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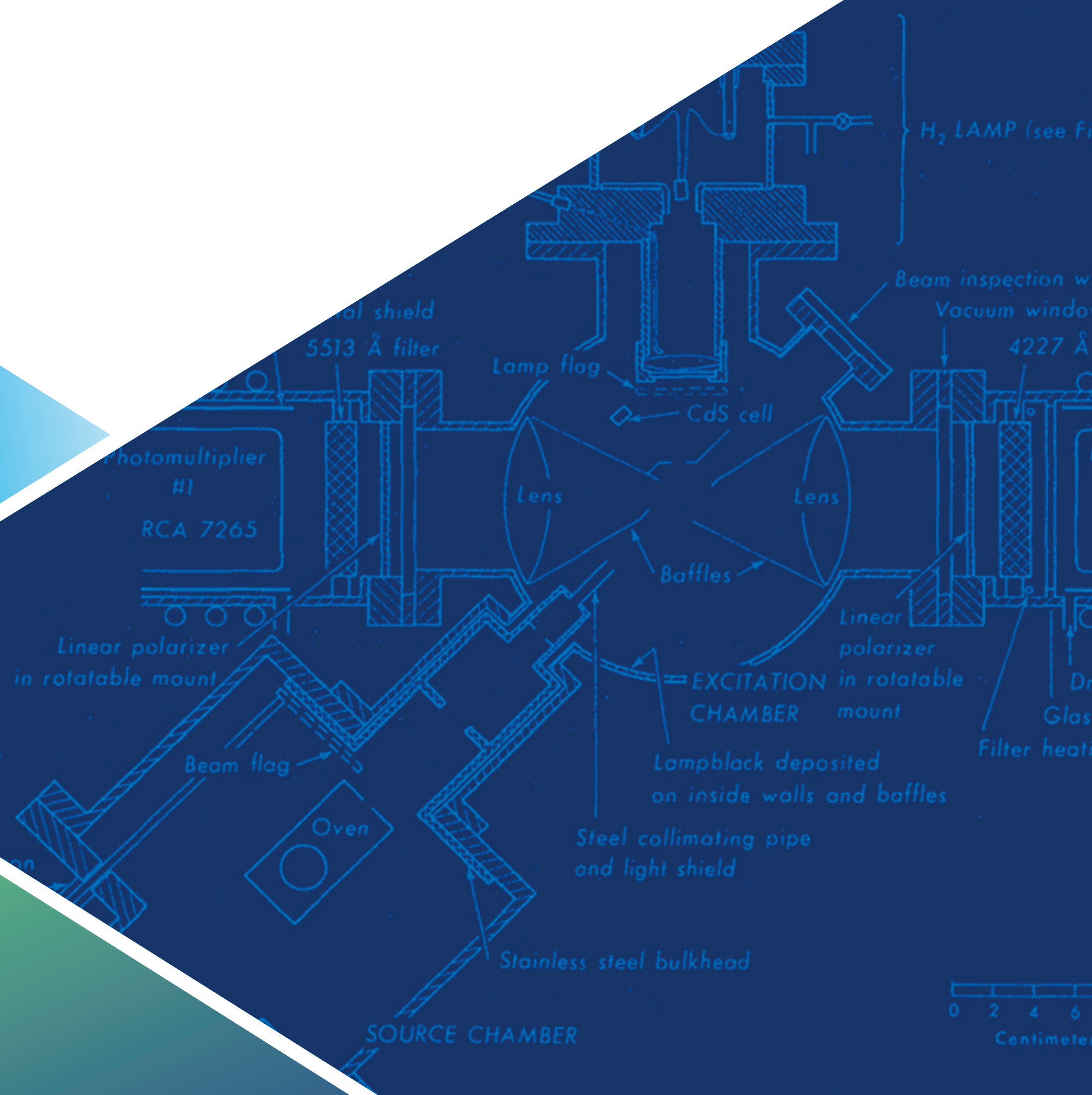

FEATURED ARTICLE

ABOUT THE NEWSLETTER

The *History Newsletter* is a biannual publication of the American Institute of Physics, 1 Physics Ellipse Dr., College Park, MD 20740; email: **history@aip.org** or **nbl@aip.org**. It reports on the activities of the history, library, and archives programs at AIP and on related activities elsewhere.

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A diagram of Carl Kocher's apparatus for measuring correlations between entangled photon. Reproduced in Carl A. Kocher, "Quantum Entanglement of Optical Photons: The First Experiment, 1964–67," *Frontiers in Quantum Science and Technology* 3, 2024, CC BY 4.0. Colorized.

IN THIS ISSUE

DIRECTOR'S INTRODUCTION: HISTORIANS, PHYSICISTS, AND THE QUANTUM YEAR

By William Thomas, Spencer R. Weart Director of Research in History, Policy, and Culture

This past August I had the pleasure of attending the 6th AIP Early-Career Conference for Historians of the Physical Sciences in Salvador, Brazil, my first as director of AIP's history program. While we support the work of historians around the world in various ways, this conference is certainly the way we make the broadest difference. AIP was pleased to fund participants' travel, but the organizing committee and our gracious hosts from the Federal University of Bahia did the heavy lifting. I would like to especially thank the chair of the organizing committee, Climério Silva Neto, for his tireless work to make this conference the great success it was. *Muito obrigado!*

As if it were not enough to organize one conference, Climério and his colleagues immediately repeated the feat the following week by hosting the Fifth International Conference on the History of Quantum Physics, or HQ5. This is a conference series that started in Berlin in 2007, and this was the first time it was held outside Europe. This issue's feature article on entanglement experiments was inspired by the scholarship showcased at the conference, and also by the work of Olival Freire, who has played a key role in building up the history of science community in Brazil.

HQ5 was also notable for its designation as a "Global Event" of the United Nations International Year of Quantum Science and Technology, or IYQ, which provided vital funding. IYQ has been an excellent opportunity to renew attention to the accomplishments of scholars who have done so much work on the history of quantum physics. Of course, IYQ is principally focused on today's world of quantum information science and the burgeoning quantum industry, which means it also presents a great opportunity to work with the scientific community to document contemporary history and bring history into closer dialogue with the present.

If we are to build these bridges, the effort will have to be sustained long past the end of 2025. As a first step, here at AIP we are launching a qualitative survey of members of the quantum community to better understand their work, careers, backgrounds, and perspectives. In past decades, we have conducted similar surveys to lay broad foundations for the history of areas such as nuclear physics, astrophysics, and geophysics. In parallel with this new survey, we also plan to expand our oral history collections in quantum science and technology and to engage members of the scientific community in constructing a thorough and usable historical record.

On the theme of engaging with physicists, by the time this issue is published, CERN will have hosted the 4th International Symposium on the History of Particle Physics. This symposium revives a series that held its first two iterations at Fermilab in 1980 and 1985 and its third at SLAC in 1992. Those events gathered scientists and historians to reflect on different eras of history, taking the story from the origins of particle physics up to the establishment of the standard model. Crucially, the participants published their papers in volumes that preserved background information on developments that are otherwise only recorded in the spare, unrevealing prose of scientific publications.

The CERN symposium covers the period from about 1980 to 2000, when discoveries became less profound and more difficult to obtain, and when the field's center of gravity shifted decisively toward Europe. The symposium will be recorded, and there are plans to publish the proceedings, but I am hopeful that these sorts of interactions can also lay foundations for sustained working relationships between scientists and historians.

I left the conferences in Brazil with great optimism for what the history community can accomplish. There are major challenges ahead, particularly in finding long-term positions for early-career scholars, but the quality of the work being produced is excellent, and the community's culture is welcoming to collaboration—including with physicists. I am certain that sustaining physicists' engagement with history will take work, simply because the way we think about the past is so different. Creating a framework that makes such collaboration easier will be a priority for us in 2026.

NEWS FROM AIP

LYNE STARLING TRIMBLE PUBLIC EVENTS

This summer's Early Career Conference in Brazil featured two keynote lectures that were also recorded for inclusion in our Trimble series. This event series is partially endowed through a generous donation that astronomer Virginia Trimble made to AIP in 2013 in honor of her late father, the chemist Lyne Starling Trimble. We are currently busy scheduling new lectures that will be held in our regular event space in downtown Washington, DC. You can access recordings of all our recent Trimble events at **aip.org/history/events** and on our YouTube channel at **www.youtube.com/@aiphistory**.

The first of the lectures in Brazil was given by **Gisela Mateos** of the National Autonomous University of Mexico. She discussed the International Atomic Energy Agency's mid-twentieth-century efforts to provide technical education in civilian nuclear science in Latin America. Radioisotopes, in particular, were viewed as a potentially accessible and useful tool for Latin American scientists, and mobile laboratories were built to bring lessons on the road. However, Mateos related how Latin American scientists already versed in radiochemistry felt such interventions were unnecessary, and she narrated the frustrations involved in transporting a buslike laboratory from country to country. Mateos also reflected on how these programs were tied to broader political, economic, and ideological currents that eventually receded in importance.

Gisela Mateos. Photo by William Thomas / AIP.

The second lecture was delivered by **Olival Freire** of the Federal University of Bahia and the Brazilian National Council for Scientific and Technological Development (CNPq) on the evolution of thinking about quantum foundations. He focused particularly on entanglement and the long debate over whether causality might be rescued through hidden variables, parsing the contributions of figures such as David Bohm, John Bell, Abner Shimony, and John Clauser. Freire also discussed efforts to develop a quantum theory of gravity and attempts to grapple with the "measurement problem" in quantum mechanics, which deals with the circumstances in which quantum uncertainty collapses.

Olival Freire Jr. Photo by William Thomas / AIP.

