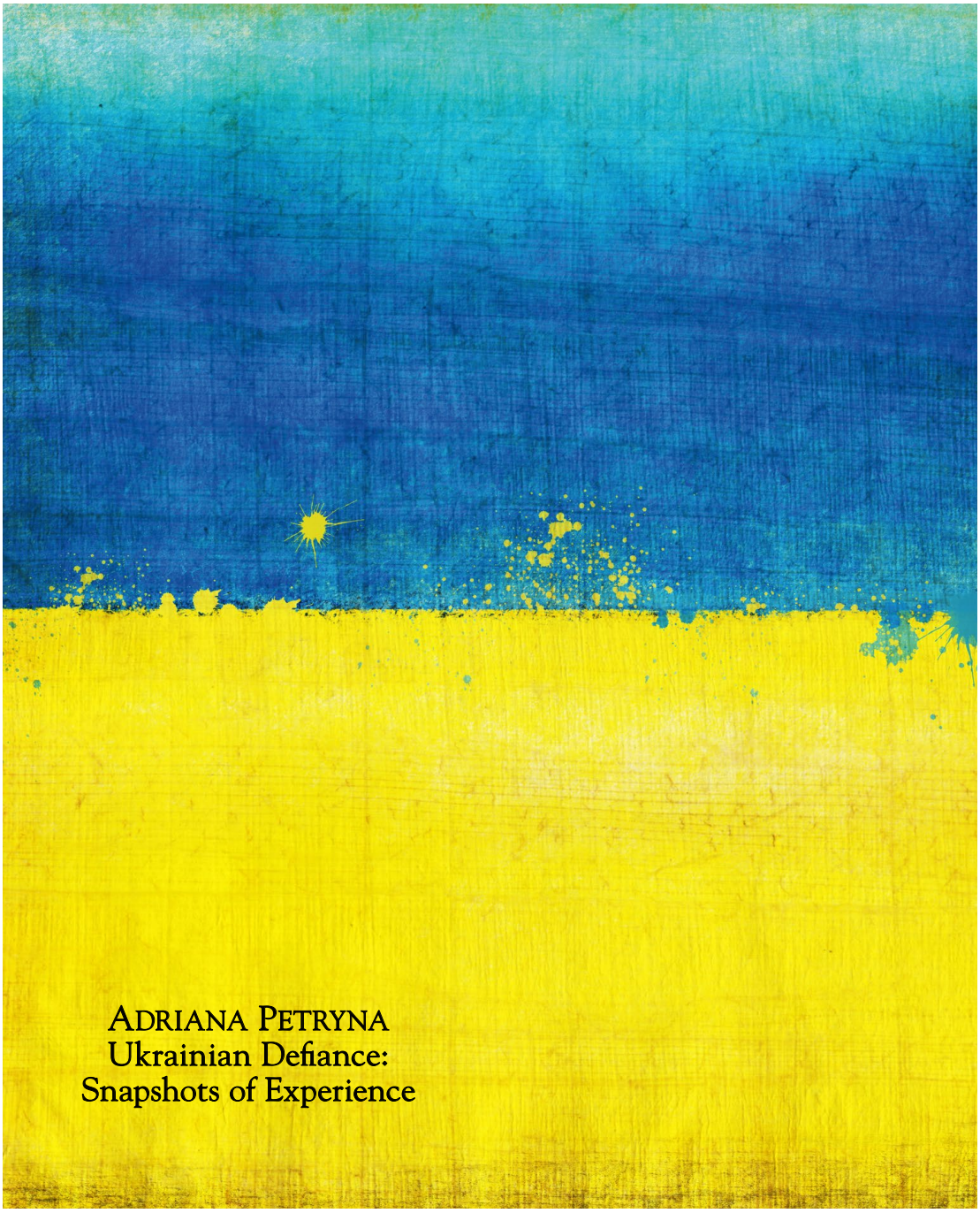
IAS | THE INSTITUTE LETTER
Spring 2022



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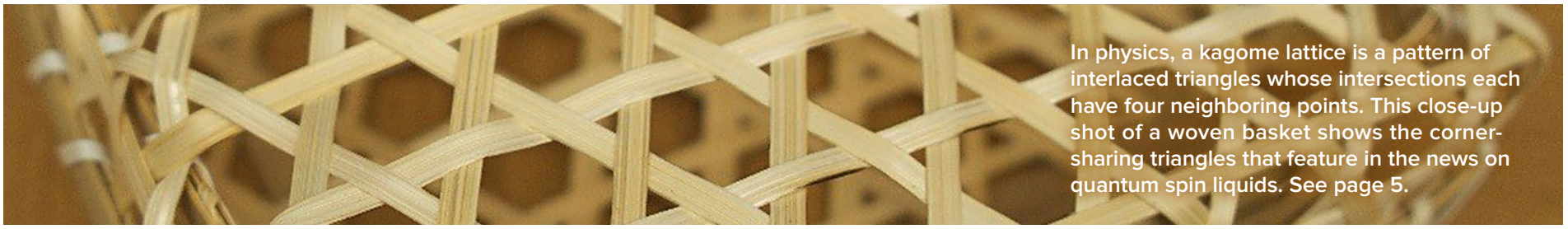

In physics, a kagome lattice is a pattern of interlaced triangles whose intersections each have four neighboring points. This close-up shot of a woven basket shows the corner-sharing triangles that feature in the news on quantum spin liquids. See page 5.

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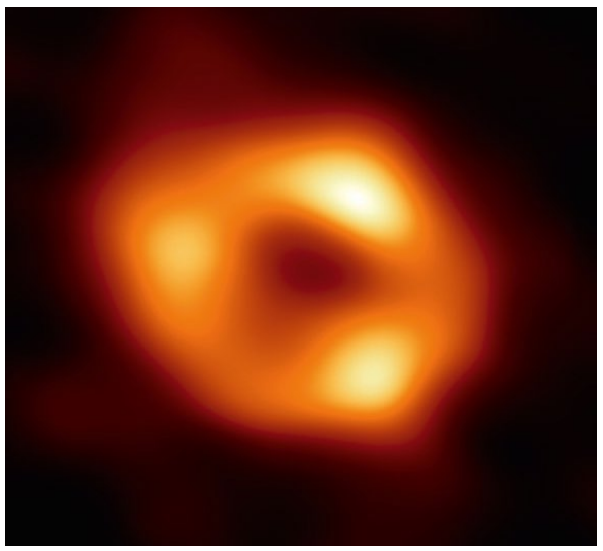
Astronomers Reveal First Image of the Black Hole at the Heart of our Galaxy



EHT COLLABORATION

Sagittarius A*, supermassive black hole at the center of the Milky Way galaxy

On May 12, 2022, astronomers unveiled the first image of the supermassive black hole at the center of our own Milky Way galaxy. This result provides overwhelming evidence that the object is indeed a black hole and yields valuable clues about the workings of such giants, which are thought to reside at the center of most galaxies. The image was produced by a global research team called the Event Horizon Telescope (EHT) Collaboration, using observations from a worldwide network of radio telescopes.

The image is a long-anticipated look at the massive object that sits at the very center of our galaxy. Scientists had previously seen stars orbiting around something invisible, compact, and very massive at the center of the Milky Way. This strongly suggested that this object—known as Sagittarius A* (Sgr A*, pronounced "sadge-ay-star")—is a black hole, and this image provides the first direct visual evidence of it.

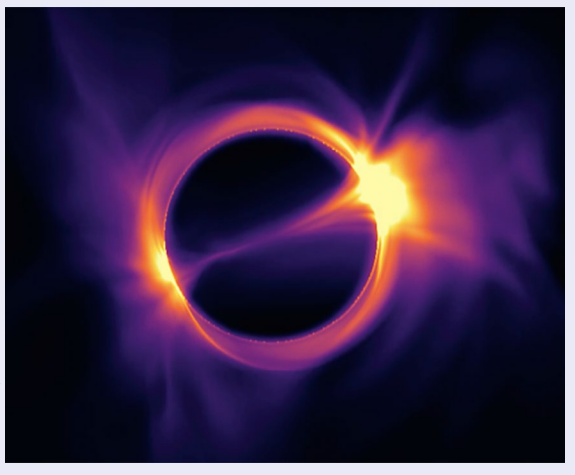
Although we cannot see the black hole itself because it is completely dark, glowing gas around it reveals a telltale signature: a dark central region (called a "shadow") surrounded by a bright ring-like structure. The new view captures light bent

(Continued on page 10)

Completing the Picture

Looks can be deceiving. The light from an incandescent bulb seems steady, but it flickers 120 times per second. Because the brain only perceives an average of the information it receives, this flickering is blurred and the perception of constant illumination is a mere illusion.

While light cannot escape a black hole, the bright glow of rapidly orbiting gas has its own unique flicker. In a recent paper, published in *The Astrophysical Journal Letters*, Lena Murchikova, William D. Loughlin Member at the Institute for Advanced Study; Chris White of Princeton University; and Sean Ressler of University of California Santa Barbara were able to use this subtle flickering to construct the most accurate model to date of our own galaxy's central black hole—Sagittarius A* (Sgr A*)—providing insight into properties such as its structure and motion.



CHRIS WHITE, PRINCETON UNIVERSITY

Simulation of glowing gas around a black hole

"Black holes are the gatekeepers of their own secrets," stated Murchikova. "In order to better understand these mysterious objects, we are dependent on direct observation and high-resolution modeling."

By reading between the proverbial lines (or flickering light), the team concluded that the most likely picture of black hole feeding in the galactic center involves directly infalling gas from large distances, rather than a slow siphoning off of orbiting material over a long period of time.

"When we study flickering, we can see changes in the amount of light emitted by the black hole second by second, making thousands of measurements over the course of a single night," explained White. "However, this does not tell us how the gas is arranged in space as a large-scale image would. By combining these two types of observations, it is possible to mitigate the limitations of each, thereby obtaining the most authentic picture." ■

Read the full story "A Flicker from the Dark: Reading Between the Lines to Model Our Galaxy's Central Black Hole" at www.ias.edu/news/flicker-from-the-dark

ALISON CARVER, AMIT JUST AMIT / CC BY-SA 4.0 AND SETSIRI SILAPASUWANCHAI

Ukrainian Defiance: Snapshots of Experience

BY ADRIANA PETRYNA

Russia's unprovoked invasion of Ukraine is a humanitarian crisis of epic proportions. It has created a refugee crisis, the scale of which has not been seen since World War II in Europe. The toll of civilian casualties is in the thousands, with countless others missing, injured, trapped, or lacking in essential medicines, food, and water. As the war continues, the Ukrainian military and ordinary citizens have taken up arms to defend their sovereignty against a massive invading army. In an unbounded catalog of resistance, civilians have blocked military vehicles with their own bodies. Advancements on critical infrastructure, such as nuclear power plants, have been met with barricades. They have flooded their own villages to slow Russian attacks. In a now-famous act that became a national rallying cry, thirteen border guards on Snake Island near Crimea refused to surrender to a Russian warship, telling it 'Go f— yourself,' before they were fired upon by the notorious Moskva (now sunk).[1] Ukrainians have seemingly forgotten the feeling of fear. What makes their resolve so stiff? Part of the answer lies in a past in which they repeatedly signed their own death warrant. The other lies in a future in which they refuse to do so again.

An Unsettled Past

Just five years before declaring independence, in 1991, the country faced a different kind of fight for its life. On April 26, 1986, the Chernobyl nuclear power plant exploded and the massive fire that followed sent fallout across Belarus, Ukraine, Russia, and Europe. Chernobyl is considered to be the worst nuclear accident of all time. Most costly to Ukraine was the process of radiological containment. Initially, robots were deployed to remove radioactive debris from the roof of the plant's third

(Continued on page 6)

News of the Institute Community

Suzanne Conklin Akbari, Professor in the School of Historical Studies, has been elected Fellow of The Medieval Academy of America.

Wendy Brown, UPS Foundation Professor in the School of Social Science, has been elected to the American Academy of Arts and Sciences. Additionally, her body of work is the focus of *Power, Liberalism, and the Reinvention of Politics: The Critical Theory of Wendy Brown* (Penn State University Press, 2022), an edited volume to which she is one of the contributors.

