SigmaCamp Lectures

August 11-18, 2019

Lecture dates are subject to change

Contents

Sunday: Opening Lecture

We Live In Interesting Times
by *Yuri Salkinder*

The world around us is changing rapidly. We will look at some recent accomplishments in science and technology as well as some daring predictions on what is yet to come.

About the lecturer: *Yuri Salkinder has a PhD in Software Engineering from the Institute for Problems in Informatics of the Russian Academy of Sciences. His career spanned academia, telecommunications and financial technology. Yuri started in research in human-computer interaction, then moved on to help build software development tools for Voice response systems. He participated in creation of some standards for wireless messaging. Nowadays Yuri is dealing with messaging of another kind the one that fuels electronic financial markets. He is currently a Managing Director at Credit Suisse Securities (USA) responsible for Equities Technology in Americas region.*

Monday

The Brave New World of Bitcoin
by *Julia Kempe*

2019 marks the 10th anniversary of the release of bitcoin, one of the first cryptocurrencies. It is a decentralized digital currency without a central bank that can be sent from user to user on a peer-to-peer network. Transactions are verified through cryptography and recorded on a public ledger called blockchain. During their short lifetime cryptocurrencies have become controversial, both accused as a means of illegal trafficking and a wonderful protector of freedom and privacy. We will review some of the underlying principles and give some history.

About the lecturer: *Julia Kempe is a mathematician and computer scientist, currently the Director of NYU's Center for Data Science and a Professor at the Courant Insistute of Mathematical Sciences. She completed her PhD in Mathematics at UC Berkeley, and has been a Senior Researcher at the CNRS in France and a Professor of Computer Science at Tel Aviv University.*

Physics of Dating
by *Nikita Nekrasov*

We shall review the physics used in measuring the age of the Earth, the Moon, the Sun, and the Universe, as we see it.

About the lecturer: *Nikita is a Professor at the Simons Center for Geometry and Physics at Stony Brook University. He thinks about the laws of Nature and natural laws and why they are not always the same. He likes to compute complicated sums which explains his attachment to SigmaCamp for many years.*

Machine Learning and Language
by *Michael Douglas*

Computers don't understand English yet, but there has been remarkable progress in modeling language and generating stories which sound like a person might have written them. In this lecture we will give a demonstration and explain the basic ideas behind GPT-2, the transformer model developed at OpenAI whose stories about unicorns were recently in the news.

About the lecturer: *Mike Douglas is a leading researcher in theoretical physics whose contributions include the first solvable models of string theory, many connections between string theory and mathematics, and statistical approaches to making predictions from string theory. He helped to build the Digital Orrery, a computer which was used to show that the orbit of Pluto is chaotic, and he has many works in computational physics, including the first six loop calculation in quantum field theory (which was referred to in an episode of "The Big Bang Theory"). He received a B.A. from Harvard in 1983, and a Ph.D. in physics from Caltech in 1988. He is currently a researcher at Renaissance Technologies and an affiliated researcher at the Simons Center for Geometry and Physics at Stony Brook University.*

Geometric Proofs from (and not from) The Book
by *Boris Khesin*

According to Paul Erdös, God keeps the most elegant proof of each mathematical result in The Book. One of such examples would be Euclid's proof that there is an infinite number of primes. In the lecture we discuss several other examples of elegant proofs and unexpected ideas, mostly from geometry: the Dandelin spheres for conic sections, Pick's formula for the area of a simple lattice polygon, whether one could cheat in the Moscow subway, where there is a restriction on the size of allowed luggage, and how to tell the time on a clock with equal hands.

