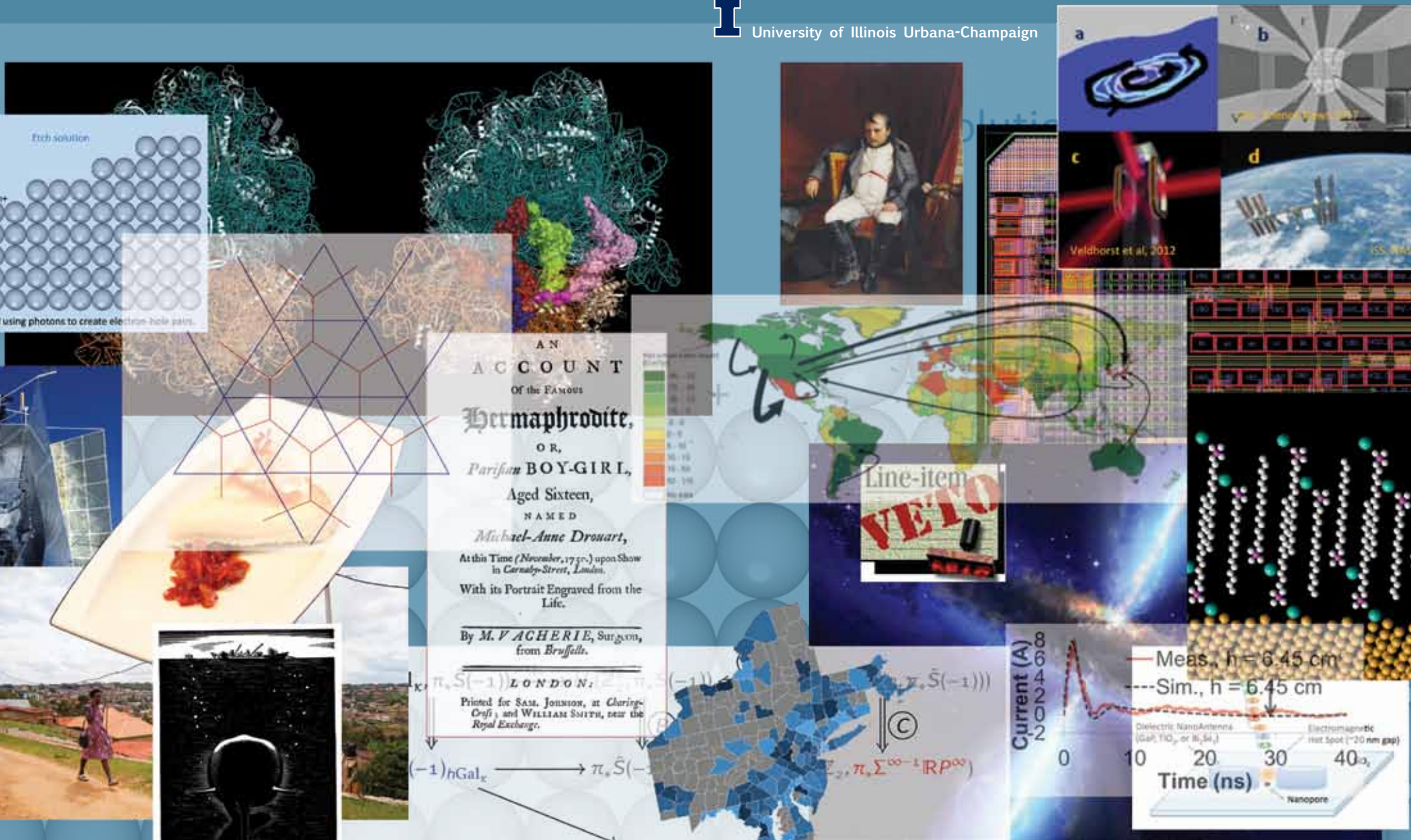
CAS

Center for Advanced Study

Research Appointments / Associates and Fellows 2018 - 19

University of Illinois Urbana-Champaign



Digital resolution biosensing, disease diagnostics, and DNA sequencing using dielectric nanoantenna-microcavity hybrids • Agricultural production, global trade and export of virtual water under future climate Conditions • Observing the Dawn of Time from Above the Clouds: New Telescopes for the Second Flight of SPIDER • Multi-depth Atomic Layer Etching of Silicon using Photo-Electro-Thermo-Chemistry • Liminal Bodies: Hermaphrodites in the Eighteenth Century • Imaging Molecular Surfaces via Atomic Scale Electron Microscopy and Spectroscopy • Development of Anti-Markovnikov Selective Pd-Catalyzed Olefin Functionalization Reactions • Rendered Obsolete: The Afterlife of the U.S. Whaling Industry in the Petroleum Age • Prediction of Future HIV New Diagnosis Rates using Spatial Bayesian Method • Persistent Effects of Diversity for Politics and Economics: The Case of Ottoman Turkey • Imaging Light Induced Excitations at the Nanoscale • Making Authority by Rewriting the Past in Islamic West Africa: The Seventeenth-century Tārīkh Ibn al-Mukhtār and the Nineteenth-century Tārīkh al-fattāsh • The Cult of Napoleon in French Visual Culture, 1815-1848 • Machine Learning Models for Reliability Analysis • Supermassive Black Hole Physics and Evolution with Time-Domain Exploration • The Disempowered Executive: Reconsidering the Line Item Veto • Homotopical arithmetic duality • Identifying, Predicting, and Preventing Disease Transmission and Antibiotic Resistance in Western Uganda • A Mathematical Theory of Creativity • Quantum vortices on Earth and beyond • African Women, ICT and Neoliberal • Politics: From Gendered Digital Divides to People-Centered Governance

CAS

Research Appointments 2018-19

Each year, the tenured and untenured University of Illinois faculty are invited to submit scholarly/creative proposals for consideration by the Center's permanent Professors. Faculty members with winning proposals are appointed Associates and Fellows and awarded one semester of release time to pursue their projects in the coming academic year.

In accordance with the Center's mission, these appointments provide an incentive to pursue the highest level of scholarly achievement. They also provide faculty members with an unusual opportunity to explore new ideas and demonstrate early results.

Along with the Professors, Associates and Fellows form the intellectual core of the Center for Advanced Study community.They participate in a yearly roundtable discussion of research interests, are invited to participate in CAS events, and have opportunities to present their work to the CAS community.Thus, each year brings together the established and the new in an ever-changing flux of ideas and disciplines.

In this brochure we are pleased to introduce the projects of the 2018-19 CAS Associates and Fellows.

CAS

CAS Review Committee

The review committee for the Associates and Fellows program consists of the Center for Advanced Study Professors. These senior scholars represent a wide range of disciplines. Their permanent appointment to the Center is among the highest forms of campus recognition.

