UNIVERSITY OF ROCHESTER
SCHOOL OF ARTS & SCIENCES AND
THE HAJIM SCHOOL OF ENGINEERING & APPLIED SCIENCES
GRADUATE RESEARCH DAY

PARTICIPANT ABSTRACTS

March 28th, 2025

GRADUATE RESEARCH TALKS

Samantha Steiner

English

"Weird Postmodern Trash: White Noise and the Return of the Renaissance Approach to the Otherworldly"

Literary academic culture in the U.S. today has cultivated a discomfort, if not an outright hostility, toward publicly expressed beliefs in spiritual forces beyond human understanding. The modernist and postmodernist movements, with their characteristic resistance to cohesive meaning, have been popularly understood as fundamentally nihilist and atheist in their orientation toward the world beyond human understanding. In this talk, I argue that modernism and postmodernism are in fact vehicles for a multitude of ideas about the world beyond human understanding, including the Renaissance concept of the weird as a manifestation of mysterious forces that may be hostile, helpful, or indifferent to human life. In Don DeLillo's 1985 novel White Noise, the weird is made both contemporary and utterly mundane as it manifests in human trash. Close readings of the novel reveal that the human connection to the weird is most apparent in what Philip K. Dick calls the "trash stratum": in the debris and discards of ordinary human life. Encounters with the trash stratum are undertaken as solitary expeditions that ultimately lead to a deeper understanding of the self, others, the past, and the future. Trash picking, in other words, is a means of contextualizing and even altering our position in place and time. White Noise marks an increasing movement toward the Renaissance understanding of the weird, paving the way for an era in which we finally engage with a reality we would otherwise ignore: that the world in which we live is bigger than we know.

Tanya Garg

Clinical Psychology

"When Expectation Meets Experience: A Virtual Reality Study on Threat Expectancy and Physiological Arousal in Trauma Exposure"

Trauma exposure can heighten threat expectancy, even in objectively safe situations, contributing to fear overgeneralization—a key feature of post-traumatic stress disorder. Evidence also indicates that trauma-exposed (TE) individuals exhibit heightened autonomic responses to trauma-related cues and even to general stressors compared to trauma-naïve (TN) individuals. Still, few studies have jointly examined both threat expectancy and physiological arousal in the context of trauma. This study investigated threat expectancy and electrodermal activity (EDA) in TE (n = 10) and TN (n = 12) individuals to isolate the effects of trauma on these outcomes. We hypothesized that TE individuals would exhibit greater threat expectancy ratings and EDA, regardless of the objective threat, compared to TN individuals. Participants (mean age = 27.1 years; 53.8% female; 46.2% White) completed a virtual reality threat-conditioning task with a danger zone (where shocks occurred) and a safe zone (shock-free). During the task, we recorded participants' threat expectancy on a 0-9 scale, and EDA via skin conductance response (SCR) and skin conductance level (SCL). Mixed ANOVA results showed that TE individuals had significantly greater threat expectancy in the danger zone, but not in the safe zone. While SCL did not differ between groups, TE individuals had lower SCR across both zones, suggesting blunted rapid physiological responses despite heightened threat appraisal. These findings indicate a dissociation between cognitive and physiological responses to threat in TE individuals. Further research could explore

how individual differences in trauma history, cognitive styles, and neurobiological factors contribute to the disparity between cognition and arousal.

Mary McMullan
Physics and Astronomy

"FLASH Simulations of Laser-Driven Experiments to Investigate Heat Transport in Astrophysical Magnetized Turbulence"

There has been an extended debate about whether the conduction of heat through the tenuous, magnetized plasma that fills galaxy clusters helps to maintain the temperatures of galaxy-cluster cores at much higher values than might be expected given their short radiative cooling times. Although heat conductivity given by the classical Spitzer model suggests that thermal conduction should play a significant role, astronomical observations of temperature fluctuations over much smaller scales than global cluster scales imply strong suppression of heat conductivity compared to the Spitzer value. The precise physical mechanism behind this suppression remains to be understood. Here we present high-fidelity FLASH simulations that were used to design and execute an experimental campaign at the Omega Laser Facility by the TDYNO (Turbulent Dynamo) collaboration, to explore and quantify the suppression of heat conduction in magnetized turbulence. Guided by the FLASH simulations, we were able maximize heat conduction suppression in the magnetized turbulence by introducing heater beams that bring collisional mean free paths to values significantly larger than the plasma Larmor radii. The work builds on our recent breakthrough at the National Ignition Facility (NIF), where the strong heat conduction suppression was first demonstrated.

Manfred Virgil Ambat
Mechanical Engineering

"Programmable-trajectory ultrafast flying focus pulses"

"Flying focus" techniques produce laser pulses with dynamic focal points that can travel distances much greater than a Rayleigh length. The implementation of these techniques in laser-based applications requires the design of optical configurations that can both extend the focal range and structure the radial group delay. This work describes a method for designing optical configurations that produce ultrashort flying focus pulses with arbitrary-trajectory focal points [1]. The method is illustrated by several examples that employ an axiparabola for extending the focal range and either a reflective echelon or a deformable mirror-spatial light modulator pair for structuring the radial group delay. The latter configuration enables rapid and automated exploration and optimization of flying foci, which could be ideal for experiments.

[1] M. V. Ambat, J. L. Shaw, J. J. Pigeon, K. G. Miller, T. T. Simpson, D. H. Froula, & J. P. Palastro, "Programmable-trajectory ultrafast flying focus pulses," Opt. Exp., 31, 19 (2023).

Dylan Wang
Philosophy

"Two Puzzles of Religious Commitment as Imagination"

A recent view in cognitive science and anthropology of religion holds that the cognitive attitude involved in faith is oftentimes not belief but imagination. This imagination theory of faith claims the advantages that it explains the coexistence of faith and doubt and explains away the apparent irrationality of religious people who hold their faith despite contrary evidence. This paper motivates two puzzles that recommend us to reconsider these two advantages. I call the first puzzle the puzzle of religious doubt. The idea is that an imaginative frame of mind seems to preclude the question of truth from arising, and thus it is puzzling how faith as imagination can allow religious doubt to happen in the first place. I argue that the best solution to the first puzzle is to say that the religious doubter is metacognitively mistaken about her religious attitude in that she thinks her religious attitude is doxastic when it is in fact imaginative. Interestingly, this best solution still generates a second puzzle I call the meta-puzzle of religious rationality. The idea is that even if religious doubters are metacognitively mistaken about their religious attitudes, they still rightly recognize the conflict between their supposed religious "beliefs" and their genuine scientific beliefs, and thus it still seems irrational for them to condone such conflict rather than rationally resolve it (and their so condoning is a theoretical leverage for imagination theorists). I conclude that more research into religious rationality is still needed for imagination theorists of faith.

Emily Speybroeck
Clinical Psychology

"Leveraging Court Appointed Special Advocates to Improve Outcomes for Children Involved in the Child Welfare System with Prenatal Alcohol Exposure"

Many children in the child welfare system are affected by prenatal alcohol exposure (PAE), facing lifelong developmental, cognitive, and behavioral challenges. These difficulties often lead to unstable placements and multiple home transitions, increasing risk of emotional, educational, and safety difficulties. Effective support for children with PAE remains limited. Implementation science offers a framework for developing solutions to increase effective support while also reducing provider burden. Court Appointed Special Advocates (CASAs) are well-positioned to provide PAE-informed advocacy in this system. This needs assessment explores CASAs' capacity to adopt evidence-based practices for supporting children with PAE in child welfare.

The current study, a needs assessment, consisted of qualitative interviews with CASA volunteers (n=8), CASA organizational personnel (n=10), and juvenile court judges (n=2). The behavior change wheel (COM-B; capability, opportunity, motivation affect behavior change) with the Theoretical Domains Framework (TDF; COM-B+TDF) was used to identify factors influencing CASAs' behavior change, guiding future interventions for increased PAE-informed advocacy.

Key findings revealed CASAs are uniquely positioned to advocate for PAE-informed care but are discouraged due to lack of knowledge, skills, and service gaps. Participants identified opportunities to integrate PAE-informed advocacy within existing CASA procedures, and emphasized the need for tailored PAE training, role clarification, and confidence-building methods such as success stories. Creative solutions for addressing service gaps were also highlighted.

This study is the first step in harnessing CASAs' potential to address systemic child welfare challenges for children with PAE and has broader implications for CASAs' potential in addressing multiple facets of child welfare reform.

Jeffrey Baron

History

"Treasure Excavations in the Medieval and Early Modern Hispanic World"

My dissertation examines the legal complexities of treasure-hunting excavations across the Spanish Empire, revealing how this practice—often dismissed as folklore—was a highly regulated legal phenomenon. Treasure hunters engaged directly with government bureaucracies, the Inquisition, and criminal justice systems, leaving behind rich documentary evidence. Drawing from archival records in Spain, Mexico, Colombia, and Peru, I argue that treasure hunting was widespread and involved individuals across all social strata. Their interactions with local officials, magistrates, and royal councils—whether legally excavating, under investigation for using magical techniques, or concealing finds to evade taxation—demonstrate its deep entrenchment in early modern society.

I challenge traditional periodization by tracing the legal tradition of licensed treasure hunting from antiquity through the early modern period. While scholarship often focuses on the role of magical techniques in treasure hunting, I show that this was only one aspect of a broader legal problem. A bureaucratic system governing buried treasure evolved over centuries. It originated in North Africa, then became increasingly refined in southern Europe, and was finally exported to colonial Latin America. This overlooked legacy of Spanish imperialism saw a diverse range of participants: Muslims and Jews obtained treasure-hunting permits in medieval Iberia, expelled moriscos were authorized to return and reclaim buried valuables in Spain, and indigenous Americans petitioned for licenses to excavate artifacts and sacred sites in Colombia and Peru. By examining these legal frameworks and licensing policies, my research highlights the intersection of law, colonialism, and cultural patrimony in the Spanish Empire.