About the lecturer: *Boris Khesin is a Professor of Mathematics at the University of Toronto. He obtained his PhD at Moscow State University and taught at UC Berkeley and Yale University. His areas of research are geometry, integrable systems, and fluid dynamics.*

Molecular Design for Research and Therapeutics
by *Nikolay Dokholyan*

Life of biological molecules spans time and length scales relevant at atomic to cellular time and length scales. Hence, novel molecular modeling approaches are required to be inherently multiscale. Here we describe multiple methodologies developed in our laboratory: rapid discrete molecular dynamics simulation algorithm, protein design and structural refinement tools. Using these methodologies, we describe several applications that shed light on the molecular etiology of cystic fibrosis and finding new pharmaceutical strategies to combat this disease, model 3D RNA structure, and design novel approaches for controlling proteins in living cells and organisms.

About the lecturer: *Dr. Dokholyan received his PhD in Physics in 1999 at Boston University, and completed the postdoctoral training at Harvard University in the Department of Chemistry and Chemical Biology as a NIH NRSA Fellow. Dr. Dokholyan joined the Department of Biochemistry and Biophysics at the University of North Carolina at Chapel Hill School of Medicine as an Assistant Professor in 2002, was promoted to Full Professor in 2011. Dr. Dokholyan has served as the Director of the Center for Computational and Systems Biology and the Graduate Director of the Program in Molecular and Cellular Biophysics at UNC. Dr. Dokholyan has published over 250 peer-reviewed articles and 20 book chapters. In 2014, Dr. Dokholyan was named the Michael Hooker Distinguished Professor. In 2018, he assumed the position of the G. Thomas Passananti Professor and Vice Chair for Research in the Department of Pharmacology and the Director of the Center for Translational Systems Research a position at the Penn State University Hershey Medical Center.*

Tuesday

Prediction of Protein Structure Using Physics, Evolutionary Information, and Deep Learning
by *Dima Kozakov*

Proteins are the basic building blocks of the living cells. Determination of protein structure, i.e. three dimensional arrangement of protein atoms, is the the key problem of biology. Solving this problem enables mechanistic understanding of the cellular function, and is critical for rational drug design. In the lecture I will describe key ideas and methods behind computational approaches to solving this problem. Finally I will describe most recent breakthrough in the field, where data driven algorithms equipped with artificial intelligence have made a big leap forward in solving this problem.

About the lecturer: *Dr. Kozakov received a B.S. and M.S. in Applied Mathematics and Physics at the Moscow Institute of Physics and Technology, and PhD in Biomedical Engineering at Boston University. Currently he is Associate Professor in the Department of Applied Mathematics at Stony Brook University, Affiliate Member at Laufer Center for Physical and Quantitative Biology, and Affiliate Member at Institute for Advanced Computational Sciences. Dr. Kozakov's research focuses on the development of mathematically elegant, computationally efficient and physically accurate algorithms for modeling of biological macromolecules, with emphasis on molecular interactions and drug design. Dr. Kozakovs protein-protein docking approach ClusPro has been consistently the best automatic approach in the worldwide blind protein docking experiment CAPRI. Currently ClusPro has more than 20000 users, with more than 200,000 jobs run in the last few years. His docking tools are licensed by Schrodinger, largest pharmaceutical software vendor in the world, and are used by multiple major pharma worldwide.*

Life, Universe and Everything: One Switch to Rule Them All
by ***Alexei Tkachenko***

We are all familiar with freezing and evaporation of water. These are just couple of examples among myriads of phase transitions observed in nature. They come in many forms and may appear in most unexpected fields of science. The conventional ones deal with matter: magnets, liquid crystals, mixtures. Then come more exotic ones: melting of DNA or condensation of certain proteins that cause Alzheimer disease. Ultimately, the phase transitions describe our social behavior, voting for the next president, and even the most fundamental properties of Universe.

About the lecturer: *Alexei Tkachenko is a theoretical physicist at Brookhaven National Laboratory working on nanoscience and in the field called soft condensed matter. He studies problems that range from from living matter (DNA, proteins, membranes) to nanoparticles, plastics and even sand. He also teaches physics at School Nova.*

From How Atomic Bombs Are Made to the USA-Iran Standoff
by ***Zohar Komargodski***

I will explain the basic physics of nuclear energy, and the technologies used in making atomic bombs and nuclear reactors. We will then analyze scientifically the Iran nuclear deal framework, its purpose, and what happens now that the USA has backed out of the agreement.

