History of Physics
NEWSLETTER
A FORUM OF THE AMERICAN PHYSICAL SOCIETY • VOLUME XIII • NO. 4 • SPRING 2017

Reykjavik Reading

Seated onstage from left to right: Al Twanmo (Gorbachev), David Jackson (Reagan), Kelsey Phelps (Director), Charles Ferguson (FAS). On right, facing audience: Brian Schwartz.

One event at the January/April APS meeting was a staged reading of *Reykjavik*, by Pulitzer Prize-winning author Richard Rhodes. Reykjavik is the capital of Iceland, an island country located about 500 miles northwest of Scotland in the North Atlantic. In 1986 Mikhail Gorbachev, the Chairman of the Politburo of the Soviet Union and General Secretary of the Soviet Communist Party, invited Ronald Reagan, the President of the United States, to meet with him. The play *Reykjavik* is a dramatic reconstruction of the two-day summit meeting during which the world leaders almost reached agreement on the total abolition of their countries nuclear weapons. The play uses the actual transcripts of the Reykjavik meeting as well as the memoirs of both Reagan and Gorbachev to dramatize how close the two superpowers, the Soviet Union and the United States, came to eliminating their nuclear weapons. The staged reading was performed by the Tonic Theater Company. Charles Ferguson, President of the Federation of American Scientists, as well as the play director and actors, stayed afterwards for a talk-back discussion. The event was produced by Brian Schwartz, CUNY and Gregory Mack, and the APS. It was sponsored by: The Forum on the History of Physics, The Forum on Outreach and Engaging the Public and The Forum on Physics and Society. ■

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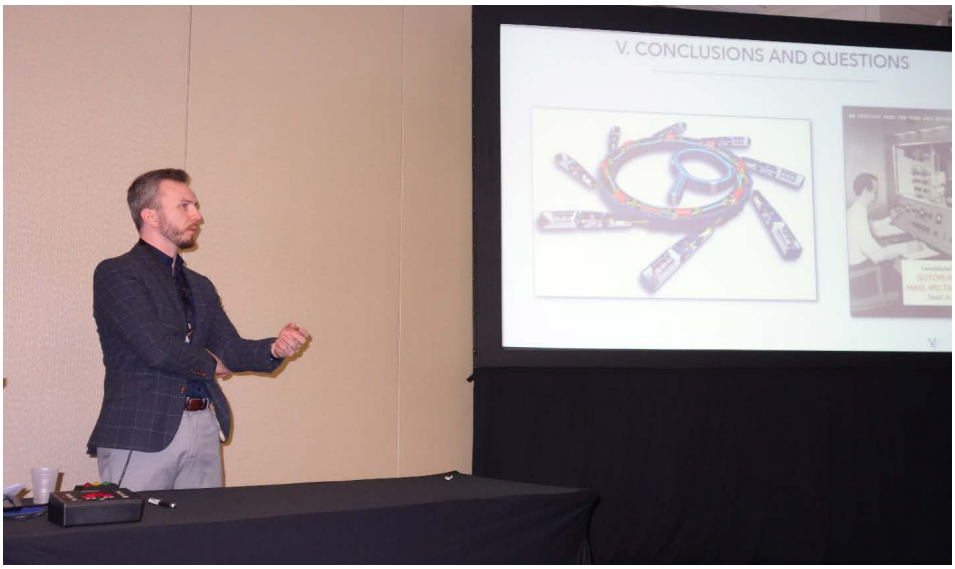
From the January / April ("Japril") Meeting:

Session Report: "Transitions in Physics and Related Fields from the Late 19th Century to Today"

By Catherine Westfall



Joseph Martin of the Consortium for History of Science, Technology, and Medicine.

