A Forum of The American Physical Society • Volume VIII, No. 5 • Fall 2002

HISTORY of Physics NEWSLETTER

FHP and the Physics Community

– *Hans Frauenfelder, Forum Chair*

The Forum on the History of Physics (FHP) serves many different customers. Three groups are particularly important: Professional historians of science may find relevant contacts among the active physicists in FHP. Physicists often believe that they know most things better than other scientists; the professional historians can teach us to treat the history of physics with the same respect that we treat physics. The second group consists of physicists who have become historians. The third, largest, group involves physicists like me who with age become interested in the historical aspects of physics, but for whom research in physics is still the primary occupation. The FHP is the forum where these different groups can interact.

Teaching for more than forty years has shown me the severe split between teaching and research that can only be overcome by a knowledge of the history. In teaching we try to outline and describe the most logical and clearest path that leads, usually from experimental data, to a concept, model, or law. Students may well be depressed by the elegance of the approach – how could anyone be so clever and arrive at the result in such an elegant way? In actuality, the path to a new law or model, be it the second law of thermodynamics, the Schrödinger equation, or the nuclear shell model, is not straight, but is like a Brownian motion in knowledge space. The path involves dead-ends, detours, and wrong conclusions till finally a correct answer (at least for a time) appears. Invited papers by historians in FHP meetings can show in specific cases how the Brownian walk occurred and how the final answer emerged. Some such descriptions may eventually find their way into texts.

Physics, in most texts and lectures, appears as an austere and impersonal subject. In reality, of course, physics is a living, exciting subject, the result of intense and dedicated work by physicists, many of them giants. I have been privileged to get to know many of the giants, for instance Bohr, Pauli, Heisenberg , and Kramers, and have observed how deeply they cared, and also how different their approaches were. FHP sessions, I believe, should also focus on the personal side of physics research

The Forum can only be a living and growing activity if all, or at least most, members are actively involved. You can help. Please encourage your friends to join FHP, send us suggestions for topics and speakers, and nominate deserving members for APS fellowship.

James T. Cushing, courtesy University of Notre Dame©

James T. Cushing (1937-2002), of Notre Dame University, was a leader in history and philosophy of twentieth century physics and the study of foundational problems in quantum theory. He was a member of FHP and a Fellow of the APS. The session at the April APS meeting, "EPR to Entanglement," was dedicated to his memory (see report below). He passed away just three weeks prior to the APS meeting.

INSIDE

Editor's Note

Help keep *Physics in Perspective* alive. This wonderful quarterly journal, published since 1999, regularly has participants' accounts of important contributions in physics, historical articles, a regular feature: "The Physical Tourist" outlining sites, laboratories with historical significance, artifacts from the history of physics, and important physicists in selected regions (e.g. "Physicists and Physics in Munich" in the latest issue), and book reviews. Another regular feature, "In Appreciation," is written about a physicist by a student, first-hand acquaintance, or colleague. This is one of the few journals or magazines that I personally value so highly that I read it cover to cover. There is no other journal like it for physicists and those interested in the history of physics, written at an accessible level, with high standards and fine writing. And there is a special price for APS members ($35 plus $10 shipping). This is a journal that all Forum members would enjoy and benefit from.

That is the good news. The bad news is that *Physics in Perspective* is in danger of succumbing due to too few subscriptions. That would be a major loss for history of physics. If you or your institution's library would like to subscribe to *Physics in Perspective*, go to the Birkhäuser Verlag website: www.birkhauser.ch/journals/1600/1600_tit.htm or contact one of the editors: John S. Rigden, American Institute of Physics, One Physics Ellipse, College Park, MD 20740, jsr@aip.org and Roger H. Stuewer, Tate Laboratory of Physics, University of Minnesota, 116 Church Street SE, Minneapolis, MN 55455, rstuewer@physics.spa.umn.edu, or contact me (Bill Evenson, see below) and I will direct your inquiry to the editors and publisher. If a significant fraction of Forum members were to try *Physics in Perspective*, its future would be assured.

Some Anniversaries for 2003

1603 - Death of William Gilbert.

1703 - Isaac Newton elected President of the Royal Society, a post he continued in until his death in 1727. Death of Robert Hooke.

1753 - Birth of Benjamin Thompson, Count Rumford.

1803 - Observation of a meteor at Orne, France, April 26 - Jean-Baptiste Biot described the event and determined that meteorites did not originate on earth. John Dalton established the concept of atomic weight. The elements cerium, osmium, palladium, and rhodium were discovered. Birth of Johann Christian Doppler, Heinrich Wilhelm Dove. Death of George-Louis Lesage.

1853 - Jean-Bernard-Léon Foucault showed that light travels faster in air than in water. William J. M. Rankine developed the concept of potential energy. Birth of Evgraf Stepanovich Fyodorov, Victor Goldschmidt, Heike Kammerlingh Onnes, Heinrich Johannes Gustav Kayser, Hendrik Antoon Lorentz, Arthur Moritz Schoenflies. Death of Dominique François Jean Arago.

1903 - Ernst Mach published his influential *History of Mechanics*. Jules-Henri Poincaré introduced the concept of high sensitivity to initial conditions in nonlinear systems. December 17, the first successful manned flight of a heavier-than-air machine, by the Wright Brothers (Orville in the plane) at Kitty Hawk, North Carolina. Birth of Frank Philip Bowden, Igor Vasilievich Kurchatov, Kathleen Lonsdale, Cecil Frank Powell, Johann Von Neumann. Death of Carl Anton Bjerknes, Josiah Willard Gibbs.

1953 - Albert Ghiorso et al. discovered fermium. Donald Glaser invented the bubble chamber. Murray Gell-Mann introduced the quantum number "strangeness." Charles H. Townes and, independently, A. M. Prokhorov and N. G. Basov, invented the maser. Death of Edwin Powell Hubble, Herbert Eugene Ives, Robert Andrews Millikan, Ludwig Prandtl.

HISTORY of Physics NEWSLETTER

The *History of Physics Newsletter* is published twice each year by the Forum on History of Physics of the American Physical Society. It is distributed free to all members of the Forum. Others who wish to receive it should make a donation to the Forum of $5 per year (+$3 additional for air mail). Each volume consists of six issues. Editor: William E. Evenson, Department of Physics, Brigham Young University, Provo, UT 84602, (evenson@byu.edu) 801 422-6078.

Editor:
William E. Evenson
Department of Physics
Brigham Young University
Provo, UT 84602
e-mail: evenson@byu.edu
tel: (801) 378-6078

Reports

Tunneling, From Alpha Particle Decay to Biology. APS March Meeting, Indianapolis, 18 March 2002.

This symposium featured four talks by leading participants in the study of tunneling phenomena who discussed manifestations and applications, including the current status of tunneling studies in physics, chemistry, and biology. It was well attended, with about 120 in the audience. The session was chaired by **Hans Frauenfelder** (Los Alamos).

Ivar Giaever (Rensselaer Polytechnic Institute) began the session by talking about his Nobel Prize-winning work on "*Tunneling in Superconductors.*" He noted that some have said that "Thomas Edison's greatest invention was the 'Research Laboratory' as a social institution." This institution has played a central role in Giaever's life and career: "My greatest discovery was when I learned at 29 years of age that it was possible to work in such an institution and get paid for doing research. I had become interested in physics, gotten a job at General Electric Research Laboratory and found a great mentor in John C. Fischer." Giaever then told about his "second greatest discovery: tunneling in superconductors." He reviewed the discovery that is reported in greater detail in his 1973 Nobel Prize talk: "Electron Tunneling and Superconductivity" [*Les Prix Nobel en 1973* or *Science* **183**:1253-1258(1974) or *Reviews of Modern Physics* **46**:245-250(1974)]. In the right place at the right time, having studied tunneling between thin metal films across an oxide barrier at GE, Giaever encountered the BCS theory of superconductivity in a course from Hill Huntington at RPI in 1960 and imagined that he could measure the superconducting energy gap in his tunneling experiments if he changed one of the metals to a superconductor. He made aluminum-aluminum oxide-lead samples (lead becomes superconducting at 7.2 K, while aluminum remains a normal metal down to 1.2 K). He found a dramatic change in the current-voltage characteristic when the lead became superconducting, and the same kind of change in reverse when he drove the lead normal with a magnetic field. Then he found equipment that allowed him to lower the temperature below 1.2 K, so both the aluminum and the lead strips in his sample would be superconducting. He found a negative resistance characteristic, as expected for tunneling between two superconductors with different energy gaps. He and Karl Megerle then measured anomalies in the current-voltage characteristics of lead, which were found to relate to the lead phonon spectrum. In retrospect, Giaever saw that they had observed the dc Josephson effect many times but discarded these observations, thinking they were caused by metallic shorts. Collaborations with John Fisher, Charles Bean, Walter Harrison, Karl Megerle, Howard Hart, and others were important in carrying out this research.

The second talk of the session was given by **Jose Onuchic** (UCSD) on "*Tunneling in Biology.*" Onuchic asked, "How do quantum mechanical processes control important mechanisms in biology? Quantum mechanics is important for the formation of chemical bonds, but does it impact biology beyond that?" He studied electron tunneling in proteins and found that a simple model of one dominant pathway explains the data well. Why not multiple paths with interference? They do find interference in reaction centers [*Science* **290**:114 (2000)], but generally the interference averages to zero due to fluctuations in the Bohr oscillations. This leaves one dominant pathway: the system finds pathways with a dominant path and otherwise destructive interference. This effect results in more efficient electron transfer. "Electron transfer reactions are fundamental in controlling several processes in bioenergetics such as respiration and photosynthesis." Onuchic presented his "recent results on how thermal motions may modulate electron tunneling in these reactions. We identified a new mechanism of nuclear dynamics amplification that plays a central role when interference among the dominant tunneling pathway tubes is destructive. In these cases, tunneling takes place in protein conformations far from equilibrium that minimize destructive interference. As an example, we demonstrate how this dynamical amplification mechanism affects certain reaction rates in the photosynthetic reaction center."

Eugen Merzbacher (U of North Carolina at Chapel Hill) reviewed the history of tunneling in *"Tunneling – the Beginning."* A version of this talk was published in *Physics Today*, August 2002. "The advent of wave mechanics almost immediately led to the insight that particles have a finite chance of being found in, and penetrating through, regions of space that are classically inaccessible to them. . . Before tunneling became the standard term for the nonclassical transmission of particles through a potential barrier, the quantum mechanical process, either in German or English, was often referred to as penetration of, or leaking through, a barrier (or sometimes a potential hill)." The first uses of the word "tunneling" to describe this process seem to have been due to Walter Schottky in 1931 (in German) and J. Frenkel in 1932 (in English). Friedrich Hund, in several papers in 1927, explored tunneling in bound states to understand molecular spectra. He derived a tunneling rate proportional to the exponential of the product of barrier width and effective wave number for penetration into the classically forbidden region. Lothar Nordheim analyzed tunneling in thermionic emission in 1927, using piecewise rectangular potentials. Then Robert Oppenheimer in January, 1928, in *Physical Review*, addressed electric field effects on hydrogen in an early version of time-dependent perturbation theory and found tunneling transition probabilities, although he did not discuss them in terms of barrier penetration. Later in 1928 Fowler and Nordheim published their calculations of tunneling through a triangular barrier, representing field-induced electron emission. "The explanation of radioactive nuclear alpha decay, by Gamow and by Gurney and Condon in 1928-1929, provided the most dramatic and influential model of quantum tunneling through a potential barrier." Gamow, in 1928, showed that tunneling fit the 1911 Geiger-Nutall law. Both alpha decay and thermionic emission provided examples in which wave mechanics and the tunneling effect contained within the theory led to satisfying unified explanations of otherwise puzzling phenomena. This strengthened both confidence in and understanding of quantum mechanics in its early days.

The final talk of this interesting session was given by **Nancy Makri** (UIUC) on *"Tunneling in Chemistry."* The tunneling probability depends on the negative exponential of the square root of the mass of the tunneling particle, so light particles have a higher tunneling probability than heavy ones. This suggests that isotopic differences can be explored and exploited in the tunnel effect. Makri discussed effects of asymmetric wells and dispersive media in quenching tunneling. For reaction rates at finite temperatures, tunneling dominates at low temperatures, where the classical rate goes to zero. These effects were studied in chemistry beginning with Hund's work on molecular spectra in 1927, which first suggested that tunneling could be important in chemical reactions. In 1932 the discovery of deuterium gave evidence for quantum tunneling and led to work on isotope effects. Tunneling was evident in studies of ortho- and para-hydrogen in 1933, and tunneling splittings were observed in ammonia in 1934. Makri reviewed a rich history of tunneling effects in chemistry that touched on bonding and band structure effects, conjugated organic molecules, biomolecules, exciton tunneling in molecular aggregates, nuclear tunneling in electron transfer reactions (R. A. Marcus, 1992 Nobel Prize in chemistry), atomic tunneling via scattering in bimolecular reactions, predissociation in unimolecular decay, and symmetric vs. asymmetric isomerizations, tunneling in molecular spectroscopy, in enzymes, in condensed phases, rotational tunneling in crystals at low temperature, competing effects in kinetics, and theoretical treatments of tunneling, culminating in the STM.

Synchrotron Radiation: From Stepchild to Star. APS March Meeting, Indianapolis, 20 March 2002.

Chaired by Arthur Bienenstock (Stanford), this symposium reviewed the history of research using synchrotron radiation. Interest was high, and the room proved to be too small for the crowd of about 100 physicists, many of whom found standing room only.

The first speaker was **Yves Petroff** (Advanced Light Source LBNL) on *"Milestones in Research Using VUV/Soft X-ray Synchrotron Radiation."* Petroff spoke of the progress during the 30-year period from 1972 to 2002. "After some pioneering work in the sixties, the use of synchrotron radiation in the VUV/Soft X-ray actually started in the seventies." In 1975 there were only a few synchrotron centers, mostly operating in parasitic mode, and with only bending magnet sources. There was a belief that VUV/Soft X-ray work could only be done on low energy machines. "In solid state physics, the possibility to obtain the band structure by angle-resolved photoemission was demonstrated and quickly followed by the discovery of resonant photoemission, the observation of core level surface states and the detection of spin." Gobeli and Allen at Bell Labs did the first ARPES (angle-resolved photoemission spectroscopy) in 1964. It then took about ten years to catch on, with major contributions by D. Eastman, N. Smith, J. Lecante, and Y. Petroff. Energy and angle resolutions have increased from about 150-300 meV and 1.0º in 1975 to 40 meV and 0.5º in 1990 and 10(2) meV, 0.05-0.1º today. Most important excitations in condensed matter physics are in the meV range.

Some major steps in this field include band structure determinations for two-dimensional systems (GaSe) in 1977 and for three-dimensional systems (Cu, 1979, and Ni, 1978, with many-body effects); discovery of resonant photoemission in 1977 (2-hole band state in Ni); tungsten surface core level states (1979); spin-polarized photoemission (1980); Fermi surface of Cu; high T_c superconductor studies in which photoemission has been very important. Petroff reviewed recent work on high T_c superconductors in some detail, noting what has been learned from synchrotron studies about the superconducting peak, gap and anisotropy, pseudogap, bilayer splitting, Fermi surface, coupling of quasi-particles and collective modes, and the possible magnetic origin of the pseudogap. He noted that "equivalent developments have happened in molecular and atomic physics," as in the measurement of photoionization cross-sections, and in the study of surfaces with great sensitivity. Developments are coming in inelastic scattering with VUV and soft X-rays, due to the availability of radiation with high resolution and penetrating ability. This area needs further development, but it could be revolutionary.

This is now an important area for the study of magnetism. Originally there were only neutron scattering and spin-polarized photoemission, but now there are about 15 techniques, "like dichroism, inelastic scattering, and microscopy." Another area of progress is probing buried interfaces with soft X-ray standing waves to obtain rocking curves and interface roughness. Magnetic circular dichroism (MCD) is depth resolvable; magnetic speckles can be seen in nanostructures. In sum, "the field of VUV/Soft X-ray synchrotron radiation is very active and successful, contrary to some statements made a few years ago."

