GRADUATE RESEARCH SYMPOSIUM
PARTICIPANT ABSTRACTS

March 27th, 2024

Constanza Aceves Rodríguez
Linguistics
Division: Social Science
"Coordination strategies in Ombeayiüts"

This work examines and provides a broad overview of the different strategies Ombeayiüts speakers employ in coordination constructions. It describes the basic patterns utilized in each semantic type of coordination (conjunctive, disjunctive, and adversative) with a diverse set of categories (NPs, VPs, adjectives, and clauses). Ombeayiüts is one of the four speech varieties of Huave, an endangered Meso-American isolate spoken by an estimated 18,000 people in the Isthmus of Tehuantepec, Oaxaca, Mexico.

The data collected demonstrates that Ombeayiüts adopts different coordination strategies for each semantic type of coordination: zero-marking for conjunction, monosyndetic for disjunction, and monosyndetic with Spanish lexical borrowings for adversative. In additive coordination constructions, it can be observed that zero-marking is the default strategy for all categories: adjective phrases, noun phrases, and verb phrases. However, there are additional conjunctive strategies available to speakers. Given that the speakers inhabit a highly bilingual community undergoing widespread language shift, it is common for them to borrow coordination markers and patterns from Spanish. This work analyzes whether these borrowings are category-sensitive and in which contexts do they seem to replace the native conjunctions.

Furthermore, in Ombeayiüts conjunctive constructions, in addition to the zero-strategy and lexical borrowing of conjunctions, there are instances in which speakers employ the additive focus particle at/atmiün 'also' or the comitative marker -kiiüb 'with' as NP-coordinators. These instances of grammaticalization are described in this work, paying particular attention to their structural features and conjunctive function limitations.

Emefa Amoah
Psychology
Division: Social Science
"The Intersection of Anti-Fat, Anti-Black, and Sexist Attitudes"

Anti-fatness is a pervasive, harmful, and increasingly recognized critical social justice issue, given its role in producing social inequalities that contribute to health disparities and other forms of marginalization. Moreover, in recent years, anti-fatness has been viewed as an extension of sexist and American anti-Black attitudes, thus positioning anti-fatness as both a feminist and civil rights issue. Despite growing scholarly awareness that prejudicial attitudes are interconnected, extant research on anti-fat, anti-Black, and sexist attitudes has predominantly examined them as independent constructs. As such, in the present study, we utilized an intersectional approach to examine the dynamic interplay

of anti-Black racism (i.e., symbolic racism), hostile sexism (i.e., misogyny), and benevolent sexism (i.e., chivalry) in predicting the expression of anti-fat attitudes. Consistent with our theorizing, anti-fat, anti-Black, and sexist attitudes were positively related to one another. Furthermore, we found that anti-Black racism's relationship with anti-fat attitudes was contingent on the extent to which individuals held hostile, but not benevolent, sexist beliefs. Said differently, our results found that anti-Black attitudes were diagnostic of anti-fat attitudes for individuals who strongly endorsed misogynistic attitudes. Taken together, the implication of these results is such that fat Black women may face the greatest risk of being targets of anti-fat attitudes and experiences of weight-based stigma and discrimination that contribute to disparities in health outcomes and quality of life.

Paul Cavanah
Brain and Cognitive Science
Division: Natural Science
"Visuospatial attention and visual working memory share theta-rhythmic performance fluctuations"

Two cognitive processes are required for visual processing of information on a second-to-second timescale: visuospatial attention (VSA), in which one must selectively sample visual information within a scene, and visual working memory (VWM), in which one actively maintains visual information that is not being perceived. We typically make use of both at the same time; for example, reading a poster requires VSA to read text within a paragraph or graphics within a figure, as well VWM to maintain the text and graphics for a few seconds while processing new information. Many studies have demonstrated that VSA-mediated information processing is theta-rhythmic, that is, hit-rate and response time during attention-requiring tasks fluctuates according to theta frequencies (3-8 Hz). Likewise, there are similar findings from VWM tasks, such as within-object and within-feature alternations in response time. Despite these findings, little research has been done that directly tests whether or not VSA and VWM have common rhythmic modulations in performance. Here, we conducted a human EEG experiment that includes VSA alone, VWM alone, and VSA and VWM combined conditions. Our results show that a frontal 8 Hz oscillation causes phase-dependent modulations in performance in both the VSA and VWM subtasks. We also have preliminary results suggesting that the specific identity of VWM items may enhance or detriment visual discrimination. A follow-up experiment is underway to clarify the latter finding. Our results so far support the hypothesis that VSA and VWM have common sampling mechanisms and overlapping neural resources.

Jiwon Chang
Computer Science
Division: Engineering & Mathematics
"Approximate Top-k Sampling Under Budget Constraint"

Massive datasets are increasingly stored in data lakes or made available online with minimal processing. Top-k query answering in these settings is highly challenging due to data volume, processing costs, and lack of sorted indexes. Furthermore, emerging applications utilize complex and non-decomposable scoring functions. As exact top-k query answering can be expensive, a user may be satisfied with an approximate solution that does not evaluate all tuples. Thus, we study the problem of maximizing the quality of a top-k query under budget constraint. Our solution leverages the fact that distribution of real data is often skewed across datasets and by insertion order. Based on an approximate histogram sketch, our sampling scheme prioritizes tables or chunks of data that are likely

to contain high-quality tuples. We show that the optimal weights can be computed using continuous submodular maximization. As a running example, we apply our algorithm to the setting of training data acquisition for active learning.

Princeton Chee
Psychology
Division: Social Science
"Feeling Awe and Pride in Parenthood: The Unique Emotional Rewards of Parenting on Well-Being"

Parenting is hard, but it is also fun, fulfilling, and rewarding. We examine how two positive emotions may uniquely strengthen well-being during parenthood. In Study 1, 505 participants were recruited from Research Match. We found that experiencing awe and pride with one's child was associated with unique components of well-being for parents. Specifically, pride was associated with greater pleasure and awe was associated with greater pleasure, purpose, and variety in life. In Study 2, we recruited 300 participants in a within-person experimental study to test the causal effects of awe and pride on well-being. Participants wrote about times they felt awe with their child, pride with their child, and a time they had a typical interaction with their child (control condition) in three separate conditions. We found that when participants recalled awe and pride experiences, they felt greater well-being in all three pleasure, purpose, and variety in life than when they recalled typical interactions with their child. In addition, we found that participants who recalled awe experiences experienced even greater variety in life than when they recalled pride experiences. We also found evidence that self-expansion and self-transcendence mediated these results. In both studies, results were consistent across child and parent age and gender. Results also largely held when controlling for child temperament and other positive emotions like joy and amusement. Across both studies, we uncover the rich emotional experiences of parents and provide correlational and causal evidence of how these emotions uniquely enhance parental well-being.

Hannah Claus
Chemistry
Division: Natural Science
"Developing Photoresponsive Artificial Chaperones"

The process of protein folding is often complicated, especially for large proteins, which make up most proteomes. Some proteins fold spontaneously on their own successfully; however, they can adopt a variety of other undesired conformations that might also be stable, resulting in a misfolded protein. These misfolded proteins often form aggregates due to interactions between exposed hydrophobic regions, and the buildup of these aggregates is linked to degenerative diseases such as Alzheimer's, Huntington's, cataracts, and type II diabetes. Molecular chaperones are specific proteins in the body that assist other proteins in efficient folding and refolding by lowering the free-energy barriers to the native state to prevent off-path intermediates that lead to aggregates. However, molecular chaperones have fixed sizes and shapes that limit their ability to adapt to different protein substrates, resulting in incomplete prevention of protein aggregation. My research focuses on implementing a supramolecular approach to develop monodisperse, dynamic chaperones that are adaptive and will interact with a variety of protein sizes. The hydrophobicity of these chaperones will be controlled using a reversible, photoswitchable motif, spiropyran. We hypothesize that our amphiphilic spiropyran dendrons will

interact with misfolded peptides and, after irradiation of ultraviolet light, induce refolding of the protein into its native conformation. We foresee our artificial chaperones being used to help treat protein aggregation-based diseases such as cataracts, where upon delivery the spiropyran dendron could interact with crystallin and refold the protein after irradiation with light.

