IAS | THE INSTITUTE LETTER

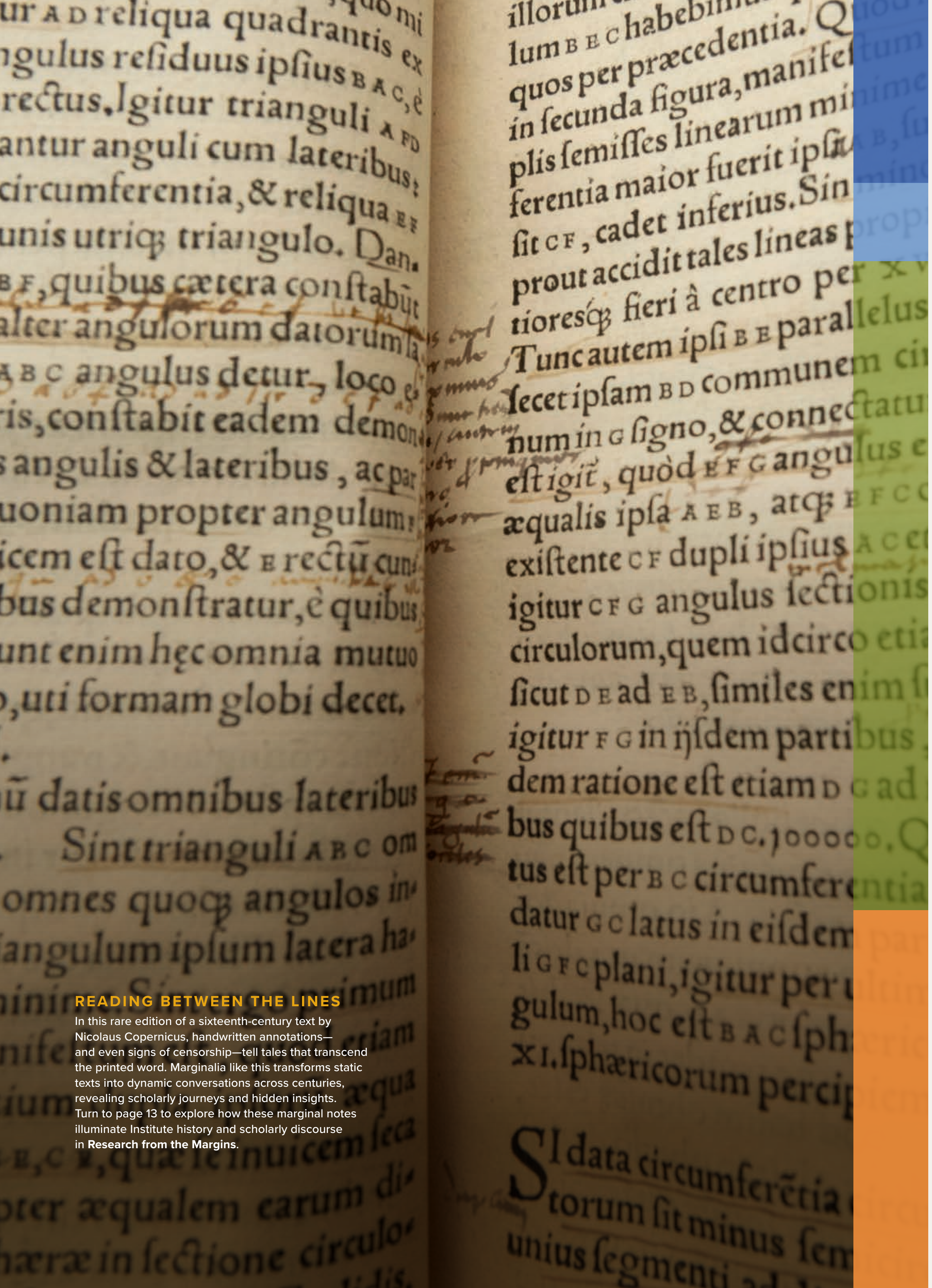
Spring 2025

Atomic Beagles

When Dogs Become Data

Research from the Margins

What is Dark Matter?



READING BETWEEN THE LINES

In this rare edition of a sixteenth-century text by Nicolaus Copernicus, handwritten annotations—and even signs of censorship—tell tales that transcend the printed word. Marginalia like this transforms static texts into dynamic conversations across centuries, revealing scholarly journeys and hidden insights. Turn to page 13 to explore how these marginal notes illuminate Institute history and scholarly discourse in **Research from the Margins**.

IAS | THE INSTITUTE LETTER

Contents

Spring 2025

Editor
Genevieve Looby

Staff Writer
Abbey Ellis

Design and Layout
ChingFoster

Communications and Public Relations Manager
Lee Sandberg

Communications Assistant
Maurianna Kowalski

Illustrator
Marcella Wylie

Cover Image
Atomic Beagles, ink and watercolor on paper, is a reflection on a complex world where science chose the beagle in its pursuit of progress. **Marcella Wylie** is a U.K.-based professional illustrator who specializes in colorful, hand-drawn botanical and animal artwork. Her illustrations have been used for a wide variety of projects by clients from around the world, including Royal Botanic Garden Edinburgh, the Royal British Legion, and the U.K. National Health Service.

Inside Front Cover and Inside Back Cover
Maria O'Leary

Back Cover
Dan Komoda

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

Issues of ***The Institute Letter*** and other Institute publications are available online at **www.ias.edu/publications**

To receive monthly updates on Institute events, videos, and other news by email, subscribe to IAS eNews at **www.ias.edu/enews**

Sowing the Seeds of Discovery

Dan Komoda

As the campus sheds its winter blanket of snow and green shoots begin to multiply in the Woods, so too the Institute for Advanced Study has burst into life.

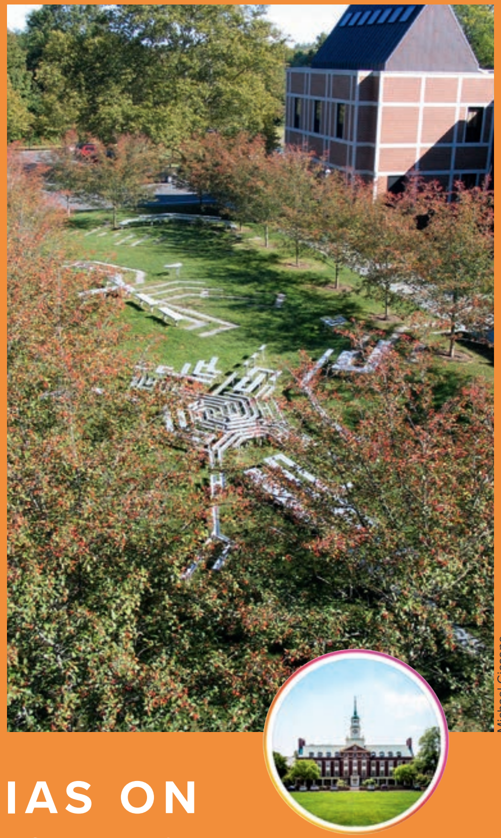
This spring, opportunities for scholarly interaction have bloomed once more, spanning from Mathematical Conversations, where scholars from the School of Mathematics gather in the Simons Hall birch garden to share their latest insights, to a new iteration of After Hours Conversations, where those from all four corners of the Institute engage in informal dialogue. Topics have ranged from the role of archives in the age of digital humanities to potential applications of formalized mathematics in artificial intelligence.

Unstructured moments such as these allow thoughts to flow freely, unconfined by the rigidity that can be found in formal presentations. They cultivate a landscape of diverse perspectives, often yielding insights that bear fruit as cross-disciplinary breakthroughs. And, perhaps most importantly, these informal settings become nurturing gardens for early-career researchers, providing them with the chance to engage with established scholars and fertilize lasting connections.

This spring's *Institute Letter* brings to the wider Institute community one of these engaging After Hours Conversations; turn to page 22 to learn about School of Natural Sciences Member Giovanni Maria Tomaselli's groundbreaking insights into the nature of dark matter—the invisible substance shaping our universe. The issue also features a dive into School of Historical Studies Member Brad Bolman's work on the role of beagles in scientific research, and an exploration of the marginalia that can be found at the Institute.

Each of these pieces touches on the ways in which things not immediately seen—the behind-the-scenes impact of incremental research with animals, a small note in the margins of a book, or the makeup of dark matter—can have a profound impact in shaping the world.

Like a newly planted seed, hidden but taking root, the connections and ideas sprouting here will continue to unfurl long after the season changes.



Michael Ciccone

IAS ON Instagram

A maze? A garden? A playground? No, the silver-grey aluminum work of art shown on this page, which can be found nestled outside Bloomberg Hall, is *Landscape Sculpture*, made by American artist and designer Mary Miss. It was unveiled in 2002 alongside the dedication of the Hall, which is home to the Institute's School of Natural Sciences.

Miss understood the research of IAS scientists as "an attempt to forge a link between the familiar and that which has yet to be recognized." This process, which she described as one of "translation," provided inspiration for the work.

For more campus art, news, and snippets of daily life from the Institute campus, scan the QR code to follow IAS on Instagram.

FOUNDERS DAY 2025

The Things We Share


Shelby White and Leon Levy Archives Center

Each May, under the once-again-green trees of campus, the Institute's community looks to its roots in celebration. When sibling philanthropists Louis Bamberger and Caroline Bamberger Fuld founded and endowed IAS on May 20, 1930, they set forward a unique place and space committed to discovery—a commitment that has seen the Institute become a haven for transformative ideas and profound scholarship.

Founders Day celebrates this shared legacy by bringing together present and past scholars, staff, and supporters to commemorate both scholarship and community. This year's event, to be held on May 16, will see Maria Loh, one of the Institute's newest Professors, present a public lecture and past Members return to IAS to share books written during their Memberships. Community activities, characteristic of the Institute, will include afternoon tea, a game of cricket, and a dinner party with live music.

Photography by Maria O'Leary

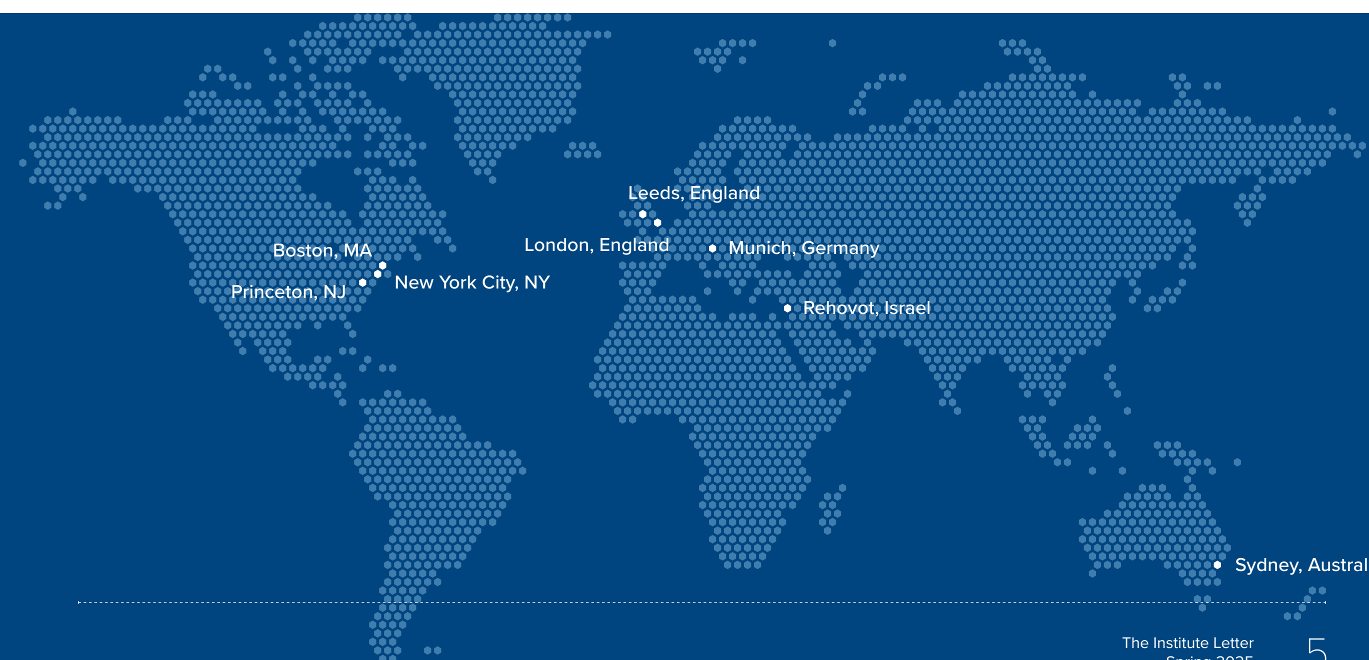
Global Gatherings

Each year the Institute brings to its campus more than 200 scholars—most of whom are first-time visitors. All of these current scholars, as well as former scholars and those accepted for future attendance, make up the Association for Members of the Institute for Advanced Study, more widely known as AMIAS. This group numbers more than 8,000 individuals worldwide.

As such, the Institute's scholar community is a mobile one. Its members arrive on campus to take part in the Institute's unique approach to discovery, and then continue onwards with fresh perspectives and enduring collaborations.

To keep these IAS connections alive and to foster off-campus networks that stretch across the globe, AMIAS has recently reinvigorated a practice of hosting events, allowing IAS scholars, past and present, to get together. These colleague-hosted, informal events have taken many different forms—a lecture, a museum tour, a bar trivia night. But all embody the cherished IAS tradition of gathering together.

Keep an eye on your email for announcements of future AMIAS gatherings.



The Jonathan M. Nelson Center for Collaborative Research

Supporting Collaboration, Advancing Knowledge

The Jonathan M. Nelson Center for Collaborative Research expands the Institute's capacity for discovery, while continuing its tradition of groundbreaking scholarship. By providing funding, technical and administrative support for complex collaborations, and collaboration space, the Nelson Center advances foundational knowledge across fields. The first Faculty projects to commence through the Nelson Center are wide-ranging, uniting disciplines, institutions, and scholars to push the borders of knowledge and shape the future of research.

Approved projects vary in scale and scope, exploring subjects from antiquity to AI and drawing on expertise from across disciplines. A sampling of current Nelson Center projects is highlighted below:

Scan to learn more about the Nelson Center and see the full range of participants and initiatives currently supported.

HISTORY OF MODERN MATHEMATICS

The History of Modern Mathematics project will establish a research group dedicated to the study of recent mathematical history, examining 20th and 21st century transformations in the field's nature, validation, and dissemination. It will adopt a broad approach, uniting mathematicians, philosophers, and historians to examine not only the internal dynamics of the field, but also the evolution of institutions, technologies, and societies. Building on the Institute for Advanced Study's tradition of connecting mathematics with humanistic disciplines, the project will integrate cultural, intellectual, and social perspectives. The project will commence with a pilot workshop in spring 2026.

THE AL-KHANJI ARCHIVE

The al-Khanji Archive, documenting the influential role of the Syrian-Egyptian al-Khanji family in the Arabic manuscript trade and publishing in the early 20th century, is a unique resource for manuscript studies, print history, and intellectual networks. The archive contains thousands of documents, including letters, correspondence with prominent scholars, and business records, offering unprecedented insights into manuscript provenance, the publishing landscape, and intellectual exchange between the Arab world and the West during this period. The project will work to examine and digitize prioritized portions of the archive, and create a digital portal to support future research, including a crowdsourced database of Khanji manuscripts.

Scan to read more about the origins of the al-Khanji Archive project.

IAS GRAVITATIONAL WAVE VIRTUAL CENTER

The IAS Gravitational Wave (GW) collaboration, founded in 2018, developed the first independent pipeline to analyze data from the LIGO observatory, from raw strain data to astrophysical interpretation. Despite many Members moving to other institutions, the collaboration continues to be recognized as the "IAS group." As the group has expanded and its members have become more geographically dispersed, the virtual center will provide tools to enhance collaboration and generate new transformative ideas. The center will also broaden its scope to include emerging areas, such as pulsar timing arrays and the Laser Interferometer Space Antenna (LISA) mission. These initiatives will strengthen connections within the gravitational wave community and encourage future collaborations.

Scan to learn more about gravitational wave research at IAS.

COGNITIVE SCIENCE OF MATHEMATICAL UNDERSTANDING

The Cognitive Science of Mathematical Understanding project, which will take the form of a workshop, aims to explore the cognitive foundations of higher-level mathematics. The focus will be on understanding the psychological aspects of mathematical judgment, explanation, and concept development. Specific topics will include what makes a proof satisfying, how mathematical explanations relate to proofs, and what attributes make a mathematical concept valuable or useful. The workshop seeks to bridge these cognitive aspects with mathematical practice, offering deeper insights into how human cognition influences mathematical reasoning—especially important in the context of recent AI advances. By bringing together experts in mathematics, philosophy, psychology, and education, the project aims to build a scholarly community dedicated to the cognitive science of mathematical understanding.

CRITICAL PERSPECTIVES ON THE AI ECOSYSTEM

Critical Perspectives on the AI Ecosystem is a collaborative research initiative that will bring together experts from the social sciences, sciences, humanities, policymaking, and civil society to examine artificial intelligence through three critical and interconnected lenses: applications, policy, and geopolitics. It aims to understand the societal impact of AI on democracy, focusing on its intersections with quantum computing, reliance on critical minerals, and related policy implications. Through workshops, working groups, and seminars, it will develop frameworks for governing AI systems, challenge existing power dynamics in AI development, and propose new methodologies for understanding its material and political prerequisites, technological limits, and social implications.