Martin Blume (APS and BNL) spoke on *"Milestones in Materials Research Using Hard X-ray Synchrotron Radiation."* This is an example of a technique that was once simply a side-effect that later evolved into a full-blown research tool. Blume gave a brief history of X-ray sources from X-ray tubes to synchrotron sources: 1913, the Coolidge X-ray tube; 1944, Pommeranchuk article in *Physical Review* on the maximal energy attainable from a betatron, in which synchrotron radiation was an undesirable side-effect; 1946, article by Blewett on radiation losses; 1946-49, Schwinger theory of synchrotron radiation; 1947, observation of synchrotron radiation at GE Research Labs.

The properties of synchrotron radiation are that it is continuously tunable, sharply collimated, of high intensity, and pulsed in time. The evolution of synchrotron sources and measurements can be seen in three generations:

	Sources	Materials characterization techniques
1st generation	Parasitic	EXAFS, XRD
2nd generation	Rings designed or reconfigured for synchrotron radiation. Insertion devices (wigglers).	Circular and linear dichroism, anomalous dispersion (resonant scattering), surface diffraction, X-ray microprobe, magnetic scattering (non-resonant and resonant)
3rd generation	Larger rings. Dedicated undulators.	Inelastic scattering, time-resolved scattering and absorption, coherence spectroscopy, speckle spectroscopy

"The advent of synchrotron radiation sources has changed qualitatively and quantitatively the nature of the materials experiments that can be performed. As the SR sources evolved and provided higher quality beams of X-rays, experiments that were formerly difficult-to-observe effects became important experimental techniques."

The third talk was *"Milestones in Biological Research using Hard X-ray Synchrotron Radiation"* by **Stephen Harrison** (Harvard). The first synchrotron radiation study of a protein was a diffraction experiment in 1970. Since 1972 protein crystallography has become possible, with crystals becoming available for XRD. The first single crystal protein diffraction experiment was carried out in 1976. In 1984 the structure of the human common cold virus was determined in an experiment that showed that synchrotron radiation would allow experiments that were otherwise impossible. In 1987 D. C. Wiley and his group found the structure of human class I histocompatibility antigen. This was an important milestone due to the "clarity of a simple picture" they produced. Now we can obtain the complete atomic structure of viruses and other objects up to about 120 nm in diameter. Coming soon: "high throughput structure determination," "molecular machines," "kinetics: molecular movies."

David Moncton (Argonne) rounded out the session with his talk, *"Faster than Moore's Law: An Historical Review of Synchrotron Source Technology and Prospects for an X-ray Laser."* He reported that the beam brilliance doubling rate is about nine months, 35 orders of magnitude since X-ray tubes. Moncton reviewed the X-ray Nobel prizes, noted the invention of the rotating anode (1966), and summarized early thinking about using synchrotron radiation. L. Parrat discussed X-ray physics with synchrotron radiation in 1958. Green and Chapman first recognized the value of low-emittance particle beams in 1975. This was followed by tremendous improvement in beam position stability to micron levels, making a new class of experiments possible. Projections to the future: First, improvements to existing machines, with up to 100-fold improvement foreseen in brilliance. Then the Ultimate Storage Ring, an energy recovery linac with small beam size, about 10^4 greater brilliance, much shorter bunch length, down to about 0.3 ps. Next, SASE Principle (Self-Amplified Stimulated Emission), with longer undulators (about 100 m) and higher electron currents, about 100 times greater flux, 10^6 greater brilliance, and peak brilliance increased by 10^{10}, bunch length about 100 ps. Finally, the era of the Free Electron Laser (FEL). Recent results on the FEL have been achieved at 130 nm wavelength, with the basic physics well confirmed down to about 100 nm. A user facility with wavelengths in the range 1 to 100 nm is possible in 2005-2008. By 2008-2010 we can expect wavelengths of 0.1 to 1 nm.

EPR to Entanglement. APS April Meeting, Albuquerque, 20 April 2002.

Report by **Ian T. Durham** (Simmons College)

This FHP Invited Session was organized and chaired by **Elizabeth Paris** of the Dibner Institute and Harvard University and was *dedicated to the memory of **James T. Cushing***. The session was held in the large Kiva Auditorium and was very well attended. It traced the historical and philosophical development of entanglement beginning with the Einstein-Podolsky-Rosen paper of 1935 and continuing through to present-day work in the field. The session consisted of four speakers and one commentary. Unfortunately, the session was shadowed by the absence of Professor James Cushing of the University of Notre Dame who was originally slated to give the commentary but who passed away unexpectedly just weeks before the meeting. Cushing was a member of the Physics Department Faculty at Notre Dame from 1966 until his death. He received his PhD in Physics in 1963 from the University of Iowa and held postdoctoral appointments at Iowa, Imperial College in London, and Argonne National Laboratory before moving to Notre Dame. He also held a four-year appointment in Notre Dame's Philosophy Department from 1990 to 1993. His life's work was dedicated to the History and Philosophy of Twentieth Century Physics and Foundational Problems in Quantum Theory. He was a member of FHP and a Fellow of the APS. He was the recipient of numerous honors and grants and was widely published. He was born in 1937 in Long Beach, California and passed away just three weeks prior to the APS meeting. He was warmly remembered by many at the conference including **Arthur Fine** who was the first speaker of the session and whose talk was entitled *"EPR: Some History and Clarification"*

Fine began by discussing the famous paper that essentially founded the field of Entanglement – the 1935 paper by Einstein, Podolsky, and Rosen published in *Physical Review*, Vol. **47**. The paper itself was a direct result of the 1930 Bohr-Einstein discussion on the indeterminacy relations. Boris Podolsky, who had worked with Einstein and Richard Chase Tolman on a previous foundational paper, joined the Institute for Advanced Study in Princeton in 1934. Also in that year, Nathan Rosen began work at Princeton University. Einstein became interested in the work of both men, and the three soon were working together. In the early spring of 1935 their famous paper "Can Quantum Mechanical Description of Physical Reality be Considered Complete?" was written. The final form of the paper was largely written by Podolsky and submitted for publication while Einstein was out of town. Einstein did not, in fact, entirely approve of the final form of the paper. Einstein's original thought experiment had involved spatially separate particles. The conclusion drawn in the EPR paper stated that all physical concepts must correspond to some aspect of physical reality. The famous quotation from that paper states: "If, without in any way disturbing the system, we can predict with certainty (i.e., with probability equal to unity) the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity." This paper sparked a great deal of interest from philosophically-inclined physicists, including Niels Bohr and Erwin Schrödinger. This led the latter to propose the now famous Schrödinger cat paradox that argued a similar stance from a different point of view. Bohr, however, came out firmly opposed to the conclusions of the paper, and most physicists later felt he successfully countered Einstein. Bohr's response contained a "Criterion of Reality" that was slightly ambiguous but came down on the side of positivism, a result concurrent with a letter to *Physical Review*, Vol. **48**, from Arthur Ruark. This move to positivism was a shift in Bohr's thinking about the quantum theory. On June 19, 1935, Einstein wrote to Schrödinger to explain that the EPR paper had essentially been written by Podolsky and had obscured the central point. The key features of the EPR argument emphasized the minimal role of Bohr's "Criterion of Reality." Bohr's responses definitively state his views on the concept of locality and the difficulty in interpreting it. On August 8, 1935, Einstein wrote again to Schrödinger describing an example involving exploding gunpowder that ultimately became a precursor of Schrödinger's cat.

The second talk of the session was given by **Martin Jones** of Oberlin College and was entitled *"Interpretations of Entanglement."* Jones began by discussing the problem of entanglement, characterizing the problems surrounding the phenomenon. Consider a quantum-mechanical system containing two subsystems, A and B. These two subsystems can be said to be in an entangled state if and only if the composite system A+B can be written as a simple tensor product of two state vectors, one pertaining to each subsystem. Another way to describe this phenomenon is to say that A and B are in an entangled state when and only when the combined state A+B can be written as a non-trivial superposition of tensor product states regardless of the choice of basis. Thus the quantum-mechanical state of the two-particle system in the EPR argument as well as the state of Schrödinger's unfortunate cat are both entangled states. Jones also pointed out that it was Schrödinger who first introduced the term 'entanglement' in the 'cat paradox' paper. He then went on to introduce the canonical example of the singlet spin state for a pair of spin-½ particles. This example was introduced by David Bohm in his 1951 text, *Quantum Theory*, when he initially spoke of 'atoms.' Jones chose to follow convention and speak of electrons.

The problem of entanglement is that it appears to introduce the concept of nonlocality. This is because there is a correlation between spatially-separated systems. But it is important to remember that nonlocality only arises in entangled states. Additionally, the problem is exacerbated by the fact that quantum mechanics itself provides no 'obvious explanation,' as Jones said. Philosophically – or physically – then, what does this tell us about the world? How can we explain these correlations? For example, if we measure a pair of entangled electrons and one comes out spin-up, how can we explain the fact that the other one automatically comes out spin-down? Perhaps it simply means the world is nonlocal. The 'spectre' of nonlocality introduces yet another problem in its apparent conflict with relativity in regard to events that are space-like related. Causal connections of space-like events in entangled states would indicate the potentiality of superluminal information transport in conflict with special relativity.

Despite these troubling issues, Jones advocated a more specific question, asking what entanglement tells us about quantum mechanics rather than about the world at large. The answer could be that quantum mechanics is limited in its scope and is not a fundamental theory of nature (i.e. it is not everywhere applicable to everything). This is the essence of Einstein's ultimate argument: that quantum mechanics is incomplete. As such, entanglement in this sense is defined purely in terms of the mathematical formalism of quantum mechanics. Ultimately there could be a difference between the statistical correlations of the mathematical formalism and true causal connections of physical reality – i.e. is nonlocality purely a statistical phenomenon or is it physical?

Jones then went on to discuss how these questions have been examined historically since the original EPR paper in 1935. In this time two main categories of interpretation have developed. The first advocates the delineation of various general constraints that any suitable theory of quantum mechanics must satisfy, while the second is the mélange of unorthodox interpretations that have cropped up.

Within the first category of general constraints, Jones mentioned the two most influential: Bell's Theorem of 1964 and the Kochen-Specker Theorem of 1967. The latter basically shows that should we attempt to assign a definite value to every observable in a system, given some natural assumptions, we will ultimately arrive at a mathematical contradiction. The only way out is to reject one or more of the assumptions or assume that some observables can lack a definite value. Bell's Theorem basically rules out hidden variables that would have predetermined the spin values of two electrons, say, at the source. As such, certain predictions satisfy Bell's Inequality while predictions of quantum mechanics do not. This is often thought to have re-ignited the idea of nonlocality.

Jones went on to explain a series of further theorems based on the two primary ones, including some that combined the approaches of Bell and of Kochen and Specker. The results of all these theorems serve to constrain general interpretations of quantum mechanics and may suggest a way of understanding entanglement by allowing us to draw some general conclusions about it, including the possibility of nonlocality.

Alternative interpretations of quantum mechanics offer other views of entanglement. The so-called 'collapse interpretations' assume that the wave function collapses (or the wavepacket is reduced), usually at the point of measurement. These interpretations endorse the idea behind the projection postulate which is that states of systems sometimes undergo indeterministic 'collapses' or 'jumps.' These formulations either assume that the Schrödinger equation is interrupted (or discontinuous) upon occasion or completely replaced by some other equation, usually some stochastic equation of motion. However, many of these interpretations reject the projection postulate as a way of describing the way collapses occur (the big question, of course, is are collapses physical processes or mathematical conveniences?).

Another category of alternative interpretation is the no collapse interpretation. Several theories fall under this category including Bohm's 1951 theory, the splitting worlds interpretation of DeWitt, several modal interpretations, several interpretations that fall under the heading of many minds interpretations, and more. These theories reject the idea that the wave function ever collapses and insist on linear, deterministic Schrödinger evolution in every situation (with minor exceptions).

Jones concluded his talk by touching on all of these theories' (both orthodox and unorthodox) specific applications to entanglement.

The next person to take the podium was **Alain Aspect** of Institut d'Optique, Orsay, France, who presented the first talk dealing with experimental aspects of entanglement (*"Bell's Theorem and the Non-locality of Quantum Mechanics"*). Aspect first reviewed the details of Bell's theorem and inequalities. The theorem was proposed as a test for hidden variables, something that had been suggested several times as a solution for the problem of incompleteness. Bell's inequality is actually just a simple probability theorem that gives conditions for a series of marginal probability distributions to be derived from a single joint distribution. If hidden variables indeed existed, the distributions would have to originate in a single joint distribution and would obey the inequality. Thus violations of Bell's inequality are usually taken to indicate that hidden variables are not possible. In essence, they indicate that quantum mechanics violates classical concepts of locality. Aspect also focused on why this theory was so important to the understanding of quantum mechanics.

With Bell's inequalities as a backdrop, Aspect then described his famous 1982 experiments at Orsay which were very close to the ideal experiment devised by Bell himself. In fact, there were three such experiments performed by Aspect and his colleagues starting in 1981 that were based on Bell's suggestions. Atoms in some source region are stimulated into an excited state by two laser beams. In returning to the ground state they emit two photons due to the existence of an intermediate state between the excited state and the ground state. The photons were passed through filters to eliminate outside sources of light and then encountered polarizers. Based on the quantum efficiency of the detectors, a certain number of the photons transmitted will be detected. Entanglement exists between the polarization states of the entire ensemble of the pairs of photons. Therefore, the detection times between the two photons in a pair are measured. Ultimately this leads to a direct test of Bell's inequality because the photons' behavior was predicted to differ depending on whether or not nonlocality was a physical reality. The Orsay experiments proved that nonlocality does indeed exist in physics.

Aspect concluded his talk by discussing the advantages to quantum optics that the 1982 Orsay experiments have provided and discussed some of the ongoing research at Orsay including work with Bose Einstein condensates (BECs) and atomic mirrors. The goal is to produce analogs of traditional optical devices for atoms.

Aspect was followed by **Anton Zeilinger** of the University of Vienna who spoke on the practical applications of entanglement (*"Quantum Entanglement and Information"*). In the early 1970s true experimental tests of Bell's theorem began, though the motivation was still simply to answer fundamental questions in physics. Practical applications of entanglement only began to emerge in recent years. The areas of application include quantum communication, quantum cryptography, quantum teleportation, and quantum computation. Some of Zeilinger's own experimental work includes not only photons but molecules as well. The basis of quantum communication is the idea that information can be multiplied several times over. For instance, some hypothetical quantum communication devices would have a receiver that read a two-bit piece of information while physically receiving only one bit. This is accomplished by having the receiver actually send the first bit (part of a two-bit entangled state) to the sender who then sends it back to the receiver with some encoded information. Due to the entangled state, the receiver actually has two pieces of information despite only receiving one. This concept is often used to allow confidential messages to be masked to unauthorized third parties – i.e. cryptography. In classical cryptography it is always possible to intercept classical key distributions without being noticed. However, recent developments have produced a quantum key distribution which allows single quanta of information (qubits) to be transferred via a quantum channel. The idea is that information cannot be gained from a system without disturbing it, and the quantum key distribution prevents the system (as a whole) from being disturbed. Ultimately, it is possible to send an encoded message that cannot be deciphered by any statistical methods.

In 1997 Zeilinger and his colleagues became the first to realize another practical application of entanglement – quantum teleportation. Classical teleportation is deemed impossible by the Heisenberg Uncertainty Principle which would prevent a perfect measurement of an object (needed to reconstruct it elsewhere – i.e. the Star Trek transporter concept is sabotaged by uncertainty). The team produced pairs of entangled photons by a process known as parametric down-conversion and used two-photon interferometry to analyze the entangled state. By this process they were able to transfer the polarization state from one photon to another, thereby teleporting a quantum property (the polarization state).

