliot Triplett
School: Colorado College
Session: Poster: P2.17
Title: Projection Operators for Protein Modeling
Advisor(s): Cory B. Scott, Mathematics and Computer Science, Colorado College
Co-Author(s): Judinelly Gonzalez
Abstract: Implicit representations of data are a new topic of machine learning research. The goal of an implicit representation is to find a way to represent a dataset that improves the performance of machine learning models by making their task easier. While implicit methods have been developed for lots of types of data like images and video, representations for other kinds of data like proteins has lagged behind. One recent approach (a GINR, or Generalized Implicit Neural Representation) represents proteins by training a small neural network to learn about the proteins' shape. However, GINRs have the drawback that they can only learn about a single protein at a time. This limits the biological application of the GINR model. We develop a version of GINRs that can be trained to represent one protein and then re-trained on ("transferred to") another. We investigate:
• What hyperparameter choices influence the accuracy of the retained model?
• What is the relationship between the similarity of the proteins, and the amount of error in transferring?
• Does this new model outperform the original GINR model?

Presenter(s): Andrew Valentini
School: Carthage College
Session: Poster: P2.23
Title: Analyzing Causes of Gravitational Wave False Alarms
Advisor(s): Gabriela González, Physics and Astronomy, Carthage College
Co-Author(s): Zach Yarbrough & Andre Guimaraes

Abstract: The prompt discovery of gravitational wave events is performed by a variety of matched-filtering search pipelines. Due to the non-Gaussian nature of the Advanced LIGO detector, these pipelines often react to transient noise sources, commonly referred to as glitches, and mistake them for gravitational wave events. Analyzing the properties of these glitches and a pipeline's reaction to them is thus crucial to improve pipeline efficiency and event validation accuracy. In this study, we perform such an analysis on one of these pipelines, GstLAL, with the intent of providing a battery of tests and models by which a given gravitational wave candidate may be evaluated against to provide a higher degree of confidence in the identification of the event origin in addition to offering a valuable perspective on the responsiveness of this pipeline to instrumental noise.

Presenter(s): Rohan Venkat
School: University of Chicago
Session: Poster: P2.07
Title: Connecting Galaxy Morphology to Circumgalactic Gas Properties
Advisor(s): Hsiao-Wen Chen, Astronomy/Astrophysics, University of Chicago
Co-Author(s):
Abstract: Understanding the properties of the gaseous halo surrounding a galaxy has been a meaningful area of research because it provides an understanding of what drives star formation. Specifically, where gas tends to be concentrated within a galaxy is important because there are competing processes in galaxies which contribute to the gas content in different regions, so determining which process is driving the star formation boils down to determining where the gas in a galaxy is mostly concentrated. However, there has been disagreement as to whether or not gas tends to primarily be concentrated in the galactic plane or perpendicular to the galactic plane, so this question has been unresolved. This research provides a comprehensive analysis of 95 galaxies taken from the Dark Energy Camera Legacy Survey (DECaLs) to determine whether or not there exists a preference for magnesium to be located within the galactic plane or outside the galactic plane by probing the orientation angle of these galaxies relative to a nearby super luminous objects known as a quasar (QSO). We found that the strength tended to be located perpendicular to the galactic plane with a correlation strength decreasing as the distance of the galaxy from the QSO increased.

Presenter(s): Lola Vescovo
School: Macalester College
Session: Oral: I.B.2
Title: Exact mixing times for random walks on trees of a fixed diameter
Advisor(s): Andrew Beveridge, Mathematics, Macalester College
Co-Author(s): Rhys O'Higgins
Abstract: A random walk on a graph is an ordered list of vertices, each chosen randomly from the neighbors of the vertex before it. Using this, we can study the mixing time, which is the expected number of steps to reach a "balanced" distribution from the worst possible starting vertex. We characterize the extremal structures for certain random walks on trees of a fixed diameter and prove that the mixing time is maximized by the double broom.

Presenter(s): Peter Wilson
School: St. Olaf College
Session: Poster: P3.14
Title: Growth of solution processed crystalline organic semiconductors for future solar cell technology
Advisor(s): Jordan Dull, Physics, St. Olaf College
Co-Author(s):
Abstract: Much of the current solar cell market focuses on silicon-based solar cells. We hope to increase the conductivity of organic semiconductors in solar cells through crystallization in order to potentially create a cheaper alternative to silicon solar cells. Our work aims to create processes for the fabrication of amorphous

and crystalline organic thin films through solution processing and to compare measured conductivity between amorphous and crystalline films for five different small molecule organic materials. We deposit our material on substrates using spin coating and then abrupt thermal anneal each sample. We characterize the samples using polarized optical microscopy, x-ray diffraction, and use atomic force microscopy to measure thickness. Then, we measure the current across the organic material at various voltages to calculate conductivity. For the four materials we were able to electrically measure, the conductivity increases after crystallization. Our largest increase occurred for 2,2′,2""-(1,3,5-Benzinetriyl)-tris(1-phenyl-1-H-benzimidazole) (TPBi), with conductivity increasing by a factor of 720 from amorphous to crystalline. The two highest conductivities we found are 2.5 * 10^-6 ± 5 * 10^-7 S/cm for crystalline TPBi and 3.5 * 10^-6 S/cm ± 6 * 10^-7 S/cm for crystalline N,N′-Di(1-naphthyl)-N,N′-diphenyl-(1,1′-biphenyl)-4,4′-diamine (NPB).