Camillo De Lellis, IBM von Neumann Professor in the School of Mathematics, has been awarded the 2022 Maryam Mirzakhani Prize in Mathematics from the National Academy of Sciences. He will be a Plenary Speaker at the Summer 2022 International Congress of Mathematicians.

Nicola Di Cosmo, Luce Foundation Professor in East Asian Studies in the School of Historical Studies, has been elected Corresponding Member of the Instituto Veneto di Scienze, Lettere ed Arti.

Didier Fassin, James D. Wolfensohn Professor in the School of Social Science, has been appointed to the French National Committee for the Ethics of Health Sciences. He delivered the 2022 Page-Barbour Lectures at the University of Virginia, authored an ethno-graphic on policing, edited a 65-author volume on the coming society, and coedited two books with former Distinguished Visiting Professors: Axel Honneth, on crises; and Marion Fourcade, on the pandemic.

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Questions and comments regarding the *Institute Letter* should be directed to publications@ias.edu.

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Myles W. Jackson, Albers-Schönberg Professor in the History of Science, has been named a visiting professor at the Technical University of Munich's Institute for Advanced Study for the summer of 2022. He also delivered the William and Myrtle Harris Lecture on Science and Civilization at the California Institute of Technology in May 2022.

Alondra Nelson, Harold F. Linder Professor in the School of Social Science, has been appointed to lead the White House Office of Science and Technology Policy. Additionally, she has been elected Fellow of the American Association of the Advancement of Science and awarded an honorary doctorate from Rutgers University on May 15, 2022.

Peter Sarnak, Gopal Prasad Professor in the School of Mathematics, has been elected as an honorary Member of the London Mathematical Society.

Sabine Schmidtke, Professor in the School of Historical Studies, has been elected corresponding member of the Austrian Academy of Sciences.

James Stone, Professor in the School of Natural Sciences, has been elected as a Member of the National Academy of Sciences.

Francesca Trivellato, Professor in the School of Historical Studies, won the Jacques Barzun Prize and the 2021 Jordan Schnitzer Book Award in the category of Medieval and Early Modern Jewish History and Culture for her book *The Promise and Peril of Credit: What a Forgotten Legend about Jews and Finance Tells Us about the Making of European Commercial Society* (Princeton University Press, 2019).

Edward Witten, Charles Simonyi Professor in the School of Natural Sciences, has received an honorary doctorate from the University of Pennsylvania.

Matias Zaldarriaga, Richard Black Professor in the School of Natural Sciences, has been elected to the American Academy of Arts and Sciences.

Phillip Griffiths, Professor Emeritus in the School of Mathematics, presented the Clay Lecture at the Isaac Newton Institute for Mathematics in Cambridge, U.K. Additionally, he has contributed an article to *Contemporary Mathematics Volume 766* (American Mathematical Society, 2021), and co-authored the essay "Positivity of Vector Bundles and Hodge Theory."

Joan Wallach Scott, Professor Emerita in the School of Social Science, received an honorary degree from the University of Liège (Belgium) on March 19, 2022.

Michael Walzer, Professor Emeritus in the School of Social Science, has delivered the fourth annual Philosophy Lecture at Hebrew University in Jerusalem.

Amol Aggarwal, Visiting Professor in the School of Mathematics, has been awarded the Dubrovin Medal and the Rollo Davidson Prize.

Mimi Dai, von Neumann Fellow in the School of Mathematics, has been granted a Centennial Fellowship from the American Mathematical Society.

Hongjie Dong, Member in the School of Mathematics, has been awarded the 2022 Research Achievement Award from Brown University.

Ronen Eldan, von Neumann Fellow in the School of Mathematics, has been awarded the 2022 Blavatnik Award for Young Scientists in Israel.

Diana S. Kim, Member in the School of Historical Studies, has been awarded the APSA 2021 Charles Taylor Book Award Honorable Mention, 2021 SSHA Allan Sharlin Memorial Book Award Honorable Mention, and the APSA Giovanni Sartori Book Award for her book *Empires of Vice: The Rise of Opium Prohibition across Southeast Asia* (Princeton University Press, 2020).

Sarah Peluse, Veblen Research Instructor in the School of Mathematics, has been awarded the 2022 Dénes König Prize by the Society for Industrial and Applied Mathematics.

Margaret Susanna Graves, Member (2015–16) in the School of Historical Studies, won the 2021 Karen Gould Prize in Art History from the Medieval Academy of America for her book *Arts of Allusion: Object, Ornament, and Architecture in Medieval Islam* (Oxford University Press, 2018).

Bernard E. Harcourt, Visiting Professor (2016–17) in the School of Social Science and IAS Trustee, has been awarded the 2021 Lionel Trilling Book Award from Columbia College for *Critique & Praxis: A Critical Philosophy of Illusions, Values, and Action* (Columbia University Press, 2022).

Fleur Johns, Member (2019–2020) in the School of Social Science, has been awarded a Future Fellowship from the Australian Research Council for 2021–25.

John Lesieutre, Member (2014–15) in the School of Mathematics, was awarded a Faculty Early Career Development (CAREER) award from the U.S. National Science Foundation.

Susana Narotzky, Member (2019–20) in the School of Social Science, has been awarded the Ramón Menéndez Pidal National Award, the highest distinction in social sciences and humanities in Spain.

Laurence Ralph, Member (2012–13) in the School of Social Science, has been awarded the 2021 Robert B. Textor and Family Prize for Excellence in Anticipatory Anthropology.

Sophia Rosenfeld, Member (2014–2015) in the School of Social Science, has been appointed Kluge Chair in Countries and Cultures of the North at the Library of Congress.

Noah Salomon, Member (2013–14) in the School of Social Science, has been named a Mellon Foundation New Directions Fellow.

W. Anthony Sheppard, Member (2011–12) in the School of Historical Studies, has been awarded the 2021 Irving Lowens Book Award from the Society for American Music for his book *Extreme Exoticism: Japan in the American Musical Imagination* (Oxford University Press, 2019).

Roger Ulrich, Member (1975) in the School of Natural Sciences, has been awarded the 2022 Kavli Prize.

A Word from Nirenberg

On May 20, 2022, IAS celebrated Founders Day in recognition of Louis Bamberger and Caroline Bamberger Fuld, the brother and sister who founded and endowed IAS on May 20, 1930, providing for its lasting and essential independence. The event, held on campus, began with a toast from Director and Leon Levy Professor David Nirenberg, after which the Friends held their Annual Meeting, and Staff, Members, Faculty, the Director, and a Trustee played in the third annual flag football game. Hardly deterred by a brief thunderstorm and downpour, the event continued with food trucks, a community dinner, and an evening of dancing in Simons Hall. Before joining the flag football game, Nirenberg opened the Friends Annual Meeting, sharing some thoughts about the value of the Institute and the Friends' support of its work.

The following is adapted from his remarks to the Friends:

Dan Komoda

It's such a pleasure to be here at my first Friends Annual meeting. Perhaps because I am in my infancy as Director of this marvelous institution, I find myself musing about the world into which IAS was born. It was a world of economic collapse and uncertainty. It was a world of sharp and legal discrimination along the lines of race, religion, and gender. It was a world of change in the technologies of communication—radio and cinema—that in turn transformed the possibilities of politics. Just think of those pictures of Roosevelt in front of a bank of microphones, or of Hitler's propaganda films. It was a world of ideology and nationalism, and the rising flames of war. In the more local neighborhood of universities and research institutions, it was a time of sharp debate about what could and should be taught, and who should teach it.

In some ways that world feels uncomfortably like our own: a time in which we see the re-emergence of borders; new barriers to the exchange of people and ideas; a rekindling of war and mass migration; and renewed conflict over the nature of universities, of research and of expertise. What we today call the culture wars.

Given the similarities, it is worth asking ourselves how the infant Institute navigated the complexities of the world in which it was founded. Here's one example: at a time when discrimination was not only legal but extensively practiced in the U.S. and many other areas of the world, the Institute's founders insisted that it was "fundamental to our purpose" that there be no discrimination on the basis of race, religion, or sex. The goal of excellence, the Bambergers felt, demanded the inclusion of talent, regardless of origin.

The infant IAS lived by those ideals at a time when it was not easy to do so. It is an accident of history that our first and most famous Faculty member was also the world's most famous refugee. But what began as accident soon became concerted strategy. Nor were refugees the only targets of inclusion at the Institute. The Institute worked to remove Japanese scientists from internment camps and bring them to Princeton. It welcomed women among its Faculty and Members at a time when the same could not be said of many institutions of higher learning. And it welcomed African Americans like the mathematician David Blackwell while they were barred from many other places.

Enacting these values was not easy, and it wasn't without conflict. Abraham Flexner, the Founding Director, worried that too many refugees would crowd out American scientists, and he was constantly fretting that the activities of Einstein and others would excessively politicize the Institute. But despite disagreement, the Institute became the example of what it means to be a refuge for the world's scholars in times of crisis.

There were many other questions debated in the early years of the Institute, including that of campus and environment. Again, we should not imagine agreement. If it were up to Flexner, for example, the Institute would not have had a campus, let alone the verdant island we inhabit. Others, like Veblen and Aydelotte, thought of field and forest as a crucial context for thought.

And what about the intellectual environment? What kinds of research should the Institute foster, what kinds of conversations should it catalyze? These too are questions that have been debated ever since the Institute was founded. We often refer to one of Flexner's contributions to that debate, the "Usefulness of Useless Knowledge." That essay's lesson was not—as is sometimes asserted—that the Institute should avoid any research that is useful or has application. Its point was the much more subtle one, reinforced over and over again across our history, that it is neither easy nor advisable to draw too clear a line between theory and application.

Kurt Gödel, for example, may seem to dwell in the realm of pure theory—or perhaps not even in this world, some who knew him might have thought—but in his last letter to his dying colleague John von Neumann, he proposed the computational possibility of automating mathematical proofs. This was an early statement of what we today call the P versus NP problem, with implications for any number of applications, such as the cryptographic techniques upon which the protection of all of our data depends.

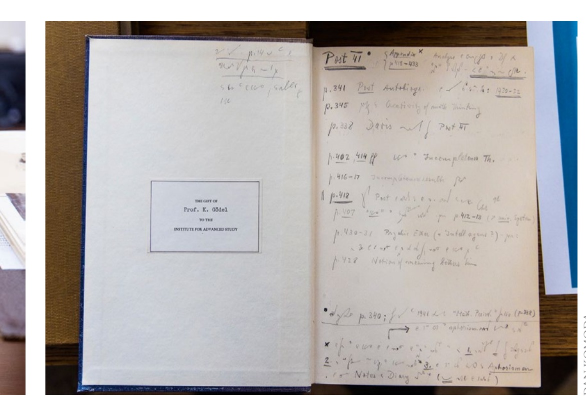
My point thus far is a simple one. The inhabitants of this Institute have often disagreed in their debates about how best to offer knowledge to an ever-changing world. But on one thing they have always agreed: the value of debate itself. The founders thought a great deal, not only about what we today call free speech and academic freedom, but also about cultivating what we today call "viewpoint diversity," so that there could be a real testing of ideas, rather than ideological or disciplinary consensus. Flexner even proposed that the Institute should go out and hire the best Bolshevik economist it could find, since ideas are tested through disagreement. I wonder what economics department today would countenance such a radical idea?

Throughout all of these debates, the goal was to create at the Institute a collection of thinkers capable of producing—through their talent, proximity, collaboration, disagreement, and conversation—insights and discoveries that could not otherwise have been produced.

Gathered as we are here today in festivity, it is easy to forget that institutions dedicated to discovery and to the free transmission of knowledge cannot be taken for granted. They have been absent in many periods of human history, and even today, they are threatened in or absent from large parts of the world. Institutions such as ours are rare. And they are fragile. They require the extraordinary support of extraordinary people like you, our Friends.

Though I have only been at IAS for a few months, that is more than sufficient time to recognize the many ways in which Friends contribute to IAS. Thank you for being among our best ambassadors, volunteers, and partners in welcoming IAS Members and families to the Princeton community. Thank you for your philanthropy—in the etymological sense of your love of humanity—which has so often sustained us, and especially through the dark years of the pandemic. Thank you on this Founders Day for your friendship, without which our Institute, and our world, would be much impoverished.