PARTICLE PHYSICS, COSMOLOGY, AND GEOMETRY

Building on the vision of the ERC Synergy Grant UNIVERSE+, the initiative will foster collaboration between leading institutions with the aim of developing a novel framework for understanding the universe at all scales. By bringing together world-class researchers, postdoctoral scholars, and students, the project will create an environment conducive to deep theoretical breakthroughs, bridging gaps between fundamental physics and advanced mathematics and providing a critical platform for cross-disciplinary research that is essential for addressing some of the most profound questions in cosmology and particle physics.

Putting DNA in the Dock

How are the rapidly expanding genetic databases within our criminal justice systems transforming fundamental concepts of criminality and human identity? In her recent book, *Genetics and the Politics of Security: A Social Science Perspective*, **Joëlle Vailly**, Member (2019–20) in the School of Social Science, analyzes how DNA functions as both a surveillance tool and a mirror reflecting broader societal developments. She explores how the increasing dependence of law enforcement agencies on genetic data for suspect identification has brought questions about the proper balance between individual rights and public security to the fore. These concerns extend to practices such as phenotyping (a method for predicting an individual's physical appearance from their DNA), which may unfairly stigmatize certain communities, as well as debates around appropriate retention periods for sensitive genetic information.

ANIRUDH, Unsplash

Maria O'Leary

Beyond Boltzmann: Unraveling Non-Thermal Distributions

The origins of Member **Uddipan Banik**'s latest research project in the School of Natural Sciences can be traced back over 200 years, to the groundbreaking work of Austrian physicist Ludwig Boltzmann.

"When considering the colliding gas particles in a room, for example," explained Banik, "Boltzmann asked how these particles would move and, importantly, at what speeds they might be moving. He found that such particles tend towards 'thermal equilibrium,' where the distribution of particle speeds follows a universal mathematical pattern." This pattern is known as a Maxwell-Boltzmann distribution.

Not all systems exhibit a Maxwell-Boltzmann distribution, however. Examples of this include collisionless plasmas like the solar wind, a constant stream of charged particles that flows away from the Sun. Satellites that monitor the solar wind, such as the Parker Solar Probe, have found that it exhibits a universal "non-thermal tail," meaning that a subset of its particles is moving at extremely high velocity with a universal power law distribution.

In a paper published in *The Astrophysical Journal*, Banik has offered a fundamental, first-principles explanation for this phenomenon. A key innovation in his approach is the incorporation of so-called "self-consistency." Unlike previous studies, Banik's model accounts for how the velocity of each charged particle influences the forces acting upon it.

Banik found that slower particles get "shielded" by other charged particles, which reduces the force they feel. Faster particles, on the other hand, whizz around without getting shielded as much. They feel stronger forces and hence get kicked to even higher energies. Over time, this difference in energy boost creates the "non-thermal tail."

Banik's work has shown that self-consistency is an important ingredient in understanding the origin of non-thermal distributions in astrophysical systems.

Unlike previous studies, Banik's model accounts for how the velocity of each charged particle influences the forces acting upon it.

A Three-Dimensional Breakthrough

Hong Wang, Member (2019–21) in the School of Mathematics, together with Joshua Zahl of the University of British Columbia, has announced a solution of the three-dimensional Kakeya conjecture. Their most recent paper, posted to arXiv in February, is the third in a series that relates to this breakthrough.

This long-standing conjecture is easily stated but has eluded mathematicians for decades: Take a thin laser beam that needs to shine in every possible direction in space. What is the smallest volume through which this beam must pass?

In two dimensions (like on a flat wall), the beam can point in all directions while passing through an area that is almost zero, but such a set cannot be too small, in that it must have maximal mathematical dimension—namely two.

> Take a thin laser beam that needs to shine in every possible direction in space. What is the smallest volume through which this beam must pass?

But what about in our 3D world? The Kakeya conjecture proposed that in three dimensions, you also cannot be as efficient—there is a fundamental limit to how compactly you can arrange all possible directions in 3D space. This is precisely what Wang and Zahl have proved: the dimension of such a Kakeya set must be three.

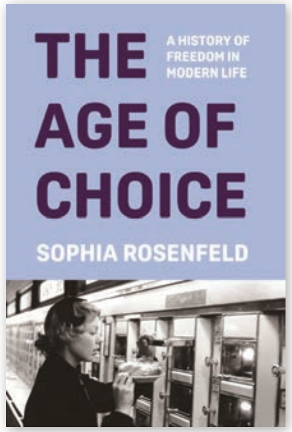
Their work builds on that of other IAS scholars. **Jean Bourgain**, Professor (1994–2018) in the School of Mathematics, established important lower bounds for the size of Kakeya sets in multiple dimensions, proving that they could not be as small as known previously. His work also made fundamental connections between the Kakeya problem and other areas of mathematics. Later, **Zeev Dvir**, frequent Member in the School, resolved an analogue of the Kakeya problem in an algebraic setting using the "polynomial method," a powerful technique from algebraic geometry. **Larry Guth**, Member (2010–11), added a vital perspective related to this method in the setting of real three-dimensional space.

In addition to this, in the first of their papers, published in 2022, Wang and Zahl employed a technique pioneered by **Terence Tao**, Member (2005, 2023), and his colleague Nets Katz. In 2014, Tao and Katz showed that a specific subset of Kakeya sets must occupy a full three-dimensional size, exactly as the conjecture predicted. Wang and Zahl's second and third papers extend this by dealing with all possible Kakeya sets.

Although Wang and Zahl have resolved a landmark open problem, further work remains. The conjecture about Kakeya sets has been made for all dimensions, and in higher dimensions, the geometry becomes more complicated.

Techniques developed for solving a problem in one area of mathematics often yield insights in another. Thus, the Kakeya problem is closely connected to important restriction conjectures about Fourier transforms, as first highlighted in the work of Princeton University's Charles Fefferman. It is also related to problems in homogeneous dynamics, as demonstrated in recent works of **Elon Lindenstrauss**, Professor in the School of Mathematics, and his collaborators.

Maria O'Leary

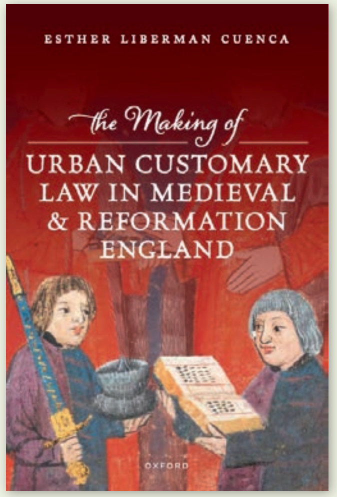


Examining a World Shaped by Choice

How has choice become a defining feature of modern freedom? This was not always the case: the option to choose where to live, what to buy, and what to believe was neither universally available nor consistently desired throughout history.

> The option to choose where to live, what to buy, and what to believe was neither universally available nor consistently desired throughout history.

Drawing from diverse sources including novels, restaurant menus, and the latest research in psychology and economics, **Sophia Rosenfeld**, Ed Kaufmann Founders' Circle Member (2014–15) in the School of Social Science, traces the evolution of choice from the seventeenth century to today. Rosenfeld's book, *The Age of Choice*, written during her IAS Membership, highlights how, despite often having fewer options themselves, women were a key driver in the rise of choice. The book also addresses a paradox inherent in the concept of choice: while commonly associated with freedom and autonomy, an abundance of options can lead to anxiety and other social costs. In her work, Rosenfeld offers a thought-provoking analysis of a fundamental aspect of modern life that can often be taken for granted.



Making Laws, Making Society

Everything from political officeholding to moral behavior in English towns from the twelfth to the sixteenth century C.E. was governed by customary law. Unlike English common law or church law, which both had long institutional and academic traditions, customary laws evolved from everyday practices and acquired the force of law over time.

In a new book, *The Making of Urban Customary Law in Medieval and Reformation England*, **Esther Liberman Cuenca**, Member (2022–23) in the School of Historical Studies, argues that such customs were instrumental in forging a distinct identity for a bourgeois class in urban England. She shows how male elites crafted laws to advance their interests, assert independence, and present themselves as moral leaders. Following the Black Death and during the Reformation, she further highlights how this legal framework increasingly focused on political authority, morality, and the "common good." Her work provides a fascinating glimpse into the development of medieval English urban society.

A Fresh Lens for Ghanian Political-Economic History

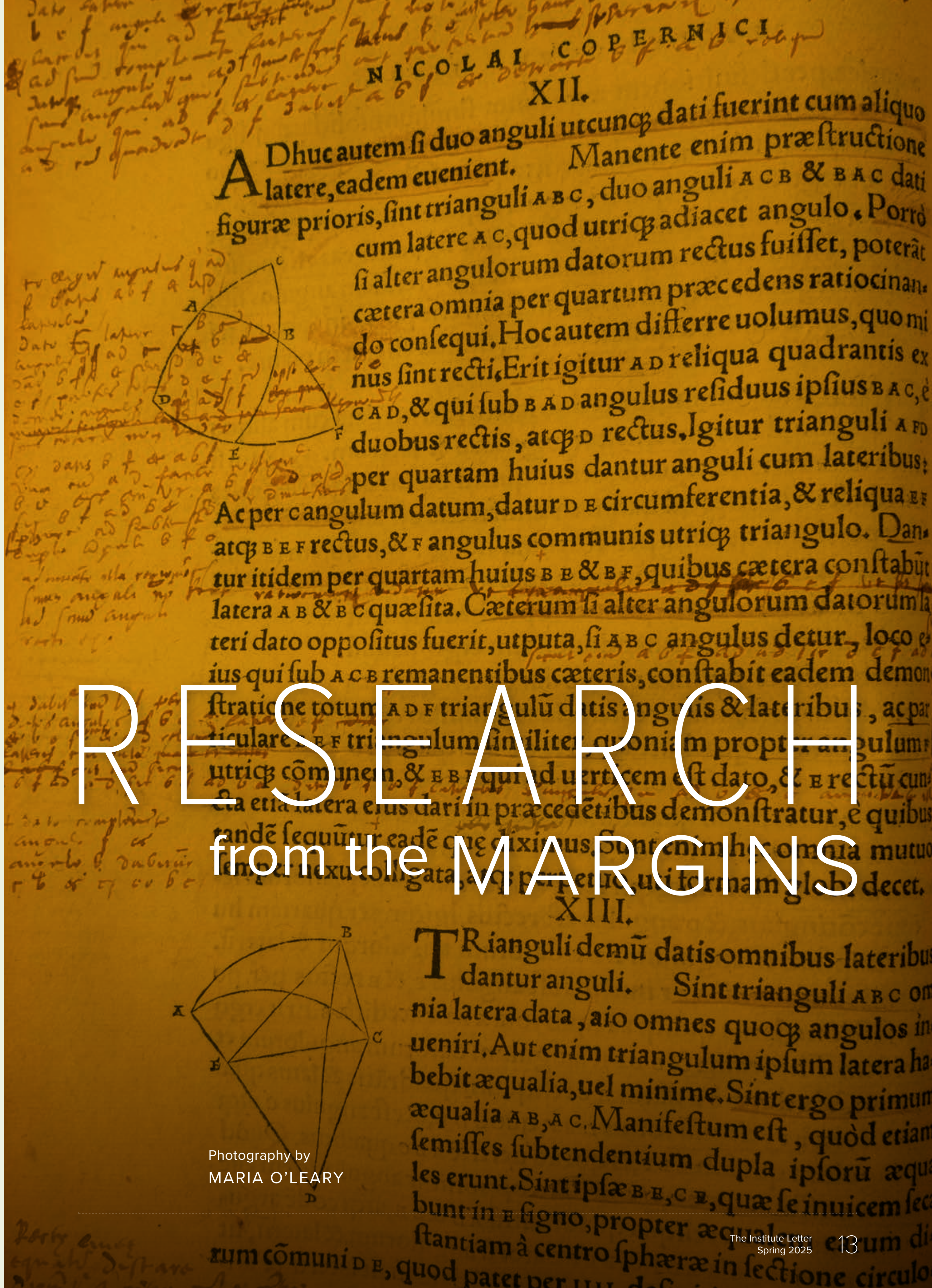
From 1957 to 1966, Kwame Nkrumah served as the President of Ghana, bringing with him to office a socialist political-economic philosophy. After the U.S.-led coup d'état in 1966, historical researchers and political commentators have primarily categorized his efforts as a failure attributed to him being either too socialist or not socialist enough.

In a 2023 article titled "Ghana and Nkrumah Revisited: Lenin, State Capitalism, and Black Marxist Orbits"—which was named a finalist for the 2024 Outstanding Article Prize from the Association for the Study of the Worldwide African Diaspora—**Nana Osei-Opare**, Member (2022–23) in the School of Historical Studies, revisits the Ghanian political economy under Nkrumah. He argues that the political-economic philosophies and policies employed were not contradictory Marxian policies, but rather showcased Black Marxists' deep understandings of Lenin's state capitalist ideas.

Tracing conceptual ideas through Black Marxists' correspondences, newspaper and magazine articles, British and American espionage files, and archival state and inter-state departmental documents from Ghana, the U.S., Britain, and Russia, Osei-Opare demonstrates how Black Marxists' combinations of socialist and capitalist development paths were key sites of ideological interrogation and experimentation.

This, in turn, shows Black thinkers as active interpreters and agents of historical and contemporaneous global political, economic, and ideological struggles, rejecting ideas that African political ideologies solely originate from a romanticized Afrocentric origin.

This, in turn, shows Black thinkers as active interpreters and agents of historical and contemporaneous global political, economic, and ideological struggles.



Photography by
MARIA O'LEARY

“I have discovered a truly marvelous proof of this, which this margin is too narrow to contain.”

So ends a note written in a copy of Diophantus’s *Arithmetica*, a list of over 200 algebraic problems dating from around 250 C.E. The note, however, was penned much later, in the seventeenth century C.E., by Pierre de Fermat, a French lawyer and amateur mathematician.

It appeared next to Diophantus’s discussion of a problem reminiscent of the famous Pythagorean equation $a^2 + b^2 = c^2$: how to split a given square number into two other squares.

Fermat made the bold claim that “it is impossible to separate a cube into two cubes, or a fourth power into two fourth powers, or in general, any power higher than the second, into two like powers.” But if Fermat did indeed have a proof of this theorem, it seems that he never committed it to paper.

Nevertheless, his tantalizing comment in the margins of the *Arithmetica*, posthumously published by his son, served as a spark, igniting a 350-year quest to (re)discover the elusive proof. Yet despite concerted efforts by generations of mathematicians, the theorem resisted proof, becoming known as “Fermat’s Last Theorem.” (Their efforts were not entirely in vain, of course, since attempts to prove the theorem brought about substantial development in the field of number theory.) The theorem’s long-standing unsolved status even saw it enter the popular imagination; it was dubbed “the most difficult mathematical problem” by the Guinness Book of World Records.

Finally, in 1994, Andrew Wiles, frequent Member and Visitor (2007–11) in the School of Mathematics, successfully proved the theorem after working on it in secret for seven years. It was formally published in 1995 to great acclaim. The centuries-long academic journey to the proof began with a single note.

Marginalia, in the form of not just notes but scribbles, doodles, corrections, and illuminations, is by no means confined to the realm of mathematics. And while in the case of Fermat’s Last Theorem such additions to printed texts were a key impetus for beginning the study of a problem, in other cases, marginalia are equally integral to a problem’s solution. Such notes—appearing in books and offprints, on photographs and squeezes, and on notecards—transform what might seem like static artifacts into dynamic records of scholarly engagement. They document the history of how scholars have interpreted, connected, and published ideas throughout time and space, creating a multilayered conversation that can even stretch across millennia.

The Institute has its own intriguing collection of marginalia. Some give insight into the character and work of IAS scholars, while others offer a glimpse into Institute history. More still offer themselves as opportunities for understanding engagement with texts over time, particularly those within the rare books collection, which includes a notable edition of Nicolaus Copernicus’s *De revolvtionibus orbium cœlestium, libri VI.*[1] These inscriptions are a visual representation of both the solitary study and the conversations through paper that profoundly enrich scholarship at the Institute, and will continue to do so as scholars carry on the storied tradition of scribbling.

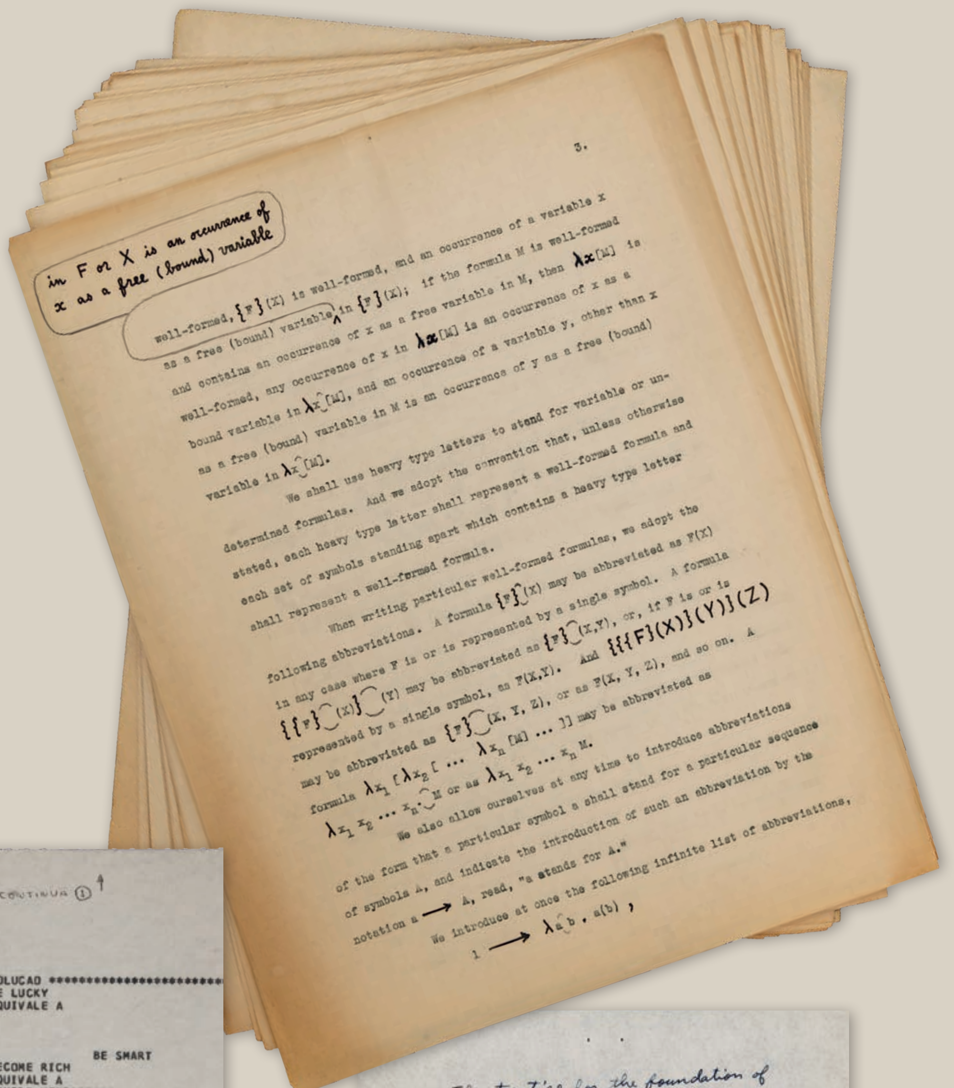
[1]An unknown reader’s handwritten annotations fill the margins in Copernicus’s *De revolvtionibus orbium cœlestium, libri VI*, published in 1543. Elsewhere in the book, one can see cross outs through sections that were banned by the Catholic church. Such censorship may have been deemed necessary due to the subject of the book: *On the Revolutions of the Heavenly Spheres*. In the text, Copernicus proposed a heliocentric model of the universe, arguing that the Earth and other planets revolve around the sun.