Presenter(s): Qianqian Wu
School: Grinnell College
Session: Poster: P3.03
Title: Minimal Hypergroups with Non-normal Structure
Advisor(s): Christopher French, Mathematics. Grinnell College
Co-Author(s):
Abstract: The concept of a hypergroup generalizes and extends the concept of a group. Similar to how normality is a special property that allows one to simplify group operations, we analyze the normality of closed subsets (analogous to subgroups) within hypergroups, which provides insight into the condition of containing non-normal closed subsets. In particular, the current paper focuses on finding the smallest hypergroups that contain a given hypergroup as a non-normal closed subset and generalizing our results to a class of hypergroups that share certain structural properties.

Presenter(s): Zewei Wu
School: University of Chicago
Session: Poster: P2.04
Title: A Predictive Study on the Faint-End Luminosity Function of High-Redshift Dwarf Galaxies
Advisor(s): Andrey Kravtsov, Department of Astronomy and Astrophysics, University of Chicago
Co-Author(s):
Abstract: Our research aims to explore the reionization period of the universe, a phase transition in Big Bang Cosmology when neutral intergalactic matter was ionized by energetic photons. The origin of these photons is still a mystery, largely due to the faintness and high redshift characteristics of the galaxies that might be contributing. Previous models have hinted that low mass dwarf galaxies could be responsible for up to 30% of the ionizing photons during this epoch. However, recent observations from the James Webb Space Telescope (JWST) have shown discrepancies between observed and predicted number densities of luminous early galaxies. This project will focus on predicting the observational properties, particularly the ultraviolet luminosity function (UV LF), of high-redshift dwarf galaxies. The end goals are to test our model on existing UV LF measurements, predict how UV LF behaves at fainter magnitudes probed by JWST, and compute the contribution of galaxies of different luminosities to the ionizing photon budget of the universe using the model UV LF.

Presenter(s): Xintan Xia
School: Macalester College
Session: Oral: I.B.4
Title: First Order Approximation on the Basilica Julia Set
Advisor(s): Taryn Flock
Co-Author(s):

Abstract: The derivatives of functions with a domain on fractals must be defined on a case by case basis, conditional on the structure of the fractal. In particular, the project considers the Basilica Julia set of the quadratic polynomial P(z) = z^2 - 1, with its successive graph approximations defined in terms of the external ray parametrization of the set. Following the model of Kigami and later Strichartz, we exploit these graph approximations to define derivatives of functions defined on the fractal, an endeavor complicated by asymmetric neighborhood behaviors at approximated vertex points across levels, and by the topology of these vertices. We hence differentiate even and odd levels of approximations of the Julia set and construct, accordingly, normal derivatives corresponding to each level category at the vertices, given their assigned ray names. We also discuss how a localized harmonic function serves as the tangent line, from which local linear approximation near vertices are obtained.

Presenter(s): Zhongyuan Zhang
School: University of Chicago
Session: Poster: P1.04
Title: A hypothesis of how CEMP-r stars are form with ejecta of Roche-lobe ov **Advisor(s):** Alexander Ji, Department ofAstronomy and Astrophysics, University of Chicago
Co-Author(s):
Abstract: Carbon Enhanced Metal Poor (CEMP) stars have low iron abundance but high carbon abundance. The study of CEMP stars is important for early universe and galactic archeology. I am trying to explain how one specific CEMP star, GDR3-0928 from an ultra faint dwarf galaxy Reticulum II, was formed and then generalizing from that to other CEMP stars. Stars in Reticulum II have similar evolution history and are enhanced with r-process elements. My idea is that during the Roche-lobe overflow in a binary system, some of the outer layers of the donor star will be ejected from the system instead of being transferred to its companion. The ejecta will pollute the atmosphere of a star several light years away from the binary system and convert it into a CEMP star. This summer, I tested my idea with some of the existing supernova progenitor models by fitting the abundance pattern of their outer layer to the one of GDR3-0928. Some of the metal poor or rotating progenitor models can fit the pattern well. I plan to test my idea both by calculating analytically and doing simulations to find out the composition and velocity of the ejecta and the accretion of the star.