All the above-mentioned applications of quantum entanglement could theoretically be combined to create some form of quantum computer which is simply using the information exchanged in these processes in some systematic manner. Zeilinger used this as a platform to predict the development of some new type of technology in the future that would create a novel kind of information technology.

The session was wrapped up in a commentary given by **Guido Bacciagaluppi** of the University of California at Berkeley. Bacciagaluppi was standing in for Jim Cushing, mentioned above, who had passed away three weeks prior to the meeting. Bacciagaluppi's commentary attempted to provoke further discussion and thought regarding the material presented in the session. He quoted Zeilinger as saying entanglement has gone from being an embarrassment to being a physical resource. Aspect gave Bell's inequalities as the turning point in the history of entanglement. Bacciagaluppi began with a fairly simple question: *why* did it take so long to realize the possibilities of entanglement? Traditionally it is thought that Bohr successfully answered the EPR paradox, though this is not quite true according to Fine. Fine also pointed out that Einstein's concerns were a bit different than is usually thought. His own version of EPR had little to do with the specific variables of the Uncertainty Principle but rather *when* a certain quantity is measured, which means abandoning the one-one correspondence of the quantum state and physical world.

Bacciagaluppi, himself a philosopher like Jones, went on to point out that advocating an observer-independent formulation does not automatically imply the espousal of philosophical 'realism.' He said that observer-independent theories such as Newtonian Mechanics could exist and one could still maintain that science is a social construction. He gave examples of 'realist interpretation' that were, in fact, just different physical theories (e.g. Bohm's). 'Realism' thus is seen as playing the role of motivator. Cushing argued in print that the Fifth Solvay Congress in 1927 could have made de Broglie's theory (which is basically Bohm's) a dominant research program. Bacciagaluppi believes a choice of observer-independent interpretation was ultimately tied to the question of which interpretation was more heuristically fruitful and in that context he says Copenhagen was more fruitful. He went on to list some of the fruitful aspects of Copenhagen including complementarity and the fact that it could even be applied to EPR situations. But what price is paid for the success of complementarity?

Before the EPR argument Bacciagaluppi holds that complementarity was connected to 'earthy' intuitions, suggesting that it applied to measuring apparatuses if the limits of applicability of classical concepts are fundamental. He said that this reasoning is less intuitive in the EPR case. In fact, Bohr had trouble making intuitive sense of the EPR argument. This physical intuition of entanglement is only now being developed. Bacciagaluppi then suggests that it has taken so long for this physical intuition to develop because the Copenhagen interpretation has not been completely successful at dealing with entanglement. He then supported this argument with some specifics as well as what he called 'circumstantial evidence' – the fact that many new interpretations (though not all full-blown physical interpretations) had been developed, which he takes to indicate that the Copenhagen interpretation has ceased to have the same heuristic force it used to.

Bacciagaluppi drew some final conclusions from all this, including the fact that the judgment of the outcome of the EPR exchange should be reexamined. Insofar as Einstein's primary concern was observer independence, Bacciagaluppi thinks he may have been right after all. He made this point with one final remark regarding the many-worlds interpretation – there cannot be a one-one correspondence between the wave function and physical reality if we hold to locality.

Interpreting *Copenhagen*. APS April Meeting, Albuquerque, 20 April 2002.

This session was organized by the Forum on Physics and Society and cosponsored by FHP. **Andy Sessler** (LBNL) chaired the session. It was preceded by a staged reading of Act One of the play, *Copenhagen*, in a special Friday evening program (April 19). **Bertram Schwarzschild** (*Physics Today*) read the role of Niels Bohr, **Olive Schwarzschild** (National Academy Press) read Margrethe Bohr, and **Phillip Schewe** (AIP) read Werner Heisenberg. Both the reading and the session were arranged by **Harry Lustig** (APS/CCNY-emeritus) and **Brian Schwartz** (CCNY).

The session was opened by **Roger H. Stuewer** (U of Minnesota), who spoke on *"An Act of Scientific Creativity: Meitner, Frisch, and Nuclear Fission."* Stuewer reviewed the discovery of nuclear fission, "the dominant event that lay in the background to Werner Heisenberg's fateful meeting with Niels Bohr in occupied Copenhagen in September 1941." The discovery and interpretation of nuclear fission occurred three years before the Copenhagen meeting. Lisa Meitner met her nephew, Otto Frisch, in Kungälv, Sweden, in late December, 1938. She had a letter from Otto Hahn indicating that he and Strassmann had found barium as a reaction product when uranium was bombarded with neutrons. Meitner and Frisch arrived at the nuclear fission interpretation of these experimental results as they walked and talked in the snow over the Christmas holidays. When Frisch told Bohr of this discovery in early 1939, Bohr was greatly surprised. Why had they not seen this possibility before?

Gamow (not Bohr) invented the liquid drop model of the nucleus in 1928 and presented it at a meeting of the Royal Society of London in February, 1929. Gamow pursued these ideas in 1929-1931 at Cambridge, then returned to Russia in the summer of 1931 to renew his passport. Unfortunately, his passport was denied, so he could not return to England. In February, 1932 Chadwick discovered the neutron. Heisenberg and Carl Friedrich von Weizsäcker took up the liquid drop model and extended it between 1933 and 1936, in the development of von Weizsäcker's semi-empirical mass formula. Then Bohr published his theory of the compound nucleus in 1936 in *Nature*, but Bohr believed that the nucleus would de-excite by emission of single particles rather than split apart.

This history of the liquid drop model can be divided into two stages: Stage I, 1928-35; Gamow, Heisenberg, von Weizsäcker; emphasized static features of the nucleus, calculation of the nuclear mass defect curve. Stage II, 1936-37; Bohr; emphasized dynamic features of the nucleus, nuclear excitations. Meitner was familiar with Stage I developments, Frisch with Stage II. Frisch later said, "We put our different kinds of knowledge together."

Bohr then carried the message of fission to the USA on a visit to Princeton. His thinking embedded in Stage II, Bohr did not associate the mass defect curve with nuclear de-excitation. The Bohr-Kalkar paper in 1937 did not cite Gamow, and this omission was propagated by Bethe in his book on nuclear physics. Then the Bohr-Wheeler paper in 1939 failed to correct the earlier oversight, so many physicists have incorrectly learned that Bohr was the originator of the liquid drop model of the nucleus.

David C. Cassidy (Hofstra) then spoke on *"New Light on* 'Copenhagen' *and the German Nuclear Project."* Immediately after World War II, some German scientists pointed to the bomb as evidence of their own moral superiority. Some also argued that the German effort had been deliberately sabotaged for moral reasons. Robert Jungk, with his 1956 book, *Brighter Than a Thousand Suns*, popularized von Weizsäcker's arguments along these lines. Thomas Powers (*Heisenberg's war: the secret history of the German bomb*, 1993) and Michael Frayn (*Copenhagen*, 1998) revived and repopularized these arguments.

On January 6, 2002, the Bohr family released eleven documents for study by historians. There is now overwhelming evidence against the sabotage thesis. Hans Bethe changed his view of Heisenberg due to the new documents, and von Weizsäcker conceded that Heisenberg was more complicated than previously portrayed. Powers claimed that Heisenberg killed the project in 1942, but there is no evidence of this. Rather, there seems to have been a technical failure by Heisenberg: he never worked out the critical mass properly; he did not think the Germans could get sufficient U-235; he did the calculation wrong; he ignored the gaseous diffusion method due to Gustav Hertz because Hertz was half Jewish; there was a graphite problem, and Heisenberg failed to recognize the need for high purity graphite; there was a design problem. Finally, changing military fortunes threatened the project: the Leningrad defeat led to a full review of all research programs, and funds were withdrawn in February, 1942; in June, 1942, modest funding was obtained from Speer after Heisenberg intervened to keep the project alive.

Cassidy argued, finally, that Heisenberg pursued this project as a means to his own professional rehabilitation and the rehabilitation of theoretical physics in Germany.

Next on the program were **David and Suzy Pines** (Los Alamos) presenting *"Niels and Margrethe Bohr – Some Favorite Memories: A Dialogue."* They used a dialogue format to share memories of Niels and Margrethe Bohr in Copenhagen and La Jolla during the years 1954-1974. They took their first trip to Europe in 1954 to the Solvay meeting, and Christian Møller invited them to Copenhagen. In 1957 they visited again, on a year-long sabbatical that began in Copenhagen. They were invited to lunch by the Bohrs in their country house. They orried about what would be appropriate gifts: Bram Pais suggested toys, so they took a slinky and water-propelled rocket. They were a great success; Bohr began playing with them himself, not even sharing them with the grandchildren, initially. "Margrethe Bohr was tall, beautiful, strong, soft, and gentle all at once." She expressed a strong interest in how the Pines' were managing in Copenhagen.

1957 was the summer of the microscopic theory of superconductivity. David Pines gave lectures on this subject at the Bohr Institute. He was warned by Aage and Ben Bohr independently that Bohr felt very deeply about this subject and could have very strong questions. The talk went well, and Bohr asked David to talk with him privately about the theory, so they went to Bohr's study and sat at a long table. Bohr would light and relight and puff on his pipe. He had an impenetrable accent in English (even in Danish he was difficult to understand). Bohr was very sharp in 1957 – also the time of his unsent letters to Heisenberg.

In June, 1958, Suzy Pines was invited by Margrethe Bohr to a luncheon at Carlsberg. Margrethe had a keen interest in politics, both national and international affairs. She asked Suzy about "your Mr. Nixon." Then, in the summer of 1960, when the Bohrs were principal guests of honor at the dedication of the General Atomic Laboratories, Margrethe told Suzy, "You were absolutely right about Nixon!"

The Pines' saw the play, *Copenhagen*, in London in 1999 with the Bohr sons (also having seen it in Copenhagen in Danish earlier). Margrethe Bohr was not present at the conversation with Heisenberg in 1941. Bohr would meet with his visitor, leave his study and consult with Margrethe, then return to the visitor, and so on. When they met in the fall of 1941, Bohr had long been encouraging Heisenberg to come out of Germany. He had offered Heisenberg a position. But Heisenberg was coming to Copenhagen to show Bohr that he had made the right decision. He then went to give lectures at the German Embassy, for which he had brought his uniform as a colonel in the German Wehrmacht.

Harry Lustig (APS/CCNY-emeritus) spoke on "*Science As Theater, Theater As Science.*" He reviewed a long history of science in the theater, from Bertold Brecht's *Galileo* in 1942 and Friedrich Dürrenmatt's *The Physicists* in 1962 to the present. "Physics and other sciences have served a number of dramatists as backdrops for the exposition of existential problems, as well as the provision of entertainment. Michael Frayn's 1998 play *Copenhagen* broke new ground by giving a central role to the presentation of scientific substance and ideas and to the examination of recent controversial and emotionally charged events in the history of science and of the 'real world.' A rash of 'science plays' erupted." *Copenhagen* has been called "the greatest science play of all time," and about twenty science plays have been produced since *Copenhagen*. "How should we physicists react to this development? Surely, it can be argued, any exposure of science to the public is better than none and will help break down the barriers between the 'two cultures.' But what if the science or the scientists are badly misrepresented or the play is a weapon to strip science of its legitimacy and its claims to reality and truth? After reviewing a half dozen of the new plays, I conclude that *Copenhagen*, though flawed, is not only the best of show, but a positive, even admirable endeavor. The contributions of Bohr, Heisenberg, Born, Schrödinger, and other scientists and their interactions in the golden years of the creation of quantum mechanics are accurately and thrillingly rendered. There may be no better non-technical exposition of complementarity and the uncertainty principle than the one that Frayn puts into the mouths of Bohr and Heisenberg. The treatment of the history of the atomic bomb and Heisenberg's role in Germany's failure to achieve a bomb is another matter. Frayn can also be criticized for applying uncertainty and complementarity to the macroscopic world and, in particular, to human interactions, thereby giving some aid and comfort to the post-modernists. These reservations aside, *Copenhagen* is a beautiful contribution to the appreciation of science."

Lustig briefly discussed several of the recent science plays, including the new *QED*, about Feynman.

Brian Schwartz (CCNY) spoke on *"Reaching the Public Through Symposia on Science and Theater:* Copenhagen *and Other Plays."* He reported on the Physics Festival in Atlanta in 1999 at the APS Centennial meeting, followed by other public programs. He and Harry Lustig organized the "Creating *Copenhagen"* Symposium in New York City on March 27, 2000. This symposium was so well received that they organized another in Washington, DC on March 2, 2002 and are planning symposia in each city of *Copenhagen*'s national tour. Other activities at CUNY include symposia on other science topics for the public and Science Vaudeville. The public has a "hunger to understand science from a point of view they are interested in."

The session concluded with questions from the audience to the panelists.

Eugene Wigner Centennial. APS April Meeting, Albuquerque, 21 April 2002.

This session was organized by the Division of Nuclear Physics in cooperation with the Division of Particles and Fields, FHP, and the Forum on International Physics. **Joseph Ginocchio** (Los Alamos) chaired. There were four speakers, all with close association with Wigner. A detailed report is not available, so the published abstracts are reproduced below.

"Wigner in Hungary" by **George Marx** (Eötvös U., Budapest). Eugene P. Wigner was born into a well-to-do family in Budapest 100 years ago. He attended the Fasori Lutheran Gymnasium, which educated, among others, John von Neumann and John Harsanyi, Nobel-laureate in economics. Wigner was influenced by his math teacher, László Rátz who taught calculus in high school. World War I, revolutions and counter/revolutions, kingdom, republic, Soviet-type council republic followed each other in dizzying sequence, so Wigner decided to continue his university studies in Berlin, where quantum mechanics was discussed and developed in the 1920s. After his Ph.D. Wigner worked in Budapest and in Berlin, and he elaborated the foundations of quantum mechanics based on symmetry principles. He wrote his book on symmetries during a summer holiday in Hungary, and this later brought him the Nobel Prize. Wigner moved to the U.S. in 1930, where he enjoyed excellent working conditions and recognition. He revisited his homeland only in the 1970s, where his ideas about the future attracted huge audiences at the Academy of Sciences, at universities, and in the Physical Society. He received high honors from his home country – a bit belatedly. The principal focus of his attention was the quantum-mechanical concept of measurement, the role of human consciousness. But even in his last years, in the 1980s, he most enjoyed his visits to high schools, attending physics classes, discussing the future of science in human society with teachers and students.

"Eugene Wigner, The First Nuclear Reactor Engineer" by **Alvin M. Weinberg** (Oak Ridge). All physicists recognize Eugene Wigner as a theoretical physicist of the very first rank. Yet Wigner's only advanced degree was in chemical engineering. His physics was largely self-taught. During WWII, Wigner brilliantly returned to his original occupation as an engineer. He led the small team of theoretical physicists and engineers who designed, in remarkable detail, the original graphite-moderated, water-cooled Hanford reactor, which produced the Pu-239 of the Trinity and Nagasaki bombs. With his unparalleled understanding of chain reactors (matched only by Fermi) and his skill and liking for engineering, Wigner can properly be called the Founder of Nuclear Engineering. The evidence for this is demonstrated by a summary of his 37 patents on various chain-reacting systems.

"Wigner's Changing View of the Elementary Quantum Phenomenon" by **John Archibald Wheeler** (Princeton, U

Texas-Austin). In 1961, Eugene Wigner argued that “the being with a consciousness must have a different role in quantum mechanics than the inanimate measuring device.” By 1981, he had changed to a totally different position, one compatible with the position of Niels Bohr, that all it requires for the elementary quantum phenomenon is an elementary process brought to a close by an irreversible act of amplification (i.e. the click of a counter or the blackening of a grain of photographic emulsion). It is instructive to review the reasons Wigner gives for this important change in his views.

