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HISTORY of Physics NEWSLETTER

Recent Forum Activities

– Michael Riordan, Forum Chair

The spring and summer of 2003 have been a period of intense activity for the Forum. Not only did we sponsor or cosponsor two slates of extremely well-received sessions on the history of physics at the March and April meetings of the American Physical Society, but we have succeeded in establishing the Abraham Pais Award for the History of Physics to honor outstanding scholarly achievements in the field. In addition, we have initiated an ongoing project in tandem with the APS staff to identify, recognize and publicize a series of historic physics sites in America, as part of the Forum's contributions to the World Year of Physics in 2005. These activities and accomplishments have benefited greatly from the untiring contributions of the Forum officers, Executive Committee and members.

At the March APS meeting in Austin, hundreds of physicists attended the two FHP sessions – a Symposium on J. Willard Gibbs organized by Michael Fisher of the University of Maryland, and an invited session on the Origins of Solid-State Physics convened by Lillian Hoddeson of the University of Illinois. *(See Reports, pp. 6 -9, this issue.)* With the aid of Steven Brush and Pierre Hohenberg, Fisher had organized two other gatherings on Gibbs, one at Maryland and the other at Yale, thus enabling him to bring Danish physics historian Ole Knudsen to Austin to talk about "Gibbs in Europe." Featuring such world-renowned speakers as Phil Anderson and Fred Seitz, Hoddeson's session was absolutely jam-packed, with standing room only and hopeful listeners crowded at the doorways. Perhaps one tenth of all the physicists present at the huge March meeting were in the lecture hall – or at least trying to get in!

At the April meeting in Philadelphia, the Forum leveraged its usual allotment of two invited sessions by cosponsoring four sessions in all with other APS units. *(See Reports, pp. 9-14.)* Executive Committee member Dan Siegel of Wisconsin teamed with his counterpart in the Forum on Education to organize a well-received session on "Using History in Physics Education," while Per Dahl and Elizabeth Paris worked with the Division of Beam Physics to pull together a smashing session on "The Development of Electron-Positron Colliders." Next came a session titled "Benjamin Franklin, Civic Scientist" that I put together with Bo Hammer of the Forum on Physics and Society, followed on Tuesday

Fred Seitz in 1937, three years before the publication of The Modern Theory of Solids. *Read below about his reminiscences (now age 92) at the March 2003 APS Mtg.*

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morning by "The History of Solar Neutrinos," cosponsored with (and largely organized by) the Division of Nuclear Physics. Although none of these four sessions could claim the attendance of those at Austin, the breadth and depth of our offerings were clear to anyone. In addition, Nobel laureate and FHP member Dudley Herschbach of Harvard presented the Sunday evening APS Public Lecture, on "Ben Franklin's Scientific Amusements," at the Franklin Institute. The Forum had a major and obvious presence in Philadelphia.

Another encouraging development was the Forum's contributed papers session, which is generally coupled with the annual FHP business meeting, open to all members. *(See Reports, pp. 14-15.)* Several of the six papers presented there on the history of physics were of high quality. At its Philadelphia meeting, the Forum Executive Committee agreed that we should devote specific attention to this session in the future and attempt to upgrade it into a widely recognized gathering where physics historians young and old are encouraged to deliver talks on their research in progress. Recently elected Executive Committee member Patrick McCrea of the University of California, Santa Barbara, has agreed to spearhead this effort.

Of all the Forum's recent activities, however, none compares with our great success in establishing the Abraham Pais Award for the History of Physics in honor of our dear departed colleague. *(See p. 16.)* As far as I know, this is the only award or prize in the world given specifically for outstanding contributions to the history of physics. I am heartened that it was our members who recognized the need for such an award and put together the successful fundraising effort to make it happen. So far, we have built an endowment of more than $115,000, which will enable the APS and AIP to begin granting the Pais Award annually in 2005 with a stipend of $5,000. It promises to become the world's premier award for scholarly contributions to the history of physics – named after a great physicist and historian of physics who embodies the international spirit of the discipline.

Recognition for the success of this effort is due to many individuals, only a few of whom can I mention in this brief column. Past Forum Chair Ben Bederson served as the indefatigable chair of the Award Committee, guiding its workings over the past two years and leading the sometimes unruly conference calls. Former APS Treasurer Harry Lustig revealed what I call the "asking gift," obtaining several key commitments of large contributions that enabled the fundraising effort to move forward in great leaps rather than a slow crawl. The most significant among these were a $30,000 outright contribution from John Armstrong, former Chair of the AIP Governing Board, and his wife Elizabeth – plus an equal matching grant, which attracted other large contributions that eventually carried us well over our original fundraising goal.

Under Roger Stuewer's able leadership, a subgroup of the Award Committee has been working out the details of the award-granting process. The results of his persistence are now available on the FHP web site under **Pais Award**; I encourage Forum members to glance at the pages describing the award and the guidelines for nominations. Roger will chair a distinguished selection committee that includes Allan Franklin, Lillian Hoddeson, Anne Kox and Spencer Weart representing the AIP. Nominations for the first Pais Award, to be presented at the 2005 APS April meeting, are due no later than 1 May 2004.

Over the summer the *Newsletter* Editorial Board, spearheaded by chair Bill Evenson, found a very able person to replace him as Editor. Coming off his great success in leading the Pais Award effort, Ben Bederson will officially assume these reins at the beginning of next year for a three-year term. I will serve as an Associate Editor during this time and step in when Ben decides to retire; hopefully, this will set up a succession process that will make sure our *Newsletter* is always in experienced hands. We are indeed fortunate in getting Ben, with his vast experience as APS Editor-in-Chief and as editor of *Physical Review A*, to take over from Bill – who deserves an enthusiastic "Thank You!" from the membership for his efforts over the past six and a half years.

Prodded by APS Deputy Executive Director Alan Chodos, who has been promoting the idea of setting up plaques to recognize U.S. sites where important advances occurred in physics, the FHP Executive Committee recently decided to establish a new Committee on Historic Physics Sites to advise the APS staff in this effort. *(See p. 18.)* Accordingly, the committee will "examine policy issues and other questions regarding the implementation of a proposed American Physical Society project to select, signify and publicize the most noteworthy locations in the United States where major advances in physics occurred." Executive Committee member Gerald Holton has agreed to serve on this committee, which is currently in formation. I seek highly distinguished senior physicists with a good sense of the history of physics to serve with him, and I solicit members' recommendations. This service will be part of the Forum's contributions to the World Year of Physics in 2005 *(see p. 17)*, when we hope that the first few of these sites can be recognized.

The program of invited sessions for the 2004 APS meetings is in good hands, with Forum Chair-Elect Nina Byers and her Program Committee putting together two full slates of invited sessions for Montreal and Denver. *(See p. 15.)* This is perhaps the most important Forum activity – and probably the most time-consuming one, too. A subcommittee of this Committee, consisting of Laurie Brown, Holton and Vice Chair Robert Romer, is already at work planning sessions about Albert Einstein for the 2005 APS meetings, to celebrate the centennial of his *annus mirabilis*.

Finally, I would be remiss indeed if I did not recognize the untiring efforts of Forum Secretary/Treasurer Ken Ford in enabling all these activities. He has been my steady consultant, confidant and partner during the past several months when many of these activities and accomplishments occurred,

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 (+$5 additional for air mail). Each volume consists of six issues.

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efficiently running the Executive Committee email meetings and votes. His firm hand on the Forum's budget and disbursement of funds has allowed me to concentrate on the direction of activities without having to worry about its financial condition, which remains solid. My hat is off to Ken!

If we are to maintain this heightened level of activity, The Forum will need more conscientious members like the ones I have mentioned (or unfortunately failed to mention) above to step forward and offer their valuable time, especially to serve on our newer committees. Therefore I hope some of you will respond affirmatively when our Past Chair Hans Frauenfelder or members of his Nominating Committee come asking your participation.

Editor's Note

These six and a half years as Editor of the *History of Physics Newsletter* have been a great experience for me. To be sure, it has been a lot of work, but the associations with physicists and historians of physics have been rewarding and stimulating. My wife, Nancy, an architect who was an undergraduate English major many years ago, has generally read the copy of each issue before I sent it for typesetting, lending her sharp eye to improve clarity and readability. I appreciate her contributions. With other commitments, it is time for me to move on, but I will continue to stay close to the Forum on History of Physics. As I pass the baton to Ben Bederson, let me echo Michael Riordan's comments about how fortunate we are that someone of Ben's experience, leadership, and personal qualities has agreed to accept this position. It is gratifying to be able to leave the *Newsletter* in such good hands.