Hossein Abolhassani

Biomedical Engineering

"Development of Innervated Organoids in a Modular Microphysiologic System for Hight-Content Toxicity Testing"

More than 90% of drug candidates fail in clinical trials, largely due to inadequate disease models and screening systems. That is the autonomic nervous system (ANS) plays a crucial role in regulating organ function, yet most biofabricated tissue models lack innervation, limiting their physiological relevance. Additionally, off-target toxicity of commonly prescribed drugs—such as chemotherapeutics, antimicrobials, and cardiovascular medications—is rarely assessed due to cost constraints. This project aims to bridge this gap by developing a multi-organ, cell-based microphysiological system (MPS) for modeling innervated three-dimensional (3D) tissue mimetics. This system integrates expertise in microbubble-array 3D culture, hydrogel-based extracellular matrix (ECM), and nanomembrane microfluidics to create physiologically relevant models for disease modeling, drug discovery, and toxicity testing. The platform is used to generate innervated salivary gland tissue mimetics (iSGm) to model ANS interactions with salivary glands and evaluate off-target commonly prescribed drugs-induced xerostomia (dry mouth). By demonstrating the MPS as a drug development tool (DDT), this project addresses a key translational barrier in drug testing. The system's arrayed format allows for high-throughput screening of neurotoxicity and side effects in a physiologically relevant environment. Upon

completion, this platform will offer a promising avenue for FDA qualification, accelerating translational research while reducing reliance on animal models for toxicity assessment.

Valeria Viteri-Pflucker
Optics

"Contribution of supergrowth to Fisher information in superresolved two-point imaging"

The resolution of an imaging system is defined by the smallest separation between features that can be distinguished. According to the Rayleigh criterion, this minimum resolvable separation depends on the optical wavelength and the size of the system aperture. This dependence on wavelength implies that there are objects that are too small to be imaged with visible light. Superresolution, the capability of an imaging system to resolve features smaller than predicted by the Rayleigh criterion, is of interest for applications in medical imaging, remote sensing, and chemistry. In recent years superresolution has been achieved by using superoscillating illumination. Superoscillations occur when bandlimited functions locally oscillate faster than their bandlimits. Experimental implementation of superoscillation-based superresolution imaging has proven challenging. Supergrowth, when a bandlimited function grows faster than its bandlimit, has been proposed as an alternative vehicle for structured illumination superresolution. It is hypothesized that supergrowth will be comparable if not more advantageous than superoscillations for superresolution imaging. In this work we analyze the contribution of supergrowth to superresolved two-point incoherent imaging by calculating the Fisher information. Fisher information quantifies the amount of information a signal carries about an unknown parameter that contributed to the signal. In our case, we calculate how much information an image of two incoherent point sources with sub-Rayleigh separation contains about the separation between the sources as we change the supergrowing properties of the illumination. We report correlations between illumination supergrowing properties and the information content of the images.

Kathrin Lachenmaier
English

"The Text(ural) Body: Indigenous DNA, Extraction, and the (Re-)Writing of Canadian History in The Marrow Thieves"

DNA research appears to yield concrete data, yet when embodied, it becomes a highly complex text. While a close reading of DNA—isolating single genes and their expressions—seemingly renders the human body legible, the living organism complicates these findings. Today, two major branches of DNA research focus on biomedicine and ancestry, with the latter pursued both academically and commercially. Genome research and the idea of ancestry as defined by genetic data become increasingly complicated ethically when ethnicity plays into the equation, as is the case with gene testing tools marketed to consumers that offer seemingly clear answers expressed in percentages of one's ethnic composition. These ethical dilemmas are central to Cherie Dimaline's novel The Marrow Thieves, which imagines a future where Indigenous DNA becomes the latest site of violent extraction, exposing the exploitative tendencies already present in the history of biomedical and genealogical research. Consumer DNA testing, while offering questionable utility to those untrained in genetics, caters to the North American obsession with origins, often fueling claims of (partial) Native American ancestry. Decoding and subsequently interpreting North American Indigenous DNA is

frequently employed to (re-)write and justify a version of history that favors the 'newcomers,' the settler colonial population, by enabling claims to Indigenous ancestry based on genetics alone while disregarding cultural ties.

Sumana Roy

Geoscience

"Exploring the phosphorus content of the pre-4 Ga terrestrial crust"

The unique chemical characteristics of phosphorus (P), including its structure and geochemical abundance, make it well-suited as a critical nutrient for life. It is necessary to form organisms' DNA/RNA and other internal supporting structures. While there are many origins of life models and no community consensus, one thing remains true: phosphorus would have been required since it is an essential element for life on Earth. Phosphorus availability on early Earth needs to be better established. We focus on characterizing the phosphorus content of the pre-4 Ga crust. We seek to address this by conducting temperature-dependent (P) partitioning experiments to derive partition coefficients (DP) between zircon ($ZrSiO_4$) and silicate (granitic) melt using an end-loaded piston-cylinder apparatus. Hydrous felsic melts (~ 10wt.% water content) in the SiO_2-Al_2O_3-Na_2O-K_2O-CaO-ZrO_2-P_2O_5-H_2O-(CaF_2) systems were chosen for this objective. Four distinct melt compositions with ASI (Aluminium Saturation Index) values of 0.8 and 1.2 were prepared, including one P undersaturated peraluminous melt (Melt 1), one P undersaturated metaluminous melt (Melt 2), one P saturated peraluminous melt (Xenotime saturated; Melt 3) and one P saturated metaluminous melt (Fluorapatite and Xenotime saturated; Melt 4) to represent a range of crustal melt compositions. In total, 25 experiments were conducted from 1300°C to 950°C at 1GPa. The concentration of P in zircon and melt was measured using an LA-ICPMS instrument. Partition coefficients (DP) were determined for each experiment. The experiments investigate potential phosphorus content in ancient terrestrial melts that might have significant implications for the origin of life studies.

Ariel Saracho

Economics

"Population Growth and Exporter Dynamics3"

Between 1987 and 2019, U.S. firm entry rates fell by 4.86 percentage points (pp), while the share of firms engaged in exporting rose by 4.34 pp. Population growth slowed down and is projected to approach zero by 2040. While existing research has examined the relationship between population growth and firm entry rates, its impact on exporters and trade has yet to be explored. In this paper, through the lens of a symmetric two-country dynamic general equilibrium model with heterogeneous firms, we argue that slower population growth leads to lower export participation rates due to higher dynamic firm turnover, shifting the firm distribution toward domestic firms less likely to export.

GRADUATE RESEARCH POSTERS

Irin Aby

Chemistry

"Kuratowski based MOFs for facile capture and degradation of per fluorinated contaminants"

Perfluoro compounds are recalcitrant chemicals widely used in various industrial processes including chemical manufacture, fire-fighting foams, semi-conductor industry etc .Selective removal and facile degradation of these chemicals from water sources is quite difficult. The project aims to use novel Kuratowski based metal-organic frameworks for the capture of these fluoro compounds, especially perfluoro octanoic acid, from water and degradation at 241°C, comparatively quite low when compared to the incineration temperature of 400-500°C for these chemicals. Adsorption has been verified using PXRD, NMR and IR spectroscopy while GC-MS, gas phase IR and NMR were employed to identify the degradation products.1-H perfluoro heptane was identified to be the major degradation product via NMR studies. The project aims at being able to recycle the MOF through cycles and further achieve superior selectivity for the perfluorinated substrates.

Hamed Ajorlou

Electrical Engineering

"Convolutional Learning for Directed Acyclic Graphs"

We develop a novel convolutional architecture tailored for learning from data defined over directed acyclic graphs (DAGs). DAGs can be used to model causal relationships among variables, but their nilpotent adjacency matrices pose unique challenges towards developing DAG signal processing and machine learning tools. To address this limitation, we harness recent advances offering alternative definitions of causal shifts and convolutions for signals on DAGs. We develop a novel convolutional graph neural network that integrates learnable DAG filters to account for the partial ordering induced by the graph topology, thus providing valuable inductive bias to learn effective representations of DAG-supported data. We discuss the salient advantages and potential limitations of the proposed DAG convolutional network (DCN) and evaluate its performance on two learning tasks using synthetic data: network diffusion estimation and source identification, and also real world datasets: Thames River Dataset. DCN compares favorably relative to several baselines, showcasing its promising potential.

Yasaman Baghban

Visual and Cultural Studies

"Representing Marginalized Communities: Satirical and Poetic Approaches in Film"

Chris Marker, a French multimedia artist and filmmaker, once stated that The House Is Black (1962) is "the Land Without Bread of Iran," drawing a provocative parallel between Forough Farrokhzad's poetic documentary and Luis Buñuel's satirical ethnographic short. This paper critically examines this comparison by analyzing the films' narrative, aesthetic, and ideological strategies. While Land Without Bread (1933) deconstructs documentary realism through irony and surrealist detachment, The House Is Black immerses the viewer in a poetic, humanizing portrayal of a leper colony

in northwest Iran. Both films depict structural violence—not through direct brutality but through poverty, disease, and systemic neglect, in other words, through marginalization.

This study employs narrative analysis to compare voice-over techniques, anthropological critique to interrogate the ethics of representation, and comparative film aesthetics to explore how Surrealism and Iranian avant-garde poetry shape each film's form. Additionally, using Johan Galtung's concept of structural violence, this paper examines how both films expose indirect violence—Buñuel through satire, revealing the absurdity of institutionalized neglect, and Farrokhzad through poetic empathy, confronting the dehumanization of illness and poverty. By situating the films within their socio-political contexts—Spain's pre-Civil War period and Iran's pre-Islamic Revolution era—this paper explores how each filmmaker challenges dominant narratives of suffering, exclusion, and marginalization. While Land Without Bread deconstructs the documentary form through dark irony, The House Is Black transforms suffering into poetic resistance. In doing so, this study reassesses whether Marker's assertion holds or if the films' fundamental differences outweigh their thematic convergences.