About the lecturer: *Zohar Komargodski is a Professor at Simons Center for Geometry and Physics, Stony Brook University. Zohar studied at the Weizmann Institute in Israel, where he received his PhD in 2008. Later he joined the Institute for Advanced Study in Princeton. In 2011 Zohar returned to the Weizmann Institute, and in 2017 joined the Simons Center for Geometry and Physics. His research is on Quantum Field Theory, which has applications on a wide variety of fields in physics, including Particle Physics and Condensed Matter Physics.*

Hidden Markov Models
by ***Helmut Strey***

In this lecture, I will introduce the concept of Markov processes. Markov processes are widely used in probability calculations to describe processes that do not exhibit memory. I will introduce some of these processes and demonstrate their behavior. Next, I will apply Markov chains to single-enzyme fluorescence experiments. Finally, we will discuss how to analyze single-molecule experimental data by using "hidden" Markov models, where "hidden" refers to the fact that the experimenter often measures the state of a system in an indirect way, keeping the state hidden.

About the lecturer: *Helmut Strey is the Director of the Laboratory for Micro- and Nanotechnologies (www.streylab.com) and Associate Professor in the Biomedical Engineering Department at Stony Brook University. Helmut Strey is a Biophysicist who is interested in developing micro- and nanotechnologies for applications in basic and applied research. Specifically, his lab is working on 1) microfluidic techniques for single-cell cancer genomics, 2) study of DNA dynamics in confined geometries to understand how gene regulation works, 3) developing wireless biosensors for home sleep studies. Helmut received the Dillon medal for research in Polymer Physics from the American Physical Society in 2003. He recently converted to Bayesianism and is passionate about making things, Soccer and Table Tennis.*

Where Linguistics and Mathematics Meet: Semantics of Quantifiers
by ***Andrei Antonenko***

In this lecture we will explore quantifiers - natural language expressions such as "every", "most", "some", etc. The theory of quantifiers was developed in the 1980 at the interface of logic, linguistics, and philosophy. In this theory, quantifiers are viewed as relations between subsets of the universe. For example, the sentence "Most birds fly" determines a relation between a set of birds and a set of fliers. We will talk about classification of quantifiers and their properties, and what is natural and can occur in the human language and what is not.

About the lecturer: *Andrei Antonenko is a lecturer in Linguistics department of Stony Brook University, NY. He has received masters in Applied Mathematics and PhD in Theoretical Linguistics from Stony Brook University in 2012. His area of specialization is generative syntax, and he works on a variety of languages, including Slavic, Germanic, Austronesian, East Asian, Caucasian, and others.*

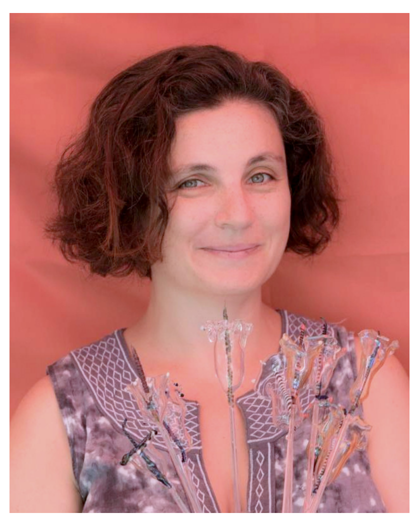
Wednesday

Data Science, Computer Science, and Real Science
by *Steven Skiena*

How is Computer Science more than just programming? How is machine learning changing the way computer science (and both the social and natural sciences) is/are done? What is data science, and how does it differ from classical fields like statistics? In this talk, I will try to clarify the relationship between these fields by presenting examples from my research in computer and data science. Finally, I will discuss the best way I know for bright high school students to get involved with real Computer Science: the US Computing Olympiad (http://www.usaco.org/) and associated algorithmic programming contests.