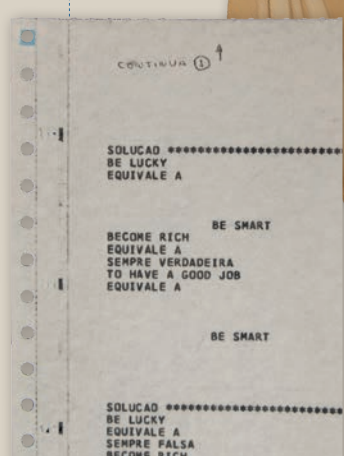
Logicians in Conversation

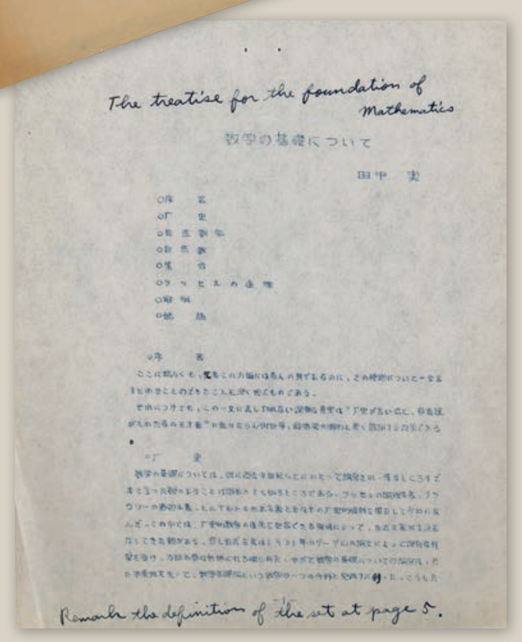
Philosophers and logicians Hao Wang, Visitor (1972, 1975–76) in the School of Mathematics, and Kurt Gödel, frequent Member and Professor (1953–78) in the School, engaged in extensive conversation over the mathematical systems that make up computers, with Wang becoming known as a Gödel commentator in the later parts of his career.

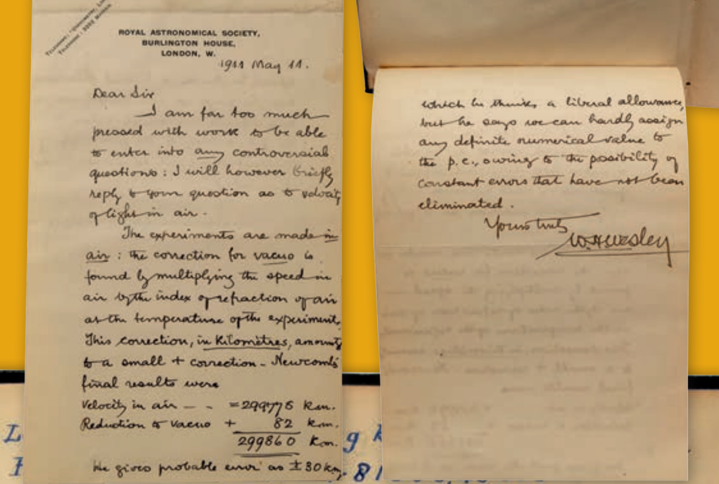
Wang was deeply interested in computer programs due to their uniform, rule-bound nature, which contrasted sharply with the more irregular patterns of human thinking. This fundamental difference between algorithmic computation and human cognition inspired Wang to develop computer programs capable of proving theorems in two distinct branches of logic: propositional calculus and predicate calculus.

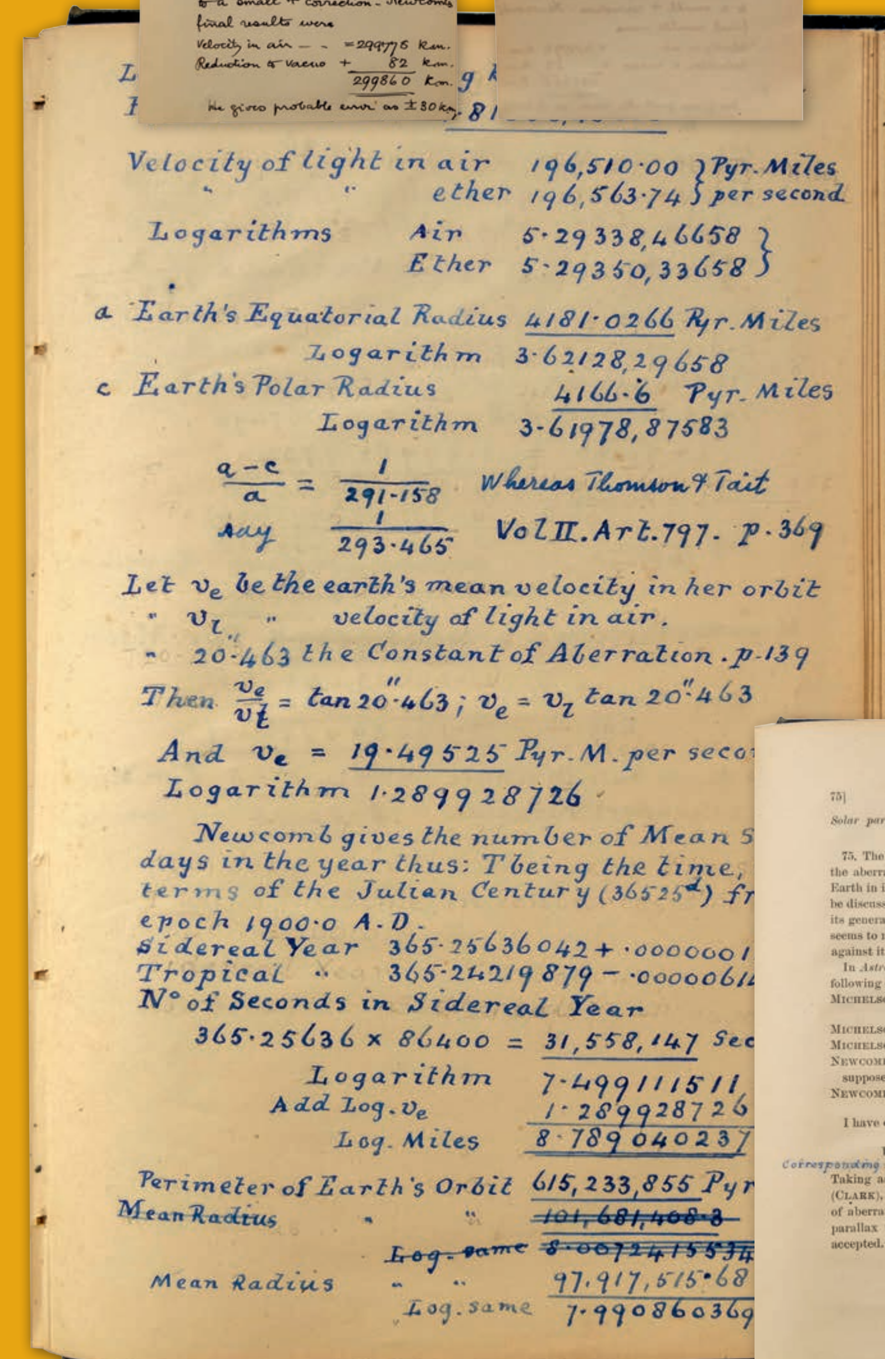
This drew Wang to Gödel's work, in particular his incompleteness theorems, which are integral to understanding modern-day computer programming. During their shared time at the Institute, Wang and Gödel had the opportunity to exchange both ideas and offprints in English and Japanese. Their dialogue is evident in these documents with numerous handwritten symbols, likely stemming from Gödel's pen.





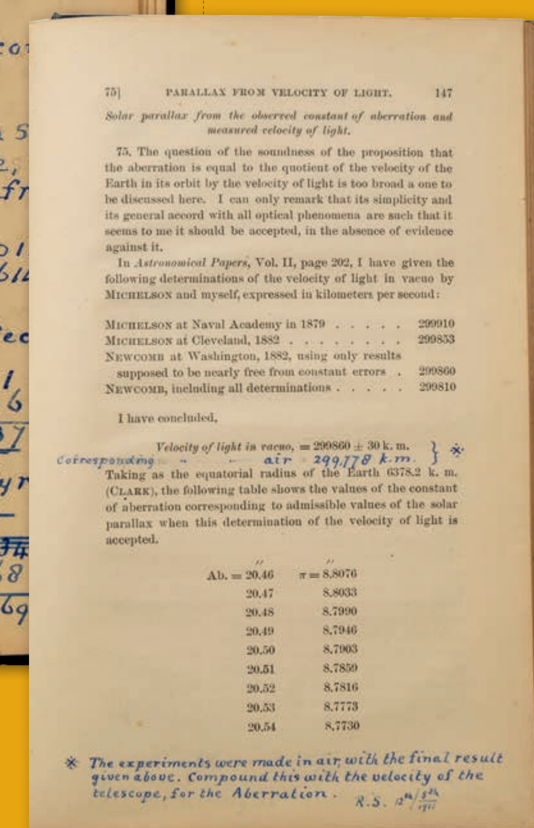






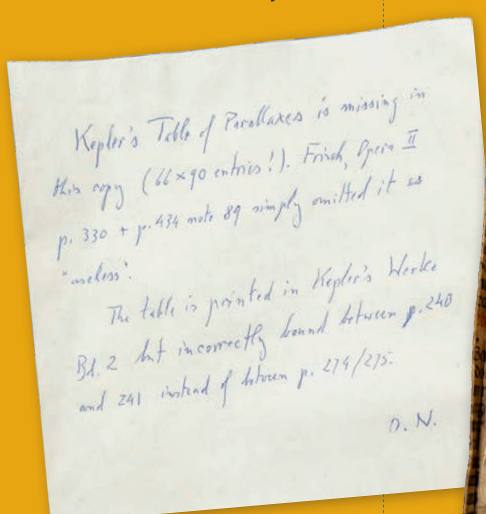
Letters of Correction

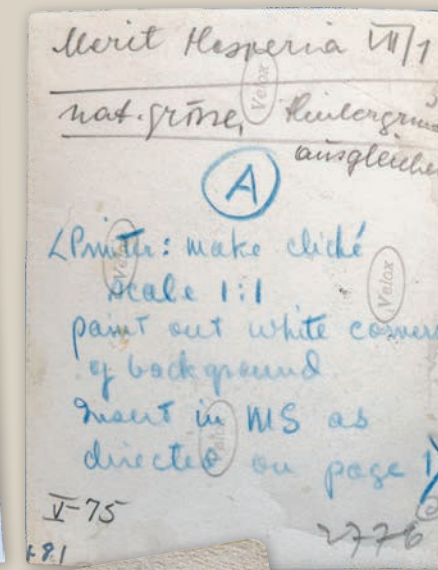
The pages of astronomer Simon Newcomb's 1895 publication, *The Elements of the Four Inner Planets and the Fundamental Constants of Astronomy*, housed in the Institute's rare book room, are filled with meticulously crafted logarithmic calculations. But most intriguing are the corrections to Newcomb's calculations of light velocity in air, added by a subsequent reader. These amendments likely originated from correspondence found attached at the back of the book—possibly authored by William Henry Wesley of London's Royal Astronomical Society—which appear to document discussions about the error between Wesley and the book's owner.

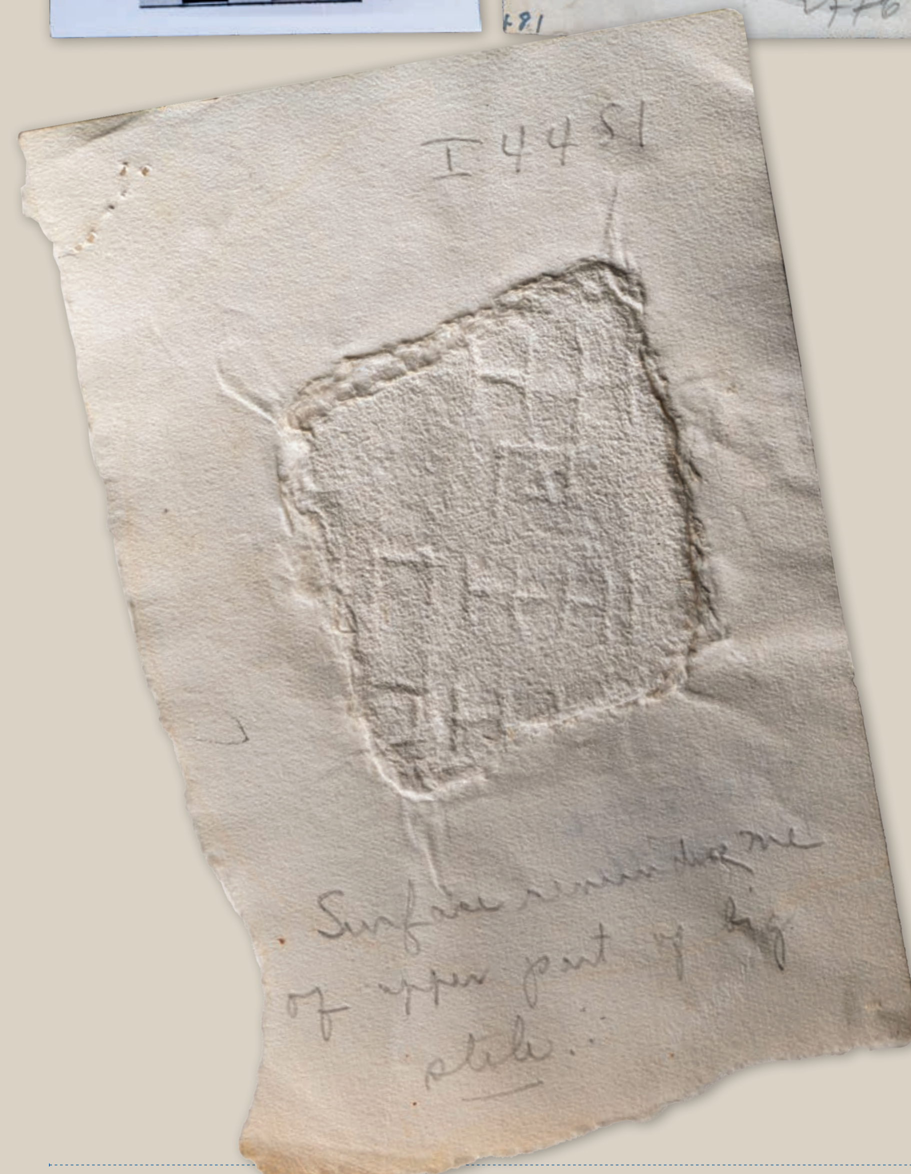


An Astronomical Palimpsest

Alongside vivid illustrations of the solar system as it was understood in the early seventeenth century, the inside front and back covers of this edition of Johannes Kepler's *Ad Vitellionem paralipomena, quibus astronomiae pars optica traditvr (Supplement to Witelo, in which the Optical Part of Astronomy is Expounded)* are filled with copious detailed annotations. In the back, some of these notes are faded, which could indicate that the page was washed to make space for new thoughts. In addition to the exquisite marginalia, a small sheet of paper tucked into the volume alerts future readers that this copy of the book is missing a table. The initials O. N. indicate that the note was written by mathematician-turned-historian of science Otto Neugebauer, a frequent Member of multiple IAS Schools, who contributed extensively to studies of the history of mathematical astronomy.







Squeezing History

Epigraphic squeezes are three-dimensional paper replicas of ancient Greek and Latin inscriptions originally carved in stone. Created by pressing dampened paper onto inscribed surfaces and allowing it to dry, these impressions faithfully capture the texture and dimensions of inscriptions in a portable format that scholars—such as Benjamin Meritt, Professor (1935–89) in the School of Historical Studies, who founded the Institute's squeeze collection—can study in the absence of the original artifacts.