Aiswarya Balakrishnana

Biology

"4-Thio-Uridine Labelling PolyA-Click-Seq (4PAC) Allows for Kinetic Analysis of PolyA site Selection"

Cleavage and Polyadenylation (CPA) is a mode of RNA-processing in which a stretch of polyA is added to the mRNA tail just after it is cleaved from the elongating polymerase. Work from the past 20 years has determined that the vast majority of protein-coding genes undergo Alternative polyadenylation (APA) where distinct polyA sites can be selected leading to production of different mRNA isoforms. The choice of where to place to the polyA tail is highly regulated and involves >20 proteins. Sequencing technologies targeted toward the 3'end of mRNA have emerged to allow for functional genomics investigations of APA in various settings. The limitations of such approaches are that they sequence mRNA 3'ends under steady state conditions, which fails to discern between the effects of differential mRNA isoform stability versus alternative polyA site selection. Here, we have developed a variation of our PolyA-Click-seq (PAC-seq) approach that identifies nascent polyA site selection. Using a short 4SU labeling and purification, we can focus PAC-seq to a narrow window of time that is restricted to ~20 minutes. We call this technology '4PAC'. To demonstrate the utility of 4PAC, we developed an auxin-inducible-degron(AID) system for NUDT21, which is a broad regulator of APA. We performed a 72-hour degradation experiment and performed either PAC-seq or 4PAC followed by computational analysis. This technology establishes an approach to measure changes in APA over time and can limit the contributions of differential mRNA isoform stability to 3'end sequencing that would normally occur when measuring steady state pools of mRNA.

Jordan Butt

Chemistry

"A Dual-Readout Photonic Sensor for Simultaneous Measurement of Enzyme Activity and Concentration"

Enzyme assays are a cornerstone of basic biology and clinical diagnosis, with a wide array of applications. Typically, enzyme activity is measured, but concentration of the enzyme is also of interest, as are comparisons between concentration and activity. Here we demonstrate a photonics-based diagnostic sensor that, to our knowledge, is the first

such sensor capable of measuring both enzyme concentration and enzymatic activity in a single assay. We used lysosomal cysteine protease cathepsin-L as a representative enzyme of interest. Both concentration and activity assays were found to be well-behaved analytically, with lower limits of detection of 2 ng/mL (concentration) and 1.8 ng/mL (activity) in doped solutions. We then verified that this biosensor could produce reliable results in a complex medium. Baseline levels of cathepsin-L in a commercial pooled human serum sample are detected through enzymatic activity and enzyme capture. Spiking in additional enzyme results in an increase to both enzymatic activity and enzyme capture. With the addition of an enzyme inhibitor to this spiked serum, we see a change in enzymatic activity while noting no change in concentration due to enzyme capture. This approach therefore validates simultaneous quantification of both enzyme concentration and activity, even in the presence of an inhibitor.

Daniela Carmona Perez

Chemistry

"Effect of Coordination Environment and Electronic Coupling on Redox Entropy in a Family of Dinuclear Complexes"

In recent years, thermocells have caught attention as effective candidates for the recovery and utilization of medium- and low-temperature heat energy. A thermocell is an electrochemical system constructed from a pair of identical electrodes and a liquid electrolyte containing a redox pair. In this system a thermoelectric potential is generated when a temperature gradient is applied between the two electrodes. The magnitude of the potential difference generated for certain system at a given temperature gradient is called temperature coefficient, and it determines the power output of a device. In efforts to increase the efficiency of thermocells, we need redox-active species that exhibit high temperature coefficients. Thus, our research focuses on identifying factors that affect the temperature coefficient in molecular systems, so we can design molecular compounds with target properties. As part of these efforts, we synthesized a series of isostructural homo- and heterometallic M2 (M = FeII, FeIII, ZnII) complexes supported by a phenoxo-centered tetrapyridyl ligand and ancillary carboxylate ligands that enabled independent change in (i) charge, (ii) coordination environment of the redox-active center, and (iii) electronic coupling strength between redox centers. Variable-temperature electrochemical analysis of the series revealed that the coordination environment and charge density change, as opposed to electronic coupling strength, are key parameters to be considered to optimize the temperature dependence of the redox potential. These results constitute the first examination of how electronic coupling influences the temperature dependence of the redox potential and provide important information for the design of molecular compounds with target redox properties.

Riesa Cassano-Coleman

Brain and Cognitive Sciences

"Perceptual features of music influence the likelihood, but not the qualities, of evoked autobiographical memories"

Music can evoke powerful autobiographical memories. While previous work has focused on how music-evoked memories are different from memories evoked by other cues (like faces, words, or TV scenes), it is unknown how various features of music influence evoked memories. To test this question, we used original popular songs and cover versions to match clips on lyrics and melody, but not perceptual features like tempo or instrumentation. Our novel corpus

contains 50 popular songs and covers from 2008 to 2019. One group of participants (N = 50) rated the perceptual similarity between original-cover pairs, another group (N = 50) rated the emotional valence and arousal of each clip, and the last group (N = 89) reported any memories evoked by the clips across two sessions. We found that perceptual similarity between originals and covers predicted the likelihood that a memory was evoked for the cover, such that covers that were more similar to the original were more likely to evoke a memory ($p < .001$). However, perceptual similarity did not predict differences in how vivid the memories were or how spontaneously they were retrieved ($p > .05$ for both). These results support a model in which the evoked memory is associated with a feature-invariant representation of song identity, where both the cover and the original can equally activate the memory if the song is recognized. In ongoing analysis, we will annotate memory descriptions for topics like driving, dancing, or mention of a friend. This work provides key insight into the mechanisms underlying music-evoked autobiographical memory.

Jin Dou

Biomedical Engineering

"Dynamic modeling of brain responses reveals earlier processing of predictable words"

In recent years, EEG (a type of brain response measured on the scalp) has been demonstrated to index the comprehension of natural narrative speech. One robust method to demonstrate this fact is by regressing time-lagged EEG responses against word predictability (the probability that a word will occur given its preceding words). The resulting linear regression weights reveal a centro-parietal negative response profile on the scalp. However, one shortcoming of this method is that it assumes the brain is a linear, time-invariant system for processing natural speech. In other words, it assumes that responses to all words share the same shape and timing properties, except for their amplitude, which will be linearly modulated by word predictability. In the present work, we hypothesize that responses to predictable words may be processed faster. We overcome the limitation of the method mentioned above by building a computational framework that can modulate the responses in terms of their amplitude and latency based on word predictability. We applied the proposed framework to the modeling of two EEG datasets collected when participants listened to an audiobook and attended to one of two audiobooks presented simultaneously. The results show that responses to predictable words peak earlier, which suggests that the previous assumption about the rigid timing of brain response to individual words in natural speech may not hold. The proposed framework provides a more flexible way to model the non-linearity of brain response to natural speech while preserving the model's interpretability.

Abigail Dweh

Biomedical Engineering

"Comparing the Impact of Systemic Pituitary Adenylate-Cyclase-Activating Polypeptide (PACAP) and Calcitonin Gene-Related Peptide (CGRP) on Balance and Auditory Sensitivities in Mice"

Migraine is a prevalent neurological disorder, with a lifetime prevalence of approximately 18% in women and 6% in men. Vestibular migraine (VM), characterized by episodic vertigo and balance impairments, affects approximately 3% of the population. Neuropeptides such as calcitonin gene-related peptide (CGRP) and pituitary adenylate cyclase-activating polypeptide (PACAP) are implicated in sensory hypersensitivity associated with migraines. While CGRP has been extensively studied in migraine pathophysiology and sensory disturbances, the role of PACAP in balance and auditory

sensitivities remains underexplored and represents a promising therapeutic target. We investigated if intraperitoneally delivered (IP) PACAP-38 impacts postural sway, imbalance, and auditory sensitivities in C57BL/6J wildtype mice using the center of pressure (CoP), balance beam, acoustic startle, and auditory brainstem response (ABR) assays. We also assessed systemic CGRP's effects on these behaviors in parallel. Our findings indicate that IP PACAP-38 significantly increased postural sway , caused balance beam imbalances, and modulated acoustic startle responses. Our findings provide preclinical evidence supporting a potential role of PACAP-38 in vestibular migraine pathophysiology. Future research will explore if PACAP antagonism can protect against PACAP-38s effects on balance and auditory behaviors, relevant to treatment of vestibular migraine (VM), especially for patients unresponsive to triptans or CGRP-targeting therapies.

Sergio E. Garcia-Hernandez

Biomedical Engineering

"Role of cell-matrix mechanical communication during lumen formation"

Lumen formation is a critical step in embryonic development. Nearly all metazoans contain internal cavities (lumens) lined by a layer of epithelial cells that serve to isolate cellular and tissue functions. While the basal extracellular matrix (bECM) plays an important role in cell polarization and lumen positioning during lumenogenesis, little is known about how mechanical properties of the bECM interact with focal adhesion signaling to balance external and cell-generated cytoskeletal forces during lumen formation and expansion. We developed optogenetic tools based on the iLID-SspB dimer to manipulate focal adhesion activity. We stably integrated these tools into epithelial cell lines (MDCKs) to precisely control focal adhesion formation and activity during lumenogenesis in 3D environments with different mechanical properties. We find that stiffer bECMs result in lumens of higher dimensions and sphericity. By combining optogenetic manipulation of cell-ECM mechanical signaling with finite element modeling of ECM deformation, we aim to understand how different bECM mechanical properties interact and feedback with active cell focal adhesion signaling and cytoskeleton to precisely regulate lumen formation, shape, and expansion.

Aida Gueye

Materials Science

"Influence of composition and cation distribution on the electrocatalytic capabilities of ternary spinel ferrites"

Ternary spinel ferrites (general formula AFe2O4) are promising electrocatalysts for a variety of transformations due to their electrochemical stability and their flexible composition. However, the impact of the identity of the A2+ metal cation, and the proportion of A2+ and Fe3+ ions in, respectively, tetrahedral and octahedral lattice sites (described by their inversion parameter) on the electrocatalytic properties of these materials is not well-understood. Here, we seek to investigate structure-function relationships (i) between the inversion parameter of ternary spinel ferrites and their ability to electrocatalyze a model reduction reaction, and (ii) between their composition and the Bond Dissociation Free Energy (BDFE) of surface O-H bonds. These BDFE values are important chemical descriptors for the ability of the oxide to participate in proton-coupled electron transfer reactions, which are key elementary steps in many electrocatalytic transformations. The electrochemically determined BDFE values (between 59-61 kcal/mol) vary with the identity of the A (Co, Ni, Fe or Zn), potentially due to surface oxygen speciation. For ZnFe2O4 , we found that

small inversion parameters produce the largest catalytic currents for reduction of hydrogen peroxide and yield of hydroxyl radical as detected by a fluorescent assay. We also observe a correlation between the magnitude of the current measured in the presence H2O2 and that of the current measured for a redox event assigned to Fe3+/Fe2+ reduction observed in the absence of H2O2. The data overall indicate that cation inversion controls the electrochemical availability of the catalytically active surface Fe3+ sites.