NEWLY POSTED ORAL HISTORIES

Mike Graham (Oct. 14, 2024)—University of Wisconsin expert in rheology

Roberta Humphreys (Jan. 6, 2016)—observational stellar astrophysicist at the University of Minnesota

Michael MacCracken (Mar. 26, 2025)—climate scientist, Climate Institute

Kal Migler (Oct. 16, 2024)—staff scientist in the Polymers Processing Group at NIST

Lyman Page (Sept. 1, 2020)—expert in observational cosmology and leader on WMAP project

Aomawa Shields (Jan. 6, 2016)—University of California, Irvine, exoplanet scientist

Brent Tully (Aug. 3, 2015)—University of Hawaii astronomer

Dale Van Harlingen (May 14, 2020)—University of Illinois condensed matter physicist

David Des Marais (May 2, 2025)—NASA Ames Research Center astrobiologist

This newsletter only arrives twice per year. Now you can learn more about history and the history community's work through our weekly and monthly email newsletters. Sign up at **aip.org/newsletters**.

REPORTS FROM GRANT-IN-AID RECIPIENTS

*AIP's Grants-in-Aid program provides funding to scholars and writers to support their research in the history of the physical sciences, with a maximum award of $2,500 per project, which is paid on a reimbursement-for-costs basis. Application deadlines fall on April 15 and November 15 each year. Application guidelines are available at **aip.org/aip/awards/history-grants-in-aid**.*

These grants enable work to proceed in a wide range of areas that we could not support solely in-house. They are also an excellent way to bring new people into our worldwide network of collaborators, and they are one of our best tools for giving students and early-career researchers experience in archival work, oral history interviewing, and applying for external research support. We are pleased to share some reports from recipients on their work.

ARCHIVAL RESEARCH ON THE SOCIAL CONTEXTS OF EINSTEIN STUDIES

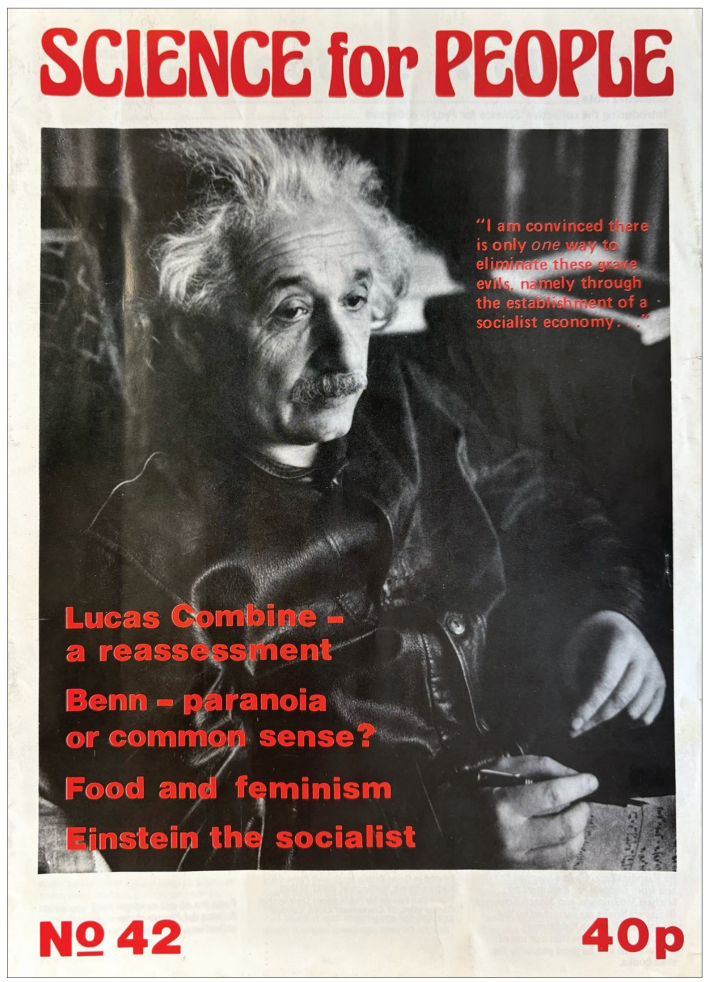
Yuxin Fang, University of Minnesota

In the late 1970s, scientists and intellectuals across the world embraced what we now call "Einstein Studies" as a means of rejecting military research and affirming a commitment to peace. Using a transnational approach, this project examines the genealogy of the field, tracing its social origins to a series of mobilizations against the Vietnam War in the 1970s across the US, the UK, and Europe.

Supported by the AIP Grants-in-Aid program, I conducted archival research at King's College London, the University of Edinburgh, and the University of Cambridge in July 2025. The materials I consulted are primarily about the British Society for Social Responsibility in Science (BSSRS), an organization founded in 1968 to address issues such as the misuse of science and technology, warfare and peace, environmental crisis, and the health of workers. The BSSRS aimed to raise awareness of the social responsibilities of scientists, challenge the neutrality of science, and imagine new ways of doing science. Beginning in 1969, it supported the establishment of local groups and published a bi-monthly magazine, *Science for People*, which provided a platform for radical scholars to share their science studies. The society also organized various peace movements and anti-Vietnam War campaigns, such as Scientists Against Nuclear Arms and Medical Aid for Vietnam.

Einstein Studies were deeply rooted in this social context. Radical scholars drew on Einstein as a leading figure to promote peace, social justice, and humanity. In 1979, for instance, American physicist Joe Schwartz published an article, "Albert—The Other Einstein," in *Science for People* (No. 42), interpreting Einstein as a radical socialist. Utilizing Einstein's political writings, Schwartz demonstrated his socialism and political activism, stating, "There is not one other scientist in Einstein's generation that was capable of making this argument at any point in their career. In the world of pure research, Einstein was the first socialist scientist." Beyond Schwartz, British general relativist Felix Pirani and biophysicist Maurice Wilkins were also actively involved in these mobilizations, invoking Einstein in their opposition to nuclear proliferation and their calls for disarmament.

My future work will build on these findings to trace the broader lineage of Einstein Studies and its development in different nations. I am grateful to the AIP for supporting this project through the Grants-in-Aid program, which made this archival research possible.



Cover of *Science for People* No. 42, 1979, published by the British Society for Social Responsibility in Science. King's College London Archives, Maurice Wilkins Collection, K/PP178/11/1/23.

ARCHIVAL RESEARCH ON UNDERGROUND NEUTRINO EXPERIMENTS

Nithyanand Rao, University of California, San Diego

In recent years, historians of science have paid much attention to the sites of astronomical telescopes. While altitude has appeared on the scholarly radar, depth is only just beginning to.

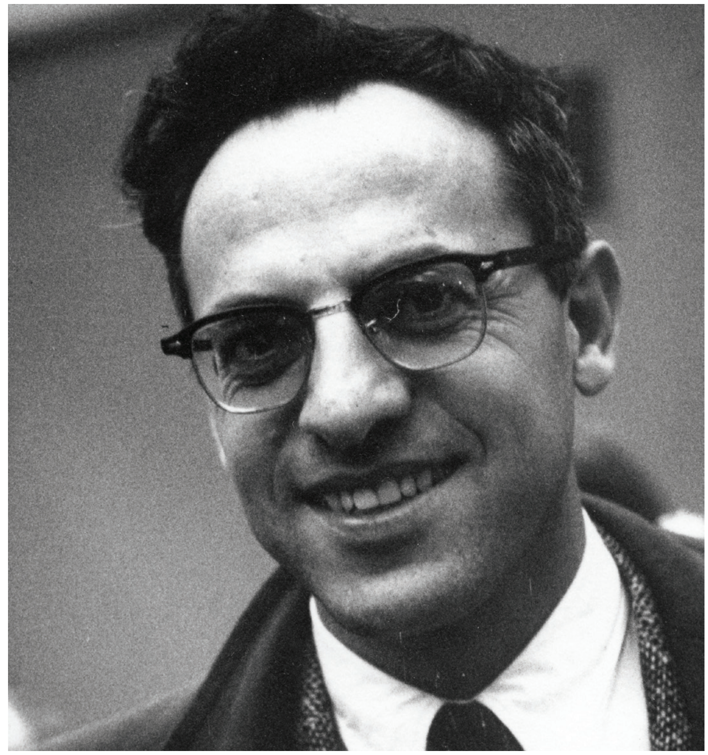
Underground experiments have led to crucial advances in physics. They began in the mid-twentieth century with studies of cosmic ray flux at various depths. Physicists then entered deep underground chambers inside mines, where the overlying rock shielded against cosmic rays, to study neutrinos.

This is a story that begins with two mines: the Kolar Gold Fields (KGF) in India and the East Rand Proprietary Mines (ERPM) in South Africa, both over three kilometers deep. This depth enabled physicists from India, the UK, and Japan at KGF, and from the US and South Africa at ERPM, to detect "atmospheric" neutrinos for the first time in 1965. These are neutrinos produced by cosmic rays interacting with Earth's atmosphere.

My PhD dissertation research began as a study of these two experiments. An AIP Grant-in-Aid allowed me to travel to access archives at the University of California, Irvine, and the Case Western Reserve University in Cleveland, which hold the papers of Frederick Reines, the US physicist who led the ERPM team. His correspondence shows that the initial plan was to set up his experiment at KGF, inspired by early work done there by the cosmic ray group at the Tata Institute of Fundamental Research (TIFR). However, TIFR's director, Homi Bhabha, denied permission, prompting Reines to move to South Africa, leading to a race between the two teams to detect the neutrino.

My dissertation has since evolved. Investigating why the deepest mines in the world were gold mines, and why they were in South Africa and India, led me to explore the political economy of gold mining, an industry reliant on low-wage labor. This labor was provided by Black African miners in South Africa and lower caste, or Dalit, miners at KGF. These mines became deep and thus enabled and subsidized the physics experiments they hosted because of the labor and ingenuity of their mining workers.

My dissertation is now a study of KGF itself, examining the discursive disjuncture between the experiments and the mines. It is less a history than a cultural study. I am interested in how the story of the KGF experiments is told in a way that detaches it from the gold mines, while the story of the gold mines, including in academic histories, marginalizes the mining workers and their knowledge. The story of Bhabha, Reines, and their race to detect the atmospheric neutrino is one that I hope to tell separately.