Frank Cwitkowitz
Electrical and Computer Engineering
Division: Engineering & Mathematics
"Toward Fully Self-Supervised Multi-Pitch Estimation"

Multi-pitch estimation is a decades-long research problem involving the detection of pitch activity associated with concurrent musical events within multi-instrument mixtures. Supervised learning techniques have demonstrated solid performance on more narrow characterizations of the task, but suffer from limitations concerning the shortage of large-scale and diverse polyphonic music datasets with multi-pitch annotations. We present a suite of self-supervised learning objectives for multi-pitch estimation, which encourage the concentration of support around harmonics, invariance to timbral transformations, and equivariance to geometric transformations. These objectives are sufficient to train an entirely convolutional autoencoder to produce multi-pitch salience-grams directly, without any fine-tuning. Despite training exclusively on a collection of synthetic single-note audio samples, our fully self-supervised network generalizes to polyphonic music mixtures, and achieves performance comparable to supervised models trained on conventional multi-pitch datasets.

Karthik Dinesh
Data Science
Division: Engineering & Mathematics
"Deep Learning for Brain Tumor Segmentation"

Brain tumors are life-threatening, particularly gliomas, which are familiar forms of brain tumors, that cause brain hemorrhage resulting in death. MRI scans, which are the most reliable tools in detecting and staging the cancers, however, have intrinsic variation resulting in difficulty in diagnosis. Computational tools are needed to accurately identify the brain cancer sub-regions. We came up with a novel architecture called V-Net Transformer which used the advantages of the V-Net's encoder-decoder-skip connections and the feature extracting capability of the transformers to perform cancer sub-region identification, particularly, whole tumor, tumor core, and enhancing tumor segmentation. We tested our model using the detailed BraTS 2020 brain tumor dataset and got some encouraging results. Our model scored an average of 74.6 out of 100, with the highest score reaching 84.7 for identifying the whole tumor. This shows our V-Net Transformer works really well and is also efficient—it does a big job with fewer resources (~46 million parameters) compared to other architectures. We are also planning to make our model even better by jointly adding the ability to predict how long patients with brain tumors might survive. This new feature is aimed at not just spotting different tumor areas but also helping to guess how the patient might do over time. We believe this will be a big help for doctors and scientists, giving them a fuller picture for diagnosing and planning treatments for brain tumor patients, leading to better care and outcomes for them.

Rebecca Everson

Linguistics
Division: Social Science
"Shekgalagadi of the Tjhauba: Culture, Subsistence, and Language in the Okavango"

Shekgalagadi (ISO-639-3 xkv, Glottolog 1887-xkv) is a minority language spoken in Botswana. It exhibits a large degree of variety and has a wide geographical distribution of speakers (Monaka 2017). The variety of Shekgalagadi spoken by the Batjhauba people, henceforth called Tjhauba, is an understudied and underrepresented variety spoken in the Okavango Delta region. Due to contact-induced phonological changes, such as the development of a large click phoneme inventory, and lexical differences, such as borrowed words from surrounding ||Ani, Mbukushu, and Yeyi communities, Tjhauba is almost incomprehensible to speakers of other Shekgalagadi varieties (Gunnink 2022, per. comm. Dr. Kemmonye Monaka and Dr. Anderson Chebanne). This contact with other language communities, as well as the national language, Setswana, has also resulted in fewer younger speakers learning Tjhauba. Through videos of interviews with elders, procedural texts, culturally salient events, and nominal elicitations centered around features of the unique ecology of the Okavango Delta, I show how community, environment, and language are inextricably linked, and preserve the language as it is spoken today. I also present my description of the phonetic, tonal, morphological and semantic properties of diverse nouns in Tjhauba. This work is funded by an Endangered Language Documentation Programme Small Grant for the period June 2023 - June 2024. All materials are openly available in the Endangered Languages Archive, including the first Tjhauba-Setswana-English dictionary (Everson 2023).

Rebecca Everson. Shekgalagadi of the Tjhauba: A documentation of culture and subsistence in the Okavango. Endangered Languages Archive. Handle: http://hdl.handle.net/2196/9022770b-448b-44c2-8179-7a4925f110b7, 2023.
Hilde Gunnink. A grammar sketch of the Shetjhauba variety of Shekgalagadi. Studies in African Linguistics, 51(1):29–55, 2022.
Kemmonye C. Monaka. Shekgalagari language of Botswana. The social and political history of Southern Africa's languages, pages 223–244, 2017.

Tanya Garg
Psychology
Division: Social Science
"How threat influences selection history: An eye-tracking study of attentional biases"

Individuals with post-traumatic stress disorder (PTSD) are known to exhibit threat-related attentional biases, or heightened responses to threatening stimuli. However, few studies have examined the effect of trauma exposure on attention allocation based on previous experiences (i.e., selection history). We used eye-tracking methodology to explore how attention allocation shifts after threat conditioning in a sample (N = 37; 18-59 years; 51.4% female; 43.2% Asian/Pacific Islander) of trauma-exposed (TE; n = 18) and trauma-naïve (TN; n = 19) individuals. Our hypothesis was that TE individuals would exhibit more attentional biases (facilitated threat detection, impaired attention disengagement and attentional avoidance) than TN individuals after undergoing threat conditioning. Before and after completing a virtual reality threat conditioning task, all participants freely viewed 30 matrices of pictures of conditioned (i.e., threatening) stimuli and unconditioned (i.e., non-threatening) stimuli, while their eye movements were continuously recorded. We found no significant change in attention allocation for either TE or TN individuals after threat conditioning. These findings suggest that trauma

exposure may contribute to, but not be the sole cause of, attentional biases. The results also underscore the need to identify additional vulnerability markers for preventative interventions for PTSD in the early aftermath of trauma exposure. Additional research is needed to determine if attentional biases manifest later in the etiological pathway for TE individuals who eventually develop PTSD.

Kevin Gausselin
Philosophy
Division: Humanities
"A Novel Account of Rich Representation in Conscious Experience"

You and a friend walk into a crowded supermarket and you see (what looks like) Barack Obama pushing a shopping cart. It seems plausible that, in such a scenario, your overall conscious experience represents not just lower-level properties like colors, shapes, and motion, but also higher-level properties like *being Barack Obama*. But it is unclear how one's visual perception can have such rich representational content. Two types of views have been defended to account for rich representational content – doxastic views and perceptual views. According to doxastic views, one's conscious experience represents *that is Barack Obama* insofar as one forms the belief that that is Barack Obama. On this view, one's perceptual experience only represents sensible properties (e.g. shape, colors, etc.) and higher-level properties are represented only in one's conscious beliefs. According to perceptual views, one's conscious experience represents *that is Barack Obama* insofar as one's perceptual experience represents *that is Barack Obama*. On this view, one's perceptual experience can represent both sensible and higher-level properties. Both doxastic and perceptual views face problems. Against doxastic views, it seems like your conscious experience at the supermarket can continue to represent *that is Barack Obama* even if you know that it is not Barack Obama (and so do not believe that it is Barak Obama). Against perceptual views, it seems like perceptual experience can only represent sensible properties. After all, what would it mean for one's visual field to represent *being Barack Obama*? This project develops a novel account according to which representation of higher-level properties in one's conscious experience is accounted for by one's visual perception of sensible properties combined with one's occurrent beliefs about higher-level properties. I call the resulting view the doxastic-perceptual account of representational content (DPC).

