



5TH EARLY-CAREER CONFERENCE FOR HISTORIANS OF THE PHYSICAL SCIENCES

ABSTRACT BOOK

ABSTRACT

Promoted by the American Institute of Physics since 2011, the goal of this conference series is to foster communication and collaboration amongst junior scholars and to provide a forum for exploring and reflecting upon current issues in the historiography of the physical sciences.

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SESSION 1: SCIENCE EDUCATION. DIPLOMACY BY OTHER MEANS (THU, AUG 31, 2.30-4 PM)

COMMENTATOR: SIMONE TURCHETTI

CHRISTINA ROBERTS: SPACEMOBILE GOES ABROAD. NASA'S COLD WAR SCIENCE EDUCATION DIPLOMACY, 1962-1969

In the summer of 1961, NASA and the Franklin Institute, a beloved and popular science museum in Philadelphia, Pennsylvania, collaborated on a traveling science education program called the Spacemobile. Two Ford Econoline vans splashed with fancy graphics and the NASA meatball logo were loaded with rockets and spacecraft models and a team of science educators each. They traversed the U.S. eastern seaboard, Puerto Rico, and the U.S. Virgin Islands, visiting over 100,000 high schoolers and interested audiences by the end of 1961. But the program quickly developed an international scope by 1962. Within a brief, but intense few years, over 50 countries in Europe, Latin and Central America, Africa, the Middle East, and Pakistan and India, received similar tours. NASA's Educational Services Program, a small Public Affairs department, collaborated with the U.S. Information Agency (USIA) and the U.S. State Department to train, deploy, and manage the international circulation of space science diplomacy at the height of the Cold War, sometimes in a blatantly racialized way. Using primary sources from NASA, the USIA, oral histories, memoirs, and foreign newspaper articles, in this paper, I argue that Spacemobile's popular appeal and NASA's portrayal of space science as an urgent but benign improvement to science education everywhere, masked its Cold War diplomacy with the rhetoric of 'pure, open, and objective' science for foreign audiences abroad, including children, citizens, dignitaries, and skeptics. Even if the Spacemobilers believed their mission beneficent, they performed the role of Cold Warrior just as well.

DUIM HUH: AMBIVALENT CONNECTION BETWEEN SCIENTIFIC THINKING AND CIVIC RESPONSIBILITY. THE APPROPRIATIONS OF DEWEYAN SCIENCE EDUCATION IN JAPAN, 1920S-1950S

Recent research has renewed interest in John Dewey's notion of science education as a means of cultivating both scientific thinking and civic responsibility through daily problem-solving experiences. My research addresses the contingent link between scientific thinking and democratic trust by focusing on the appropriations of Deweyan ideas in prewar and postwar Japan. The Deweyan science curriculum, which was first adopted in Japan in the 1920s, was later appropriated during WWII by a group of nationalist officials and educators to cultivate the 'Japanese spirit' against the decadent materialistic Western scientism. Here, Deweyan scientific thinking, civic responsibility, and students' interests in local problems and the environment were transformed, respectively, into a Japanese way of thinking, nationalistic responsibility, and the love and devotion for their nation. Similarly, the postwar Deweyan ideas adopted during the U.S. occupation were also replaced and appropriated with nationalistic and developmentalist agendas in the 1950s by the educators who had established the wartime curriculum for cultivating the 'Japanese 'spirit.' They promoted scientific thinking as an effective educational method for empowering students' intellectual ability while arguing for the superiority of wartime pedagogy over Deweyan educational thought. By examining educational discourse and textbooks, my research will show how scientific thinking concepts and problem-solving activities, which were originally used to cultivate democratic responsibility, came to support nationalistic and developmentalist ideologies in the 1940s and 1950s Japan. Thus, in this study, I will suggest that

the Deweyan notion of science education should be complemented by a reflection of the cosmopolitan and collaborative aspects of scientific research in order to serve its democratic goals.

LOUKAS FRERIS: SMALL DEVICES AND DESIGN ADVICES. THE INTRODUCTION OF RADIATION PROTECTION RULES IN POSTWAR GREECE

This paper aims to explore the introduction of radiation protection methods in postwar Greece as a result of the accession of the Greek Atomic Energy Commission to the International Atomic Energy Agency (IAEA). After World War II, the expansion of the use of radioisotopes created the need for a series of regulations for their safer use by citizens, hospitals, and laboratories. The IAEA took advantage of this situation in order to consolidate its position. Followingly, its main vehicles to this end were the Technical Assistance (T.A) programs provided to its Member States. I will follow Alfred Maddock, a professor at the University of Cambridge, a veteran of the Manhattan Project and consultant to the IAEA, who came to Greece to offer his assistance in a radioisotopes training course. But in addition to educational services, Maddock achieved something much more important. He was he who, as the mediator of the Agency, introduced radiation protection ideas in Greece in accordance with IAEA safety protocols. He brought dosimetry devices (film badges) while at the same time reviewed, modified, and created from scratch the architectural designs of the Greek Nuclear Center's laboratories in order to comply with IAEA safety standards. This paper argues that Maddock's visit to Greece was not just a Technical Assistance mission. The International Atomic Energy Agency, through small devices such as film badges and rigorous architectural design rules, attempted to gain the confidence and support of the public in order to eventually dominate the field of radiation protection.