Yue Guzhang

Brain and Cognitive Sciences

"Attention-related N2pc component of the visual evoked potentials as a marker of fine-grain shifts of attention within the foveola"

Previous work demonstrated that covert attention can be selectively directed within the 1-deg foveola, enhancing fine spatial vision. The N2pc component, a well-known EEG marker of covert attention, has been extensively studied extrafoveally using large stimuli spanning >1-deg of visual angle. Investigating the N2pc component when attention is selectively shifted within the foveola between stimuli close to the resolution limit is challenging due to difficulties in maintaining precise stimulus lateralization in the presence of constant fixational eye movements. Here, we circumvented these challenges and examined whether the N2pc component is associated with selective attention shifts within the foveola when observers focus on fine spatial detail. Participants (N = 11) were instructed to attend to either a red or green stimulus. The color assignment was counterbalanced across blocks. While maintaining central fixation, a red and a green square (0.12° in size) were briefly presented 0.33° to the left and right of fixation. One square had a small gap positioned either at the top or bottom. Participants reported the gap location as quickly and accurately as possible. In informative blocks, the gap appeared in the cued stimulus, whereas in uninformative blocks, it appeared randomly between the two stimuli. Leveraging high-precision eye-tracking and retinal stabilization, we ensured that the stimuli remained at the same retinal location throughout each trial. Participants discriminated high-acuity stimuli more accurately ($p=0.0467$) and responded faster ($p=0.0019$) in informative than uninformative trials, confirming that selective attention was engaged. Additionally, a clear N2pc component was observed in both types of trials. Yet, its amplitude was larger in informative trials ($-2.05\mu V \pm 1.34\mu V$ vs. $-0.80\mu V \pm 0.87\mu V$, $p = 0.0064$). These findings show that even fine-grain visual attention shifts within the foveola can reliably elicit an N2pc, with amplitude varying based on the attentional focus.

Abhay Hegde

Physics and Astronomy

"Time-resolved Stochastic Dynamics of Quantum Thermal Machines"

Steady-state quantum thermal machines are typically characterized by a continuous flow of heat between different reservoirs. However, at the level of discrete stochastic realizations, heat flow is unraveled as a series of abrupt quantum jumps, each representing an exchange of finite quanta with the environment. In this study, we present a framework that resolves the dynamics of quantum thermal machines into cycles that are classified as engine-like, cooling-like, or idle. We explore the statistics of each cycle type and its duration, enabling us to determine both the fraction of cycles useful for thermodynamic tasks and the average waiting time between cycles of the same type. Our framework presents a novel

approach in characterizing thermal machines, with significant relevance to modern experiments such as mesoscopic transport using quantum dots.

Hasibul Hasan Hredoy
Biomedical Engineering

"CFD-Guided Engineering of Microfluidic Devices: A Strategy for Early-Stage Research Optimization"

In a recent hearing held by the Subcommittee on Cybersecurity, Information Technology, and Government Innovation, it was revealed that over $20 billion is wasted on ineffective research. Although no source was provided for the claim, it foreshadows the growing pressure to come with the transition to a new government administration and policies. Considering the limited resources in research, it is essential to properly test any hypothesis before conducting any expensive and time-consuming experiment to reduce the waste of resources. In this study, we will demonstrate the effectiveness of Computational Fluid Dynamics (CFD) to customize and engineer a microfluidic device incorporating Microbubble technology at an early stage of research. Comsol Multiphysics was utilized to design and simulate the microfluidics device. Parameters such as fluid flow rate, porosity of membrane, number and distance between microbubble were varied in the simulation. The result demonstrated that porosity of membrane, initial flow rate, the number of Microbubbles affects the velocity and flow pattern inside the Microbubble. The obtained data was utilized to re-engineer the device to control the flow pattern inside the Microbubble. This work exemplifies the application of CFD in optimizing microfluidic devices before experimental implementation, ultimately enhancing research efficiency and reducing resource waste.

Jinfa Huang
Computer Science

"Identity-Preserving Text-to-Video Generation by Frequency Decomposition"

Identity-preserving text-to-video (IPT2V) generation aims to create high-fidelity videos with consistent human identity. It is an important task in video generation but remains an open problem for generative models. This paper pushes the technical frontier of IPT2V in two directions that have not been resolved in literature: (1) A tuning-free pipeline without tedious case-by-case finetuning, and (2) A frequency-aware heuristic identity-preserving DiT-based control scheme. We propose ConsisID, a tuning-free DiT-based controllable IPT2V model to keep human identity consistent in the generated video. Inspired by prior findings in frequency analysis of diffusion transformers, it employs identity-control signals in the frequency domain, where facial features can be decomposed into low-frequency global features and high-frequency intrinsic features. First, from a low-frequency perspective, we introduce a global facial extractor, which encodes reference images and facial key points into a latent space, generating features enriched with low-frequency information. These features are then integrated into shallow layers of the network to alleviate training challenges associated with DiT. Second, from a high-frequency perspective, we design a local facial extractor to capture high-frequency details and inject them into transformer blocks, enhancing the model's ability to preserve fine-grained features. We propose a hierarchical training strategy to leverage frequency information for identity preservation, transforming a vanilla pre-trained video generation model into an IPT2V model. Extensive experiments demonstrate

that our frequency-aware heuristic scheme provides an optimal control solution for DiT-based models. Thanks to this scheme, our ConsisID generates high-quality, identity-preserving videos, making strides towards more effective IPT2V.

Songsong Huang

Psychology

"Contexualizing growth mindset: The moderating role of school competitiveness on the mindset–performance link among Chinese and American adolescents"

The generalizability of the Growth Mindset Theory to East Asia remains underexplored. Building on the Mindset × Context Theory, this study investigated the cultural and educational factors that influence the effects of growth mindsets. Utilizing multilevel analyses on the Program for International Student Assessment (PISA) 2018 sub dataset (n > 15,000), this study examined whether school competitiveness moderated the relationship between growth mindsets and academic performance among Chinese and American adolescents. Results revealed cultural differences: in highly competitive Chinese schools, a stronger growth mindset was associated with lower academic performance, whereas no moderation was found among American students. These findings offer novel evidence regarding the Mindset × Context Theory and underscore culturally and contextually sensitive applications of mindset frameworks.

Lucy Huffman

Chemistry

"Assessing Structure and Dynamics of Iron Complexes Supported by Tris(amidyl)amine Ligands"

Chelating ligand platforms derived from tris(2-aminoethyl)amine (TREN) can facilitate low coordination numbers and provide opportunities to tune the steric and electronic profile of the secondary coordination sphere. Herein, we examine the ability of two related tris(amidyl)amine ligands to stabilize low-coordinate complexes of trivalent iron, and further use molecular dynamics (MD) simulations to gain insight into the dynamics of both the primary and secondary coordination spheres. Our cavitand-inspired ligand allows for the isolation of four-coordinate FeLOCH2O via oxidation of the anionic ferrous precursor, yielding the first crystallographically characterized example of an iron(III) species in a trigonal monopyramidal geometry. While this discovery is enabled by the rigid macrocycle in the secondary coordination sphere, MD simulations suggest that this macrocycle negligibly alters dynamics in the primary coordination sphere, and suggests a route by which exogenous ligands may bypass the rigid cavity opening yet still access the intracavity coordination site in [MLOCH2O]n complexes.

Alana Huynh

Chemistry

"Engineering Cytochromes c of Different Organisms for Hydrogen Evolution"

Engineered biomolecules are promising catalysts for alternative energy applications. Our understanding of biomolecule structure and its effect on function in engineered systems are still being explored. Here, we investigate systems for photocatalytic hydrogen evolution using cobalt-substituted cytochromes c from two different organisms, Pseudomonas aeruginosa and horse. These cytochromes have similar overall folds but different sequences and dynamics, specifically of the axial methionine-bearing loop that covers the distal side of the heme proposed to be critical in catalyzing hydrogen

evolution. This project focuses on how protonated residues around the porphyrin affect this catalysis. In the horse heart cyt c scaffold, there are multiple lysine residues near the distal side of the porphyrin, specifically in the 72, 73, and 79 positions; however, the Pseudomonas aeruginosa cyt c scaffold has no lysine residues in this area. We hypothesize that protonated residues around the distal methionine near the heme porphyrin play a role in donating protons needed in the hydrogen evolution reaction to produce H2. By making amino acid mutations in this area, we can study how the properties of the amino acids around the porphyrin affect catalytic activity for H2 production. This project aims to demonstrate how we can engineer native protein scaffolds to be used as efficient catalysts for sustainable hydrogen production.

Md Saiful Islam

Computer Science

"Accessible, At-Home Detection of Parkinson's Disease via Multi-task Video Analysis"

Limited accessibility to neurological care leads to under-diagnosed Parkinson's Disease (PD), preventing early intervention. AI-driven video analysis can contribute to improved accessibility. However, existing AI-based PD detection methods primarily focus on unimodal analysis of motor or speech tasks, overlooking the multifaceted nature of the disease. To address this, we introduce a large-scale, multi-task video dataset consisting of 1102 sessions (each containing videos of finger tapping, facial expression, and speech tasks captured via webcam) from 845 participants (272 with PD). We propose a novel Uncertainty-calibrated Fusion Network (UFNet) that leverages this multimodal data to enhance diagnostic accuracy. UFNet employs independent task-specific networks with built-in uncertainty quantification, followed by calibrated and self-attended fusion of features. The design of UFNet ensures that the model gives more attention to tasks with confident signals and less to those with uncertain signals. Finally, we evaluated the model on 20% of all participants whose data was unavailable during training and model selection. UFNet significantly outperformed single-task models regarding accuracy, area under the ROC curve (AUROC), and sensitivity while maintaining non-inferior specificity. Withholding uncertain predictions further boosted the performance, achieving 88.0% accuracy, 93.0% AUROC, 79.3% sensitivity, and 92.6% specificity, at the expense of being unable to predict for 2.3% data. Further analysis suggests that the trained model does not exhibit any detectable bias across sex and ethnic subgroups and is most effective for individuals between 50 and 80. Requiring only a webcam and microphone, our approach facilitates accessible home-based PD screening, especially in regions with limited healthcare resources.