James D. Anderson
education policy, education desegregation, African-American public education

Renée L. Baillargeon
early conceptual development, infant cognition

Tamer Başar
distributed decision making, robust estimation and control, dynamic games, network economics

May R. Berenbaum
entomology, chemical ecology

Bruce C. Berndt
analytic number theory, Srinivasa Ramanujan

Antoinette Burton
British empire, colonial India, race and sexuality mobility

David M. Ceperley
quantum Monte Carlo methods, quantum many-body systems

Leon Dash
immersion journalism, domestic and international reporting

Gary S. Dell
Language production, speech errors

Eduardo H. Fradkin
Quantum field theory, condensed matter physics

Matthew W. Finkin
labor and employment law, legal issues in higher education

Martha U. Gillette
cellular neuroscience, circadian rhythm

Nigel Goldenfeld
condensed matter physics, evolution, microbial ecology, statistical mechanics

Martin Gruebele
computational modeling, laser techniques, complex molecular systems

Bruce Hajek
communications engineering, stochastic methods

Anthony James Leggett
low-temperature physics, superconductivity

Harry Liebersohn
music and globalization, transnational cultural encounters

Stephen P. Long
environmental physiology, global atmospheric change, C4 photosynthesis

Michael S. Moore
law and philosophy, jurisprudence, criminal law, ethics and meta-ethical philosophy, philosophy of punishment and responsibility, philosophical psychology

Catherine J. Murphy
Nanomaterials, cellular imaging, chemical sensing, photothermal therapy

Tere O'Connor
dance, choreography, consciousness

Gene E. Robinson
genomics, social behavior, social insects

Jay Rosenstein
journalism, film, documentaries

Jonathan Sweedler
bioanalytical chemistry, peptide hormones, neurotransmitters, neuromodulatory agents

Maria Todorova
history, Balkans, nationalism

Lou van den Dries
model theory, o-minimality

Dale J. Van Harlingen
experimental low-temperature physics, superconductivity, microfabrication of superconductor devices, scanning probe microscopy, mesoscopic systems

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Invitation to Apply
We invite the campus faculty to submit proposals for the **2019-20** academic year. For more information, please consult our website at www.cas.illinois.edu

Application deadline:
October 2, 2018

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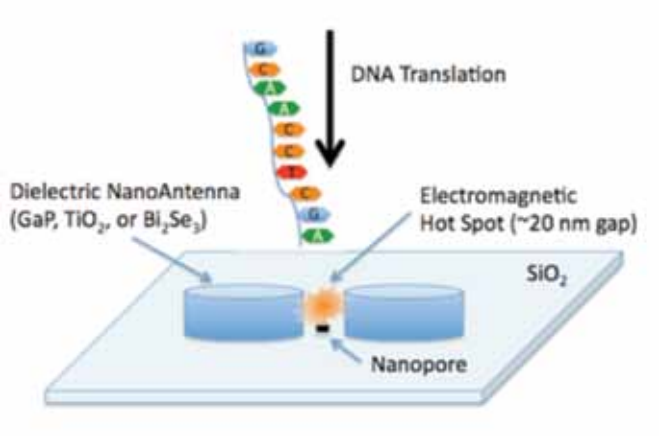
Digital Resolution Biosensing, Disease Diagnostics, and DNA Sequencing Using Dielectric Nanoantenna-Microcavity Hybrids

Brian Cunningham
Associate

Electrical & Computer Engineering

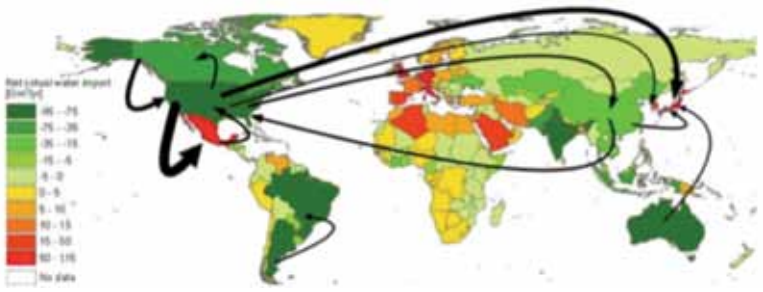


The goal of Professor Cunningham's project is to explore new nanostructures that can enhance the interaction between light and biological materials with the goal of achieving ultrasensitive biosensors with single-molecule detection resolution, and even the ability to sense specific regions within a single biomolecule. The approach will utilize novel configurations for "nano-antennas" comprised of nonconducting dielectric materials that can focus electromagnetic energy into nanometer-scale volumes without heating the molecules being observed. Applications for this work include high sensitivity cancer diagnostics and rapid all-optical genome sequencing.

Agricultural Production, Global Trade and Export of Virtual Water Under Future Climate Conditions

Sandy Dall'erba
Associate

Agricultural & Consumer Economics and Regional Economics Applications Laboratory



Virtual water balance per country (countries in green have more water imbedded in their export than in their import) and direction of gross virtual water flows related to trade in agricultural and industrial products over the period 1996-2005. Only the biggest flows are shown. Figure from Mekonnen, M.M. and Hoekstra, A.Y. (2011): National water footprint accounts: the green, blue and grey water footprint of production and consumption, *Value of Water Research Report Series No.50, UNESCO-IHE, Delft, Netherlands.*

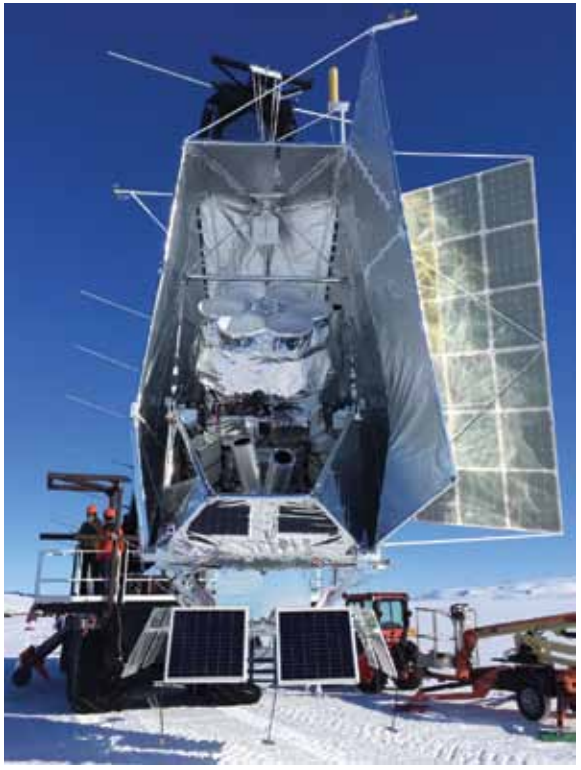
This project investigates the sustainability of the amount of virtual water used in the global economic production and trade of agriculture. This sector is by far the largest consumer of water across most countries, but growing world population and the uncertain hazards that accompany climate change have put an increasing pressure on the management and sustainability of the water balance. Compared to previous contributions in the literature, this project traces how water is used by all economic sectors through the entire global supply chain to satisfy intermediate and final demand. In addition, the most recent input-output data encompassing 26 sectors and 187 countries during 1990-2013 will be used.