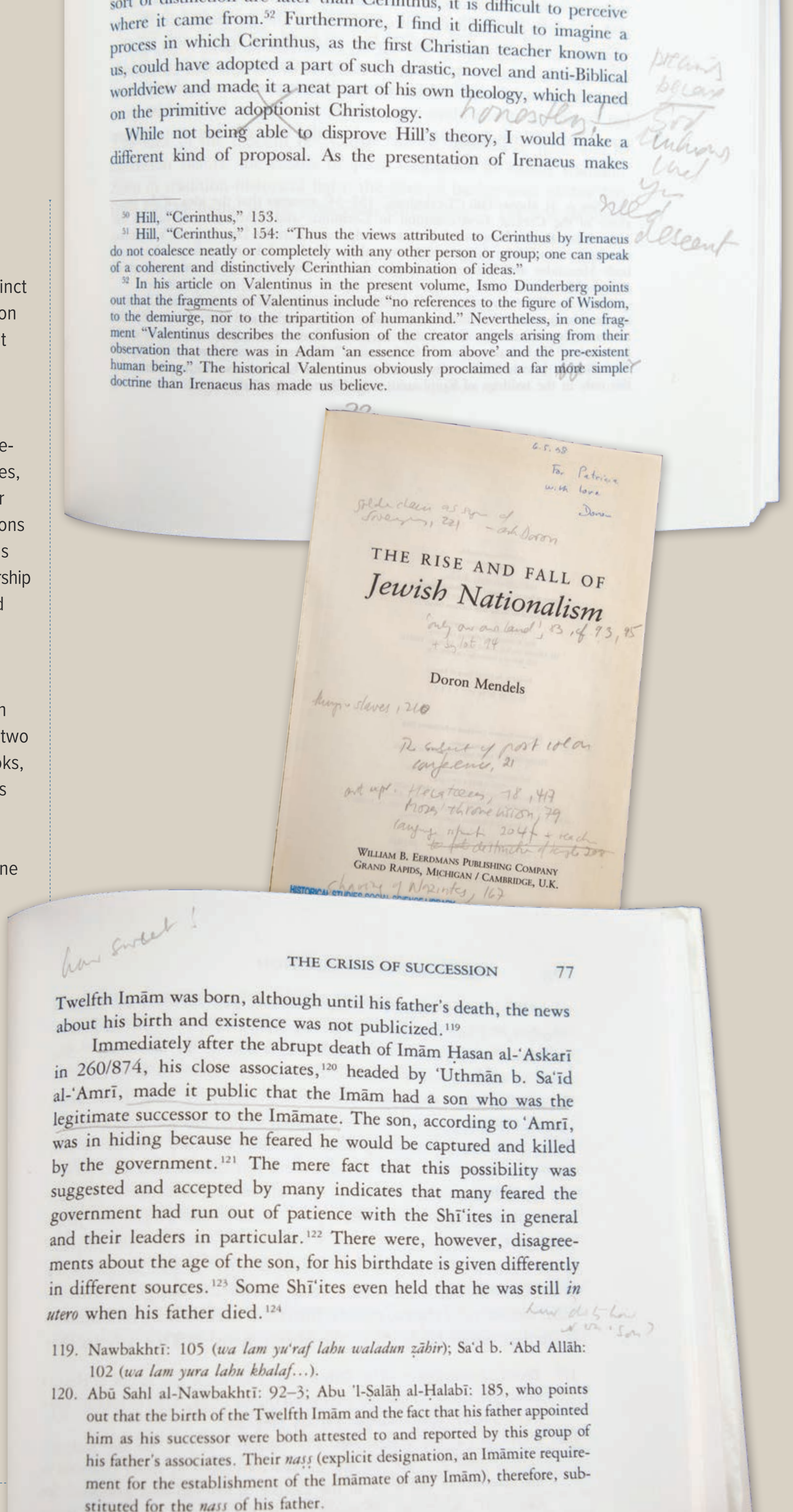
This squeeze is of an inscription from the Athenian Agora (marketplace), which originally formed part of a list of tribute payments given to the city by its allies. The squeeze bears pencil annotations where a scholar noted, the "surface reminds me of the upper part of the big stele," highlighting a crucial moment of insight that connects this small fragment to a larger known monument.

Beyond the squeezes themselves, the photographs of original inscriptions also housed in Meritt's collection reveal another layer of scholarly process. On their reverse sides, the photographs bear Meritt's specific instructions for how the inscriptions should appear when published in the academic journal *Hesperia*. These handwritten notes directly influenced how ancient artifacts were visually presented to the scholarly world, shaping both interpretation and understanding for the researchers that followed.

Marginalia as Memoir

Patricia Crone, Professor (1997–2015) in the School of Historical Studies, had a distinct character that was felt both on campus and in her significant collection of books, many of which she donated to the Historical Studies - Social Science Library. Crone, a foremost scholar in Islamic studies, engaged thoroughly with her texts, leaving many annotations and comments in the margins of works she read. Her scholarship shed light on and challenged existing knowledge about Islamic culture, history, and the Near East.

Her bold personality can be seen in the marginalia of two of her personally owned books, where numerous annotations display Crone's reactions and critiques of the text. In a declaration of fondness, Crone notes "How sweet!" and, on another page, textually exclaims "Honestly!" Crone was a critical scholar, daring in her work and an active participant in discussion at the Institute, traits that are evident in the marginalia of the texts with which she engaged.



where it came from.[52] Furthermore, I find it difficult to imagine a process in which Cerinthus, as the first Christian teacher known to us, could have adopted a part of such drastic, novel and anti-Biblical worldview and made it a neat part of his own theology, which leaned on the primitive adoptionist Christology.

While not being able to disprove Hill's theory, I would make a different kind of proposal. As the presentation of Irenaeus makes

[50] Hill, "Cerinthus," 153.

[51] Hill, "Cerinthus," 154: "Thus the views attributed to Cerinthus by Irenaeus do not coalesce neatly or completely with any other person or group; one can speak of a coherent and distinctively Cerinthian combination of ideas."

[52] In his article on Valentinus in the present volume, Ismo Dunderberg points out that the fragments of Valentinus include "no references to the figure of Wisdom, to the demiurge, nor to the tripartition of humankind." Nevertheless, in one fragment "Valentinus describes the confusion of the creator angels arising from their observation that there was in Adam 'an essence from above' and the pre-existent human being." The historical Valentinus obviously proclaimed a far more simple doctrine than Irenaeus has made us believe.

THE RISE AND FALL OF *Jewish Nationalism*

Doron Mendels

WILLIAM B. EERDMANS PUBLISHING COMPANY
GRAND RAPIDS, MICHIGAN / CAMBRIDGE, U.K.

THE CRISIS OF SUCCESSION 77

Twelfth Imām was born, although until his father's death, the news about his birth and existence was not publicized.[119]

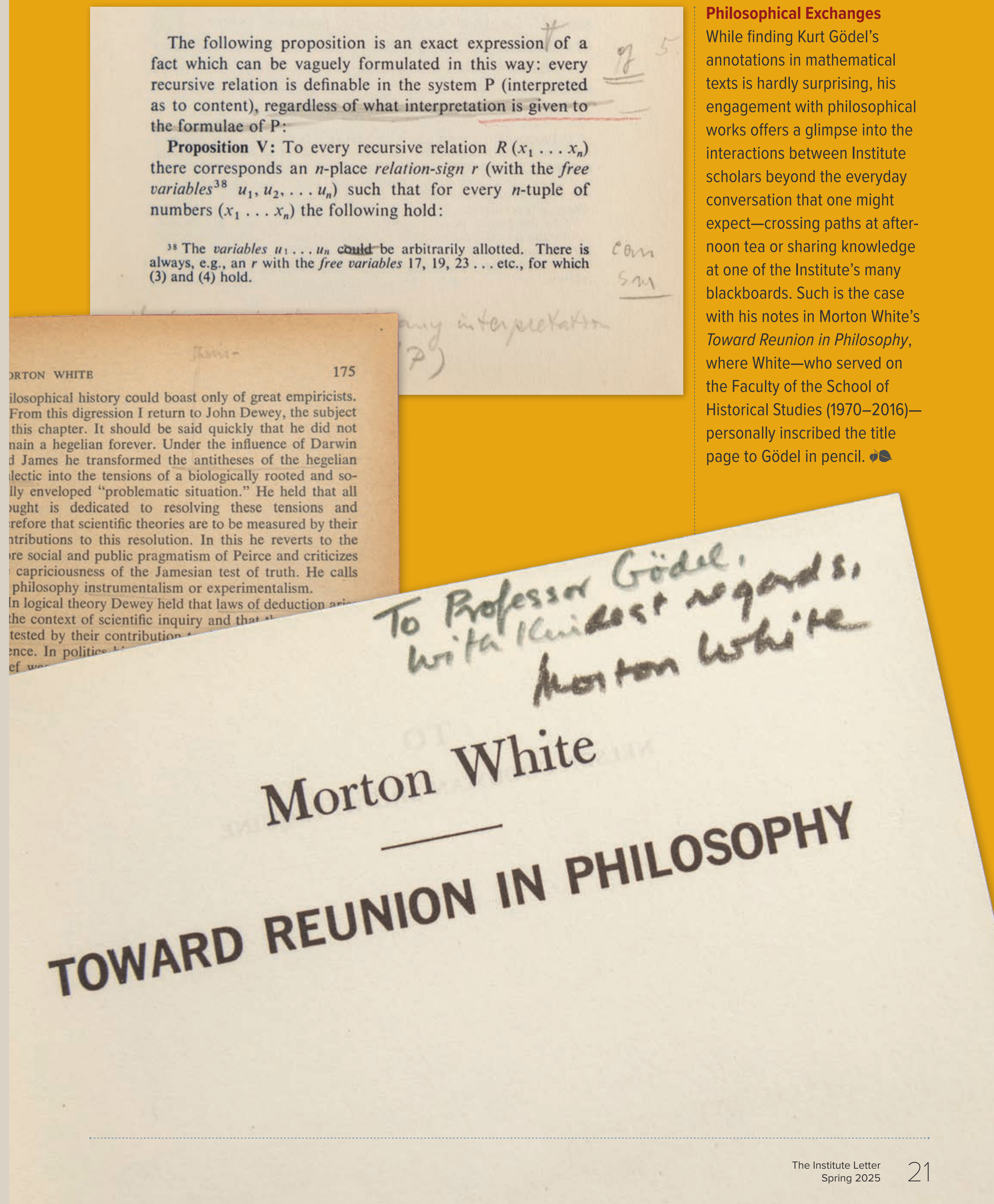
Immediately after the abrupt death of Imām Ḥasan al-ʿAskarī in 260/874, his close associates,[120] headed by ʿUthmān b. Saʿīd al-ʿAmrī, made it public that the Imām had a son who was the legitimate successor to the Imāmate. The son, according to ʿAmrī, was in hiding because he feared he would be captured and killed by the government.[121] The mere fact that this possibility was suggested and accepted by many indicates that many feared the government had run out of patience with the Shīʿites in general and their leaders in particular.[122] There were, however, disagreements about the age of the son, for his birthdate is given differently in different sources.[123] Some Shīʿites even held that he was still *in utero* when his father died.[124]

119. Nawbakhtī: 105 (*wa lam yuʿraf lahu waladun ẓāhir*); Saʿd b. ʿAbd Allāh: 102 (*wa lam yura lahu khalaf*…).

120. Abū Sahl al-Nawbakhtī: 92–3; Abu 'l-Ṣalāḥ al-Ḥalabī: 185, who points out that the birth of the Twelfth Imām and the fact that his father appointed him as his successor were both attested to and reported by this group of his father's associates. Their *naṣṣ* (explicit designation, an Imāmite requirement for the establishment of the Imāmate of any Imām), therefore, substituted for the *naṣṣ* of his father.

Philosophical Exchanges

While finding Kurt Gödel's annotations in mathematical texts is hardly surprising, his engagement with philosophical works offers a glimpse into the interactions between Institute scholars beyond the everyday conversation that one might expect—crossing paths at afternoon tea or sharing knowledge at one of the Institute's many blackboards. Such is the case with his notes in Morton White's *Toward Reunion in Philosophy*, where White—who served on the Faculty of the School of Historical Studies (1970–2016)—personally inscribed the title page to Gödel in pencil.



The following proposition is an exact expression of a fact which can be vaguely formulated in this way: every recursive relation is definable in the system P (interpreted as to content), regardless of what interpretation is given to the formulae of P:

Proposition V: To every recursive relation $R(x_1 \ldots x_n)$ there corresponds an n-place *relation-sign* r (with the *free variables*[38] $u_1, u_2, \ldots u_n$) such that for every n-tuple of numbers $(x_1 \ldots x_n)$ the following hold:

[38] The *variables* $u_1 \ldots u_n$ could be arbitrarily allotted. There is always, e.g., an r with the *free variables* 17, 19, 23 . . . etc., for which (3) and (4) hold.

ORTON WHITE 175

ilosophical history could boast only of great empiricists. From this digression I return to John Dewey, the subject this chapter. It should be said quickly that he did not nain a hegelian forever. Under the influence of Darwin d James he transformed the antitheses of the hegelian lectic into the tensions of a biologically rooted and so-lly enveloped "problematic situation." He held that all ought is dedicated to resolving these tensions and refore that scientific theories are to be measured by their ntributions to this resolution. In this he reverts to the re social and public pragmatism of Peirce and criticizes capriciousness of the Jamesian test of truth. He calls philosophy instrumentalism or experimentalism. In logical theory Dewey held that laws of deduction ari- the context of scientific inquiry and that tested by their contribution ence. In politics

Morton White

TOWARD REUNION IN PHILOSOPHY

WHAT IS DARK MATTER?

BY ABBEY ELLIS

Imagine that you are baking a cake. You weigh out and combine the flour, eggs, and other ingredients, but mysteriously, the resulting mixture is six times heavier than you expected. You check everything again—the recipe, the scale, your math—but the measurement remains heavier than anticipated. There is only one possible conclusion: something that you cannot see must be adding mass to your batter.

It might sound ridiculous, but this is essentially the difficulty that astrophysicists face when trying to understand phenomena such as the "rotation curves" of galaxies.

A rotation curve is a diagram that plots how fast the stars are orbiting around a galaxy, depending on their distance from the galaxy's center. The speed of a star's orbit depends on the strength of the galaxy's gravitational field, and gravitational fields are in turn sourced by the mass present in the galaxy. Therefore, the more mass in the galaxy, the faster the stars should orbit.

But there is a problem. Many stars within galaxies are observed to orbit much faster than they ought to, given the amount of matter that we can observe in those galaxies. To account for this discrepancy, astrophysicists believe that there must be some additional invisible or "dark" matter present in galaxies, increasing their total mass.[1]

This mysterious matter is often referred to as "dark matter." And there is a lot of it hanging around! Estimates suggest that about 85 percent of all matter in the universe is "dark," with ordinary matter making up the remaining 15 percent.

Dark matter is of great interest to many IAS scholars, including Giovanni Maria Tomaselli, Member in the School of Natural Sciences. At a recent After Hours Conversation event, he presented compelling evidence for the existence of such matter and introduced three of the leading candidates that might explain its composition. His own innovative research examines the wave-like properties of dark matter, focusing on how such waves interact with pairs of black holes—work that could eventually unlock new methods for detecting this invisible cosmic component.

[1] The first scientists to identify the discrepancy were Vera Rubin and W. Kent Ford Jr. Their work was later cited by others as evidence for the existence of dark matter.

NASA, ESA, S. Beckwith and the HUDF Team (STScI), and B. Mobasher (STScI)

THERE IS CONVINCING EVIDENCE to suggest that dark matter exists, says Tomaselli. In addition to rotation curves, he cites the Bullet Cluster, which is itself composed of two galaxy clusters, located about 3.8 billion light years from Earth.[2]

"The two galaxy clusters from which the Bullet Cluster is made have passed through each other. We can observe this very clearly from Earth—the cluster is perfectly aligned in the sky," Tomaselli explains. When scientists mapped where gravity exerts its pull in the cluster versus where its ordinary matter is located, they found something remarkable. "They are in different places!" says Tomaselli.

The majority of the ordinary matter in the Bullet Cluster takes the form of X-ray-emitting gas, which is indicated by the pink regions of the image. Meanwhile, most of the other luminous objects in the image are galaxies. Some of them are part of the Bullet Cluster, while the others are "background objects" that exist in the distance behind it.

Light from these background objects is bent by the gravity of the cluster, a phenomenon known as gravitational lensing. "The amount of lensing that we see depends on the total mass of the cluster in foreground," explains Tomaselli. By measuring where the gravitational lensing is most pronounced, one can determine where gravity is at its strongest. These areas are indicated by the blue regions on the image.

Even the most cursory glance reveals that in the Bullet Cluster, gravity is strongest in areas where there is not much ordinary matter at all. There must, therefore, be some unseen mass within the cluster that causes the gravitational effects to be observed elsewhere.

For Tomaselli, this provides powerful evidence for dark matter. One might argue that if the *amount* of matter alone was more than expected, that a conversion error might be the cause. In the case of the rotation curves, could we simply be underestimating how much mass there is in ordinary matter? But in the case of the Bullet Cluster, it is not only the amount of matter but its *location* that is at issue. This strongly suggests that there is some matter present that we have not identified.

SO FAR, SO MYSTERIOUS. But what do we know about this dark matter? There are a few things that we can say with relative certainty, states Tomaselli.

First, dark matter produces a gravitational field, but does not seem to interact strongly, if at all, through other forces. Second, it is slow moving, which is what makes it capable of clumping into gravitationally-bound structures.[3] Third, there is a lot of dark matter in the universe, but we do not know the mass of its constituent parts. "Is it comprised of lots of not-so-massive things, or a few, very massive things?" asks Tomaselli.

In Tomaselli's words, the search to identify dark matter has led scientists to "a few viable candidates,"[4] but we do not yet know which, if any, is correct.