SESSION 2: GENDER, RACE, CLASS, AND THE PHYSICAL SCIENCES (THU, AUG 31, 4.30-6 PM)

COMMENTATOR: KARIN TYBJERG

ELIZABETH COQUILLETTE: BEYOND THE STARS. EXAMINING PERSONAL, GENERATIONAL, AND SOCIAL IMPACTS ON THE CAREERS OF THE HARVARD WOMEN ASTRONOMICAL COMPUTERS (1875-1950)

This paper argues that the personal, generational, and social realities of the women astronomical computers working at Harvard from 1875-1950 provide important context for understanding their professional contributions to astronomy and astrophysics. This research builds on existing scholarly work on the most famous of the women, but it takes a novel approach in that it foregrounds the over 140 Harvard-affiliated women whose trailblazing astronomical work has not yet been widely recognized. Areas of research include the impact of marriage and motherhood; the role of social bonds, female mentorship, and intergenerational educational pipelines at women's colleges; and the impact of socioeconomic status and social privilege on the women's career trajectories, particularly in terms of opportunities for independently driven research versus assistant work. This paper also explores the powerful contributions of the wives of prominent male astronomers to facilitating discourse within the field and to establishing new observatories internationally, as well as those of female philanthropic donors who supported women's work in astronomy. This paper also describes a research methodology, including insights for other scholars to apply to their own collections. The first year of work focused on researching and writing biographies for individual women computers, and then that individualized research became an opportunity to identify trends and themes across this cohort without being biased by preset hypotheses. The research process incorporated historical records, correspondence, scientific notes, and other primary sources, as well as using geographic information systems technology to visualize data about the women's home addresses, social positions, and career moves.

MICHELLE FRANK: TANGLING WITH ENTANGLEMENT HISTORY. EARLY QUANTUM CONTRIBUTIONS OF CHIEN-SHIUNG WU

On New Year's Day of 1950, in a one-page letter to *Physical Review*, Chien-Shiung Wu documented the first evidence of entangled photons. Her findings have been hidden in plain sight for over seventy years. My research asks why. In 1949, Wu's stated goal was to test John Wheeler's pair theory. With her graduate student, Irving Shakhov, Wu tracked annihilation radiation from matter-anti-matter collisions using two photo-multiplier tubes, anthracene crystals, and an improved scintillation counter as a gamma-ray detector. When Wu succeeded in proving Wheeler's theory, she also became the first to document evidence of entanglement. Twenty years later, as quantum foundations research began to emerge from the shadows, Wu revisited her 1949 experiment in 1971 with a more refined approach. She shared results with Stuart Freedman, known today for his collaboration with John Clauser. Later, Clauser, et.al., would distinguish Wu's work, arguing that in part because of its reliance on Compton scattering to measure photon polarization, Wu's experimental model could not conclusively disprove hidden variables. In 2022, the Nobel Committee honored Clauser, Aspect, and Zeilinger, each of whom had produced increasingly convincing proof of entanglement. Working separately, each built on their predecessors' experimental designs, closing loopholes, and ruling out one alternative explanation after another until, finally, entanglement was the only conclusion left standing. When the awards were announced last fall, Wu's foundational work, from almost three quarters of a century ago, was not mentioned. Combining historical and biographical methodologies, my research aims to bring Wu's photons back into the light.

NITHYANAND RAO: INVISIBLE LABOR AND THE "GHOST PARTICLE"

Science Studies has shown that science, despite appearing placeless, is the product of situated practices in localized spatial settings. However, for physics and astronomy, how such spatial conditions for producing science are themselves produced has escaped scrutiny. I ask this question through a case study of particle physics experiments performed in the deep underground mines of Kolar Gold Fields (KGF) in south India, where neutrinos produced from cosmic rays were first detected in 1965. Such experiments require specific conditions, the most important being the depth of the underground chamber. I bring together recent scholarship that views cosmic ray physics as a field science, with labor histories of the mines and archival material about the experiments, to argue that KGF, which its British mining company ran by taking advantage of a "racial pyramid," reached more than three kilometers deep over a century of mining because of the labor of Dalit miners who worked in difficult and dangerous conditions for less than subsistence level wages. Further, running the experiments depended on the labor that kept the mines functioning. This labor is visible in the archival material only when it was unavailable due to labor strikes or accidents. In these ways, it is colonial extraction, cheap labor, and the hierarchies of race and caste that produced KGF as a space suitable for science. Other mines with underground neutrino experiments—in South Africa, the U.S. Canada and Japan—also have their violent colonial/imperial histories, illuminating how the spatial conditions for such science were produced.