Gang Hu
Biology
Division: Natural Science
"A partition function model to predict melting curves for RNA structure"

Introduction. Previous work demonstrated that the traditional method of analyzing melting curves, which is based on the two-state model of RNA folding, might not always accurately predict the stability of RNA structures (Dimitrov and Zuker 2004). In particular, evidence suggests that RNA structures may exhibit non-two-state behavior, with partial denaturation or unfolding occurring at intermediate temperatures. To provide more accurate predictions, a partition function model was developed to fit the parameters to melting data, without assuming two-state behavior (Spasic et al. 2018). These parameters are called nearest neighbor parameters, and they are used to estimate RNA folding stability (Turner and Mathews 2010).

Results. We developed a model and software to estimate RNA melting of duplexes and hairpins. This estimates melting temperatures, the temperature at which half of RNA strands are denatured, and equilibrium concentrations of interacting strands. We also show that this software can inform the design of small model systems by identifying models that will form alternative structures during melting experiments. This software will be made freely available as part of the RNAstructure software package (Reuter and Mathews 2010).

Lucy Huffman
Chemistry
Division: Natural Science
"Isolation of Low-coordinate, High Valent Iron Centers within Rigid Cavities"

Trivalent iron complexes tend to adopt high coordination numbers unless prohibited by steric constraints. In ligand environments that promote trigonal coordination environments, the overwhelming number of formally Fe(III) complexes exist in a trigonal bipyramidal geometry. Herein a novel, high-spin, trivalent iron is reported in a trigonal monopyramidal coordination environment. The paramagnetic properties are verified through various spectroscopic techniques (EPR, UV-Vis, IR). Intracavity binding of hydroxide is reported, a key intermediate in the radical rebound mechanism for C–H functionalization. Generation of this species also serves as a model for other linear ligands to bind high valent iron in unique geometries.

Hafsa Irfan
Chemistry
Division: Natural Science
"Study of structure-function relationship in cobalt-substituted cytochrome c for biocatalytic hydrogen evolution"

Concerns of climate change have accelerated the need for cleaner and greener fuels for energy storage. Molecular hydrogen is a promising alternative to fossil fuels, with its high-energy density and clean combustion.

Cobalt-substituted horse heart cytochrome c (Hh cyt c) has proved to be an efficient biocatalyst for photocatalytic and electrocatalytic proton reduction in neutral water with high turnover number (TON). Using [Ru(bpy)3]2+ as a photosensitizer, the TON reaches 10,000 with longevity over 48 h. While using CdSe quantum dots as photosensitizers, the TON and longevity rise up to 70,000 and 1 week, respectively. In both the systems, the activity of Co- Hh cyt c surpasses another cobalt-substituted cytochrome c, namely Pseudomonas aeruginosa (Pa cyt c) which has half the TON. A similar trend was observed in electrocatalytic system, whereby Co- Hh cyt c significantly outperformed Co- Pa cyt c in terms of activity and longevity.

Spectroscopic evaluation of the native structure of these proteins reveals the key difference in their secondary structure responsible for their catalytic performance: the loop in Hh cyt c catalytic site is shorter and more flexible, which can "flap open" in the site of the substrate (protons), unlike Pa cyt c, which has rigid polyproline residues in its enzymatic cavity, hampering substrate access for catalysis. Future work entails protein engineering of Pa cyt c's rigid polyproline chain with a more flexible amino acid chain of glycine and evaluating the proton reduction capability of the mutated protein. This study

instigates the rational design for engineering proteins for biocatalysis.Cobalt-substituted horse heart cytochrome c (Hh cyt c) has shown to be an efficient biocatalyst for photocatalytic proton reduction in water with turnover number (TON) exceeding 8,000 with photosensitizer, [Ru(bpy)3]2+, and longevity over 48 h. Using CdSe quantum dots as photosensitizers, the TON and longevity rises up to 70,000 and 1 week, respectively. In both the systems, the activity of cobalt- Hh cyt c surpasses other cobalt-substituted cytochrome c, namely Pseudomonas aeruginosa (Pa cyt c) which has half the TON. Spectroscopic evaluation of the native structure of these proteins reveals the key difference in their secondary structure responsible for their catalytic performance: The loop in Hh cyt c catalytic site is shorter and more flexible, which can "flap open" in the site of the substrate (protons), unlike Pa cyt c, which has rigid polyproline residues in its enzymatic cavity, hampering substrate access for catalysis. Future work entails protein engineering of Pa cyt c's rigid polyproline chain with a more flexible amino acid chain of glycine and evaluating the proton reduction capability of the mutated protein. This study instigates the rational design for engineering proteins for biocatalysis.

Madelyn Jeske
Chemical Engineering
Division: Engineering & Mathematics
"Photobase Initiated Networks for Two-Photon Polymerization: Improving and Expanding Applications for Micro Polymers"

Additive manufacturing for the fabrication of microdevices, metamaterials, and cell scaffolds requires high resolution, precise material placement. Two-photon-polymerization (TPP) uses a femtosecond 780 nm laser to 3D print polymers at the sub-micron scale; however, majority of resins used are commercial with proprietary components and resulting chemical networks are not well reported in literature. In this work, "click" chemistry was used with TPP for high fidelity printing due to the mechanism's chemical selectivity. For the first time, a photobase (PBG) initiator was used in place of a free-radical photo-initiator to facilitate the reaction, producing a more ordered and stiffer polymer network structure with an elastic-moduli of 30 MPa and 2-10 MPa at 25°C and 70°C, respectively. Additionally, thiol-ene chemistry allows for shape-memory behavior to induce 4D printing (movement with time), printing structures capable of surviving 12% strain and 99% shape recovery were printed with sub-micrometer resolution and were robust enough to withstand several shape-memory cycles. Raman spectroscopy data from TPP samples show that networks formed with the PBG initiator have a higher selectivity for thiol-ene coupling than do networks formed with a free-radical initiator, which results in increased crosslinking density. An in-house mechanical press and dynamic mechanical analysis was used to evaluate temperature dependent stiffness and adhesive abilities of TPP prints. Results help guide the development of 2PP resins for printing polymers with improved uniformity, mechanical properties, and reduced shrinkage to benefit manufacturing of inertial confinement fusion targets and biotechnological devices.

Kathrin Lachenmaier
English
Division: Humanities
"On the Grid, Off the Grid: Negotiating Landownership and Alterity at the Frontier in James Fenimore Cooper's Novels 'The Pioneers' and 'The Chainbearer'"

In James Fenimore Cooper's novels 'The Pioneers' (1823) and 'The Chainbearer' (1845), the frontier in Upstate New York resembles what Mary Louise Pratt calls a contact zone in which American ideals, alterity, and notions of property are negotiated among landlords, squatters and other social outsiders, and Native Americans. The novels are set after the American Revolution, a time during which extensive land surveys were conducted and a Cartesian grid laid out, which not only facilitated land sales to benefit the state but also introduced Enlightenment idea(l)s in the wake of its advancement. However, the desire to transfuse the opaque and unfamiliar land with Reason and logic until it becomes transparent and familiar is extended to the (racially) Other who, however, resist integration and, subsequently, risk marginalization and removal. In the wake of this development, debates about laws and landownership ensue. Regarding genre, the conflicts are mirrored in Cooper's juxtaposition of Romantic and Gothic tropes, which evaluate the Enlightenment in contrasting ways in that the former embraces it while the latter critiques Reason. My argument, therefore, is that the spatial grid that abjects the Other in the novels is extended in its logic to the law and time, introducing what Mark Rifkin calls 'settler time' to create outsiders, outlaws, and outdated Others pushed off the grid of a growing nation.