Anushka Jain

Biology

"Ubiquitination Patterns in Nascent Proteins"

The relationship between a protein's molecular age and its functions, modifications, and interactions is a largely unexplored area in biology. To address this gap, we have developed a technique termed as "proteome birthdating" to metabolically barcode proteins based on their time of synthesis within a cell. Through sequential incorporation of NeuCode lysine isotopologues, proteome birthdating partitions the proteome into distinct age-groups that are distinguishable by mass spectrometry. We have used proteome birthdating to investigate the age distribution of the ubiquitinome within human fibroblasts. Our results show that the majority of ubiquitinated proteins that accumulate

after proteasome inhibition consist of newly synthesized proteins. We used a combination of structural modeling and proteomic approaches to assess the ubiquitination patterns and folding properties of newly synthesized ubiquitinated proteins. We show that unlike proteins that are ubiquitinated at an older age, nascent ubiquitinated proteins are modified at lysine residues that are expected to be buried within the native structure of correctly folded proteins. Analysis of methionine oxidation patterns provide further evidence that nascent ubiquitinated proteins are misfolded. Together, the results indicate that a significant fraction of the nascent proteome misfolds and is targeted for proteasomal degradation during or soon after translation.

Donya Khaledyan
Electrical Engineering

"Reconstructing Maps of Regional Brain Stiffness Variations from Shear Wave Patterns in OCT scans with conditional GAN"

Optical Coherence Elastography (OCE) is a noninvasive imaging technique widely used to evaluate tissue elasticity. OCE is particularly well-suited for studying brain stiffness due to its ability to provide high-resolution, real-time imaging and its exceptional sensitivity to biomechanical changes. Its ability to detect regional biomechanical variations makes it invaluable for both clinical diagnostics and research. However, it can be difficult to estimate local stiffness from 2D shear wave patterns acquired via elastography techniques. In this study, we proposed a conditional GAN-based (cGAN) model to reconstruct elastogram maps showing brain stiffness variations from 2D patterns of propagating shear waves measured at at different frequencies. By training on paired data of 2D shear wave patterns and corresponding elastogram maps, the models can learn to transform the input patterns into output elastograms reconstructing the regional stiffness variations.

Alanna Klose
Materials Science

"Lambda Theta Reflectometry for protein biosensing"

Label-free reflectometry sensors detect proteins by measuring the reflectance properties of a thin film on a substrate. As light encounters a thin film layer stack, interference occurs when reflections from the interfaces between the layers and the substrate interact with the incident beam. The amplitude and phase of these reflections determine if the sum is constructive or destructive. An antireflective condition occurs when the interference is fully destructive. Existing reflectometric biosensing techniques measure changes in an interference spectrum as analyte binds to surface-bound ligand or measure an increase in reflectance from an initial antireflective condition at fixed angle and wavelength. These techniques are limited by low multiplexing capability, limited sensitivity, or by requiring high manufacturing tolerances. Lambda Theta Reflectometry (LTR) is a novel reflectometric technique that measures analyte binding to a ligand/SiO2/Si substrate by measuring the location of null reflectivity as a function of wavelength (lambda) and angle of incidence (theta). The substrate is simultaneously illuminated with a range of angles and wavelengths and reflected light is angularly and spectrally resolved. The optical thickness of the thin film is retrieved by fitting the location of the null in lambda theta space. A prototype LTR reflectometer has demonstrated the ability to measure SiO2 layer thickness with sub-Ångstrom precision. LTR measurements differ from spectroscopic ellipsometry by 0.03% across a SiO2

thickness sweep ranging from 1401 to 1466 Å. LTR enables sensitive measurements across a range of analyte concentrations without requiring stringent control over initial layer stack thickness.

Howard Li
Brain and Cognitive Sciences

"Spatial Encoding via visuomotor integration"

It is commonly assumed that the visual system encodes spatial information by the relative locations of neuronal receptive fields. The eyes, however, are never stationary; even when attending to a single point, incessant small movements (fixational drifts) also occur. How does the visual system integrate the retinal motion during drifts and knowledge of the motion when encoding space? To investigate this question, we decoupled eye movements from their normal retinal consequence via high-resolution eye-tracking and gaze-contingent display control. In a 2AFC orientation discrimination task, subjects were asked to report the orientation of a grating (±45-deg) while maintaining fixation. Stimuli were presented with a directional inconsistency between fixational drifts and the expected temporal modulations. This was accomplished by moving the stimulus on the display according to eye movements, so that, on the retina, the stimulus moved as if the eye had drifted in a different (rotated) direction, but with the same velocity. All subjects' performance was greatly impaired when the retinal motion and the eye trajectory differed by 90-deg, a manipulation that drastically alters the relationship between grating orientation and the spatiotemporal structure of the luminance fluctuations resulting from eye movements. In contrast, performance recovered when retinal and drift trajectories were rotated by 180-deg, a condition that restores consistency between luminance fluctuations resulting from eye movements and grating orientation. These results suggest that knowledge of drift direction provides critical spatial information, and a violation of the contingency between the expected and the actual retinal luminance flows is detrimental to visual processing.

Raye Liu
Computer Science

"A Novel Framework for Differentially Private Synthetic Data Generation in Multi-Modal Databases"

Generating differentially private synthetic data while preserving statistical utility is a critical challenge in data privacy research. This project examines the effectiveness of attacks like membership inference attack (MIA) on vectorized data embeddings, and proposes a novel pipeline that integrates a Gaussian Differential Privacy (GDP)-based Exponential Mechanism with a Maximum Spanning Tree (MST) framework on purpose of preserving privacy for confidential information stored in a multi-modal database. By leveraging GDP-based regularized sampling and dynamically adjusting marginal selection using kernelized mutual information, our method improves efficiency, convexity, and privacy guarantees while better preserving statistical relationships in high-dimensional datasets. Unlike the previous MST-based approaches, our method enhances privacy guarantee by incorporating l2 regularization into the sampling process, ensuring stronger protection and efficient optimization. Additionally, our approach addresses sparsity in high-dimensional data by introducing domain compression and reconstruction techniques, maintaining data consistency while mitigating information-leakage risks.

Yuxuan Liu
Materials Science

"Catch-and-Display Immunoassay (CAD-IA) for Point-of-Care Diagnostics of Traumatic Brain Injury"

Point-of-care (POC) diagnostics enable rapid, cost-effective biomarker analysis, facilitating timely intervention for traumatic brain injury (TBI). However, detecting TBI biomarkers in serum remains challenging due to extreme dilution and interference from biocontaminants, which hinder antigen-antibody interactions. Conventional immunoassays, such as ELISA, suffer from high background noise and limited sensitivity, restricting clinical utility. To overcome these limitations, we developed the Catch-and-Display Immunoassay (CAD-IA), an ultrasensitive molecular detection platform for TBI biomarkers in serum. CAD-IA integrates a silicon nanomembrane-incorporated μSiM biosensor, enhancing nanoparticle capture and signal amplification. Fluorescent immunocomplexes colocalize with captured nanoparticles in the presence of TBI biomarkers, enabling precise quantification via confocal microscopy. This approach achieved a limit of detection (LoD) of 0.1 μg/mL for S100B, a key TBI biomarker, with strong linearity in a serum-mimicking environment. The CAD-IA platform represents a significant advancement in POC TBI diagnostics, offering enhanced sensitivity and accuracy for rapid clinical decision-making.

Mathew McClure
Optics

"Spatial degree of unpolarization of full Poincaré beams"

Unpolarized light is useful in diverse fields such as materials science, metrology, spectroscopy, and interferometry due to the probabilistic nature of its instantaneous polarization. The degree of polarization (DoP) is a commonly used metric that quantifies what fraction of an optical beam is polarized. Unpolarized light has a DoP of zero, whereas fully polarized light has a DoP of one. The DoP fails to differentiate different kinds of unpolarized beams, as they all have an identical DoP despite having different statistical properties. We demonstrate the practical use of a newly developed metric, the degree of unpolarization (DoUP), by calculating the DoUP of various unpolarized beams. The DoUP was created as a comprehensive quantification of the differences between unpolarized sources, intended to quantify the deviation from ideal unpolarization. Originally proposed for time varying instantaneous polarizations, we extend the definition of the DoUP to beams with transverse spatially varying polarization features. To test this new metric, we model and calculate the DoUP of a well-established class of unpolarized beams called full Poincaré (FP) beams. Across such beams all possible polarization states are realized, and they can possess a DoP of zero. We demonstrate that the DoUP is a practical metric with the capability of differentiating different unpolarized sources by modeling FP beams with zero-valued degrees of polarization but varying degrees of unpolarization.