This project has three objectives: first, to identify which countries/sectors are the most water-demanding; next, to simulate how more frequent heat waves and changes in precipitation patterns would modify their production and trade system; and finally, to quantify the amount of water that some countries could save under three adaptation scenarios. These are: 1) increasing the price of water used in agriculture or other water-intensive sectors, 2) decreasing the quantity of goods these sectors export, and 3) increasing the technological efficiency by consuming less water per unit produced. Economic costs associated to each of these cases will be assessed in order to identify the most appealing strategy. Professor Dall'erba will build on his experience measuring the dynamics of water used by agriculture and the economic impact of water-saving strategies for the state of Arizona to focus on an extension to the global trade network and global climate data offered in the current project.

Observing the Dawn of Time from Above the Clouds: New Telescopes for the Second Flight of SPIDER

Jeffrey Filippini
Fellow

Physics



Professor Filippini's research group explores the deep connections between the universe's workings on its largest and smallest scales. To that end, they build instruments to observe the cosmic microwave background (CMB), the relic glow of the hot early universe as it existed more than 13 billion years ago. Measurements of the CMB draw upon numerous fields of science and engineering, from condensed matter physics and electronics to aerospace engineering and data science, and have yielded critical insights into the composition and history of our universe.

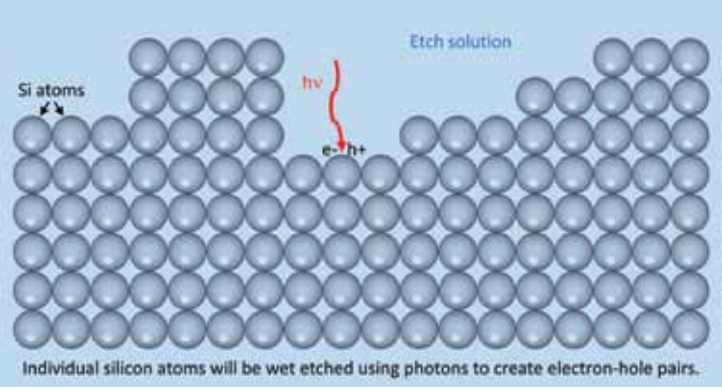
The research group hopes to build and deploy new telescopes for the second observing flight of SPIDER, a balloon-borne instrument designed to characterize the polarization of the CMB. These observations will be used to seek evidence of primordial gravitational waves from the universe's earliest moments, which would yield transformative information about how our cosmos began. These new telescopes will enable SPIDER to better discriminate this primordial signal from contaminating glow from our own galaxy, enabling the most powerful probe to date of cosmic origins.

During his CAS appointment, Professor Filippini and his team will prepare the SPIDER instrument for its upcoming Antarctic flight and complete scientific analysis of the data from SPIDER's first flight.

Multi-depth Atomic Layer Etching of Silicon using Photo-Electro-Thermo-Chemistry

Lynford Goddard
Associate

Electrical & Computer Engineering



Individual silicon atoms will be wet etched using photons to create electron-hole pairs.

The amazing communications, computing, and information gathering capabilities of your smart phone are made possible by the continual exponential increase in the number of transistors in the microprocessor that was fabricated on a silicon wafer. Currently, these transistors are each roughly only 20 atoms wide by 100 atoms long by 20 atoms tall in size. If the manufacturing process (silicon etching) produces transistors that are just a single atomic layer too thin or too thick, the error in device dimension would be 5%. This is a huge error and enough to noticeably deteriorate the overall performance of the entire microprocessor. Therefore, controlling the etch depths in the silicon wafer with an accuracy of a single atomic layer is critical.

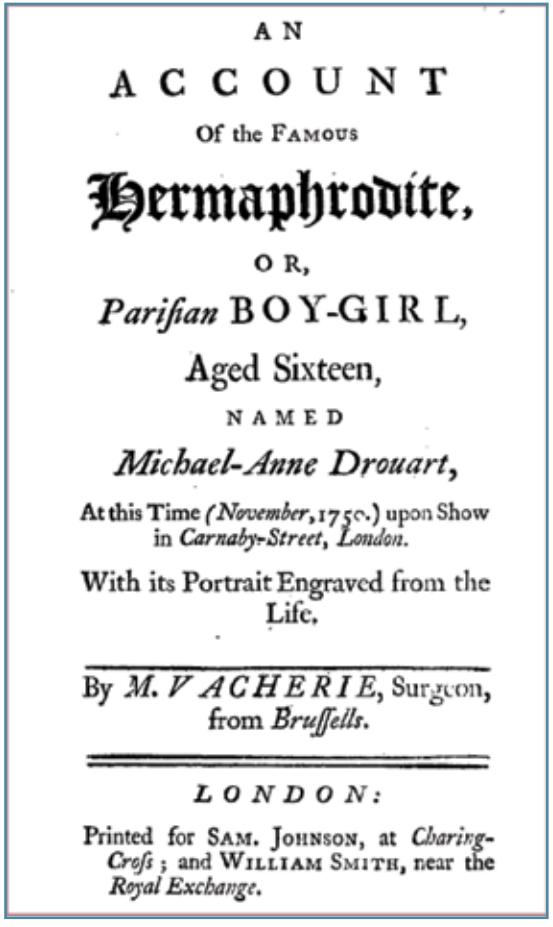
Currently, the semiconductor manufacturing industry relies on a binary process for etching. Some wafer regions are exposed to a chemical or physical reaction and thereby etched to a specific depth while other regions are covered and not etched at all. It is not possible to etch to a depth in between these two values in a single step. This stifles the creativity of modern engineers because they are limited to using architectures that are 2D or quasi-3D. They do not have continuously varying height structures in their device design palette.

This project explores using high speed optical, electrical, and thermal effects to realize a new approach for atomic layer etching. It seeks not only to address the grand challenge of controlling the etch depth with atomic layer accuracy but also to enable this depth to be varied across the wafer surface. Prof. Goddard will use his CAS appointment to work in the lab with his graduate and undergraduate research students to design, build, and characterize a prototype system.

Liminal Bodies: Hermaphrodites in the Eighteenth Century

Stephanie Hilger
Associate

Comparative and World Literature



A N

A C C O U N T

Of the Famous

Hermaphrodite,

O R,

Parisian BOY-GIRL,

Aged Sixteen,

NAMED

Michael-Anne Drouart,

At this Time *(November,* 175c.) upon Show in *Carnaby-Street, London.*

With its Portrait Engraved from the Life.