Michael Lavell
Mechanical Engineering
Division: Engineering & Mathematics
"Development of a collision model for simulating fusion plasmas"

We present the development and verification of a Monte Carlo binary collision model for simulating elastic and inelastic collisions in particle-in-cell simulations. We apply the binary collision model to Coulomb collisions, elastic neutral–neutral and charged–neutral collisions, electron impact ionization, excitation, fusion, and bremsstrahlung radiation. The model's implementation is described and verified through a series of simulations, including thermal relaxation of charged particles, slowing of electrons in warm solid-density aluminum, collisional damping of electron plasma waves, helium gas breakdown in an applied electric field, and thermonuclear fusion. We use the model to investigate plasma properties in nuclear fusion reactor concepts including hydrogen plasma formation in the Princeton field-reversed configuration, as well as the fusion–radiation power balance in the burning of the aneutronic fusion fuel p–11B.

Zihao Li
Biomedical Engineering
Division: Engineering & Mathematics
"*In vivo* Localization of a Breast Cancer Targeting Molecular Probe for Fluorescence Imaging and Photodynamic Therapy"

Breast cancer (BrCa), characterized by its increasing incidence rates, stands as one of the most common malignancies affecting women globally. However, complete removal of all malignant cells during breast conserving surgery (lumpectomy) is a considerable challenge, since tumors are typically identified through visual confirmation and palpation, which leads to a high re-excision rate (~10-50%) following initial lumpectomy. So, we introduce a BrCa targeting probe based on the 18-4 peptide, which is recognized for its broad-spectrum binding affinity to major BrCa subtypes. We have synthesized a peptide based single modal targeted molecular image agent (TMIA) probe containing a

near infrared fluorophore (IR78), which will allow fluorescence-guided surgery and photodynamic therapy (PDT) for BrCa.

In this study, murine BrCa models were developed by initiating EMT6 tumors in the mammary fat pad of female BALB/c mice (n=8) through injection of 10^6 BrCa cells. To test these probes *in vivo*, one group of mice (n=4) received free IR78, and the other group (n=4) received 18-4 conjugated IR78. Longitudinal full body fluorescence images were obtained by capturing a series of eight images, each with an exposure time of 10 seconds. Each image was then flat-field corrected and montaged using an estimated 2D elliptical Gaussian function.

From the longitudinal fluorescence measurements, we found that the fluorescence intensity at the tumor region is higher and will last for long time using the 18-4 conjugated IR78 than free IR78. That encourage us to further investigate its potential in fluorescence guided surgery and PDT of BrCa.

Yuanhao Li
Brain and Cognitive Sciences
Division: Natural Science
"Ultra-fine knowledge of gaze position in saccade planning"

Sensorimotor integration is an important component of spatial representations, as retinotopic information needs to be combined with extra-retinal knowledge about eye movements to properly locate objects in space. Recent research has shown that extra-retinal oculomotor knowledge extends to fixational drift, the persistent wandering of the eye in between saccades: human observers are capable of inferring geometrical configurations purely based on motor knowledge of eye drift. Here we examine whether extraretinal information about fixational drift is also used to control eye movements. Specifically, we study whether saccade planning takes into account drift-induced displacements of the line of sight from the intended fixation location.
Observers maintained fixation on the location P0 of a previously briefly displayed marker in complete darkness during which the eye drifted to a new location PE. A saccade cue then instructed subjects to perform a 4-degree horizontal saccade. Subjects were tasked to perform a return saccade to the remembered location of P0.
Our data show that the return saccade compensated for the previous drift displacement. This compensation accounted for 68% of the angular correction needed to fixate back to the target. Similar results were found when the task was replaced by a 2AFC where subjects performed a saccade toward one of two cues at positions P0 and PE. In both conditions, performance was higher than when subjects visually selected P0 or PE with a joypad instead of a return saccade, suggesting that the uncertainty in extraretinal drift estimation is smaller in the motor modality than for visual judgments.

Chen Li
Brain and Cognitive Science
Division: Natural Science
"Goal-directed alpha power actively filters initial afferent activity in early visual cortices"

Spatial attention is the process through which we prioritize processing at specific locations in space, occurring through both the enhancement of behaviorally important locations and the suppression of potentially distracting locations. Despite extensive research demonstrating that goal-directed spatial

attention can influence processing in various visual regions, debate persists regarding its timing, particularly its influence on initial afferent activity in early visual cortices. In this study, we aimed to address this question using human electroencephalography. We utilized the C1 component, which serves as a measure of initial afferent activity. To evaluate goal-directed attentional modulation, we used alpha-band activity (8–14 Hz), a well-established neural marker of sensory suppression. Participants detected targets at a cued location while distractors (i.e., task-irrelevant stimuli) were presented at a non-cued location. We first replicated attentional modulation of the C1, and then replicated an increase in alpha band power over regions representing task-irrelevant sensory information—evidence of the alpha-related suppression. From this, we moved to investigate the relationship between C1 amplitude and pre-stimulus alpha power. The results revealed that higher alpha power was associated with lower C1 amplitudes at the distractor location and higher C1 amplitudes at the target location (i.e., at the attended location). This pattern of results was replicated in the majority of participants at the single-subject level. Overall, our findings provide the first evidence that initial afferent activity in early visual cortices can be actively suppressed through goal-directed, alpha-related gating of sensory processing.

Matthew Loman
Earth and Environmental Sciences
Division: Natural Science
"Development of a high-resolution gridded inventory of anthropogenic methane emissions in New York State"

Anthropogenic sources of methane have been an important area of research in recent years, as municipalities such as New York State (NYS) have begun to mandate methane emission reductions for their benefits to both air quality and climate. In preparation for top-down inverse modeling to quantify regional methane emissions, we present a newly developed anthropogenic methane emission inventory for NYS at 100-meter horizontal resolution and monthly temporal resolution. The gridded inventory leverages a variety of databases to spatially distribute the emissions reported in the NYS Department of Environmental Conservation (DEC) Statewide Greenhouse Gas Emission Report and the New York State Energy Research and Development Authority (NYSERDA) NYS Oil and Gas Methane Emissions Inventory, in which emissions are provided as statewide totals for each sector or countywide sums across all sectors. Our future work will build on this gridded inventory by incorporating direct measurements to align our estimated emissions with observational data.

Tyler Mason
Chemical Engineering
Division: Engineering & Mathematics
"Minimizing Outgassing from High-Power Vacuum Transmission Lines"

In the field of plasma science, pulsed-power drivers are used extensively to study matter at extreme conditions. The Z machine delivers currents as large as 26 MA over ~100 ns to various loads that can be used to study topics such as inertial confinement fusion and laboratory astrophysics. We desire to build machines capable of delivering even larger currents, but there exist physics limitations that must first be overcome. One such limitation is the vacuum power flow to the load in the center of the machine. Even though the current is insulated both by vacuum and a strong self-magnetic field,

losses are observed that scale unfavorably with larger machines. To overcome this, several material modifications to 304L stainless steel are being explored.
Here, we present a load geometry designed to test these material modifications with ~1-MA class pulsed-power drivers. The test fixture features a parallel-plate region that is scaled to create highly uniform electric and magnetic fields like those seen on Z, and the impact of a material treatment can be gauged by measuring the amount of plasma that is formed upon applying a pulsed current. Additionally, we present the development of a numerical model being built to study the desorption of gasses from steel, which we hope will provide insight to the amount of plasma formation observed in our experiments. In particular, we are interested in the desorption of hydrogen which is heavily impacted by the grain structure of the steel.
SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525

Hailemariam Mitiku
Chemistry
Division: Natural Science
"Synthesis, Reactivity, and Photophysical Properties of Pyridone-supported Bimetallic Ni(I) Complexes"

Pyridones make up an important class of ligands that can be involved in metal-ligand cooperativity (MLC). They form the reactive center in metalloenzymes such as [Fe]-hydrogenases and artificial catalyst systems. Pyridones, however, adopt various coordination modes as they can tautomerize and exist in both protonated and anionic state. This can consequently make controlling complex speciation challenging. We have designed a class of 2-iminopyridones (IPyOH) ligands to resolve speciation challenges and with a potential functionality for group delivery through MLC fashion. Metalation of neutral IPyOH with Ni(cod)2 affords bimetallic Ni(I) complexes, [((IPyO)Ni]2 featuring a Ni-Ni covalent bond. The properties and reactivity of these binuclear complexes across two application classes are described. (1) Ground state reactivity of the bimetallic complexes towards transfer hydrogenation of olefins using Lewis acidic hydride sources. (2) The [((IPyO)Ni]2 complexes exhibit electronic absorption features in the near-IR region that are attributed to metal-to-ligand charge transfer (MLCT) from the Ni–Ni bond. To evaluate the prospects of photochemical applications, strategies to elongate the excited state through ligand scaffold modification were pursued, resulting in improved lifetime of 34 ps.