Frederick Reines. AIP Emilio Segrè Visual Archives, Physics Today Collection.

ARCHIVAL RESEARCH ON THE PHYSICAL SCIENCE STUDIES COMMITTEE

Duim Huh, University of Tokyo

An important starting point for my archival research was the first International Conference on Physics Education, held in Paris, in 1960, under the auspices of the International Union of Pure and Applied Physics and supported by institutions including AIP and the American Association of Physics Teachers. The Physical Science Study Committee (PSSC) curriculum was presented there through textbooks, experiment apparatus, and films, introduced directly by J. R. Zacharias, who led the PSSC project. Among the six international committee members was Japanese physicist Toshiro Kinbara, whose involvement proved critical for implementing the PSSC in Japan. The project included translating textbooks and films and promoting experiment-based education in 1960s Japan as part of Cold War science diplomacy.

My research on transnational development of PSSC focuses on the interactions between scientists in the US and Japan, aiming to uncover the reciprocal nature of international cooperation in science education.

The PSSC curriculum was the first and most influential program in the Cold War promotion of science education. Archival research at the AIP Niels Bohr Library and Archives, the National Archives, and North Carolina State University has provided valuable sources for understanding this atmosphere of international

Continued on page 8

collaboration. In particular, valuable contextual information can be found in the records of AIP's Education and Manpower Division, directed by William C. Kelly, who served as a counterpart of Kinbara. The papers of Harry C. Kelly—who was assistant director at the National Science Foundation and chair of the US–Japan Committee on Scientific Cooperation—contain extensive correspondence with Japanese scientists and diplomats.

Building on the international cooperation fostered by the PSSC, I turned to similar cases to see how scientists sought to extend their professional and educational networks abroad. The institutional records of the Biological Science Curriculum Study, preserved in the Bentley Glass papers at the American Philosophical Society, were especially useful in clarifying their collective objectives and activities in international exchange. Likewise, the records of the Chemical Education Material Study Program at the Science History Institute shed light on institutional efforts to promote cross-national collaboration through curriculum development.

This archival research has given me invaluable access to manuscript collections, including institutional records and personal correspondences, which have been crucial for examining the prevalence of Cold War science curricula. This broader context will help me trace connections to Japan in the 1960s, revealing the reciprocal collaboration between American and Japanese scientists that shaped the implementation of the PSSC curriculum in Japan.

William C. Kelly. Photo by Heka Davis, courtesy AIP Emilio Segrè Visual Archives, Physics Today Collection.

AIP HELLEMAN PROGRAM LAUNCHES NEW GRANT OPPORTUNITY

AIP launched a major new initiative this fall in our support for historians of the physical sciences. Using endowed funds from our Robert H. G. Helleman Memorial Grant and Fellowship program, we are inviting proposals for multi-institutional collaborative research projects that also support historians' career development. These projects can receive up to $150,000 per year, and we expect to be able to support two such projects at any given time.

The new grants are inspired by our sense of how important it is to sustain and interconnect a global community of historians, as evidenced by the relationships built through our Early Career Conferences and the worldwide demand for our Grants-in-Aid program. Building on the intercontinental collaborative relationships that already exist among historians, we feel that these grants can further increase international exchange, facilitate use of a wider variety of archives, and help bridge distinct research cultures.

Projects will be led by senior investigators, who will devise collaborative structures for working with colleagues at other institutions and recruiting students or postdoctoral researchers. Grants will be for an initial period of two years, and they are extendable to a third following demonstrated progress. After that, project leaders can compete to continue projects in up to two future cycles. The deadline for applications in the current cycle is March 20, 2026, and we plan to select projects in April using a panel of outside experts. Projects can start any time between August 2026 and September 2027.

We are excited to see what historians will propose for this program. Our hope is that the requirements of the program will inspire some creative thinking about collaboration, while leaving enough flexibility for scholars to design projects that we would not have anticipated. We look forward to reporting on what comes from this opportunity in future editions of the *Newsletter*.

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TWO WEEKS IN BRAZIL BRIDGING GENERATIONS AND CONTINENTS

By Climério Silva Neto, Federal University of Bahia

For two weeks in August, the city of Salvador in the northeastern Brazilian state of Bahia was the site of two large international gatherings of historians of physics. Scholars from five continents packed their suitcases and flew to the peninsula surrounded by warm, emerald-green waters to attend the Sixth AIP Early Career Conference (ECC) and the Fifth International Conference on the History of Quantum Physics (HQ5).

This conjunction of conferences was in many ways unprecedented. Although both have been running over the last two decades, this was the first time they converged, the first time either convened south of the equator, and, most revealingly, they were enabled by a remarkable coalition of organizations committed to promoting the history of physics on a global scale.

Building on the tradition of its earlier iterations, the ECC was designed to bring early-career scholars together into a global community to share their work and foster professional collaboration, with a special focus on celebrating the centenary of quantum mechanics and promoting diversity in the history of the physical sciences. The conference showcased exceptional gender balance and a comprehensive program.

Presentations explored a wide range of topics, including traditional disciplinary and conceptual histories of major theories and experiments, as well as geopolitics, gender, race, and marginalized labor. Discussions also covered the materiality of scientific instruments and the abstractness of quantum field theories. The event featured two keynote Trimble lectures, talks by IUPAP Early Career Prize awardees, and a career-training workshop designed to help participants prepare papers for a special issue of *Physics in Perspective*.

The conference also offered many opportunities for networking. Unstructured interactions during coffee breaks, lunches, dinners, a boat trip, and visits between the two conferences to the Nautical Museum and Salvador's historic center played a crucial role in helping establish connections among a new generation of historians. Judging by the results of previous ECCs, these connections will have a lasting impact on their future careers.

HQ5 was an International Year of Quantum Science and Technology (IYQ) Global Event that coincided with the centenary of quantum mechanics, revived the prestigious "HQ" conference series, and aimed to encourage interaction among generations of historians. The program included about 25 oral presentations, a dedicated poster session featuring the work of graduate students, and five keynote lectures.

There were also two roundtables on the topics "Two Decades of Scholarship on the History of Quantum Mechanics" and "Visions for the Scholarship on the History of Quantum Mechanics." The productive discussions during these sessions served as the basis for a vision document, which aims to provide goals and recommendations for the future global development of the history of quantum science and technology.

The diversity that characterized both conferences, reflecting Bahia's unique blend of African, American, and European cultural traditions, showcased the strength of our community. As the second week drew to a close, the final discussion underscored that our community's strength lies in its diverse approaches. Moving forward, we must embrace an expansive and inclusive identity.

The success of these conferences was made possible through the generous support of AIP, the Inter-Union Commission for the History and Philosophy of Physics, Brazil's National Council for Scientific and Technological Development (CNPq), and the IYQ partner organizations, as well as the hard work of many dedicated people. The ECC was organized by Carla Almeida, Climério Silva Neto, Duim Huh, Jean-Philippe Martinez, Jinyan Liu, Rebecca Charbonneau, and Will Thomas. The HQ5 organizing committee was Alexander Blum, Climério Silva Neto, Carla Almeida, Daniela Monaldi, Indianara Silva, Jinyan Liu, Roberto Lalli, Thiago Hartz, and Will Thomas. We also received invaluable support from Judith Mulvey and Annette Gratton at AIP, in addition to assistance from many local graduate students. The results of this collective effort were clearly evident during the two weeks in Bahia.

Top left: Climério Silva Neto. Photo by William Thomas / AIP.

Top right: Early Career Conference participants following the conference dinner. William Thomas / AIP.

Bottom: Participants at the Sixth AIP Early Career Conference for Historians of the Physical Sciences. Photo courtesy of Climério Silva Neto.


AIPECC25

ENTANGLEMENT AND EXPERIMENT

By William Thomas, Spencer R. Weart Director of Research in History, Policy, and Culture

Quantum entanglement is a phenomenon wherein two or more particles are united within a single quantum system. Although notoriously hard to control, such particles' interlocked behaviors are poised to have revolutionary applications in areas such as computing, cryptography, and sensing. Entanglement is, therefore, of absolute importance in today's flourishing landscape of quantum information science and the nascent quantum technology industry.

The idea of entanglement is commonly traced to a 1935 *Physical Review* paper referred to as "EPR" after its authors: Albert Einstein, Boris Podolsky, and Nathan Rosen. But for many years, the physics community mustered little interest in the subject, relegating it to the status of an intellectual curiosity. It was only toward the end of the last century that work on entanglement gained real momentum—a shift punctuated by the award of the 2022 Nobel Prize for Physics to John Clauser, Alain Aspect, and Anton Zeilinger for experiments confirming entanglement's quantum mechanical nature.

Scholars have become increasingly interested in how entanglement moved from the outer edges of physics to the center. In his 2011 book *How the Hippies Saved Physics*, David Kaiser stressed the importance of the 1970s counterculture as an environment amenable to discussions of foundational issues in quantum physics that were anathema elsewhere in the profession. That culture also helped popularize quantum phenomena through works such as *The Tao of Physics*, but its enthusiasm for subjects like extrasensory perception risked dragging entanglement deeper into the scientific fringe.[1]

This article is about another narrative thread focused on experiments that, while certainly conducted on the margins of physics, also had significant connections with the mainstream. Beginning about 20 years ago, historians Olival Freire and Joan Bromberg began reconstructing how efforts to test entanglement not only sharpened understanding of quantum behaviors but also pointed the way toward building devices that exploit those behaviors.[2] Today, historical research on this subject is burgeoning as new generations of scholars take up the reins.

FROM THOUGHT EXPERIMENTS TO REAL EXPERIMENTS

There were initially no substantive connections between entanglement and the laboratory, even though the heart of the EPR paper was a so-called "thought experiment." The EPR experiment was one in a series imagined during a years-long dispute between Einstein and Niels Bohr that, far from being serious proposals for actual tests, were more like weapons in a duel of ideas. Einstein's and Bohr's goal was to resolve, conceptually, whether the indeterminate features of quantum mechanics reflect limitations in its theoretical framework or describe the fundamental nature of reality, at least insofar as it is accessible to human inquiry.[3]

Niels Bohr and Albert Einstein. Photo by Paul Ehrenfest, courtesy AIP Emilio Segrè Visual Archives.