This session, which was organized and chaired by Catherine Westfall, began with a lively talk by Joseph Martin, from the Consortium for History of Science, Technology, and Medicine. In the talk, "Before New Big Science: Alfred O. C. Nier and the Resurrection of Mass Spectrometry, Martin told the story of the transformation from the 1940s to the 1960s of the mass spectrometer from a purpose-built instrument into a flexible analytical tool useful to a wide range of researchers in the natural sciences. Martin described this transition through the story of Nier, a University of Minnesota spectroscopist who found new applications and built an interdisciplinary team of

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The Forum on History of Physics of the American Physical Society publishes this Newsletter biannually at *http://www.aps.org/units/fhp/newsletters/index.cfm*. Each 3-year volume consists of six issues.

The articles in this issue represent the views of their authors and are not necessarily those of the Forum or APS.

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2017 History of Physics Essay Contest

The Forum for History of Physics (FHP) of the American Physical Society is proud to announce the 2017 History of Physics Essay Contest.

The contest is designed to promote interest in the history of physics among those not, or not yet, professionally engaged in the subject. Entries can address the work of individual physicists, teams of physicists, physics discoveries, or other appropriate topics. Entries should be 1500-2000 words, and while scholarly should be accessible to a general scientific audience.

The contest is intended for undergraduate and graduate students, but open to anyone without a PhD in either physics or history. Entries with multiple authors will not be accepted. Entries will be judged on originality, clarity, and potential to contribute to the field. Previously published work, or excerpts thereof, will not be accepted. The winning essay will be published as a Back Page in APS News, and its author will receive a cash award of $1000, plus support for travel to an APS annual meeting to deliver a talk based on the essay. The judges may also designate one or more runners-up, with a cash award of $500 each.

Entries will be judged by members of the FHP Executive Committee and are due by September 1, 2017. They should be submitted to fhp@aps.org, with "Essay Contest" in the subject line. Entrants should supply their names, institutional affiliations (if any), mail and email addresses, and phone numbers. Winners will be announced by December 1, 2017. ■

Session Report: "The Scientific Legacy of the Manhattan Project"

By Vince Cianciolo

Susan Seestrom from Los Alamos National Laboratory (LANL) started the session on the Manhattan Project Scientific Legacy (cosponsored by the DNP and FPS) with a talk on "Accelerator Based Tools of Stockpile Stewardship". Susan's talk started by emphasizing the importance of the fundamental science knowledge that formed the basis for the Manhattan project's success, and pointed out the under-recognized role of female scientists in the development of that knowledge. Susan discussed how the urgency of the war effort necessitated a more empirical approach that, during the cold war, developed into an extensive live-testing program which demonstrated successful weapon design and fabrication by detonating a subset of those weapons. Today the Los Alamos, Livermore and Sandia Laboratory Directors must certify the readiness of the nation's nuclear stockpile without the certainty given by that testing program, a task that becomes more difficult as the stockpile ages. In order to fulfill this mission there has been a renewed emphasis on the development of fundamental scientific knowledge – Science-Based Stockpile Stewardship. Susan's talk focused on modern accelerator-based techniques pioneered at LANL, such as proton, neutron and x-ray radiography.

Ed Hartouni from Lawrence Livermore National Laboratory (LLNL) concluded the session with a talk on "The Quest for Fusion at the National Ignition Facility (NIF)". Ed provided an interesting historical overview of nuclear fusion, pointing out that fusion was recognized as a physical process two decades before nuclear fission, with Arthur Eddington correctly identifying it as the Sun's power source. Eddington also recognized that fusion is a double-edged sword, "…it seems to bring a little nearer to fulfilment our dream of controlling this latent power for the well-being of the human race --- or for its suicide." Hydrogen bombs ("uncontrolled" nuclear fusion) were successfully detonated in 1952. The laser was invented in 1960, and Ed noted that very soon after the laser was recognized by both US and Soviet scientists as a possible path to "controlled" nuclear fusion using inertial confinement. NIF uses an array of 192 lasers to compress fuel pellets containing a mixture of deuterium and tritium. New diagnostic techniques have been and continue to be implemented to provide a better understanding of the data and of how to push forward to ignition – current "shots" are within a factor of two of

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Session Report: "The Social Legacy of the Manhattan Project"

By Allen Sessoms

Social legacy of Manhattan project: Allen Sessoms, Daniel Kevles.