Oviya Mohan
Brain and Cognitive Sciences
Division: Social Science
"Experimental Emergence of Conventions in Humans"

Conventions can be defined as arbitrary and self-sustaining practices that emerge in a population and facilitate solving coordination problems. A recent study (Formaux et al. 2021) successfully traced the formation of simple conventions in a small population of captive baboons (Papio papio) in the context of a touch-screen-based colour-matching 'game'. Nonetheless, several questions remain, including whether and how conventions form depending on how much information subjects have about the task. We replicated this task with human dyads under a variety of conditions (with or without visual access to the partner's screen; with or without prior information on the task structure) and found that more information delayed the formation of conventions (arbitrary rankings of colours that determined

choices in any given colour-pairing). Interestingly, dyads maintained their conventions even when they were given visual access to their partner's screen, despite the availability of an alternative, potentially simpler, cognitive strategy. We hypothesise that these differences are rooted in the extent to which human subjects are prompted to employ cognitively less or more sophisticated processes, which were assessed via self-reported strategies. We discuss our results in light of how animal, including human, groups solve coordination problems, with significant implications for our increasingly interconnected societies.

Mohammad Elious Ali Mondal
Chemistry
Division: Natural Science
"Quantum Dynamics Simulations of the 2D Spectroscopy for Exciton Polaritons"

We develop an accurate and numerically efficient non-adiabatic path-integral approach to simulate the non-linear spectroscopy of exciton–polariton systems. This approach is based on the partial linearized density matrix approach to model the exciton dynamics with explicit propagation of the phonon bath environment, combined with a stochastic Lindblad dynamics approach to model the cavity loss dynamics. Through simulating both linear and polariton two-dimensional electronic spectra, we systematically investigate how light–matter coupling strength and cavity loss rate influence the optical response signal. Our results confirm the polaron decoupling effect, which is the reduced exciton–phonon coupling among polariton states due to the strong light–matter interactions. We further demonstrate that the polariton coherence time can be significantly prolonged compared to the electronic coherence outside the cavity.

Neeley Pate
Computer Science
Division: Social Science
"Impact of Educational Attainment on Belief Rigidity and Social Network Construction"

With the growth of polarization on social media, it has become crucial to conduct research into how users build their networks and what factors determine who they trust. The focus of this paper is to better understand how educational attainment as a demographic cue, or a piece of information that the user offers about themselves, affect a user's predisposed beliefs and network building. Using a simulated network, data were collected as participants provide their own beliefs, and then are exposed to other's beliefs and interact with their responses. The analysis conducted on these data highlights how educational attainment does not affect user's beliefs, but does impact the social network construction.

Suhasini Patni
Linguistics
Division: Social Science
"/ɦ/ Deletion in Spoken Hindi and Hinglish"

Hinglish is the umbrella term that encompasses both “indigenized Indian English forms” and “code-switching practices unintelligible to Monolingual Hindi or English speakers” (Parshad, Bhowmick, Chand, Kumari & Sinha 2016). Speakers below the age of 35 in North India use this language variety. While the effects of this hybrid variety on Hindi are a relatively understudied phenomenon, the most major influence it has had on Hindi is that of /ɦ/ deletion. This study uses a corpus to analyze non-linguistic factors such as gender, regional identity, and use of transliterated orthography to provide evidence for the popularity of this deletion across all Hindi varieties and study the sociolinguistic motivations behind this deletion.

In Hindi, /ɦ/, a voiced glottal fricative, deletes in fast colloquial speech. I created a corpus of 30 reels taken from Instagram which includes the works of 20 creators below the age of 35 who predominantly grew up in North India: New Delhi, Uttar Pradesh, Rajasthan, and Punjab. Some of the creators were also from Maharashtra, a state in central India. The reels include 16 male speakers and 18 female speakers. Based off of my intuition as a native Hindi speaker from Rajasthan, I posit that this deletion takes place in the following four contexts.

(1) The verb t͡ʃɑ:.ɦɪ.je (‘should, to want’)
ʊsɛ dɑ:l khani t͡ʃɑ:.ɦɪ.je
Him lentil eat should
‘He should eat lentils.’
This utterance changes to [ʊsɛ dɑ:l khani t͡ʃəi.je].

(2) Progress Aspect
vəhə gɑ:na gɑ: raha: ɦɛ
He song sing PROG COP
‘He is singing a song.’
This utterance changes to: [vo gɑ:na gɑ: ra: ɦɛ].

(3) Nahi (‘no’)
kʊtʃʰ nəɦi ɦua:
Some no happen
‘Nothing happened.’
This utterance can change variably to [kʊtʃʰ nəyi ɦua:] or [kʊtʃʰ ni ɦua:].

(4) Word-initial /ɦ/ deletion
kja ɦua:
What happen
‘What happened?’
There is the possibility of pronouncing the sentence [kja ua] in fast speech.

The corpus was analyzed to count the number of tokens where /ɦ/ was retained and deleted. Non-linguistic factors such as gender and regional identity were analyzed to compare the percentage of deletion. Word-initial deletions were analyzed using Praat (Paul Boersma & David Weenink). It was found that in all instances of [t͡ʃɑ:.ɦɪ.je] /ɦ/ was deleted. Deletion occured in 90% of the instances where progressive aspect was used, 70% instances of nahi, and about 30% instances of the word-initial lexemes, mostly copula. There was no significant variation in deletions between speakers from New Delhi and Mumbai or across gender. Because gender and regional identity did not play a significant role in this deletion, it is probable that this a rule most speakers of the new variety of Hindi follow.

Manasvi Patwa
Data Science
Division: Natural Science
"Quantitative Assessment and Prediction of Ocean Plastic Motivating Actions to Mitigation"

Plastic debris has been piling up on dumpsites and is finding its way into the oceans as a result of widespread usage of plastics and inadequate waste management procedures, therefore adding to the global problem of ocean plastic pollution. There has not been a comprehensive assessment of the amount of plastic that enters the ocean through the Indian riverine system. Evaluation of natural elements such as river flow, rainfall, and a variety of other factors like population, harbor activities, climate change, wind speed, amount of fishing, etc., have made quantitative measurements of river plastic difficult and cumbersome. In this paper, we aim to attain a sustainable development goal (SDG13) on climate action through the "Microsoft AI for Earth" grant under project id AI4E-2245-K6x8-21,100,305. Plastic waste generated by the major rivers of India is calculated for the past 10 years to develop a machine learning model for the prediction of the amount of plastic waste contributed by the Indian rivers to the ocean over the next five years.

Chari Peter
Chemistry
Division: Natural Science
"Surface Interactions between CdSe QDs and Polyoxovanadates that influence charge transfer"

Colloidal quantum dots (QDs) have been widely utilized to harvest solar energy and to convert it into electricity or chemical fuel, which requires efficient separation of photoinduced electron–hole pairs (excitons). Hole extraction, from CdE (E=Se, Se) QDs, has proven more challenging, because holes have a higher effective mass and thus lower mobility, which leads to poorer electronic overlap between QDs and their redox partners. In this work we aim to use Polyoxovanadate (POV) clusters as homogenous hole acceptors for the hybrid POV-QD system. We are exploring the installation of functional groups to clusters that will allow for attachment to QDs surfaces.