Learn more about the Friends at www.ias.edu/support/friends-of-ias



Dan Komoda

Items from the Shelby White and Leon Levy Archives Center, displayed for Founders Day

Shelby White Awarded IAS Bamberger Medal

On May 6, 2022, the IAS Bamberger Medal was presented to Shelby White, IAS Trustee Emerita and Founder of the Leon Levy Foundation, at a celebration on the Institute's campus in Princeton, NJ. Shelby has championed the Institute throughout the four decades since her late husband Leon Levy's appointment to the Board of Trustees in 1988. She herself served on the IAS Board of Trustees from 2003 to 2019.

A significant philanthropist of our time, Shelby has made investments of great depth and breadth in the Institute. Her generosity has fortified IAS in innumerable ways, establishing the Leon Levy Professorship—held by the IAS Director—cultivating the cohesive beauty of the Institute's campus landscape, and providing resources to support scholarly initiatives. Shelby also created the Shelby White and Leon Levy Archives Center to document IAS history and the many significant people who have shaped it. She truly embodies the curiosity and dedication fundamental to the Institute mission.

Charles Simonyi, Shelby White, and David Nirenberg (left to right)

David Nirenberg, IAS Director and Leon Levy Professor, said in his speech, "Very few in the contemporary world have done as much to ensure that humanity's knowledge is expanded, transmitted, and preserved." Board of Trustees Chair Charles Simonyi and Vice Chair Nancy Peretsman also spoke at the event, and correspondence was read from landscape architect Patrick Chasse and previous IAS Director Robbert Dijkgraaf. Ann Hampton Callaway and Liz Callaway gave a lively musical performance. For the final performance of the evening, Ann Hampton Callaway wrote a song on the spot for Shelby after briefly interviewing her.

The IAS Bamberger Medal, the Institute's highest honor, is named in honor of Caroline Bamberger Fuld and Louis Bamberger, the sister-and-brother philanthropists who provided the founding $5 million gift to establish IAS as envisioned by the education reformer Abraham Flexner, the Institute's founding Director. ■

Jinyoung Park and Huy Tuan Pham Prove the Kahn-Kalai Conjecture

Past Member (2020–21) Jinyoung Park, a Szegö Assistant Professor at Stanford University, and Huy Tuan Pham, a Stanford Ph.D. student, proved the Kahn-Kalai Conjecture, a central problem in probabilistic combinatorics.

The conjecture concerns determining the precise point (e.g., temperature, pressure, probability, etc.) at which a "phase transition" occurs in a large variety of systems. The systems are studied widely in statistical mechanics and graph theory. While this point is extremely hard to compute, in 2006 Jeff Kahn and Gil Kalai, past IAS Member (1995, 2000) and frequent Visitor, conjectured that it is very close to another parameter which is much easier to compute. If true, it could be possible to approximate well when phase transitions occur. This has been called "the expectation threshold conjecture."

Jinyoung Park and Huy Tuan Pham (left to right)

Learn more about Park's academic journey and her motivation to explore "deep" mathematical questions in the IAS video series "Paths to Math."

Two years ago, Park—and a team including Kahn, Keith Frankston, and past IAS Visitor (2020–21) Bhargav Narayanan—proved a weaker form of the conjecture. Despite excitement and attempts by experts, proving the full conjecture using their technique evaded all. In a blog post, Kalai said that proving "the full expectation threshold conjecture looked like a difficult task." This April, Park, with Pham, surprised everyone, finding a direct simple argument (which settles another conjecture of French Mathematician Michel Pierre Talagrand), solving one of the major puzzles in the field.

Avi Wigderson, Herbert H. Maass Professor in the School of Mathematics, said "Jinyoung Park was a postdoc in my group last year, working relentlessly on this conjecture and related ones. Her stamina and ingenuity are remarkable." ■

Launched following the Russian invasion of Ukraine, the School of Historical Studies has created a resource page with a variety of links regarding the ongoing conflict. Read the latest analysis from IAS scholars and find links to support scholars at risk, safeguard Ukrainian culture and heritage, and stand up for diversity and human rights. **Learn more by visiting ias.edu/hs/ukraine-resource-page.**

The links and information on this page are meant for informational purposes only. Participation is voluntary and at the sole discretion of readers.

Gopal Prasad Professorship Established at IAS

The Institute is proud to announce the creation of the Gopal Prasad Professorship in recognition of prolific mathematician and six-time Member of IAS, Gopal Prasad. The professorship, endowed with a gift from the Prasad family, ensures that future generations of scholars, from all regions of the world, have the opportunity to benefit from the unique environment of discovery at IAS.

Peter Sarnak, current Professor in the School of Mathematics, has been selected as the inaugural Gopal Prasad Professor. The professorship is to be held by Faculty in the Schools of Mathematics and Natural Sciences.

"For half a century the Prasad family has been intimately associated with the work of the IAS," stated David Nirenberg, IAS Director and Leon Levy Professor. "It is therefore a special joy to see the Prasad name permanently associated with the Institute and its enduring mission. It feels especially fitting for this professorship to be shared by the Schools of Mathematics and Natural Sciences, given that close collaborations between these Schools have produced so many fundamental insights and discoveries."

Gopal Prasad

Gopal Prasad, considered a leading expert on Lie groups and algebraic groups, is currently the Raoul Bott Collegiate Professor Emeritus of Mathematics at the University of Michigan. He joined IAS as a Member for the first time in 1973, returning every decade through 2013. Over the years—not only those spent at IAS—he enjoyed fruitful collaborations and discussions with Faculty including Harish-Chandra, Armand Borel, Robert Langlands, Pierre Deligne, and Peter Sarnak.

"Like so many scholars around the world, my father is a direct beneficiary of the creative and collaborative environment at IAS, which richly informed his research and academic partnerships," explained Anoop Prasad. "In establishing this professorship, my family is investing in the ongoing IAS legacy as an enabler and diffuser of scientific knowledge globally."

As a child, Anoop came to IAS with his parents in 1973 and spent a year at Crossroads Nursery School. During Gopal's subsequent visits to IAS, Anoop attended Johnson Park Elementary School and Princeton High School. After earning a Ph.D. in theoretical physics from Caltech in 1997, Anoop joined D. E. Shaw where he is now a Managing Director and Head of the Equities Group. He joined the Friends of IAS in 2012 and has served on the Friends Executive Committee since 2018.

Ila Fiete, Gopal's daughter, also enjoyed her stays on the IAS campus and attended Princeton schools in her childhood. She is now a physicist and computational neuroscientist, currently serving as Professor in the Department of Brain and Cognitive Sciences within the McGovern Institute for Brain Research at the Massachusetts Institute of Technology.

The family's connection to IAS and intellectual progress also extends to Gopal's brothers: Pawan Kumar, Visiting Professor (1996–2002) in the School of Natural Sciences; Shrawan Kumar, Member (1988–89) in the School of Mathematics; and Dipendra Prasad, Member (2006–07 & 1992–93) in the School of Mathematics.

"I am very honored to be the inaugural Gopal Prasad Professor," remarked Sarnak. "Gopal's foundational works in Group theory and in the related areas of Geometry, Representation Theory, and Number Theory enjoy a broad and far-reaching impact. I, and many others, are regular users of his many theorems, as well as his masterful and insightful presentations thereof. His long association with the Institute, and with my colleagues, makes this Professorship special for me."

Peter Sarnak has made major contributions to number theory and to questions in analysis motivated by number theory. His research in mathematics is wide-ranging, focusing on the theory of zeta functions and automorphic forms with applications to number theory, combinatorics, and mathematical physics.

Gopal Prasad received his Ph.D. in Mathematics from the University of Bombay, India, in 1976. In 1975, he began an appointment at the Tata Institute of Fundamental Research, and was named a Professor in 1984. He moved to the United States in 1991, was appointed a Professor of Mathematics at the University of Michigan in 1992, and in 2008, he was named the Raoul Bott Collegiate Professor of Mathematics. His numerous visiting appointments have included stays at Yale University and the Mathematical Sciences Research Institute, Berkeley.

"My visits to the Institute were very inspiring and fruitful," recalled Gopal Prasad. "I found the atmosphere there to be extremely conducive to research and collaboration, unencumbered by any responsibilities and I learnt much from discussions with the Faculty and Members." ■

New State of Matter Observed through Entangled Particles

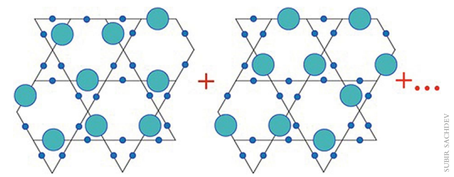
A new state of matter, known as quantum spin liquid (QSL), was observed for the first time by IAS and Harvard University researchers. The results were published in the journal *Science*.

Subir Sachdev, Maureen and John Hendricks Distinguished Visiting Professor in the School of Natural Sciences and Herchel Smith Professor of Physics at Harvard, is a theoretical physicist and co-author of the new study led by the Harvard Quantum Initiative (HQI).

As a theorist, Sachdev has worked for years on developing a framework to understand QSLs, predicted nearly fifty years ago by physicist Philip W. Anderson. In a 1991 paper, Sachdev and co-author Nicholas Read provided the first description of the specific type of quantum entanglement (the Z2 spin liquid) observed in the new HQI experiment.

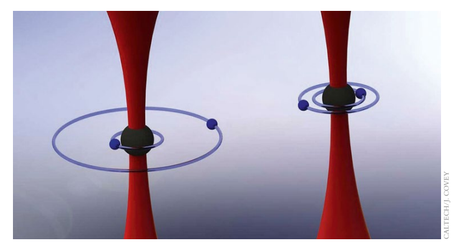
The theory of quantum entanglement, however, can be traced back even further to an IAS teatime conversation in 1935 between Albert Einstein, Boris Podolsky, and Nathan Rosen. The resulting "EPR" paper provided a foundation for quantum information research and is associated with Einstein's famous remark, "spooky action at a distance."

With the successful observation of QSL in the lab, spooky action may now be a little less spooky. In fact, researchers today use tools like "laser tweezers," allowing them to arrange atoms like pieces on a checkerboard.



SUBIR SACHDEV

Quantum spin liquid state of rubidium atoms trapped in an array on the links of a kagome lattice. The smaller blue circles indicate rubidium atoms in the lowest energy state, while the larger circles indicate atoms in the higher energy state. The quantum spin liquid is an entangled state of many such configurations of rubidium atoms, only two of which are shown here.



CAITLIN LOVEY

A pair of laser tweezers (red) trapping one rubidium atom each. The smaller atom is in the lowest energy state of rubidium, while the larger atom has been excited to a higher energy state by another laser (not shown).

"You can move the atoms apart as far as you want, you can change the frequency of the laser light, you can really change the parameters of nature in a way that you couldn't in the material where these things are studied earlier," said Sachdev. "Here, you can look at each atom and see what it's doing."

As part of this study, rubidium atoms were arranged into a kagome lattice structure. The pattern, a symmetrical tiling of triangles and hexagons, derives its name from Japanese basket weaving and is naturally occurring in the atomic structure of certain minerals. By exciting specific rubidium atoms within the lattice structure from their ground state, the researchers were able to encourage particles to interact and entangle on a large scale.

QSLs have promising applications in terms of various quantum technologies and may help to overcome challenges of reliability in quantum computers. The team's success also opens the door to a variety of new experiments and the possibility of new theoretical connections. ■

Read more about this research in the Harvard press release. The published journal article is available at Science.

reactor, which stood next to the destroyed reactor. But radiation levels were so high that the electronics powering the robotic equipment failed. A month later, young men were conscripted to complete the job. With their bodies covered by primitive lead suits, rubber gloves, and cloth face masks, they shoveled highly radioactive debris into the mouth of the destroyed reactor in one-minute stints—enough time for them to absorb a lifetime's worth of radiation exposure—and the one-minute rule was not evenly enforced. They called themselves "bio-robots." In fact, their lives were expendable. As one member of a crew put it, biological resources "to be used and thrown out."