SESSION 3: MOTIVATION AND INTERPRETATION (FRI, SEP 1, 9-10.30 AM)

COMMENTATOR: RICHARD STALEY

ANNELIE DRAKMAN: THE PHUN OF PHYSICS. THE EMERGENCE OF SUBJECTIVE ENJOYMENT AS A MEANS OF MOTIVATING SCIENTIFIC PURSUITS AFTER WORLD WAR II

This text investigates the emergence of a new way of motivating scientific pursuits from the 1950s onwards – because the scientist finds it fun. Until this point in time, why one pursued science had primarily been motivated either by its practical usefulness or by awe and wonder. But after World War II, in the American context, scientists began speaking publicly and emphatically of their own personal enjoyment of science. Why did it become acceptable to say that one did science for the fun of it? To answer this question, self-depictions by two of the most influential public intellectuals of the time are investigated: Richard Feynman (Nobel Laureate in Physics, 1965) and James Watson (Nobel Laureate in Physiology or Medicine, 1962). The primary sources are their autobiographies, *Surely You're Joking, Mr. Feynman!* and *The Double Helix*, due to their huge popularity, both selling millions of copies, and far-reaching influence. The focus on having fun in these self-depictions is contextualized in regards to the American discomfort with conformity in the 1950s, as expressed in for instance J.D. Salinger's *The Catcher in the Rye*. Furthermore, it is argued that depicting oneself as having fun was a way of displaying vitality, by means of showing off characteristics and traits such as impulsivity, charm, creativity. This was contrasted to contemporary science which was described as pompous, predictable, and routine, a vilification which explains the title of another one of Watson's autobiographies: *Avoid Boring People*.

MIGUEL OHNESORGE: RECOVERING A LOST ARC IN THE HISTORY STATISTICAL INFERENCE. GEODETIC STATISTICS FROM LAPLACE TO PEIRCE

Few scientific disciplines occupy such a central position in the modern history of statistics as physical geodesy – the “science of modelling and measuring the Earth’s figure and gravity field” (Helmert 1880, xi). As has been widely noted, eighteenth-century geodesists even pioneered principled regression techniques (Stigler 1993; Howarth 2001). Despite such acknowledgements, little attention has been paid to subsequent development of statistical methods by geodesists. My concern here is to fill that gap, showing how nineteenth-century geodesists – from major figures to forgotten practitioners – debated the aims of statistical inference and significantly shaped its history. Based on an analysis of Laplace’s *Mecanique Celeste* (1789-1825), I show that algebraic statistics first entered geodesy as technique for exposing possible sources of systematic measurement error. However, a series of popular textbooks in the 1820s and 30s significantly altered the purposes for which geodesists relied on statistical reasoning. It soon became common practice to treat all measurement errors as random and use regression as a tool of estimating best-fit values. In the 1860s and 70s, Philip Fischer and Heinrich Bruns, two rather obscure German geodesists, leveled a systematic attack on this development, calling attention to systematic errors lurking below their colleagues’ results. I show that their critiques travelled the Atlantic and influenced Charles Sanders Peirce and John Hayford at the US Coast and Geodetic Survey. The former became widely known for establishing statistical methods for distinguishing spurious and genuine results (Hacking 1990, 200), while the latter’s work on systematic errors culminated in the “Hayford ellipsoid” – the first standard model of the Earth’s figure and external gravity field.

LEWIS BREMNER: INTERPRETING THE WORLD. PHYSICS, ASTRONOMY, AND TRANSLATION IN TOKUGAWA JAPAN

This paper explores the work of the Japanese scholar and interpreter Shizuki Tadao, and in particular his three-volume manuscript, *Rekishō shinsho* ('New Book on Calendrical Phenomena'), which he completed in 1802. The book was nominally a translation of two collected books by the Oxford astronomy professor John Keill, *Introduction to True Physics* (1702) and *Introduction to True Astronomy* (1718). In *Rekishō shinsho*, Shizuki presented to Japanese readers for the first time detailed explanations of several of Newton's central ideas, including optics and universal gravitation, and covered a wide range of concepts in astronomy and physics including the fundamental forces, planetary motion, particle physics, and the extent of the universe. Having used a Dutch translation of Keill's work, he also gained renown among contemporary scholars as the foremost expert in European languages of his day, a reputation that outlasted his early death in 1806. However, in many places in Shizuki's book the content differed from Keill's text, sometimes radically so. Previous scholarship on the physical sciences in Japan has described these divergences as mistakes or mistranslations that, despite the quality of the work, reflect its underdeveloped grasp of science and adversely affected the circulation of scientific knowledge from Europe. By contrast, this paper considers these divergences as points at which Shizuki's intentional, coherent, and critical engagement with knowledge of nature can be observed most clearly, revealing his practices of not only translating ideas, but also testing, reformulating, and creating them in pursuit of a better understanding of the universe.