“Eugene Wigner and Symmetries In Physics” by **Marcos Moshinsky** (UNAM, Mexico). Concepts of symmetry in physics have had a long history, particularly if they are of a geometric or crystallographic origin, yet in classical physics they had a somewhat esoteric position. This situation changed radically when in the XX Century we passed from classical to quantum mechanics. In the former a state for a system of particles was given by a number of points in phase space and the transformation groups related with symmetries mainly gave the invariance of concepts such as energy or angular momentum. In the latter the state is characterized by a vector in Hilbert space in which the transformations had a representation. Eugene Wigner was the right man (for his mathematical ability and physical intuition) at the right place and time (Germany, in the twenties) to take full advantage of this new situation. His first interest was atomic spectroscopy (then a very active field) and the fact that its basic states were related with irreducible representations of the orthogonal group in three dimensions O(3). The German version of his book on *Group theory and Applications*, published in 1931, established, as he quotes “that almost all rules of spectroscopy follow from the symmetry of the problem.” His later extension to the direct product of two or more representations led to his development of the 3-j symbol, that he explicitly derived, and his interest in the properties of 6-j, 9-j, etc. His awareness of time inversion as an antiunitary operator, and the analysis of its combination with the unitary representations of other symmetries, proved fundamental for deriving the features of time-reversed reactions from their direct behavior. His interest in space reflection and the concept of parity led to important selection rules, and was of relevance even in weak interactions where parity is not a good symmetry.

His later interest in nuclear physics, solid state, elementary particles, etc. was almost never without a component of the role of symmetry in these problems. The best example of this is his work on the “Unitary representations of the inhomogeneous Lorentz group” (1939) which led later to the possible form of equations and interactions in the elementary particle field.

Eugene Wigner was certainly one of the giants of XX Century physics and his contribution not only influenced the field in his time but is also likely to be fundamental in the century that will follow the centennial we are celebrating now.

History of Los Alamos. APS April Meeting, Albuquerque, 21 April 2002.

This FHP Invited Session was chaired by **Damon Giovanielli** (Los Alamos). This session is reported by the published abstracts.

“The Role of the Special Engineering Detachment at Los Alamos during WWII” by **Val L. Fitch** (Princeton). The Special Engineering Detachment was a creation of General Groves in the fall of 1943 to supply the technical assistance that was required in the development and construction of nuclear weapons. Army personnel who had technical training or education were selected out of regular army units and sent to work at Los Alamos alongside and beholden to civilian scientists. By the end of the war almost 800 enlisted men had been so assigned and came to occupy positions ranging from technician to group leader. I will briefly describe the life of the SEDs.

“Los Alamos from the Inside and Out” by **Richard Garwin** (IBM T.J. Watson Research Center).

“Building Bridges from Micro Scale to Macro Scale” by **Francis Harlow** (Los Alamos). A major focus of research at the Los Alamos National Laboratory since its inception in 1943 has been to characterize very complex small-scale processes in terms of bulk constitutive relations that capture the essence of the collective behavior. Examples include the development of equations of state, the investigation of material mix at an unstable interface, the examination of metal pore growth with strong tensile stress, and characterization of the response of a polymeric foam to large-strain-rate insults. Bridging techniques include transport for probability-distribution-function evolution, and the use of Reynolds decomposition with moment closure. The research described in this presentation combines theoretical and experimental activities with model building for scientific and engineering computer codes.

“Post-Cold War Science and Technology at Los Alamos” by **John C. Browne** (Los Alamos). Los Alamos National Laboratory serves the nation through the development and application of leading-edge science and technology in support of national security. Our mission supports national security by: ensuring the safety, security, and reliability of the U.S. nuclear stockpile; reducing the threat of weapons of mass destruction in support of counter-terrorism and homeland defense; and solving national energy, environment, infrastructure, and health security problems. We require crosscutting fundamental and advanced science and technology research to accomplish our mission.

The Stockpile Stewardship Program develops and applies advanced experimental science, computational simulation, and technology to ensure the safety and reliability of U.S. nuclear weapons in the absence of nuclear testing. This effort in itself is a grand challenge. However, the terrorist attack of September 11, 2001, reminded us of the importance of robust and vibrant research and development capabilities to meet new and evolving threats to our national security. Today through rapid prototyping we are applying new, innovative science and technology for homeland defense, to address the threats of nuclear, chemical, and biological weapons globally.

Synergistically, with the capabilities that we require for our core mission, we contribute in many other areas of scientific endeavor. For example, our Laboratory has been part of the NASA effort on mapping water on the moon and NSF/DOE projects studying high-energy astrophysical phenomena, understanding fundamental scaling phenomena of life, exploring high-temperature superconductors, investigating quantum information systems, applying neutrons to condensed-matter and nuclear physics research, developing large-scale modeling and simulations to understand complex phenomena, and exploring nanoscience that bridges the atomic to macroscopic scales.

In this presentation, I will highlight some of these post-cold war science and technology advances, including our national security contributions, and discuss some of challenges for Los Alamos in the future.

History of Physics Contributed Papers. APS April Meeting, Albuquerque, 22 April 2002.

The FHP Contributed Session was chaired by **Benjamin Bederson** (NYU). There were three talks: *"Edward A. Bouchet"* by **R. E. Mickens** (Clark Atlanta U), *"The Uncertain Sir Arthur Eddington"* by **Ian Durham** (Simmons College & U of St. Andrews), and *"Quantum Computers and Reality: Deutsch's Anti-Positivist Campaign for Explanations-in-General, Apart From His Many Worlds Interpretation"* by **Thomas W. O'Donnell** (U of Michigan). In addition to the talks, there was one history of physics poster contributed on Saturday: *"Statistical Challenges in Medieval Astronomy"* by **Virginia Trimble** (U of Maryland & UC-Irvine).

Edward Alexander Bouchet (1852-1918). Report provided by **R. E. Mickens** (Clark Atlanta U).

Edward Bouchet was the first African American to receive the doctorate in any field of knowledge in the United States and that area was physics. He was granted the degree in 1876 from Yale University, making him at that time, one of the few persons to hold the physics doctorate from an American University.

Bouchet was born September 15, 1852 in New Haven, Connecticut to William and Susan Bouchet. His mother, a native of Connecticut, was born in Westport on October 1, 1817 and died in New Haven on February 11, 1920. His father's birth date and place are uncertain, but in some accounts it is given as c.1817 in New Haven; he died there in 1885. William and Susan had four surviving children of whom Edward was the youngest and only son.

Bouchet's primary education began at the Artesian Street Colored School which was founded in 1811 and the oldest of four primary schools for black children in New Haven. He next attended Hopkins Grammar School for two years where he graduated first in his class and gave the valedictory address at graduation.

In 1870, Bouchet entered Yale College and became one of the outstanding students of his class. During his undergraduate years he took courses in the sciences (astronomy, mathematics, mechanics, and physics) and also studied English, French, German, Greek, Latin, logic and rhetoric. At graduation in 1874, he ranked sixth in a class of 125. He was also elected for membership in Phi Beta Kappa, but was not actually inducted until 1884.

During his senior year, Bouchet was approached by Alfred Cope about remaining at Yale and obtaining the doctorate in physics. Cope was a member of the Board of Managers of the Institute for Colored Youth (ICY), a Quaker school for black children located in Philadelphia. Because of his own personal interest in science and mathematics, and his desire to have the students at ICY receive training in these areas, Cope developed a scientific department and hoped that Bouchet would direct it after completing additional advanced studies at Yale. Bouchet agreed to stay at Yale for graduate study with Cope providing the necessary funds.

In the fall of 1874, Bouchet returned to Yale as a candidate for the doctor of philosophy degree in science. At the 1876 commencement, he received the Ph.D. in experimental physics in the area of geometrical optics. His dissertation title was "Measuring Refractive Indices." Bouchet's research advisor was Professor Arthur Williams Wright, the first person to receive the physics doctorate from Yale in 1861.

For twenty-six years, beginning in 1876, Bouchet taught at the Institute for Colored Youth. In addition to his academic duties, he actively involved himself in projects related to the general welfare of the black people of Philadelphia. He lectured extensively before various church, community, and trade groups. Even when the ICY began to give preference to industrial education over pure academics and his salary was cut, he nevertheless remained at the school.

Bouchet also became involved in the Philadelphia Yale Alumni Association and faithfully attended its meetings and annual dinners. According to the 1919 Biographical Record of the Class of 1874 in Yale College, "he won and retained the regard and kindly interest of its other members and was always received by them with cordiality and respect."

Bouchet was also a member of the Franklin Institute, one of the country's oldest scientific societies. He regularly attended its meetings, lectures, and dinners. In addition, he was a member of the American Academy of Political and Social Science and was on the board of directors of the Century Building and Loan Association of Philadelphia.

In 1902, the managers of the ICY suspended the academic department and fired Bouchet, along with all the other teachers. The ICY was disbanded and moved to a rural location approximately twenty miles from Philadelphia. The new curriculum, at what became the Cheyney Training School of Teachers, was based largely on the industrial arts programs at Hampton and Tuskegee Institutes. Bouchet was not in sympathy with these changes and was the only instructor at the ICY not to receive several months additional salary after its closure.

During the period from 1902 to 1916, Bouchet held a number of positions at various locations around the country: teaching mathematics and physics at the Sumner High School (1902-1903), St. Louis; business manager at Provident Hospital (1903-1904), St. Louis; U.S. Inspector of Customs at the Louisiana Purchase Exposition (1904-1905), St. Louis; director of the Academic Department at St. Paul's Normal and Industrial School (1905-1908), Lawrence, VA; principal at Lincoln High School (1908-1913), Gallipolis, OH; and Bishop College (1913-1916), Marshall, TX. This list of employment strongly indicates that Bouchet was never again able to find the contentment in teaching and service to his community that was available to him during his long twenty-six year tenure at the ICY.

In 1916, Bouchet retired from Bishop College and returned to New Haven. His main reason for both actions was his failing health. After two years of care by his mother and sisters, he died on 28 October 1918.

While Bouchet did not have an active role in physics research, he played a significant role in the education of African Americans during the last quarter of the 19th century through his teaching and mentoring activities at the ICY in Philadelphia. He was one among a small number of African Americans who achieved advanced training and education within decades of the American Civil War. These persons provided direction, leadership, and role models for what eventually became the civil/human rights movements. The years 2001 and 2002 mark, respectively, the 125th celebration of his receiving the doctorate degree and the 150th year beyond his birth.

1. R. E. Mickens (editor), *Edward Bouchet: The First African American Doctorate*. Singapore: World Scientific, 2002.

2. *Obituary Record of Graduates Deceased during the Year Ending July 1,*

1919. New Haven, CT: Yale University, 1920.

3. Linda M. Perkins, *Fanny Jackson Coppin and the Institute for Colored Youth, 1865-1902*. New York: Garland, 1987.

The Uncertain Sir Arthur Eddington. Report adapted from a draft paper, *"Eddington and Uncertainty,"* by **Ian Durham** (Simmons College & U of St. Andrews).

Sir Arthur Eddington is considered one of the greatest astrophysicists of the twentieth century, and yet he gained a stigma when, in the 1930s, he embarked on a quest to develop a unified theory of gravity and quantum mechanics. His attempts ultimately proved fruitless, and he was unfortunately partially shunned by some physicists in the latter portion of his career. In addition, some historians have been less than kind to him regarding this portion of his work. His brilliant career finished with a flair when the culmination of nearly two decades of work was posthumously published under the title, *Fundamental Theory*. Eddington's attempt to merge relativity and quantum mechanics was, in fact, one of the earliest attempts to develop a Theory of Everything (TOE). It was a cumbersome and obscure work that enjoyed some initial success largely out of deference to his other brilliant work. But the work has been largely a historical oddity for the past half century.

However, a detailed analysis of how this work got started shows that Eddington's theories were not as outlandish as they are often purported to be. His entire theory rested on the use of quantum mechanical methods of uncertainty in the reference frames of relativity. Along the way he astutely predicts several items that have only recently become apparent, including the need for a quantum-specified standard of length and even certain aspects of string theory. A re-analysis of this portion of his somewhat forgotten work has shown more wisdom and foresight than he was ever credited with and has a tremendous amount of historical significance to the study of the development of quantum field theory and cosmology. Though the work was not ultimately fruitful, in hindsight it did foreshadow several later results in physics, and his methods were definitely rigorous. In addition, his philosophy regarding determinism and uncertainty was actually fairly orthodox for his time.

Today unification is widely considered the Holy Grail of physics. Physicists have successfully wedded the strong, weak, and electromagnetic forces, but the marriage with gravity has yet to be accomplished. Theodor Kaluza in 1919 and Oskar Klein in 1926 began a program to unify general relativity with electromagnetism. Dirac's famous papers of 1928 and 1929, in which he described a relativistic wave equation for the electron, were attempts at unification. Sir Arthur Eddington, disappointed that Dirac's work did not appear in tensor form, sought to rework the formulae essentially to put quantum theory into the language of relativity. The work was the starting point for a grand, though not often fruitful, series of cosmological theories developed by Eddington, Dirac, and E. A. Milne. Eddington's work, which is arguably the most thoroughly studied of the theories, began with the simple premise that quantum mechanics and relativity could be united under a common framework, specifically centered around the idea of coordinates.

What we can say for certain about Eddington's work is that it did successfully predict a number of methods and results that are in use today. He correctly predicted the need for a quantum mechanical standard for the measurement of length and, in his development of the concept of the uranoid, he employed an early version of a philosophy that appeared later in some versions of quantum field theory – namely, the inseparability of an object and its environment. His idea that there is a fundamental link between quantum mechanics and relativity, based on the concept of coordinates, is not far off, since both theories rely heavily on coordinates and both theories delve into concepts relating to topology. His mathematical work was carefully and impeccably done. Only his physical interpretations could truly be called heterodox.

"Quantum Computers and Reality: Deutsch's Anti-Positivist Campaign for Explanations-in-General, Apart From His Many Worlds Interpretation" by **Thomas W. O'Donnell** (U of Michigan) (published abstract).

David Deutsch (Oxford) is known for "Deutsch's algorithm" – for going beyond the initial ideas about quantum computing (QC) of Benioff, Bennett, and Feynman, to describe a quantum Turing machine, and sparking today's widespread experimental research to actually build one.

Deutsch does not accept the standard Copenhagen Interpretation (CI) of quantum mechanics (QM); he supports the Many Worlds Interpretation (MWI) and credits it for his insights. In his book, *The Fabric of Reality*, and numerous articles and talks, he argues that the adoption of the MWI is *necessary* for making the advances required for quantum computing. His argues that physicists must resolutely take a "realistic" viewpoint to its logical conclusions, and, that the MWI is *the* realistic theory. In response to ubiquitous assertions by the majority of physicists that "both systems give the same numbers," and "all physics does (or can do) is to predict the outcome of experiments," he argues strenuously for the importance of explanations in quantum physics, and to scientific progress in general. Hence, I argue that there are two, reasonably separable, layers here: (i) opposition to positivist and instrumentalist arguments against the validity and/or value of *any* explanation(s) *as such*, and (ii) an argument about just what is the correct explanation: the MWI over the CI. While establishing the validity of (i) may possibly undermine CI's spirit, nevertheless (i) can be strongly validated independent from complications of an overlap with issues of the interpretation of QM. I develop some simple, historical contradictions regarding point (i), (without passing judgment on Deutsch's MWI or involving the CI). For example, the majority viewpoint identifies its seemingly "non-philosophical" and non-"metaphysical" mindset as archetypically "scientific," while seemingly quite unaware of the theoretical difficulties with positivist notions of truth, such as the fact that the foundations of universal *classical* computation theory rest squarely upon the work of Gödel. His proof (undecideability) showed logical-positivist notions of truth to be clearly mistaken.(1) It is therefore not surprising that Deutsch, today working to achieve a more powerful and general *quantum* version of the Church-Turing thesis and *Quantum* Universal Computation, rejects positivist notions of truth, just as Gödel found it necessary to do in the process of clearing the road to the development of the *classical* versions. Up to this point, Deutsch stands on solid, established ground, and this is, it seems, independent of anyone's interpretation of QM.

In summary, Deutsch is correctly seeking to discredit the logical-positivist and instrumentalist surfeit of the majority of the physics community, and it appears that this can be done without acceptance of the MWI. Assessment of this second part of his program (MWI) is beyond the scope of the present paper.