In the last issue I asked, "What can history of physics do for physics?" I suggested that we should use history of physics more often as a guide in our research in physics, as a guide in the teaching of physics, and as a guide in explaining science to the public and to policy makers. In all our use of history of physics, for maximum impact we need to convey fully the realities of doing physics: including discovery with all its false starts and blind alleys, recycling old concepts into new, the ways that routine, hard work is interspersed with exhilarating moments of new insight, and the deep satisfactions that come from developing a thorough understanding of some complicated working of nature. History of physics helps bring the perspective to understand and articulate what is meant by the "unity of physics." With that perspective, we can do better at relating between subdisciplines and at articulating to the public, to students, and to policy makers why what we are doing in physics is important and exciting and worthy of their attention. We need to look at how history of physics teaches us to see physics as a discipline and consider what we are doing today that might figure in the history of physics written in 2053. History of physics can give us perspective that helps us set realistic priorities and value those activities and worldviews that will sustain both the unity and the freshness of physics.

A thoughtful response to these suggestions came from Leonardo Colletti (Livermore) and is reproduced in part in the Research Reports below. He makes the point that a critical view of science, such as can be acquired in the study of the best philosophy of science, is an essential perspective to add to our historical perspective. He says, "You need a scientific method in everyday life also, not only in a lab!" after having made the point that a critical philosophical understanding of that method is essential to enable one to apply it sensibly and fruitfully. I agree, and reiterate the suggestion I made previously that we look to the historical/philosophical work of scholars such as Allan Franklin, twice former Chair of FHP. Philosophy of science, when done with a careful hold on the realities of doing physics, can be enlightening and enabling.

Some Anniversaries for 2004

1054 - Observation on July 4 of a supernova in Crab Nebula that remains visible for 22 months.

1304 - Theodoric of Freibourg, Germany, accurately explains several aspects of the formation of rainbows.

1604 - Galileo observes that a falling body increases its travel distance as the square of time. Johannes Kepler at Prague and, independently, Korean and Chinese astronomers observe a supernova in the constellation Ophiuchus that lasts 12 months.

1654 - German physicist Otto von Guericke demonstrates atmospheric pressure through experiments in which the muscle power of humans or animals competes with air pressure. French mathematicians Blaise Pascal and Pierre de Fermat found probability theory.

1704 - Publication of Newton's *Opticks*, *De Quadratura Curvarum* (on the calculus), and *Enumeration of Curves of Third Degree*.

1754 - In the first application of quantitative analysis to chemical reactions, Scottish chemist Joseph Black discovers that carbon dioxide is a component of air. Birth of Joseph-Louis Proust.

1804 - Birth of Carl Gustav Jacob Jacobi, Emil Khristianovich Lenz, and Wilhelm Eduard Weber. Death of Joseph Priestley.

1854 - Hermann von Helmholtz predicts the "heat death" of the universe. He also posits that gravitational contraction is the source of the sun's energy, leading Lord Kelvin to calculate a famously young age for the sun and the earth in 1862 (before the discovery of radioactivity). Georg Riemann develops his non-Euclidean geometry. Birth of Johann Elster, August Föppl, Richard Glazebrook, Louis-Georges Gouy, Jules-Henri Poincaré, Johannes Rydberg, and Karl Hermann Struve. Death of Macedonio Melloni and Georg Simon Ohm.

1904 - Charles D. Perrine discovers the sixth satellite of Jupiter, beginning a century-long series of discoveries of new Jovian moons. Johannes Franz Hartmann discovers spectral absorption lines that indicate the existence of interstellar clouds of gas and dust. German chemist Richard

Abegg suggests that chemical reactions occur when electrons transfer from one atom to another. Jacob Bjerknes publishes *Weather Forecasting as a Problem in Mechanics and Physics*. Hertha Marks Ayrton becomes the first woman ever to address the Royal Society, reading a paper on the origin and growth of ripple marks in sand. She also becomes known for her research on electric arcs. J.J. Thomson proposes the plum pudding model of the atom. Experimenting with the scattering of X-rays, Charles Glover Barkla discovers that the number of charged particles in an atom varies according to its mass. He also shows that X-rays are transverse waves like light, confirming their electromagnetic nature. William Henry Bragg shows that alpha particles are emitted with a discrete energy spectrum. John Ambrose Fleming invents the first electron radio tube, the diode thermionic valve. Birth of Pavel Cherenkov, George Gamow, Gerhard Herzberg, Louis Néel, and J. Robert Oppenheimer. Death of Emilio Villari.

1954 - George Gamow proposes the existence of a multinucleotide genetic code. Physicists at the University of California build the bevatron. CERN is founded. C. N. Yang and Robert Mills develop Yang-Mills gauge-invariant field theory. Abraham Pais coins the term "baryon." Silicon transistors are introduced to the commercial market by Texas Instruments. Death of Karl Taylor Compton, Enrico Fermi, Yakov Ilyich Frenkel, Kotaro Honda, Theodor Kaluza, John Edward Lennard-Jones, Fritz London, Theodore Lyman, and Alan Turing.

Call for readers to report their activities in history of physics

Readers who are engaged in research and writing in history of physics, biographies of physicists, histories of physics departments or colleges of science, memoirs, or other physics history work, please alert the editor to your interests and any requests for information from other readers. See the address and email in the box on p. 2.

Physics in Perspective

A year ago I issued a call to help keep the journal *Physics in Perspective* alive. This wonderful quarterly journal deserves many more subscribers. I remind readers to subscribe at the inexpensive rate for APS members ($35 plus $10 shipping) and to have your institutional libraries subscribe. Go to the publisher's web site: Birkhäuser Verlag, 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). Two readers have offered to sponsor an annual subscription to *Physics in Perspective* for an individual who could benefit from it. Does anyone else want to join this effort? Suggestions to identify individuals, especially outside the developed nations?

Question for readers about Newsletter format

About seven years ago FHP members were surveyed about their reaction to moving the *Newsletter* to electronic format. There was considerable sentiment against such a move at that time. Because of the cost of the paper *Newsletter*, the question arises again as to the acceptability of providing an online *Newsletter* once a year, with provision for paper copies on request, and a fully paper issue for the second issue each year. Please respond to the incoming editor, Ben Bederson (ben.bederson@nyu.edu; Department of Physics, New York University, 4 Washington Place, New York, NY 10003) considering the following three options:

a) definitely opposed to exclusively online *Newsletter* once a year.

b) online OK once a year, but with paper version mailed on request.

c) online OK once a year without paper version.

Either choice b) or c) would allow for considerable saving in mailing costs assuming most members do not ask for paper. It is not proposed that both semiannual issues be online. Online issues could be provided in multiple formats.

Reports

Research Reports

E.G.D. Cohen (Rockefeller University) sent his article on Boltzmann, entitled "Boltzmann and Statistical Mechanics", published in the Proceedings of the International Meeting "Boltzmann's legacy 150 years after his birth", Rome, Italy, 25-28 May 1994, *Atti della Academia della Lincei* **131**:9-23 (1997). It was later also published in the proceedings of another meeting, *Dynamics: Models and Kinetic methods for Non-Equilibrium Many Body Systems*, J. Karkheck (ed.), pp. 223-238, Kluwer Academic Publ., The Netherlands (2000). The paper gives a personal account, half historical and half scientific, of Boltzmann's work in statistical mechanics. Boltzmann's predilection for mechanics , as opposed to statistics, is discussed and the more recent developments in statistical mechanics, based on dynamical systems theory, appear to confirm his view. Cohen therefore puts Boltzmann's historical contributions in the context of the modern theoretical and experimental study of statistical mechanics. He briefly contrasts the approaches of Boltzmann and Gibbs and traces Boltz-mann's legacy in modern practice. This paper will be valuable to anyone interested in statistical mechanics, whether from an historical, a practical, a theoretical, or a philosophical point of view.

Charles Falco (U of Arizona) has worked with David Hockney applying optical principles to understand the historical use of optical instruments by artists. An invited paper at the 8th International Conference on "Education and Training in Optics and Photonics" (ETOP 2003), October 6–8, 2003, presented their evidence, as they explain in the abstract: "Recently, one of us (DH) observed that certain drawings and paintings from as early as the Renaissance seemed almost 'photographic' in detail. An extensive visual investigation of western art of the past 1000 years resulted in the revolutionary claim that artists even of the prominence of van Eyck and Bellini must have used optical aids. However, art historians insisted there was no supporting evidence for such a remarkable assertion. This paper presents some of the optical evidence we subsequently discovered that convincingly demonstrates optical instruments were in use – by artists, not scientists – nearly 200 years earlier than widely thought possible, and that accounts for the remarkable transformation in the reality of portraits that occurred early in the 15th century."

On August 3, 2003, the segment "Was it Done With Mirrors?" was replayed on CBS "60 Minutes." Especially considering the limitations of a 15-minute TV segment, the program did an excellent job telling a complex story that impacts our understanding of 600 years of Western art. You can read about these discoveries in David Hockney's book, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters* (Viking, 2001), as well as about some more recent details at www.optics.arizona.edu/ssd/FAQ.html.

A conference in Paris May 31- June 1, 2003 also dealt with these questions: "Measuring Art: A Scientific Revolution in Art History," cosponsored by the University of Chicago and the American University of Paris. And a European Science Foundation Exploratory Workshop in Ghent, Belgium, 12-15 November 2003 was entitled "Optics, Optical Instruments and Painting: The Hockney-Falco Thesis Revisited," indicating the seriousness with which this work is now being taken.