SESSION 4: INTERNATIONAL EXCHANGE (FRI, SEP 1, 11-12.30 PM)

COMMENTATOR: CHRISTIAN JOAS

MASAHIRO INOHANA: RYOKICHI SAGANE'S ACTIONS AND IDEAS ON INTRODUCTION OF FOREIGN NUCLEAR REACTORS TO JAPAN

While much of the history regarding the introduction of nuclear power in Japan has been described in terms of bureaucracy and policy, studies of scientists who promoted nuclear power during its introduction are insufficient. This presentation focuses on Ryokichi Sagane (1905—1969), a major physicist during the introductory period, and analyzes his actions and ideas, as well as the background behind them. Sagane's father was Hantaro Nagaoka (1865—1950), one of Japan's most influential physicists in the early 20th century. From 1935 to 1938, Sagane conducted research at the Lawrence Radiation Laboratory and learned techniques for operating the cyclotron. When the atomic bomb was dropped on Nagasaki, a letter from American scientists to Sagane was also dropped with it. Since the late 1950s, Sagane worked on the development of atomic energy in Japan. He became a board member of the Japan Atomic Energy Research Institute (JAERI) and Japan Atomic Power Company. As a member of the survey team for overseas nuclear reactors, he toured various countries and led the contracting of nuclear reactors. His words and actions during the introduction of nuclear power were based on his sense of mission that scientists make good use of nuclear energy and the rational economic sense he acquired while studying in the U.S. They were based on Sagane's unique experience, which was different from that of other Japanese scientists.

HIROTO KONO: SHŌJI NISHIKAWA'S RESEARCH AND EDUCATION IN CRYSTALLOGRAPHY

Shōji Nishikawa (1884—1952) was a Japanese physicist who made remarkable contributions to the development of crystallography. In the early 1910s, influenced by Torahiko Terada (1878—1935), he started working on X-ray diffraction and explored the space group theory of crystal symmetry. While studying in the U.S. and Europe from 1917—1920, he was invited by Edward L. Nichols (1854—1937) as a visiting researcher at Cornell University, where he taught and collaborated with Ralph W. G. Wyckoff (1897—1994), who was still in his teens but would become a major figure in X-ray crystallography. Wyckoff would further develop Nishikawa's method of space group and form

the research groups in this direction, which, for example, would stimulate Linus Pauling (1901—1994)'s research in Pasadena. After returning to Japan in 1922, Nishikawa launched his research group at the Institute of Physical and Chemical Research, which soon became a powerful center for crystallography. He fostered young scholars in the field such as physicist Seishi Kikuchi (1902—1974) and chemist Isamu Nitta (1899—1984). In this talk, drawing from his materials including the X-ray photographic plates and the unpublished manuscripts, I examine Nishikawa's research method and education in crystallography.

JINYAN LIU: CHINESE SCIENTISTS IN DUBNA (1956-1965)

The work of Chinese scientists conducted at the Joint Institute for Nuclear Research (JINR) (1956—1965) was inextricably linked to the Sino-Soviet relations in the 1950s—1960s. During the early stage of the JINR, with the aid of advanced equipment and the international cooperation mechanism, Chinese scientists achieved crucial results, such as the discovery of the antisigma-minus hyperon and the proof of the law of partial conservation of axial current (PCAC). After the Sino-Soviet split, Chinese scientists' activities at the JINR were hampered by political tensions, eventually resulting in China's withdrawal from the JINR in 1965. But through the involvement at the JINR, Chinese scientists were trained in scientific practices and participated in international exchange and cooperation which turned them into a new force in China's nuclear industry, boosting its nuclear weapons, particle physics theory, and accelerator technology. In the meantime, the Chinese scientists' activities extended the international influence of the JINR. The withdrawal of China from the institute impacted both the and the development of science in China.

SESSION 5: PHYSICS IN WEIMAR CULTURE (FRI, SEP 1, 4-5.30 PM)

COMMENTATOR: CHRISTOPH LEHNER

ELENA SCHAA: A ROMANTIC GENIUS? SCIENCE AND RELIGION IN WERNER HEISENBERG'S POPULAR COMMUNICATION

Since the early 1940s, Werner Heisenberg engaged increasingly in popular science communication. He gave speeches, e.g. "The unity of the scientific image of the world [Die Einheit des naturwissenschaftlichen Weltbildes]" (1941), published books, e.g. *Physics and Philosophy* (1958), accepted awards, e.g. Romano Guardini Prize in 1973, and gave interviews, e.g. "Double Dialogue" (1974). In the introduction of his memoir, *The part and the whole. Conversation around the Particle Physics [Der Teil und das Ganze. Gespräche im Umkreis der Atomphysik]* (1969), Heisenberg writes that he hopes to empower the lay audience to engage in the "philosophical, ethical, and political discussions" arising from modern physics. Departing from a close examination of a selection of Heisenberg's popular communication, the paper discusses the role of religion in Heisenberg's communication physics beyond the scientific community. The paper analyses firstly, Heisenberg's arguments about the relationship between religion and science, along with the characterization of religion. Secondly, focusing on the aesthetic patterns of his writings, such as extended metaphors, the paper highlights the interference of science and religion. By going beyond the argumentative level, the paper shows that the Romantic aesthetics of immediate experience of nature is central to the promoted ideal of scientists and advancing science. Ultimately, I show that Heisenberg's popular communication promotes a romantic worldview, which challenges the differentiation of science and religion in light of modern physics.