By *M. VACHERIE,* Surgeon, from *Brussells.*

LONDON:

Printed for SAM. JOHNSON, at *Charing-Cross*; and WILLIAM SMITH, near the *Royal Exchange.*

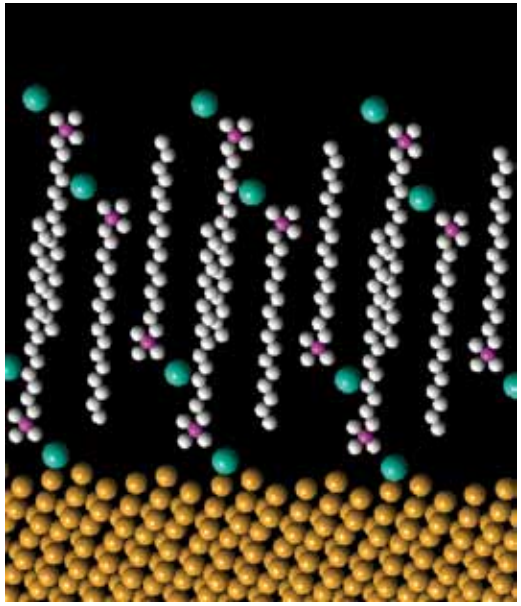
Invoking Greek mythology, the term "hermaphrodite" was used for all bodies that did not fit within the gender binary. Professor Hilger's book *Liminal Bodies* investigates the fascination with these hermaphrodites in the context of broader epistemological debates by focusing on the genre of the case study. This genre gained in popularity during the Enlightenment as it used conventions of both scientific writing and literature, satisfying the demand for empiricism while using the same narrative framework that popularized the novel in the eighteenth century, namely the focus on one single individual in a specific contemporary context, often extreme or unusual.

Liminal Bodies examines mid- to late-eighteenth-century case studies on hermaphrodites from three different languages and national contexts—British, French, and German—and focuses on those written about Anne Grandjean, Michel Anne Drouart, Maria Dorothea Derrier, and an unnamed "Angolan hermaphrodite." Multiple case studies were published about each of those individuals and will be discussed throughout five chapters, each of which focuses on one momentous epistemological shift in the eighteenth century: an increasing focus on empirical science, professional specialization in the medical field, the expanding market for popular scientific literature, changing notions about generation and reproduction, and the exploration of foreign territories.

Imaging Molecular Surfaces via Atomic Scale Electron Microscopy and Spectroscopy

Pinshane Huang
Beckman Fellow

Materials Science & Engineering

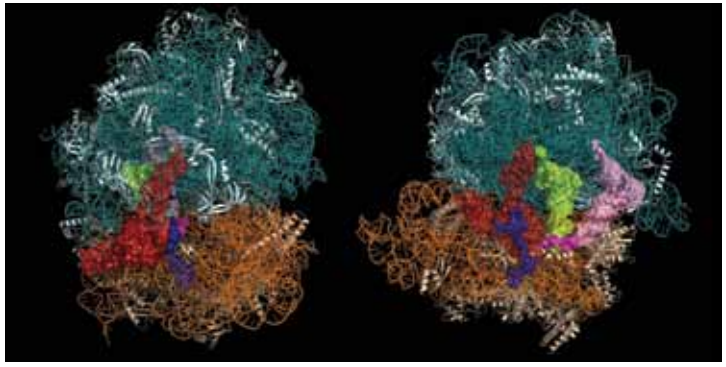


The structure and chemistry of molecular coatings can be tailored to control properties as diverse as the efficiency of next-generation photovoltaics and the ability of drugs to selectively target cancers in the body. A missing component needed to rapidly predict and design the properties and functionality of molecular coatings is the ability to visualize and understand their structure and chemistry at the atomic scale. Professor Pinshane Huang plans to develop methods that utilize a new, state-of-the-art scanning transmission electron microscope electron microscope at the University of Illinois to focus electrons down to sub-angstrom beams in order to directly visualize small molecule structure and chemistry. These methods will provide a new window into understanding how molecular coatings can be used to direct the synthesis, assembly, and interactions of complex nanostructures across the fields of energy harvesting, catalysis, and medicine. In addition to the impact of the specific research conducted in this project, Professor Huang's work with the new electron microscope aims to transform the new analytical electron microscope into a leading national resource for atomic-scale chemical mapping of dose-sensitive materials.

Development of Anti-Markovnikov Selective Pd-Catalyzed Olefin Functionalization Reactions

Hong Jin
Fellow

Biochemistry



Translation produces proteins that are the major determinants of cellular functions. In all organisms, translation is catalyzed in the ribosome, an extraordinary RNA-protein molecular machine in every living cell. Furthermore, 5'-untranslated regions (5'UTRs) of mRNA are essential for translation. The average length of 5'UTR sequences has increased over evolution, suggesting that their utilization contributes to the complexity of translational regulation and organism speciation. Professor Jin and her lab propose that structured 5'UTRs can facilitate translation initiation via sequential remodeling: the 5'UTR undergoes sequential conformational changes that are facilitated by RNA binding proteins and translational factors, which ultimately leads to recruitment of the ribosome for translation of the mRNA. Currently, the 5'UTR remodeling and activation remain structurally and mechanistically uncharacterized for eukaryotic mRNAs. To elucidate the molecular mechanisms, structures and principles important for this process, Professor Jin will determine the precise sequential events in the 5'UTR remodeling in transcript-specific translation and solve structures of biological complexes involved in this process using biochemistry and structural biology.

At present, initial data from Professor Jin's lab suggests that unique interactions between the 5'UTR, associated proteins and the ribosome lead to formation of transcript-specific translation machinery important for cell physiology. Research in this area will not only open a new avenue of exploration in basic science, but also lead to medical innovations: uncovering disease-related mechanisms and providing therapies that directly target specialized translation.

Rendered Obsolete: The Afterlife of the U.S. Whaling Industry in the Petroleum Age

Jamie Jones
Fellow

English

Rockwell Kent, illustration from chapter 99, "The Doubloon," from Herman Melville, *Moby-Dick: or, The Whale*, vol. 3 (Lakeside Press, 1930), 76. Rights courtesy of Plattsburgh State Art Museum, State University of New York, USA, Rockwell Kent Collection, Bequest of Sally Kent Gorton.