Eri Yagi (Toyo U, Emerita) retired in April 2002. At that time her collected papers, *A Historical Approach to Entropy*, were published in a commemorative volume. This volume includes eight papers and a supplement. The papers were previously published in international journals and proceedings. They reflect her work of 20 years on Rudolf Clausius and his work on entropy. She is now Director of the Institute for History of Science.

Howard Huff (International Sematech) has shared some of his recent work on the history of the semiconductor industry: "The 'Ultimate' CMOS Device: A 2003 Perspective (Implications For Front-End Characterization And Metrology)" by Howard R. Huff and Peter M. Zeitzoff, presented at the 2003 International Conference on Characterization and Metrology for ULSI Technology (March 24-28, 2003) and to be published in the Conference Proceedings. "From the Lab to the Fab: Transistors to Integrated Circuits" by Howard R. Huff, presented at the 2003 International Conference on Characterization and Metrology for ULSI Technology (March 24-28, 2003) and to be published in the Conference Proceedings. "Silicon-on-Insulator (SOI) Wafers: A Brief Taxonomy of Fabrication Techniques, Trends and IC Application Opportunities" by Howard. R. Huff and Peter M. Zeitzoff, submitted to *Solid Sate Technology*.

Louis Brown (Carnegie Institution of Washington, Emeritus) reports that he has completed a manuscript history of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, as part of the celebration of the Institution's centennial. Its length is 84,000 words with 101 figures. The Department, generally referred to as DTM, has engaged in research on geomagnetism, atmospheric electricity, the ionosphere, experimental nuclear physics, cosmic rays, wartime development of the proximity fuze, palaeomagnetism, radio astronomy, optical astronomy, biophysics, geochronology, geochemistry, and seismology. A separate volume is intended for each of the Institution's five departments, to be published as a set by Cambridge University Press on completion of all five.

Doug Mounce (U of Washington) suggests that the history of fiber optic technology would be interesting to develop. Laws like Snell's law are foundational because they weren't proven or derived when proposed, but testing this one generated a classic disagreement between Fermat and Descartes on the speed of light. It ends with Feynman's development of path integrals, following a line from Fermat to Huygens and Maupertuis in the development of optimization principles. Everyone's insight, except perhaps Feynman's, was overshadowed at the time by a larger personality like Descartes, Newton, or Voltaire. David Gao wrote an article that outlined this relationship. It's a nice historical approach to understanding path integrals.

Leonardo Colletti (Livermore) sent comments on my Editor's Note in the last issue. He says, "You are right when you point out how useful history of physics could be for teaching physics. I would add that it could be even more useful if accompanied along with a philosophical critique of the particular knowledge we call "science." More, I would dare to say that a critical consciousness about the difference between the scientific method and other human ways of knowledge should be the very core of all that a non-science major student should know about science.

"As an Italian high school student, I had the opportunity to appreciate science, and physics in particular, more by means of the philosophy lessons, where we read papers by Popper, Kuhn, Lakatos and others, than via the succession of often unexplained formulae. It was by reading Popper that I understood the greatness of physics and the humility of physicists.

"After coming to the United States as a post-doc last year (a wonderful experience of life, not only of research) I was impressed by two observations related to the theme above. First, more technically, I don't see among physicists much attention to philosophy. When they look outside their specific field of research seeking connections, on one side they refer to history of physics, while on the other side the only connection that they seem to see between physics and society (see the APS *Physics and Society Newsletter*) are weapons-related issues. I think there is something missing in between, and it should be a discussion about the role and status of the scientific method in society (very briefly: 'how to learn from errors and how to improve successive attempts'). You need a scientific method in everyday life also, not only in a lab!"

Colletti also raises the question of religion in America and the disconnect between scientific inquiry and the faith professed by some scientists. He says, "Facts [at the base of a religion] should be subjected by definition to scientific inquiry. So, how is it possible that people used to the scientific method look at these [particular] facts in an odd, anti-scientific way? I'm not speaking about the theological side and interpretations, but just about facts. On the other side, for example (I'm just quoting what I know), the Catholic Church refers to a highly qualified scientific committee (physicists, physicians, historians etc.) every time an investigation about miracles and sources is needed. A true faith shouldn't be afraid of facts and counterfacts. This is in my opinion where the misunderstanding between science and religion starts, and this is something that should find place in the reflections about the connections between physics and society. I think the two disciplines could be most useful to one another and together fruitful for humanity if correctly used. I would really appreciate your (and other scientists') thoughts about this issue. I look at this (and other similar) e-mail as a sampling of the interests about such a discussion in the physics world."

Workshop on Oral Histories: "For the Record: A Workshop on Conducting Oral Histories of Science" was held in conjunction with the 2003 annual meeting of the History of Science Society on November 20, 2003. The workshop included discussions and activities dealing with strategies for planning an oral history project, equipment needs and use, legal and ethical issues, and interviewing skills. Organizers and Sponsors: Amy Crumpton (AAAS), Patrick McCray (AIP and UC-Santa Barbara), and Elizabeth Paris (Argonne National Laboratory and University of Chicago). The workshop was supported by the National Science Foundation, the History of Science Society, the American Institute of Physics, and the Dibner Institute for the History of Science and Technology.

Symposium on Islam, Science and Cultural Values was held at the Library of Congress on October 9, 2003. Co-sponsored by the Library of Congress, African and Middle East Division; Georgetown University, Center for Muslim-Christian Understanding; American Association for the Advancement of Science, Dialogue on Science, Ethics and Religion; and National Academy of Sciences, Office of International Affairs. The program included a keynote address by Seyyed Hossein Nasr, University Professor of Islamic Studies, George Washington University, on "Islamic Critique of Modern Sciences – Problems and Challenges." A session on "Science in Islamic Countries – Historical and Cultural Perspectives" was moderated by Audrey Chapman (Director, Science and Human Rights Program, and Senior Associate for Ethics, Dialogue on Science, Ethics and Religion, AAAS),with speakers George Saliba (Professor of Arabic and Islamic Science, Columbia U) on "The Birth of Scientific Thought in Early Islamic Civilization" and Osman Bakar (Visiting Professor and Malaysia Chair of Islam in SE Asia, Center for Muslim-Christian Understanding, Georgetown U) on "Scientific Growth in a Religious Culture: Lessons from Islamic Science," and respondent Mustanir Mir (Director, Center or Islamic Studies, Youngstown State U). A second session addressed the topic "Science and Religion – Are They Culturally Compatible in Islamic Countries?" It was moderated by Prosser Gifford (Director, Kluge Center and Office of Scholarly Programs, The Library of Congress), with speakers Ahmad Dallal (Chair and Professor, Department of Arabic Language, Literature and Linguistics, Georgetown U) on "Tolerance or Compatibility? The Search for a Qur'anic Paradigm of Science" and Ebrahim Moosa (Research Professor of Religion, Duke U) on "Mediating Modern Science through Islamic Law and Theology," and respondent Ibrahim Kalin (Assistant Professor, Religious Studies Department, College of the Holy Cross). The symposium also included a panel discussion on "The Future of Science in Islamic Countries – Social, Cultural and Religious Factors."

J. Willard Gibbs and His Legacy: A Double Centennial. APS March Meeting, Austin, 3 March 2003.

Report by **Stephen G. Brush** and **Michael E. Fisher** (U of Maryland)

From February 28 through March 6, 2003, the APS Forum on the History of Physics collaborated with Yale University and the University of Maryland to commemorate the publication of Gibbs's book *Elementary Principles in Statistical Mechanics* (1902) and celebrate his life: 1839-1903.

J. Willard Gibbs, Professor of Mathematical Physics at Yale University, was one of the most important American scientists of the 19th century, although his achievements were recognized in Europe before they became known in his own country. His formulation of the laws and concepts of thermodynamics is a fundamental part of theoretical physics and physical chemistry; it has found widespread applications in research on the properties of matter and in engineering. In his famous book, building on the work of Maxwell and Boltzmann, Gibbs established a new branch of theoretical physics. Indeed, he invented the name "statistical mechanics" and the terms "canonical" and "microcanonical," and introduced the "grand ensemble." Statistical mechanics proved to be the best way to treat systems of a large number of atoms and molecules, as well as photons and other particles, especially when quantum effects play a crucial role. The technique of vector analysis, which Gibbs published in 1901, is widely used in scientific calculations.

At the American Physical Society meeting in Austin, on March 3, the Forum sponsored a symposium organized by **Michael Fisher** and **Stephen Brush** (U of Maryland), featuring four speakers. **Martin J. Klein** (Yale) talked about *"Gibbs and Statistical Mechanics a Century Ago."* The paper described what we know about the development of Gibbs's ideas on statistical mechanics, ideas that were published only in their fully developed form in his book of 1902. His work was given its historical setting in his own career and also in the context of the physics of the time. Indeed it turns out that Gibbs's book was, in fact, overdue! Despite his marked resistance to putting down his deep insights in book form, as requested by Lord Kelvin and others, Gibbs was evidently persuaded to prepare his book in honor of the bicentenary of Yale's foundation in 1701. He completed the book in December 1901, but publication came only in 1902. It was his last work before his death on 28 April 1903.