THIJS LATTEN: ON THE ROLE OF ADVAITA VEDĀNTA IN ERWIN SCHRÖDINGER'S WORK

As is well-known, Erwin Schrödinger formulated his famous wave function in 1925 (published 1926). Lesser known, however, is Schrödinger's collection of essays (2008) displaying his deep philosophical commitment to Indian thought, written in the same year he formulated the wave-function. Indian Vedantic insights, Schrödinger writes, play the central role in the worldview formulated in these essays. Furthermore, Schrödinger's biographer Walter Moore writes Schrödinger 'found in the philosophy of Vedanta his understanding of the nature of scientific research' (Moore, 1989, 348-349), and suggests Indian 'Buddhist wisdom' may have enabled Schrödinger to formalize his unintuitive quantum mechanics (ibid., 169). Now, Moore's account stops short of a comprehensive analysis of Schrödinger and Indian thought and the literature lacks a thorough account. Should we separate Schrödinger's interest in Indian philosophy strictly from his physics or construe it as more than a personal interest? My in-progress research engages with this historical episode and aims to elucidate how Schrödinger's grasp of Indian philosophy relates to his physics. The commitment to Indian thought of the Austrian-Irish physicist, who ended every conference with the Upanisadic wisdom 'Atman = Brahman,' is apparent (Bitbol, 1998, 13). Schrödinger's scepticism towards the ability of 'materialist science' to contribute to understand reality shows the relevance of investigating what, according to him, his ground-breaking physics did accomplish. Although he remained prudent with directly relating Indian thought to physics, as I am too, his physics seems to be rather embedded in his philosophical convictions than something that can be separated from it.

SOFIA GUILHEM BASILIO: INTELLECTUAL ENVIRONMENT AND THE DEVELOPMENT OF QUANTUM THEORY. AN ANALYSIS OF ERWIN SCHRÖDINGER'S WORK

The ways historians study the history of science and its interplay with broader cultural and social phenomena have changed significantly during the past fifty years. In the history of the physical sciences, a key role is played by what is known as the "Forman thesis." In work published in the early 1970s, the historian of physics Paul Forman argued that German physicists during the 1920s embraced the new quantum mechanics—in particular, its acausality—because of their adaptation to the Weimar Republic's intellectual environment (Forman 1971). In my talk, I will build upon and further investigate the Forman thesis by studying the intellectual trajectory and scientific work of the Austrian physicist Erwin Schrödinger between 1918 and 1926 and by relating them to the cultural and intellectual milieu of the time. Based on an analysis of Schrödinger's correspondence, notebooks, and published work, I claim that Schrödinger was concerned with the concept of causality and its consequences on the development of physics well before the advent of quantum mechanics. I will show that Schrödinger's epistemological outlook built upon an extensive reading of, among others, Spinoza, Schopenhauer, Mach, Richard Semon, and Richard Avenarius (Schrödinger 1985). I will argue that Schrödinger's philosophy of science is deeply intertwined with his scientific practice.

SESSION 6: INSTRUMENTS AND METHODS, (SAT, SEP 2, 9-10.30 AM)

COMMENTATOR: JAUME NAVARRO

ENES TEPE: CROSS-CULTURAL ANALYSIS OF TIMEKEEPING INSTRUMENTS. TWO EXAMPLES OF MIZZĪ & SUTTON

Astrolabic quadrants, a class of astronomical portable quadrants derived from plane astrolabes, were prominent timekeeping instruments in the Islamic civilization and the Western Europe for centuries. Muḥammad ibn Aḥmad al-Mizzī in 14th century Damascus and Henry Sutton in 17th century London can be considered among the most accomplished instrument makers of their respective cultures who designed, produced, used, taught, and wrote about astrolabic quadrants. From these instrument makers, who were highly influential among their peers and their successors, a number of astrolabic quadrants have survived. For my PhD project, I am reconstructing one of the astrolabic quadrants of each of them for conducting a cross-cultural examination of the operations with the replication method. That is to say, I am practicing according to the instructions from the primary source materials by reading mathematical-astronomical treatises from the Mamluk Sultanate and Stuart period of England. One research question is whether operating the instruments can help us understand the cultural contexts of historical timekeeping. In this talk, I will briefly introduce the two astrolabic quadrants by Mizzī and Sutton and provide examples of timekeeping by each of these instruments to address this inquiry.