Noah Reger
Biology
Division: Natural Science
"Histone buffering in zebrafish and fly embryos: mechanisms and function"

Early embryos are dependent on maternally provided histones, including the variant histone H2A.Z, to develop. In Drosophila embryos, increasing nuclear H2A.Z levels leads to alterations in developmental timing, dramatic changes to the transcriptome, and reduced hatching success. To limit the total level of nuclear H2A.Z, these embryos employ a buffering system: large amounts of H2A.Z are sequestered in the cytoplasm, bound to organelles called lipid droplets via anchor protein Jabba. Preliminary evidence suggests that zebrafish embryos also have a cytoplasmic H2A.Z pool, but it is unknown how this pool is established and if it buffers nuclear H2A.Z levels. In addition, our understanding of failure to buffer remains incomplete. My project will focus on three questions. First, how is histone buffering accomplished in other organisms? Preliminary data indicates that in zebrafish,

the histone chaperone Anp32e may serve this function. Second, do flies have additional buffering mechanisms beyond what is already characterized? I have found that loss of fly Anp32e leads to increased nuclear H2A.Z levels and altered developmental timing. Finally, are there additional consequences to failed buffering? In fly embryos, elevated H2A.Z in flies results in increased nuclear falling, a phenomenon associated with DNA damage. I will use TUNEL to determine whether the falling observed is the result of DNA damage. My project will begin to address these questions and expand on the how and why of histone buffering in early embryogenesis.

Alison Salamatian
Chemistry
Division: Natural Science
"Selective CO_2 Reduction by a Synthetic Biocatalyst"

Cobalt-mimochrome VI*a (CoMC6*a), a synthetic mini-enzyme, is reported as a leader in semi-synthetic biomolecular catalysts for electrochemical and photochemical CO_2 reduction in water. The catalytic turnover numbers reach ~2,100 for CO with a max selectivity of ~80%. Comparison of CoMC6*a with other previously published cobalt porphyrins linked the enclosed active site of CoMC6*a with higher selectivity for CO_2 reduction. Selectivity for CO_2 over H^+ reduction was also controlled through applied potential and buffer pK_a. A less cathodic applied potential favored CO production over H_2, proposed to be due to avoidance of Co(I) negating the chance of H_2 production, due to the Co(I) favorable protonation. A high pK_a buffer favored CO over H_2 production in both electrochemical and photochemical conditions. Herein, we report a highly active synthetic enzyme for CO_2 reduction along with methods to increase the selectivity of the system.

Sanchari Sannigrahi
Chemistry
Division: Natural Science
"Ab-initio exploration of photo induced dynamics in the collective coupling regime."

Polariton chemistry is an emerging field for its wide-reaching effects on photochemical and photophysical applications. A polariton is a hybrid state of light and molecular degrees of freedom, capable of modifying the potential energy landscape of the bare molecular system. Vibrational motion in these systems induce a coherent exchange of energy between the excited molecules and photons inside an optical cavity. The coupled electron-nuclear-photon dynamics become even more complicated when considering many molecules coupled to the cavity. This is the so-called collective coupling regime where collective molecular excitations couple to the quantized cavity field to reveal novel new pathways for intermolecular energy transfer facilitated by individual nuclear motion and the dynamic exchange of photons. In this work, we develop an ab initio description of a many-molecule system using the well-known Shin-Metiu model. We explore the photo-induced dynamics of coupled Shin-Metiu models inside the cavity using mixed quantum-classical approaches and the Pauli-Fierz quantum electrodynamics Hamiltonian including the exact nuclear forces that stem from the nuclear gradients on the molecular dipole among all molecules. This high-level treatment leads to a detailed understanding of cavity-induced energy transfer pathways between molecules via nuclear motion and the dynamic interaction of photons with collective molecular excitations.

Yusuke Satake
Philosophy
Division: Humanities
"Absence as Indeterminacy"

Negative truths have long baffled truthmaker theorists. The problem is as follows. Some negative truths are true because of how the world is. If so, there are worldly facts that make such propositions true. However, then, it seems that what is not must be part of the world, a collection of what is. Indeed, unicorns don't exist not because unicorns' absence is part of the world but because unicorns are not a portion of reality. After all, how can the world make negative truths true? To solve the problem, I will propose a view that some negative propositions are neither true nor false and require no truthmakers. True negative propositions are made true by some positive facts incompatible with their falsity. To motivate this idea, I will first discuss three extant approaches to the problem of negative truths: negativism, holism, and incompatibilism. The first two impose unreasonable ontological cost, existence of absence, while the third doesn't explain some negative truths. Given this, I will argue that the problem should not be settled merely by an ontological consideration of what makes negative truths true but also by a semantic consideration of what negative propositions are true. In the second part, I will flesh out my view. As for ontology, I will argue that absence falls into two kinds: absence as incompatibility with positive facts and absence as indeterminate existence. As for semantics, I will propose a trivalent framework allowing for the truth-value of indeterminacy to make sense of absence as indeterminacy.

Sarah Sawler
Political Science
Division: Social Science
"Who Benefits? Experimental Evidence of Gender Differences in Evaluations of the Deserving Poor"

This study examines how Americans evaluate the deservingness of men and women applying for government aid using a survey experiment. I find that, on average, male applicants earn less than female applicants with identical needs. Further, I find the amount awarded to women varies conditional on being rated a "Poor" or "Excellent" worker, while there is no difference in the amount awarded to men who are rated "Poor" workers compared to men who are rated "Excellent." Thus, women's advantage over men applicants extends only so far as women are perceived as deserving and hard workers. The totality of these results suggest that people are more inclined to help poor women rather than poor men, but only when the quality of women applicants is validated by an external source.

Jaimin Shah
Data Science
Division: Engineering & Mathematics
"Granger Causality Analysis of US Housing Market Influence on Substance Abuse Trends (2004-2011)"

This study assesses the causative link between US housing market trends and substance abuse incidents from 2004 to 2011. Utilizing time series analysis, we investigate substance abuse trends

across the United States, juxtaposing them with the US Housing Index. Granger causality tests are deployed to determine whether one time series can aid in predicting another, revealing significant causal relationships at particular lags. This suggests a multifaceted correlation between economic conditions and social health dynamics. The research enhances our understanding of the predictive capacity of economic indicators for social issues, underlining the value of informed policy interventions. It posits that the US Housing Index's temporal changes Granger-cause Substance Abuse, meaning the housing market could potentially forecast substance abuse trends, assuming no other time series affects the period studied.

Ayoub Shahnazari
Mechanical Engineering
Division: Engineering & Mathematics
"Generating Synthetic 2D XRD Patterns for Advanced Deep Learning Analyses"

Two-Dimensional X-Ray Diffraction (2D XRD) is an advanced technique used for the analysis of materials. Unlike traditional X-ray diffraction methods that provide one-dimensional data, 2D XRD captures diffraction patterns in two dimensions. This allows for more comprehensive information on the structure, phase, orientation, and strain of materials.
2D XRD patterns can be classified into two main types: ring patterns (for polycrystals) and spot patterns (for single crystals). In this project, we have focused on generating synthetic 2D XRD spot patterns.