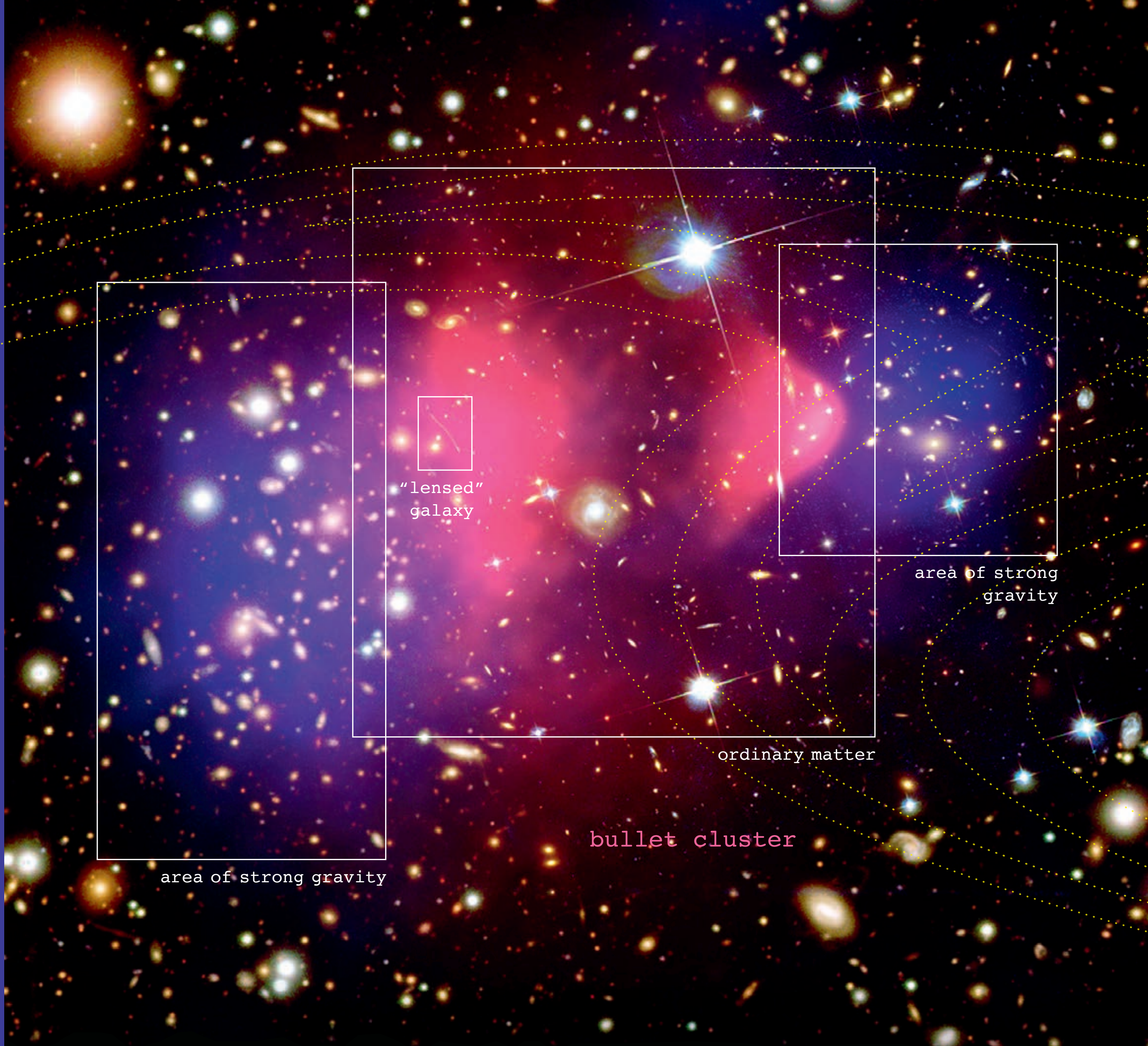
It might seem conceivable that dark matter is comprised of black holes. Black holes are, of course, very massive objects and do not emit light, so cannot be seen by ordinary telescopes.

However, the so-called "astrophysical" black holes with which one might be familiar are unlikely to be dark matter candidates. The main reason for this is timing.

Astrophysical black holes are believed to form from the gravitational collapse of massive stars, meaning that these stars have to already be present for the black hole to be created. Dark matter, though, must have been present in the very early universe.

This is evidenced by the cosmic microwave background (CMB), which essentially provides a snapshot of radiation in the universe from approximately 380,000 years after the Big Bang—long before any stars had formed. The CMB displays distinctive fluctuation patterns that cannot be explained without the presence of dark matter, leading to an important conclusion: since dark matter existed before stars, it cannot primarily consist of black holes that formed from collapsed stars.

However, there is a kind of black hole that has been considered a dark matter contender: so-called primordial black holes (or PBHs). "Primordial black holes may have formed in the earliest moments after the Big Bang from extreme density fluctuations in the infant universe," explains Tomaselli. Unlike their stellar counterparts, primordial black holes did not result from the collapse of stars—they emerged directly from these primordial density variations, meaning that they



could be present at the time the CMB was formed.

Despite being possible dark matter contenders, PBHs are only viable candidates at certain mass ranges. "It is possible that dark matter is formed from primordial black holes," says Tomaselli, "but when black holes are modeled across their wide spectrum of masses—from microscopic to very massive—there are some problems."

"For each specific mass range, astrophysicists have developed different observational techniques and constraints to determine whether these black holes could constitute dark matter. They have systematically ruled out PBHs as the dominant component of dark matter across most mass ranges," he continues.

PBHs of smaller masses are ruled out due to radiation. PBHs, like all black holes, emit radiation. "This is usually negligible for black holes formed from collapsing astrophysical objects," explains Tomaselli. "But for primordial black holes that have a very small mass, the radiation process would be very fast, causing them to evaporate! This evaporation would happen much quicker than the age of the universe, meaning that small primordial black holes could not form the dark matter that we feel the impact of today."

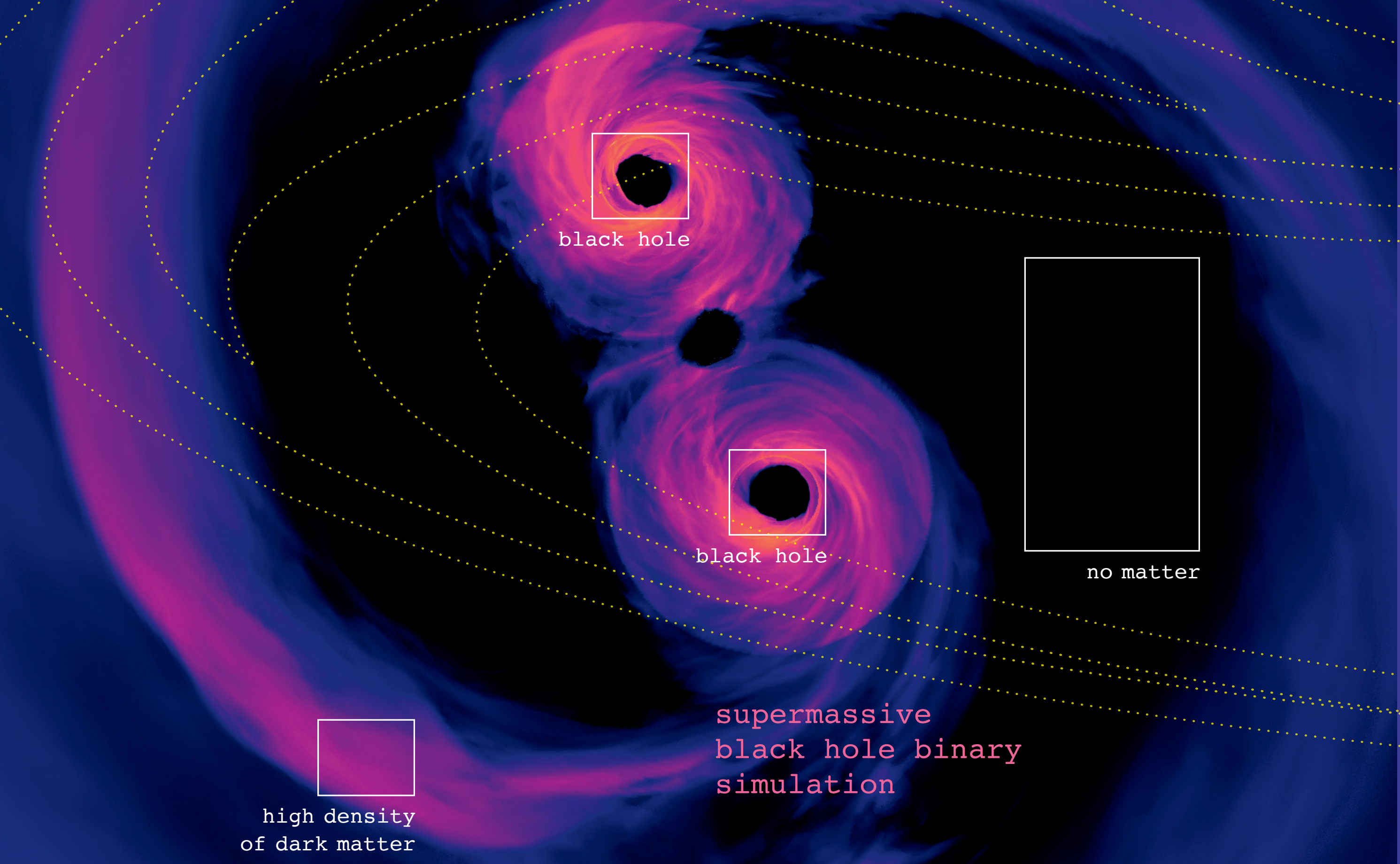
For PBHs of higher masses, there are problems too. When black holes merge, they produce detectable gravitational waves. Scientists can compare the observed rate of these merger events with what would

[2] The Bullet Cluster is officially known as 1E 0657-56.

[3] The blue regions in the Bullet Cluster image are an example of such a structure.

[4] This article discusses three candidates for dark matter that are described by Tomaselli as "the most popular." But there are more possibilities beyond this, including sterile neutrinos, namely elementary particles that do not interact much, and MAssive Compact Halo Objects (MACHOs), astrophysical objects that emit little or no radiation and drift through interstellar space.

NASA, CXC, M. Weiss



be expected if primordial black holes made up all dark matter. Tomaselli notes that "we can estimate the rate of merger events compared with the observed rates and it doesn't match." Again, this mismatch suggests that all of the dark matter that must be present in the universe cannot be comprised of primordial black holes with larger masses.

These combined constraints significantly limit the possible mass ranges where primordial black holes could still be viable dark matter candidates, meaning that another explanation is required.

Another leading candidate for dark matter is a class of particles known as WIMPs, or Weakly Interacting Massive Particles. "WIMPs are hypothetical particles that are proposed to have properties like those of dark matter," states Tomaselli. WIMPs are thought to interact only through the weak nuclear force and gravity, to have a large mass compared to standard particles, to be electromagnetically neutral, and to move relatively slowly.

The WIMP hypothesis arose as a potential solution to the dark matter problem in the 1970s. Such particles are theorized to have been produced during the earliest moments after the Big Bang, similar to the way in which ordinary matter formed.

Dark matter could indeed be made from WIMPs, which would explain several astrophysical and cosmological observations. Including WIMP-like dark matter in simulations of galaxy formations and structure produces results that closely match observations.

However, detection experiments, such as the XENON experiments that took place at the INFN Laboratori Nazionali del Gran Sasso, Italy,[5] have not found evidence of WIMPs. Even indirect detections that might confirm the existence of such particles have been unsuccessful. As Tomaselli explains, "in some models, WIMPs are thought to annihilate and emit photons. Because we have not experimentally identified any such photons, we can eliminate many WIMP models."

Thus, while WIMPs remain a potential candidate for dark matter, their existence is still hypothetical, and alternative theories such as axions are also being explored.

Like WIMPs, axions are hypothetical elementary particles. But, in Tomaselli's words, they are "much harder to eliminate" as candidates for dark matter. Axion particles are theorized to be extremely light, electrically neutral, and would interact very weakly with ordinary matter—properties that make them a suitable dark matter candidate.

Axions were first proposed as a theoretical solution to a problem in the field of quantum chromodynamics. They were named by Frank Wilczek, Professor (1989–2000) in the School of Natural Sciences, after a brand of laundry detergent! This is supposedly because the particles "cleaned up" a major outstanding problem in his area of research.

A *New York Times* article, published in 2024, that discussed the search for dark matter dubbed axions "darker than night [and] barely more substantial than a thought." Indeed, if they do comprise dark matter, the tiny mass of axions and their extremely weak interactions with other matter and light would explain why they remain so difficult to detect.

Axions possess another important quality. "If dark matter is made of axions, we can think of it as a wave, rather than as a collection of particles," explains Tomaselli. "This is because every particle has a 'wavelength.' The less mass a particle has, the larger its associated wavelength. So, very light particles tend to be spread out and their wavelengths overlap with each other. That's why you can consider them as one collective fluid."

Tomaselli's own research focuses on wave-like dark matter. While many researchers concentrate on identifying particular dark matter particle candidates (such as axions), Tomaselli explores the broader implications of treating dark matter as a wave-like phenomenon. "I am not proposing that dark matter consists of a specific hypothetical particle," he says. "Instead, I am using wave dark matter as a framework."

TOMASELLI'S MOST RECENT PAPER, written during his time at IAS, examines how wave dark matter would interact with pairs of supermassive black holes that exist in the universe today.[6] The pairs of black holes that he is interested in orbit one another and are known as "black hole binaries."

He explains: "If you have two black holes that orbit each other and also some dark matter, specifically wave dark matter, around them, what is the energy exchanged between the black hole binary and the dark matter around it? How does the dark matter profile look around the binary?"

While other researchers have approached this question through computer simulations, Tomaselli took a more fundamental approach. "Simulations had identified some interesting results, namely that wave dark matter forms a distinctive density pattern around orbiting black hole pairs," he says. "My contribution was to re-do this work analytically. So, with pen and paper plus some aid from the computer, I solved the first principal equations for the problem. This gives you more insight into what's going on than the simulation alone."

Tomaselli provided a mathematical explanation for this density pattern, showing that it results from a scattering process where dark matter waves fall into the binary's gravitational field and are then kicked back out by the spiraling black holes.

In addition to changing the patterns in the dark matter, the interaction also affects the binary system. "A small amount of energy is drawn away from the binary," says Tomaselli. The black holes begin to "spiral a bit faster" toward each other, causing them to merge more quickly.

Perhaps most importantly, Tomaselli's paper proposed a potential way to observe this phenomenon. His research suggests that these interactions between wave dark matter and supermassive black hole binaries could leave signatures in gravitational wave observations.

Specifically, he argues that "pulsar timing arrays, which are a new way of detecting low frequency gravitational waves, could be used to probe this kind of interaction and provide some insight on wave dark matter."

Looking wider, Tomaselli's innovative work on wave-like dark matter offers a promising new avenue, suggesting that gravitational wave observations may provide a window into this hidden realm.

THOUGH CURRENTLY INVISIBLE to our eyes and even the most sensitive detection instruments, dark matter continues to silently shape the cosmos, inviting scholars at IAS and beyond to develop new tools and perspectives to unveil its secrets.

Giovanni Maria Tomaselli is a Member in the School of Natural Sciences. In 2024, he received his Ph.D. from GRAPPA (Gravitation & Astroparticle Physics Amsterdam) at the University of Amsterdam. Beyond dark matter, his research interests span gravitational physics, theoretical and astrophysical aspects of black holes, gravitational wave astronomy, and particle physics beyond the Standard Model. His work has been published in *Nature Astronomy*, *Physical Review*, and the *Journal of Cosmology and Astroparticle Physics*, among others.

[5] XENON experiments use tanks of ultra-pure liquid xenon located deep underground to search for dark matter. Their sensitive instruments aim to detect tiny light flashes produced when particles such as WIMPs interact with xenon atoms. Despite being among the most advanced detectors in the world, they have yet to find conclusive evidence of dark matter.