JACK KLEMPAY: MATTERS OF RECORD. FILM, PAPER, AND THE "BUREAUCRATIC MEDIA" OF RADIATION PROTECTION AT NUCLEAR TEST SITES

This paper analyzes the role of photodosimetry in the administration of radiation protection during nuclear testing by the United States. Throughout the 1940s and 50s, soldiers, workers, and scientists wore small strips of film that darkened when exposed to radiation, making it possible to estimate the cumulative dose that had been absorbed by gauging the darkness of the film. Drawing inspiration from historian Ben Kafka's reinterpretation of Marx's writings on bureaucracy, I argue that film was a "bureaucratic medium" that enabled administrators to produce and manage knowledge about exposures at the test sites. I show how administrative perceptions of exposure were shaped by the materiality of film and the paperwork that surrounded it, from the limited range of chemical emulsions to errors in the spelling of names and the transcription of dose data. Moving from the laboratory to the offices of test administrators to the archives where exposed films were filed away in anticipation of future litigation, I describe how film badges were part of a larger technopolitical system that was designed generate knowledge about exposures while limiting competing viewpoints on the hazards involved in nuclear testing. My analysis combines approaches from the history of science, STS, and media studies, and the paper contributes to growing bodies of scholarship on the technopolitics of nuclear things and the materiality of bureaucratic organizations.

E.L. MESZAROS: ALGORITHMIC RELATIONSHIPS IN BABYLONIAN ASTRONOMICAL PROCEDURE TEXTS

Babylonian astronomical procedures make up a small portion of the surviving Mesopotamian material concerning astral sciences. Their descriptions of the mathematical methods of prediction, however, make them a significant interest to modern scholars. Despite consistent treatment of these texts over the decades since their recovery, the relationship between individual procedures and the overall makeup of the tablet itself is frequently ignored. Instead, these procedures are often labeled as "algorithms" without critiquing the modern semantic weight of that term and then examined as separate entities. The unnuanced examination has proven fruitful and productive, but interrogating the "algorithm" label and intra-tablet interaction of procedures can shed additional light on how ancient practitioners used these astronomical tablets. This talk will present some initial findings of my dissertation research on the interaction between astronomical procedures on Babylonian tablets. Using algorithms as a lens, this research looks into implicit knowledge, the relationship between procedures and provided data, and representations of methods within the tablets. Such an algorithmic lens is informed by modern algorithmic analysis

but focuses on features of the ancient texts themselves rather than prescribing algorithmic characteristics to Babylonian scientific practices. This presentation will provide a critical analysis of the term "algorithm" in a historical, Mesopotamian context and an application of the algorithmic lens as an analytical tool for thinking about the relationship between astronomical procedures.

SESSION 7: WAYS OF SEEING (SAT, SEP 2, 11-12.30 AM)

COMMENTATOR: HANNE ANDERSEN

SEBASTIAN FERNANDEZ-MULLIGAN: FROM THE MODEL TO THE GLANCE: HOW ASTRONOMERS LEARNED TO SEE GRAVITATIONAL LENSES, 1960-1990

Between the late 1960s and today, the process by which astronomers identified a gravitational lens went from a time-consuming spectroscopic experiment to a two-second glance at a telescope image. This talk will analyze discoveries of gravitational lenses over this period to explore the questions: How did astronomers learn to see new objects in the sky, and how did they train their eyes to effortlessly recognize these patterns in nature? Rather than separating quantitative and qualitative approaches, I argue that the mathematical modeling and the spectroscopic identifications of the sixties and seventies were necessary scaffolding for the development of expert intuition in the eighties. By developing an intuition for what a lens looked like, astronomers increasingly relied on their own expert judgement rather than spectroscopy or calculations to initially identify lensing candidates. Through this historical case, this talk will highlight intuition as a skill and will explore the methods by which scientists train and retrain their intuition over the course of a career. The gamut of gravitational lens discoveries reveals that scientists used models to not only describe the world as it is, but to also teach themselves what it could look like. To retrain their intuition and to learn how to see gravitational lenses, astronomers learned to see their models.

MICHELLE MERCIER: HOW TO SEE AND HOW TO COMMUNICATE WHAT HAS BEEN SEEN? THE CASE OF THOMAS YOUNG'S DOUBLE-SLIT EXPERIMENT (1807)

In 1807, Thomas Young published a description of an experiment that is now canonized as Young's double-slit experiment. The basic principle of the experiment is well known today, but the experiment performed by Young is not: his description leaves many questions unanswered and is unspecific in its details and therefore difficult to understand, for example in respect to the apparatus he used and the result of his experiment. As part of my PhD project, I analyzed Young's double-slit experiment by using the replication method. Experiences made (experimentally) will be described in this talk; I will focus in particular on the difficulties in observing and communicating what is seen: skills which are needed to acquire first (experimentally) in order to make experimental observations as described by Young, as well as problems to communicate experimental results that are not numerical values but visual perceptions of the senses and subjective in nature. By doing so, not only the question arises as to what skills Young did draw upon in making these observations, but also to what extent they may have influenced his experimental activities as well as the communication of experimental results. What means and methods did he use to communicate his experimental results? And how were his descriptions of experimental results understood by other natural philosophers in the beginning of the 19th century in England? The meaning of the experiences made for the understanding of Young's descriptions of the experiments will be discussed in the conclusion.