Ole Knudsen (U of Aarhus, Denmark) spoke on *"Gibbs in Europe."* In 1866, at the age of 27, J. Willard Gibbs set out from his native New Haven on a three-year study tour that was to take him to Paris, Berlin, and Heidelberg. His previous education at Yale had given him an adequate grounding in geometry and mechanics and a Ph.D. in engineering (the first in the United States); he came back with enough knowledge of higher mathematics and advanced physics to begin a brilliant career as a mathematical physicist. Based on the extant source material, mainly three notebooks with entries on the courses he attended and the books and papers he read during his trip, Knudsen gave an impression of the content and style of the physics he was exposed to in Europe, and showed how his later work was influenced by his European experience.

Johanna Levelt Sengers (NIST) discussed *"Key Concepts from Gibbs that Empowered van der Waals, Korteweg and*

Kamerlingh Onnes." In 1873, Gibbs laid the foundation for a geometric approach to thermodynamics, studying the energy surface as function of entropy and volume. If the surface is touched by a plane in more than one point, these tangent points represent coexisting phases. Merging of two tangent points results in a critical point. In his papers of 1876 and 1878, Gibbs introduced the chemical potential, formulated the equilibrium conditions for coexisting phases in mixtures, and derived his famous phase rule. In 1873, van der Waals produced the first equation of state able to describe vapor and liquid, as well as criticality. Around 1890, van der Waals, thoroughly acquainted with Gibbs's work, had generalized his equation of state to binary mixtures, using the analogy of the isothermal Helmholtz energy surface of the mixture with Gibbs's energy surface. He found both vapor-liquid and liquid-liquid phase separation. Simultaneously, the mathematician Korteweg developed the theory of folds and critical points on surfaces, as well as their evolution as a function of a parameter, with application to the van der Waals mixture equation. Around 1890 as well, Leiden experimentalists Kamerlingh Onnes and his student Kuenen started to produce the first reliable data on binary mixtures near critical points: retrograde condensation, critical azeotropy, critical endpoints and three-phase equilibrium, all subsequently derived from the van der Waals equation. Based on the experimental data, Kamerlingh Onnes constructed several plaster models of the isothermal Helmholtz surfaces of mixtures. Chemical potentials and coexisting phases can be read from these models, conserved at the Leiden Boerhaave Museum. (References: J. L. Sengers, *How Fluids Unmix*, 2002; J. L. Sengers & A. Levelt, "Diederik Kortweg, Pioneer of Criticality," *Physics Today*, December 2002)

Leo P. Kadanoff (U of Chicago) presented *"Reflections on Gibbs: From Critical Phenomena to the Amistad."* J. Willard Gibbs, the younger, was the first American theorist. He was one of the inventors of statistical physics. His introduction and development of the concepts of phase space, phase transitions, and thermodynamic surfaces was remarkably correct and elegant. These three concepts form the basis of different but related areas of physics. The connections among these areas have been a subject of deep reflection from Gibbs's time to our own. The connections can be analyzed using concepts suggested by the work of Michael Berry and explicitly put forward by the philosopher Robert Batterman. This viewpoint relates theory-connection to the applied mathematics concepts of asymptotic analysis and singular perturbations. Finally, Kadanoff remarked that J. Willard Gibbs, the younger, had all his great achievements concentrated in science; but his father, also J. Willard Gibbs, also a professor at Yale, had one great achievement that remains unmatched to our day. This "social triumph" was described by Kadanoff in his talk.

A symposium on Gibbs was also held on February 28 at Yale University, organized by **Daniel Kevles**. Speakers and topics were: **Ole Knudsen** (U of Aarhus, Denmark), *"Gibbs in Europe"*; **Martin J. Klein** (Yale), *"Gibbs and Statistical Mechanics a Century Ago"*; **Daniel J. Kevles** (Yale), *"Engineering and Physics in Gibbs' America."*

A third symposium took place on March 5 and 6 at the University of Maryland, co-sponsored by the National Institute of Standards and Technology, and organized by **Stephen Brush** and **Michael Fisher** (U of Maryland). Speakers and topics were: **Ole Knudsen** (U of Aarhus, Denmark), *"Gibbs in Europe"* [abstract above]; **Robert W. Batterman** (Ohio State U), *"Gibbs and Asymptotic Relations between Theories"* (Batterman's work was alluded to by Kadanoff, as mentioned above); **Johanna Levelt Sengers** (NIST), *"Key Concepts from Gibbs that Empowered van der Waals, Korteweg, and Kamerlingh Onnes"* [abstract above]; **C. David Levermore** (U of Maryland), *"The Legacy of Gibbs' Geometric View of Entropy."*

Support for the Gibbs symposia was provided by the American Physical Society, the National Institute of Standards and Technology, the University of Maryland (through the Institute for Physical Science & Technology, the Chemical Physics Program, and the Committee on Philosophy and the Sciences), and by Yale University.

The Early Days of Solid State Physics. APS March Meeting, Austin, 4 March 2003.

Report by **Howard R. Huff** (International SEMATECH)

The session on *The Early Days of Solid Physics* on Tuesday, March 4, 2003 was one of the most densely packed sessions this reviewer has ever attended. Surely 600 plus persons were in attendance, crowding the aisles, floors and even the space adjacent to the speakers. No wonder, with the line-up of speakers: **Hans Bethe, Lillian Hoddeson, Frederick Seitz and Philip Anderson**. A brief summary of their talks follows. A number of photographs of persons referred to by the speakers may be found in several of the books noted in the summaries below.

Hans Bethe – *"Reflections on Arnold Sommerfeld and the Beginnings of Modern Solid-State Theory."* N. David Mermin kindly arranged a videotaped interview with Bethe (1967 Nobel Prize winner in Physics) in Ithaca, New York. This interaction, in and of itself, was a most stimulating endeavor. That is, Bethe, one of the key figures in the initiation of the quantum-mechanical based solid-state physics discipline in the late 1920s in Munich, and Mermin, co-author of the seminal textbook *Solid State Physics* (with Neil W. Ashcroft) published in 1976. (The videotape is available as indicated in the Notes and Announcements section of this *Newsletter*.)

The style of Sommerfeld in establishing a broad frontal assault on virtually the complete field of theoretical physics in his *Lectures on Theoretical Physics* afforded Bethe a wide-ranging view of theoretical physics. Indeed, Sommerfeld played the key role in extending Bohr's 1913 theory of the hydrogenic atom into the early 1920s via the Bohr-Sommerfeld quantization rule, often classified under the old quantum theory (in contradistinction to the work of Heisenberg, Jordan, Born, Pascal and Dirac et al. on the newer quantum mechanics and the wave mechanics of Schrödinger, building on De Broglie). Before the theory of electronic conduction in solids was promulgated in the late 1920s by Bloch, one of Heisenberg's first two Ph.D students along with Rudolf Peierls, the concept was anticipated and appeared most natural to Bethe and his colleagues, notably Rudolf Peierls. Indeed, Bethe and Sommerfeld had resuscitated the Drude free-electron theory of metals, adapting it to fit experimental results by utilizing some ideas of the new quantum theory. A number of additional technical gems are distributed throughout the dialogue between Bethe and Mermin.

It was most exciting to hear Bethe note, in response to Mermin's question, "How long did it take you to write your famous

1933 article *Elektronentheorie der Metalle* in the *Handbuch der Physik*?" Bethe responded about one year. He wrote a sheet of manuscript paper, turned it over into a pile and simply continued writing the next sheet – while still getting eight hours of sleep every night! Mermin noted that it took him and Ashcroft about eight years to complete their textbook.

Interestingly, regarding the *Handbuch der Physik* article co-authored with Sommerfeld, Bethe noted that Sommerfeld was the lead author (even through Sommerfeld only wrote the first chapter) because Sommerfeld was extremely well known, and they wanted to indicate the seriousness of the manuscript. Mermin noted, and Bethe agreed, that today, generally the student's name is listed first to advertise the student's capability. Nevertheless, the famous book *Quantum Mechanics of One- and Two-Electron Atoms* (which this reviewer remembers studying very hard in graduate school in 1962) was authored by Bethe and Salpeter!

Lillian Hoddeson – "*The Quantum Theory of Solids Enters American Graduate Programs in the 1930s: John Bardeen at Princeton and Harvard.*" Eugene Wigner at Princeton (who had applied group theory to quantum mechanics in Berlin, sharing the 1963 Nobel Prize with Maria Goeppert-Mayer and J. Hans D. Jensen) and John Slater at MIT established the first graduate quantum theory of solids programs in America in the early to mid-thirties. This was a most significant period in America, during which Wigner's first three graduate students (Frederick Seitz, John Bardeen and Conyers Herring) "were in the first generation of physicists who called themselves 'solid-state' theorists." Indeed, Seitz's textbook *The Modern Theory of Solids*, published in 1940, became the paradigm against which all subsequent solid-state textbooks were judged.