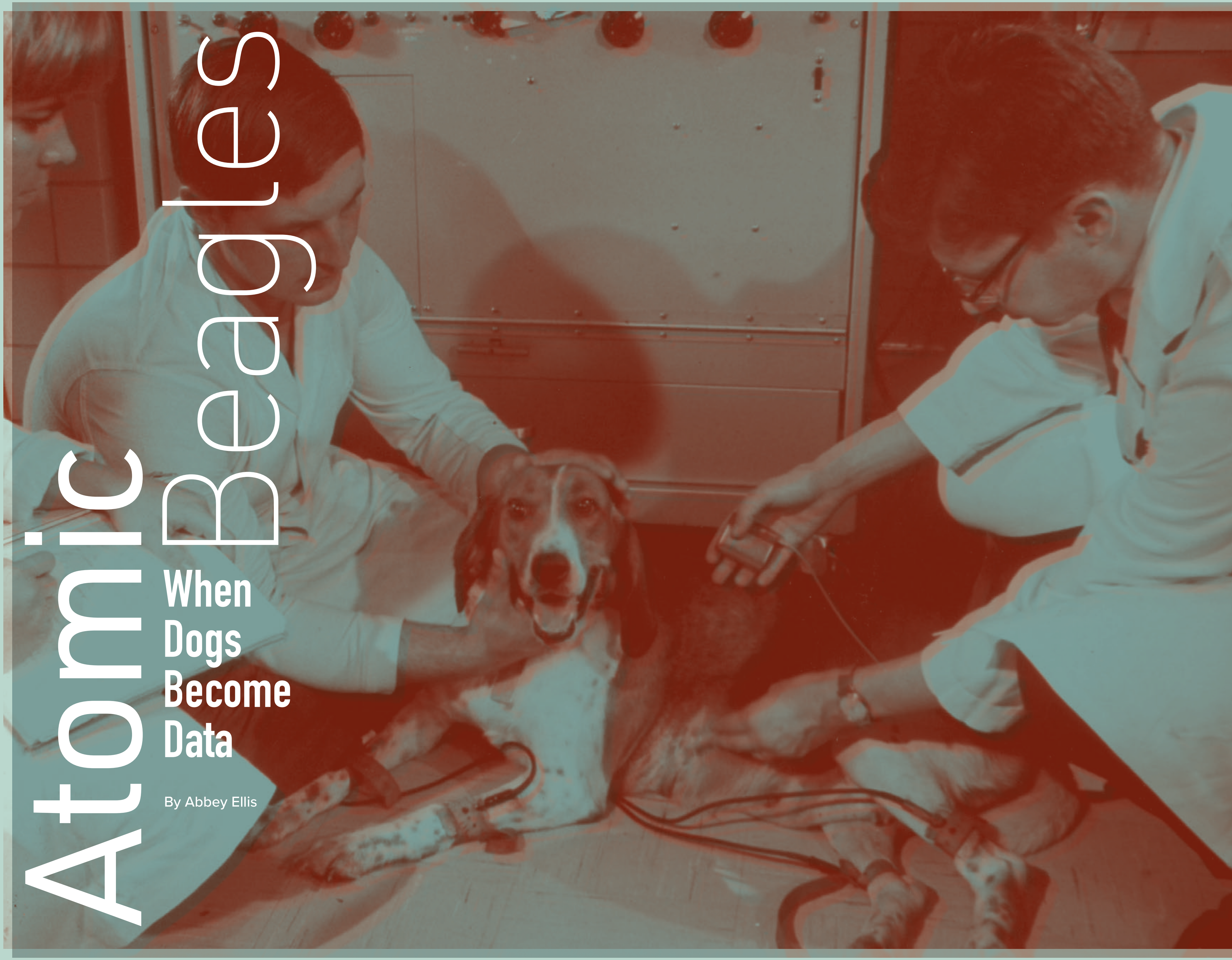
[6] Tomaselli, G. M. 2025. "Scattering of wave dark matter by supermassive black holes." https://doi.org/10.1103/PhysRevD.111.063075

NASA's Goddard Space Flight Center and Scott Noble, simulation data by d'Ascoli et al. 2018

Atomic Beagles

When Dogs Become Data

By Abbey Ellis



In the annals of scientific progress, certain notions loom large: the brilliant researcher, the groundbreaking discovery, the transformative new application of knowledge.

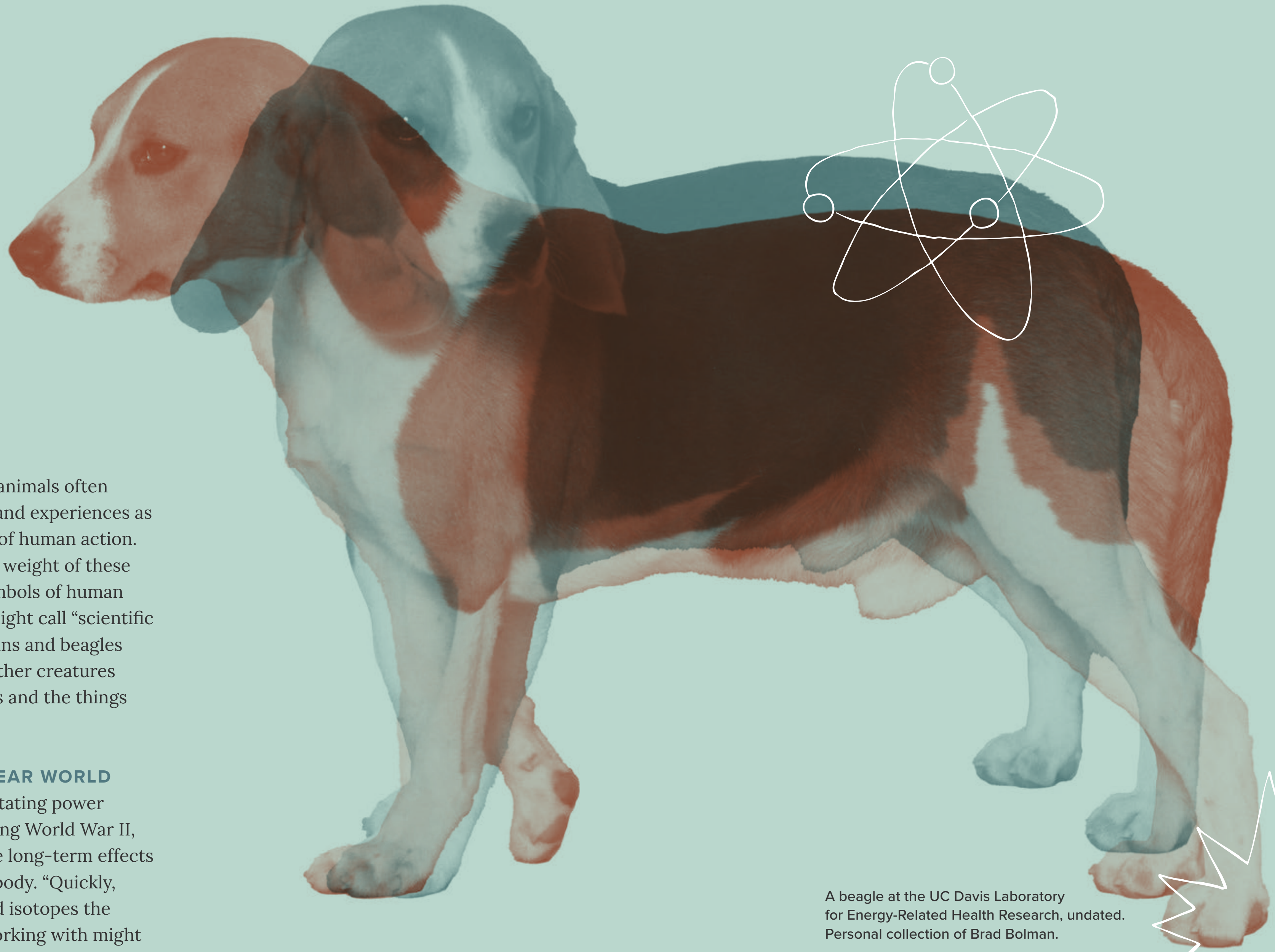
For example, when one thinks of scientific developments during World War II, one will likely picture the Manhattan Project, led by IAS Director (1947–66) J. Robert Oppenheimer, undertaking top secret work at Los Alamos. In developing the world's first nuclear weapons, Oppenheimer and his colleagues made a truly monumental breakthrough that effectively ended the war, a narrative immortalized by Christopher Nolan's recent film.

But this is not the only story to be told.

What springs to the mind of Brad Bolman, Member in the School of Historical Studies, when he thinks of World War II is beagles. His research, set to be published as *Lab Dog: What Global Science Owes American Beagles* by the University of Chicago Press this May, delves into the fascinating and often unsettling story of how the beagle became the most popular dog breed for scientific experimentation in the twentieth century. Although intimately entwined with the Manhattan Project and World War II, this history is far less known.

Through his investigations into beagles, Bolman's work highlights the value of discoveries that are not always characterized by dramatic triumphs and are instead the result of slow, incremental, but nevertheless meaningful contributions to knowledge.

A beagle implanted with a nuclear-powered pacemaker at the National Heart Institute of the National Institute of Health, Bethesda, Maryland. c. 1972. ENERGY.GOV - HD.17.080.



A beagle at the UC Davis Laboratory for Energy-Related Health Research, undated. Personal collection of Brad Bolman.

It also brings into focus the way animals often serve as proxies for human ailments and experiences as scientists address the consequences of human action. Beagles, in particular, have borne the weight of these human dilemmas, serving as both symbols of human empathy and casualties of what we might call "scientific progress." The entanglement of humans and beagles reflects how our relationships with other creatures shape our understanding of ourselves and the things on which we place value.

A STANDARD DOG FOR A NUCLEAR WORLD

As the world grappled with the devastating power and promise of nuclear weapons during World War II, scientists also began to scrutinize the long-term effects of radiation exposure on the human body. "Quickly, it became clear that the elements and isotopes the Manhattan Project scientists were working with might be quite dangerous," says Bolman.

In the early part of the twentieth century, the dangers of certain radioactive substances, such as radium, were already well-documented. "Marie Curie's fatal illness from radium poisoning and the horrifying cases of watch dial painters falling sick from radium paints were common knowledge," Bolman recounts. But plutonium, a newly discovered and highly unstable element, posed a far greater mystery. How would prolonged exposure to even small amounts of such radioactive materials affect human health over decades?

To investigate such questions, at the same time that Oppenheimer and his team were at work in the desert of New Mexico, so-called "health physicists" elsewhere in the U.S. were conducting basic biological research into the effects of plutonium exposure. Gathering such data with traditional lab animals, like rats, was extremely difficult, so scientists turned to larger animals, including dogs, to gain greater insight.

In their quest, they strove to identify a so-called "standard dog," a consistent, predictable research subject that could be used across various experiments, a model organism that would allow scientists to draw reliable conclusions about the effects of radiation on living beings. "A lot of different dog breeds were explored," says Bolman. "But beagles were among the most popular dogs in the United States at the time. With their medium size and gentle temperament, they emerged as the breed of choice."

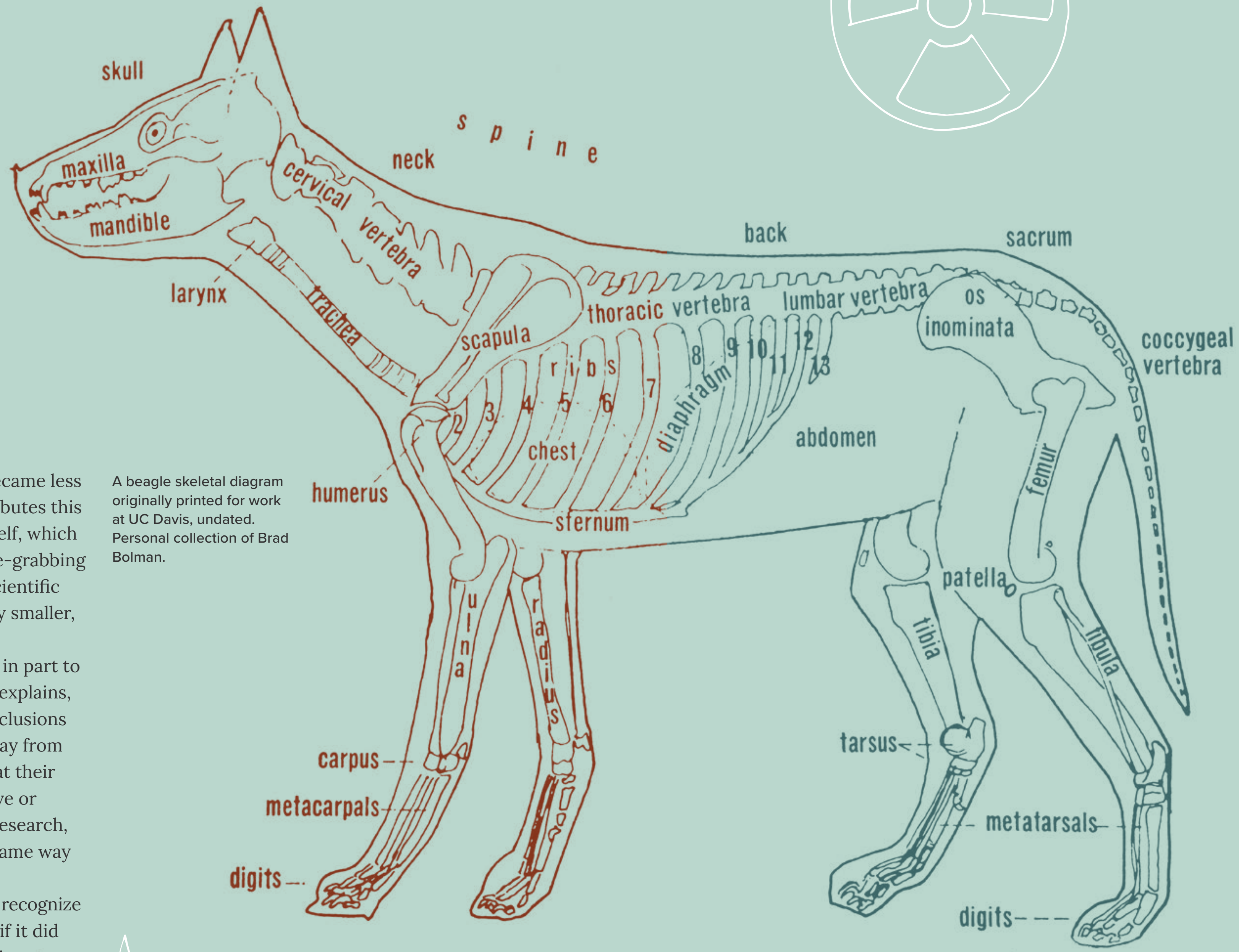
Large-scale beagle laboratories were established across the United States. These facilities subjected dogs to controlled doses of radiation. "Beagles were fed radioactive food or injected with small amounts of radioactive material, for instance," states Bolman.

These experiments served multiple purposes. On one hand, they were meant to help scientists understand how to protect those working directly with radioactive materials. On the other, they addressed broader questions about the safety of nuclear technology. "People started to think very quickly about what would happen when nuclear reactors became widespread after the war," explains Bolman. "Scientists asked whether it was safe for soldiers to fly in planes powered by atomic reactors, or for employees to work for years at civilian reactors."

Indeed, research with beagles did prove to be important for establishing the terms of radioactive safety. In 1949, American, British, and Canadian researchers met at Chalk River in Ontario, to decide on international standards for "safe" exposures to radiation. "The conference resulted in strict limits for what scientists called a 'permissible dose' of radiation, which would transform operations at nuclear laboratories," states Bolman. Letters exchanged among scientists working on nuclear projects, which Bolman analyzed for his book, showed that there were concerns over the potential impact on ongoing research. "Scientists, for instance at Los Alamos, were worried that if the Chalk River limits were adopted as the U.S. federal standard, many of their projects would have to be shut down," continues Bolman.

The first beagle research programs aimed to revise those standards. Starting in 1950, beagle projects were set up at the University of Utah, the University of California Davis, the Hanford Site in Washington, the Lovelace facility in Albuquerque, and the Argonne National Laboratory in Chicago. Research conducted at these facilities became the foundation for future ideas about radiation safety and protection.

Yet despite their critical contributions, the role of beagles in research has remained, for many years, largely overlooked. Studies with dogs, which were once



A beagle skeletal diagram originally printed for work at UC Davis, undated. Personal collection of Brad Bolman.

considered essential to scientific progress, became less popular with the public. But Bolman also attributes this lack of attention to the nature of the work itself, which was slow, methodical, and lacked the headline-grabbing breakthroughs often associated with major scientific achievements. Beagle research was defined by smaller, incremental discoveries.

"When the projects were shut down, due in part to Reagan administration funding cuts," Bolman explains, "many ended without reaching the grand conclusions scientists had hoped for. The ultimate takeaway from some of these projects was ambiguous, even at their end, many decades later." This lack of definitive or transformative outcomes meant that beagle research, as Bolman puts it, was not "valorized" in the same way as other celebrated scientific advancements.

However, Bolman emphasizes the need to recognize the importance of this kind of research, even if it did not produce groundbreaking discoveries. "This sort of quotidian, basic work—like taking care of a dog for decades—is really critical to the production of knowledge," he argues. "Although not all research projects ultimately produce world-changing transformations, they nevertheless contribute to the broader undertaking of trying to understand what human beings are and how we should live—as well as what other animals are and how they should live. This less 'glamorous' research is still an essential piece of the history of science."

"Atomic beagles," in their silent (or barking) service, have contributed to more than just an understanding of radiation exposure. Their sacrifice is a reminder of the quiet, often invisible labor that underpins scientific progress—and of the ethical and existential questions that arise from a reliance on animals in the pursuit of human understanding.

BLURRED LINES FOR MAN'S BEST FRIEND

Bolman's research also uncovers a paradoxical relationship between the scientists and the beagles they studied. Despite conducting sometimes painful experiments, researchers also identified deeply with the animals, even building a sense of community around them.

"The people running these facilities thought of themselves as part of a 'Beagle Club,'" Bolman notes. Club members met regularly, shared "beagle news," and referred to each other using canine metaphors.

For example, at the Davis laboratory, one of the longest-running beagle research facilities, director Leo Bustad affectionately referred to his colleagues as "Beaglers," a term traditionally used for those who hunt with beagles. His letterhead featured a cartoon of him with a beagle rummaging through a trash can, and annual reports often featured beagles on their covers. The scientists seemed to define themselves through their relationship with the dogs.

This odd relationship between man and dog further underscores the symbolic role that beagles played in scientific contexts. Beyond radiation studies, beagles were used in experiments exploring the effects of cigarette smoking, the long-term use of hormonal contraceptives, and even Alzheimer's disease. Just as they served, in Bolman's words, as "simulated humans" for understanding the impact of radiation exposure, the dogs also stood in for habitual smokers, women taking birth control, or aging parents.

The duality of the beagle—as both deeply humanized and expendable—highlights the blurred lines between species in scientific research. In some cases, the distinction between beagle and human was neatly erased, with the dogs treated as stand-ins for human physiology and cognition. Yet in others, the boundary was stark and unforgiving: many dogs were ultimately sacrificed to benefit the humans they were meant to represent.

Bolman's research explores how scientists have thought about this contradiction over many decades: "How do you justify killing an animal that is so similar to us, and how do we decide that one animal is more similar than another? Why would you pick a beagle as opposed to a pig or a goat or a horse? These are surprisingly difficult and fundamental questions."