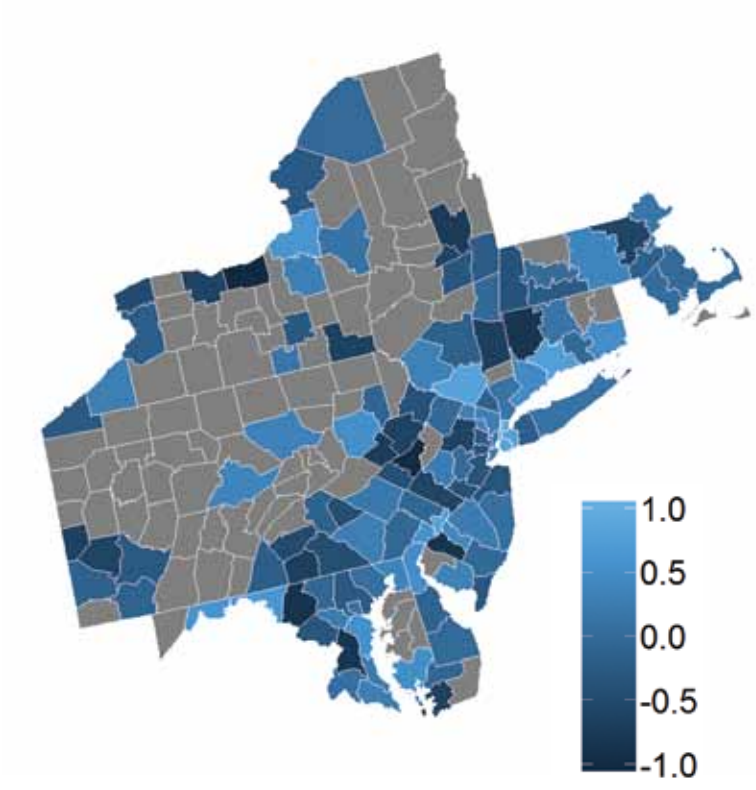
Rendered Obsolete: The Afterlife of the U.S. Whaling Industry in the Petroleum Age chronicles the United States whaling industry from its decline and obsolescence in the second half of the nineteenth century through its commemoration in the early twentieth century. Whale oil was a key element of industrialization and urbanization in the United States, serving as an illuminant and as a lubricant for industrial machinery. But by the late nineteenth century, the United States whaling industry had been rendered obsolete: its main commodity, whale oil, supplanted by petroleum produced in U.S. oilfields. Throughout the course of its peak production and especially—surprisingly—in its decline, the U.S. whaling industry was the subject of a profuse and widely-circulated cultural production: a body of personal narratives, novels, engravings, newspaper accounts, public performances, films, and exhibitions that documented, dramatized, and, in some cases, romanticized the industry even as its main commodity was rapidly supplanted by petroleum. *Rendered Obsolete* assembles this archive for the first time and offers a new reading of Herman Melville's *Moby-Dick* as a work of "peak whale oil" that forecasts the impending obsolescence of the whaling industry.

Rendered Obsolete examines the cultural afterlife of whaling in order to pursue the question: Where do industries go when they die? The whaling industry did not disappear as it obsolesced; rather, it attests to obsolescence as a process of persistence. The U.S. whaling industry migrated from the realm of oil extraction to the realms of culture, tourism, and politics. The culture surrounding the extraction of whale oil also provided conceptual templates that shaped the energy regime that replaced it: petroleum. Whaling culture provided ways of imagining energy that remain with us.

Prediction of Future HIV New Diagnosis Rates using Spatial Bayesian Method

Bo Li
Associate

Statistics



The county level evolution rates of HIV new diagnosis cases using an autoregressive model with order one in New England States (Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York and Pennsylvania). The grey area indicates missing data over these counties.

Human immunodeficiency virus (HIV) infections are life-changing events and if left untreated can lead to acquired immunodeficiency disease (AIDS). The Centers for Disease Control and Prevention has reported dramatic outbreaks in regions that were not traditionally affected, besides the geographic regions that consistently exhibit high HIV rates. The National HIV/AIDS Strategy has identified a key goal of intensifying efforts in the communities with the greatest concentration of HIV cases. Regional prediction of disease is central to orchestrating appropriate public health responses. The presence of infection in a region is certainly partly influenced by the social and economic demographics and the prevalence of other sexually transmitted diseases in its population. However, these covariates alone are insufficient to explain the entire variability in the HIV data. After the effects due to the covariates are removed, the spread of infection across the U.S. still exhibits strong spatially and temporally varying patterns as values among neighboring regions and time periods tend to be similar. This presents both a challenge for data modeling as well as an opportunity of tackling the data sparsity issue due to the rarity of the HIV disease.

During her CAS appointment, Professor Li will develop prediction methods that take advantage of the spatial and temporal dependency structures so that the statistical inference at one location can borrow strength from neighboring regions in both space and time. She will generate algorithm and code for future new HIV diagnosis prediction at county level for the entire US, produce maps of predictions together with their uncertainties, and provide a detailed report of the methodology and results to the health department attempting to improve the health prevention system.

Persistent Effects of Diversity for Politics and Economics: The Case of Ottoman Turkey

Avital Livny
Fellow

Political Science

Despite considerable interest in the political and economic consequences of diversity, its true impact is difficult to estimate precisely because of the role of endogenous sorting in creating and then undoing patterns of inter-group contact. As a result, it is not yet clear what we know about the effects of diversity, especially in the longer-term. Professor Livny suggests that the Turkish case can be used to gain leverage on this very question.

Generations of intermingling between Muslims, Armenians, Greeks and Jews came to an abrupt end toward the end of the Ottoman Empire and in the early decades of the Turkish Republic through a state-sponsored program of homogenization, leaving behind an almost entirely religiously homogenous country.

During her CAS appointment, Professor Livny will investigate how historical levels of religious diversity correlate to patterns of economic development, public goods provision and inter-group tolerance in Turkey today, combining geo-referenced Ottoman census data with contemporary statistics and representative survey data. Initial results suggest a substantive and significant positive effect of diversity on inter-group tolerance, indicating that diversity may indeed have a longer-term impact, one that does not operate through formal institutions, as is often assumed, but may indicate alternative, less formal channels of transmission, such as culture.

Imaging Light Induced Excitations at the Nanoscale

Vidya Madhavan
Associate

Physics

Some of the most interesting problems being tackled by physicists today involve the study of emergent phenomena in complex materials. The word emergence captures the idea that when simple elements interact, they can display collective effects, which cannot be easily explained on the basis of the constituent elements and their interactions. Correlated electron systems and high temperature superconductors are two examples of complex materials where a myriad of interesting phenomena are observed which defy explanations using simple models. In some cases, it would seem like the community is stuck in a deadlock with no progress being made on either the theoretical or experimental fronts. This is where new instruments come in. Developing new instrumentation or combining instruments in new ways provides new perspectives on problems that can also lead to new and unexpected discoveries.

Professor Madhavan's expertise lies in imaging properties of quantum particles in solids with high spatial and energy resolution, using a scanning tunneling microscope (STM). During her CAS appointment, she will explore the development of new instruments and investigate techniques to image time-dependent processes in correlated electron systems and superconductors by coupling light to the STM. If successful, the instrument will push the boundaries of understanding of the dynamic properties of complex materials. Progress in understanding these systems has fundamental as well as practical implications for future applications.