AMELIA URRY: FEELING INTO ICE, SEEING THROUGH TIME. RADAR SOUNDING AND THE ARCHAEOLOGY OF DATA

Radio echo sounding (RES) emerged as a technique to probe the subsurface structure of ice sheets in the 1960s, becoming one of the earliest applications of remote sensing technologies in the polar regions. An early collaboration between the Scott Polar Research Institute (SPRI), the U.S. National Science Foundation (NSF) and the Technical University of Denmark (TUD) established the technique and its instrumentation for airborne applications in the 1970s. Subsequently, radar sounding has become a standard tool for understanding the subsurface dynamics and history of ice sheets. But as the technology and research questions of radioglaciology evolved—most notably with questions of ice sheet stability and the possibility of climate-induced collapse—the original SPRI-NSF-TUD data captured in Antarctica and Greenland seemed to offer new insights. Efforts to digitize and re-analyse photographic records demonstrate the materiality of this data, which proves to be both resilient to loss and yet fragile to interpretation. In order to contextualize old data, contemporary scientists often find themselves reconstructing the mindset and methods of their predecessors. Thus, the physical history of the ice sheet is linked to the human history of its exploration. This talk will move from the history of the SPRI-NSF-TUD program into an exploration of these contemporary efforts to dig up this old data for new interpretation, with a particular emphasis on the role of the Danish institutions and instruments.

SESSION 8: POLITICS OF PHYSICS AFTER WORLD WAR II (SAT, SEP 2, 2-3.30 PM)

COMMENTATOR: KRISTINE HARPER

BARBARA HOF AND GERARDO IENNA: PHYSICISTS “ON TRIAL”. THE ACCUSATIONS OF EUROPEAN RADICALS IN THE CONTEXT OF THE US MILITARY OPERATION IN VIETNAM

Drawing on archival sources, the planned presentation will offer new insights into radical movements within the physical sciences in Europe. Two events provide the framework: the invitation of Murray Gell-Mann, particle physicist who proposed the quark model, to lecture at the CERN summer school in Grado, Italy, in May 1972, and a conference at the International Center for Theoretical Physics in nearby Trieste in September 1972, which Gell-Mann also attended. While the first event went undisturbed, militant students and scientists protesting the US intervention in Vietnam forced the organizers of the Trieste conference to move to another lecture hall, guarded by security forces. In the intervening months, Gell-Mann and other members of Jason (a top-secret branch of physicists advising the US Department of Defense) were confronted with protests in several European cities. Protesters contended that Jason members were complicit in genocidal practices. Furthermore, Gell-Mann, who was working at CERN that year, was forced to cancel his scheduled lecture there. Staff members went beyond criticizing Jason, however: they collected signatures calling on the CERN Council to take a clear stance against the misuse of science for warfare. The planned presentation covers opposite views about the role of physics in world affairs. The aims are: 1) to place scientific internationalism and radical movements in local contexts; 2) to contribute to historical research on perspectives "from above, below" by critically assessing how laboratory management responded to protesting radicals; 3) to draw conclusions on "silence about politics" as a form of scientific communication, and 4) to deconstruct narratives about pure physics, thereby contributing to historical studies examining the myths of the neutrality of science.

MICHEL BRON: RADIOACTIVE KNOWLEDGE. THE ROLE OF OIL GEOLOGISTS AND GEOPHYSICISTS IN THE DEVELOPMENT OF THE NUCLEAR INDUSTRY

The history of nuclear energy is a history of radioactive knowledge in geophysics and applied geology. From the Manhattan Project to managing nuclear reactors in the 1970s, geologists dominated the development of the nuclear industry. This paper focusses on the essential, and hitherto underexplored, role that the development of knowledge about radioactivity and the detection of natural radiation in geophysics and applied geology played in the worldwide

development of atomic energy. In this way, this paper shows that to build a global nuclear industry, knowledge from geophysics and geology was indispensable, and the involvement of the oil sector was not just a diversification project but may be better interpreted as a geoscience spill over. At the core of this paper are the stories of oil actors who operated at the intersection of geosciences and nuclear science, such as Sir Edward Crisp Bullard, Herman Schürmann, and Robbert van Erpers Roijaards. Through these case studies, this paper examines how knowledge of natural radiation moved from the laboratories of William Conrad Roentgen, Henri Becquerel and Marie and Pierre Curie to geophysicists and geologists in the oil sector who would then play an important role in the creation of the atomic bombs in the Manhattan Project, the first uranium mining in the United States and ultimately the establishment of a nuclear industry in France, Italy, the Netherlands and the United States.