Ziyi Meng
Materials Science

"Complete Electrocatalytic Defluorination of Perfluorooctane Sulfonate in Aqueous Solution with Nonprecious Materials"

Per- and poly-fluoroalkyl substances (PFAS) are widely used synthetic chemicals that are harmful to human health. The exceptionally high thermodynamic stability of carbon-fluorine bonds in PFAS makes them highly resistant to

degradation, posing a significant challenge for destruction. Existing destruction methods, including incineration, γ-irradiation, non-thermal plasma, sonolysis, and electrochemical oxidation with boron-doped diamond or other precious anodes, suffer from high costs and energy demands, limiting their commercial viability. [1]

We developed a complete electrocatalytic defluorination process for perfluorooctane sulfonate (PFOS) in aqueous media using nonprecious materials. Laser-made nickel-iron layered double hydroxide nanocatalysts immobilized on hydrophilic carbon fiber paper were employed as anodes in aqueous lithium hydroxide electrolyte, using pulsed electrolysis and low-intensity deep ultraviolet light irradiation. We found that the defluorination process occurs in the anode microenvironment via deprotonated hydroxyl radicals and is facilitated by high lithium hydroxide concentrations. [2] Mechanistic investigations using two-dimensional nuclear magnetic resonance spectroscopy revealed that Li–F ion pairing and competitive adsorption of hydroxide ions plays a crucial role in preventing anode fouling and sustaining fluoride removal. This cost-effective and scalable method offers a promising alternative for PFAS remediation, overcoming the limitations of existing technologies. [3]

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Pegah Mohammadi

Mechanical Engineering

"Investigating pressure-driven phase transitions in layered ferroelectric CuInP2S6"

Recent developments in 2D van der Waals (vdW) ferroelectric materials have been driven by their intralayer and interlayer degrees of freedom, leading to unconventional properties. Among these materials, CuInP2S6 (CIPS) stands out due to its negative piezoelectricity, polarization switching, ionic conductivity, and quadruple-well ferroelectricity. These unique properties stem from the displacive nature of Cu1+ ions within the CIPS crystal structure. This study explores the influence of hydrostatic pressure on CIPS, employing first-principles density-functional theory (DFT) methods to investigate structural phase transitions in the pressure range 0-18 GPa. We results reveal a structural phase transitions near 6.8 GPa, from a non-centrosymmetric monoclinic Cc phase (spg#9) to a non-centrosymmetric trigonal P31c phase (#159). At higher pressures, a centrosymmetric phase, P-31c (#163), may coexist with the P31c phase due to their comparable enthalpy. The trigonal P-31c phase is identified as the paraelectric counterpart to the ferroelectric P31c phase. Furthermore, our DFT calculations predict that with increasing pressure, the electronic bandgap decreases. Overall, this study provides theoretical insights into the high-pressure phase transitions of vdW-layered CIPS ferroelectrics.

Mohammad Elious Mondal

Chemistry

"Collective effects in Polariton Spectroscopy"

Molecular polaritons, the hybridization of excitonic states in molecules with photonic excitation inside a cavity, play an important role in fundamental quantum science and technology. Understanding the decoherence mechanism of

molecular polaritons is among the most significant fundamental questions. We theoretically demonstrate that hybridizing many molecular excitons in a cavity protects the overall quantum coherence from phonon-induced decoherence. The polariton coherence time can be prolonged up to 200 fs with a realistic collective Rabi splitting and quality factor at room temperature, compared to the typical electronic coherence time, which is around 15 fs. We directly simulate 2DES spectroscopy and demonstrate a prolonged oscillation period of the off-diagonal beating between the upper and lower polariton states. The center line slope of the Lower polariton diagonal peak signal will decrease, indicating the decoupling from vibrations. These direct simulations of the pro-longed polariton coherence will provide invaluable guidance for our ongoing experimental verification of coupling CdSe Nanoplates to the optical cavity.

Ellise Moon

Linguistics

"A Solution to the Problem of Minimal Parts"

Some noun phrases can refer to both something and to parts of that thing. This is known as homogeneity or homogeneous reference. While plural and non-countable nouns in English have homogeneous reference, defined in terms of their cumulative and divisive reference, singular count nouns do not. A noun has cumulative reference if for any two things that noun refers to, the sum of those two things can also be referred to with that noun; for example two groups of penguins are also referred to as "penguins," but a group composed of two singular tigers are is not called "a tiger." A noun has has divisive reference if any part can also be referred to with the same noun; for example, any part of a glass of water can also be called "water."

However, formal semantic proposals for divisive reference predict that all parts of the stuff that "water" refers to can also be referred to as "water," including parts like hydrogen and oxygen atoms. The formal semantics over-generates, which is known as the Problem of Minimal Parts. This project presents a new formalization of divisive reference which avoids these problems by introducing a distinction in the ways that the parts of something are related to one another. Only parts which satisfy the formal criteria of Leveling, where the embedding of components is irrelevant to the identity of the whole, are taken into consideration. Revising divisiveness in this way avoids the Problem of Minimal Parts while still preserving homogeneous reference.

Adiba Proma

Computer Science

"The Role of LLMs in Tackling Political Misinformation"

How can we leverage emerging technologies and personalization to combat misinformation during critical political periods such as the 2024 presidential election? Utilizing personal preference in news sources and rhetorical style, we design a large language model agent in curating a tailored response to combat misinformation and support the truth. Our personalized AI agents empathetically engage with users' existing beliefs and trusted sources to support movement toward factual information. We then evaluate our model through a case-control study during the 2024 United States Presidential Election to show the impact of such an intervention on individuals with over 1200 participants in total. We

find that our intervention is effective in supporting beneficial belief updates regarding political topics, across varying conditions when compared to the control. Our findings can be used to better understand the potential role of LLMs in the political domain, and our methods can be adapted for designing personalized LLMs for other similar tasks.

Justin Ramsey

History

"Transporting the Proletariat: City Transit and Soviet Socialism, 1920s-1960s"

My research analyzes the history of Soviet city transportation to demonstrate the historical fluidity to the meaning of Soviet socialism across and beyond the Stalin era. Instead of viewing Soviet socialism as a well-arranged representation applied throughout a fixed periodization, city transportation provides a plurality of connotations that continually illustrate the contemporary state of Soviet "modernity." By looking at the history of Soviet city transportation enables us to highlight the global historical intersection of mass politics, mass urbanization, and mass transportation. In the case of Soviet socialism it demonstrates not only its engagement alongside historic contemporaries in navigating moving the masses but indeed the legitimization of Soviet power was entwined with it.

Noah Reger

Biology

"Deconvoluting the function of Anp32e in H2A.Z-dependent gene activity using fruit flies"

Proper incorporation of the histone H2A.Z into chromatin is necessary for correct gene expression. In vertebrates, the histone chaperone ANP32e directly interacts with H2A.Z and regulates gene activity by limiting H2A.Z incorporation. But exactly how this regulation occurs has not been established. In addition, the presence of multiple ANP32 orthologs has confounded mechanistic interpretations. Since fruit flies express a single ANP32e ortholog, they appear to be a promising model for establishing the mechanism of ANP32e action. However, to date, there is very little evidence whether fly ANP32e is even present near chromatin or if it interacts with H2A.Z. We therefore investigated ANP32e expression in early fly embryos using fluorescently tagged ANP32e. We found ANP32e is expressed and highly enriched in interphase nuclei. Intriguingly, it partially relocalizes to the cytoplasm during mitosis, indicating a previously unknown cell cycle dependance. Using AlphaFold, we predicted the structure of fly Anp32e with H2A.Z. The resulting model was consistent with a direct ANP32e-H2A.Z interaction. To test if this interaction occurs in vivo, we utilized a proximity ligation assay. In this assay, H2A.Z and the known H2A.Z interactor Jabba yielded strong signal in the expected cytoplasmic location. Early evidence suggests ANP32e and H2A.Z interact in both the nucleus and cytoplasm. It therefore appears that flies can be used to interrogate how ANP32e regulates H2A.Z. Future work will focus on determining the dynamics and function of ANP32e in the embryo. These results will help reveal how ANP32e facilitates proper H2A.Z-dependent gene activity.

Jacob Sacks
Optics
"Aberration Design of Zoom Lenses"

Zoom lenses change their field of view by moving lens groups along the optical axis. As the lens groups move, their aberrations change, and correcting these changing aberrations poses a challenge for the lens designer. After the designer determines the power and locations of the lens groups, it is common to create an aberration design, where the aberration properties of each lens group are optimized without knowing the exact construction of the lens group. We modify H. H. Hopkins' method of aberration design and implement it in Python. Then, we test the modified Hopkins method on examples derived from patent literature and find that the aberration designs produced by the modified Hopkins method are very similar to the aberrations in the patent examples. This finding challenges the commonly held belief that aberration balancing in a zoom lens is extremely complex and has no global minimum. We then explore these ideas with a new interpretation of aberration theory we call the natural aberrations.

Akza Sam
Physics and Astronomy
"Streamers in Star Formation: A Survey of Class 0/I Protostellar Envelopes in IC348"

Streamers are asymmetric, infalling gaseous material that supply mass to protostellar disks. While streamers have been discovered serendipitously in observations of protostellar envelopes, recent efforts have focused on systematically identifying them. In this study, we conduct a survey of Class 0/I protostellar envelopes in the IC348 star forming region in the Perseus cloud to determine the prevalence of streamers and their role in star formation.Using continuum and molecular line imaging to trace streamers (C18O, H2CO, SO, 13CO) and outflows (12CO), we model the Keplerian motion to determine the mass of the protostar and the disk kinematics.

Sanchari Sannigrahi
Chemistry
"Exploration of collective coupling effects in photo-induced dynamics"

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 with a single mode inside the cavity using mixed quantum-classical approaches and the Tavis-Cummings quantum electrodynamics Hamiltonian. 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.

Ayoub Shahnazari
Mechanical Engineering

"Advancing automated classification of crystallographic structures using synthetic two-dimensional X-Ray diffraction patterns and deep learning"

This study presents a novel approach to automate the classification of crystallographic structures using synthetic two-dimensional (2D) X-ray diffraction (XRD) patterns and deep learning (DL). A Python-based Auto-Diffraction Pipeline (ADP) was developed to generate synthetic 2D XRD datasets from 52,191 Crystallographic Information Files (CIFs) across 230 space groups and seven crystal systems. These datasets enabled the training of convolutional neural networks (CNNs) designed to classify crystal systems and space groups with high accuracy. By leveraging multiple zone axes, including unseen axes, the models were evaluated under diverse conditions such as material deformation, atomic substitutions, occupancy variations, and defect introduction. The results demonstrated robust performance, with accuracies exceeding 90% for crystal system classification and substantial accuracy improvements with increased data diversity. These findings underscore the potential of synthetic datasets and DL to address challenges in experimental XRD, such as data scarcity and manual analysis errors. This work highlights the transformative potential of integrating synthetic XRD data with DL for high-throughput, automated crystallographic analysis, paving the way for advancements in materials discovery and characterization.

Snigdha Shrivastav
Data Science

"Preliminary Steps Towards a Wearable Device for Real-Time Cardiac Monitoring among Active Firefighters to Prevent Sudden Cardiac Events"

Background: Sudden cardiac death (SCD) is the leading cause of on-duty fatalities among firefighters. To address this risk, we developed H2M, a deep-learning model with 97% accuracy for monitoring cardiac rhythm. This study assessed the usability of a wearable device and conducted preliminary external validation of H2M using data collected from the device.