While Bohr and his allies firmly insisted on the latter interpretation, Einstein was loath to concede that objects could, for example, have a position that was truly indeterminate until measured, or that an event could happen without any immediate cause. The EPR paper sought to seal the case for Einstein's view by positing a situation in which two particles with intertwined but indeterminate properties are separated. Then, the property of one is fixed by measurement. Since that particle could no longer affect the other, the fact that the other particle's property would presumably always correlate with that of the first suggested their properties had been jointly determined from the beginning.

The point of the EPR thought experiment was to reveal an ostensible incompleteness lurking within quantum mechanics. The only seeming alternative was if one supposed that both particles' properties had truly been undetermined until the measurement of one instantaneously discovered what value the property of the other would have when it was measured—a phenomenon Einstein later dismissively called "spooky action at a distance."

That the thought experiment posed questions that could be settled by real experiments was a possibility that went unexplored for years. Quantum mechanics worked, and that was good enough for most physicists, who accepted that Bohr won the argument, if they thought about it at all. The first person to press the idea of an actual experimental test was David Bohm.

Like Einstein, Bohm was skeptical that indeterminacy in quantum mechanics reflected reality, and he sought to develop a theory that allowed for "hidden variables" governing quantum behaviors. Having left the United States after falling victim to anticommunist persecution, Bohm spent several years in Brazil and arrived at the newly established physics department at the Technion in Israel in 1955. There, he addressed the prospect of testing the EPR "paradox" in a paper he published in 1957 with graduate student Yakir Aharonov.[4]

David Bohm in 1949, when he was called to testify before Congress about his political activities. Acme Telephoto, New York World-Telegram and the Sun Newspaper Photograph Collection, Library of Congress, courtesy of the AIP Emilio Segrè Visual Archives.

Philosopher Guy Hetzroni has been interviewing Aharonov, who went on to a highly successful career and is now in his 90s.[5] Hetzroni relates that, according to Aharonov, Bohm asked him to calculate the correlation of polarization between photons emitted by the mutual annihilation of positrons and electrons. This was a variation on a version of the EPR thought experiment that Bohm published in 1951 featuring measurements of particles' spin. Spin, like polarization, is a binary up-or-down property that was simpler to handle theoretically and experimentally than nonbinary properties like position or momentum.

Bohm then discovered a *Physical Review* paper published in 1950 by Columbia University physicist Chien-Shiung Wu and graduate student Irving Shaknov, which presented experimental data about just such photon correlations. Sure enough, these aligned with Aharonov's calculation.[6] Per Aharonov, this led to the 1957 paper, which dealt broadly with test designs that could determine whether the EPR paradox could be escaped by supposing that correlations between spatially separated particles might break down spontaneously—an outcome forbidden in quantum mechanics. The Wu-Shaknov experiment showed the correlations, and quantum mechanics, remained intact.

Irving Shaknov in Korea. Courtesy of CNA Corporation.

The Wu-Shaknov paper did not itself mention EPR, framing its experiment as a test of a prediction John Wheeler had made about the polarization properties of photons in electron–positron annihilation. However, in just the past few years, the paper has attracted an avalanche of renewed attention in pieces written by Indianara Silva; Michelle Frank; Chon-Fai Kam, Cheng-Ning Zhang, and Da Hsuan Feng; and Yu Shi, who stress its importance as the first experiment to clearly demonstrate entanglement.[7]

These authors all regard the experiment as a neglected contribution by Wu, who is otherwise best known for her 1956 experiment demonstrating the nonconservation of the parity property in radioactive decays. As we have little historical documentation on the Wu-Shaknov experiment beyond the paper, many of these authors are also hunting for evidence that Wu and Shaknov had the EPR thought experiment in mind but declined to mention it, perhaps because the subject was seen as disreputable.[8]

In any event, while it has long been widely felt Wu was unjustly denied the Nobel Prize for the parity nonconservation discovery, her career was extremely successful by any other measure. She was one of only a handful of women and Chinese Americans of her generation to reach the top echelons of the US physics profession, and in 1975 alone she received the National Medal of Science and became the first woman to be president of the American Physical Society.

Irving Shaknov's story was unfortunately tragic. After completing his doctorate, he joined the Operations Evaluation Group, an

Continued on page 14

MIT-administered contractor organization that conducted studies for the US Navy. While flying on a mission in Korea in 1952, he was killed when his plane was shot down by enemy fire. He was posthumously awarded the Medal of Freedom.[9]

If the Wu-Shaknov experiment has become less familiar with time, it remained a standard citation as interest in testing the EPR paradox grew during the 1960s and beyond.

Asher Peres and Paul Singer, who both earned their doctorates under Nathan Rosen at the Technion, published a paper on EPR in 1960. They argued that analysis of photon behavior, and thus the Wu-Shaknov experiment, could not resolve whether correlations between properties were preserved, and they suggested alternative approaches. Although the paper made few waves, Peres maintained his interest in quantum foundations and was one of the theorists who developed the concept of quantum teleportation in 1993.[10]

From left: Yakir Aharonov, Wendell Furry, Nathan Rosen, Boris Podolsky, and Eugene Wigner. AIP Emilio Segrè Visual Archives, Physics Today Collection.

"Action at a distance" (sans the "spooky" descriptor) was the first topic on the agenda of a small, landmark conference on quantum foundations that Boris Podolsky organized in 1962 at Xavier University in Cincinnati. Podolsky and Aharonov both cited the relevance of the Wu-Shaknov experiment in addressing the phenomenon. The conference transcript, available online, includes a brief but amusing exchange with hints of Abbott and Costello:[11]

> *Aharonov [addressing Eugene Wigner]: I wonder if you are familiar with an article that was written on this subject by Professor Bohm and myself, in which we analyze an experiment that was done by Yu. (He pronounced it like "you")*
>
> *Wigner, wholly astonished asks: By who?*
>
> *Aharonov: By Wu.*

Around 1964, Eyvind Wichmann, a theorist at the University of California, Berkeley, suggested to Carl Kocher, a graduate student working under Eugene Commins, that he try constructing a device to measure correlations in the polarization of photons. In a recent retrospective, Kocher recalled that Wichmann thought of it as a "tabletop" apparatus for instructing undergraduate students, but it ultimately became Kocher's thesis, which he completed in 1967. While the thesis confined a discussion of the EPR paradox and the Wu-Shaknov experiment to an appendix, an article that Kocher and Commins published the same year made the connections clear in the second paragraph.[12]

After Kocher completed his work, two people independently seized on his experiment: Abner Shimony, a philosopher-physicist working at MIT, and John Clauser, a graduate student at Columbia University. While they did not regard Kocher's result as especially significant in itself, they saw it as a jumping-off point for testing an obscure new theorem that promised to firmly prove or disprove the reality of quantum indeterminacy.

BELL'S THEOREM AS AN IMPETUS TO EXPERIMENTATION

The quest to test Bell's theorem has become reasonably well-trodden historical territory, having been covered by the physicist David Wick in his 1995 book *The Infamous Boundary* and Olival Freire in his 2006 paper "Philosophy Enters the Laboratory" and 2015 book *The Quantum Dissidents*. The retelling here draws heavily on interviews from AIP's collections that Joan Bromberg conducted with some of the principals in the early 2000s.[13]

John Bell in 1973. © CERN.

Theoretical physicist John Bell agreed with David Bohm that quantum mechanics likely obscured hidden variables. However, working in the early 1960s at CERN, he usually avoided discussing his personal interest in quantum foundations with colleagues. It was not until he was on leave visiting Stanford University, Brandeis

University, and the University of Wisconsin that he wrote up his ideas about how to design an EPR-style experiment that could actually distinguish whether or not hidden variables were at work.

Bell's theorem appeared in print toward the end of 1964 in a brand-new boutique journal called *Physics*, and it received very few citations throughout the 1960s. This lack of interest was certainly linked to the broader lack of interest in quantum foundations, but the theorem was also slow to gain appreciation among those who were interested.

Detail from the group photo taken of the participants at the 1962 Xavier University conference. Abner Shimony is at the back left; Yakir Aharonov is in front. Babst Photography and Xavier University, courtesy of AIP Emilio Segrè Visual Archives, Gift of Abner Shimony.

Abner Shimony received his PhD in philosophy from Yale University in 1953 and a second doctorate in 1962, this time working in physics under the esteemed physicist Eugene Wigner at Princeton. It was Shimony who was responsible for stoking Wigner's interest in quantum foundations, and both attended the Xavier University conference, which introduced Shimony to the small community of physicists who paid attention to the subject.

Shimony told Bromberg he learned of Bell's paper when a colleague at Brandeis mailed him a draft. He recalled,

> *I had several reactions when Bell's paper came. I thought, "Here's another kooky paper that's come out of the blue." I'd never heard of Bell, and it was badly typed, and it was on the old multigraph paper, with the blue ink that smeared. There were some arithmetical errors. I said, "What's going on here?" But I re-read it, and the more I read it, the more brilliant it seemed. And I realized, "This is no kooky paper. This is something very great."*

Bell's theorem in hand, Shimony set out to discover whether there was evidence that would satisfy the test it proposed. Taking his cues from Bohm and Aharonov, he started looking for it in the physics literature, beginning with the Wu-Shaknov experiment, which he quickly realized did not include the needed measurements.