More than 600,000 soldiers, firefighters, and other workers from across the Soviet Union were sent to the disaster site to clean up or contain the radiation—some people removed smoldering chunks of radioactive nuclear core near the ruined reactor unit with no more equipment than shovels and buckets—before a structure designed to safely hold the fourth reactor unit's highly radioactive remains for a century was completed in 2019. In an interview I conducted a year after independence, a man on a two-week break from clean-up work lifted his pant leg and showed me a patch of skin that had puckered up to form a strange ring above his ankle. "This is from radiation," he told me. He counted himself among the "living dead": "Our memory is gone. You forget everything—we walk like corpses." The Chernobyl Exclusion Zone, where people cannot live and scientists can stay for only short amounts of time, extends 1,000 square miles around the reactor site. I went on to interview scores of sick cleanup workers and resettlers in the 1990s for my book *Life Exposed: Biological Citizens After Chernobyl*,[2] and learned how the memory of the explosion and the fight against radiation that followed is carved into Ukraine, and how it would inspire a dedicated defense of a free country.

The tragedy of Chernobyl is only one in a succession of historical shocks. Before Chernobyl, the Terror-Famine of 1932 and 1933—the outcome of a Soviet policy of deliberate starvation under Joseph Stalin—killed nearly 4 million Ukrainians.[3] While official Soviet history and the foreign press corps[4] helped silence the fact that this catastrophe ever took place, its reality was never lost on Ukrainians for whom it became part of the chilling ancestries in the so-called bloodlands.[5] Here, I recall an encounter in 1992 with an elderly man in a southwestern Ukrainian town, where a massacre of civilians in the late 1930s had taken place. He described how, in the late 1980s, history students were ordered to shovel skeletal remains into the crypt of a baroque-styled Dominican-church-turned-storage-facility for agricultural supplies. The students used their hands to disturb the corpses—to erase history was the history lesson.

I WENT ON TO INTERVIEW SCORES OF SICK CLEANUP WORKERS AND RESETTLERS IN THE 1990S FOR MY BOOK *LIFE EXPOSED: BIOLOGICAL CITIZENS AFTER CHERNOBYL*, AND LEARNED HOW THE MEMORY OF THE EXPLOSION AND THE FIGHT AGAINST RADIATION THAT FOLLOWED IS CARVED INTO UKRAINE, AND HOW IT WOULD INSPIRE A DEDICATED DEFENSE OF A FREE COUNTRY.

And by the 1990s, the Soviet industrial framework was falling apart. Hyperinflation wiped out household financial savings. A Chernobyl health crisis unfolded as people with cancers, heart and autoimmune problems, and other disorders poured into clinics. Its impacts on citizens, from the widows of deceased cleanup workers to those who continued working in the zone, overwhelmed the unprepared health system in which I conducted fieldwork. After telling one man that he couldn't help him, a doctor turned to me and commented: "He's on the border with death. We have many like that." They were looking for relief from ills that they claimed were related to Chernobyl, but such connections were dismissed by international scientific experts and their Soviet counterparts because the patients had little to no documentation of their exposure. They were faced with an impossible burden of proof, even as the devastating public-health consequences of the disaster were downplayed.

Meanwhile, throughout that decade, the West rested in the conviction that it had 'won' the Cold War. Ukraine was once home to the third-largest nuclear arsenal in the world, thanks to the Soviet legacy. In 1994, it gave up its arsenal, comprised of some 1,900 strategic nuclear warheads, in exchange for diplomatic recognition, economic support, and security assurances from the United States, Britain, and Russia. As part of a denuclearization deal, Ukrainian military officers blew up intercontinental ballistic missile silos, located in the outskirts of strategic towns. Specialists dismantled nuclear bombers and soldiers demolished cruise missiles with circular saws.[6] The nuclear materials were shipped to Russia, which promised "to respect the independence and sovereignty and the existing borders of Ukraine." In that celebrated era of nuclear disarmament for which the U.S. took credit[7], Russia also promised "to refrain from the threat or use of force" against Ukraine. Whether the country had ceded its security by giving up those weapons is a subject of debate.[8]

In fact, Ukraine had enough problems to deal with, painful realities which juxtaposed such geo-political 'triumphs.' Health care workers were desperate to secure critical medical supplies. When then-U.S. Secretary of State Warren Christopher visited a children's hospital in Kyiv, the hospital director set up an "exhibit" of babies affected by Chernobyl. My notes from conversations with staff about these babies are as follows, "One born prematurely, another survived the death of his twin; another born with a dysfunctional esophagus; […]. One born to a mother who, at age nine, was evacuated from the Chernobyl zone; her infant has half a lung. Another was born to a [clean-up] worker: there are six fingers on his left hand. He's missing a trachea […]. His left ear is gnarled and deformed." These were the children of the bio-robots, one doctor said to me. Such human challenges got lost when set against an international stage, another form of historical erasure against which Ukrainians struggled. Through these years, they were again and again made to face down their own demise, their efforts often unacknowledged or even denied as they settled for a bare survival. They refuse to settle again.

The Right to a Future

Today, amid the bombing of civilian targets, factories, schools, hospitals, theaters, museums, residential buildings, and nuclear power plants, this war puts many forms of weaponization on display—not just the conventional weapons of war, but ones linked to nuclear instability and Russian fossil fuel reliance that threaten both Europe and the world with multiple kinds of "dirty" power. Even so, in early March, the Kremlin forbade Russians from even calling it a "war." It only allows talk of a "special military operation" as it continues to hide the toll of Russian casualties from the Russian public.[9] The Nobel Peace Prize-winning journalist, Dmitry Muratov, suspended reporting on the war in his independent newspaper, *Novaya Gazeta*, as a result of censorship and the threat of criminal prosecution. He likened Putin's domestic wartime disinformation campaign to a disastrous radiation release, telling *The Observer*, "Propaganda is like radiation. And it has touched many here."[10]

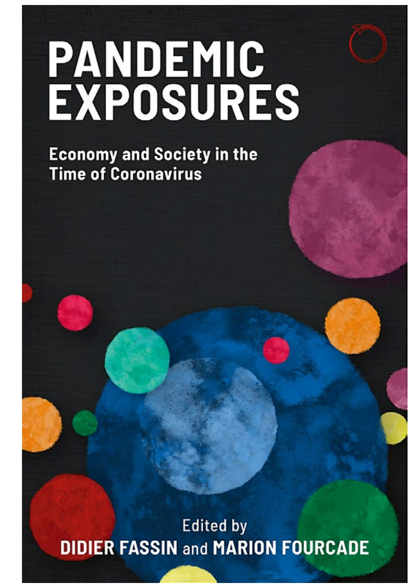
The story of how historical erasure becomes its own act of aggression does not stop there. On the first day of its military assault on Ukraine, Putin's army stirred up a painful memory of Soviet disregard when it overtook the Chernobyl nuclear facility. Whatever the reasoning was, the implication for Ukrainians was clear: the potential for a repeat of the disaster, which they had spent three long decades and considerable resources trying to prevent. Ukraine's Ministry of Energy called the attack "one of the most appalling threats to Europe today." It stated that "any provocation by the Chernobyl invaders…could turn into another world environmental catastrophe." The "invaders" had subsequently held captive for weeks highly specialized staff who had been working at gunpoint and without critical replacements as they tried to keep sensitive equipment running and radiation levels in check. Even radioactive waste wasn't safe from the looting.[11]

The Zaporizhzhia nuclear plant, the largest nuclear power plant in Ukraine and Europe, was next in line to be attacked. On March 3, drone footage showed local residents attempting to block Russian troops from entering the plant. They had barricaded the main road to the facility with trucks, cars, tires and sandbags.[12] They knew that any disaster there would dwarf the one at Chernobyl. That night, Russian troops shelled the plant, setting off a fire in one location.[13] Indeed, Ukraine's fifteen active nuclear power plants were not built to withstand a full military invasion. Some may survive aircraft crashes, but probably not missile or artillery attacks. An invading army, in control of these reactors, could increase the threat of nuclear terror.[14] Tampering with these plants could be, in the words of one U.S. military analyst, like having "nuclear

(Continued on page 9)

To Kill or Let Die

An excerpt from an article on the Covid pandemic by Webb Keane, Member (1997–98 & 2019–20), School of Social Science



From **Pandemic Exposures: Economy and Society in the Time of Coronavirus,** *edited by Didier Fassin and Marion Fourcade, published by Hau Books (2022).*

In much of the world, the COVID pandemic brought into sharp relief some fundamental and long-standing tensions among democratic governance, economic reasoning, scientific authority, and moral intuitions. These tensions are especially strong in the United States, given the peculiar coexistence of free market fundamentalism, patriotic communitarianism, libertarianism, social conservatism, positivism, and religiosity so distinctive of this country. The pandemic forced choices whose public expression—which ranged from folksy common sense to austere utilitarian logic—took increasingly stark and dichotomized forms. Eventually even the simple wearing of a protective mask became a simple either/or political statement. The debates over lockdowns, vaccines, and other measures centered on how we weigh lives against economic well-being. They expressed something fundamental about the way Americans think about economics, the public good, and the legitimacy and powers of social agency. Because of the way these arguments tended to portray the responses in sharply dichotomous terms, they often bore a strong resemblance to the so-called "Trolley Problem" in moral philosophy.

The trolley problem is a thought experiment originally developed by moral philosophers to clarify their intuitions about agency and responsibility (Foot 1967; Thompson 1976, 1985). Although highly artificial, the trolley problem mimics the dilemmas of medical triage and military situations in which stark choices must be made between clear alternatives, either one of which will inevitably result in harm to someone. In its basic form, it asks you to imagine that you see an out-of-control trolley hurtling toward five people. There is no time to warn them and no way to stop the trolley. The puzzle emerges from the two scenarios that follow. In one, you could pull a switch that diverts the trolley onto another track that has only one person on it. In the other, you could push a man in front of the trolley, whose weight is sufficient to bring it to a stop. The objective outcome is the same in both cases: one life lost in order to save five. The utilitarian calculus that follows seems indisputable: you should pull the switch or push the man. Yet most people who would accept the first option recoil at the second. How do these actions differ?

The debates around this have been unending and intricate. One theme running through them is known as the Doctrine of Double Effect. This doctrine, which dates back to Thomas Aquinas, turns on a distinction between the intended results of an action, on the one hand, and the unintended but foreseeable consequences of an action, on the other. The doctrine holds that whereas it is immoral to kill (the result of pushing someone), it is morally permissible to let die (the foreseeable but unintended consequence of diverting the trolley to the track with one person). Put in other terms, by pushing the man, you use a person as the means to an end, the saving of five lives. In the Western tradition within which this debate takes place, moral philosophers tend to agree that humans should not be treated instrumentally (this is why a doctor should not kill one patient in order to distribute her organs to save numerous other patents). Unlike pushing the man, in diverting the trolley, one person's death is merely collateral damage, ancillary to the means by which lives are saved. Put another way, were there no man on the other track, diverting the trolley would still save five lives. In the case of pushing, by contrast, someone must die: the body of one man is necessary for stopping the trolley.

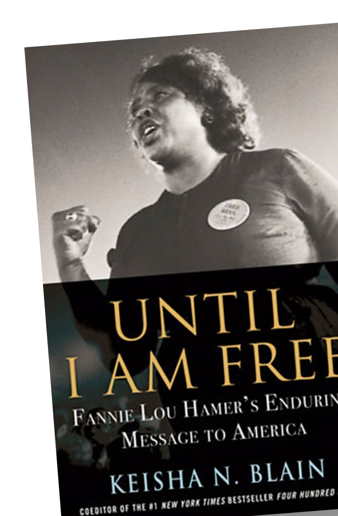
Most anthropologists are likely to say that thought experiments like this vastly oversimplify a complex world, as well as smuggling in ethnocentric assumptions about autonomous decision-making, anonymity, calculation, and so forth. But even if we were to accept the value of thought experiments for purposes of conceptual clarification, applying them to real life still faces the challenge of finding the right analogies. It seems that the Doctrine of Double Effect can play out in opposite directions, depending on how you see the analogy. For [some], the economy is the man we are pushing in front the trolley in order to save the granddads down the track. You are killing the economy. Conversely, for [others], we risk pushing granddad in order to save the economy. You are killing granddad. What are the respective moral alternatives they favor? [Some] would let granddad die (or at least risk dying) in order to save the economy. [Others] would let the economy die (or at least suffer harm) in order to save granddad.

THE DEBATES OVER LOCKDOWNS, VACCINES, AND OTHER MEASURES CENTERED ON HOW WE WEIGH LIVES AGAINST ECONOMIC WELL-BEING.