Alicia Shipley
Biology
Division: Natural Science
"The role of Impa2 in histone exchange and organization of actin-rich structures"

Lipid droplets (LDs) are universal fat storage organelles that, in fruit fly embryos, play active roles in handling the histone variant H2Av. H2Av exchanges (transfers back and forth) between LDs via transient sequestration to the LD protein Jabba in both ovaries and embryos. In embryos, this mechanism paces nuclear import of H2Av, which is critical for regulation of chromatin assembly and gene expression. Exchange of H2Av is dynamic early in embryogenesis and then suddenly stops. To determine how H2Av exchange between LDs is temporally regulated, we are testing the role of Importin alpha 2 (Impa2). Impa2 acts in the nuclear import of certain proteins and – by some unknown mechanism - promotes correct organization of specialized actin-rich structure in ovaries called ring canals. Our lab had found that Impa2 is also necessary for H2Av exchange and localizes to LDs in a Jabba-dependent manner. Using western blotting and imaging, we now find that around the time H2Av exchange stops, Impa2 undergoes several changes: it is enriched on LDs, undergoes massive dephosphorylation, and localizes to ring-like structures at the cellularization front, in close proximity with actin. In ovaries, Impa2 colocalizes with ring canals and the actin-rich nurse cell cortex periphery, raising the possibility that Impa2 modulates actin organization directly and in multiple instances. Going forward, we will test if Impa2's roles in histone exchange and actin organization are intertwined.

JohnPaul Sleiman

Earth and Environmental Sciences
Division: Natural Science
"Measuring Lobate features on Mars and determining the scaling relative to terrestrial solifluction patterns"

Solifluction lobes, large-scale soil patterns commonly observed on Earth's hillslopes in cold environments, form due to frost-heave processes. Recent studies have proposed that similar patterns found on Mars may be valuable paleoenvironmental indicators, but it remains unclear whether they form from the same icy processes as solifluction lobes on Earth. Solifluction lobes have recently been theorized to exhibit a non-linear scaling with lobe height and topographic slope, based on a physical mechanism akin to fluid instabilities found at flow fronts. Initial studies using a large dataset of solifluction lobes in Norway corroborated this theory, with climate indices found to control absolute lobe size. Here we utilize Digital Terrain Models (DTMs) created from the High-Resolution Imaging Science Experiment (HiRISE) camera to determine whether lobate patterns in several Martian craters exhibit the same scaling as solifluction lobes on Earth. Our findings suggest similar scaling and morphology on Earth and Mars, with possible implications for our understanding of Martian surface processes and past climates. We have implemented new semi-automated methods for accurately determining lobe morphology on Mars, using flow direction and the steepest slope to calculate lobe heights and wavelengths with increased precision. These techniques have also been applied to our terrestrial data, enhancing the accuracy of our cross-planet comparisons. Our refined methodologies offer an improved understanding of solifluction lobe morphology, and the parallels between the physical processes on Earth and Mars.

Samantha Steiner
English
Division: Humanities
"Hands as Symbols of Black Motherhood in Daughters of the Dust"

Julie Dash's 1991 film Daughters of the Dust was the first feature film directed by a Black American woman to be distributed in U.S. theaters. Over a quarter of a century later, the film retains an important place in U.S. cultural vocabulary, as evinced by its influence on Beyonce's 2016 visual album Lemonade. In this project, I conduct a series of visual experiments using film stills from Daughters of the Dust. I select close-ups on human hands, which I superimpose one upon the other in order to reveal similarities and relationships between these close-ups. I argue that the hands of Black mothers are the site at which the past shapes the present and the present shapes the future. Furthermore, they ensure the physical and spiritual safety of future generations. When the agency of Black mothers is in danger, we are all in danger.

Vincent Tanzil
Philosophy
Division: Humanities
"Antirealism about Social Properties"

There is a tension about the ontological status of socially constructed entities, some claiming that they are real although socially constructed while others claim that they are not real for the same reason. In this paper, I focus on social properties, that is properties that are socially constructed. Some generally

accepted examples of socially constructed properties are like racial categories, being the president, being a woman, being influential, being held guilty or not guilty by the legal system, etc. I point out that given the fallibility and inconsistency of human beings, it is possible for social inconsistency to happen. Social inconsistency is when an object both have and not have a social property. This is contrasted with properties simpliciter, which does not admit of this possibility. I claim that this is a reason to be an anti-realist about socially constructed properties. I continue by rebutting common objections against anti-realism and offer positive reasons to accept anti-realism.

Yuxiang Wang
Electrical and Computer Engineering
Division: Engineering & Mathematics
"Predicting Global HRTF from Head Geometry using Deep Learning and Compact Representations"

We propose an head-related transfer functi on (HRTF) personalization method employing convolutional neural networks (CNN) to predict a subject's HRTFs for all directi ons from their scanned head geometry. To ease the training of the CNN models, we propose novel pre-processing methods for both the head scans and HRTF data to achieve compact representations.
A CNN model is trained to predict the SH coefficients of the HRTF magnitudes from the SCH coefficients of the scanned ear geometry and other anthropometric measurements of the head. Combining the magnitude and onset predictions, our method is able to predict the global HRTF data. A leave-one-out validation with the log-spectral dis- tortion (LSD) metric is used for objective evaluation. The results show a decent LSD level at both spatial & temporal dimensions compared to the ground-truth HRTFs and a lower LSD than the boundary element method (BEM) simulation of HRTFs that the database provides.

Jialong Wang
Chemistry
Division: Natural Science
"Investigating Cavity Quantum Electrodynamics-Enabled Endo/Exo- Selectivities in a Diels-Alder Reaction"

Coupling molecules to a quantized radiation field inside an optical cavity has shown great promise in modifying chemical reactivity. While most ongoing work is leveraging resonance effects between the electronic transitions and the frequency of the cavity, the ground state can also be modified through non-resonant effects dominated by dipole self-energy contributions. In this work, we predict that the ground state selectivity of a Diels-Alder reaction can be fundamentally changed by strongly coupling to the cavity, generating preferential endo or exo isomers. These products are formed with equal probability from the same reaction outside the cavity. We use the recently developed ab initio polariton chemistry approach and theoretically compute the relative energy of the transition states at the TD-DFT level, which indicates the kinetically preferred reaction pathway. We benchmarked our results with the high-level QED coupled cluster approach. We explore the coupling of the reaction to an arbitrary polarization vector, which leads to the maximal and minimal possible cavity-induced effects on the reaction. We have further provided an analysis of the ground state electron density difference between inside and outside the cavity, and we demonstrate how coupling to the cavity can change the charge distribution, which leads to preferential endo or exo intermolecular bond formation.

Caroline Warrick-Schkolnik
English
Division: Humanities
"Antisemitic Conspiratorial Fantasies in Western Culture"

This project traces the long, fraught history of the antisemitism from which current conspiracy culture spawns by highlighting key moments within this history that demonstrate the prominence and relevance of antisemitic discourse. I will foreground Western antisemitism in literary and media history beginning in the twelfth century, and subsequently look at what I deem to be landmarks in the development of the pervasive antisemitic tropes that continue to be disseminated today, including Svengali from Du Maurier's Trilby and Shakespeare's Shylock. I will use Bram Stoker's novel Dracula as a point of textual analysis, examining the confluence of previously familiar antisemitic tropes and the intense fear of Jewish people at the time. I will highlight the convergence of vampirism and antisemitism in this novel and its popularity in Western culture to demonstrate the relationship between Jews and vampires that continues to define modern and post-modern antisemitism. I will then examine a similarly imperative text for understanding the place of antisemitism in the American socio-political sphere: the far-reaching hoax text The Protocols of the Elders of Zion. I will also note the antisemitism present in the Satanic Panic of the 1980s and 1990s and the relevance of both Dracula and the Protocols to this moral Panic. Armed with this arsenal of context, I conclude by addressing the behemoth of conspiracy culture that is rising in popularity today and draw upon this research to examine the present and possible future of antisemitic conspiratorial thought.

Braden Weight
Physics and Astronomy
Division: Natural Science
"A Diffusion Quantum Monte Carlo Approach to the Polaritonic Ground State"

Making and using polaritonic states (i.e., hybrid electron-photon states) for chemical applications have recently become one of the most prominent and active fields that connects the communities of chemistry and quantum optics. Modeling of such polaritonic phenomena using ab initio approaches calls for new methodologies, leading to the reinvention of many commonly used electronic structure methods, such as Hartree-Fock, density functional, and coupled cluster theories. In this work, we explore the formally exact diffusion quantum Monte Carlo approach (DQMC) to obtain numerical solutions to the polaritonic ground state during the dissociation of the H$_2$ molecular system. We examine various electron-nuclear-photon properties throughout the dissociation, such as changes to the minimum of the cavity Born-Oppenheimer surface, the localization of the electronic wavefunction, and the average mode occupation. Finally, we directly compare our results to that obtained with state-of-the-art, yet approximate, polaritonic coupled cluster approaches.