About the lecturer: *Steven Skiena is Distinguished Teaching Professor of Computer Science and Director of the Institute for AI-Driven Discovery and Innovation at Stony Brook University. His research interests include the design of graph, string, and geometric algorithms, and their applications (particularly to biology). He is the author of six books, including* The Algorithm Design Manual*,* The Data Science Design Manual*, and* Who's Bigger: Where Historical Figures Really Rank*. Skiena received his Ph.D. in Computer Science from the University of Illinois in 1988, and is the author of over 150 technical papers. He is a former Fulbright scholar, and recipient of the ONR Young Investigator Award and the IEEE Computer Science and Engineering Teaching Award. More info at http://www.cs.stonybrook.edu/˜skiena/.*

What Is a Collection
by *Victoria Bershadsky*



What does it mean to collect things? Hoarding or being refined? Where do we draw the line and how? What do people collect? What happens when collection becomes big and public? Let's explore the nuances of the world of collecting.

About the lecturer: *Victoria has a degree in Economics and Art History. She worked with numerous cultural organizations and was involved in various history, art, and anthropology programs. Victoria still spends a lot of time on arts and history. At SigmaCamp Victoria wants to show a different angle of life by opening up the world beyond science.*

Sensing, Learning, and Communicating: Are Our Cells Better Than We Are?
by *Ilya Nemenman*

To survive in this world, all living systems must sense their environment, learn from experience, and communicate the information to their kin. It turns out one can characterize cellular sensing and information processing in the same terms as we use to describe man-made digital devices, and we can talk about how many bits cells measure and transmit. It turns out that even “simple” cells are extremely good at infromation processing tasks, beating most human-engineered devices. And where the achievable performance is not sufficient, cells have found ingenious ways of becoming even better. We will explore a few of such examples.

About the lecturer: *Ilya Nemenman received his PhD in Physics from Princeton University in 2000 for his work on problems connecting theoretical physics, information theory, and neuroscience. He worked at the University of California, Santa Barbara, Columbia University School of Medicine, and at Los Alamos National Laboratory. Currently he is a Professor of Physics and Biology and Director of Initiative in Theory and Modeling of LIving Systems at Emory University. He served as a chair of the Division of Biological Physics of the American Physical Society (APS) and is an APS Fellow. His research is on how biological systems process their sensory information and act on it.*

The Hubble Trouble: Expanding Universe and Dark Energy
by *Gregory Gabadadze*

I will introduce basic concepts of cosmology and how they lead to a conclusion that our universe is expanding with acceleration. Physical interpretations of the accelerated expansion will be discussed.

About the lecturer: *Greg Gabadadze is a professor of physics and chair of the physics department at New York University, where he previously served as director of the Center for Cosmology and Particle Physics. Gabadadze holds a Ph.D. in physics from Rutgers University in New Jersey and an M.S. from Moscow State University. Greg is also an associate director of the Mathematics and Physical Sciences division of the Simons Foundation.*

Chemistry of DNA, Mutations, and Cancer
by *Mark Lukin*

I believe everybody knows that the word "carcinogen" refers to some substances that cause cancer. According to most mass media, carcinogens are everywhere, especially in the high-tech materials made by humans, and the mechanism of their action is too complex to be understood by a layman. In this lecture, we will discuss how the most common carcinogens work and dispell some myths associated with them.

About the lecturer: *Mark Lukin is a Research Assistant Professor in Pharmacology Department of Stony Brook University, NY. The focus of Mark Lukins scientific interest are nucleic acids (DNA and RNA) — the molecules responsible for storage and transfer of hereditary information in living organisms. How does DNA get copied? What happens when DNA molecules break? To answer these, as well as many other questions, Mark needs to prepare artificial (modified) nucleic acids and their building blocks, the crazy compounds that normally do not exist in nature. The only way to obtain them is to do a chemical synthesis, the thing Mark likes the most. Besides that, Mark loves music, history, Greek philosophy, and science fiction. When he was young, he loved to do simple but spectacular chemical experiments. Recently, he realized he still loves to do that. He plans to do some of those experiments in SigmaCamp 2019 with our campers.*

Thursday

Space, Time, and Quantum Teleportation
by ***Herman Verlinde***

What makes space-time hang together? Can one escape from a black hole? Is it possible to see inside a black hole? In this talk I will describe how one can teleport an object from one place to another far away place without actually moving it, by using a special property known as "quantum entanglement". I will then explain what this has to do with the above questions.