It is well known that Americans respond far more easily to rare forms of harm suffered by individuals than to commonplace ones known only through statistics. Heroic efforts to save Thai Boy Scouts trapped in a cave (an incident that captured worldwide attention in 2018; see Beech, Paddock, and Suhartono 2018) or children with rare diseases seem to require no calculation of expense—unlike the public response to car crashes or diabetes. Probabilistic deaths are harder to grasp in terms of personal tragedy and heroic interventions (and of course it is harder to see one's own contribution to large scale effects such as climate change).

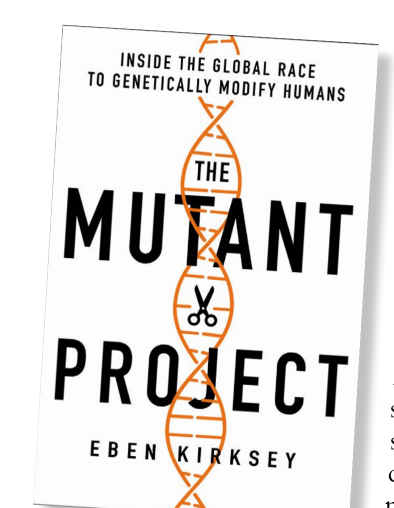
This may be why, in terms of the Doctrine of Double Effect, they are easier to think of as merely "letting die" rather than "killing." In other words, the relative acceptability of common disease deaths across a population over individual misfortunes may be due to the sense that they are the result of merely letting events take their course (death that just happens to result when I divert the trolley car) rather than purposely undertaking an action (pushing the man onto the tracks).

Some have claimed this is a universal cognitive bias. Whether or not this is the case, the bias is surely amplified and reinforced by the American ideology of individual autonomy. ■



Until I Am Free
Keisha N. Blain

Until I am Free: Fannie Lou Hamer's Enduring Message to America (Beacon Press, 2021) highlights Fannie Lou Hamer, a galvanizing figure in the work and achievements of the Student Non-violent Coordinating Committee (SNCC) and the civil rights movement. Historian Keisha N. Blain, Member (2021–22) in the School of Social Science, centers Hamer's ideas and political philosophies—as well as her unwavering commitment to group-centered leadership and her unapologetic expression of her own lived experiences—to demonstrate how to speak to our current racial climate.



The Mutant Project
Eben Kirksey

The Mutant Project: Inside the Global Race to Genetically Modify Humans (St. Martin's Press, 2020), an ethnography from cultural anthropologist Eben Kirksey, Member (2019–20) in the School of Social Science, follows CRISPR technology around the globe to create a "mosaic portrait" of the people and concerns on all sides of the power dynamics emerging with CRISPR technology. As the text hops between a variety of people with stakes in the new world of gene editing—from scientists, lobbyists, and businessmen, to patients, doctors, and activists—Kirksey examines the present and future of genetic engineering, and its implications.

Albers-Schönberg Professorship in the History of Science Established at IAS

The Institute for Advanced Study is pleased to announce the establishment of the Albers-Schönberg Professorship in the History of Science in the School of Historical Studies.

"The Albers-Schönberg name is illustrious in the history of science, with important contributions across three generations of scholars and researchers. It is an honor to have it now permanently connected to the Institute. And it is for me a joy and a privilege, in one of my first announcements as IAS Director, to express the Institute's gratitude for this visionary gift," remarked David Nirenberg, IAS Director and Leon Levy Professor.

Heinrich Albers-Schönberg (1865–1921), a physician and one of the earliest radiologists, helped revolutionize X-ray technology. His son, Ernst Albers-Schönberg (1897–1980), developed memory elements out of ceramics for early computers, filing his first patent in 1951, a critical development for the computer industry. Georg Albers-Schönberg received a Ph.D. in chemistry from the University of Zurich and did his post-doctoral work at the Massachusetts Institute of Technology before joining Merck & Co. His late wife, Joyce Kovatch Albers-Schönberg (1943–2018), was a biochemist and later earned distinction as a financial analyst in the healthcare sector. Georg's mother, Elisabeth Albers-Schönberg (1903–2000), was instrumental in fostering an environment that nurtured science and enriched the family through her love of the humanities, especially art history and classical philosophy.

Robbert Dijkgraaf, former IAS Director, remarked "I don't think there can be a better home than the Institute for this professorship."

The history of science has been a field of research at the Institute since the early '50s with the active support of J. Robert Oppenheimer, then Director of the Institute, who saw it as a bridge between the humanities and natural sciences. The appointment in 1950 of Otto Neugebauer, a historian of Egyptian and Babylonian mathematics and astrology, was followed in 1964 by Marshall Clagett, a specialist of medieval science, and in 1998 by Heinrich von Staden, a classicist and historian of science with a particular focus on ancient Greek medicine.

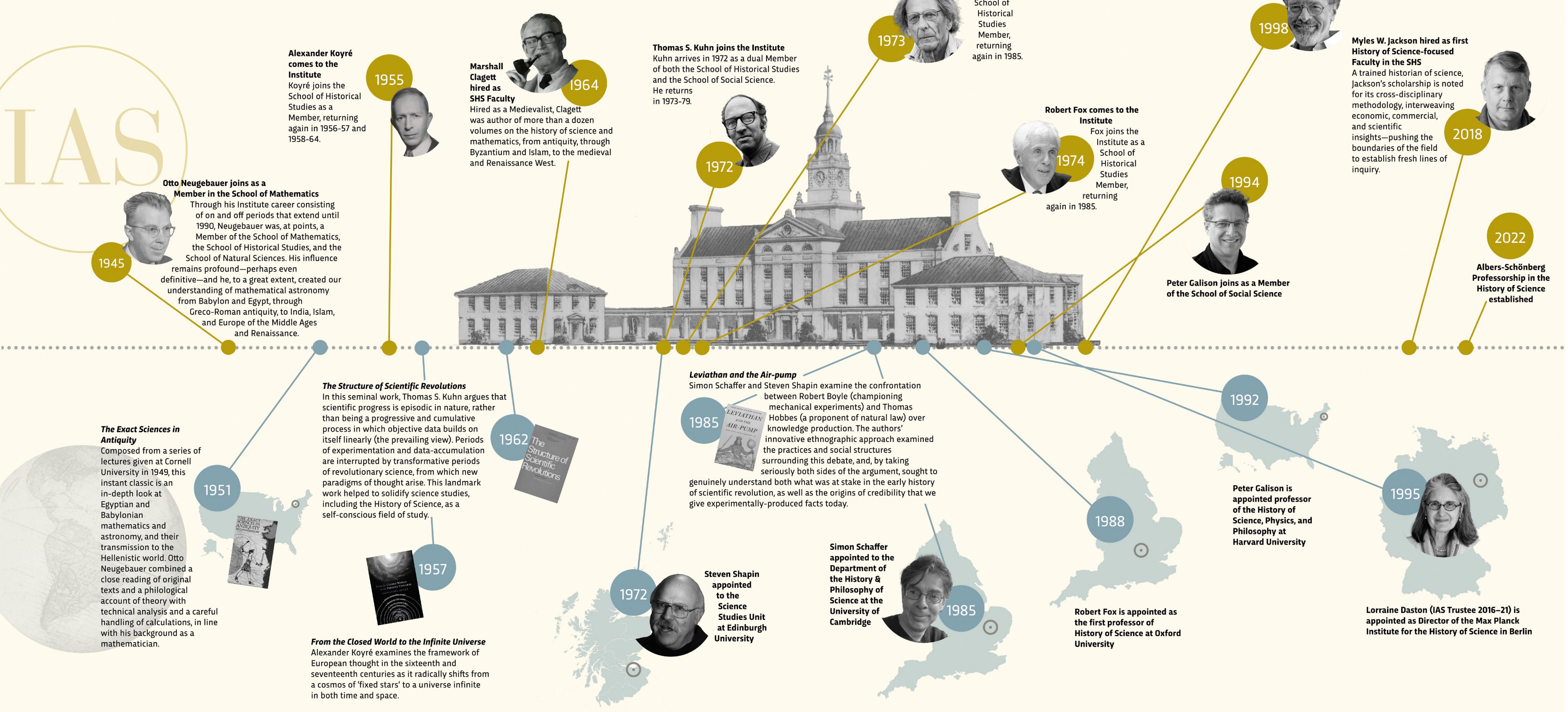
"Thanks to Georg's generosity, the history of science will continue to be an important area of research and mentoring at the Institute for Advanced Study long after I have shuffled off this mortal coil," said Myles W. Jackson, who will hold the inaugural professorship. "His gift will benefit both the IAS and the discipline of the history of science, which will continue to serve as the link between all the IAS Schools. It will also help ensure that Princeton remains a major center for the history of science given my superb colleagues in the field at the university."

Jackson was appointed to the IAS Faculty in 2018 and explores the intersections between science, technology, aesthetics, and history. His work is noted for its cross-disciplinary methodology and range of study—from the artisanal production of scientific knowledge in nineteenth-century Germany to issues of intellectual property, knowledge sharing, ethical regulation, and bioengineering to the collaborations between natural scientists, engineers, and musicians on creating new forms of aesthetics.

"I join those who are profoundly grateful to Georg Albers-Schönberg for his magnanimous and timely gift," stated Heinrich von Staden, Professor Emeritus in the School of Historical Studies. "Myles Jackson's superb, groundbreaking scholarship as well as his exceptional gift for nurturing the research of other scholars, young and old, at the Institute promises to render him an outstanding holder of the Albers-Schönberg Professorship in the History of Science." ■

The History of the History of Science

The history of science is a discipline that studies science as a body of knowledge by examining its foundations, assumptions, methodologies, communicabilities, practices, and implications. Although works detailing the history of one or another branch of science have been published since antiquity, the discipline—distinct from such works and characterized by a program of training—coalesced in the twentieth century. Globally, the history of science intersects with other disciplines interested in scientific knowledge, including sociology, anthropology, and philosophy. While its methodologies are richly diverse, the discipline shares a commitment to understanding the historical development of the natural sciences, medicine, technology, and mathematics.



ANNA LAQUA. PHOTO CREDITS: BROWN IMAGE LIBRARY; HERMAN LANDSHOFF; SAGE ROSS; VAN URFALIAN; CONRAD ERB; PAFIJO; PAUL HOROWITZ; STIJN DEBROUWERE; CLIFF MOORE; ANDREA KANE. IMAGE SOURCES: SHELBY WHITE AND LEON LEVY ARCHIVE CENTER; FROM THE CLOSED WORLD TO THE INFINITE UNIVERSE.

UKRAINE *(Continued from page 6)*

war without bombs."[15] All this could create uninhabitable zones throughout Ukraine and force the country's population back into dangerous decontamination work.

The children and grandchildren of the bio-robots in Ukraine know exactly how hard the war against invisible radiation was and how pivotal the war against authoritarianism is today. During the 2013–14 Revolution of Dignity, a turning point in the consolidation of a Ukrainian civic-based citizenship,[16] Ukrainian women held torso-sized mirrors up to a wall of armed riot police. Thousands of protesters from all regions of the country occupied Kyiv's Independence Square. They formed a half-mile-long barricade around it to safeguard a fragile democracy and its civic institutions. Holding their mirror-shields up to Soviet legacies of corruption and violent repression, the women, together with the protesters, overthrew an autocratic puppet who found refuge in Putin's military dictatorship. "If Ukraine's democracy survives, it will crush the arguments of tyrants who describe democracies as weak, incapable, chaotic," writes journalist Nataliya Gumenyuk.[17] In its mirror-shields, war is chaos. But it is also where so many live: on the front lines, where the right to a future must be defended. ■

This is an opinion and analysis article, and the views expressed by the author are not necessarily those of the Institute.

Adriana Petryna is Professor and Director of the MD-PhD program in Anthropology at the University of Pennsylvania. She is a former Member (2003–04) and Visitor (2006) in the School of Social Science and recent Guggenheim fellow. Her most recent book is Horizon Work: At the Edges of Knowledge in an Age of Runaway Climate Change *with Princeton University Press (2022).*

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BLACK HOLE *(Continued from page 1)*

by the powerful gravity of the black hole, which is four million times more massive than our Sun.

"We were stunned by how well the size of the ring agreed with predictions from Einstein's Theory of General Relativity," said EHT Project Scientist Geoffrey Bower from the Institute of Astronomy and Astrophysics, Academia Sinica, Taipei. "These unprecedented observations have greatly improved our understanding of what happens at the very centre of our galaxy, and offer new insights on how these giant black holes interact with their surroundings." The EHT team's results were published in a special issue of *The Astrophysical Journal Letters*.