Bevan Whitehead
Chemistry
Division: Natural Science
"Selective Point Source Capture of Perfluorinated Gas Using MOFs with Dynamic Corrugated Ultramicropores"

Perfluorocompound gases (e.g. CF4, C2F6, and NF3) play pivotal roles in semiconductor manufacturing as plasma etchants and deposition chamber cleaning agents, however pose a severe global warming threat due to their long atmospheric lifetimes, intense heat-trapping capabilities and kinetic inertness to atmospheric conditions. The development of sorbents that can capture PFC gases from industrial waste streams has lagged substantially behind the progress made over the last decade in capturing CO2 from both point emission sources and directly from air. Herein, we show that the metal–organic framework Zn(fba) (fba2– = 4,4'-(hexafluoroisopropylidene)bis-benzoate) displays an equilibrium selectivity for CF4 adsorption over N2 that surpasses those of all water-stable sorbents that have been reported for this separation. This selectivity is enabled by adsorption within narrow corrugated channels lined with ligand-based aryl rings, a site within this material that has not previously been realized as being accessible to guests. Analyses of adsorption kinetics and X-ray diffraction data are used to characterize sorption and diffusion of small adsorbates within these channels and strongly implicate rotation of the linker aryl rings as a gate that modulates transport of CF4 through a crystallite. Multi-component breakthrough measurements demonstrate that Zn(fba) is able to resolve CF4 and N2 under flowing mixed-gas conditions. Taken together, this work illuminates a more complete picture of the dynamic structure of Zn(fba), and also points toward general design principles that can enable large CF4 selectivities in sorbents with more favorable kinetic profiles.

Wenxiang Ying
Chemistry
Division: Natural Science
"Theory of Vibrational Strong Coupling Induced Polariton Chemistry"

We present a complete theory of vibrational strong coupling (VSC) modified reaction rate constants in polariton chemistry when coupling a single molecule to an optical cavity. We derive an analytic rate constant expression under the lossless regime based on steady-state approximation and Fermi's golden rule (FGR). The analytic expression exhibits a sharp resonance behavior, where the maximum rate constant is reached when the cavity frequency matches the vibration frequency. The theory also explains why VSC rate constant modification closely resembles the optical spectra of the vibration outside the cavity. This analytic expression, together with our previous analytic rate expression under the lossy regime, provides a complete theory for the VSC-modified rate constant. Our analytic theory suggests that there will be a turnover of the rate constant as one changes the cavity lifetime, and the rate constant will first scale quadratically with respect to the light-matter coupling strength and then saturate. The analytic rate constants agree well with the numerically exact hierarchical equations of motion (HEOM) simulations for all explored regimes. Further, we discussed the temperature dependence of the VSC-modified rate constants, where the analytic theory also agrees well with the numerical exact simulations. Finally, we discussed the resonance condition at the normal incidence when considering in-plane momentum inside a Fabry-P\'erot cavity.

Chloe Zhang
Biomedical Engineering
Division: Engineering & Mathematics
"Towards quantifying cerebral blood flow of patients undergoing extracorporeal membrane oxygenation (ECMO) with diffuse correlation spectroscopy (DCS) and speckle contrast optical spectroscopy (SCOS)"

Extracorporeal membrane oxygenation (ECMO) is a form of life support for critically ill patients with heart and lung failure by providing respiratory and cardiocirculatory functions through an external pump to oxygenate and circulate blood. However, approximately 13% of adult ECMO patients are found to have neurologic injuries. Failure to recognize injury in time is reportedly associated with poor outcomes in patients on ECMO. Hence, there is a clear need for bed-side non-invasive neuromonitoring technology in monitoring the cerebral pathophysiology for ECMO patients to minimize neurological injury.
Diffuse correlation spectroscopy (DCS) provides a non-invasive, continuous bedside neuromonitoring method to measure cerebral blood flow (CBF). Previous work in our lab has demonstrated the feasibility of using DCS for bedside monitoring on ECMO patients. The main limitation of DCS is its low signal-to-noise ratio (SNR), cost, and its limited imaging region to be forehead area only. To improve the limitations, we developed a new SCOS system which calculates speckle contrast to quantify blood flow information while using relatively inexpensive optics and camera. Arm cuff occlusion tests will be performed to demonstrate SCOS can capture blood flow change, and results on average relative blood flow (rBF) will be compared between DCS and SCOS to show equivalency in performance. Ultimately, we want to demonstrate that the new SCOS system is capable of non-invasive and continuous measurement of human CBF for patients undergoing ECMO and has the potential to expand into full head imaging.

You (Neil) Zhang
Electrical and Computer Engineering
Division: Engineering & Mathematics
"SingFake: Singing Voice Deepfake Detection"

The rise of singing voice synthesis presents critical challenges to artists and industry stakeholders over unauthorized voice usage. Unlike synthesized speech, synthesized singing voices are typically released in songs containing strong background music that may hide synthesis artifacts. Additionally, singing voices present different acoustic and linguistic characteristics from speech utterances. These unique properties make singing voice deepfake detection a relevant but significantly different problem from synthetic speech detection. In this work, we propose the singing voice deepfake detection task. We first present SingFake, the first curated in-the-wild dataset consisting of 28.93 hours of bonafide and 29.40 hours of deepfake song clips in five languages from 40 singers. We provide a train/validation/test split where the test sets include various scenarios. We then use SingFake to evaluate four state-of-the-art speech countermeasure systems trained on speech utterances. We find these systems lag significantly behind their performance on speech test data. When trained on SingFake, either using separated vocal tracks or song mixtures, these systems show substantial improvement. However, our evaluations also identify challenges associated with unseen singers, communication codecs, languages, and musical contexts, calling for dedicated research into singing voice deepfake detection. The SingFake dataset and related resources are available at https://singfake.org/

Yu Zhang
Mechanical Engineering
Division: Natural Science
"Kinetic study of laser-driven quasi-parallel magnetized shocks and particle acceleration"

Quasi-parallel collisionless shocks (in which the shock normal is approximately parallel to the background magnetic field) are believed to be the most efficient accelerators in the universe. Our NIF (National Ignition Facility) experiments in FY24 will be the first experiments to achieve the formation of a quasi-parallel collisionless shock in the laboratory. Compared to quasi-perpendicular shocks, quasi-parallel shocks are more difficult to form in the laboratory and to simulate because of their large spatial scales and long formation times. Our 2-D particle-in-cell simulations show that the early stage of quasi-parallel shock formation is achievable at the NIF, and that particles accelerated by diffusive shock acceleration are expected to be observable experimentally. Repetitive ion acceleration by crossings of the shock front, a key feature of DSA, is seen in the simulations. Collisionless dissipation mechanisms and particle spectra for different magnetic field angles to the shock normal will be presented.

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Yineng Zhao
Materials Science
Division: Engineering & Mathematics

"Artificial SEIs by Ultrathin, Conformal Fluoropolymers for High Coulombic Efficiency Lithium Metal Anodes in Dilute Electrolytes"

An ultrathin conformal layer of fluoropolymer (< 30nm) was engineered as an artificial solid electrolyte interphase at a Li metal/liquid electrolyte interface via initiated chemical vapor deposition. The F-rich ASEI improved the average Coulombic efficiency to 99.3% in a 1M LiFSI in DOL:DME (1:1) electrolyte. The density of the deposited Li was improved with the ASEI and no evidence of Li dendrites was observed. These improvements cannot be explained by LiF enrichment at the interface.