(1) Davis, Martin, *The Universal Computer*, Norton, NY, 2000, pp. 118-9.

"Statistical Challenges in Medieval Astronomy" by **Virginia Trimble** (U of Maryland & UC-Irvine) (published abstract).

A number of well-known figures contributed to the development of both astronomy and statistics, including Galileo (moons of Jupiter and least absolute deviations), Halley (comet and survival tables), and Gauss (asteroid orbits and least squares). The poster will focus on several less famous examples, including James Bradley (aberration of starlight and error distributions), John Michell (discovery of binary stars and the "birthday problem"), Neville Maskelyne (proper motions of stars and the excess of systematic over random errors), and how a method for analyzing discordant data developed by Tobias Mayer (to track the libration of the moon) came to be called Euler's method (after a chap who failed to develop it to track the mutual perturbations of Jupiter and Saturn).

The Seven Pines Symposium

Roger H. Stuewer (U of Minnesota).

The Seven Pines Symposium is dedicated to bringing historians, philosophers, and physicists together for several days in a collaborative effort to probe and clarify significant foundational issues in physics, as they have arisen in the past and continue to challenge our understanding today.

The sixth annual Seven Pines Symposium was held May 15-19, 2002, on the subject, "Symmetry and Symmetry Breaking in Physics." It was held in the Outing Lodge at Pine Point near Stillwater, Minnesota, a beautiful facility surrounded by spacious grounds with many trails for walking and hiking. Its idyllic setting and superb cuisine make it an ideal location for small informal meetings. Its owner, Lee Gohlike, is the founder of the Seven Pines Symposium.

Unlike the typical conference, twice as much time is devoted to discussions following the talks as to the talks themselves, and long mid-day breaks permit small groups to assemble at will. As preparation for the talks and discussions, the speakers prepare summarizing statements and background reading materials, which are distributed in advance to all of the participants. Nineteen historians, philosophers, and physicists were invited to participate in this year's symposium. James Glanz, science writer for the *New York Times*, also attended.

Each day the speakers set the stage for the discussions by addressing major historical, philosophical, and physical issues related to symmetry and symmetry breaking in physics. The morning of Thursday, May 16, was devoted to the topic of "Lorentz Invariance," with Michel Janssen (Minnesota) speaking on "The Role of Lorentz Invariance in Reshaping Fundamental Physics, 1895-1911," and William G. Unruh (British Columbia) speaking on "Lorentz Invariance and its Status in General Relativity and String Theory." The topic that afternoon was "The Rise and Fall of Charge Symmetry," with Allan D. Franklin (Colorado) speaking on "The Discovery of CP Violation: A Convincing Experiment," and Bruce Winstein (Chicago) speaking on "Charge, Parity, and CP Violation." In the morning of Friday, May 17, Otávio Bueno (California State, Fresno) spoke on "Group Theoretical Methods in Quantum Mechanics: Weyl and Wigner," and Yuval Ne'eman (Tel Aviv) spoke on "Symmetry Groups in Particle Physics." That afternoon the topic was "The Noether Theorems," with Michel Janssen (Minnesota) and Tilman Sauer (Caltech) speaking on "Einstein, Hilbert, and Klein: The Background to Noether's Theorems," and Harvey Brown (Oxford) speaking on "Philosophical Perspectives on the Noether Theorems." The morning of Saturday, May 18, was devoted to the topic of "Gauge and Internal Symmetries," with John Earman (Pittsburgh) speaking on "The Nature of Gauge Symmetry," and Serge Rudaz (Minnesota) speaking on "Symmetries in the Standard Model and their Spontaneous Breaking." That afternoon Jeffrey Harvey (Chicago) spoke on "Supersymmetry," and Katherine Brading (Oxford) spoke on "Some Philosophical Reflections on Symmetry." The closing discussion on Sunday morning, May 19, was chaired by Roger H. Stuewer (Minnesota).

Lee Gohlike, the founder of the Seven Pines Symposium, has had a life-long interest in the history and philosophy of physics, which he has furthered through graduate studies at the Universities of Minnesota and Chicago. To plan the symposia, which are held annually, he established an advisory board consisting of Roger H. Stuewer (Minnesota), Chair, Jed Z. Buchwald (Caltech), John Earman (Pittsburgh), Geoffrey Hellman (Minnesota), Don Howard (Notre Dame), and Alan E. Shapiro (Minnesota). Also participating in the sixth annual Seven Pines Symposium were John D. Norton (Pittsburgh) and Robert M. Wald (Chicago).

The seventh annual Seven Pines Symposium will be held May 7-11, 2003, on the subject, "The Concept of the Vacuum in Physics."

Forum News

FHP Sessions planned for the March and April 2003 APS Meetings

The FHP Program Committee has planned and organized a diverse set of sessions on the history of physics for the March and April 2003 APS meetings. At the March meeting, to be held in Austin, Texas, we will have sessions on Monday and Tuesday, March 3 and 4. **Michael Fisher** and **Steven Brush** of the University of Maryland have organized a session for Monday afternoon entitled *"J. Willard Gibbs and His Legacy: A Double Centennial."* It will feature four distinguished speakers:

1. **Martin Klein**, Yale University, *"Gibbs and Statistical Mechanics a Century Ago"*
2. **Ole Knudsen**, University of Aarhus, Denmark, *"Gibbs in Europe"*
3. **J.M.H. Levelt Sengers**, NIST, *"Key Concepts from Gibbs that Empowered Van der Waals, Korteweg and Bakhuis Roozeboom"*
4. **Leo P. Kadanoff**, University of Chicago, *"Reflections on Gibbs: From the Amistad to Complexity Theory."*

On Tuesday afternoon, there will be an FHP session on *"The Early Days of Solid State Physics"* that **Lillian Hoddeson** of the University of Illinois has organized. It also features four speakers:

1. **Hans Bethe**, Cornell University (by

speaker phone), *"Arnold Sommerfeld and the Beginnings of Modern Solid-State Theory"*

2. **Lillian Hoddeson**, University of Illinois, *"The Quantum Theory of Solids Enters American Graduate Programs: John Bardeen at Princeton in the 1930s"*

3. **Frederick Seitz**, Rockefeller University, *"How We Came to Know What We Knew about Semiconductors During World War II"*

4. **Philip Anderson**, Princeton University, *"When Band Theory Doesn't Work: The Magnetic State."*

Those interested in attending these sessions should consult the meeting program for details.

For the April meeting, to be held April 5-8 in Philadelphia, we are leveraging our allotment of two full sessions by cosponsoring four sessions in all with other APS units. They are:

1. *"Using History of Physics in Education,"* cosponsored by the Forum on Education

2. *"Benjamin Franklin, Civic Scientist,"* cosponsored by the Forum on Physics & Society

3. *"History of Electron-Positron Colliders,"* cosponsored by the Division of Physics of Beams

4. *"History of Solar Neutrinos,"* cosponsored by the Division of Nuclear Physics.

The details of these sessions are still in flux as this *Newsletter* goes to press, so they will be published in the Spring *Newsletter*, due out next February. Those interested should consult it for dates of these sessions and the speakers making presentations.

-Michael Riordan, Program Chair

Contributed papers for the April 2003 meeting

The next FHP contributed paper session will be at the 2003 April APS meeting in Philadelphia. History talks are allowed twice the usual time for contributed papers: 20 + 4 minutes. The deadline for submitting abstracts for this session is January 10, 2003. ***Members are strongly encouraged to submit abstracts on their current work.***

Call for Nominations

Nominations are invited for Forum officers to be elected in early 2003 for terms beginning immediately following the Executive Committee meeting in April, or for future elections. Offices that will be open in 2003 are Vice-Chair and two Members-at-Large of the Executive Committee. In 2004 nominations will be needed for Vice-Chair, Secretary-Treasurer, and two Members-at-Large of the Executive Committee. Send nominations to the chair of the Forum Nominating Committee: Prof. Virginia Trimble, Physics Department, University of California-Irvine, Irvine, CA 92697; Phone (301) 405-5822; Fax (301) 314-9067; vtrimble@astro.umd.edu.

APS Fellow Nominations

Nina Byers is chair of the Forum's Fellowship Committee for 2002-03. Any Forum members who wish to nominate a candidate for Fellow in APS are invited to send her their suggestion(s), along with a c.v. and letter describing the candidate's achievements in history of physics. Send suggestions to Prof. Nina Byers, Department of Physics, UCLA, 405 Hilgard Ave, Los Angeles CA 90024; Phone (310) 825-3588; nbyers@physics.ucla.edu.

Forum Officers

Hans Frauenfelder, Los Alamos National Laboratory (frauenfelder@lanl.gov), became Chair in April 2002 at the end of Ben Bederson's term. **Michael Riordan**, UC-Santa Cruz (michael@slac.stanford.edu), became Chair-elect and will succeed to Chair in April 2003. **Nina Byers**, UCLA (nbyers@physics.ucla.edu), was elected Vice-Chair and will succeed to Chair-Elect in April 2003.

Per F. Dahl, Lawrence Berkeley National Laboratory-emeritus (pfdahl@aol.com), and **Daniel Siegel**, University of Wisconsin (dmsiegel@facstaff.wisc.edu) were elected to three-year terms on the Executive Committee. Their terms end in April 2005. The continuing members of the Executive Committee are **Elizabeth Urey Baranger**, University of Pittsburgh (eub@pitt.edu) and **Michael E. Fisher**, University of Maryland at College Park, whose terms expire April 2003. **Daniel M. Greenberger**, CCNY (dansuzy@nyc.rr.com), and **Elizabeth Paris**, Argonne National Laboratory (eparis@anl.gov), continue terms that end in April 2004.

Kenneth Ford, retired Executive Director of AIP (kwford@bellatlantic.net), continues as Secretary-Treasurer until 2004. **Gloria Lubkin**, *Physics Today* (gbl2@aip.org), continues as Forum Councillor until December 2005. **Bill Evenson**, Brigham Young University (evenson@byu.edu), as *Newsletter* Editor, and **Spencer R. Weart**, Director of the AIP Center for History of Physics (sweart@aip.org), serve as *ex officio* members of the Executive Committee.

Many thanks to **Benjamin Bederson**, Department of Physics (emeritus), New York University (ben.bederson@nyu.edu), for his good work as Chair during 2001-2002, and to **Laurie M. Brown**, Department of Physics and Astronomy (emeritus), Northwestern University (brown@lotus.phys.nwu.edu), for his continued help as Past Chair during 2001-2002. Thanks also to **Michael Nauenberg**, UC-Santa Cruz, and **Allan A. Needell**, National Air & Space Museum, Smithsonian Institution, for their work on the Executive Committee during the last year.

Executive Committee

The annual meeting of the Executive Committee was held on April 21, 2002, at the APS April Meeting in Albuquerque. It was chaired by Ben Bederson, who thanked the many Forum members who helped with FHP projects this year, especially the Program Committee, Award Committee, and Nominating Committee. The Program Committee, led by Hans Frauenfelder, planned a set of remarkably successful sessions this year, as reported in this *Newsletter*. FHP membership has been holding steady at about 3,000 for the past 6 years. Participation in the election was about average at 7.7%. FHP remains in good financial condition, with a small reserve fund that is adequate for exceptional expenses, usually associated with FHP programs. The Program Committee will consider strategies to encourage more contributed papers in history of physics at future meetings. The Award Committee is working vigorously on fund raising to make the FHP award a reality.

Forum Committees

For 2002-03, the Standing Committees of the Forum are:

Program Committee: **Michael Riordan** (chair), Nina Byers, Per Dahl, Elizabeth Paris, Dan Siegel

Nominating Committee: **Virginia Trimble** (chair), Elizabeth Baranger, Jay Pasachoff, Robert Resnick, Fritz Rohrlich

Fellowship Committee: **Nina Byers** (chair), Per Dahl, Martin Gutzwiller, Elizabeth Paris, Michael Riordan

Membership Committee: **Ken Ford** (chair), Dan Greenberger

Award Committee: **Ben Bederson** (chair), Stephen Brush, Gloria Lubkin, Harry Lustig, Michael Riordan, Roger Stuewer, Spencer Weart

Editorial Board and Publications Committee: **Bill Evenson** (chair), Ken Ford

Request for Information about Memorial Sessions for Prominent Physicists

When readers of this *Newsletter* hear of memorial sessions being planned to honor prominent physicists, please notify Bill Evenson, Editor of the *History of Physics Newsletter*, and Spencer Weart, Director of the AIP Center for History of Physics, at the addresses below. We want to be able to notify others in the history of physics community and gather records of the physicist's life as appropriate.

Bill Evenson: Department of Physics, Brigham Young University, Provo, UT 84602-4645; evenson@byu.edu.

Spencer Weart: Center for History of Physics, American Institute of Physics, One Physics Ellipse, College Park, MD 20740; sweart@aip.org.

Suggestion for International Physics Year

2005 is being touted as the time of an "International Physics Year," similar in spirit to the famous International Geophysical Year of 1957-8. A suggestion has come to FHP that important physics historical sites in the USA be identified and that plaques describing their importance be prepared and erected at the sites. There are many places that would warrant such identification, including sites where major discoveries were made, or major physics achievements accomplished.

Such a project would take substantial effort and funding. It would require volunteers from FHP, APS, etc. Forum officers would like to know how FHP members respond to this suggestion and how much interest there is. Please send your comments to FHP Past-Chair, Ben Bederson, ben.bederson@nyu.edu.

APS and AIP NEWS

Peer Review Materials for *Physical Review*: *The Physical Review*, published by the American Physical Society, has preserved peer review materials, including referee reports, on submitted articles for several decades. Microfilm records go back as far as 1938 and are essentially complete since about 1960. In the future, new material will be saved electronically.

This material is confidential and access is restricted. Individual requests to access material will be considered by the Editor-in-Chief as they are received. Material involving living people will not be released.

Requests should be sent to: Editor-in-Chief, American Physical Society, Box 9000, Ridge, NY 11961-9000.

- Stephen G. Brush, Chair, Committee to Advise the Editor of *Physical Reviews* on Preservation of and Access to Referee Reports

AIP Center for History of Physics

Grants-in-Aid for History of Modern Physics and Allied Fields (Astronomy, Geophysics, etc.)

The Center for History of Physics of the American Institute of Physics has a program of grants-in-aid for research in the history of modern physics and allied sciences (such as astronomy, geophysics, and optics) and their social interactions. Grants can be up to $2,500 each. They can be used only to reimburse direct expenses connected with the work. Preference will be given to those who need funds for travel and subsistence to use the resources of the Center's Niels Bohr Library (near Washington, DC), or to microfilm papers or to tape-record oral history interviews with a copy deposited in the Library. Applicants should name the persons they would interview or papers they would microfilm, or the collections at the Library they need to see; you can consult the online catalog at our website, www.aip.org/history, and please feel free to make inquiries about the Library's holdings.

Applicants should either be working toward a graduate degree in the history of science (in which case they should include a letter of reference from their thesis adviser), or show a record of publication in the field. To apply, send a vitae, a letter of no more than two pages describing your research project, and a brief budget showing the expenses for which support is requested to: Spencer Weart, Center for History of Physics, American Institute of Physics, One Physics Ellipse, College Park, MD 20740; phone: 301-209-3174, Fax: 301-209-0882 e-mail: sweart@aip.org.

Note NEW DEADLINES for receipt of applications: DECEMBER 31, 2002, APRIL 15, 2003, and thereafter APRIL 15 and NOVEMBER 15 of each year.

Syllabi and bibliographies for teaching history of physics

An updated and enlarged collection of syllabi for courses on the history of science, primarily physical sciences, can be seen at the web site of the Center for History of Physics, American Institute of Physics: www.aip.org/history/syllabi. They would appreciate receiving more syllabi from colleagues. Please send inquiries or information to chp@aip.org.