The session on the social legacy of the Manhattan Project brought together three experts from very different backgrounds to look at the matter. The first was Daniel Kevles, emeritus professor of the history of science at Yale University and the author of *The Physicists*, an excellent study of some of the key players in modern American physics. He spoke of the environmental legacy of the project, in particular the environmental damage done at the Hanford reservation in Washington State, especially as it affects the Native American peoples in the area. Kelsey Davenport of the Arms Control Association discussed the Nuclear Nonproliferation Treaty

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Session Report: "The Manhattan Project: History and Heritage"

By Alan Chodos

The Manhattan Project: History and Heritage" was one of three sessions, organized by FHP in collaboration with the Division of Nuclear Physics and the Forum on Physics and Society, commemorating the 75th anniversary of the Manhattan Project. Of the three, it was the session most devoted to history, and the one that was specifically organized by FHP.

The first speaker, Cameron Reed of Alma College, undertook the almost impossible task of giving an overview of the Manhattan Project in only 30 minutes. He pointed out, perhaps contrary to most people's general impression, that at the President's direction the US was actively investigating the possibility of a fission bomb quite early, a couple of years before the establishment of the Manhattan Project itself. Leading figures in this effort were Vannevar Bush and James B. Conant, and it included eminent physicists like Arthur Compton and Ernest Lawrence.

The Manhattan Engineering District, from which the Manhattan Project took its name, was established in August, 1942, and Colonel (soon promoted to General) Leslie R. Groves was brought in to head it in September. He made the unlikely choice of Berkeley professor Robert Oppenheimer to lead the scientific effort at Los Alamos. Reed stressed how different Groves and Oppenheimer were as individuals, but nevertheless they forged an extremely effective working relationship.

John Coster-Mullin, displaying pieces of Fat Man and Little Boy to the audience.

Reed went on to describe the efforts not only at Los Alamos, but also the equally important laboratories at Oak Ridge, Tennessee and Hanford, Washington. The former undertook the enrichment of uranium, using separation by means of both the calutron mass spectrometer (which, Reed emphasized, involved a textbook use of Maxwell's equations) and of gaseous diffusion. At the latter, three reactors produced plutonium inside uranium rods. These were then transported to special facilities where the plutonium was chemically separated from the uranium in which it had been created.

In the brief time available, Reed then described the designs of the two types of bomb (Little Boy and Fat Man) produced at Los Alamos, and recounted the history of the Trinity test and the use of the bombs on Hiroshima and Nagasaki.

The second speaker, Cindy Kelly, gave a talk titled "Welcome to the Manhattan Project Park!" She is the president of the Atomic Heritage Foundation, which has advocated, since its founding in 2002, for the preservation of the history of the Manhattan Project. After many political twists and turns over a period of about 15 years, in which Kelly and her organization played a major role, Congress enacted the Manhattan Project National Historical Park Act, signed by the President on December 19, 2014.

Uniquely among national parks, the Manhattan Project Park has 3 separate sites, at Los Alamos, Oak Ridge, and Hanford. Kelly pointed out that in fact there are several other sites relevant to the Manhattan Project, for example in New York City, Chicago, Berkeley and Washington DC. She hopes to include these in some fashion in the future.

The Los Alamos site includes several interesting buildings, including what she called the "crown jewel", the house occupied by Oppenheimer and his family. There are other dwellings associated with well-known scientists, and also the "V site", where the plutonium bomb casings were assembled.

At Oak Ridge and Hanford, there is partial access to the facilities, although some of the key structures have been demolished (there are plans to partially reconstruct them), others are still in use, and some are off-limits due to lingering radioactivity.