It should also be noted that Bardeen had studied quantum mechanics in the late 1920s at the U of Wisconsin as an undergraduate with John H. van Vleck (1977 Nobel Prize winner with Philip W. Anderson and Nevill F. Mott) as had Walter Brattain with van Vleck earlier in the 1920s at the U of Minnesota. Wigner's and Slater's graduate programs were subsequently followed in the 1930s by the establishment of quantum theory courses in America by Linus Pauling at Cal Tech (1954 Nobel Prize winner in chemistry and 1962 Nobel Peace Prize) and E. Bright Wilson, Jr. at Harvard.

Of particular interest was Hoddeson's observation that Bardeen's post-doc time at Harvard was focused on a host of issues, generically related to what eventually became the beginnings of many-body phenomena. Bardeen was exploring a spectrum of issues of interest to him! It seems that times have indeed changed, with the emphasis in today's world on ensuring the successful completion and publications related to the research contracts at hand. Additionally, the friendships and easy relationships established during those years amongst Seitz, Bardeen and Herring with their colleagues at Harvard (Percy Bridgman and John H. van Vleck) as well as with John Slater and Bill Shockley at MIT, generally withstood the test of time in most cases.

Let me summarize these brief comments noting that the 2002 book *True Genius: The Life and Science of John Bardeen* by Hoddeson (co-authored with Vicki Daitch) and published by the Joseph Henry Press, Washington, DC, expands the above theme in the most exciting manner. Indeed, the book follows Bardeen's career from Princeton and Harvard through his World War II service work, into the Bell Labs point contact semiconductor amplifier research (i.e., the point-contact transistor) earning Shockley, Bardeen and Brattain the 1956 Nobel prize in physics, and culminating in the resolution of the fifty-year superconductivity enigma by Bardeen (then at the U of Illinois) with Leon N. Cooper and J. Robert Schrieffer, with their 1972 Nobel Prize in Physics (Bardeen's second in physics).

Frederick Seitz – "*How We Came to Know What We Knew About Semiconductors During World War II.*" Frederick Seitz, in a tour de force, reviewed the history of silicon from its discovery by Berzelius in the 1820s, the days of H. Cavendish and A. L. Lavoisier in the late 18th century through the 19th and, finally, the 20th century. It was noted that Faraday in the 1840s observed that some materials were neither good metals nor good insulators. Reginald Fessenden in 1890 noted that silicon added to iron enhanced the magnetic properties of iron while silicon's addition to steel increased steel's toughness. After a brief review of the contributions of Hertz and Bose, Seitz noted that by 1905 metallurgical silicon was deduced to offer the best rectification properties based on an experimental investigation of over 1,000 material combinations. The onset of Lee de Forest's diode and, subsequently, triode vacuum tube, however, delayed further significant utilization of silicon until World War II. At that juncture, it was observed that silicon (and germanium to some extent) extended the frequency range of detectors appropriate for war-time needs. The contributions of Schottky, Mott, Davidov and Bethe were instrumental in clarifying the nature of the rectification phenomenon. Finally, the role of Mervin Kelly, Bell Telephone Laboratory's research director who established an interdisciplinary team in 1945 with the goal of replacing the vacuum-tube amplifier and the electro-mechanical relay-type devices, utilized in the Bell System, by a solid-state amplifier and switch, respectively, brought us into the modern age of silicon technology.

Due notice was taken of the contributions of Herbert Matare who discovered a form of transistor action in polycrystalline germanium in France after World War II as well as the role of H. Welker in identifying the promising benefits of III-V semiconducting compounds. As regards the former case, the Bell Labs contemporary research program simply overwhelmed the French work, while the latter, although of great importance from a scientific standpoint, never successfully replaced the elemental semiconductors germanium and then silicon, at least in the dominant commercial markets.

Indeed, it was silicon technology that became the workhorse of the discrete transistor and, subsequently, the integrated circuit (IC) era. Seitz's historical overview (with N.G. Einspruch) in their 1998 book, *Electronic Genie: The Tangled History of Silicon* (U of Illinois Press) is essential reading for those interested in the contributions that led to the observation, clarification and utilization of the historical silicon and its evolution as the pre-eminent semiconductor in the modern IC electronics era.

Philip W. Anderson – "*The Magnetic State: Mott Insulators, Magnetic Impurities and the Like.*" Philip Anderson (1977 Nobel Prize winner with John H. van Vleck and Nevill F. Mott) noted that, aside from Pauli's explanation of paramagnetism, the heroic quantum mechanics era of the 1920s did not clarify the nature of magnetism (although Hund's rules were a useful classifying scheme – note entered by the reviewer). Although Fe, Co and Ni were treated somewhat successfully by the band theory, and Kramers did introduce the concept of long-range ordering in 1934 (referred to as super-exchange), a host of issues were carried over into the 1950s.

Of course, there were useful developments between the 1930s and the 1950s, including the Mott insulator phenomenon clarified by Mott in 1949 and 1956, building on Rudolf Peierls's suggestions in 1937. This was discussed in terms of the atomic wave function overlap and the broadening of the bands. Anderson then reviewed his theory of antiferromagnetic superexchange and of magnetic impurities as well as the Hubbard model for magnetic metals. The antiferromagnetic exchange was noted as an example of frustrated band-forming tendencies. And yet, according to Anderson, these significant advances have not been sufficiently promulgated in the more modern solid-state textbooks, in spite of three Nobel Prizes being awarded to physicists working in these fields. Anderson discussed several reasons for this situation, which apparently remained controversial even into the 1980s.

Using History in Physics Education. APS April Meeting, Philadelphia, 5 April 2003.

Report by **Daniel Siegel** (U of Wisconsin-Madison)

This most interesting session made a strong case for the use of historical materials in teaching physics and provided a wealth of useful suggestions for carrying out this program. The speakers were **Stephen Brush, David Cassidy, Robert March, Michael Nauenberg, and Daniel Siegel**; Siegel was chair, and his talk was in part commentary and response to the others. The session was well attended, with a lively audience of about 50.

The participants brought to this session a wealth of experience with using history in physics education. Three are authors of textbooks representing landmark contributions to the use of historical material in physics education: Gerald Holton and Stephen G. Brush, *Physics, the Human Adventure: From Copernicus to Einstein and Beyond* (New Brunswick, NJ: Rutgers University Press, 2001); David Cassidy, Gerald Holton, and James Rutherford, *Understanding Physics* (New York: Springer, 2002); and Robert March, *Physics for Poets*, 5th ed (Boston: McGraw-Hill, 2003). Michael Nauenberg has used historical material in his teaching at the University of California-Santa Cruz; Daniel Siegel has used such material in the Integrated Liberal Studies Program at the University of Wisconsin-Madison, as described in "Historical and Philosophical Elements in the Integrated Liberal Studies Natural Sciences Sequence," in *Proceedings of the Third International History, Philosophy, and Science Teaching Conference, Minneapolis, Minnesota*, ed. Fred Finley, Douglas Allchin, and Steve Fifield (Minneapolis: U of Minnesota, 1995), **2**:1050-1061.

David Cassidy, in his talk, "*Understanding Physics: A Textbook Integrating History into Physics Education,*" provided important background on the development of the historical approach in physics teaching. *Understanding Physics* is an outgrowth of the pioneering Project Physics enterprise at Harvard in the 1970s and 1980s; as Cassidy observed, "Utilizing the historical approach in science education has since taken on national proportions. It has been emphasized during the past decade in nearly every effort at the national level to reform science education. The historical approach appears, for instance, in the influential recommendations offered in the National Research Council's National Science Education Standards and in the recent Benchmarks for Science Literacy published by Project 2061 of the AAAS." (The recent ascendancy of the historical approach in science teaching is reflected also in the establishment, in 1987, and subsequent rapid growth, of the International History, Philosophy, and Science Teaching Group. The Group holds biennial conferences, attended by 200-250 science teachers at all levels, science teacher educators, historians, philosophers, and cognitive scientists; the Group publishes a journal, *Science & Education*. As concerns physics *per se*, the American Association of Physics Teachers has seen a flourishing of the activities of its Committee on the History and Philosophy of Physics, which is forging links with our own Forum on History of Physics of the APS, to pursue the common interest of promoting the use of historical materials in teaching physics.)

And what is the utility of the historical approach – how does it help in teaching physics? All of the speakers agreed in stressing that historical material was helpful in getting at the process of science: historical episodes provide the most authentic narratives of how science is really done. **Michael Nauenberg**, in his talk, *"By Hooke or by Crookedness and Other Tales about Scientific Discoveries,"* presented a sustained narrative illustrating concretely the process of science. He concentrated on the interaction of Isaac Newton and Robert Hooke, in their correspondence of 1679, first in developing a description of motion, involving the "crookedness" or curvature of orbits, and then in proceeding to dynamical considerations, leading to the development of the concept of universal gravitation, and forming the background for Newton's *Principia*.