About the lecturer: *Herman Verlinde is Class of 1909 Professor of Physics and Chair of the Physics Department at Princeton University. He received his PhD cum laude from University of Utrecht in 1988. He has held faculty positions at the University of Amsterdam, the Princeton Center of Theoretical Science and has been a visiting member at the Institute of Advanced Study. He is the author of more that 70 scientific publications and has made influential contributions to string theory and the quantum theory of black holes.*

The Secret Life of an Experimental Chemist
by ***Eugene Pinkhassik***

What happens when lighting strikes a nuclear reactor? And why would a chemist know? There is a hidden side of science — something that you cannot find in research papers or learn in college. Many things take place behind the scenes — breakthroughs and setbacks, comedy and drama, crushing defeat and overpowering exhilaration. I will share a few stories from my research group showing both sides of scientific discovery, including a question that took us ten years to answer, the role of human element in science, and unexpected perks of being a scientist.

About the lecturer: *Eugene Pinkhassik graduated from Kazan State University in Russia and obtained his PhD in Chemistry in the Institute of Chemical Technology in Prague, Czech Republic. After a visiting scientist stay in Parma, Italy and a postdoctoral fellowship at the University of Colorado, Boulder, he began an independent faculty career. He is currently an Associate Professor at the University of Connecticut. His research interests focus on making nanomaterials and nanodevices with new and superior properties to address current problems in energy-related technologies, medical imaging and treatment, and environmental sensing.*

Advancing Diversity and Excellence in Science, Technology, Engineering, and Math (STEM)
by *Eboney Hearn*

The results of scientific innovation and research can impact all of humanity. Conducting scientific research often requires scientists working with others to devise solutions to complex problems. Research suggests that the most progressive and innovative scientific research is best achieved when scientists can see problems from different or diverse perspectives. Professor Scott Page, author of the book *The Difference*, suggests that the ability to see problems differently, not simply "being smart", often is the key to a breakthrough. If diversity in perspective is essential to doing impactful science, how can we ensure that all members of our society — not just those who are privileged — have the opportunity to contribute to innovation in STEM that truly benefits all? This talk will discuss several initiatives at MIT focused on supporting a talented pipeline of future scientists and engineers from underrepresented and underserved backgrounds.

About the lecturer: *Eboney Hearn is the Executive Director of the MIT Office of Engineering Outreach Programs. As Director, Eboney oversees programs offered through the MIT School of Engineering focused on creating access in STEM for underrepresented and underserved students. The OEOP currently serves more than 350 middle and high school students in Saturday, residential, and online programs and more than 1,000 alumni at undergraduate institutions around the country. She earned her bachelors degree in chemical engineering from MIT and her masters in education with a focus on teaching and learning from Harvard University. Her work in the OEOP combines her passions of problem-solving and improving educational opportunities for others.*

Unconscious Patterns in Human Language
by *Robert Hoberman*

Human language is like an iceberg: the vast majority of it is below the level of consciousness. Linguistics is the science of language, taking as its data what people actually do when they use their language (and not what they think they ought to do), and how children acquire their native language. In this lecture, participants will probe their own intuitions about English and discover surprising regularities in sounds, words, and sentences. We will then go on to examine some quite different patterns in other languages. The overall goal is to understand that what is taught in English and foreign-language classes only scratches the surface of what we unconsciously "know" when we know a language.