As Kelly summed up, "The Manhattan Project National Historical Park is a work in progress. It may take several years for the National Park Service to provide interpretive resources and the Department of Energy to restore and allow public access to its sites. However, now that the national historical park is established, we can be assured that the complex story of the making of the atomic bomb will be preserved for generations to come."

The final speaker was John Coster-Mullen, an independent researcher who may be the only "Nuclear Archaeologist" in existence. He is the author of the unique volume "Atom Bombs: the top secret inside story of Little Boy and Fat Man." For more than a quarter century he has been tracking down documents and artifacts related to the Manhattan Project, and has succeeded to such an extent that he has been able to determine the exact specifications of the two Los Alamos bomb designs in exquisite detail and amazing precision. In the course of his researches he has undertaken archaeological expeditions to secret locations in the western US, where he has retrieved samples from Fat Man prototypes that were tested in practice bombing runs. He has buried some of the large samples in hopes

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Session Report: "History of the Search for Gravitational Waves"

by Alan Chodos

The direct observation of gravitational waves, announced last year, has propelled LIGO into the headlines and has been widely recognized as the leading scientific achievement of the year. What is not always stressed, however, is how long and tortuous the road has been to get to the point where that discovery was possible.

The April Meeting session (held on January 30) "History of the search for gravitational waves" was organized by FHP to tell that story. Speakers were Virginia Trimble of UC Irvine, Barry Barish of Caltech, and Richard Isaacson of NSF (retired).

Trimble reminded the audience that the first experimental efforts to find gravitational waves were not interferometric, but rather used resonant metal bars. The person who led this effort was Joseph Weber, to whom Trimble was married from 1972 until Weber's death in 2000.

Weber graduated from the US Naval Academy in 1940, and had a distinguished naval service career during World War II. After the war he joined the faculty at the University of Maryland, where he was a pioneer in the development of the maser and the laser, and then became interested in the possibility of detecting gravitational waves as predicted by Einstein's general relativity.

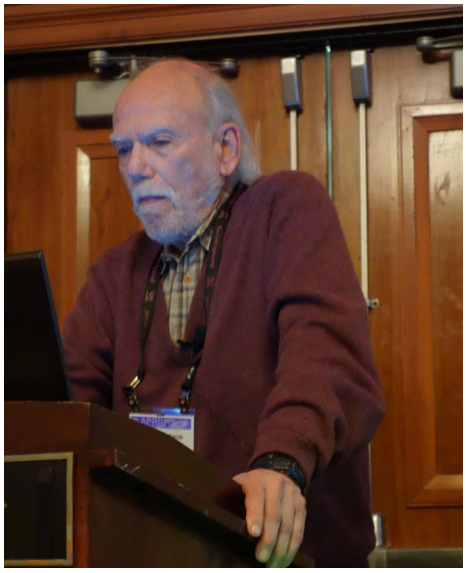
Weber began his experiments in the mid 1960's, and by the late '60s he was reporting positive results. However, in Trimble's terminology, by the mid '70s Weber had been "voted off the island". The physics community had decided that Weber's results were not reproducible, and probably just statistical noise. Whether or not he ever saw gravitational waves, however, Weber introduced many experimental and analytical techniques that carried over to other experiments like LIGO.

Despite the skepticism of the community, Weber continued to improve and refine his instruments, for example experimenting with cryogenic techniques and increasing the sensitivity of the piezoelectric strain detectors. Later in his career he also became interested in using similar techniques to detect neutrinos.

In Trimble's summation, "if Joe had not been looking for gravitational waves back then, perhaps no one would be looking for them even now."