As concerns the characterization of the process of science in more general terms, there was widespread agreement among the speakers that there is no single, unique generalization possible concerning how science is done – there is no single "Scientific Method" characterizing all of science. Nevertheless, there was one approach to scientific method – namely, the hypothetico-deductive, or H-D method – that was discussed at some length in two of the talks: **Stephen Brush**, *"Is Physics 'Scientific'?"* and **Daniel Siegel**, *"Wrong Physics and Right Teaching."* Siegel pointed out that philosophers of science such as Charles Sanders Peirce in the 19th century and Ernan McMullin in the 20th century have distinguished three ways of doing science:

1. The inductive methodology, championed by Francis Bacon in the 17th century, which proceeds by observation and generalization.
2. The deductive methodology, advocated by Rene Descartes in the 17th century, which proceeds logically and deductively from self-evident basic truths, as in geometry.
3. The hypothetico-deductive, or H-D methodology, which was something of a methodological orphan in the 17th and 18th centuries (hypotheses were in bad odor), and was fully articulated only in the 19th century (as emphasized by both Brush and Siegel), most notably by the British scientist and philosopher John Herschel.

In the H-D approach, a hypothesis or

conjecture is formulated – often concerning entities that cannot be observed directly, as in the 19th-century kinetic-molecular hypothesis; the consequences concerning observable phenomena to be expected if the hypothesis is true are derived – such as the perfect gas law in the case of the kinetic-molecular hypothesis; those consequences are then compared with experiment, and agreement is taken as evidence (albeit indirect) in favor of the hypothesis. Brush, in his talk, took up the question of prediction in connection with the H-D methodology: Some would suggest – notably, the philosopher Karl Popper – that if the hypothesis predicts novel results, which have not previously been observed or measured, then verification of these predictions will constitute especially strong corroboration of the hypothesis, as compared with a situation where the hypothesis serves merely to explain known results. Brush, however, took issue with this perspective, considering as an example the case of General Relativity early in the 20th century: Two consequences of the theory – the "hypothesis" – were found to be in agreement with experiment, namely: the precession of the perihelion of Mercury, which was a previously known and measured phenomenon; and the bending of light as observed in the 1919 eclipse, which was a novel prediction. Here, Popper would contend that the bending of light was the stronger evidence in favor of General Relativity, because it was a prediction; whereas the historical record shows, according to Brush, that the community of physicists considered the calculation of the precession of the perihelion of Mercury as just as convincing, even though it did not constitute a novel prediction. Brush concluded that novel prediction is not, in actual scientific practice, so highly prized as Popper and others seem to think, and supported this with further examples.

Siegel, in his talk, continued the discussion of the H-D methodology, including John Herschel's characterization of it as a bridge to the unknown, useful for getting at four kinds of entities that are not directly observable (at the given time): the very small, such as atoms and molecules, in the 19th century; the very large and distant, such as planetary orbits, in the 16th and 17th centuries; occurrences in the distant past, such as geological and biological macroevolution; and ideal or inaccessible regimes, such as frictionless motion, in the 17th century, or motion at velocities comparable with that of light, in the early 20th century. Subsequently, direct observations supporting the earlier H-D reasoning became possible in three of the four examples: the Millikan oildrop experiment, the Wilson cloud chamber, etc. for atoms and molecules; stellar parallax for planetary orbits; and vacuum and particle experiments for frictionless and high-velocity regimes. These successful subsequent verifications by direct observation, it may be argued, serve to legitimate the H-D methodology.

In the absence of a time machine, however, the distant past – and perforce biological and geological macroevolution – seem to remain inaccessible to direct observation. Our discussion of the process of science, then, led ultimately to a consideration of the limits of science. Relatedly, **Robert March**, in his talk, *"Bringing Physics to Life through History and Biography,"* emphasized that science does not provide certainty, that there is no central control mechanism in science for establishing dogma, and that it is doubt, rather than certainty, that is the key to progress in science (here making contact with the discussion of Popper by Brush). (Lively discussion at the end of the session was directed to the question of whether Siegel's suggestion that the H-D methodology was validated by subsequent direct observation would be convincing to students who were inclined to go perhaps too far under the banner of doubt.)

March went on to distinguish three reasons for using history and biography in teaching science:

1. Historical narrative illuminates the process of science, as discussed above.
2. Historical material – especially biographical considerations – can help to motivate the study of science.
3. History can illuminate the science itself.

In the Scientific Revolution, for example, one encounters some "fascinating people" – such as Galileo, Kepler, Brahe, and Newton; beyond this, the Scientific Revolution also illustrates some central features of science itself, such as the interaction of observation and theory – including, on the observational side, issues of experimental strategies, instrumentation, and the role of precision; and, on the theoretical side, the role of mathematics. Foci of 20th-century biographical interest that were highlighted in March's talk included Michelson, and how his career was tied to the rise of the American research university; Einstein, and how his career trajectory reflected the European culture of the era; Bohr, and the importance for him of intuition, and science as play; and the Pauli-Heisenberg duo, with their contrasting personalities, illustrating the variety of personal styles in science.

Both March and Cassidy drew attention to the utility of the historical mode of presentation in treating the interaction of science and technology and its social impact. March discussed the interaction of energy science with the technology of the steam engine – a complicated interaction, in which technology stimulated energy science, and the resulting science of thermodynamics in turn influenced the further development of engine technology – yielding the internal combustion engine, for better and/or for worse. Cassidy alluded to the variety of socially relevant science/technology issues treated in *Understanding Physics*, such as global warming and ozone depletion, energy use and resources, and the technologies based on condensed-matter physics. (All too often, when these kinds of issues are treated in science courses, the instructor winds up preaching to the student audience about his or her favorite science and technology policy issues; but anyone who has interacted with teenagers and young adults knows how useless it is to preach to this audience. The better alternative is a truly historical presentation of these kinds of questions, which enables students to understand the issues, see the range of opinions that have been voiced, and ultimately arrive at their own considered and informed conclusions.)

A final theme, treated by Cassidy and Siegel, is broached in Siegel's title, "Wrong Physics and Right Teaching." How can it be helpful, Cassidy's students ask (and some of our physics colleagues also ask) for students to learn wrong theories, wrong physics? The first answer – as Cassidy emphasized and all of our speakers have agreed – is that students can learn about the process of science, in an authentic way, by going through the successive stages of "wrong physics" that our intellectual forbears traversed. Secondly, Siegel discussed an "ontogeny recapitulates phylogeny" pedagogical strategy, in which students approach complex and abstract modern physics concepts by easy stages, going through the steps that the scientific community went through historically. Research in physics education (and Cassidy emphasized that we must pay attention to this research) shows that we cannot completely shield our students from "wrong" ideas about physics concepts, for two reasons: first, these students come to us with "wrong" natural philosophies of their own already in place; second, in working physics problems of any complexity, students will tend to cycle through all possible "wrong" ideas along the way to a solution. The research shows that ignoring these misconceptualizations will not make them go away. Instead, we must help students to confront these incorrect ideas, explicitly, and overcome them; and studying the history of how the scientific community overcame similar errors in the past is of the greatest help in this endeavor.

In conclusion, a strong case was made for the use of historical materials in teaching physics, and a wealth of useful suggestions for carrying out this program were provided.

The Development of Electron-Positron Colliders. APS April Meeting, Philadelphia, 6 April 2003.

Report by **Elizabeth Paris** (U of Chicago & Argonne) and **Ronald Ruth** (SLAC)

This invited session, co-organized by FHP and the Division of Physics of Beams, chronicled fifty years of electron-positron machines in the United States and Europe. As a substitute for scheduled chair Andy Sessler, who was unable to attend, **Ronald Ruth** (SLAC), who proposed the joint session, stepped in to keep all parties relaxed and engaged.

The session opened with an historical talk from **Elizabeth Paris** (U of Chicago and Argonne) concerning *"The Birth of Lepton Colliders in Italy and the United States."* Paris proceeded to argue that origins of lepton colliders can be traced to protons, proton physics, and proton physicists. The argument was not one of technical evolution, but historical contingency. She related how the succession of accelerators meant to achieve the highest possible center-of-mass energies had focused on protons in such a way that, when ideas surfaced for colliding beams, the magnetic configurations most suitable for protons were afforded the lion's share of prestige and resources. In the late 1950s, the promise of FFAG (Fixed-Field Alternating Gradient) machines for achieving proton collisions seemed just over the horizon. The high-energy establishment in the United States generally had little interest in the alternative idea of storage rings, which were being championed by a young Princeton physicist named Gerry O'Neill. Thus, despite his best efforts, O'Neill failed in his quest to obtain a suitable proton injector for testing his design. Hence, he eventually looked to electrons to provide a less-expensive, less-complicated proving ground. The move took him to the 500 MeV linear electron accelerator at Stanford University's High Energy Physics Laboratory under the direction of Wolfgang Panofsky. There he met a young post-doc named Burton Richter. Thrown together as a result of O'Neill's rejection by a proton-centered establishment, it was at Stanford that the storage ring idea first coupled with electron aficionados to produce actual hardware for the United States – in the form of the electron-electron Princeton-Stanford collider. This, along with an Italian physicist's realization of the possibilities for electron-positron annihilations, would lead to the US adventures in electron-positron colliders, the subject of the session's second talk.