About the lecturer: *Bob is a Professor in the Department of Linguistics at Stony Brook University. He has also held teaching and research positions at Cornell University, the Hebrew University of Jerusalem, St. Petersburg State University, and in Berlin. He works on the structure of Semitic languages, focusing on Arabic, Hebrew, and Aramaic in both their classical and modern colloquial varieties. He has studied several modern Aramaic languages through fieldwork with speakers from Iraqi Kurdistan and Iran. He has also worked on Maltese, which, like Aramaic and modern Hebrew, is a Semitic language that has undergone radical structural change in intimate contact with Indo-European languages. He especially enjoys working with speakers of little-studied languages and dialects, to document the languages and analyze their structures. He is also interested in writing systems, the history of Yiddish, Jewish interlinguistics, and ethnic, linguistic, and religious minorities in the Middle East.*

Chernobyl' Disaster on HBO and in Real Life
by *Igor Zaliznyak*

This year, HBO made a mini-series about the 1986 disaster at the Chernobyl nuclear power plant. In the past two years, I prepared a presentation of my own, covering the science, the causes, the timeline, and the consequences of the Chernobyl disaster. Last fall, I visited the site of the disaster and explored the current situation there. Now, I will discuss how my findings compare with the HBO TV series and how accurate the series is in depicting the 1986 events and the science behind them.

About the lecturer: *Dr. I. Zaliznyak is a physicist at Brookhaven National Laboratory, where he studies microscopic quantum properties of matter using neutron particles. Among others, these include exotic quantum states of electrons in metals, such as superconductivity, magnetism, and superfluidity in quantum liquids. Dr. Zaliznyak obtained his Ph. D. degree at the P. Kapitza Institute for Physical Problems, Moscow, in 1993. He also teaches math at SchoolNova.*

Friday

What Kind of Machine is a Human Brain?
by *Richard Granger*

Machines calculate trillions of possible chess and Go positions; humans do not. Humans make effortless decisions and inferences; current AI, ML, RL, and NN systems do not. Neurons are low precision (2-3 bit), sparsely connected ($p < 0.1$), and very slow (milliseconds); these and other nonstandard engineering designs confer unusual information processing powers, compared to customary computers. Analyses of mammalian brain circuit systems illuminate how artificial mechanisms still eclipse us in massive numerical calculation, such as in games – and conversely, how humans continue to outstrip AIs at tasks such as reasoning and language – addressing crucial questions of human computational capacities and limitations.

About the lecturer: *Richard Granger received his Bachelors and Ph.D. from MIT and Yale. He is a Professor at Dartmouth with joint appointments in the Department of Psychological and Brain Sciences, the Thayer School of Engineering, and the Cognitive Science Program; he directs Dartmouths interdisciplinary Brain Engineering Laboratory (brainengineering.org), with publications and patents ranging from computation and robotics to cognitive and basic neuroscience. He advises multiple technology corporations and government research agencies, is co-inventor of FDA-approved devices and drugs in clinical trials, and has been the principal architect of a series of advanced computational systems for military, commercial and medical applications.*

Anti-gravity Top: Physics of Magnetic Levitation
by *Sasha Abanov*

A Levitron is a fascinating toy. The spinning top hovers above the ground defying common sense. It is captivating and entrancing. We are going to talk about the physics behind it and play with the Levitron and other flying and rotating objects.

About the lecturer: *Sasha is a Professor in Department of Physics and Astronomy and a Deputy Director of the Simons Center for Geometry and Physics at Stony Brook University, NY. Sashas research is in theoretical condensed matter physics and in mathematical physics. He is mainly interested in systems whose properties are defined by the laws of quantum physics. Some examples of such systems are superfluids, superconductors and Quantum Hall effect systems. Sasha enjoys teaching physics and mathematics at different levels. He has a lot of experience in teaching school students in various summer camps and math circles.*

Tail Wagging the Dog
by *Marina Polonskaia*

The ability of parasites to alter the behavior of their hosts has recently generated an unusual interest in both scientists and non-scientists. What happens when one organism is possessed by a parasitic puppet master? These masters of mind control manipulate their hosts from within, causing them to act in self-destructive ways that ultimately benefit the parasite.