Trimble was followed by Barry Barish, who led the LIGO Laboratory and collaboration in the crucial period 1994-2005. In his talk, Barish gave a comprehensive history of the scientific aspects of gravitational waves, from their first discussion by Einstein in 1916 to their discovery a century later. As Trimble had also mentioned, it was not universally agreed among theorists that general relativity actually predicted the existence of waves. There were tricky issues regarding singularities and coordinate choices. Barish recounted one incident in the mid-1930s, when Einstein himself, in collaboration with Rosen, submitted a paper to *Physical Review* asserting that waves did not exist. He received a referee's report pointing out some errors in the analysis, which so offended Einstein that he never again published in *Physical Review*. However, the referee, Howard Percy Robertson, communicated to Einstein through Leopold Infeld; Einstein realized the error, revised the paper, and published it in a different journal. (Interestingly, Infeld later became the foremost skeptic about the existence of gravitational waves).

Barish acknowledged Weber's pioneering contributions, including sensitive noise analysis, use of coincidence, and using time slides for estimating background. He mentioned early work on interferometry, both in Russia and the US, which led to serious experimental work beginning in the 1990s. LIGO started construction in 1994, with a two-stage plan that would result in LIGO first becoming operational, and then undergo significant upgrades to "Advanced LIGO", which would finally reach the sensitivity at which actual detection became probable. LIGO has separate laboratories in Louisiana and Washington State; coincident signals at the two locations is a necessary condition for detection.



Barry Barish of the LIGO Laboratory.

Barish discussed the factors, at various frequencies, that limited the detectors' sensitivity. Among them are seismic noise at low frequencies, thermal noise at intermediate frequencies, and high-frequency "shot noise". Mitigation of these effects is achieved by better suspension and isolation of the mirrors, and increasing the power of the laser to improve statistics and limit shot noise.

Barish noted that in addition to LIGO, other detectors are either beginning operation or are under construction worldwide, for example GEO and Virgo in Europe and KAGRA in Japan. With all these operational, sensitivity and frequency range will be enhanced, and directional information on any observed sources will be greatly improved.

Following Barish was Richard Isaacson, who played a pivotal role in making sure LIGO received the necessary support for what has been the largest facility ever funded by NSF. He noted the seminal contributions of what he

called the "three musketeers", Rai Weiss of MIT and Kip Thorne and Ron Drever of Caltech. However, he pointed out that many others were key contributors along the way.

Many people worked on prototype interferometers in the '70s, including Weiss at MIT, Drever and his group at Glasgow, and a group at the Max Planck Institute, Garching. In the '80s, the MIT and Caltech groups started to come together, Drever moved to Caltech, and a proposal for the LIGO laboratory was submitted to NSF, with Rochus "Robbie" Vogt as the Project Director. But Isaacson pointed to the appointment of Barry Barish as the Director in 1994 as a watershed moment. Barish brought "big science" experience from high-energy physics to bear on LIGO. He helped develop the two-stage LIGO/Advanced LIGO plan, established the LIGO Scientific Collaboration (LSC), with more than a thousand scientists worldwide, to operate in tandem with the laboratory, but with separate governance, and he introduced "modern project management and planning techniques to break down this very complex project into understandable modules."

As a result, Isaacson stated, "LIGO was successfully completed ... on time, on scope, and on budget."

In addition to the LIGO facility and the LSC, Isaacson mentioned the numerical relativity community, dating back to early work in the '60s and '70s, and culminating in the ability to predict the signals that LIGO should see from various astrophysical events. "We have finally extracted the details of the exact dynamical predictions from Einstein's theory, and solved the fundamental gravitational 2-body problem with radiation."

Isaacson went on to describe the relationship of LIGO to NSF, which has contributed about $1.1B over 40 years. He mentioned prominent support from Physics Division Director Marcel Bardon, and from Erich Bloch, who was the NSF Director under whom LIGO began construction. In addition, he cited numerous program officers who were instrumental in supporting theoretical gravitational research, computing initiatives, and the LIGO laboratory itself.

As Isaacson concluded, "There are lots of men and women who deserve recognition for their essential intellectual contributions and decades of hard work building the world's most sensitive instrument." ■

Session Report: "The Manhattan Project: History and Heritage"

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of one day being able to return with the equipment necessary to transport them. He has also twice visited Tinian, the island in the South Pacific that was the site of the assembly of the bombs used at Hiroshima and Nagasaki, and the takeoff point for the missions that dropped them.