Across the Atlantic, the Italians had been busy. Wanting to regain their prominence in physics as quickly as possible after World War II, some members of the remaining community had organized in order both to take part in the creation of what was to become CERN as well as to build their own national laboratory. With the expense and innovation in high-energy proton machines allotted to the CERN collaboration, they felt compelled, both politically and economically, to initiate a program that would be exciting, relatively inexpensive, swift to begin, and complementary to (rather than competitive with) the research that would be taking place at CERN. Hence, they had built themselves an electron synchrotron, locating it in a grape-producing region near Frascati, just outside of Rome. The 1.1 GeV synchrotron was completed in 1959. Meetings ensued to decide on the next major direction for the laboratory.

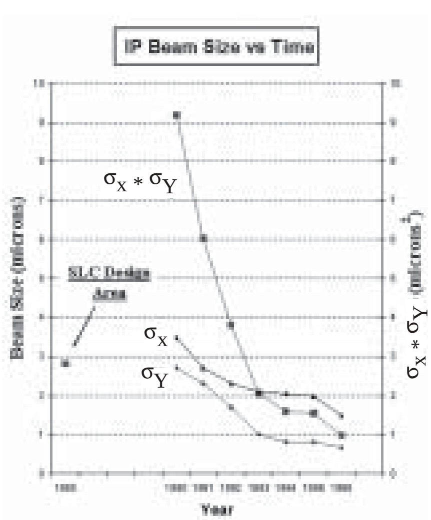
At one such gathering in February, 1960, University of Rome physicist Bruno Touschek suggested that the most appropriate and exciting thing to do at Frascati would be to store electrons and positrons in the same magnetic lattice and cause them to collide. Throughout the experimental world, the culture of high energy particle physics was dominated by the use of protons for probing the nature of matter. However, as one of his collaborators later recalled, Touschek considered protons to be "hooligans," and much preferred electrons, which he reportedly considered "gentle probes."

So, armed with an electron machine and a theorist's convincing affinity for the beauty of electron-positron annihilations, Frascati began its road to electron-positron colliders, beginning with the small storage ring, AdA (Annello di Accumulazione) and later bearing full fruit with the large-scale ring, Adone.

The next speaker was former Cambridge Electron Accelerator Laboratory researcher and current SLAC professor emeritus **John Rees**, who picked up on the American story where Paris had left off. In *"The CEA Bypass Project and SPEAR"*, Rees discussed the fierce competition that ensued in the early to mid-1960s as both CEA and SLAC vied for the right to construct the United States' first electron-positron collider. Eventually the Atomic Energy Commission appointed a committee, headed by L. Jackson Laslett, to decide between the two proposals. When the committee chose SLAC, CEA found itself "severely handicapped" but responded with several new discoveries and innovations including the idea of "low beta" sections and an elaborate, multi-stage injection scheme. These provided a means by which the laboratory could turn its existing electron synchrotron into a "synchrotron-storage ring hybrid with a worthwhile luminosity," a project known as the CEA Bypass . SLAC, meanwhile, submitted proposals for a purpose-built ring year after year without obtaining funding. Finally, in 1969, SLAC redesigned their proposed machine to contain two asymmetric rings at a less costly location, with reduced energy in each beam and cheaper buildings. The new proposal was christened SPEAR (Stanford Positron Electron Asymmetric Rings). Then, SLAC went on to eliminate one ring entirely, leaving a single asymmetric ring and the possibility of adding a second one later if money became available. Although there was still no construction money, the lowered cost made the project feasible through use of equipment funds. The only further significant design change was the overcoming of problems created by the asymmetry. Thus "SPEAR" was no longer "asymmetric," but the old name stuck and is still usually capitalized by practitioners to this day. Spear achieved its first collisions on April 28, 1972.

During these years CEA struggled with its Bypass, a struggle Rees once characterized as "the Book of Job of the accelerator builders." It eventually began running collision experiments for physics in 1971 with a few milliamps of current at 2 GeV and a luminosity around 10^{28}. Although shut down after a couple of years, it was able to obtain measurements of the R-ratio (number of events with hadrons vs. number of muon-pair events) at energies of 2 GeV and 2.5 GeV per beam. Spear, once it began to operate, measured the R-ratio at energies between 1.5 GeV and 2.5 GeV per beam, and its measurements ran right through the CEA points. Spear's results would soon generate a share of the Nobel prize awarded for the discovery of the J/psi particle. Spear still operates today as a synchrotron light source.

Albert Hofmann, a veteran of CEA, SLAC, and now retired from CERN, recounted the second generation of electron-positron storage rings – this time across the Atlantic – in *"Colliders Come of Age in Europe: PETRA and LEP."* He enumerated the many technical and design advances achieved through DESY's work on PETRA, its second major project in this area (after its first collider, DORIS). He characterized this generation of storage rings as aiming at optimization and scaling.



The main goal for PETRA was achieving high luminosity by utilizing exceptionally low beta and by controlling the beam emittance. The design used a multi-cell radiofrequency system and attempted to reduce as much as possible the cross section changes in the ring. The accelerator technology and beam physics developments achieved at PETRA (and its sister collider, PEP, at SLAC) formed the foundation for Europe's next – and the world's largest – circular collider, LEP.

Indeed, the innovations paid numerous dividends for CERN's large ring, amongst whose technical achievements was a one kiloamp peak current. Hofmann recounted how LEP's energies were chosen for specific experiments and that the choice paid dividends in the creation of Z^0 particles, among others. He related the struggles at LEP for more luminosity and finer energy resolution in the face of errors such as flux loops and lunar gravitational effects. One story in particular recounted the "dirty effect" of the French Geneva-Paris train whose 500V and high currents were creating a circuit which included LEP and a local river! He noted, however, that the 15 kV, 15 Hz Swiss trains had presented no problems. (Hofmann is Swiss.)

The last speaker of the afternoon was former SLAC director **Burt Richter** whose more forward-looking talk laid out background and plans for an international 500 GeV electron-positron linear collider, building on experiences with the hybrid Stanford Linear Collider. In *"The First Linear Collider,"* Richter spoke of the struggle to build an international collaboration for the machine, a machine whose origins he traced back as far as a 1965 article by Maury Tigner in *Nuovo Cimento* and whose energy recovery scheme Richter noted as being reinvented by Ugo Amaldi in *Physics Letters* in 1976. He recalled a 1972 meeting in Switzerland in which G. I. Budker may have discussed linear colliders, and failed efforts by himself and others to make LEP a US-European collaboration. He recalled the ICFA (International Committee for Future Accelerators) meeting at Fermilab in 1978 at which a few members were considering electron-positron linear colliders in addition to the abundant discussion of a very large proton accelerator.

In exploring the linear collider idea into the 1980s and beyond, Richter reported that stability problems for the linear accelerator were the biggest surprise and challenge. Here Richter related a vivid analogy to illustrate the problem for a linear collider: consider stretching mechanical pencil leads to half a meter. Then, shoot one from Denver and one from Chicago, and force a head-on collision to occur over the Mississippi River. Every time. Of course, many specific challenges were discussed as well. One particular example, which engendered a highly counter-intuitive solution in the case of the SLC and arose again in the question period, involved wake fields: since such fields are proportional to the beam intensity, *reducing* the intensity actually *increased* the beam density and the luminosity by permitting a decreased cross section at the interaction point. The Stanford SLC project provided a testing ground for accelerator techniques and technology with an eye towards the hoped-for, larger, purpose-built machine. Muon background problems were solved through deflection by cheap, solid iron magnets, and stability problems in the linac were addressed with help from laboratories worldwide, including a great deal from the Russian laboratory at Novosibirsk. Although the SLC initially had enormous problems with large beam cross-sections, a task force was formed to attack the difficulty. In the early running of the SLC the beam cross section was more than three times the original design. The solutions which were discovered throughout the mid-1990s reduced the cross section to a third of the original design, creating a huge boost for the linear collider cause. (See figure at left.)

Just as the first physics results were coming in from the SLC in 1989, the effort towards a much larger linear collider began in earnest with a sequence of workshops aimed at stimulating the development of the necessary physics and technology for the collider. Although SLAC, DESY, and the Japanese laboratory, KEK, had signed an interlab memorandum of understanding, hopes for the large collider in 1993 were delayed seven or eight years. The project, initially termed the Next Linear Collider (NLC), became associated with the United States. Richter pointed to a "mistake" in socio-political tactics. Different labs worked on specific questions, and each technology got a local label. What should have been done, he lamented, was to locate

10-15 individuals from each laboratory into other laboratories, thus uniting the effort. Today, according to Richter, there is world consensus for a single 500 MeV linear collider. The ICFA technical review is complete, and an OECD (Organization for Economic Co-operation and Development) Global Science Forum has been held on how to structure the laboratory. The projected price tag was quoted at "a mere 5 billion." By the end of 2004, reported Richter, the high energy physics community will have to have chosen a technology and a site for its new machine.