Methods: From April to June 2024, firefighters were recruited to wear a chest-mounted device (FX2, Fourth Frontier, Austin, TX) during training. The device recorded single-lead ECG data, closely matching lead V5 (r=0.88) and V4 (r=0.86). Firefighters self-applied the device and returned it by mail. Demographics, satisfaction, and ease-of-use ratings (0–10 scale) were collected. ECG data was pre-processed and annotated by PhD-prepared nurses, and results were compared to 24-hour Holter data (NR011077). Internal validation utilized leave-one-out cross-validation, while external validation involved unseen data from one firefighter. Signal quality indices (SQI) were compared to age-, sex-, race-, BMI-, and history-matched subjects.

Results: Six firefighters (mean age 41; 100% male; 100% white) contributed 31.7 hours of ECG data and 136,827 heartbeats. Of these, 98.4% were normal, aligning with Holter data from 112 firefighters. Heart rates were higher during training (mean HR=107.6 bpm; max HR=150.4 bpm). Comfort and ease-of-use ratings averaged 9.4 and 9.7, respectively. Model accuracy and precision were ~92%.

Conclusions: The wearable device provides high-quality ECG data and is user-friendly, supporting its potential for continuous cardiac monitoring in firefighters. Ongoing enrollment will further assess H2M's performance under varying conditions.

Snehitha Srirangam

Chemical Engineering

"First-principles Study on the Role of Metal Oxide in Tandem In2O3-Pt/Al2O3 catalyst for Oxidative Propane Dehydrogenation"

Tandem catalysts that integrate metals and metal oxides hold significant potential in advancing complex alkane chemistries. A recent example is In2O3-Pt/Al2O3, which is composed of the Pt/Al2O3 catalyst overcoated with Indium oxide layers for Oxidative Propane Dehydrogenation (ODHP).1 ODHP, an efficient alternative to Propane Dehydrogenation (PDH) for propylene production, has received extensive attention in recent years. In2O3-Pt/Al2O3 demonstrates stable selectivity for a longer duration compared to the state-of-the-art ODHP catalysts. However, large-scale application of such catalysts is limited by the lack of atomic-level understanding of multiple surfaces, primarily due to the vast configuration space arising from various phases and surface defects. To address this, a novel theoretical framework, combining the modified SurfGraph method with electronic structure calculations, is developed to systematically explore a phase space of ~10^4 configurations and obtain stable Indium oxide (InOxHy) configurations on the platinum (Pt) surface. Our thermodynamic analysis reveals that InOxHy enhances propane activation while suppressing deep dehydrogenation by selectively blocking the Pt defect sites and controlling the side reactions. These results are crucial for designing next-generation $M_1@M_2O_x$ catalysts and advancing the understanding of metal oxide films deposited on metal via Atomic Layer Deposition (ALD).

[1] Yan., H. et al., Science 371, 1257–1260 (2021)

Colin Steiner

Materials Science

"Terahertz Conductivity of Gadolinium Thin Films Deposited on Sapphire Substrate"

Due to the combination of ferromagnetic order with a critical temperature, Tc, of 293 K and high spin-orbit interaction, gadolinium is a promising material for developing new spintronic THz emitters. Investigations into the charge-carrier dynamics that take place in Gd are necessary to understand the process of spin- and orbit-to-charge transfers that take place in Gd-based structures. For our research, three gadolinium films of thicknesses 7, 23 and 67 nm were deposited on a monocrystal (0001) sapphire substrate via DC sputtering. These deposited gadolinium films are polycrystalline, as evidenced by X-ray diffraction peaks associated with both face-centered cubic and close-packed hexagonal gadolinium. Electrical conductivity measured using the Van der Pauw method for the 7 nm, 23 nm, and 67 nm samples gave values of 0.24 M S/m, 0.78 M S/m, and 1.26 M S/m respectively. Conductivity was also measured using THz time domain spectroscopy, following the Tinkham formula, giving values of 0.84 M S/m, 1.32 M S/m, and 0.91 M S/m at 1 THz, respectively. These values show good agreement with each other and with conductivity values for gadolinium presented in the literature (0.77 M S/m). The conductivity values calculated from THz time domain spectroscopy were also fit

with the Drude-Smith model to estimate the carrier lifetimes of the samples. These carrier lifetimes for the 7 nm, 23 nm and 67 nm samples according to the best fit of the model were 130 fs, 100 fs, and 90 fs, respectively.

Sayan Swar
Electrical Engineering

"Making Love Visible in Noise: Enhanced Surface Wave Detection Using Slepian Tapers"

Seismic interferometry has become a widely adopted method for subsurface imaging across a range of spatial scales. Since its revival in the early 2000s, much research has focused on developing algorithms to compute and extract surface wave dispersion from ambient noise correlations. These algorithms typically enhance signal quality by emphasizing time-domain techniques, such as One-Bit Normalization, Frequency-Time Normalization, and Welch Waveform Stacking (Bensen et al., 2007; Seats et al., 2012; Shen et al., 2012). However, they do not address the signal quality in the frequency domain, which is crucial for enhancing surface wave detection using the spatial autocorrelation (SPAC) method first introduced by Aki in 1957. In this study, we present an algorithm for rapid computation of high-quality (low-variance) frequency-domain SPAC based on Thompson's Multi-taper method. We calculate pairwise coherence using K-overlapping Slepian tapers that are carefully localized in both time and frequency. Preliminary results from a pair of low-quality transverse seismograms recorded in Africa demonstrate that multi-taper coherence significantly enhances the detection of Love waves and reduces uncertainty in phase and group dispersion measurements. Future work will address challenges related to memory, processing speed, and convergence when using a large number of tapers. We anticipate that this approach will enable the creation of a comprehensive high-quality catalog of short-period dispersion measurements, contributing to the refinement of global models of Earth's crust and mantle lithosphere.

Teona Taseska
Chemical Engineering

"Nonprecious Robust Anodes for Complete Aqueous Defluorination of Per- and Polyfluoroalkyl Substances"

The transition from large-scale, energy-intensive processes to ethical, sustainable, and climate-friendly technologies is crucial to meeting global needs and ensuring a livable Earth for future generations [1]. Electrocatalytic processes powered by renewable electricity offer a sustainable alternative, enabling the production of solar fuels and upgraded chemicals, and the destruction of harmful pollutants like per- and polyfluoroalkyl substances (PFAS) [1, 2]. PFAS are highly stable molecules resistant to chemical and biological decomposition [2]. We have developed an ultraviolet-light-assisted electrocatalytic process in aqueous LiOH electrolyte that achieves complete defluorination of hexafluoropropylene oxide dimer acid (GenX) and perfluorooctane sulfonate (PFOS) [3, 4]. Our approach utilizes robust nonprecious anodes and requires no auxiliary agents, providing a scalable and environmentally sustainable strategy for PFAS destruction [3, 4].

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Aldo Tecse Castillo
Biomedical Engineering
"Exogenous All-Trans Retinoic Acid Induces Myopia and alters scleral ultrastructure in mice"

This study explores how all-trans retinoic acid (atRA) influences the development of myopia (nearsightedness) and changes the structure of the eye in mice. We fed atRA to mice and monitored how it affected the shape and structure of their eyes over two weeks. Then, we measured the length of the eye, the thickness of different eye parts (cornea, lens, retina), and refractive error (how well the eye focuses light). We also examined the sclera, the white part of the eye, to see if the collagen fibers that make up its structure were altered.
The results showed that atRA treatment caused the mice to develop myopia, with a significant increase in the length of the eye, which is a key characteristic of myopia. While the shape of the front part of the eye (cornea, lens) didn't change, the structure of the sclera did. The collagen fibers in the sclera became more disorganized, and the scleral tissue became thinner in certain areas. These findings suggest that atRA influences the eye in a way that promotes myopia and affects the eye's structural components, especially in the sclera. Finally, this research could help in understanding how myopia develops and lead to potential treatments.

Harrison Todd
Geoscience
"Earliest Earth: New Outcrop Yields Three Ancient Zircons"

Earth is 4.54 billion years old, but its oldest surviving rocks are more than 500 million years younger. To explore Earth's history during this gap–a time known as the Hadean Eon–geoscientists rely on data gathered from small (100 μm) crystals of the mineral zircon. The Jack Hills of Western Australia hosts the largest source of these Hadean (pre-4.031 Ga) zircons. These crystals are rare; the global total known to science would not fill a teaspoon. The oldest are rarer still, with zircons older than 4.3 Ga representing around 1 in 10,000 grains by some estimates. We report on a new outcrop in the Jack Hills where the yield of these especially ancient, pre-4.3 Ga zircons is two orders of magnitude higher than previous estimates, presenting a new window through which to study Earth's first 150 million years. 141 zircons from the new outcrop with low common Pb and high concordance were U-Pb dated at the UCLA Secondary Ion Mass Spectrometer Laboratory. Of these, 20 were found to be Hadean, with 3 older than 4.3 Ga. Additionally, a series of zircons with ages between peaks at 3.7 and 4.0 Ga was identified, a range across which zircons from the Jack Hills discovery site are virtually absent. Kernel density estimates establish that zircons of any age older than 3.7 Ga are more common at the new outcrop than the discovery site, establishing this location as the premier sample site for early Earth geoscientists.

Linh Tran
Computer Science
"Investigation of Racial Bias in Vision-Language Assistants"

It is becoming increasingly common for Vision-Language Assistants (VLAs) built from pretrained Large Language Models (LLMs) to be used in every day life. However, since machine learning models are trained from human data, VLAs can carry racial bias shown in the real world. In this paper, we study racial bias in some popular open-sourced VLAs with respect to personality traits, skills, and occupations related to workplace. Our results shows that this VLA is biased towards Caucasian when associating attributes given an individual's images, and that certain attributes are biased towards certain races. This result closely resemble the percentage of Caucasian individuals in the workforce.