Shimony also consulted directly with Aharonov, now at Yeshiva University in New York City. He recalled that Aharonov dismissed the need for a new test, saying that his 1957 paper with Bohm had settled the matter. Shimony reflected to Bromberg:

> *Aharonov is a very fast thinker and a very fast talker, and I was in awe of him, and thought, "He's right… Maybe he's right, but maybe he isn't right." The more I thought of it, the less convinced I was.*

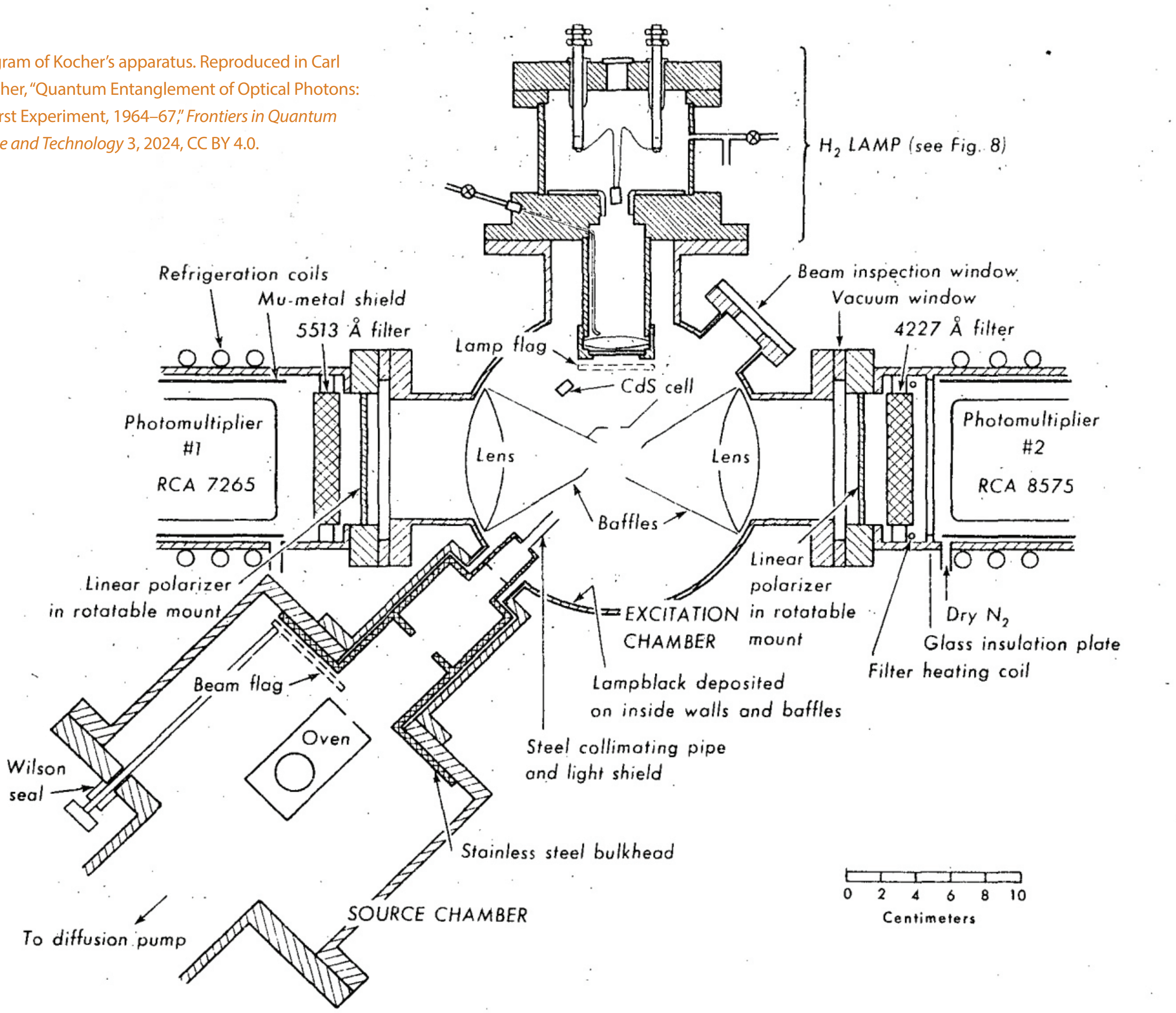
Ultimately, Shimony concluded a new experiment was needed, but the opportunity only arose when he moved from MIT's philosophy department to Boston University's physics department in 1968 and introduced the idea to graduate student Mike Horne. They in turn consulted colleagues at nearby Harvard University, which led them to Kocher's experiment. They found that, much like the Wu-Shaknov experiment, it was not properly designed to test Bell's theorem, but they did feel it could be adapted, and they were soon introduced to Harvard experimenter Frank Pipkin and his student Dick Holt, who was working with a similar apparatus.

Meanwhile, Clauser was working on a doctorate in astrophysics at Columbia, but he found himself sidetracked by his perplexity over the abstractions of quantum mechanics. In his self-guided efforts to understand the subject better, he dove deep into interpretive issues and soon adopted Bohm's interest in hidden variables, leading him to take notice of Bell's paper. Clauser later recalled,[14]

> *I was astounded by its result. However, I was not yet willing to accept the paper's far-reaching implications until I finally saw some experimental evidence that decided between its two significantly different predictions.*

Clauser found the same inadequacies in the Wu-Shaknov experiment that Shimony had. Looking for a way forward, his interest was piqued by another approach based on scattering suggested in Peres and Singer's 1960 paper. In early 1969, he secured an invitation to present his ideas at a seminar at MIT, where Dan Kleppner was undertaking similar experiments. Although Shimony was nearby at Boston University, he was not in attendance. However,

Continued on page 16



A diagram of Kocher's apparatus. Reproduced in Carl A. Kocher, "Quantum Entanglement of Optical Photons: The First Experiment, 1964–67," *Frontiers in Quantum Science and Technology* 3, 2024, CC BY 4.0.

Kocher, freshly arrived at MIT as a postdoc, was there and told Clauser about his work at Berkeley.

Speaking with Bromberg, Clauser said that Kocher asserted his experiment had already accomplished what he was proposing to do. He recalled,

> *Carl actually didn't have any reprints available, but he wrote down the reference to it, and as soon as I got back to my office in New York, I went to the library and picked it up and read it. As soon as I read it, I realized, "No, this is a crock. He hasn't done it at all."*

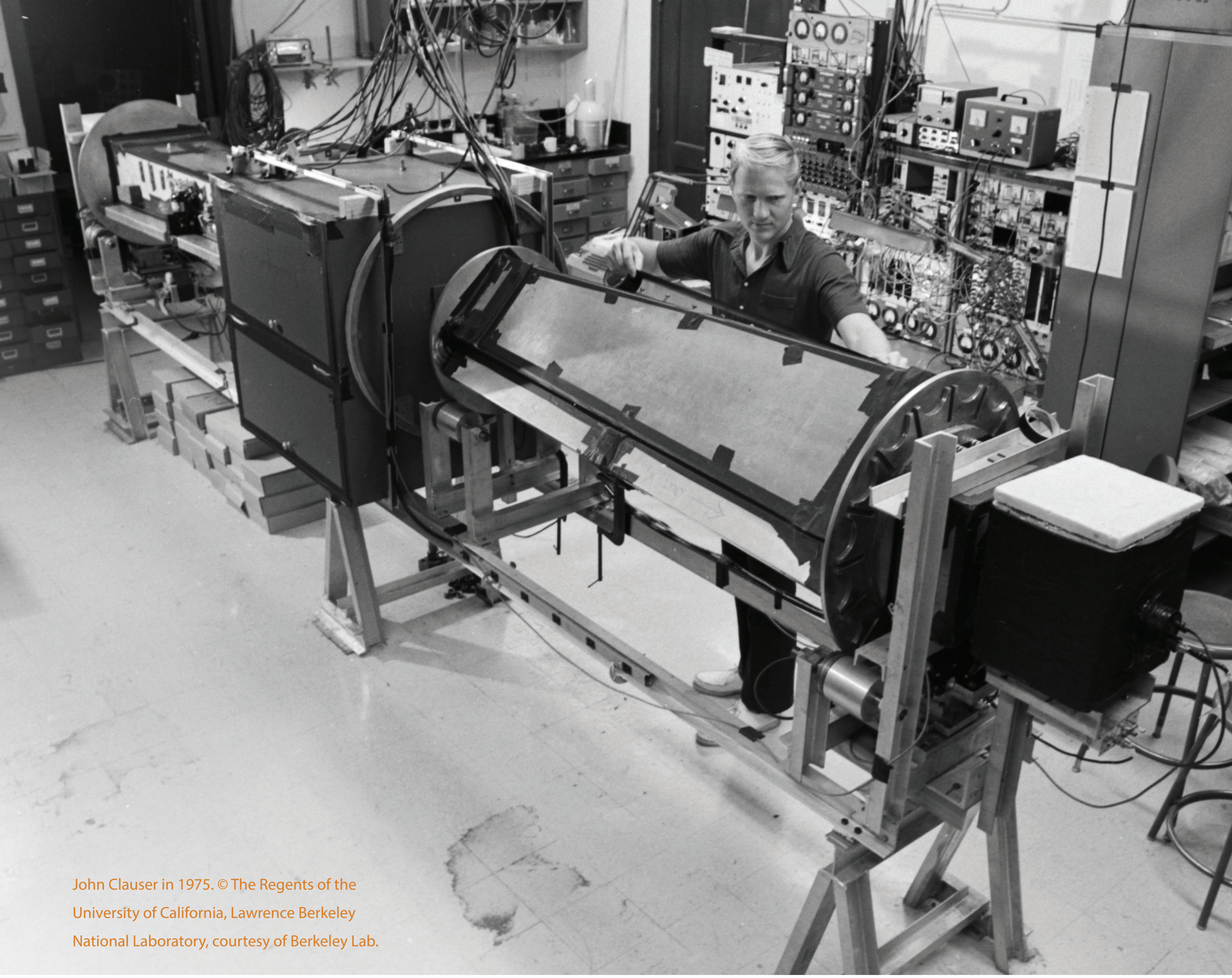
Realizing, as Shimony did, that Kocher's setup could be the basis for a new and decisive experiment, he drafted a short description of one in an abstract for an upcoming American Physical Society meeting that was printed in the APS Bulletin.