MADISON RENNER: CRAFTING A HISTORY FOR CLIMATE SCIENCE. HOW THE KEELING CURVE BECAME A DISCOVERY

This paper offers a new history of the so-called "Keeling curve," a widely distributed graphical representation of increasing atmospheric carbon dioxide (CO₂) and an icon of global climate change. Much existing historiography credits the Keeling curve (by name) with inspiring scientific and public attention to greenhouse warming beginning around 1960, when its eponym — American chemist Charles Keeling first shocked contemporaries with his "epochal finding" of CO₂ rise. I argue by contrast that the idea of a 1960 "discovery" of rising CO₂ was a product of debates about global warming during the 1980s, a response to the very anxieties that the Keeling curve is now thought to have caused. In the 1970s, Keeling gained renown for his enduring commitment to what was widely considered non-discovery science; by 1980, associates were using his name in casual conversation to denote the rising CO₂ trend. A key semantic shift occurred when diverse mentions and depictions of "Keeling's observations" (plural) were consolidated as "the Keeling curve" — a singular finding which emerged in relief to the ongoing work of "routine monitoring." It was a journalist seeking to convey scientific certainty about greenhouse warming who first attributed the curve to a "discovery." I trace this framing from his 1990 book into turn-of-the-century historiography and into scientists' (revised) accounts; within a few years, even Keeling attested to a 1959 "Eureka moment" he previously denied. I discuss some implications of this account for the historiography and sociology of scientific discovery, collective memory, and climate science and politics more broadly.

SESSION 9: SEEKING THE (UN)SEEN (SUN, SEP 3, 9-10:30 AM)

COMMENTATORS: HELGE KRAGH AND ANJA SKAAR JACOBSEN

VALENTINA ROBERTI: THE HELMHOLTZ LEGACY IN COLOR THEORY. AN ACCOUNT OF SCHRÖDINGER'S RESEARCH ON COLOR

Modern color science finds its birth in the middle of the 19th century. Among the chief architects of the new color theory, the name of Hermann von Helmholtz stands out. A keen experimenter and profound expert of the latest developments of the fields of physiological optics, psychophysics and geometry, he exploited his transdisciplinary knowledge to define, between the years 1891-1892, the first Riemannian line-element in color space. However, the outstanding work of Helmholtz fell into oblivion for at least a quarter century, until Erwin Schrödinger, one of the founders of quantum mechanics, rediscovered its precious value in the 1920s. After a deep study of Helmholtz's

papers on color space, Schrödinger detected some shortcomings in Helmholtz's treatment of the line-element that led him to undertake a re-examination of the entire metrical theory of color perception. Schrödinger's first papers on this topic, published in 1920, contain his proposal of a Riemannian metric compatible with both Abney's and Weber-Fechner's law. In this contribution the content of Schrödinger's 1920 memoirs will be discussed in order to highlight the profound influence of Helmholtz's work on Schrödinger's research on color. Particular focus will be given to significant aspects of both Helmholtz's and Schrödinger's color theory that have laid out the basis for all subsequent studies on the geometry of color spaces up to the present time. Moreover, a brief overview of all of Schrödinger's writings on color - which have been largely unnoticed - will be provided.

URKO GORRIÑOBEASKOA: THE SEMANTIC LAYERS OF ETHER

Epistemic objects are a particular kind of object of inquiry for the history and philosophy of science. They are objects in the sense that we take them to be real, material things, although most of the times they are not directly perceivable. They are epistemic as they are only what we conceive of them and in interaction with them; in Kantian terms, they belong to the realm of phenomena, as we cannot access the noumena. What is particular about these objects is that they are historical. They are born, they evolve, reproduce and, eventually, they might die. In this presentation I introduce my PhD project about the history of the ether as an epistemic object. I propose that Klaus Hentschel's (2018) methodology of 'semantic layers' fits quite well as a tool with which to study the history of such epistemic objects. According to this methodology, a concept in science is a conjunction of many layers of meaning that are gradually added to it through time. Combining historical research with a philosophical/conceptual analysis, Hentschel's method can trace the history of an object such as the ether through its many changes. This methodology is useful to show what different conceptions of ether had in common and what they differed on. Also, it shows how some of the semantic layers of ether tried to outlive the concept after its abandonment in early twentieth century.

JEAN-PHILIPPE MARTINEZ: THE STRANGE CONCEPT THAT ALMOST NOBODY SEEMED TO BE CONCERNED ABOUT. VIRTUAL PARTICLES IN THE EARLY POST-WAR PERIOD

Virtual particles are nowadays an integral part of the conceptual framework of quantum field theory (QFT), our best approach to building models describing particles and their interactions. Short-lived, unobservable, and not subject to the usual rules of conservation of energy and momentum, they nevertheless present many strange features. These have led, in the last decades, to philosophical discussions about the ontological status of virtual particles and sometimes to the clear denial of their potential existence. At the heart of these debates is their profound interrelation with Richard Feynman's diagrammatic technique for QFT calculations, whose popularity has led to their wide diffusion among the masses of physicists. Feynman's seminal work in the late 1940s was in fact the final piece of two decades of evolution. It provided the first systematized, generalized, but also visual description of virtual particles. Nevertheless, at that time, the odd characteristics of the latter remained curiously little, if at all, debated. This presentation proposes to discuss the reception of the concept of virtual particles in the early post-war period, to examine how it initially remained immune to ontological debates, and how these debates actually gradually emerged. In particular, it will reveal the weight of various aspects of pre-Feynman developments, which have now mostly disappeared from the discussions, but which once guaranteed a stronger phenomenological grounding of the scientific practices related to the use of the virtual particle concept.