Coster-Mullen's talk was profusely illustrated with rare photographs of the bombs and the bomb builders. More than once he commented that "they should never have let me see this, but they did." (He stressed, however, that everything he has obtained has been publicly available). Helped by his son, he also displayed a number of actual relics from his archaeological expeditions. The overall impression was of unwavering dedication to finding out the truth about Little Boy and Fat Man, which has provided the public with a wealth of detailed knowledge that would otherwise never have seen the light of day. ■

Session Report: "The Social Legacy of the Manhattan Project"

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Social legacy: Kelsey Davenport.

Social legacy: Carlton Stoiber.

(NPT), its evolution from the Atoms for Peace proposal of president Dwight D. Eisenhower, its successes and current challenges. Wrapping up the session was Carlton Stoiber, a more than 30 year veteran of the State Department, who spoke in broader terms of the legacy of Atoms for Peace, its successes, such as creating the International Atomic Energy Agency (IAEA) and the NPT, its failures, such as giving cover for nuclear weapons programs in India, Pakistan and North Korea, and ongoing challenges to the peaceful uses of atomic energy. ■

Session Report: "Transitions in Physics and Related Fields from the Late 19th Century to Today"

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Robert Smith of the University of Alberta.

Anne Robinson of the University of Massachusetts, Amherst.

users. Martin argued that this development was a precursor to what has been dubbed the "New Big Science" by Robert P. Crease and Catherine Westall, which began to emerge in accelerator laboratories starting in the 1980s.

Robert Smith from the University of Alberta spoke of another transition in his talk "Across the Divide: From the One Galaxy Universe to the Expanding Universe." He noted that near the end of the 19th century astronomers had little concern for the universe and its history or in knowing what was beyond our galaxy. That changed in the first decades of the twentieth century, thanks to a number of factors including the development of quantum mechanics and relativity. Smith then spoke of the emergence of the idea of the expanding universe in subsequent decades.

The last talk, "An Attempt to Solve the Controversies Over Elements 104 and 105: A Meeting in Russia, 12 September 1975," was given by Ann Robinson from the University of Massachusetts, Amherst. Robinson examined the controversy that pitted Gerogy Flervo and Yuri Oganessian and others from the Soviet Union against Glenn Seaborg and Albert Ghiorso from the US, through a close reading of notes associated with a crucial meeting meant to iron out competing claims about who discovered the elements. As Robinson notes, a key issue was whether chemical or physical evidence clinched the case. She went on to argue that the impossibility of settling the dispute paved the way formal procedures for such cases adjudicated by external experts, dominated by physicists. ■

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that goal.

The results of experiments described by both speakers are used to validate and improve computer simulations that in turn provide confidence in the stockpile's integrity. The development of all the associated scientific techniques and scientists is a testament to the vision for the role of science in the service of the nation laid out in Vannevar Bush's hugely influential 1945 report "Science: The Endless Frontier." ■

FHP Invited and Contributed Events at the 2017 March Meetings

March 13-17, 2017 Meeting, New Orleans, LA

Monday, March 13, 8:00 am - 11:00 am
The Physicist and the Philosopher: Einstein, Bergson, and the Debate That Changed Our Understanding of Time

Monday, March 13, 2:30 pm - 5:30 pm
Pais Prize Session

Tuesday, March 14, 8:00 am - 11:00 am
60 Years Since BCS and 30 Years Since Woodstock

Wednesday, March 15, 8:00 pm - 9:30 pm
Stage play, *Moving Bodies*, by Arthur Giron

Know of an individual deserving of being made an APS Fellow for work related to the history of physics?

Email FHP Fellowship Committee Chair Paul Cadden-Zimansky, paulcz@bard.edu, to submit their name.

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