Shimony told Bromberg that he and Horne missed the deadline to submit an abstract for the meeting:

> *I remember telling Mike, "It doesn't matter. Nobody is working on this sort of thing. This is so far out. We'll write up a full paper with all our calculations, and that will be much better than one paragraph in a bulletin." Then the* Bulletin *came out, and there was our work, and we felt pretty low. We really felt pretty sick.*

On Wigner's advice, Shimony reached out to Clauser and enticed him into a collaboration as Holt had a clear path to conducting the experiment at Harvard. Together, Clauser, Horne, Shimony, and Holt wrote a paper reworking the idealized experiment in Bell's paper so that it could be tested on a practical apparatus.[15]

Then, in late 1969 Clauser moved on to a postdoctoral position at Berkeley, where he persuaded his supervisor, the eminent Charles



John Clauser in 1975. © The Regents of the University of California, Lawrence Berkeley National Laboratory, courtesy of Berkeley Lab.

Townes, as well as Eugene Commins, to let him adapt the device that Kocher had used to perform his thesis experiment. In Clauser's recollection, although Commins was unenthusiastic, the weight of Townes's support led him to make another of his students, Stuart Freedman, available to work on the experiment.

Clauser remembered the experiment as demanding a major overhaul of Kocher's device:

> *We ended up using one piece of Kocher's equipment, which was a stainless-steel insert at a collimator.… Once we started the design on the new experiment, each time we'd try to think, "Okay, well, how much of this stuff can we use?" And as the design progressed, more and more pieces became inappropriate. So, they got pitched out, and we kind of joked about it. At the end, we looked back and we went, "Well, what are we really using out of all of Kocher's hardware?" And it was almost nothing. I'm not even sure whether we used the same vacuum pumps. We built the polarizers from scratch.*

By 1972, the work was done and Clauser and Freedman's experiment had secured results that seemed to clearly rule out the possibility the photons' measured properties were predetermined by hidden variables. This dashed Clauser's hope of dealing a revolutionary blow to prevailing ideas about quantum mechanics, but the experiment's meaning was still up for grabs. Clauser told Bromberg that for some who had never given any credence to hidden variables, the experiment's agreement with quantum mechanics simply showed the entire effort had been a waste of time.

MEASURING EXPERIMENTAL PROGRESS

What, then, did the Freedman-Clauser experiment accomplish?

Initially, it was not certain it had even worked properly. Back at

Continued on page 18

Harvard, Holt's results soon came in and contradicted predictions from quantum mechanics. While that experiment was never published under the presumption something had gone wrong, it nonetheless lurked like a specter, prompting Clauser to replicate Holt's design, yielding results agreeing with his prior experiment with Freedman. By the time Clauser and Shimony published a landmark review paper in 1978 surveying what had become a full constellation of experiments, the outlook was clearer.[16]

Chien-Shiung Wu in the late 1950s. Photo by Heka Davis, courtesy of AIP Emilio Segrè Visual Archvies, Physics Today Collection.

Then there was the question of what exactly any given experiment was or was not adequate to demonstrate. Notably, back at Columbia, Chien-Shiung Wu had revived her interest in her experiment with Shaknov and tasked graduate student Leonard Kasday with replicating it, except now with Bell's theorem in mind. He obtained results by 1970 that agreed with quantum mechanics. While the result accorded with Clauser and Freedman's later experiment, Clauser and others regarded it as unconvincing due to limitations in the experiment's design that prevented it from clearly ruling out hidden variables.[17]

Of course, Clauser and Freedman's experiment had its own limitations preventing it from ruling out signaling between its separated photon detectors; this "loophole" was only overcome by Alain Aspect's experiments in France in the early 1980s.[18] But given that so few physicists even took occult mechanisms like hidden variables seriously, the question arises of why closing off loopholes became such an influential measure for what constituted a significant experiment. From that perspective, the Wu-Shaknov and Kocher experiments might well be reasonably regarded as crucial ones.[19]

Still another way of looking at the Freedman-Clauser experiment is that successfully testing Bell's theorem was an important step in being able to identify, isolate, and control exotic quantum phenomena in the laboratory. From this view, it was not just one experiment in a line running back to Wu-Shaknov or even the EPR thought experiment itself; it was part of a broad landscape of experiments that was beginning to emerge in its time. Climério Silva Neto has recently examined the instrumentation used in the early tests of Bell's theorem, including in the Soviet Union, and how they served as a bridge with other research fields like atomic, molecular, and optical physics. Following Bromberg, Gautier Depambour has looked specifically at the links between the Bell experiments and the emerging field of quantum optics.[20]

It is an exciting time to be piecing together our historical map of quantum science, and there is much left to be done. This year, the Nobel Prize in Physics was awarded to John Clarke, Michel Devoret, and John Martinis for work in the mid-1980s on macroscopic quantum tunneling—another quantum behavior underlying today's quantum technologies that has yet to find its historians. Hopefully the prize will further energize scholars to keep expanding their work in new directions.

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FROM OUR ORAL HISTORY COLLECTIONS

Michel Devoret. Photo by Harold Shapiro, courtesy of Yale University.

MICHEL DEVORET

Michel Devoret shared the 2025 Nobel Prize in Physics for his research in the early 1980s with John Clarke and John Martinis at the University of California, Berkeley, on macroscopic quantum tunneling. In an interview with AIP in 2021, he recalled how, just after that work, he moved to France, where his continuing research on quantum behaviors took inspiration from Alain Aspect's tests of Bell's theorem.

> *I think it was the best opportunity I had at that time to continue experiments on what I was calling "quantronics," which is a sort of contraction of quantum-mechanical electronics. The idea that we would do fundamental quantum physics experiments but with electrical degrees of freedom, like currents and voltages, was something I found fascinating. You know, at that time, people doing fundamental quantum experiments like Alain Aspect were doing them on optical photons. As Aspect wannabes basically, instead of doing experiments in quantum optics, we would do them with electrical degrees of freedom in superconducting circuits. This was very much in line with my former electrical engineer training.*

Jay Gambetta. Photo courtesy of IBM.

JAY GAMBETTA

In September, Jay Gambetta took over as IBM's director of research, having previously led the company's efforts in quantum computing. In an interview last year with AIP, he reflected on how his PhD work in Australia in the 1990s on quantum foundations led him into quantum computing as a way of better understanding the nature of quantum mechanics.

> *At university, I discovered that the courses that I found the most difficult were quantum mechanics, and these were the ones I liked best.… I had a few lecturers that took time to explain it, but I did not fully understand why. So, I said, "Why don't I do my PhD on interpretations of quantum mechanics?"… The output of my PhD was inconclusive. You could use all interpretations to describe this equation and it could be extended to have a family of non-Markovian stochastic Schrödinger equations; it was just the same math. That's when I decided, rather than to keep doing foundations, I would move to quantum computing and see if we could build a quantum computer to test if quantum mechanics worked.… I convinced myself the best way to understand what interpretation was the correct one is to answer the question: could we build a quantum computer?*

Melissa Franklin in the mid-1980s. Department of Physics, University of Illinois at Urbana-Champaign, courtesy AIP Emilio Segrè Visual Archives.

MELISSA FRANKLIN

In 2020, the experimental particle physicist Melissa Franklin discussed the importance of CERN in the life of an early-career physicist and beyond: research potential, data, and professional connections.

> *Summer at CERN was incredible. I was working on an experiment at what was called the ISR, the intersecting storage rings. That's just protons, proton-proton collisions... [Leon] Lederman had two experiments at that time. He had an experiment at Fermilab, which was what that summer discovered the bottom quark. And then he was working on this experiment at CERN, which discovered nothing pretty much. But all the theorists at CERN knew that I was working for Leon and they knew something was coming, because, of course, everybody hears rumors. And so, they kept inviting me places trying to get some information about what was happening with the discovery of the bottom quark. It made it a little bit more fun to be at CERN because otherwise it's kind of lonely. I worked on a number of things at CERN, but I didn't discover the bottom quark.*

Vera Rubin. Photo by Mark Godfrey, courtesy AIP Emilio Segre Visual Archives, Gift of Vera Rubin.

VERA RUBIN

The trailblazing historian of women in science Margaret Rossiter passed away in August of this year. She is remembered by colleagues, and her legacy lives on in her published work that informed historians and scientists alike. The astronomer Vera Rubin mentioned her in the 1995 interview with historian David DeVorkin.

> *I read in Margaret Rossiter's book on women in science that in 1948 or 1949 Cornell had one woman assistant professor. And I presume that's Martha Carpenter—Martha Stahr at that time. She was there when I came, and I didn't know who to expect. I enjoyed her very much. I took a course in astrochemistry under Shaw, which wasn't bad. It was really spectral analysis and stuff like that, really pretty fun. I had to write a term paper and I wrote about the uncertainty on the orbits of the planets. I wrote a paper attempting to prove that you could never know the orbits accurately enough to extrapolate them back. I just sort of studied what little uncertainties would grow into, something very close to chaos now. And that was not bad.*

A CALL FOR PHOTOS AND MEMOIRS FOR OUR COLLECTIONS

By Trevor Owens, AIP Chief Research Officer

AIP's Emilio Segrè Visual Archives is a remarkable collection of more than 30,000 photos, sketches, and other visual materials documenting the lives and work of physical scientists. Built up over decades through gifts and donations from members of the physical sciences community, it is the most widely used resource of AIP's Niels Bohr Library & Archives.

A core strength of our collection is its inclusion of both formal and candid photos. These can give researchers information about people, places, objects, and events and express ideas that are not easily conveyed in other media, such as the exact layout of a lab or interpersonal dynamics between individuals captured in facial expressions. They are a way to learn about what is important to the people in the photograph and to the photographer.

With that noted, the collection in its current state does not fully represent the range of professionals and practices, especially in the more recent history of the physical sciences. Photos influence public and professional understandings of science: who we imagine scientists to be, what we assume scientific work looks like, and whose contributions get remembered. Our goal is to support research, education, and public dialogue by cultivating a visual archive that is as diverse and dynamic as the community it represents.