Because the black hole is about 27,000 light-years away from Earth, it appears to us to have about the same size in the sky as a donut on the Moon. To image it, the team created the powerful EHT, which linked together eight existing radio observatories across the planet to form a single "Earth-sized" virtual telescope. The EHT observed Sgr A* on multiple nights, collecting data for many hours in a row, similar to using a long exposure time on a camera.

The breakthrough follows the EHT collaboration's 2019 release of the first image of a black hole, called M87*, at the center of the more distant Messier 87 galaxy.

The two black holes look remarkably similar, even though our galaxy's black hole is more than a thousand times smaller and less massive than M87*. "We have two completely different types of galaxies and two very different black hole masses, but close to the edge of these black holes they look amazingly similar," says Sera Markoff, Co-Chair of the EHT Science Council and a professor of theoretical astrophysics at the University of Amsterdam, the Netherlands. "This tells us that General Relativity governs these objects up close, and any differences we see further away must be due to differences in the material that surrounds the black holes."

This achievement was considerably more difficult than for M87*, even though Sgr A* is much closer to us. EHT scientist Chi-kwan ('CK') Chan, from Steward Observatory and Department of Astronomy and the Data Science Institute of the University of Arizona, U.S., explains, "The gas in the vicinity of the black holes moves at the same speed—nearly as fast as light—around both Sgr A* and M87*. But where gas takes days to weeks to orbit the larger M87*, in the much smaller Sgr A* it completes an orbit in mere minutes. This means the brightness and pattern of the gas around Sgr A* was changing rapidly as the EHT Collaboration was observing it—a bit like trying to take a clear picture of a puppy quickly chasing its tail."

The researchers had to develop sophisticated new tools that accounted for the gas movement around Sgr A*. While M87* was an easier, steadier target, with nearly all images looking the same, that was not the case for Sgr A*. The image of the Sgr A* black hole is an average of the different images the team extracted, finally revealing the giant lurking at the center of our galaxy for the first time.

The effort was made possible through the ingenuity of more than 300 researchers from 80 institutes around the world that together make up the EHT Collaboration. In addition to developing complex tools to overcome the challenges of imaging Sgr A*, the team worked rigorously for five years, using supercomputers to combine and analyze their data, all while compiling an unprecedented library of simulated black holes to compare with the observations.

Lia Medeiros is a co-lead of the EHT Gravitational Physics Working Group, a member of the EHT's junior Scientist Council, and an NSF Astronomy and Astrophysics Postdoctoral Fellow at the Institute for Advanced Study. She co-coordinated one of six collaboration papers (Paper VI), presenting the 2022 Sgr A* results. Her work involves developing simulations of accreting black holes and devising novel algorithms to interpret EHT data and to constrain deviations from General Relativity.

George N. Wong, Member in the School of Natural Sciences and Associate Research Scholar at Princeton University, was also part of the EHT research team, providing expertise in numerical methods and high-energy accretion astrophysics. He primarily works in the theory group, studying model uncertainties and producing a physical interpretation of the data.

Scientists are particularly excited to finally have images of two black holes of very different sizes, which offers the opportunity to understand how they compare and contrast. They have also begun to use the new data to test theories and models of how gas behaves around supermassive black holes. This process is not yet fully understood but is thought to play a key role in shaping the formation and evolution of galaxies.

"Now we can study the differences between these two supermassive black holes to gain valuable new clues about how this important process works," said EHT scientist Keiichi Asada from the Institute of Astronomy and Astrophysics, Academia Sinica, Taipei. "We have images for two black holes—one at the large end and one at the small end of supermassive black holes in the Universe—so we can go a lot further in testing how gravity behaves in these extreme environments than ever before."

Progress on the EHT continues: a major observation campaign in March 2022 included more telescopes than ever before. The ongoing expansion of the EHT network and significant technological upgrades will allow scientists to share even more impressive images as well as movies of black holes in the near future.

"What is so special about these new results is that we have a collaboration paper dedicated solely to testing the predictions of General Relativity," remarked Medeiros. "We perform extensive and comprehensive calibration with hundreds of thousands of simulations, explore whether this object has an event horizon, use the new bounds on the size of the black hole shadow to constrain alternatives to General Relativity, and compare our results with other tests of gravity. Astoundingly, our findings corroborate predictions made more than 100 years ago."

"As a theorist, it's incredibly exciting that we now have real, high-resolution observations of accretion in the extreme environments near multiple supermassive black holes," Wong noted. "Our results inform new, particularly interesting constraints on the astrophysical models, which I anticipate will drive a surge of theoretical work and predictions for the next generation of observation." ■

What is the Black Hole Shadow?

The black hole shadow is unlike any shadow encountered in everyday life. Here's why:

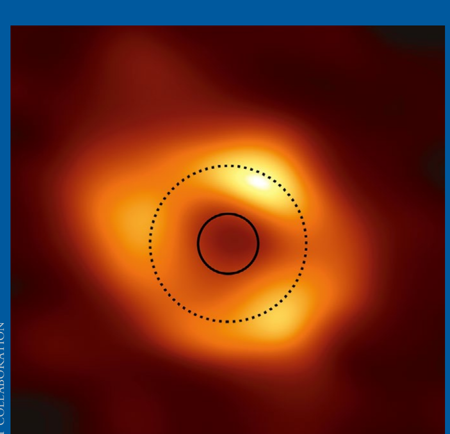
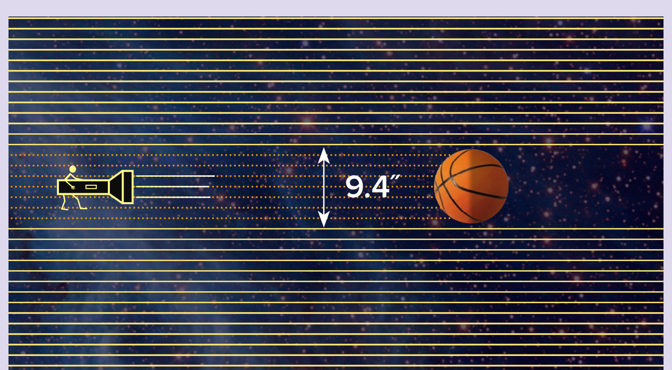
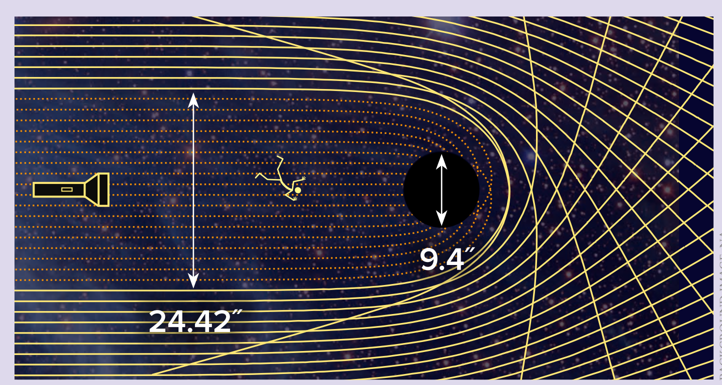


Image of Galactic Center black hole, Sagittarius A*. The dashed circle denotes the size of the black hole shadow while the solid circle shows the size of the event horizon.

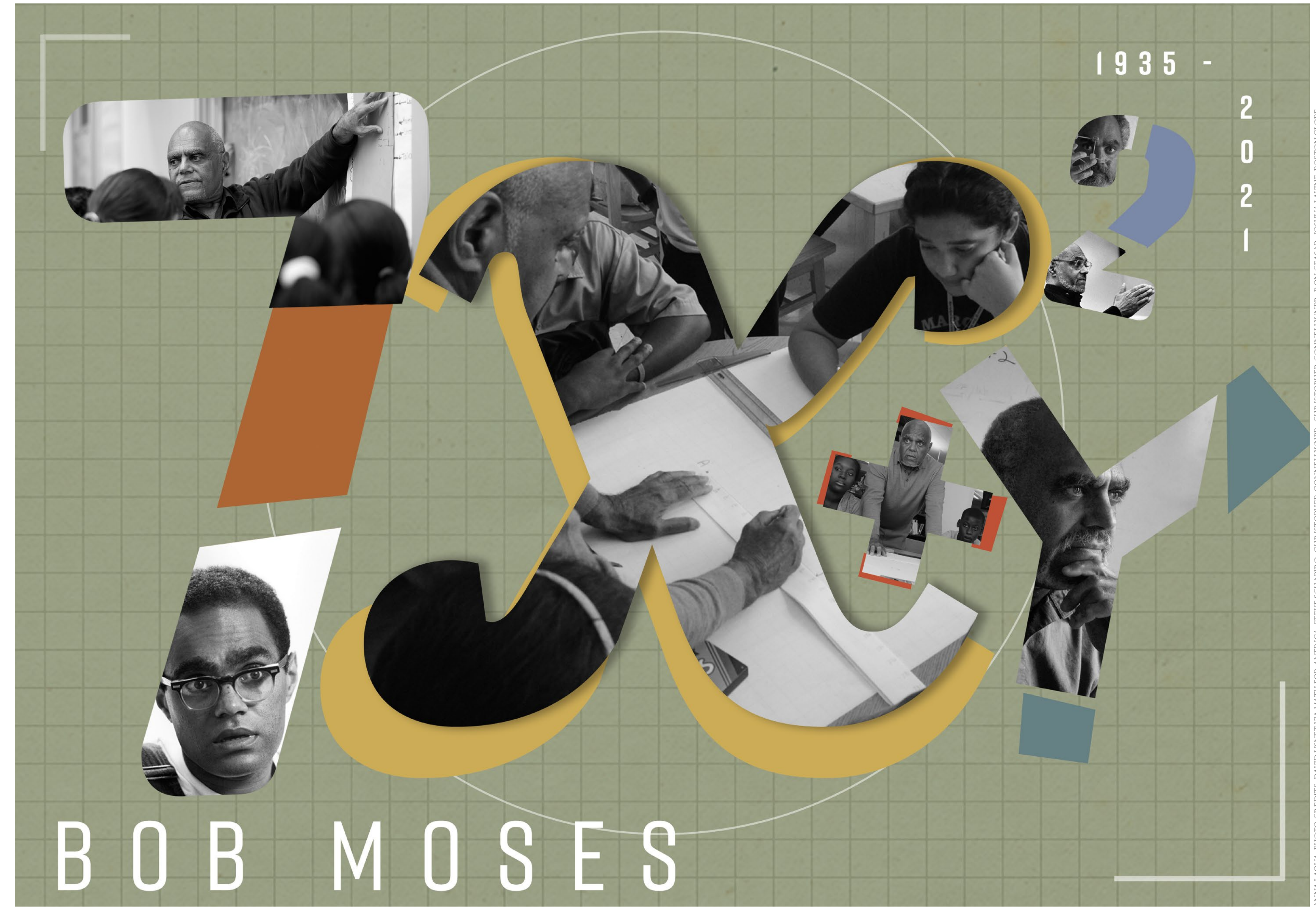




Picture a basketball illuminated by a very distant, large flashlight. The trajectory of all light rays from this idealized flashlight are parallel. Therefore, only the light rays that are directed straight at the basketball (dotted rays) are blocked, casting a circular shadow (approximately 9.4 inches in diameter) as one would expect.

Now imagine shining the same flashlight at a black hole. Unlike the basketball, the black hole noticeably warps spacetime in accordance with Einstein's theory of general relativity, causing light rays to follow curved paths. The result is that more light rays—even those not directed straight at the event horizon—will fall into the black hole (dotted rays). This expanded region of light, which disappears into the black hole, is used by scientists to define the black hole shadow. For comparison, if the event horizon—the region from which no light rays can escape—was the same size as the original basketball, the black hole shadow would be approximately 2.6 times larger, or 24.42 inches in diameter.

Researchers are now able to use the size and shape of the black hole shadow to test whether the geometry of the black hole is consistent with the predictions of general relativity. This was one of the major questions investigated by the EHT Collaboration in a paper co-led by Natural Sciences Member Lia Medeiros and announced on May 12, 2022.