About the lecturer: *Marina Polonskaia received her B.S. in Physics and Physics education and M.S. and Ph.D. in Biophysics from Krasnoyarsk, Russia. Her postdoctoral training was in Molecular biology and Oncology in UIC (University of Illinois at Chicago). Later she worked as a research scientist at HMS (Harvard Medical School) and SBU (Stony Brook University). Since 2004 Marina is running an academic enrichment program for k-12 students, SchoolNova. She has extensive experience in teaching biology to students during summer months in Russia and USA. She was among the group of people who opened SigmaCamp back in 2012 and have been a full-time faculty or visiting lecturer every year ever since.*

How Much Math Plants Should Know
by *Michael Bershadsky*

Intriguing math appears in various plants - sunflowers, pine cones, cauliflower. The seeds, petals and leaves arrangements follow predictable mathematical patterns. Some plants show similarity-like structures. The talk includes topics from Fibonacci numbers to lattices, tiling of the cylinder and fractals. Similar patterns also appear in various branches of physics.

About the lecturer: *Michael Bershadsky got his PhD in physics from Princeton University in 1990. Immediately after this he came to Harvard University, where he was on the faculty until 2000. In 2000 he resigned from Harvard University and joined a private company.*

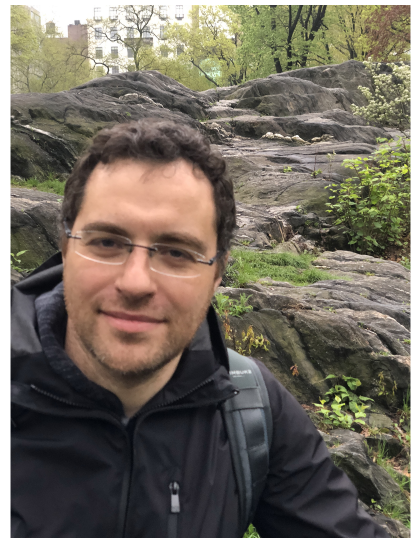
Freedom of Speech: Basic Principles and Current Controversies
by ***Nadine Strossen***

I will outline basic free speech principles (under international human rights law, as well as US law), including the speech rights of young people and students. We will then debate and discuss any current free speech controversies that students would like to consider, such as: What power (if any) should government have to regulate potentially dangerous, harmful speech, including "hate speech", speech promoting terrorism, or disinformation? What speech (if any) should social media companies bar? What limits (if any) should schools and colleges enforce to protect students' sense of equal dignity and inclusion?

About the lecturer: *New York Law School professor Nadine Strossen is a leading scholar, advocate, and frequent speaker/media commentator on constitutional law and civil liberties issues. The immediate past President of the American Civil Liberties Union (1991-2008), she serves on the national advisory boards of the ACLU, Electronic Privacy Information Center, FIRE (Foundation for Individual Rights in Education), and Heterodox Academy. The National Law Journal has named Strossen one of Americas "100 Most Influential Lawyers". Her acclaimed 2018 book* HATE: Why We Should Resist It with Free Speech, Not Censorship *has been selected by both Washington University and Washburn University as their 2019 "Common Read."*

Saturday

From Inscribed Worlds to Non-Euclidean Geometry: History and Geometry of Kepler's Laws
by *Roman Bezrukavnikov*



Kepler laws of planetary motion is a mathematically elegant statement that had a tremendous impact on development of modern science. The apparatus of calculus studied in an undergraduate math class allows to deduce them quickly from Newton's laws but that derivation does not match the statement of the laws in elegance and transparency. I will talk about the history of Kepler laws and a geometric way to derive them.