Our collection and collecting practices have also not yet taken full advantage of the shift from analog to digital photography, which has allowed for the more routine capture and sharing of all the various aspects of scientists' work and lives. We are interested in what your own collection may have to show. To ease submissions for potential use in our collection, we have set up a new submission tool at **aip.org/submit-a-photo**.

When you submit a photo through this form, you'll notice that you can only submit one photo at a time. That is by design: we encourage this approach because we are generally interested in your curated and individually described selections rather than full runs of images. We also ask that you take time with your photo descriptions. Who is in the photo? When and where was it taken? What is happening? What did it feel like to be there? These small details are what turn an individual snapshot into the rich kernel of our broader shared story.

Aside from visual material, we are also actively expanding our collection of manuscript biographies. AIP is justly renowned for its expansive oral history collection, but it is not necessary to be interviewed or to publish an autobiography to lend your memories to the historical record. Our collections also include long and short unpublished memoirs that record scientists' lives and offer unique perspectives on scientific work.

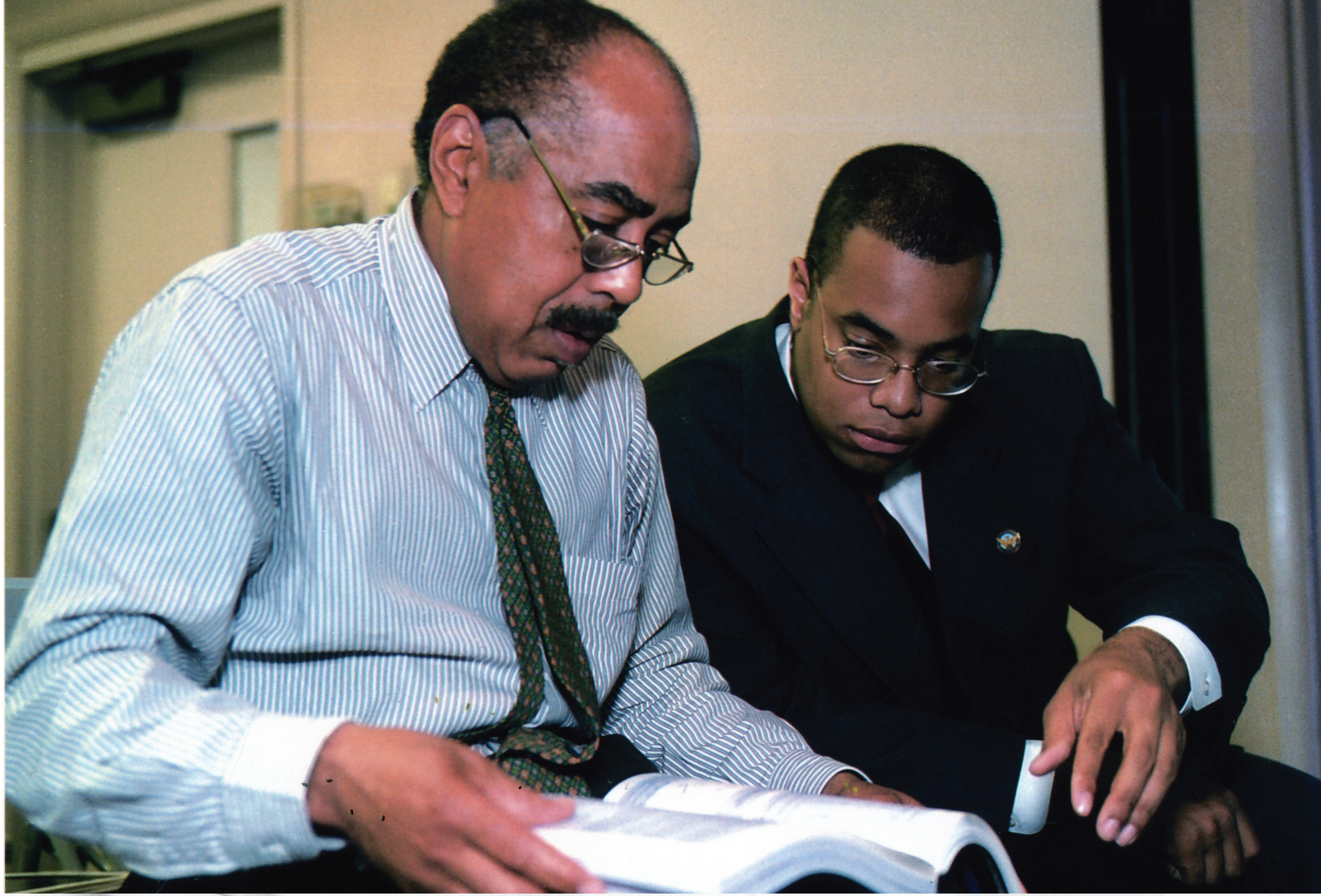
No matter what kind of career you might have had, your recollections can be professionally preserved for posterity and made available for historical research. If you have already written down your recollections, we would be interested in including your writing in our collections. Please contact our library and archives staff at **nbl@aip.org**.

Finally, I'm excited to report that AIP has received a generous $220,000 grant from the Henry Luce Foundation to launch a major initiative focused on documenting and celebrating women's contributions to the physical sciences. Over the next year, we'll be specifically working to collect, preserve, and share stories that reflect the many ways women have shaped, and continue to shape, the field.

As part of this initiative, we invite women at all stages of their physical science careers to document their experiences, through words or images, and to contribute them for consideration for inclusion in our collections. You can help by likewise encouraging others to share their photos. Reach out to mentors, colleagues, or classmates—especially those whose stories deserve to be seen—and offer to support them in uploading images. If you'd like to write something to encourage participation, or if you want us to present or write about this initiative to a group or newsletter you're part of, we'd be happy to help. Feel free to reach out to me directly at **towens@aip.org**.

Top: Walter Massey with student Ike T. Umunnah. AIP Emilio Segrè Visual Archives, Ronald E. Mickens Collection.

Bottom: Nancy Roman, at center, conducts a demonstration with Smith College students during a visit to NASA. AIP Emilio Segrè Visual Archives, Roman Collection.

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REMEMBERING JOHN STACHEL

By Michel Janssen, University of Minnesota, School of Physics and Astronomy

On May 9, 2025, John Stachel, founding editor of The Collected Papers of Albert Einstein, passed away. Lucid to the very end and surrounded by his children, grandchildren, and two newborn great-grandsons, he died peacefully in the home of his daughter Laura in Berkeley, where he had moved from Boston a few years after the death of his wife Evelyn (1928–2011).

John was born March 29, 1928, in New York City into a Jewish Communist family in a predominantly Christian capitalist society. His father, a leader of the American Communist Party, was imprisoned during the McCarthy era, and John would remain a staunch Marxist his whole life. One of the many quotes with which he used to regale his friends and colleagues was: "The problem with the Communist Party was not that it was too far to the left but that it was too far to the east."[1]

John got his undergraduate degree at City College, followed by graduate work at the Stevens Institute of Technology, earning his PhD in physics in 1958 with a dissertation on general relativity. As he remarked in "Autobiographical Reflections" at a conference in Berlin in 1998 to mark his 70th birthday, this career choice made him part of yet another distinct minority.[1]

As the roster of contributors to the Festschrift in which these reflections were published makes clear, John made some important contributions to general relativity and its foundations. He is best remembered, however, for his work in Einstein Studies. As a beneficiary of these efforts, this is what I will focus on, but I would be remiss if I didn't mention John's wariness of disciplinary boundaries. "Go where the problem takes you," he would exhort those following in his footsteps.[2]

One of his best known contributions illustrates the point. John Stachel was the first to propose a new reading of Einstein's "hole argument" (*Lochbetrachtung*) purportedly showing that generally covariant field equations cannot determine the metric field uniquely. Earlier commentators had accused Einstein of mistaking two different coordinate representations of the same field for two different fields. John showed that Einstein actually used such different coordinate representations to construct what looked like genuinely different fields. This led to renewed interest in the hole argument and its resolution through Einstein's "point coincidence argument," not just among historians and philosophers of science but also among modern relativists thinking about quantum gravity.[3]

John first presented this reading of the hole argument in a talk he gave in Jena in 1980, which was eventually published in 1989 in the first volume of Einstein Studies, a series he founded together with Don Howard.[4] This volume was based on the proceedings of a conference on the history of general relativity that John organized at Boston University, the first of seven such conferences held between 1986 and 2005.

I first met John at the second one, held in Luminy, France, in 1988. John was the towering figure at this conference, and the same can be said about the next five. He was the undisputed leader of the community of Einstein scholars, first as editor of the Einstein Papers Project from 1976 till 1989, which John took with him from Princeton to Boston University, where he was professor of physics, then as director of the Center for Einstein Studies, also at Boston University. (The Einstein Papers Project moved to Caltech in 2000.)

It was only toward the end of John's tenure as editor of the Einstein papers that the first two volumes appeared, in 1987 and 1989, respectively. It obviously took time to lay the groundwork for the edition, but the project was also held up by legal wranglings involving the executors of Einstein's will, Helen Dukas and Otto Nathan, staunch defenders of the plaster-saint image of Einstein, which John set out to replace by a warts-and-all portrait of an endlessly fascinating human being.[5]

Even though John edited only volumes 1 and 2 of the Einstein edition, it is hard to overestimate the importance of these two. The big revelation of volume 1 was the newly discovered "love letters" between Einstein and his first wife Mileva Marić.[6] Because of the efforts to obtain these letters, as John explains in an essay about editing the Einstein papers,[7] *The Aspern Papers* by Henry James became required reading for all aspiring Einstein editors.