Making Authority by Rewriting the Past in Islamic West Africa: The Seventeenth-century *Tārīkh Ibn al-Mukhtār* and the Nineteenth-century *Tārīkh al-fattāsh*

Mauro Nobili
Beckman Fellow

History

Scholars have misunderstood one of the most important internal Arabic sources for pre-colonial African history: the *Tārīkh al-fattāsh* ("The Chronicle of the Inquisitive Researcher"), allegedly written by a sixteenth-century scholar from Timbuktu, Maḥmūhd Kaʿti. Professor Nobili's research proves that this ascription is apocryphal and that the chronicle is actually a nineteenth-century work written by Nūḥ b. al-Ṭāhir (d. 1857-8), a scholar of the Caliphate of Ḥamdallāhi (1818-1862). Professor Nobili also argues that the widely used 1913 edition of the text is substantially flawed. The edition conflates two chronicles: Nūḥ b. al-Ṭāhir's nineteenth-century *Tārīkh al-fattāsh*; and an earlier, seventeenth century chronicle of the region that he calls *Tārīkh Ibn al-Mukhtār* ("The Chronicle of Ibn al-Mukhtār") after the name of its author. This earlier chronicle was used by Nūḥ b. al-Ṭāhir as the basis for his work. These sources, accurately dated and contextualized by the forthcoming study, can—when correctly distinguished from one another—provide crucial knowledge on two important phases of West African history: the seventeenth century, which marks the end of the great West African empires; and the nineteenth century, characterized by the emergence of Islamic theocracies.

Professor Nobili's current book project is titled *Sultan, Caliph, and Renewer of the Faith: Aḥmad Lobbo, the* Tārīkh al-fattāsh *and the Making of an Islamic State in Nineteenth-Century West Africa* (accepted for review by Cambridge University Press). The book explores the foundations of authority and the mechanisms of legitimation in the theocratic states that resulted from eighteenth– and nineteenth–century West African Islamic revolutions. This project has its counterpart in Professor Nobili's forthcoming scholarly edition and translation of both the *Tārīkh al-fattāsh* and the *Tārīkh Ibn al-Mukhtār.*

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The Cult of Napoleon in French Visual Culture, 1815-1848

David O'Brien

Associate

Art History

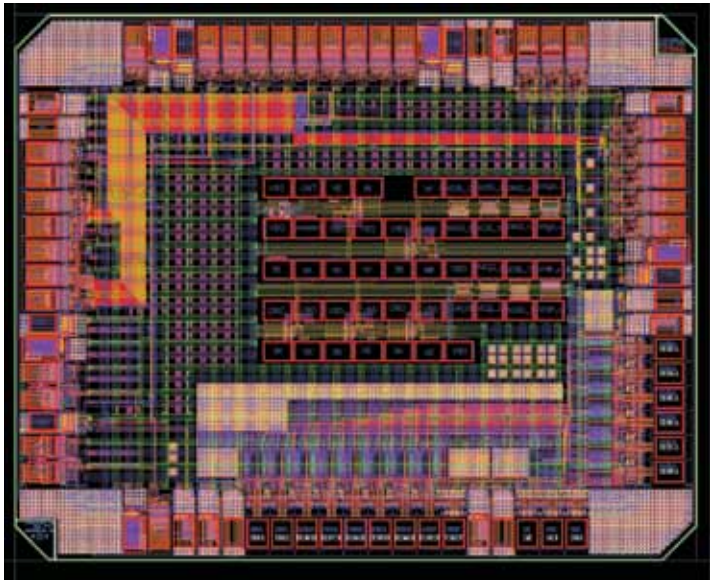
Paul Delaroche, *Napoléon Bonaparte abdicated in Fontainebleau,* 1845, Museum der bildenden Künste.

Professor O'Brien's new book project will investigate representations of Napoleon Bonaparte and his times in the visual culture of the Restoration (1815-1830) and the July Monarchy (1830-1848). Napoleonic themes dominated French visual culture in this period, combining history, memory, politics, art, and entertainment in strikingly new ways. This book will interpret the Napoleonic images and objects not only as reinterpretations of the recent past and responses to contemporaneous social and political issues, but also as the products of new modes of visual culture spawned by new technologies, new markets, and new viewing practices. This analysis will include the fine arts but also extends to new or recently invented media such as lithography, panoramas, and mass-produced trinkets, as well as to the full range of vernacular visual media, including such things as advertisements, cheap woodcuts, book illustrations, handicrafts, and wax museums. Professor O'Brien will focus on five prominent themes: the revival of republican versions of Napoleon; Napoleon as an imperfect human being; an ever-tightening association of masculinity, nationality, and militarism in depictions of ordinary Napoleonic soldiers; the varying, emergent strategies for representing the suffering and trauma engendered by the experience of war; and the transferal of religious modes of representation to Napoleon and his life.

Machine Learning Models for Reliability Analysis

Elyse Rosenbaum
Associate

Electrical & Computer Engineering



Machine-learning is the application of statistical learning theory to build models (or predictors) from data. ProfessorRosenbaum will use machine-learning methods to optimize the design of electronic systems, with a special focus on reliability. Electronic systems range from a system-on-a-chip to a computer tablet to an automotive electronic control unit.

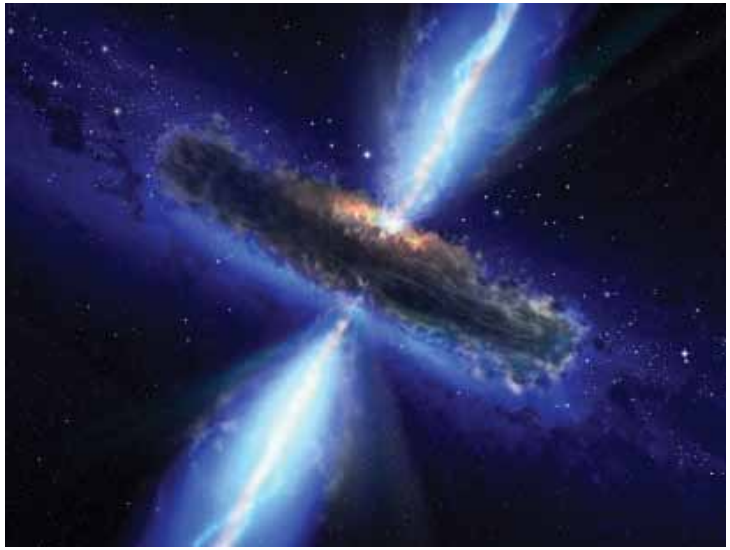
Today, systems (or products) are designed to meet specifications, that is, to be good enough. In contrast, an optimal design would achieve the lowest possible power consumption, or the highest data-rate, or the longest lifetime, or the lowest price, depending on the metric or metrics used to measure goodness. The optimal design cannot be identified through a full design-space exploration because the number of variables is too large. Additionally, the system components have variability, both due to imperfect control of the manufacturing process as well as to fundamentally stochastic physical processes. Finally, imperfect physical understanding impedes the development of mathematical models of certain phenomena. It is hypothesized that machine-learning methods can remove these hurdles, allowing for the creation of (i) behavioral models that can be used for design space exploration, (ii) generative (stochastic) models that can be sampled from to obtain a representation of the range of system responses, and (iii) models learned directly from data.