Bob Moses's Legacy

Organizing Innovative Change in Education

BY GENEVIEVE LOOBY

When Karen Uhlenbeck was a MacArthur fellow, between 1983–88, she went on a series of incredible adventures visiting other MacArthur fellows and learning about their projects. "This was actually one of the high points of my life," Uhlenbeck said to me, laughing. She recalls whale watching in Hawaii with Roger Payne, a trip to the Amazon to see Philip DeVries's work with butterflies, studying lemurs in Madagascar with Pat Wright, and a Montana dinosaur dig with Jack Horner. Amidst these escapades, Uhlenbeck and her cohort also visited Jackson, Mississippi to see Bob Moses's work with the Algebra Project, a program taking a community organizing approach to innovation in education. "It was just a very impressive experience to see how he was organizing this," Uhlenbeck states, adding that "it was an extremely important thing to do."

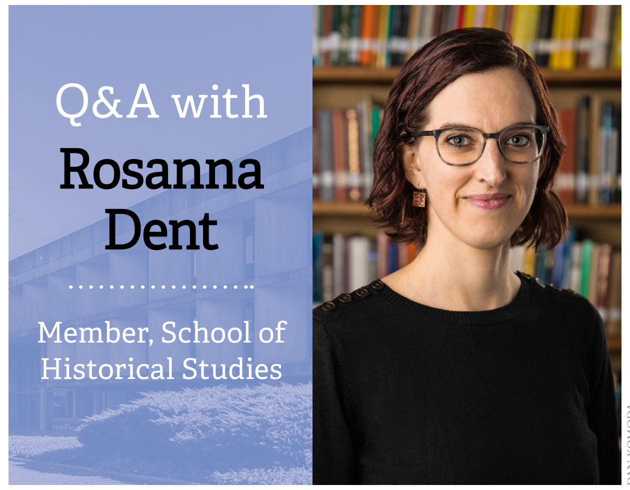
Bob Moses was born in 1935 in Harlem, where he was raised. He studied philosophy at Hamilton College and then at Harvard University, where he received his master's degree in 1957 (and where he eventually worked on his doctorate in the Philosophy of Mathematics). He spent a few years teaching middle school math at a private school in the Bronx, but was compelled by the 1960 Greensboro, North Carolina sit-in to spend his summer that year in Atlanta, working at the Southern Christian Leadership Conference (SCLC) headquarters, which was also home to the newly-formed Student Nonviolent Coordinating Committee (SNCC). He returned to the Bronx to fulfill his teaching commitment, but in 1961, he again joined SNCC—this time, in McComb, Mississippi—where he remained for the next four years working to organize a grassroots effort around voter registration.

It was this experience—organizing a movement from the ground up—that would help shape the efforts of the Algebra Project. SNCC's focus on voter registration stemmed from a consensus that this issue was crucial and urgent. Because of this consensus, they were successfully able to organize their efforts and attract resources and volunteers from around the country. Furthermore, this agreement empowered the target population to make demands for itself, an essential aspect, Moses believed, to creating sustainable change. Another significant impact this experience had on Moses was in showing him the crucial connection between young people and adults. When the younger generation got involved in SNCC's work, eventually the community's adults—who may have been more reluctant to get involved—were brought along. Such intergenerational relationships were essential to building and sustaining the movement in Mississippi, according to Moses. These values of consensus and community similarly appear in Moses's Algebra Project.

The seed of the work that would become the Algebra Project was planted when, in 1982, Moses learned that his daughter's school—she was then entering eighth grade at Dr. Martin Luther King, Jr. School in Cambridge, Massachusetts—did not offer algebra for eighth graders. While she was prepared to take algebra, she would have to wait until high school to start that course. Moses was surprised, as learning algebra in middle school was a necessary step for his daughter and her classmates to be able to take honors-level math and science courses in high school. In the end, Moses took on teaching algebra to his daughter, Maisha, and three of her classmates. Fortunately, that same year, he was granted a MacArthur fellowship in light of his civil rights work, affording him the time to take on this work (and continue the project as it grew through the years). Although he was working on his doctorate, Moses was starting to see this as his essential work.

As Moses taught that first group of students in 1982, he looked around the school, noticed that the math courses tended to be skewed across racial and class lines, and began to think about who takes math and what kinds of math they take. Moses considered it an old problem that traditional math courses operate as tools to single out potential mathematicians

(Continued on page 13)



DAN KOMODA

Rosanna Dent is a historian of science, a Member in the School of Historical Studies and an Assistant Professor of Federated History at the New Jersey Institute of Technology. She pursues research at the intersection of medicine, Latin American history, Native studies, and feminist science/technology studies.

Her work focuses on the politics and effects of research relationships. Her current book project, "Studying Indigenous Brazil: Moral Economies of Research in A'uwẽ-Xavante Territory," combines historical, ethnographic, and community-based methods to explore the human sciences and their afterlives in Indigenous communities.

This Q&A has been edited for length and clarity.

How do you describe your work to friends and family?

I study iterative processes of research in Indigenous communities that are highly studied. This is the case in many communities in colonial, post-colonial, or settler colonial contexts. Specifically, I collaborate with a group of A'uwẽ (Xavante) communities in Central Brazil that have been hosting researchers for the past sixty years. They have hosted all kinds of scholars: anthropologists, geneticists, public health researchers, and others. I am working to understand how they, as research subjects, experience, influence, and make political use of science, and how they have influenced scientific disciplines in the process. We're building a digital archive together so community members can access the materials that have been created about them by outsiders and annotate and use the materials as they wish.

What question(s) within your field do you most want to answer and why?

I am most interested in how histories and historians of science can contribute to a more just present and future. Some of the questions that animate my work are: How can historians work with and be accountable to communities that have suffered harm from scholarship in the past? How can understanding human subjects' experience of research help us envision anticolonial knowledge making across the disciplines?

Who or what has had an outsized influence on you in your academic career? And what is one of your most memorable moments as an academic?

I'll answer these questions together. Early in my first stay in the A'uwẽ (Xavante) community of Pimentel Barbosa in 2015, I was questioning whether I should be there. I wasn't sure whether the nascent community archive project I was working on was something that really interested my hosts. It had taken me a long time to decide that I should reach out to community members, and that the benefits of the work could be worth the potential damage of unequal power dynamics, but I still had my doubts.

One evening in a crisis of confidence, I went to visit Sidówi Wai'azase Xavante, an Elder and leader who had spoken on behalf of the project several times. Sidówi and his wife Angelica took me into their home, talked with me, encouraged me, and even comforted me. I'll never know exactly what Sidówi did, but after that, things suddenly started to move with the project. One of his sons and a nephew showed up each morning to start teaching me A'uwẽ language skills. Elders came to look at historical documentation. People showed up for community meetings about the archive.

Though I'd been interested in the labor of community members related to hosting research, this moment really crystalized for me how much work it is to engage with us and look after us. It focused my attention on the affective dynamics of this research: the way that Sidówi and Angelica practiced care for me, without knowing if I would understand or follow through on my obligations within the relationship. Sidówi joined the ancestors in 2017, but his memory and his certainty that gaining access to historical documentation would be important for his community continues to motivate my work.

Why IAS?

It's hard to imagine a better place to do this work. For me, thinking is a social act. Since I want my book to speak to a wide and interdisciplinary audience, revising and refining my arguments while sharing space with social scientists, natural scientists, and historians will be priceless. ■


GIANNI DAGLI ORTI/SHUTTERSTOCK

Ancient Jury Duty Comes to Life at IAS

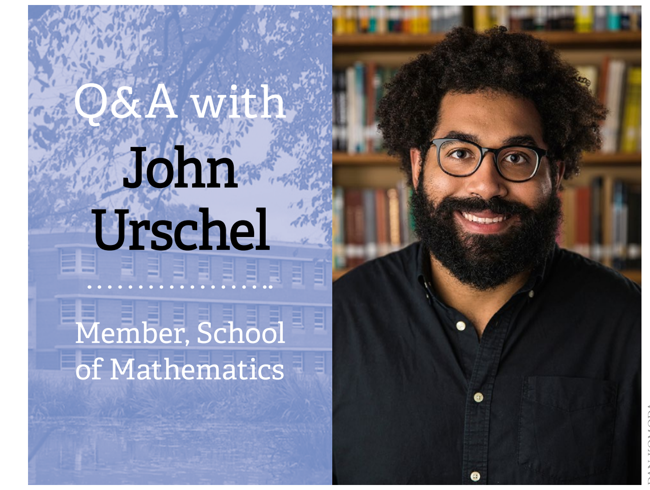
BY ABBEY ELLIS

Pinakia, here shown as casts made of Plaster of Paris, were small bronze plates used in ancient Athens for the process of democratically selecting a group of citizens to serve on a jury. Athenian citizens would nominate themselves for jury duty, volunteering their bronze plates to be inserted into a kleroterion (a machine with rows of slots and a built-in lottery system).

Athenians' willingness to participate might surprise a modern reader, but jury duty was highly sought-after in ancient Athens. The role offered guaranteed pay and did not require physical strength—conditions which may have led to the development of a class of professional jurors, if we take seriously the caricatures in comic plays such as Aristophanes' *Wasps*.

These pinakia were recently discovered in the storage cupboards of the Institute's epigraphic library. While the making of casts such as these has historically been common place in archeological practice, the precise role of these casts in archeological studies at IAS is unclear.


MARIA O'LEARY



DAN KOMODA

John Urschel, Member in the School of Mathematics, is an applied mathematician/theoretical computer scientist as well as a former professional football player, who spent three seasons with the Baltimore Ravens. Urschel retired from the NFL in 2017, and went on to complete his Ph.D. at the Massachusetts Institute of Technology (MIT) in 2021.

His interests include linear algebra, numerical analysis, and graph theory, with research topics ranging from eigenvalue algorithms and spectral graph theory to determinantal point processes.

This Q&A has been edited for length and clarity.

How do you describe your work to friends and family?

I often tell my non-scientific friends and family that I work with arrays/spreadsheets of numbers and study interesting properties about them. When I'm talking to scientists (or someone who's studied matrices), I talk about methods for solving linear systems and eigenvalue problems, and theoretical questions involving graphs and matrices.

What question(s) within your field do you most want to answer and why?

This is a tough question to answer. I find that I'm happiest when I'm working on problems that are fundamentally interesting and exciting to me, independent of application or perceived prestige. I'm not sure this is the best approach, but it's definitely the most fulfilling one for me. I have a couple of questions, mostly related to things I studied during my Ph.D., that I want to answer. There's a few theoretical questions involving eigenvalues of matrices that I want to pin down, and I'm also looking into some deep questions involving Gaussian elimination (a very old and very popular method for solving a linear system). I feel like it's important to take the things you've learned and done, and always try to improve on them. With that said, I'm looking forward to learning about new things while I'm here and also working on some problems I wouldn't have otherwise thought about.

Who or what has had an outsized influence on you in your academic career?

I think my experiences with math have been unique in some way. My first experience with higher level math was when I was a little kid running around in Chapters (a Canadian bookstore), reading random books while my father was doing work in the cafe. I picked up a book on Algebra I, and was fascinated by the concept of letters as numbers and solving pairs of linear equations in two variables. Looking back, I think the method by which I learned math had a huge impact on my career. I learned almost everything I knew about math as a kid from books. This persisted almost all the way through college, and it led to an opinion of mathematics that was much different from some of my friends. My ability to learn math or my experience in math wasn't at all shaped by class lecture or fellow students; I did all my problem sets alone and didn't spend much time with other math majors. In many ways, that made my experience with math much purer and more personal. Of course, since then, I've learned the importance of learning from not just what others write, but what they say in lecture and talks, and also the importance of collaboration. Still, I think my personal, solitary experiences with math earlier on had a lot of benefits. I never doubted myself or my ability to do math, and I never got discouraged or questioned my place in the mathematics community. I can't say these things never happen to me now, but I'm in a much more mature place to deal with these doubts.

What is one of your most memorable moments as an academic?

I think getting my Ph.D. in math from MIT has to be at the top of the list. When I was an undergraduate at Penn State, I switched from engineering to a math major because I loved my math classes so much more. At the time, I didn't know what I could do with math, or what I should aspire towards. But the more time I spent in math, the more I realized just how much I loved the subject, and that I wanted to be a researcher. Being a Ph.D. student at MIT was a dream come true. It was a great environment, full of so many brilliant people who just love math. My five years there were some of the best times of my life. With that said, I'm really looking forward to being at IAS this year and doing good work around some really great people.