Volume 2 revolves around the papers from 1905, Einstein's *annus mirabilis*. Essays based on the editorial headnotes for this volume were later collected in a separate volume and remain the best guide to these papers.[8] These and subsequent volumes of the Einstein edition did much to dispel what John identified as the biggest myth about Einstein, i.e., that he was born at the age of fifty.[9]

Though John wrote insightful papers on all facets of Einstein's scientific output, his papers on Einstein and general relativity are probably his most important. For one thing, they make the chapters on general relativity in what is still the best scientific biography of Einstein look the most dated.[10]

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I got to know John better when, in the early 1990s, I joined what would become a flagship project of Jürgen Renn's Abteilung of the Max-Planck-Institut für Wissenschaftsgeschichte founded in Berlin in 1994. The project revolved around the analysis of Einstein's so-called Zurich Notebook.[11] A seminal 1984 paper by John Norton,[12] building in part on John Stachel's 1980 talk in Jena, had made it clear that this notebook was critically important for the reconstruction of Einstein's path to general relativity, yet many of its pages remained to be deciphered. Shortly after I joined, I heard others on the project—in hushed and reverent tones—refer to "Stachel's famous sleepless night," during which, as project lore has it, he cracked page 20L of the notebook. On this page, as John realized, Einstein first suggested adding a term with the trace of the energy-momentum tensor to candidate linearized field equations.

It was also during these meetings that I first heard what we have come to call "Stachelisms," often variations on famous quotes that were nonetheless new to us. About geodesics: Going straight in a crooked world. About sufficient versus necessary conditions: Comforting but not conclusive. About wild speculations: We can conjecture with certainty. Another classic: All analogies limp, but this one goes on crutches. And a personal favorite: Entre nous and me (inspiring Tony Duncan and me to come up with a similar one in Spanish: Let's vamos).

John seemed to have a quote ready for any occasion and was particularly fond of quoting Bertolt Brecht. A few years ago,[13] he told me how attending a performance of the *Dreigroschenoper* (in English) starring Lotte Lenya in Greenwich Village in the 1950s had made him a lifelong Brecht-Weill fan. He liked to quote this gem from Mahagonny: "*Verkauf dich nicht*" (don't sell yourself)—at which point John inserted a pregnant pause—"*für ein paar Dollar*" (for a few bucks). He also liked to quote this line from my great hero, Bob Dylan: "I was so much older then, I am younger than that now."[14]

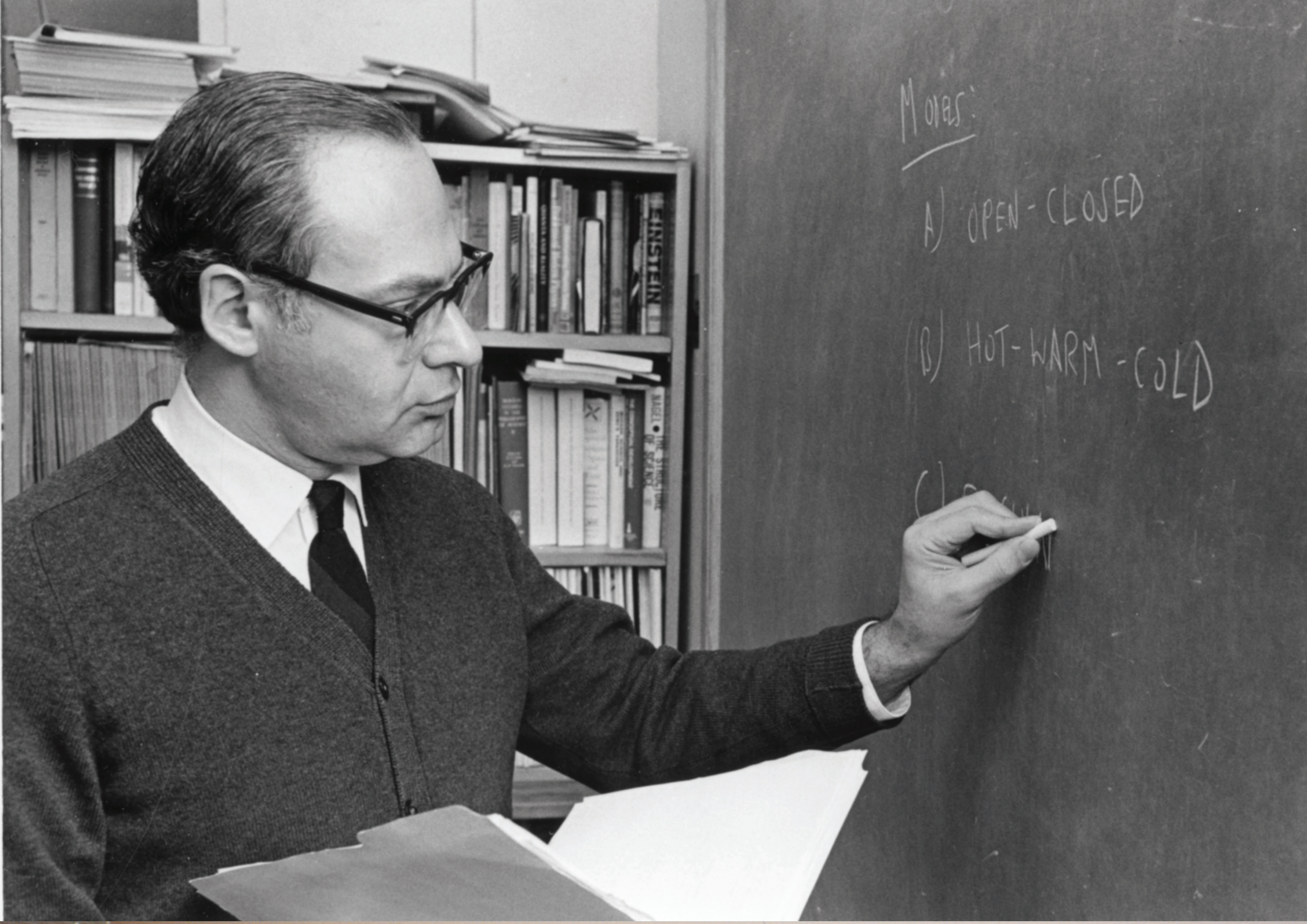
With John, the community of Einstein scholars and the broader history and philosophy of science community, loses one of its giants. Those of us who got to know him personally also lost a mentor and a friend. John ended his autobiographical reflections in Berlin in 1998 talking about his "intellectual family." "Like all parents," he said, "I take special pride in the younger people who think of me as their colleague and some of whom I like to think of (to myself) as my intellectual children."[1] Thinking about what picture to choose for this piece, I thus decided to use one that shows John surrounded by two of his intellectual children and two of his intellectual grandchildren. I am proud to be one of the latter.

Notes and References:

1. John Stachel, "Autobiographical Reflections," in *Revisiting the Foundations of Relativistic Physics. Festschrift in Honor of John Stachel*, eds. Abhay Ashtekar et al., *Boston Studies in the Philosophy of Science*, vol. 234 (Kluwer, 2003), xi–xiv.
2. In the introduction to a "greatest hits" collection of his papers on Einstein, he identifies "the vanity of … disciplinary boundaries" as "[p]erhaps the most important lesson" of his career. John Stachel, "Einstein from 'B' to 'Z'," *Einstein Studies*, vol. 9 (Birkhäuser, 2002), xi.
3. For an overview, see John Stachel, "The Hole Argument," *Living Reviews in Relativity* (http://www.livingreviews.org).
4. John Stachel, "Einstein's Search for General Covariance, 1912–1915," in *Einstein and the History of General Relativity*, eds. Don Howard and John Stachel, *Einstein Studies*, vol. 1 (Birkhäuser, 1989), 63–100.
5. For discussion of these legal wranglings, see, e.g., Roger Highfield and Paul Carter, *The Private Lives of Albert Einstein* (St. Martin's Press, 1993), ch. 12.
6. Jürgen Renn and Robert Schulmann, eds., *Albert Einstein–Mileva Marić: The Love Letters* (Princeton University Press, 1992).
7. John Stachel, "'A Man of my Type'—Editing the Einstein Papers," revised and updated version in *Einstein from 'B' to 'Z'* (Birkhäuser, 2002), 97–111.
8. John Stachel, ed., *Einstein's Miraculous Year: Five Papers That Changed the Face of Physics, Centenary Edition* (Princeton University Press, 2005).
9. John Stachel, "Albert Einstein: The Man Beyond the Myth," in *Einstein from 'B' to 'Z'* (Birkhäuser, 2002), 3–11.
10. Abraham Pais, *Subtle Is the Lord*: *The Science and Life of Albert Einstein* (Oxford University Press, 1982). John Stachel's review is reprinted in *Einstein from 'B' to 'Z'* (Birkhäuser, 2002), 551–554.
11. Jürgen Renn, ed., *The Genesis of General Relativity*, 4 vols. (Springer, 2007).
12. John D. Norton, "How Einstein Found His Field Equations: 1912–1915," *Historical Studies in the Physical Sciences* 14, 1984: 253–316. Reprinted in "Einstein and the History of General Relativity," eds. Don Howard and John Stachel, *Einstein Studies*, vol. 1 (Birkhäuser, 1989), 101–159.
13. In an email of July 27, 2020, in response to me sharing a link with him to a rendition of a song from the *Dreigroschenoper* by my son, whom John and Evelyn had known since he was a baby.
14. As he wrote in the autobiographical reflections cited in note 1: "My experiences have been such as to make me critical of many current shibboleths, including many that were once my own. As Iago says [in Shakespeare's *Othello*], 'I am nothing if not critical.' I hope my experiences have made me much less dogmatic now than I used to be" (p. xi).

Top: John Stachel. Boston University Photography, courtesy of AIP Emilio Segrè Visual Archives, Physics Today Collection. Used with permission.

Bottom: The core members of the Zurich Notebook Project during the fifth conference on the history of general relativity held in Amsterdam in 2002. From left: Tilman Sauer, John Norton, John Stachel, Michel Janssen, and Jürgen Renn. Photographer unknown, courtesy of Michel Janssen.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