2003-04 Congressional Science Fellowship Programs

The American Institute of Physics and the American Physical Society are accepting applications for their 2003-2004 Congressional Science Fellowship programs. Fellows serve one year on the staff of a Member of Congress or congressional committee, learning the legislative process while lending scientific expertise to public policy issues. Application deadline is January 15, 2003. For more information, visit www.aip.org/pubinfo or www.aps.org/public_affairs/fellow/index.shtml.

2003-04 AIP State Department Science Fellowship Program

This fellowship program represents an opportunity for scientists to make a unique and substantial contribution to the nation's foreign policy. Each year, AIP sponsors one fellow to work in a bureau or office of the U.S. State Department, becoming actively and directly involved in the foreign policy process by providing much-needed scientific and technical expertise. Application deadline is in November. For more information, visit www.aip.org/mgr/sdf.html.

NOTES and ANNOUNCEMENTS

History of Science Society Invitation.

Stephen G. Brush, one of the founders of the Forum on History of Physics and the first Secretary-Treasurer and *Newsletter* Editor of FHP, extends the following invitation to Forum members:

Dear Colleague,

I write both as a member of the Forum on History of Physics of the American Physical Society and as a member and former President of the History of Science Society to urge you to join the History of Science Society.

The History of Science Society is the world's largest organization dedicated to understanding science, technology, medicine, and their interactions with society and culture in their historical contexts. As a member of the Forum you well know that such understanding is most crucial in a world increasingly interconnected by science and technology. Your HSS membership supports an international effort to produce and disseminate cutting-edge knowledge about the history of science. You would thereby join with over 3,000 scholars and research institutions committed to advancing research and teaching in history of science.

Membership in the History of Science Society brings valuable intellectual and professional benefits, especially access to the resources you need for your research and teaching. These benefits include:

•A subscription to ***Isis***, the premier journal in the history of science, published online with the March 2002 issue (volume 93:1). Recent ***Isis*** articles related to the history of physics are listed on the reverse of this letter.

•Access to the History of Science and Technology Bibliographic Database, an online guide to the latest research in the field.

•The annual *Current Bibliography in the History of Science and Its Cultural Influences*, a significant bibliography of history of science and technology articles published worldwide.

•The quarterly *HSS Newsletter*, which annually provides more than 150 pages listing grant competitions, conference announcements, job notices, and other news about the Society, its members, their discipline, and the profession.

•Listing in the History of Science Society/Philosophy of Science Association Online Membership Directory, a valuable tool for quickly connecting with colleagues.

•Advanced notice of and reduced-rate registration at the Society's annual meetings. Future annual meetings are scheduled for Cambridge, MA, and Austin, TX.

•A 30 percent discount on issues of ***Osiris***, the Society's annual volume of research focused on significant themes in its field of interest.

•Online access to news of hundreds of grant competitions, jobs listings, and calls for papers, collected from around the world and sorted to help members find the grant or job or conference they need.

•The forthcoming *Guide to the History of Science*, a volume designed to lead members through the growing maze of research institutions, graduate programs, journals, and other societies that support scholarship and training in the field.

In addition to these benefits, members who join in 2002 will also receive:

•A free copy of *Catching Up with the Vision*, a 359-page award-winning volume (published to celebrate the Society's 75th anniversary) that reviews the development of the history of science in America.

• A 50 percent discount on selected University of Chicago Press books.

For more details, please visit the HSS website at www.hssonline.org, the ***Isis*** Web site at www.journals.uchicago.edu/Isis, and the ***Osiris*** website at www.journals.uchicago.edu/Osiris.

With many thanks for your attention. I look forward to welcoming you to membership in the History of Science Society.

Sincerely yours,

Stephen G. Brush

Distinguished University Professor (University of Maryland, Institute for Physical Science and Technology)

Recently published articles in ***Isis*** of interest to scholars of the history of physics include:

Ann Blair, *Mosiac Physics and the Search for a Pious Natural Philosophy in the Late Renaissance*, *Isis* 91:1 (2000)

Michael F. Conlin, *The Popular and Scientific Reception of the Foucault Pendulum in the United States*, *Isis* 90:2 (1999)

C.W.F. Everitt and **Anna Muza**, *History, Theory, and the Ziggurat of Physics, an essay review of* ***Peter Galison's*** Image and Logic: A Material Culture of Microphysics, *Isis* 91:2 (2000)

Peter Harrison, *Curiosity, Forbidden Knowledge, and the Reformation of Natural Philosophy in Early Modern England*, *Isis* 92:2 (2001)

Frederic L. Holmes, *The Revolution in Chemistry and Physics: Overthrow of a Reigning Paradigm or Competition between Contemporary Research Programs?*, *Isis* 91:4 (2000)

John Krige, *Distrust and Discovery: The Case of the Heavy Bosons at CERN*, *Isis* 92:3 (2001)

Joost Mertens, *Shocks and Sparks: The Voltaic Pile as a Demonstration Device*, *Isis* 89:2 (1998)

A special order form showing the free copy of **Catching Up with the Vision** ***and the 50% discount on selected University of Chicago Press books is available from Dr. Alexandra A. O'Brien, The University of Chicago Press, 1427 East 60th Street, Chicago, IL 60637-2954, aobrien@press.uchicago.edu.***

The Basic Prize in History of Science. The Basic Prize is intended to encourage young scholars and to communicate the importance and interest of the subject to an intelligent general readership. The Prize is open to any new scholar in the fields of History of Science, History of Technology, History of Medicine, and closely related areas. Only first-time authors will be considered. To be eligible, manuscripts must not be under contract with any publisher at the time the award is decided.

Selection Criteria: The Prize will be awarded for the best book-length manuscript submitted during each year. Manuscripts must be unpublished and must either fall clearly within the subject area or be closely relevant to it. Consistent with the goals of the prize, manuscripts will be evaluated both for their scholarly contribution and for quality of writing; the manuscript that best combines both attributes will be awarded the prize.

The Prize will consist of publication by Basic Books; a $7,500 advance against royalties; and a $1,000 stipend for travel to the annual convention of the History of Science Society.

Guidelines for Submission: The next deadline for receipt of manuscripts is 30 June 2003. Submit two (2) copies of the manuscript, one to Basic Books and one to any one judge listed below. This year's Prize will be announced at the 2002 meeting of the History of Science Society.

Judges: Norton Wise, Department of History, UCLA, Los Angeles, CA 90095. Mary Jo Nye, Department of History, Milan Hall 306, Oregon State University, Corvallis, OR 97333. Robert J. Richards, Morris Fishbein Center for The History of Science, University of Chicago, Chicago, IL 60637. David Lindberg, Department of History of Science, 7143 Social Sciences Bldg., University of Wisconsin, Madison, WI 53706.

Send one copy of the manuscript to: Basic Books - History of Science Prize, 387 Park Avenue South, 12th Floor, New York, NY 10016. For more information email william.frucht@perseusbooks.com.

Cushing Prize in History and Foundations of Physics. A prize has been established in memory of James T. Cushing (1937-2002), who at the time of his death was a Fellow of APS and a long-time member of the Forum. The annual prize of $1,000, honoring Cushing and his contributions to the history and philosophy of physics, will be awarded for significant new work by younger scholars in the history and philosophical foundations of modern physics. Nominations for 2003 are now being accepted, and the winner will be announced in April. The 2002 Call for Nominations can be found at www.nd.edu/~cushpriz Nomination.htm.

Contributions to the endowment for the prize are being accepted at Cushing Memorial Prize, Program in History and Philosophy of Science, University of Notre Dame, 346 O'Shaughnessy, Notre Dame, Indiana 46556. For more information, please contact Don Howard at 574-631-7547 or Cushing.Prize.1@nd.edu.

***Physics in Perspective*.** Most journals are targeted to a small group of scholars. That is not the case for the journal *Physics in Perspective*, which has now been published since early 1999 for a wide audience of historians, philosophers, physicists, and the interested public. The editors believe that scholarly papers written by historians of physics, philosophers of physics, and physicists themselves can be an effective means for bringing the ideas, the substance, and the methods of physics to non-specialists, provided jargon is avoided and care is taken in the writing.

Physics in Perspective is published quarterly. Besides articles and book reviews, the journal has two regular features: first, "The Physical Tourist," identifies sites for the traveler whose interests include artifacts from the history of physics, laboratories with historical significance, birthplaces of well-known physicists, and the like; second, "In Appreciation" is written about a physicist by a student, first-hand acquaintance, or colleague. *Physics in Perspective* is available to members of the American Physical Society at the special subscription rate of $35 per year plus $10 shipping and handling. Additional information can be found at the Birkhäuser Verlag website, www.birkhauser.ch/journals/1600/1600_tit.htm.

First-hand accounts of participants in interesting and important research projects – experimental, theoretical, or computational – often become documents of historical import. The editors of *Physics in Perspective* welcome such first-hand accounts and hereby extend an invitation to physicists, and particularly to members of the Forum on History of Physics, to submit manuscripts for publication. (John S. Rigden, American Institute of Physics, One Physics Ellipse, College Park, MD 20740, jsr@aip.org and Roger H. Stuewer, Tate Laboratory of Physics, University of Minnesota, 116 Church Street SE, Minneapolis, MN 55455, rstuewer@physics.spa.umn.edu).

A retirement celebration for Lawrence Badash was held in Santa Barbara on May 11, 2002. Badash has made many important contributions to the history of the modern physical sciences.

***"Physicists and the 1945 Decision to Drop the Bomb"* by Nina Byers.** The *CERN Courier* has scheduled for their November issue an article by Nina Byers entitled "Physicists and the 1945 Decision to Drop the Bomb." It is a followup of a paper she wrote for publication in the Proceedings of the University of Chicago 2001 Reunion in honor of Enrico Fermi. (See her talk *"Fermi and Szilard"* at http://xxx.lanl.gov/html/physics/0207094.)

The American Philosophical Society Library Resident Research Fellowships 2003-2004. The American Philosophical Society Library accepts applications for short-residential fellowships for conducting research in its collections. The Society's Library, located near Independence Hall in Philadelphia, is a leading international center for research in the history of American science and technology and its European roots, as well as early American history and culture. The Library houses over 7 million manuscripts, 250,000 volumes and bound periodicals, and thousands of maps and prints. Outstanding historical collections and subject areas include the papers of Benjamin Franklin; the American Revolution; 18th and 19th-century natural history; western scientific expeditions and travel, including the journals of Lewis and Clark; polar exploration; the papers of Charles Willson Peale, including family and descendants; American Indian languages; anthropology, including the papers of Franz Boas; the papers of Charles Darwin and his forerunners, colleagues, critics, and successors; history of genetics, eugenics, and evolution; history of biochemistry, physiology, and biophysics; 20th-century medical research; and history of physics. (The Library does not hold materials on philosophy in the modern sense.)

The fellowships, funded by The Andrew W. Mellon Foundation, the Grundy Foundation, the Isaac Comly Martindale Fund, the Phillips Fund, the John C. Slater Library Research Fund, and other generous gifts by individual donors, are intended to encourage research in the Library's collections by scholars who reside beyond a 75-mile radius of Philadelphia. The fellowships are open to both U.S. citizens and foreign nationals who are holders of the Ph.D. or the equivalent, Ph.D. candidates who have passed their preliminary exams, and independent scholars. Applicants in any relevant field of scholarship may apply. The stipend is $2,000 per month, and the term of the fellowship is a minimum of one month and a maximum of three, taken between June 1, 2003 and May 31, 2004. Fellows are expected to be in residence for four consecutive weeks during the period of their award.

There is no special application form and this notice provides all the essential information needed to apply. Applicants should submit the following: (1) cover sheet stating a) name, b) title of project, c) expected period of residence, d) institutional affiliation, e) mailing address, f) telephone numbers, and e-mail if available, and g) social security number; (2) a letter (not to exceed three single-spaced pages) which briefly describes the project and how it relates to existing scholarship, states the specific relevance of the American Philosophical Society's collections to the project, and indicates expected results of the research (such as publications); (3) a c.v. or résumé; and (4) one letter of reference (doctoral candidates must use their dissertation advisor). Guides to the collections are available on the Society's website: www.amphilsoc.org. Applicants are strongly encouraged to consult the Library staff by mail or phone regarding the collections.

Address applications or inquiries to: Library Resident Research Fellowships, American Philosophical Society Library, 105 South Fifth St., Philadelphia, PA 19106-3386. Telephone: (215) 440-3400. Applications must be received by March 1, 2003. Notice of awards will be mailed after May 1, 2003.

German Commission for History of Geophysics, Cosmical Physics and Space Physics founded. A commission for the history of geophysics, cosmical physics and space physics has been founded under the leadership of Professor Dr. Hans-Jürgen Treder, formerly director of the Einstein Laboratory for Theoretical Physics of the Academy of Sciences.The commission publishes a journal entitled *Contributions to the history of geophysics and cosmical physics*, which is open to all authors. It is a discussion forum for the interdisciplinary discussion of problems in history and philosophy of geosciences and its sub-disciplines, including solar-terrestrial physics and its special problems in development and history, and space physics. This also includes space science education, the public understanding of space science and the history of space science and aeronautics in general. The discussion will cover from the first steps since Fabricius, Scheiner and Galilei up to the recent space experiments of the present day. A recent volume has been published under the title *Pathways to Science*, which includes authors such as Sir Ian Axford, Syuin-I. Akasofu, Sir Allan Cook, David Oldroyd, Giovanni Gregori, Helmut Moritz, formerly president of IUGG, and many others. The authors describe their path to science, especially to geophysics. Another study dealt with the aurora of March 17, 1716 and includes the original text by Ch. Wolff, G. Langhausen, and C. Kirch.

Another purpose of the commission is to collect old instruments, biographical notes, scientific correspondence. Selected correspondence of the seismologist Emil Wiechert with Hendrik A. Lorentz (Nobel Laureate) and Arnold Sommerfeld (theoretical physicist) have been published by Wilfried Schröder (Archive Hist. Ex. Science, 1982ff), as well as a comprehensive book on the life and work of Emil Wiechert (Wilfried Schröder, *Emil Wiechert: Geophysicist, Physicist and Organizer of International Science*, Bremen: Science Editions, 2000; see also:http://huhu.franken.dehistory-geophysics/Wiechert.htm). The lives of other German geophysicists have also been recorded, including Julius Bartels, Ludwig Biermann, Hans Ertel, Max Eschenhagen, Leonhard Euler, Wilhelm Foerster, Carl-Friedrich Gauß, Beno Gutenberg, Hermann von Helmholtz, Cuno Hoffmeister, Alexander von Humboldt, Johann von Lamont, Helmut E. Landsberg (for his German time with Gutenberg), Otto Jesse, Adolf Schmidt, Wilhelm Weber (a book on Weber has been published by member Karl-Heinrich Wiederkehr), Alfred Wegener, and others.

The commission welcomes comments and suggestions from all colleagues. Contact Geomoppel@t-online.de and visit the website: http://huhu.franken.de/history-geophysics/english.html.

-Wilfried Schröder, Geophysical Institute, Bremen, Germany

French Journal issue on historical and philosophical analyses of quantum theories: *Philosophia Scientiae*, Vol. 5, No. 1: Analyses Historiques et Philosophiques sur les Théories Quantiques.

The results of the **1998 HSS Women's Caucus Workshop** held at Princeton University have been published as a volume from University of Chicago Press entitled ***Feminism in Twentieth-Century Science, Technology, and Medicine***, ed. Angela N. H. Creager, Elizabeth Lunbeck, and Londa Schiebinger (2001). Contributors: Ruth Schwartz Cowan, Linda Marie Fedigan, Scott F. Gilbert, Evelynn M. Hammonds, Evelyn Fox Keller, Pamela E. Mack, Michael S. Mahoney, Emily Martin, Ruth Oldenziel, Nelly Oudshoorn, Carroll Pursell, Karen A. Rader, and Alison Wylie. The volume is available in both hardback and paper.