The ambiguity of the human/animal relationship extends beyond individual experiments to broader ethical debates about animal research. Bolman argues that animal experimentation is often oversimplified into binaries: good or bad, moral or immoral. But the reality is multifaceted. "Some research dogs lived far longer than their pet counterparts, and some studies contributed unexpectedly to veterinary practice. We can be critical of troubling research without arguing that nothing was learned from decades of work," he explains.

Indeed, many researchers cared deeply for the animals in their charge. During the 1980s, when many beagle research programs shut down, scientists fought to keep the projects alive. In Bolman's view, they did this not only because of the scientific value of the work, but also because they had grown emotionally invested in the dogs.

Furthermore, some scientists referred to the beagles as the "governors" of the research projects, acknowledging that the daily rhythms of laboratory life were dictated by the dogs' needs and behaviors. Even the breeding cycles of the beagles shaped the pace of the experiments.

Yet despite the scientists' emotional attachments and their evident awareness of the dogs' agency, beagles remained tools for solving human problems. Bolman emphasizes this by saying: "We created the atomic bomb and all of the problems that followed from that, and the dogs emerged, in part, as a way to find answers." In this sense, the beagles were transformed into "living tools," proxies used to address the consequences of human action. "It's our human follies that often become the subject of research with animals," Bolman adds. "One newspaper story from the 1950s about the beagle research described it as an inability to put a leash on ourselves." In his book, Bolman argues that if we want to rethink how animals are treated in scientific research, we must first reconsider the organization of human worlds. The problems that humans create—whether nuclear fallout, pharmaceutical dependency, or environmental degradation—so often become the justification for animal experimentation. The story of beagles in science is a record of many of the major dilemmas of modern life.

Bolman, who lives with a rescue dog, stresses that humans have long used dogs as tools in one form or another. "Beagles were originally designed, or bred, as hunting technologies, and many pet breeds were advertised as leisure technologies," he notes. But other ways of living together, in which dogs and humans can both thrive, are possible. "Doing better for dogs will require us to do better for each other," Bolman concludes.

John Dalby, active 1826–53, *Beagles in Full Cry*, 1845, Oil on canvas, Yale Center for British Art, Paul Mellon Collection, B2001.2.195.

MOVING FORWARD TO FUNGI

Bolman's next book, focused on the history of the study of mycology, flips the questions that initiated his work on *Lab Dog* on their head. "With the dogs project, I was interested in what happens when someone conducts research on an organism that is understood to be like us," he explains. "But in the history of mycology, you see people working to understand organisms that seem radically different from them. We don't identify so much with fungi: they can be difficult to see and difficult to visualize. I want to explore how scientists deal with this."

His projects represent two sides of the same coin, seeking to understand how human relationships with both the familiar (in the case of the beagles) and the alien (in the case of the fungi) shape our understanding of ourselves.

Brad Bolman is a Member in the School of Historical Studies. He received his Ph.D. in the history of science from Harvard University in 2021 and moved to the Institute in 2023 after completing postdoctoral research at the University of Chicago's Institute on the Formation of Knowledge. He is an incoming Assistant Professor in History and Environmental Studies at Tulane University. His articles have been published in the *Journal of the History of Biology*, *Isis*, and popular magazines such as *The Drift*.

Limestone head of a boy, almost life-size, dated 230 C.E.

Courtesy of Ny Carlsberg Glyptotek, Anders Sune Berg

A Face Out of Place

In 2024, Rubina Raja, Member (2019) in the School of Historical Studies, received a Semper Ardens Advance grant from the Carlsberg Foundation for her project titled "Locally Crafted Empires" (LoCiS). This project builds on work that she conducted during her time at IAS, namely a study of more than 4,000 Roman-period portraits from Palmyra in Syria. Below, Raja shares, in her own words, an up-close look at one of the so-called "loose heads" that make up the Palmyra Portrait Project.

Around 4,000 portraits survive from Palmyra in Syria, making it the largest sculptural corpus from the ancient world outside of Rome itself. That makes it hugely significant. But only 1% of that portraiture has actually been found in its original archaeological context—that is, the place it was set up after production in antiquity.

This head came to Ny Carlsberg Glyptotek, Copenhagen in the 1880s as part of brewing magnate and art collector Carl Jacobson's efforts to buy up the largest collection of Palmyrene portraits that survives from the ancient world.

Its procurement was less than salubrious: the head has been chopped out of the larger relief of which it was originally a part. Such actions by nineteenth century "collectors'" networks were not unusual—this is why we have so many loose heads from Palmyra! And actually, that's how it is with most archaeological material that entered European collections in the eighteenth and nineteenth centuries. The looting of graves and archaeological sites was common back then, and remains so today in Syria, the wider Mediterranean, and beyond.

One of the problems with a lot of archaeological material in general, in collections around the world, is that they have no primary context. This head is a great example; because of its "classicizing" style—i.e., its imitation of ancient Greek sculptural styles—David Simonson, who first catalogued the head in 1889, believed that it could certainly not be Palmyrene, but had to be imported from Greece.

Today, we know that this is entirely wrong. The head is made out of the local limestone sourced right outside of Palmyra.

It would have been part of a relief showing a scene of banqueting or religious activity such as a sacrifice. The figure would likely have represented a servant wearing a local costume.

It might be tempting to say, "Oh, the local Palmyrans were simply mimicking beautiful, Greek sculptures that they had seen in other places," but when we consider the likely context of the object, we actually see that they picked and chose various elements (local, eastern, and "classicizing") for unique, local situations.

The realization that this was not an imported Greek piece and was

Courtesy of Ny Carlsberg Glyptotek, Anders Sune Berg

instead produced onsite by local craftsmen in local material flips the worldview of what sort of place Palmyra was in the ancient world.

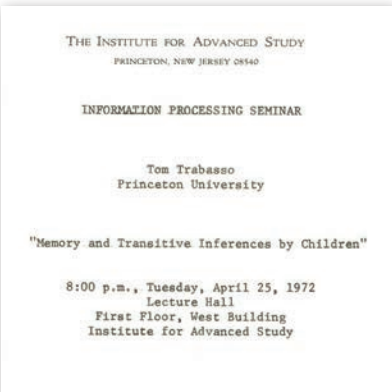
Context forces us to think about the ancient world with a completely different perspective, opening up avenues for new discussions of knowledge. So, even if we can't place things back exactly in the primary situation in which they would have been found, we still need to think around the piece and around its original function, and not make assumptions about it.

Objects make us think about things in a nonverbal way. We can then put that thinking into our own narrative about a place or about the ancient world more broadly. That's what I find exciting about objects—that they give us insights into stories or ideas or ways of dealing with the past, and ways that the past dealt with their contemporary world, which texts that survive from antiquity simply can't.

Organization, Communication, and Decision

The Cognitive Revolution at IAS

By Karen Clausen-Brown

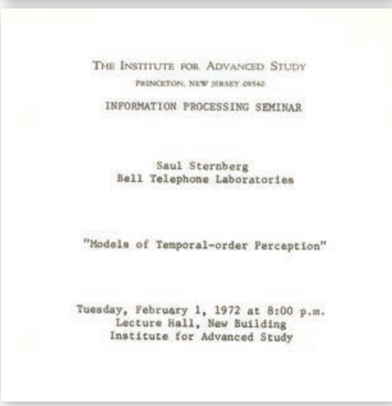

THE INSTITUTE FOR ADVANCED STUDY
PRINCETON, NEW JERSEY 08540

INFORMATION PROCESSING SEMINAR

Tom Trabasso
Princeton University

"Memory and Transitive Inferences by Children"

8:00 p.m., Tuesday, April 25, 1972
Lecture Hall
First Floor, West Building
Institute for Advanced Study


THE INSTITUTE FOR ADVANCED STUDY
PRINCETON, NEW JERSEY 08540

INFORMATION PROCESSING SEMINAR

Saul Sternberg
Bell Telephone Laboratories

"Models of Temporal-order Perception"

Tuesday, February 1, 1972 at 8:00 p.m.
Lecture Hall, New Building
Institute for Advanced Study

Information Processing Seminar flyers, 1972. From the Institute for Advanced Study (Princeton, NJ). Director's Office. Member records

At a meeting of the Institute Faculty held on November 2, 1966, Carl Kaysen, IAS Director (1966–76), announced his idea for a program in the new School of Social Science. He explained that the program would focus on "what might best be described as organization, communication, and decision." This area of study, he said, would be an interdisciplinary field in which "the work of sociologists, political scientists, economists, psychologists, neuropsychologists, linguists, and students of the logic of computing, all converged." Kaysen did not yet have a name for this new area of study, but today we know it as "cognitive science" and we refer to its beginnings as the "cognitive revolution."

In the cognitive revolution, psychologists, recognizing that developments in information processing had potential for studying the human mind, sought for the first time to apply new ideas in early artificial intelligence, computer science, and neuroscience to psychology. The Institute, as the home of one of the first modern computers, was uniquely poised to serve as an early hub for this nascent field of study. The Institute's tenure as a gathering place for cognitive scientists would ultimately prove short-lived, yet the program Kaysen began in the School of Social Science represents a milestone in the Institute's history, a significant early attempt to venture into a new and still undefined area of research. Records in the Institute's Shelby White and Leon Levy Archives Center offer a glimpse at this bold effort, decades in the making.

In May 1946, twenty years prior to Kaysen's announcement, several of the Institute's early scholars attended the first in a series of interdisciplinary conferences focused on applying tools from the physical sciences and mathematics to the biological and social sciences. For eight years, the Josiah Macy Jr. Foundation hosted this series of conferences, now known as the Macy Conferences, in New York City and Princeton. The conferences included John von Neumann, Professor (1933–55) in the School of Mathematics and head of the Electronic Computer Project (1946–55); Claude Shannon, Member (1940–41) in the School; and Julian Bigelow, who served as a Member from 1946–2003 across the Electronic Computer Project and the Schools of Mathematics and Natural Sciences. They worked alongside Princeton University Professor Oskar Morgenstern and significant social scientists such as Margaret Mead and Gregory Bateson. For nearly a decade, the conferences placed Institute community members at the forefront of efforts to apply information theory and computing to human and social sciences.

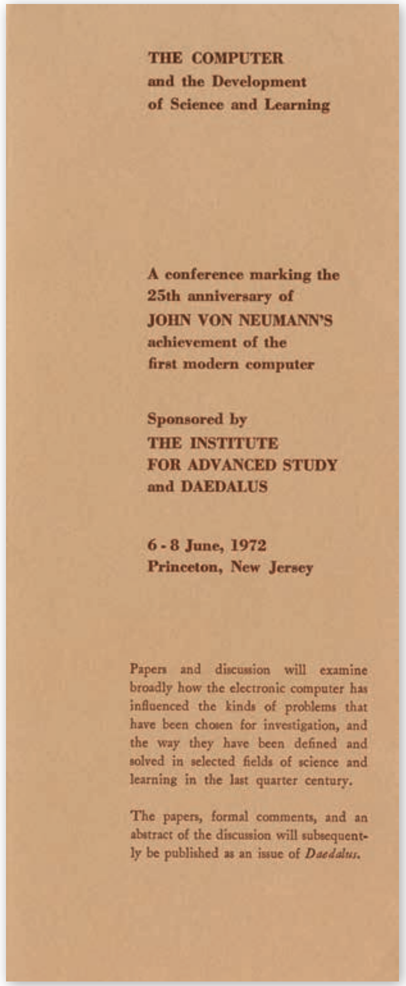
Meanwhile, IAS Director (1947–66) J. Robert Oppenheimer, laid the groundwork for a program that would bring this work to the Institute. Seeking to broaden the kinds of research being conducted at the Institute, Oppenheimer asked the Board of Trustees in 1947 for a special fund that would offer "opportunity for exploring new fields outside and beyond the specific areas of the schools." The Board granted Oppenheimer a Director's Fund to bring in individuals working in disciplines outside of the established Schools of the Institute. They included a host of distinguished scholars, including important literary theorists and writers, like T. S. Eliot, and distinguished biologists, like George Wald. Anticipating an opportunity on the horizon for fruitful new work in psychology, Oppenheimer also began to explore the idea of using the fund to invite psychologists.

Computer tape containing Herman Goldstine's lecture for the Conference Marking the 25th Anniversary of John von Neumann's Achievement of the First Modern Computer, June 6–8, 1972. From the Carl Kaysen papers

Oppenheimer first expressed an interest in psychology, and particularly in the new efforts to use quantitative methods in psychology, in a planned address for the American Psychological Association (APA) in 1948. Though Oppenheimer never actually delivered the proposed lecture due to scheduling conflicts, he wrote to the APA President Donald Marquis that he had "hoped in particular to stress some of the important analogies between the work in physics and the work in psychology."

By November 1949, Oppenheimer would use the new Director's Fund to invest in an exploratory psychology conference at the Institute. Jerome Bruner, a pioneer in cognitive science who would become a co-founder with George Miller of the Center for Cognitive Studies at Harvard in 1960, was invited, as well as a group of other eminent scholars: Frank A. Beach, Edwin Boring, Dorwin Cartwright, Ernest Hilgard, David M. Levy, Donald Marquis, Helen Peak, Robert Richardson Sears, David Shakow, Edward C. Tolman, and Dael Wolfle. Jerome Bruner reported in his notes that the conference served "to assess the kinds of theoretical inquiry which might be fruitfully undertaken by a smaller working team of psychologists at the Institute."

Identifying the areas of inquiry that seemed suitable to psychologists at the Institute was more difficult than Oppenheimer had hoped, however. And, more widely, determining the direction and goals for the new interdisciplinary field as a whole proved a formidable challenge. Later, in a 1950 letter to Oppenheimer, Jerome Bruner reflected on the conference: "Our week in Princeton served well in showing that there is no such clear-cut objective to be sought. The field of psychology is not highly enough developed to be able to name in advance its most promising objective with any hope of being able to reach that objective, or even to sketch it with clarity in advance." Based on what Oppenheimer observed at the 1949 conference, he decided against establishing a full-fledged



THE COMPUTER
and the Development
of Science and Learning

A conference marking the
25th anniversary of
JOHN VON NEUMANN'S
achievement of the
first modern computer

Sponsored by
THE INSTITUTE
FOR ADVANCED STUDY
and DAEDALUS

6 - 8 June, 1972
Princeton, New Jersey

Papers and discussion will examine broadly how the electronic computer has influenced the kinds of problems that have been chosen for investigation, and the way they have been defined and solved in selected fields of science and learning in the last quarter century.

The papers, formal comments, and an abstract of the discussion will subsequently be published as an issue of *Daedalus*.

Program for the Conference Marking the 25th Anniversary of John von Neumann's Achievement of the First Modern Computer, June 6–8, 1972. From the Institute for Advanced Study (Princeton, NJ). Director's Office. Faculty records

psychology program at the Institute.

Apparently still believing that promising work lay ahead for psychology, however, Oppenheimer began to fund individual scholars working in the field of psychology who might benefit from time at the Institute. The first of these psychologists began to arrive in 1950, including George Miller, Member (1950–51) in the School of Mathematics, an early contributor to the field of psycholinguistics; Jerome Bruner, Member (1951–52) in the School; and David M. Levy, also Member (1951–53) in the School, an innovator in child psychology.

These first scholars opened the door for others. In May 1952, Oppenheimer sent a letter of invitation to the psychologists Boring, Bruner, Miller, and Tolman, as well as Paul Meehl and Ruth Tolman. In the letter, Oppenheimer invited the addressees to serve on an advisory panel that would consult on "instances in which membership in the Institute would be of benefit to scientific progress in psychology." This advisory panel consulted with Oppenheimer throughout the 1950s. In that decade, the Institute hosted about a dozen eminent scholars in psychology, including Jean Piaget, Member (1954) in the School of Mathematics, and Noam Chomsky, Member (1958–59) in the School, another founder of the field of cognitive psychology.

For reasons that remain undocumented, the Institute and Oppenheimer ceased such targeted efforts in 1961. Yet Carl Kaysen, within months of stepping into the role of Director in 1966, redoubled Oppenheimer's earlier efforts. In a press release dated June 19, 1967, the Institute announced the beginning of a three-year experimental pilot "Program in Social Science," which would run from 1968 to 1971. This program would include scholars working on "organization, communication, and decision."

The new program represented the most robust effort yet to provide a home for scholars working in cognitive science. In the spring of 1968, Kaysen extended a formal offer of the position of Visiting Professor to R. Duncan Luce, a preeminent scholar in mathematical psychology. Kaysen proposed that Luce would explore the "theoretical aspects of the study of organization, communication and decision in both social organizations and in the functioning of the individual" and would be "invited to take the lead in shaping this part of the program." Kaysen turned to George Miller as a second senior scholar to lead the program, and Miller returned to the Institute as a Member (1970–72) and Visitor (1972–76), first in the Program in Social Science and then the School of Social Science.

The 1970–71 and 1971–72 academic years saw the peak of the Institute's involvement in the cognitive revolution. Kaysen first hosted a conference in the fall of 1970, which aimed "to collect views from various eminences as to what the school might do." Participants included several cognitive scientists, with Luce and Miller foremost among them. From 1970–72, Luce organized regular seminars on topics in cognitive science, inviting participants from Bell Telephone Laboratories, the Educational Testing Service, Princeton University, Rutgers University, and the University

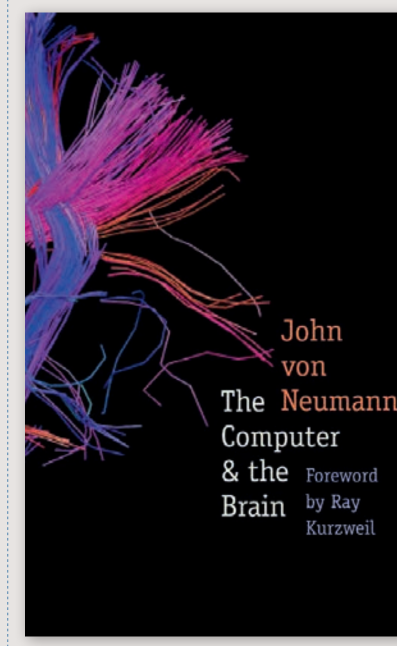
In the cognitive revolution, psychologists, recognizing that developments in information processing had potential for studying the human mind, sought for the first time to apply new ideas in early artificial intelligence, computer science, and neuroscience to psychology.

of Pennsylvania. These seminars offered occasions for cognitive scientists to gather and collaborate.