During her CAS appointment, Professor Rosenbaum will focus on creating methods to model system-level ESD response and circuit aging. ESD—electrostatic discharges—are unavoidable during the (mostly automated) manufacturing process as well as during routine handling by end-users, e.g., consumers. The behavior of an integrated circuit—its ability to filter a signal or process data—slowly changes as a function of the operating hours, a process referred to as aging.

Supermassive Black Hole Physics and Evolution with Time-Domain Exploration

Yue Shen
Fellow

Astronomy



Artist's impression of an Active Galactic Nucleus
Copyright: ESA/NASA, the AVO project and Paolo Padovani

Accurately measured masses of supermassive black holes (SMBHs) in distant Active Galactic Nuclei (AGN) are cornerstones for understanding the cosmic assembly of SMBHs and their co-evolution with massive galaxies. BH mass estimates are available for a small sample of nearby AGN using a technique called reverberation mapping (RM).

The small sample size and the fact that the current sample does not probe the full parameter space of the distant AGN population impose severe limitations in the studies of the cosmic growth of SMBHs and their co-evolution with host galaxies. The only way to improve the situation is by expanding substantially the sample of AGN with RM measurements, to improve the statistics and to cover AGN parameter space uniformly.

The proposed project aims to advance this field significantly using the first major multi-object RM program (SDSS-RM), developed and led by Professor Shen, that performs efficient RM for a large, uniformly-selected AGN sample that covers a wide range of redshifts and physical properties. The key objectives include the measurements of broadline region (BLR) sizes and the BH masses of these distant AGN, and the investigation of the redshift evolution of the correlations between BH mass and host galaxy properties. Overall, the scientific results expected from this project will significantly advance the field of AGN and galaxy formation, and will have tremendous value to a diverse research area and a broader astronomical community. Improved methods of BH mass estimation in distant AGN will benefit essentially all studies on SMBHs, such as the demographics and evolution of AGN, the physical processes of BH accretion and feedback, and the co-evolution of SMBHs and galaxies.

The Disempowered Executive: Reconsidering the Line Item Veto

Gisela Sin
Associate

Political Science

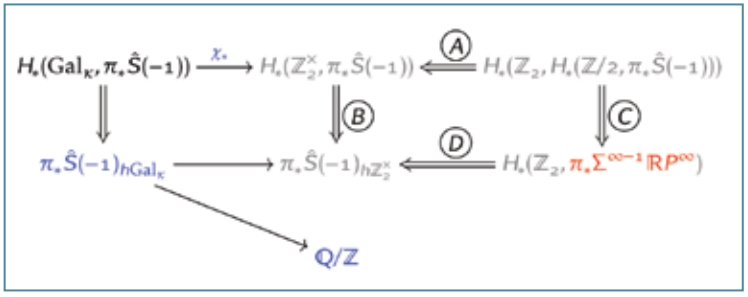
The proposed study of the effects of the line item veto (LIV) is of paramount importance for both practical and scholarly reasons. On the practical side, U.S. states, Latin American countries, and emerging democracies are discussing – and in many cases, embarking – on constitutional reforms that aim to change the powers held by the executive. In Rhode Island, for example, the LIV has been the main issue informing the decision on whether to hold a convention to revise the Constitution. In the international arena, the main controversy in the design of constitutions or the reform of old ones, is whether and how to expand or moderate the degree to which executives influence the law-making process.

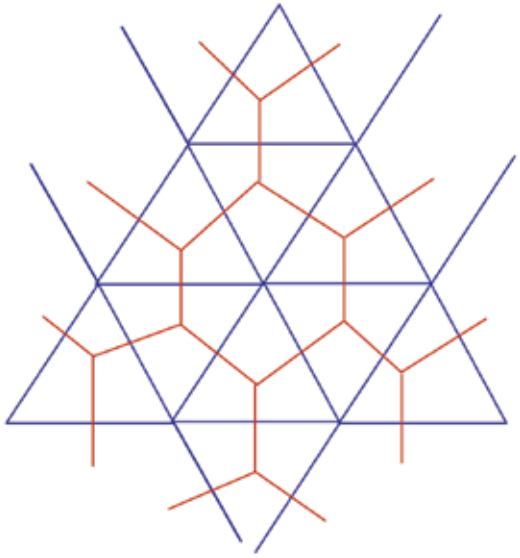
Scholars have investigated the LIV at some considerable depth, and an especially prevalent idea is that the LIV empowers executives to shape the budget and advance their agendas, by allowing them to delete sections or words from bills and create what might be considered a new bill. Contrary to this prevalent view, Professor Sin will argue that the LIV in fact prevents them from reaching favorable agreements with the legislature, contributing to increased gridlock and polarization. Because executives are able to modify bills just before they become laws, there is no way for them to bind themselves to deals made previously with the legislature. Anticipating this reality, legislators lack incentives to bargain extensively with the executive over the shape of bills. As a result, legal frameworks that allow executives to use the LIV *reduce* the executive's influence over the lawmaking process. The compromised influence over laws and public goods provision is of crucial importance when we consider that, in opposition to parochial legislative interests, executives usually represent broader and larger constituencies such as a state or country.

Homotopical Arithmetic Duality

Vesna Stojanoska
Beckman Fellow

Mathematics





A doughnut-shaped surface, perhaps with more than one hole – or none at all, can be cut into triangles, and if we record how the cuts were done, we can put the surface back together by gluing. Alternatively, we can create a dual surface, where we make new triangles with a vertex for each of the original ones, and sides corresponding to the touching data of the original triangles. Poincaré's amazing theorem from 1895 tells us that the dual shape will have the same number of holes as the original, regardless of the way cuts were done. Since its discovery, this duality result has been improved on and generalized in many different areas of mathematics. One notable example comes from number theory, and the starting point of this proposed project is establishing a relationship between duality and the basic but extremely difficult question of when does a polynomial equation have solutions in the rational numbers. Formally adding solutions to rational polynomials, and studying their interrelationships, ultimately leads to the creation of a shape whose abstract characteristics resemble that of a doughnut-shaped surface. The algebraic avatar of a duality phenomenon in this setting was studied by Poitou and Tate in the 1960s, and goes under the name arithmetic duality.

Basic principles in homotopy theory lead to the observation that if one coherently adds information about continuous deformations of those polynomial solutions, a stronger, homotopical version of duality should hold. Professor Stojanoska's preliminary work indicates that this homotopical duality will not only recover all known obstructions to solving polynomial equations, but will also deliver a new and unexplored obstruction. In addition to developing the theory, she plans to design a procedure for effectively calculating the resulting obstructions.