The *Annals of Science* Prize for Junior Scholars is offered each year to the author of an unpublished essay in the history of science or technology. The article must not be under consideration for publication elsewhere. The prize, supported by Taylor and Francis, is intended for those who have been awarded their doctorate within the past four years, and for doctoral students. Essays should be submitted to the Editor in a form suitable for publication in *Annals of Science* and may be in English, French, or German. Essays should be between 6,000 and 9,500 words in length, including footnotes. The winning essay will be published in the journal and the essay's author will be awarded $500. Papers should be submitted by 1 September. For further information, visit the Taylor and Francis Web site at www.tandf.co.uk.

Robert Grosseteste and the Origins of Experimental Science 1100-1700, by A. C. Crombie has recently been reprinted by Oxford University Press from the original 1953 publication.

NASA History: News and Notes is published quarterly by the NASA History Division, Office of Policy and Plans, Code ZH, NASA Headquarters, Washington, DC 20546. You can receive *NASA History: News and Notes* via email. To subscribe, send a message to domo@hq.nasa.gov. Leave the subject line blank. In the text portion simply type "subscribe history" without the quotation marks. You will receive confirmation that your account has been added to the list for the newsletter and to receive other announcements that may interest you. The latest issue of this newsletter is also available on the web at www.hq.nasa.gov/office/pao/History/nltrc.html.

A Dirac Centenary Conference was held at Baylor University September 30 to October 2, 2002. This interdisciplinary conference explored the continued fecundity of Dirac's contributions to physics, mathematics and the heuristics of physical theory. Speakers at the conference included John Baez (UC-Riverside), Laurie Brown (Northwestern), Richard Dalitz (Oxford), Michael

Dickson (Indiana U), Gordon Kane (U of Michigan), David Olive (U of Wales, Swansea), Don Page (U of Alberta), Roger Penrose (Oxford), John Polkinghorne (Cambridge), John Roberts (U of Rome), John Roe (Pennsylvania State), Simon Saunders (Oxford), and Cumrun Vafa (Harvard).

A chapter of the new book, *Prematurity in Scientific Discovery: On Resistance and Neglect,* is now available on a special web site: go.ucpress.edu/prematurity. The book is edited by Ernest B. Hook, Professor at the School of Public Health, University of California, Berkeley, in which an eminent group of scientists, historians, sociologists and philosophers focus on the fascinating problem: why are some discoveries rejected at a particular time but later seen to be valid?

Lorenz Krüger postdoctoral fellowship for 2003/05 at the Max Planck Institute for the History of Science in Berlin. This fellowship is for an outstanding junior scholar whose current research combines perspectives from the history of science with those of the philosophy of science and/or the history of philosophy. The fellowship is named in honor of the late Professor Lorenz Krüger, of the University of Göttingen, whose work sought to connect philosophy with the history of science. The Lorenz Krüger Fellowship is awarded for a two-year stay at the Institute in Berlin, beginning 1 October, 2003.

The fellowship is open to scholars of all nationalities who have completed their Ph.D. no earlier than 1998 and no later than September 2003. The stipend for applicants from abroad is Euro 1.841 per month. Women are encouraged to apply. Qualifications being equal, precedence will be given to candidates with disabilities. Applicants are invited to send a curriculum vitae, a brief research proposal (maximum 1000 words), and two letters of recommendation by 31 January 2003 to Max Planck Institute for the History of Science, "Lorenz Krueger Fellowship," Wilhelmstraße 44, 10117 Berlin, Germany.

Tools and Modes of Representation in the Laboratory Sciences, an edited collection, has recently been published by Kluwer, as volume 222 of *Boston Studies in the Philosophy of Science*, Ursula Klein (ed). All 14 articles are primarily about chemistry.

Wigner Centennial Conference was held in Pécs, Hungary, 8-12 July, 2002. The proceedings of the conference are in preparation and will be published by *Acta Physica Hungarica*. All of the proceedings will appear on CD-ROM and on the web, while selected proceedings, including those of invited and plenary speakers will be imprinted in "Heavy Ion Physics" and "Quantum Electronics," the two series of *Acta Physica Hungarica*, as well. More information about this conference, including abstracts, is available at quantum.ttk.pte.hu/~wigner.

New guide on the use of oral history, "Making Sense of Oral History." This guide relies on the internet to show individuals how to "read" oral history as evidence of the past. It was created through the efforts of *History Matters* and the Visible Knowledge Project. It presents an overview of these sources, including how historians use them. The guide then uses explanatory text and interactive examples to consider what critical questions to ask when working with these materials. For example: "Who is talking?" "Why are they talking?" It is available on the web at historymatters.gmu.edu/mse/oral.

The guide was prepared by Linda Shopes, a historian at the Pennsylvania Historical and Museum Commission. She has worked on, consulted for, and written about oral history projects for more than 25 years. She is co-editor of *The Baltimore Book: New Views of Local History* and is past president of the Oral History Association.

Pushing gravity: New Perspectives on Le Sage's Theory of Gravitation, Matthew R. Edwards (ed.) has recently been published in Montreal by C. Roy Keys, Inc. (ISBN 0-9683689-7-2, pb, $25). More information is available at redshift.vif.com/BookBlurbs/PushingGravity.htm,

Meetings

Robert Hooke Tercentenary Conference will be held at The Royal Society, London, 6-10 July, 2003. Keynote speakers are Michael Nauenberg (UC-Santa Cruz)on *Robert Hooke's Dynamics*, Jim Bennett (Museum of the History of Science, Oxford) on *Robert Hooke and Scientific Instrumentation*, Moti Feingold (Cal Tech) on *Robert Hooke: Gentleman of Science*, Jacques Heyman (U of Cambridge) on *Hooke and Bedlam*.

Robert Hooke (1635-1703) was a true polymath. Author of the influential *Micrographia* (1665), he was one of the leading natural philosophers of his day. As an inventor, he was second to none. He also played a major role in the rebuilding of London after the Great Fire, while his diaries give a revealing picture of his lifestyle and milieu in the Restoration metropolis.

This major international conference, organised under the auspices of Gresham College, London, and co-sponsored by The Royal Society, will give attention to all aspects of Hooke's life and work.

Registration: Those who would like to attend or wish additional information should correspond with the administrator, Mrs Julie Jones (julie.jones6@btinternet.com) or telephone her (01235 762744). Information and registration details can also be obtained from the Gresham College website at www.gresham.ac.uk/hooke.

21st Annual Mephistos Conference, a Graduate Student Conference on the History, Philosophy, and Sociology of Science, Technology, and Medicine will be held 6-8 March 2003 at the University of Wisconsin-Madison. Deadline for submissions: 15 January 2003. For more information visit athena.english.vt.edu/cgi-bin/netforum/ishlist/a/14--13.3.1.

"Discovering the Nanoscale," conference. Philosophers, historians, sociologists of science and technology are invited to submit proposals concerning the significance of nanoscale research for the "Discovering the Nanoscale" conference. The conference will be held 20-23 March 2003 at the University of South Carolina, Columbia, and 10-12 October 2003 at the Technische Universität Darmstadt, Germany. The discussions will begin in Columbia, SC and continue six months later in Darmstadt, Germany. 500-word proposals can be submitted to either or both meetings (the second conference allows for the presentation of substantially revised or expanded drafts). Send electronic submissions (pdf or RichText formats) by 1 December 2002 to Alfred Nordmann at Nordmann@phil.tu-darmstadt.de For more detailed information concerning topic and format visit www.cla.sc.edu/Phil/scistud/call.html.

The Canadian Society for History and Philosophy of Science (CSHPS) is holding its annual conference in Halifax, Nova Scotia, on 29-31 May 2003. The program committee invites historians and philosophers of science, as well as scholars from any field whose work relates to history and philosophy of science, to submit abstracts for individual papers or proposals for sessions.

Submissions may be in English or French. Individual paper submissions should consist of a title, a brief abstract of 150-250 words, and complete contact information for the author. Session proposals should consist of a session title, titles and brief abstracts for each paper, and complete contact information for the session organizer. Proposals must be received by 31 December 2002 and must be sent by email (rtf attachment preferred) to the following email address: cshps03@arts.ubc.ca

The complete call for papers can be found at www.psych.yorku.ca/orgs/cshps/call2003.htm. Information about Congress registration and accommodation can be found at the Humanities and Social Sciences Federation of Canada web site. Canadian Society for History and Philosophy of Science: www.ukings.ns.ca/cshps/. Congress of the Social Sciences and Humanities: www.hssfc.ca/.

Vienna International Summer University 2003: Biological and Cosmological Evolution, Vienna, July 14-27, 2003, organized by the University of Vienna and the Institute Vienna Circle. This is a two-week high-level summer course on questions about evolutionary aspects in physics and genetics from a comparative and interdisciplinary point of view.

Main Lecturers: Karl Sigmund (U of Vienna), Robert M. Wald (U of Chicago), Eörs Szathmáry (Eötvös Loránd U, Hungary). Assistant Lecturer: Daniel Holz (UC-Santa Barbara).

Application deadline January 15, 2003. (Later applications may be considered if space is still available.) For further information contact Professor Friedrich Stadler, Friedrich.Stadler@univie.ac.at. or consult the IVC's Web site: ivc.philo.at/VISU or the University of Vienna's Web site: www.univie.ac.at (click Vienna Summer University).

Panel on "20th Century Physics, International Human Rights Legislation, and Conceptions of Human Agency," in the Association of Social Anthropologists Decennial Conference, University of Manchester, 14-18 July, 2003 organized by Stephanie Koerner (University of Manchester), les1.man.ac.uk/sa/ASA/Decennial.

History of Science Society, 2003. The HSS Annual Meeting in 2003 will be 20-23 November in Cambridge, MA. Information can be found at www.hssonline.org. In 2004 HSS will meet in Austin, TX, 18-21 November.

***Mundi Subterranei*: Scientific Instrument Collections in the University**, an international symposium at Dartmouth College, 24-27 June 2004, co-sponsored by the Scientific Instrument Commission and Dartmouth College, Hanover, NH.

The Dartmouth collection of historic scientific instruments, one of the oldest and largest at a North American university, is currently being reorganized and catalogued. Other universities and colleges around the world have begun similar projects, seeking to formalize collections that, until now, have been virtually unknown even within their institutions. Taken individually, such collections present unique windows into the role of instruments in higher education and in transmitting scientific knowledge to public audiences. Taken collectively, they represent a vast scholarly resource that is still largely hidden from view and under-appreciated.

With this in mind, Dartmouth will host a conference in June of 2004, focusing on the theme of instrument collections in academic institutions. We hope 1) to encourage the development of a network among these collections, 2) to provide a forum to discuss practical problems that pertain to such collections, including cataloguing, web exhibits, storage and exhibition space, safety issues such as potentially toxic substances, and the profile of such collections on campus and their use in teaching and research, 3) to facilitate presentation of scholarly papers and posters relating to scientific instruments, their histories and the collections in which they reside.

Parts of the Dartmouth Collection will be on display and the Shattuck Observatory (1853) will be open. In addition, excursions are planned to the Precision Museum in Windsor, Vermont, and to turret telescopes in Springfield, Vermont. For those who wish to explore other nearby instrument collections, the Harvard collection in Cambridge and the University of Vermont collection in Burlington are each about 2 hours away by auto.

For further information, to express interest, or to receive the second circular, contact Frank Manasek, francis.j.manasek@dartmouth.edu.

Web Resources

Web to reveal Pauling's methods and musings. Digital versions of Linus Pauling's lab notebooks were released online on 28 February, the 101st anniversary of the double Nobel prizewinner's birth. The 46 notebooks span the years between 1922 and 1994, and include details of the work that earned Pauling the 1954 Nobel Prize in Chemistry for his studies of chemical bonds between atoms. Pauling campaigned against the development of nuclear weapons during the cold war, and in 1958 presented a petition to the United Nations, signed by more than 9,000 scientists, that called for the end of nuclear testing. He was awarded the Nobel Peace Prize for this work in 1962. The notebooks have been digitized by staff at Oregon State University, who say the records contain autobiographical musings as well as Pauling's experimental records. Go to osulibrary.orst.edu/specialcollections.

Searchable online bibliography of the history and philosophy of chemistry is now available on the web. This bibliography combines numerous thematic bibliographies. The database presently includes some 5,800 titles and is rapidly growing as further thematic bibliographies are being added. Access is free at www.hyle.org/service/biblio.htm.

New version of Panopticon Lavoisier, including a bibliography and inventory of Lavoisier's manuscripts and instruments: moro.imss.fi.it/lavoisier.

The British Society for the History of Science has a newly redesigned and expanded website at www.bshs.org.uk. The Society's former pages on the University of Manchester's CHSTM server are now defunct. The Society now has an expanded links directory at www.bshs.org.uk/links, covering journals, societies, lists, museums and online resources by subject area.

New British Society for the History of Science *Guide to History of Science Courses in the UK*: www.bshs.org.uk/courses.

New, free, online Navigational Aids for the History of Science, Technology & the Environment can be accessed at www.nahste.ac.uk. This is a large, web-based index of archive material newly catalogued in the University of Edinburgh, in Heriot Watt University, and in the University of Glasgow, brought together with funding from the UK Research Support Libraries Programme.

Dibner Institute for the History of Science and Technology

Fellows Programs 2003-2004. The Dibner Institute for the History of Science and Technology invites applications to its two fellowship programs for the academic year 2003-2004: the Senior Fellows program and the Postdoctoral Fellows program. Some twenty-five Dibner Fellows are resident at the Institute each year. The Dibner Institute is an international center for advanced research in the history of science and technology, established in 1992. It draws on the resources of the Burndy Library, a major collection of both primary and secondary material in the history of science and technology, and enjoys the participation in its programs of faculty members and students from the universities that make up the Dibner Institute's consortium: the Massachusetts Institute of Technology, the host institution; Boston University; and Harvard University. The Institute's primary mission is to support advanced research in the history of science and technology, across a wide variety of areas and a broad spectrum of topics and methodologies. The Institute favors projects that address events dating back thirty years or more.

The deadline for receipt of applications for 2003-2004 is December 31, 2002. Fellowship recipients will be announced in March 2003. Please send requests for further information and for application forms directly to: Trudy Kontoff, Program Coordinator, Dibner Institute for the History of Science and Technology, MIT E56-100, 38 Memorial Drive, Cambridge, Massachusetts 02139; 617-253-6989; fax: 617-253-9858; dibner@mit.edu; website: dibinst.mit.edu.

Dibner Institute Names Fellows for 2002-2003. The Dibner Institute for the History of Science and Technology is pleased to announce the appointments of the Dibner Institute Resident Fellows for 2002-2003. The Institute will welcome eleven Senior Fellows, two Senior Visiting Research Fellows, seven Postdoctoral Fellows and has renewed the appointments of five Postdoctoral Fellows. In addition, they have appointed six Graduate Student Fellows, Ph.D. candidates writing their doctoral dissertations at Dibner Institute consortium-member institutions. The Fellows come from several nations and pursue many different aspects of the history of science and technology. Those working in or close to history of physics are listed below. A complete list can be found on the Dibner Institute website.

Dibner Institute Senior Fellows

Robert P. Crease is a Professor at SUNY, Stony Brook and also an Historian at Brookhaven National Laboratory. He is the author of *Making Physics: A Biography of Brookhaven National Laboratory, 1946-1972*, (1999) and, with Robert Serber, *Peace and War: Reminiscences of a Life at the Frontiers of Science*, (1998). At the Dibner Institute he will continue his work on a new volume of the history of the Brookhaven National Laboratory, covering the period 1973-1997.

Robert DiSalle, Professor at the University of Western Ontario, Canada, is the author of two forthcoming papers: "Newton's Philosophical Analysis of Space and Time," *The Cambridge Companion to Newton*, ed. I. B. Cohen and G. E. Smith (2002) and "Conventionalism and Modern Physics: A Re-Assessment," *Noûs* (6/2002). At the Dibner Institute he plans to continue to investigate the evolution of theories of space and time in a work to be titled "Conceptual Analysis and the Conceptual Development of Physics."