In June of 1972, the Institute hosted yet another important conference. It commemorated the 25th anniversary of the first modern computer, developed by John von Neumann. The speakers at the conference came from diverse areas of study, including pure and applied mathematics, logic and the foundation of mathematics, physics and astrophysics, applied physical sciences, economics, historical social sciences, biological sciences, and what was termed "language, learning, and models of the mind." In this final area of study, George Miller was the invited speaker.

Miller's lecture offered insightful reflection on the state of the cognitive revolution in the early 1970s as well as a succinct summary of how the computer had fundamentally altered the field of psychology over the past several decades. According to Miller, the most influential effect of the computer in his field had been what he called "the computer metaphor," specifically, the idea that "men and computers are merely two different species of a more abstract genus called 'information processing systems.'" Thus, von Neumann's theoretical work had contributed to a new metaphor for understanding of the mind. In *The Computer and the Brain*, von Neumann wrote, "The human brain is, after all, the best example we have of an intelligent system ... we can use these biologically inspired paradigms to build more intelligent machines." In Miller's address, he argued reciprocally that the computationally inspired paradigm of the machine could be used to better understand the human mind.

By the mid 1970s, the Institute's governing bodies agreed that it could no longer serve as a hub for the field of cognitive science. Under the influence of Clifford Geertz, Professor (1970–2006) in the School of Social Science, the School became an increasingly significant center for anthropological and sociological studies. Nonetheless, the Institute's efforts to foster the new field of cognitive science represent an important chapter in its history of sponsoring innovative, trailblazing research. The connections that George Miller drew between von Neumann's work and the work of later cognitive scientists like himself highlight the Institute's role in the development of modern computing, and how its unique approach to discovery positioned it to participate in the cognitive revolution. Recognizing its standing strengths but also seeking to expand its reach, the Institute sprang on the opportunity to venture into a new area of study and, in the process, played an important role in the birth of cognitive science.



John von Neumann, *The Computer and the Brain*. Foreword by Ray Kurzweil. New Haven: Yale University Press, 2012

FACULTY

Wendy Brown, UPS Foundation Professor in the School of Social Science, received a Sakıp Sabancı International Research Award for her lifetime contributions to scholarship on the theme of "Realigning Values in a Transforming World Order." Her work was the subject of a conference, "Democracy in Nihilistic Times: Thinking with Wendy Brown." She contributed to the inaugural "International Scientific Report on the Safety of Advanced AI," presented at the AI Action Summit hosted by the French Government, and was announced as the recipient of an honorary doctorate from Amherst College.

Francesca Trivellato, Andrew W. Mellon Professor in the School of Historical Studies, was selected to be a Visiting Fellow at the University of Oxford's All Souls College in May and June 2025.

2025 Frontiers of Basic Science Awards

The following Faculty and current Members were recognized in the 2025 International Congress of Basic Science (ICBS) Frontiers of Basic Science Awards:

SCHOOL OF NATURAL SCIENCES

Yichul Choi, Roger Dashen Member (Physics)
Juan Maldacena, Carl P. Feinberg Professor (Physics)
Nathan Seiberg, Charles Simonyi Professor (Physics)
Edward Witten, Professor Emeritus (Physics, Mathematics)
George N. Wong, Frank and Peggy Taplin Member (Theoretical Computer and Information Science)

SCHOOL OF MATHEMATICS

Xander Kelley, Member (Mathematics)
Camillo De Lellis, IBM von Neumann Professor (Mathematics)
Aaron Naber, Professor (Mathematics)
Akshay Venkatesh, Robert and Luisa Fernholz Professor (Mathematics)

Didier Fassin, James D. Wolfensohn Professor in the School of Social Science, published *Moral Abdication: How the World Failed to Stop the Destruction of Gaza*, and *Exile: Chronicle of the Border*, co-written with Anne-Claire Defossez, Visitor in the School.

Alondra Nelson, Harold F. Linder Professor in the School of Social Science, received three honors: the Morals & Machines Prize for impactful policy research; the NAACP – Archewell Digital Civil Rights Award for advancing digital inclusion; and New York University's Martin Luther King, Jr. Humanitarian Award for exemplifying "persistence in purpose."

Avi Wigderson, Herbert H. Maass Professor in the School of Mathematics, was inducted into the New Jersey Hall of Fame for groundbreaking insights in computer science.

EMERITI

Arnold J. Levine, Professor Emeritus in the School of Natural Sciences, was presented with an honorary doctorate in biochemistry and molecular biology from the University of Rome, Tor Vergata.

MEMBERS

Peter H. Christensen, Member (2022) in the School of Historical Studies, had his book *Prior Art* selected by the American Library Association's Choice Reviews as a 2024 Outstanding Academic Title.

Chris Hamilton, John N. Bahcall Fellow in the School of Natural Sciences, was recognized in the 2024 Early Career Collection of the Physics of Plasmas journal for a paper co-authored with Jean-Baptiste Fouvry, NASA Hubble Fellow (2016–19) in the School.

Ellie M. Hisama, Edward T. Cone Member in Music Studies (2024) in the School of Historical Studies and Visitor (2024–25) in the School of Social Science, received an honorary membership of the American Musicological Society.

John J. Hopfield, Visiting Professor (2010–13) in the School of Natural Sciences, was among the winners of the 2025 Queen Elizabeth Prize for Engineering.

Yue Hu, NASA Hubble Fellow in the School of Natural Sciences, was was awarded a 2025 Cecilia Payne-Gaposchkin Doctoral Dissertation Award from the American Physical Society's Division of Astrophysics.

Masaki Kashiwara, Member (1977–78) in the School of Mathematics, was awarded the 2025 Abel Prize.

David Leslie Kennedy, Member (1986–87, 2004) and frequent Visitor in the School of Historical Studies, was appointed as a Member of the Order of Australia.

Magdalena Małecka, Member (2020–21) in the School of Social Science, was awarded a Consolidator Grant by the European Research Council for a project titled "Encoded Knowledge: Epistemology of Computer Technology in Modern Economics."

John Forbes Nash, Member in the School of Mathematics (1956–57, 1961–64), was inducted into the New Jersey Hall of Fame in the category of Education & Science.

Nana Osei-Opare, Member (2022–23) in the School of Historical Studies, was recognized by the Association for the Study of the Worldwide African Diaspora as a 2024 Outstanding Article Prize finalist, for "Ghana and Nkrumah Revisited: Lenin, State Capitalism, and Black Marxist Orbits."

Sophia Rosenfeld, Ed Kaufmann Founders' Circle Member (2014–15) in the School of Social Science, had her book *The Age of Choice: A History of Freedom in Modern Life* selected as an Editors' Choice by *The New York Times*.

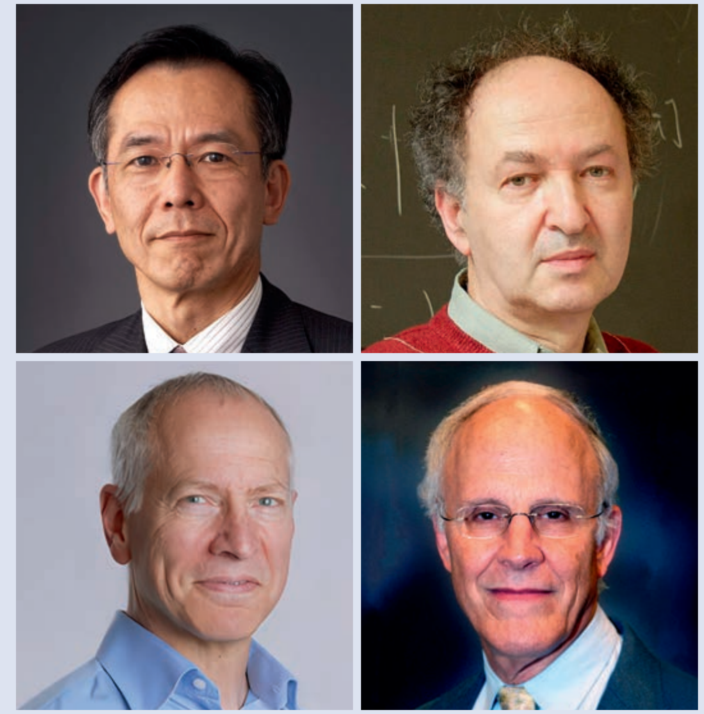
SherAli K. Tareen, Patricia Crone Member in the School of Historical Studies, was shortlisted for an American Academy of Religion award for his book *Perilous Intimacies: Debating Hindu-Muslim Friendship After Empire*.

INSTITUTE

Derek Bermel, Artist-in-Residence (2009–13), was named a member of the American Academy of Arts and Letters.

Robbert Dijkgraaf, IAS Director and Leon Levy Professor (2012–22), was appointed as President-Elect of the International Science Council.

David M. Rubenstein, IAS Trustee since 2005, was awarded the Presidential Medal of Freedom by President Joe Biden. He was also presented with the Dwight D. Eisenhower Medal for Leadership and Service by Eisenhower Fellowships.



Four IAS Scholars Recognized with Basic Science Lifetime Awards

The International Congress of Basic Science (ICBS) has announced their 2025 Basic Science Lifetime Award laureates; four of the six are past IAS Members. The honor recognizes scientists who have brought about "fundamental change" in their fields over the course of the past thirty years or more.

Shigefumi Mori, Member (1981–82) in the School of Mathematics; **George Lusztig**, Member (1969–71, 1988, 2020) and Distinguished Visiting Professor in the School (1998–99); **Robert Tarjan**, Member (1990) in the School; and **David Jonathan Gross**, Member (1973–74, 1977–78) in the School of Natural Sciences, have received the prestigious award.

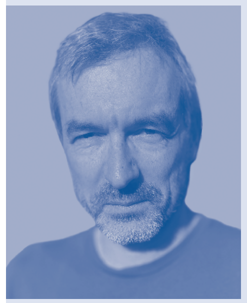
Mori was recognized for his "groundbreaking contributions to algebraic geometry," which have "shaped the discipline and inspired generations of mathematicians."

Lusztig was lauded for his "pioneering work" in Deligne-Lusztig theory—named for him and Pierre Deligne, Professor Emeritus in the School of Mathematics.

Tarjan, who ICBS dubbed "a trailblazer in computer science and engineering," was described as having "reshaped the field of information science."

Gross was cited for his significant contributions to understanding the fundamental forces of nature, which have helped to unravel "the deepest mysteries of the universe."

Three IAS Scholars Named as 2025 Breakthrough Prize Foundation Laureates



Three IAS scholars have been named among the 2025 Breakthrough Prize Foundation laureates: **Dennis Gaitsgory**, Member (1996–97, 1998–99) in the School of Mathematics; **Gerard 't Hooft**, Visitor (1973) in the School of Natural Sciences; and **John Pardon**, Visitor (2016–17) in the School of Mathematics.

Gaitsgory was awarded the Breakthrough Prize in Mathematics for "his central role in the proof of the geometric Langlands conjecture." His work was described as "a monumental advance, expected to have deep implications in other areas of mathematics."

't Hooft received the Special Breakthrough Prize in Fundamental Physics. He was lauded for having made "crucial contributions to the foundations of what would later become known as the Standard Model of the sub-atomic particles."

Pardon was one of three winners of the New Horizons in Mathematics Prize. He was praised for producing "a number of important results in geometry and topology, particularly in the field of symplectic geometry and pseudo-holomorphic curves."

Past IAS Scholars Honored in 2025 AMS Awards

Ten past IAS scholars from the School of Mathematics have received 2025 American Mathematical Society (AMS) Awards.

Jinyoung Park, Member (2020–21), received the Levi L. Conant Prize for her "exquisitely written" article titled "Threshold Phenomena for Random Discrete Structures."

Sean Keel, Member (1994–95, 2017), and **Maxim Kontsevich**, Member (1992–93) and Visitor (2002), were among the recipients of the E. H. Moore Research Article Prize for an article on cluster algebras.

Ana Caraiani, Veblen Research Instructor (2013–16) and Veblen Fellow (2015–16), was presented with the Ruth Lyttle Satter Prize in Mathematics for "contributions to arithmetic geometry and number theory."

Ben Green, Member (2007), was the recipient of the inaugural I. Martin Isaacs Prize for Excellence in Mathematical Writing.

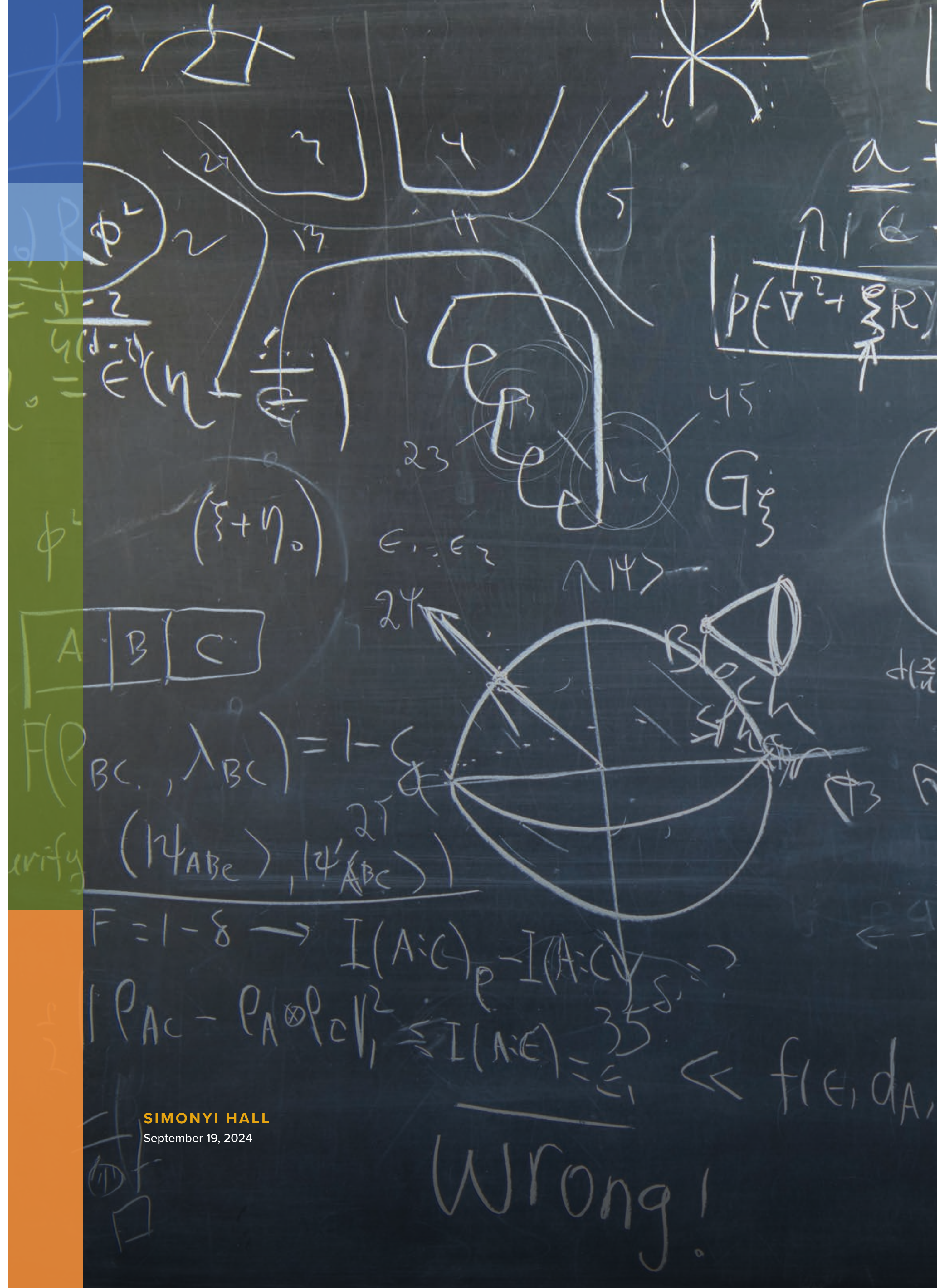
Dusa McDuff, Member (1976, 2002) and Visitor (1977–78), was announced as the recipient of the Leroy P. Steele Prize for Lifetime Achievement for "her outstanding and seminal contributions."

Richard Thomas, Member (1997–98), shared the prestigious Oswald Veblen Prize in Geometry with Soheyla Feyzbakhsh for their "dramatic impact" on the study of Donaldson-Thomas theory.

James S. Milne, Member (1976–77, 1982, 1988), was presented with the Leroy P. Steele Prize for Mathematical Exposition.

Kenneth A. Ribet, Visitor (1983–84), received the Leroy P. Steele Prize for Seminal Contribution to Research for a 1976 paper that has led to "major advances" in numerous areas.

Allen E. Hatcher, Member (1975–76, 1979–80), was awarded the inaugural Elias M. Stein Prize for Transformative Exposition.



SIMONYI HALL
September 19, 2024

Have you moved?
Please notify us of your change of address.
Send changes to:
Communications, Institute for Advanced Study
1 Einstein Drive | Princeton, NJ 08540
or email publications@ias.edu

Non-Profit Org.
U.S. Postage PAID
Permit #49
Princeton, N.J.

IAS | INSTITUTE FOR ADVANCED STUDY

1 Einstein Drive | Princeton, NJ 08540
www.ias.edu | 609.734.8000