Why IAS?

For me specifically, I think the prospect of working with Peter Sarnak was not something I was willing to pass up. He's a brilliant mathematician, we have a lot of shared interests, and I'm looking forward to having lots of interesting mathematical conversations with him.

In general, I think IAS is a great choice for any academic. I've only been here two weeks, and it's already clear to me how great of an environment there is here at the Institute. I live on the Institute grounds in a beautiful wooded area. I'm a one-minute walk from the preschool and the gym, a four-minute walk from my office, and a six minute walk from the cafeteria. Everything here is close, convenient, and set up so that everyone who comes here can focus on what they do best, without worrying about other things. I can already tell this is going to be a very productive year for me.

How might the reopening of campus (and society at large) influence you and your work?

I'm not sure. I'm not sure how much I'll travel (academically) once society fully reopens. If anything, I think I've learned that I'm capable of meaningful and interesting collaboration even when working remotely. And I've enjoyed the extra time that being at home has given me with my daughter.

How can we make academia more inclusive?

I don't have a great answer to this question, but I find myself thinking a lot about my personal role in this. I try to do my best to make sure that when I teach, I'm serving all my students and ensuring that their academic needs are being met. I've found that in mentorship, I'm disproportionately paired with/contacted by students from underrepresented groups, which I guess isn't so surprising. What I've noticed is that the biggest issues students can face isn't a lack of preparation or ability, but a lack of confidence or sense of belonging. I think if each of us constantly asked the question, "What can I do to make all of the people around me (students/mentees/colleagues) feel welcome and valued?", act on those things, and listen to feedback about ways we can do better, that's already a big step to making academia more inclusive.

What other activities or pastimes do you enjoy?

When I'm not doing math, I like doing a bunch of different things. I spend a lot of time playing with or teaching my daughter. I used to play professional football, and I still like playing sports and exercising, time permitting. I also like playing chess, though I'm a complete amateur. ■

MOSES *(Continued from page 11)*

and steer them towards university math programs—creating a priesthood of arcane math secrets only accessible by some God-given talent or magic—rather than creating literacy in the subject. Worse, math illiteracy was acceptable, and even expected, the way that illiteracy in reading and writing was not.

Moses realized these conditions were even more insidious in the modern world which placed a premium on math and science knowledge. Without developing an intuition around math and the skills for doing it, people would not be able to take advantage of new technologies and economic opportunities. Moses found this to be the most urgent social issue affecting poor people and people of color, and this belief spurred the development of his work from teaching a few students algebra into the eventual creation of the Algebra Project. "That is what's driving the project. The Algebra Project is not simply transferring a body of knowledge to children. It is about using the knowledge as a tool to a much larger end," he wrote in his memoir *Radical Equations* (Beacon Press, 2001). And like his work on voter registration during the civil rights movement, Moses believed that this idea of "algebra for all" could gain consensus, engage whole communities, and create innovative systematic change, this time within education.

When Moses passed away in 2021, Uhlenbeck recalled her trip to Jackson and the impression Moses left on her. "He was a very impressive character," she recalls. "Very laid-back. Not at all over-powering. Not at all intimidating to the students and very good at getting people to work for him." This was indispensable: Moses's work was not meant to be undertaken by a small group of reformers, but was an effort that belonged to the community. "Bob Moses's idea was to get these things started and then to enlist people to help," reflects Uhlenbeck. As a way to honor his legacy, she established at IAS a fund in his name to support scholars from a variety of diverse backgrounds. "I thought, that's really the right name to put on it," she said, "because that's someone who's had this dream of access to education for minority students." When asked for any final thoughts, she replied, "I guess just to say that he's one of my heroes." ■

Meet Fernando Brancoli:

Fellow, Summer Program in Social Science

Fernando Brancoli is a social scientist studying far-right Brazilian politics. Currently, his research is interested in Bolsonarismo, a term used to describe the non-cohesive coalitions orbiting President Jair Bolsonaro, as both a domestic phenomenon and one with international connections. From collaboration with the Trump administration, to gestures toward the Holy Land and Israel, Brancoli tracks the way internal discourses become informed by external discourses, reinterpreted and reformed, in Brazilian far-right organizations and subjectivities.

The Summer Program in Social Science, funded by the Andrew W. Mellon Foundation and organized by James D. Wolfensohn Professor Didier Fassin, invites early-career scholars who are at an advanced stage of their research to join a two-year cycle of scholars from countries in Africa, the Middle East, and Latin America. Beginning with a two-week session in Princeton and followed by a week at a collaborating institution, the program aims to bring together different intellectual traditions, perspectives, and scientific disciplines to strengthen international networks among social scientists in the global South.

Brancoli, a member of the 2021–23 cohort, spoke to us about his research and his experience in the Summer Program from his home in Rio de Janeiro.

Institute Letter: How did you end up studying far-right politics in Brazil? Do you have any specific inspirations?

Fernando Brancoli: Well, I'm a journalist by undergraduate training. And I was doing a lot of international journalism back in the day. I was working in the Middle East, in Africa, and also in Palestine and Israel. And during this specific period, I was able to track how a lot of those I interviewed were integrating in Brazil. I was interviewing, for example, private security companies in Afghanistan that were then hired here in Rio de Janeiro. So, during my Ph.D. work, I was trying to understand how those specific security groups were circulating amidst the global South. And then when Bolsonaro was elected four years ago, I slowly started to track that those guys are now in the government. It was like, 'well, I actually interviewed you 20 months ago,' or 'I interviewed you three years ago,' and they're all getting key positions among the security positions in Brazil. I'm interested in how they create this discursive scenario which has a huge impact on how Brazil is now behaving internationally.

IL: Why switch from journalism to social science?

FB: I was missing, I think, a broader and deeper discussion. I mean, journalism, by nature, is a really quick and fast discussion. Journalists are supposed to be telling different stories every day, and I felt I was missing these, sort of, broad and important narratives.

IL: What unique perspectives do you think you bring as a Brazilian scholar?

FB: I think there is a huge discussion in Brazil right now, and among global South scholars, that we can actually produce theory. We can produce tools to understand the world, rather than just applying or reusing the methodological and epistemological discussions that people are doing in the global North. Like, in Brazil right now there's a huge discussion regarding anthropophagy; for decades, the concept of anthropophagy has been used in Brazil to characterize the epistemological process of combining various foreign ideas and native thoughts. It's coming back in the sense that we can engage different methodologies, different points of view from across the globe, and sort of mutate and digest it, and create something new.

IL: Has being at the Institute benefited your work?

FB: I think the whole structure of the Institute helps. We're having lunch and dinner together. We're having coffee together, as well. And then you have the Members joining us from time to time, coming over and commenting on our work. I mean, it's like a dream for academics, right? People are going there to do their research, but also to engage in this specific type of collaborative thought. I'm quite sure if we were staying at different hotels, we wouldn't be able to have this sort of engagement. It's this broad scenario that tries to connect people and gives you all the tools to do this.

IL: What's your favorite thing about where you're from?

FB: I would say this sort of kaleidoscope of different perspectives and ethnicities and religions and discussions and food. I think we are at our best when we are meshing everything together. I think that's the beauty of Brazil and also what is quite powerful about the country. ■

A gathering of Bolsonaro's daily supporters. President Bolsonaro highlighted Brazil's international allies and spoke on how the country is fighting globalism.

Read the full version of this interview at ias.edu/ideas

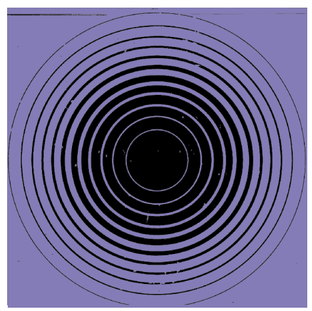
School of Mathematics as Members in 1948–49 assemble in front of Fuld Hall: Cheng Shu Wang Chang, Sheila Power (later Tinney), Sumi Yukawa (wife of Hideki Yukawa), Cécile Morette (later DeWitt-Morette), and Hideki Yukawa. Photographer unknown, circa 1948–49, from the Institute for Advanced Study.

The Shelby White and Leon Levy Archives Center engages in critical work to sustain and highlight the unique histories that distinguish the Institute for Advanced Study. With this work in mind, the Archives Center would like to shine a spotlight on former Member in the School of Mathematics Hideki Yukawa (1907–1981).

Former Institute Director J. Robert Oppenheimer invited Yukawa as part of a prestigious group of young physicists in 1948. The cohort included Cheng Shu Wang Chang, Sheila Power, Bruria Kaufman, George Uhlenbeck, and Cécile DeWitt-Morrette, as well as Freeman Dyson. Yukawa came to the United States to continue his work on the interactions of elementary particles with a particular focus on developments in meson theory. The work proved extraordinarily significant; upon leaving the Institute in 1949, Yukawa became the first Japanese scientist to win the Nobel Prize for this contribution to the field of physics. Yet, Yukawa's theoretical advances remain only part of the legacy of this former Member; his ties to the Institute also point to a less well known aspect of his history. Yukawa remains one of many scholars working at the forefront of science who provided early warnings of the ethical and moral dangers of atomic theory. In 1955, Yukawa signed the famous Einstein-Russell Manifesto linking himself to another important Institute figure. Like Albert Einstein, Yukawa's unique position as both a ground-breaking physicist and a citizen of a nation deeply impacted by atomic progress placed him (either by choice or force of circumstance) at the front of international dialogues about the nature of scientific progress in the 20th century.

However, following the tensions between the United States and Japan after World War II, many of these histories receded into the background of the political landscape. Today, Oppenheimer and Einstein headline films about the era, and yet there is more to be learned about the Institute's history at the frontier of scientific ethics.

With these legacies in mind, the Historical Studies-Social Science Library recently acquired *Hiroshima-Nagasaki: document 1961.* The book of photographs begins with a preface by Yukawa titled "Japan: The Japan Council against A & H Bombs, 1961." Yukawa's preface relays the complicated histories of atomic science from his own singular perspective. In remembering these histories, the Libraries and Archives hope to highlight the contributions of scientists of Asian identity whose work and perspective continues to enliven and enrich this community of scholars. — *Jenna Finan, Curatorial and Collection Development Intern at IAS*



Photographs from the HS-SS Library's recently acquired copy of Shomei Tomatsu and Ken Domon's *Hiroshima-Nagasaki: document 1961* with a preface by Hideki Yukawa published by The Japan Council against A & H Bombs, 1961.

IAS ON Instagram

instituteforadvancedstudy

PHOTOS BY DAN KOMODA

Tucked in a corner behind Bloomberg Hall lies *Slate Oasis* by sculptor Richard Long. Otherwise known on campus as the rock or slate garden, *Slate Oasis* was described, in Long's 2007 proposal, as "a plane with ripples." These ripples—of time and space, of sound and seasons—are enumerated in Long's accompanying poem:

From there and here to the New York Vermont border
To a blue-green/red rockface to the Tatko family
To water snakes to slate mud to the Cairngorm Mountains
To White Water Line to A Disappearing Number
To the Idiot Wind to a Chakra blanket
To Penn Station to stone to stone to choice to chance
To a unique diminishing resource to a change of plan
To sedimentary time to a map of reverie
To sweaty gloves to infinite variety
To the cawing of crows (Mind Rock) to parallel worlds
To Autumn leaves to then and now.

Slate Oasis is composed of over ten tons of slate, primarily red and irregular, taken from the New York–Vermont border. #InstituteArt

For more campus art, news, and snippets of daily life around IAS, follow us on Instagram @instituteforadvancedstudy.

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Please notify us of your change of address.
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or email mailings@ias.edu

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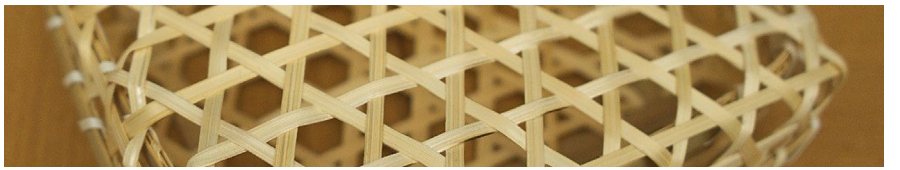

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