Presenter(s): Jingzhi Zhou
School: Grinnell College
Session: Poster: P1.23
Title: 3-projective hypergroups
Advisor(s): Christopher French, Math department, Grinnell College
Co-Author(s):
Abstract: The notion of a hypergroup is a generalization of the notion of a group. While in a group G, the binary operation combines two elements in G to form an element in G, in a hypergroup H, the hyperoperation combines two elements in H to form a set of elements in G. An element h of a hypergroup H is called an involution if h ≠ 1 and {1, h} is a closed subset of H. A projective hypergroup is a hypergroup where all non-identity elements are involutions. Zieschang has proven that each projective hypergroup correspond to a projective space and for each finite projective space we can find a corresponding projective hypergroup. In this research project, we study hypergroups called 3-projective hypergroups and find connection between 3-projective hypergroups and projective hypergroups. In particular, in a 3-projective hypergroup, the set of non-identity elements can be partitioned into subsets that form a non-symmetric closed subset of order 3 with the identity and the multiplications of these subsets commute.

Presenter(s): Yifan Zhao
School: University of Chicago
Session: Poster: P1.13
Title: Exploring Machine Learning in Type Ia Supernova Standardization

Advisor(s): Joshua Frieman, Rick Kessler, Department of Astronomy and Astrophysics, University of Chicago
Co-Author(s):
Abstract: Type Ia Supernova (SNe Ia) are standardizable candles used to probe cosmological distances, and their standardization has relied primarily on the SALT programs. The SALT programs describe SNe Ia light curves as a combination of factors (color, stretch, etc.) that may be incomplete due to human pre-determination of what is crucial. We attempt to seek an alternative to the SALT standardization process by utilizing machine learning. We applied a Convolutional Neural Network (CNN) to SNe Ia data simulated by SALT3 to predict the distance modulus, effectively reconstructing the standardization process. We trained on photometric data pre-processed through a 2D Gaussian Process to create two-dimensional image representations of the flux values of each supernova detection as inputs to the CNN. Our model predicts the distance modulus with an R-squared score >50%, meaning that the CNN has successfully learned features that determine the standardization function as used in SALT. Our model is the first application of CNN in SNe Ia standardization, and we show that CNN is a viable method for this problem. Further investigation to include real data will give insights into factors in the standardization function not included in SALT.

All Students Presenting at MCMS Undergraduate Research Symposium, University of Chicago, Physical Sciences, Mathematics and Computer Science

University of Chicago

JJ Abu-Halimah, Avery Antes, Dillon Bass, Finn Braaten, Madeline Busse, Jessica Cao, Pravan Chakravarthy, Rishi Chebrolu, Evan Cook, Tate Flicker, Kaleb Funk, Joshua Edwards, Michelle Hu, Kyle Hulle, Smayan Khanna, Bethel Kifle, Rachel Kovach-Fuentes, Melody Leung, Hanchen Li, Xiangchen Li, Dana Lin, Yoyo Ma, Ezekiel Meulbroek, Megan Morales, Dang Nguyen, Jian Park, Zoey Papka, Abbey Piatt Price, Manuela Pinheiro, Bianca Pol, Kate Powledge, Rachel Quan, Audrey Scott, Jen Spinoglio, Jen Tang, Raul Teixeira, Julia Tuttle, Rohan Venkat, Zewei Wu, Zhongyuan Zhang, Megan Zhao

Washington University in St. Louis

Harry Gao, John Georgiades, Xiao Hong, Avital Isakov, Julie Lampert, Zisheng Luo, Emily Oh, Sarah Olsen

Beloit College

Sadeen Alsabbagh, Mohammad Tanzil Idrisi, Vu Anh Le, Takeshi Matsuda, Tianlong Wang

Carthage College

Ava Beyers, Héctor Rauda, Teagan Steineke, Andrew Valentini, Jordan Wheeler, Justin Wheeler

Colorado College

Maria Riek, You Jung Ji, Destiny McLaws, Callista Tran, Enrique Hernandez Salcido, Elliot Triplett, Lily Johnston, Liam Keeley, John Lê, Yousheng Tang

Grinnell College

Halvor Bratland, Mark Krysan, Sahil Kumar, Connor McMillin, Zeineb Mezghanni, Allison Rabbani, Rachel Rudacille, Minwoo Son, Qianqian Wu, Jingzhi Zho

Gustavus Adolphus College

Zoya Akhtar, Izzy Austin, Jos Bhandari, Sarah Carr, Katy Cash, Erin Coleman, Samara Goltz, Soren Grant, Sophy Smith, Gabriella Stoudt

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Hasif Ahmed, Brett Bamfo, Trent Ediger, Daniel Godoy, Avery Greene, Adam Krekeler, Eileen Limon, Haley Siculan

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Sona Baghiyan, Maya Ballard, Maureen Bowen, Houssam Ennoura, Hind Flaih, Liam Gallagher, Kaashya Khandelwal, Murali Meyer, Ionela Popa, Peter Wilson

Participating Faculty

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Cheng Chen, University of Chicago

Tom Clayton, Knox College

Kevin Crosby, Carthage College

Jill Dietz, St. Olaf College

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