Giuliano Pancaldi is Professor at the University of Bologna, Italy. He is the author of the forthcoming *Enlightenment and the Battery. Alessandro Volta and the Cultures of Science in Europe* and *Darwin in Italy: Science Across Cultural Frontiers* (1991). His work while at the Dibner Institute is titled "Enlightenment, Diversity, and the Cultures of Science and Technology."

Emily Thompson, Professor at the University of Pennsylvania, is the author of *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America 1900-1933* (2002) and, co-edited with Peter Galison, *The Architecture of Science* (1999). Her project at the Dibner Institute is titled "Sound Men: Engineering the Sound Revolution in the American Film Industry."

Richard Yeo is Professorial Fellow at Griffith University, Australia. He is the author of *Science in the Public Sphere: Natural Knowledge in British Culture, 1800-1860* (2001)and *Encyclopedic Visions: Scientific Dictionaries and Enlightenment Culture* (2001). He plans to write on the subject, "Managing Knowledge in Early Modern Europe 1650-1800" while he is at the Dibner Institute.

Dibner Institute Senior Visiting Research Scholars

Constance Barsky is Director, Program in Learning by Redesign, The Ohio State University. She is the author, with Kenneth Wilson, of two articles which appeared in *The One Culture: A Conversation About Science*, ed. Labinger and Collins: "From Social Construction to Questions for Research: The Promise of the Sociology of Science" and "Beyond Social Construction." At the Dibner Institute, she will be working with Kenneth Wilson on a catalog of technological history.

Kenneth Wilson, who received the Nobel Prize in Physics for his work on the renormalization group, is Youngberg Professor in the Physics Department, The Ohio State University. He is the author, with B. Daviss of *Redesigning Education* (1994) and *Broken Scale Invariance and the Light Cone*, coedited with M. Gell-Mann (1971). At the Dibner Institute, he will be working on two projects: the first, connected with the Sloan-Dibner project in the History of Recent Science and Technology, will explore the conditions requisite for community-wide, sustained developments in science and technology; the second, with Constance Barsky, will be to initiate a catalog of socio-technological transformations.

Dibner Institute Postdoctoral Fellows

François Charette recently defended his dissertation, "Mathematical Instrumentation in 14th-Century Egypt and Syria" for the Program in History of Science, Frankfurt University, Germany. He has written a chapter, "Islamic Astrolabes," for the forthcoming "Astrolabes at Greenwich. A Catalogue of the Planispheric Astrolabes in the National

Maritime Museum," ed. K. van Cleempoel. His project while at the Dibner Institute is titled "The Visual Language of Islamic Science."

H. Darrel Rutkin, doctoral candidate at Indiana University, is the author of the article, "Celestial Offerings: Astrological Motifs in the Dedicatory Letters of Galileo's *Siderus Nuncius* and Kepler's *Astronomia Nova*," in *Secrets of Nature: Astrology and Alchemy in Early Modern Europe*, ed. Grafton and Newman (2001). At the Dibner Institute he proposes to develop a book on the place of astrology in premodern western science, c.1250-1500.

Christopher Smeenk defended his dissertation, "Approaching the Absolute Zero of Time: Theory Development and Evaluation in Early Universe Cosmology," Spring, 2002 at the University of Pittsburgh. He is the author, with John Earman, of "Take a Ride on a Time Machine," to appear in "Reverberations of the Shaky Game," edited by Jones and Ehrlich, and he is assistant editor, with J. Renn, M. Schemmel, and C. Martin of the forthcoming two-volume work, "The Genesis of General Relativity." The title of his work while at the Dibner Institute is "An Inflationary Field: The Heyday of Early Universe Cosmology."

Dibner Institute Postdoctoral Fellows Appointed to a Second Year

Elizabeth Cavicchi received her Ed.D. from the Harvard Graduate School of Education, where she was a Lecturer and developed courses in teaching science. She is the author, with P. Lucht and F. Hughes-McDonnell, of "Playing with Light," *Educational Action Research* (2001) and "Experimenting with Magnetism: Ways of Learning of Joann and Faraday," *American Journal of Physics* (1997) and will present a paper at the 2002 Bakken Museum Conference on the lightning rod. For her Dibner Institute project, she is doing research on induction-coil-making by 19th-century amateurs and the educational and historical ramifications of replicating their experiments.

Alberto Martinez received his Ph.D. from the University of Minnesota and was subsequently a Dibner Library Resident Scholar, Smithsonian Institution. He was an Organizer for the Seminar on the Investigation of Difficult Things, 1999-2000 and for the Seminar on Natural Philosophy, 1996, both at the University of Minnesota, and has been a participant in the Seven Pines Symposium for History and Philosophy of Physics, 1997, 1999. At the Dibner Institute he is preparing a book on the history of kinematics, the modern science of motion. He is also finishing a book entitled "Physical Mathematics."

Yunli Shi was Professor, Department of History of Science, University of Science and Technology of China, from which he received his Ph.D. He is the author of several books in Chinese, including *History of Astronomy in China* and the forthcoming "Chinese Astronomy and the Importation of Western Knowledge." His most recent article in English is "The Korean Adaptation of the Chinese-Islamic Tables," forthcoming in *Archive for History of Exact Sciences*. His research project at the Dibner Institute is titled "European Background of Jesuit Predictive Astronomy in 18th Century China."

Dibner Institute Graduate Student Fellows

Jeremiah James received the B.A. from St. John's College, Annapolis, Maryland and will receive the Ph.D. from the History of Science Department, Harvard University. He is the author of the forthcoming article, "Disunifying Science: The Fragmentation of the Pauling Program," *Chemical Heritage Foundation Magazine*. His dissertation will examine the development of new research programs and their identities as scientific disciplines, built upon work done by Linus Pauling in the 1930s.

Chen Pang Yeang received the B.S. from National Taiwan University and the Sc.D. in Electrical Engineering from MIT, and is now enrolled in MIT's Program in Science, Technology, and Society. He is the author, with W. He, of the paper, "How the Magnetic Core Memory became a Core Memory in the Digital Computer," submitted to *Technology and Culture*. The title of his thesis is "Transmission, Reception, and Interference: Radio Technology and Science, 1900-1940."

BOOK REVIEWS

John Hedley Brooke, Margaret J. Osler, and Jitse M. van der Meer, editors, *Science in Theistic Contexts: Cognitive Dimensions* (Osiris, **16**, University of Chicago Press, 2001). ISBN: 0226075648, $39 (cloth); 01160756586, $25 (paper).

Reviewed by John S. Rigden, American Institute of Physics.

History eschews simplicity. It is commonly believed that the Galileo affair represents a clearcut example of science vs. religion – of good vs. evil or evil vs. good, depending on one's point of view. However, as Maurice A. Finocchiaro shows in this collection, some churchmen lined up with Galileo and some scientists opposed him. Not quite so clearcut. The title of Finocchiaro's paper, "Science, Religion, and the Historiography of the Galileo Affair: On the Undesirability of Oversimplification," tells its own story.

Most scientists, if asked, would acknowledge that cultural values and philosophical predilections exert an influence on the conduct of science. Most scientists, physicists in particular, would also acknowledge that science can be influenced by aesthetics – perceptions of beauty, elegance, simplicity, and symmetry. But religion? Does religion also insert itself into the practice and content of science? This issue of *Osiris* shows that the answer is a resounding "Yes," at least in earlier eras. In 14 case studies featuring several headline scientists of the 17th, 18th, and 19th centuries, the influence of religion on science is developed in detail. While most of the case studies (12) focus on scientists who are Christians, there is one case study that focuses on each of the other two monotheistic world religions. These case studies are preceded by two essays of a broader nature designed to provide a framework for the specific case studies that follow.

The first essay, "Religious Belief and the Content of Science," is by John Hedley Brooke, who is also the author of *Science and Religion: Some Historical Perspectives*, (Cambridge). Brooke's position is that "religious beliefs and practices can shape worldviews, that worldviews may find expression in a commitment to metaphysical principles that govern theory construction, and that these, in turn, may govern the degree of assent one might give to particular explanatory theories" (p. 6). Brooke develops arguments designed to show that religion shapes not only the content of science, but also the practice of science. Brooke's position begs the question: What is a religious belief and, more to the point, how does one distinguish between religious and metaphysical beliefs? For example, one can believe in the unity of nature for religious and/or metaphysical reasons. This issue is the subject of the second introductory essay, "Religious Beliefs, Metaphysical Beliefs, and Historiography of Science," by Stephen J. Wykstra.

The case studies feature Johannes Kepler, Galileo and his much-studied controversy with the Catholic Church, Robert Boyle, Isaac Newton, Alfred Russel Wallace, and Charles Darwin. Other case studies delve into more general issues. There is no doubt that religion has had decisive influences on the work of the named individuals. For example, the paper by Peter Barker and Bernard R. Goldstein, "Theological Foundations of Kepler's Astronomy," demonstrates convincingly that "...theology plays a central role in Kepler's scientific thinking" (p. 89), not only in his *Mysterium Cosmographicum* (1596) but also in his *New Astronomy* (1609), where his laws of planetary motion are developed. In the paper by Stephen D. Snobelen, "'God of gods, and Lord of lords:' The Theology of Isaac Newton's General Scholium to the *Principia*," the author argues that an "interpenetration existed at a fundamental level between the cognitive content of the theological and natural philosophical features of Newton's grand study" (p. 197). In other words, Newton's theology informs his natural philosophy. I believe the authors demonstrate successfully that the content of both Kepler's and Newton's science was directly influenced by their religious faith. But as Snobelen acknowledges, this should not be surprising as it occurred in an age before "God's Word and Works had ... bifurcated" (p. 197).

In the context of the 17th century, it seems legitimate to ask, "How, if at all, did Boyle's religious beliefs relate to his scientific study of gases?" (p. 30). Boyle was, after all, both a religious man and a scientist, and these two strong influences shaped his thought. Could the same question be asked of Maxwell, who came nearly two centuries later? Of course, we are free to ask the question and the answers would definitely reveal that Maxwell was a religious believer. For example, in the case study, "Victorian Sciences and Religions: Discordant Harmonies," the author Bernard Lightman refers to Maxwell's 1873 address, "Molecules," delivered to the British Association for the Advancement of Science, in which Maxwell argued that the precise properties of molecules could not have come about "by any process we call natural" (p. 353) but were the work of a divine creator. But this statement does not suggest that science and religion "interpenetrated" in Maxwell's mind as it did in Newton's. In my reading of the essays, things had changed in the years between Newton and Maxwell.

What about today? After reading this collection of papers, I wondered: Do the religious beliefs of today's physicists influence the content and practice of their physics? There are first-rate contemporary physicists whose lives are ordered by their strong religious beliefs. Such physicists, I expect, would see in various natural phenomena evidence for "intelligent design." As did Maxwell. However, are the Kepler-types and the Newton-types, in whose minds an "interpenetration" did occur, a thing of the past? This question is left unanswered by this interesting collection of case studies.

Harry von Kroge, *GEMA: Birthplace of German Radar and Sonar*, translated from the German and edited by Louis Brown (Institute of Physics Publishing, Bristol & Philadelphia, 2000). 250 pages, ISBN: 0750307323, $75 (£50) cloth.

Reviewed by Per F. Dahl, Lawrence Berkeley National Laboratory.

Radar progress in Germany (and Japan) before and during World War II comes as a surprise to many, with all the literary hype about Allied radar development. This skewed impression is partly due to the fact that the people writing the histories were active participants, and thus tended to push their own agenda, and the destruction and dispersal of German records and apparatus when the war ended. In particular, it is little appreciated that GEMA, an acronym for Gesellschaft für elektroakustische und mechanische Apparate, built the first functioning radars and sonars in Germany. This problem is rectified by Harry von Kroge with his short but excellent volume, ably translated by Louis Brown of the Carnegie Institution of Washington – himself author of the recent and masterful *A Radar History of World War II: Technical and Military Imperatives*. Notes Brown in his Translator's Preface, certain technical materials in Kroge's book, of interest to engineers and physicists, are marked in **boldface**, and may be skipped without losing the thread.

The story had its beginnings in the 1920s when a Dr. Rudolf Kühnhold joined the German Navy's Nachrichtenmittel Versuchsanstalt (NVA), in the development of underwater sound technology, for communication, listening, and directing naval fire. When lackluster results were obtained, Kühnhold was impelled to go beyond the limits of his assignment, and turn to radio transmissions above the water. In so doing, he hired two young engineers, Paul-Günther Erbslöh and Hans-Karl Freiherr von Willisen, boyhood pals who had channeled their childhood hobby of amateur radio into Tonographie, a small firm for manufacturing phonograph records and recording equipment. Before long they formed GEMA, so called to deflect the curious by its reference to previous activities. The eventual upshot was the famous Freya air-warning and Seetakt ocean-surveillance radars.

After dwelling on the origins of GEMA, the author proceeds with early underwater sound and radar equipment, with some surprises here and there, including the complicated circumstances in which GEMA dropped the magnetron oscillator in favor of the triode (and thereby missed the cavity magnetron that ultimately helped the Allies win the war). All this was before the beginning of the war. The rest, and most of the volume, deals with GEMA in World War II, not only successes and failures of radars and sonars, but gives us an interesting history of an industrial corporation in wartime Germany.

"On 31 May 1945 [notes Kroge] GEMA at Lensahn was officially closed. This happened after the British authorities had thoroughly cleared out the German war material there so they could use the space to intern Wehrmacht personnel being returned from Norway and Denmark. This clearance took place on 16/17 May, and all of the tirelessly saved experimental models and prototypes of GEMA development were destroyed, so that when the research-minded British Intelligence Service arrived, only wreckage remained."

The volume ends with an informative epilogue by Louis Brown, in which he finds a remarkable parallel of GEMA's efforts with those of two American laboratories, the Naval Research Laboratory and the Signal Corps Laboratory. He also notes an aspect of the German effort that differed from that of the Allies: numerous corporate rivalries in the German program. This may be accounted for by the fact that Allied radar research was largely carried out in government laboratories, with smaller corporate contributions.

Following Brown's epilogue, there are nearly 30 pages of excellent photographs of personalities, apparatus, and locations, and name and subject indexes. All in all, the volume is well written, perhaps partly due to Brown's involvement.

Briefly Noted:

Hiro Tawara, *Pioneers of Physics in the Early Days of Japan* (North Holland, n.d.). 58+iv pages, paper.

This little booklet is a paperbound essay by Hiro Tawara, a respected atomic collision physicist, about Japan's scientific development. It begins with a brief review of "Science and Scientists Before the Meiji Era (1868-1912)." Beginning in the 16th century, Tawara makes brief note of the influence of Western scientific concepts and instruments in Japan, along with early Japanese practitioners of science. The 18th and 19th centuries saw early Japanese contributions to physics, but these efforts were limited due to the closure of the society to outside cultures. Nevertheless, Tawara sketches the contributions of seven Japanese physicists who helped raise the level of science in Japan during this early period.

With the overthrow of the Shogunate in 1868, the Meiji government established universities that eventually included advanced physics courses. This was followed by the founding of academic societies and journals. The second half of this essay gives brief sketches of the contributions of individual physicists in Japan in this later, more open period, up to World War I. This includes influential western teachers who were brought into the Japanese universities in the early days (1870s and 1880s), followed by important Japanese physicists who took up leadership of science in Japan in the second generation. Tawara closes his essay by noting the emergence of Japan to world-class influence in physics after World War I, but his essay does not address this later period that saw the full flowering of Japanese physics.

Sharon Bertsch McGrayne, *Nobel Prize Women in Science*, 2nd edition (Joseph Henry Press, Washington, DC, 1998). 451+xii pages, ISBN: 0309072700, $19.95, paper.

This update of McGrayne's 1993 book (originally published by Carol Publishing Group, Secaucus, N.J.) is a welcome reissue of an important book on the lives and achievements of women science Nobel Laureates. The new edition adds the story of 1995 Nobelist, Christiane Nüsslein-Volhard. McGrayne explores the challenges and discrimination these women faced, along with the motivations that underlay their great achievements.