About the lecturer: *Roman Bezrukavnikov is a mathematics professor at the Massachusetts Institute of Technology and the chief research fellow at the HSE International Laboratory of Representation Theory and Mathematical Physics who specializes in representation theory and algebraic geometry.*

Duality in Physics
by *Sergei Razamat*

We will discuss the notion of duality in theoretical physics. Duality in this context usually means that two seemingly very different ideas and theoretical frameworks actually describe the same reality. In particular we will see how hard computations using one framework can become trivial in the dual one. Moreover, we will talk about gravity and a dual way to think about it using the holographic principle.

About the lecturer: *Dr. Razamat received his Ph.D. in Physics from Technion (Israel) in 2007, and held postdoc position at YITP Stony Brook (2007-2011), was a member at the IAS (Princeton) (2011-2014), and a postdoc at NHETC (Rutgers) (2014-2015). He is currently an assistant professor at the Department of Physics in Technion. The main research interests of S. Razamat are general aspects of Quantum Field Theory.*

The Story of Two Poisons: polonium-210 and Novichok
by ***Tanya Pyatina***

The lecture will discuss the recent poisoning events of former KGB officers in England from a historic perspective of warfare in the Soviet Union and in the West. Is it certain that both poisonings were done by Russian agents? How was the radioactive polonium poisoning identified in an English hospital? How did the chemical weapons change in time? "Novichok" used for the second poisoning is among the most potent nerve agents; however, it did not kill intended victims. How, despite the high lethal power of the poison, was it possible to save the former KGB officer and his daughter?

About the lecturer: *Tatiana Pyatina holds PhD in environmental engineering and chemistry from Caltech. After obtaining her PhD she worked with Schlumberder service company developing materials for subterranean well constructions. Presently she is a materials scientist at Brookhaven National Laboratory and develops new materials for geothermal energy production.*

How to Be a Brain Scientist Without Talking Like One
by ***Jonathan Hamilton***

Modern brain science has a communication problem. Its often done by teams that include biologists, physicists, mathematicians, epidemiologists, surgeons, and engineers. And each of those disciplines speaks a different language. So brain researchers are having to learn how to express themselves in ways that dont rely on scientific jargon, technical shorthand, and arcane references. Its a skill every scientist should have.

About the lecturer: *Jon Hamilton is a correspondent for NPR's Science Desk. Currently he focuses on neuroscience and health risks. In 2014, Hamilton went to Liberia as part of the NPR team that covered Ebola. The team received a Peabody Award for its coverage. Following the 2011 earthquake and tsunami in Japan, Hamilton was part of NPR's team of science reporters and editors who went to Japan to cover the crisis at the Fukushima Dai-ichi nuclear power plant.*

Living Neural Networks: From the Brain Cells Behind Human Behavior by ***Amina Qutub***

Snapchat lets you quickly share a school event with many friends. A hug comforts your mom. A conversation on a plane connects you to a stranger. We favor some forms of communication over others based on our relationships, and what information we want to convey. Cells in our body also have multiple forms of communication: biochemical, mechanical, and electrical. And just like us, they vary their mode of communication depending on context and who they are communicating with. Cellular communication and an ability to switch modes of communication is particularly critical during processes of tissue growth and regeneration — and perhaps most critical in the human brain. This talk will describe studies aimed at illuminating how human brain cells form networks and communicate, and how brain cell communication relates to our daily habits like exercise, sleep and social interactions.

About the lecturer: *Amina Qutub received her Ph.D. in Bioengineering from the University of California, Berkeley and UCSF. Following her postdoctoral training in Biomedical Engineering at Johns Hopkins University, School of Medicine, she served on the faculty at Rice University before joining UTSA in the Fall of 2018. Dr. Qutub develops experimental-computational methods to identify mechanisms of cell communication in the bone marrow and brain, with applications to treating hematological cancers and neurodegenerative diseases. She directs the Quantu Project (QuantuProject.org), a human subjects and modelling project launched in 2018, with the goal of optimizing brain health over a lifespan. Amina is a member of the Joint UTSA/UTHSC Graduate Group in Biomedical Engineering and the Brain Health Consortium, and co-founder of DiBS, an adaptive data visualization startup.*