Leena Twal
Developmental Psychology
"Delineating Specificity in Parental Responses to Children's Distress: Associations with Neighborhood Risk and Children's Socioemotional Outcomes"

Parental responses to children's distress are a key feature of emotion socialization practices, teaching children about appropriateness of emotional displays. However, a majority of the literature groups response strategies into general "supportive" and "nonsupportive" categories, not allowing for specificity in researching outcomes. Furthermore, the function and effectiveness of parenting behaviors are influenced by the context in which families are situated (Dunbar et al., 2017; Sturge-Apple et al., 2021). The current study addresses this by researching specific emotion socialization behaviors in the context of the protection domain (Grusec & Davidov, 2010) to identify effects of neighborhood risk on socioemotional outcomes. Specifically, we test direct and indirect effects of neighborhood risk on children's anxiety and behavioral problems over time through mothers' and fathers' use of four distinct distress-response strategies.

Data was drawn from a larger project of 220 family triads. Responses to Children's Distress were observed during an interaction task, and analyses utilize Expressive Encouragement (EE), Emotion-Focused Reactions (EFR), Problem-Focused Reactions (PFR), and Minimizing-Supportive Reactions (MSR). Parallel mediation SEMs were tested. In all models, neighborhood risk was associated with EFR and PFR for mothers and fathers, and MSR for mothers. Mothers' EFR (β=-.166, p=.002) and PFR (β=-.212, p=.001) predicted lower levels of anxiety, and mediations were significant. Fathers' EE predicted higher levels of behavioral problems (β=.168, p=.008). Use of strategies differentially impacted children's outcomes over time, indicating gendered contributions to parents' influences on children and offering greater insight into the interaction between environmental contexts and the family system.

Braden Weight
Physics and Astronomy
"Cavity Quantum Electrodynamics Enables para- and ortho- Selective Electrophilic Bromination of Nitrobenzene"

Coupling molecules to a quantized radiation field inside an optical cavity has shown great promise to modify chemical reactivity. In this work, we show that the ground state selectivity of the electrophilic bromination of nitrobenzene can

be fundamentally changed by strongly coupling the reaction to the cavity, generating the ortho- or para-substituted products instead of the meta product. Importantly, these are products that are not obtained from the same reaction outside the cavity. A recently developed ab initio approach was used to theoretically compute the relative energies of the cationic Wheland intermediates, which indicate the kinetically preferred bromination site for all products. Performing an analysis of the ground state electron density for the Wheland intermediates inside and outside the cavity, we demonstrate how strong coupling induces reorganization of the molecular charge distribution, which in turn leads to different bromination sites directly dependent on the cavity conditions. Overall, the results presented here can be used to understand cavity-induced changes to ground-state chemical reactivity, from a mechanistic perspective, as well as to directly connect frontier theoretical simulation to state-of-the-art, but realistic, experimental cavity conditions.

Bevan Whitehead

Chemistry

"Capturing Perfluorinated Greenhouse Gases with Metal–Organic Frameworks"

Fluorocompound gases (FC) (e.g. CF4, C2F6, CHF3, and NF3) play pivotal roles in semiconductor manufacturing as plasma etchants and deposition chamber cleaning agents. However, owing to their long atmospheric lifetimes, 103-104 years, intense heat-trapping capabilities, and kinetic inertness to atmospheric conditions, FC gases possess global warming potentials that are orders of magnitude higher than that of CO2. Capture processes that facilitate the recovery and recycling/reuse of PFC gases remain, to our knowledge, unimplemented on the industrial scale. My research seeks to address this in several ways.

Our first approach is to utilize the literature framework, Zn(fba) to selectively uptake CF4 over N2. Using a variety of techniques, we have been able to model where the fluorinated gas molecules are being trapped in the framework, the uptake kinetics, and the degree of selectivity of this material for CF4 vs. N2. Our research has shown that Zn(fba) has one of the highest CF4 vs. N2 selectivities for all known water-stable sorbents, while remaining completely inert to both water and O2.

Our second approach is to take the literature framework M2(dopbdc) (H4-dobpdc = 4,4′-dihydroxy-(1,1′-biphenyl)-3,3′-dicarboxylic acid) (M= Mg and Zn) and post synthetically append long fluorinated amine chains onto the metal centers. This allows for material tunability based on chain length enabling us to probe the effect of chain length on uptake of FCs. Using SCXRD and adsorption measurements, we have been able to study these materials uptake behaviors under various temperature and dosed gas conditions as well as track the chain positional changes.

Madeleine Wilsey

Materials Science

"Low-Impedance Nanocatalyst–Support Composites via Pulsed Laser Grafting for Electrocatalytic Applications"

Electrocatalytic processes will play a critical role in global decarbonization and water pollutant destruction. The efficiency of these technologies is determined by the electrode performance, which can be improved through the incorporation of nanoparticles on high surface area conductive supports. Advancing electrocatalysis requires the development of rapid, scalable, customizable, and reproducible fabrication methods to produce efficient and durable nanoparticle-based electrodes.

Here, we introduce a new one-step pulsed laser grafting methodology to fabricate nanocatalyst–support composites with superior electrocatalytic activity and long-term stability compared to conventionally prepared analogues. This versatile and widely applicable process simultaneously generates nanoparticles and attaches them to surfaces within an eco-friendly aqueous environment, addressing persistent challenges in nanoparticle adhesion and electrical connectivity. By eliminating the need for separate synthesis, purification, and attachment steps required by conventional methods, our innovative approach mitigates common limitations in composite preparation, including time constraints and reproducibility issues. Compared to conventionally-synthesized or laser-synthesized materials, pulsed laser grafted gold or nickel–iron layered double hydroxide nanocatalysts on carbon fiber paper composites show enhanced electrocatalytic performance for bicarbonate reduction or water oxidation, demonstrating lower impedance at catalyst–support interfaces, increased catalytic activity, and enhanced durability. Our environmentally benign pulsed laser grafting process provides a transformative pathway for manufacturing nanoparticle–support composites for electrocatalysis and holds significant potential to accelerate the global transition toward sustainable energy technologies and decarbonization.

Yang Xu
Physics
"High-fidelity spatial information transfer through scattering media by an epsilon-near-zero time gate"

Non-destructive deep-tissue imaging using near-infrared (NIR) light is a fast-evolving imaging modality for in vivo cancer diagnosis due to the low phototoxicity of the long-wavelength source. However, such imaging modalities struggle with balancing transmittance and speed because of the strong in-tissue scattering and the lack of affordable high-efficiency detector in the IR range. This project tackles this by leveraging the nonlinear response of indium tin oxide (ITO) to selectively capture and up-convert ballistic photons, which are unaffected by scattering, to the visible range. This approach offers an unprecedented ability to capture clear images at sub-mm resolution in real time, even in media that significantly disrupts light paths. The resulting imaging system not only enhances signal-to-noise ratios in complex visual settings but also advances the potential applications, where traditional methods falter. Our experiment highlights a novel fusion of ENZ materials with high-resolution up-conversion imaging.

Qingzhi Ruby Zeng
Brain and Cognitive Sciences
"Prosodic and other paralinguistic features of speech differ across social contexts and roles"

Prosodic (e.g., pitch, rhythm, timbre) and other paralinguistic features (e.g., laughter) shape speech dynamics, but the ways in which different communicative demands, such as social context and role, influence these features remain unclear. To answer this question, we built a naturalistic speech corpus in which each speaker's voice is sampled across multiple days, and we analyzed speech prosody and paralinguistic cues across two social contexts (monologue and dialogue) and roles (host and guest). Differences across these conditions will offer insights about the natural variability of speech patterns and its relation to social influences. First, we extracted an 18-dimensional vector that comprehensively captures prosodic features across 5 categories (pitch, rhythm, loudness, timbre, and voice quality). We found that

prosody vectors from the same speaker were more correlated across days than those from different speakers, validating that the vector represents a stable profile for each speaker. Next, we found that these prosodic profiles are distinct to monologue and dialogue, such that dialogue exhibited more variable pitch, faster rhythm, narrower loudness range, more stable timbre, and rougher voice quality than monologue. Additionally, we annotated several paralinguistic features: proportion of laughter, proportion of interjections, and response offsets (inter-speaker gaps). Results showed that speakers laughed more during dialogue than monologue, and hosts tended to laugh more and interject less than guests, while both groups had similar response offsets. Ongoing analyses will investigate role-based prosodic differences and the dynamic interplay between these features.

Tianyu Zhang
Computer Science

"EmboDyverse: Investigating Effects of Virtual Hands Representations and Object Feedback on Embodiment and Proteous Effect"

Object interactions such as grasping and reaching are common and fundamental tasks in Virtual Reality (VR). In this work, we investigate and compare how different appearances of both the virtual hands and the virtual objects influence users' Sense of Embodiment (SoE) and Proteus Effect in VR. Previous research has explored realistic and non-humanoid virtual hands controls, yet there has been limited comparison among those different types, especially virtual hands with different skeleton structures, or combinations of different virtual hands and object interaction feedback. We conducted two experiment to find out how 1) different appearances of virtual hands and 2) different object appearances and interaction feedback affect the users' SoE and Proteus Effect on various object interaction tasks, including reaching, Pick-and-Place, and squeezing.

Tong Zhao
Philosophy

"A Defense of Lucky Understanding"

Knowledge and understanding are both central aims of scientific and non-scientific inquiry. The nature of knowledge has long been a focal point of philosophical investigation. Most philosophers, if not all, argue that knowledge, by its very nature, is incompatible with luck. In other words, if we arrive at a correct conclusion by mere guesswork, it does not constitute knowledge. However, it remains unclear whether this point applies to understanding as well. Many philosophers claim that there is no fundamental distinction between knowledge and understanding—that understanding is merely a species of knowledge. Therefore, understanding is also incompatible with luck. I argue that this is a misconception. Many people have the pre-theoretical intuition that understanding is more holistic and intimately connected to the subject than knowledge. I aim to preserve this pre-theoretical intuition about understanding by arguing that understanding and knowledge are different epistemic states. A crucial difference is that understanding, unlike knowledge, is compatible with luck. The aforementioned misconception, I believe, stems from a failure to distinguish the role that belief plays in knowledge versus understanding. While beliefs are integral to knowledge, they serve only as a pathway to understanding. The central component of understanding is not belief but rather an individual's integrated experience.