Identifying, Predicting, and Preventing Disease Transmission and Antibiotic Resistance in Western Uganda

Rebecca Stumpf
Associate

Anthropology

Professor Stumpf oversees disease and antimicrobial resistance (AMR) surveillance sampling in the complex, natural environment of her research site in Western Uganda. Using seed money from the Gates Foundation, she and her colleagues will sample interconnected ecological sources to track the burden of antimicrobial resistance (AMR) and the presence of two common viruses (adenovirus and rotovirus). After sequencing these samples, they will apply novel microbial phylogenetic forensic methods to identify AMR strains and viruses and track their routes of transmission. They hypothesize that AMR and viruses transit across a broad swath of host species and environments in Western Uganda, and that variation in the strains and distribution of AMR genes and viruses across hosts and ecologies provides an effective means of identifying, tracking, predicting, and limiting pathways for transmission.

This CAS appointment allows Professor Stumpf to ensure rigorous sampling in Uganda and establish proof of concept needed to develop a competitive proposal for Gates Phase II funding. Because AMR and viral transmission are complex problems with multiple interconnected drivers, a zoonotic and anthropogenic community-wide characterization of the presence and prevalence of AMR genes and viruses is needed. Ultimately, this research will help to identify and manage the interacting anthropogenic and environmental forces driving the rapid spread of AMR and disease in this region and beyond, leading to more effective prevention and treatment of infection.

A Mathematical Theory of Creativity

Lav Varshney
Beckman Fellow

Electrical & Computer Engineering

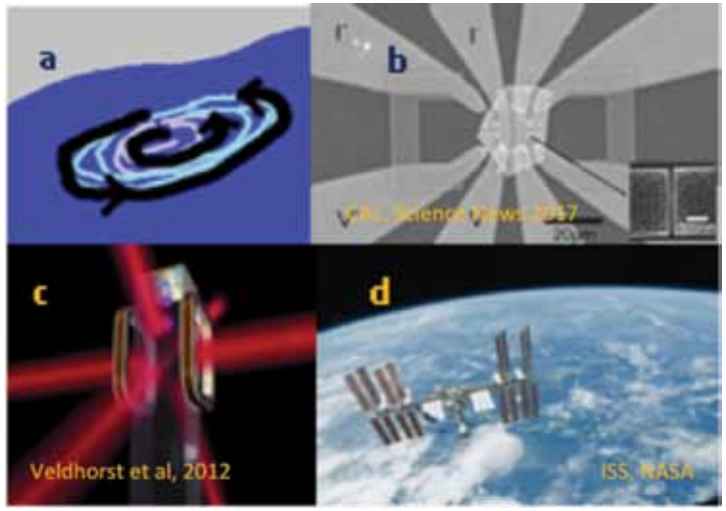
Lime pie with mango and honey ice cream and ginger/pepper salsa, which was served at the 2013 Falling Walls Conference in Berlin.

Creativity is often thought of as the pinnacle of human intelligence. Computational creativity systems within the field of artificial intelligence such as IBM Chef Watson (conceptualized and led by the PI) or Google Magenta are now approaching human creative abilities. But are there limits to how creative any system can be, whether human, machine, or hybrid? Just as thermodynamics established the fundamental mathematical limits of energy systems and information theory established the fundamental mathematical limits of communication systems, Professor Varshney aims to establish the fundamental mathematical limits of creativity systems in terms of basic tradeoffs between novelty and quality in the creative domain. He will also study whether or not particular cognitive systems are close to fundamental limit. One key step in proving mathematical theorems is to first establish a closed deductive system within which to reason, by abstracting and preserving only the most important aspects of the problem. As such, one key point of discussion of interest across the academy is whether intentionality is needed in creativity. In addition to the setting of one creator, the proposed work will also consider group creativity.

Quantum Vortices on Earth and Beyond

Smitha Vishveshwara
Associate

Physics



Quantum vortices (a) in nanoscale architectures (b) and cold atomic gases (c) aboard the International Space Station (d)

This project explores vortices—swirling currents—on the surfaces of quantum fluids in two contexts brought together by a common theoretical framework. In the context of nanoscience, so-called topological materials have recently come to the limelight for their controlled realization in experiments and their potential for quantum computation. A key challenge lies in designing and implementing a topological material-based platform for performing basic quantum bit operations. Quantum vortices in patterned nanoscale architectures composed of topological materials and superconductors offer a prospective realization of such qubits. In collaboration with experimentalists, steps will be taken towards designing and realizing such an architecture and related quantum bit protocols.

Concerning the second context, the past decade has witnessed the spectacular creation of superfluids suspended in near vacuum and their beguiling quantum behavior in the coldest spaces in the universe—in cold atomic laboratories on our own planet, the Earth. The technology developed on Earth is making its way to outer space aboard the International Space Station so as to study superfluids under microgravity conditions. One of the associated experiments will create shell-shaped superfluid structures. This project investigates the manner in which quantum vortices, ubiquitous to superfluids, would emerge and distribute themselves in these shell-shaped structures. The study is of direct relevance to the planned experiments aboard the International Space Station as well as to certain stellar bodies expected to contain superfluid shells, such as neutron stars.

African Women, ICT and Neoliberal Politics: From Gendered Digital Divides to People-Centered Governance

Assata Zerai
Associate

Sociology

How can we promote people-centered governance in Africa? Very recent research has shown that broad access to cell phones and other information and communications technologies (ICTs) is linked to more democratic governance structures. These structures are defined by World Bank indicators such as rule of law, control of corruption, regulatory and government effectiveness, political stability, low levels of violence, and voice and accountability. But in key areas these neoliberal indicators of democratic governance fall short: they do not encompass gender equity, disability services, or pro-poor policies seen in bottom-up approaches to democratic governance. To better understand and promote people-centered governance in Africa, Professor Zerai's project will shift our focus to the marginalized, understood on two levels: she will examine whether access to ICTs by marginalized groups, especially women, makes a difference to the success of bottom-up governance structures; and she will show how research by African scholars, too often marginalized, must be used to expand and redefine the goals and indicators of democratic governance in African countries.

This CAS appointment will allow Professor Zerai to complete her book manuscript, *African Women, ICTs and Neoliberal Politics: The Challenge of Gendered Digital Divides to People-Centered Governance* (under contract with Routledge). The heart of the book is a focus on ICTs, women's status and governance in Zimbabwe, Uganda and Nigeria, respectively. Professor Zerai examines regional differences to discuss the varied ways that women's status, diffusion of knowledge, and quality governance are represented throughout these countries. On the basis of African women's scholarship, she will build on Asongu and Nwachukwu's 2016 analysis of 2000-2012 World Bank development and governance indicators, and challenge both their definitions of good governance as well as their conclusion that a gender-blind understanding of diffusion of knowledge sufficiently explains factors resulting in better governance in Sub-Saharan Africa.

CAS Center for Advanced Study

University of Illinois Urbana-Champaign
Levis Faculty Center—Suite 200
919 West Illinois Street
Urbana, IL 61801

Phone: 217.333.6729
www.cas.illinois.edu