Also worth noting from the session as a whole, the contributions from Gersh Budker and the innovative laboratory in Novosibirsk were cited by both speakers and discussants. Although none of the talks specifically addressed this subject, Novosibirsk's efforts were often recognized as providing a large portion of the earliest and of the most important work concerning electron-electron and electron-positron colliders.

Benjamin Franklin, Civic Scientist. APS April Meeting, Philadelphia, 7 April 2003.

Report by **Michael Riordan** (UC-Santa Cruz)

As Philadelphia is the city of brotherly love and Benjamin Franklin, I agreed to put together an invited session on this Founding Father's scientific interests and how they influenced his better-known political activities on behalf of the nascent American republic in the late 1700s. Fortunately, I was aided in this effort by close cooperation with **Philip ("Bo") Hammer**, who has been Chair of the Forum on Physics and Society, which cosponsored the session, and is now Vice President of the Franklin Center in Philadelphia. We took our cue from a concept that **Neal Lane** had enunciated and elaborated while in U.S. government service as Director of the National Science Foundation and then Presidential Science Adviser during the Clinton Administration. Using Franklin as a shining example, speakers explored the many facets of what it meant to be a prominent scientist deeply involved in and devoted to public service.

Opening the session, the first two talks were given by two Franklin admirers who had appeared prominently on the two-hour PBS miniseries about him that aired the previous fall, **Claude-Anne Lopez** of Yale and **Dudley Herschbach** of Harvard. Having organized and then pored through the Franklin Archives for decades, and also published several books about him (including *Benjamin Franklin and the Ladies of Paris*, ooh-la-la!), Lopez was well suited to talk, in her lecture *"At the Dawn of Science,"* about his personal side and relationships with such famous French scientists as Antoine Lavoisier.Herschbach, who had just given the APS Public Lecture on a similar subject the previous (Sunday) evening, focused on Franklin's scientific activities, especially his experiments on electricity, in *"Ben Franklin: A Curiosity-Driven Scientist, a Service-Driven Citizen."*

The third speaker, **James McClellan** of Stevens Institute of Technology, took a much more critical approach. The only card-carrying historian in the session, he argued that Franklin's scientific activities were being exaggerated by scientists-turned-historians trying to using his exemplary life to promote their own current agendas. Unfortunately, many of the audience of more than a hundred then began to exit the hall, leaving **Neal Lane** to deliver his thoughtful closing talk on *"The 'Founding Father' of Civic Science"* to a much-reduced group. Franklin, he noted, had long ago anticipated and achieved much of what he (Lane) was advocating that scientists should be doing in the public arena. (Lane's talk was subsequently published in *Physics Today*, October 2003.) **Hammer** then closed the session with a brief commentary and led a general discussion among the faithful who remained in the room.

The History of Solar Neutrinos. APS April Meeting, Philadelphia, 8 April 2003.

Cosponsored by the Division of Nuclear Physics and chaired by **Hans Frauenfelder** (Los Alamos), the speakers included **Allan Franklin** (U of Colorado), **John Bahcall** (Institute for Advanced Study), **Kenneth Lande** (U of Pennsylvania), **Vladimir Gavrin** (Institute for Nuclear Research, Russian Academy of Sciences), and **Yoji Totsuka** (U of Tokyo). A topic of much current interest, the session was well attended, with about 100 in the audience.

Franklin spoke on the topic *"Where Are The Neutrinos? The Early History of the Solar Neutrino Problem."* He discussed the early experiments whose results led to the "solar neutrino problem," the fact that the observed number of solar neutrinos was far less than that predicted by the Standard Solar Model. These included the Homestake Mine experiment of Davis and collaborators and the later SAGE, GALLEX, and Kamiokonde experiments. He began by briefly discussing the early history of the neutrino, including the experiments that led to its suggestion by Pauli, the early indirect evidence for it, and the first experimental demonstration of its existence by Reines and Cowan.

Bahcall, whose talk was titled *"History of the Solar Neutrino Problem: A Theoretical Perspective,"* related the theoretical history of the problem, including the extensive work that he and collaborators did in exploring the extent of freedom allowed by plausible modifications of the standard solar model. These studies did much to establish that the "solar neutrino problem" was a real problem.

"The Homestake Chlorine Solar Neutrino Detector" was **Lande**'s title. He reviewed the history of the Homestake detector: it began operation in 1967 and observed neutrinos from the Sun for over three decades. During this period the detector made the first observations of neutrinos from nuclear fusion reactions in the solar core, determined that the flux of solar electron neutrinos is a third of that predicted by the standard solar model and, when combined with the recent SNO observations, determined that the ^{7}Be electron neutrino flux is also about a third of that predicted. He described the history of this detector, the results obtained and possible future applications of the radiochemical technique involved.

"The Gallium Experiments" were discussed by **Vladimir Gavrin**. In spite of great progress in the last several years in solar neutrino research, at the present time only the radiochemical gallium experiments are able to measure and monitor the low-energy part of the solar neutrino spectrum. This is because they are mainly sensitive to its principal component – the flux of p-p neutrinos. The deficit of high-energy solar neutrinos compared to the prediction of the standard solar model,

discovered by the chlorine experiment and confirmed by the Kamiokande and SNO experiments, has been shown by the gallium experiments to extend to the low-energy part of the spectrum. He briefly discussed the history of SAGE and GALLEX/GNO, gave the general principles of the gallium experiments, presented their results as well as the p-p solar neutrino flux derived by combined analysis of all solar neutrino experiments, and discussed the implications of the gallium results for solar and neutrino physics.

The last talk was given by Yoji Totsuka on *"The Kamioka Experiments."* (No report available.)

History of Physics Contributed Session. APS April Meeting, Philadelphia, 6 April 2003.

This was another successful contributed session, with six history talks. The first was *"Elmer Samuel Imes"* by **Ronald E. Mickens** (Clark Atlanta U). Imes graduated from Fisk University (Nashville, TN) in 1903 with a BA degree in science. In 1915, he also received the MS degree from Fisk. In the same year, he entered the University of Michigan's doctoral physics program where he worked under the direction of Harrison M. Randall who had just returned from Germany. For the next three years, Imes investigated the infrared spectrum of several diatomic molecules with the particular interest of obtaining definitive evidence that the rotational spectrum was also quantized as had been shown for vibration. In 1918, Imes published his dissertation results in a long article in Astrophysical Journal **50** (1919), 251-276. This work had a major impact on molecular physics. In the two decades after publication, Imes' work was extensively cited in research papers and reviews on the rotational-vibrational spectra of diatomic molecules; and, discussions of this work and Imes' precision spectrum of HCl would be incorporated into the standard textbooks on modern physics. This presentation examined issues related to Imes' family background, the reaction to his research, his career, and later life.

Virginia Trimble (U of Maryland) spoke on *"Emergence of Cosmic Structure: The First Two Centuries of the First Two Eons."* The process by which we have come to appreciate the large scale structure of a universe of superclusters and voids resembles a game of snakes and ladders or "lose on the swings what you gain on the roundabouts." In practice, for a number of decades, some people were working on what we now think of as astronomy of the second half of the 20th century while others were simultaneously working on distinctly 19th century astronomy. It is possible to argue about whether this is just a description or some sort of explanation. Incidentally, the *K* term (which we now call Hubble's constant, *H*) arose within stellar astronomy to describe a seemingly analogous phenomenon among hot stars.

Michael A. Day (Lebanon Valley College, Annville, PA) spoke on *"Rabi, Snow, and 'The Two Cultures'."* John Rigden in his biography of I.I. Rabi, *Rabi: Scientist and Citizen* (1987, 2000 with a new preface) includes an intriguing footnote concerning Rabi's influence on C. P. Snow. According to the footnote, when Snow and his son were visiting the Rabis in New York City, Rabi's wife heard Snow tell his son that Rabi was "the man who gave me [Snow] the idea for the two cultures." In this talk, after a brief overview of Rabi's views on science and society, the mutual influence between Rabi and Snow is explored. On the basis of chronology and an interpretation of Rabi's works (published and unpublished) as well as letters between Rabi and Snow, a case is made that Rabi could very well have been the man who gave Snow the idea for "The Two Cultures."

"Fritz Reiche and German Refugee Scientists" was the topic for **Benjamin Bederson** (NYU). Fritz Reiche (1883-1969) was a distinguished theoretical physicist, a student and colleague of Wilhelm Roentgen, Max Planck, Fritz Haber, Rudolf Ladenburg, James Franck, Max Born, Max von Laue and other early luminaries. He was coauthor of the famous Thomas-Reiche-Kuhn sum rule, and author of the seminal book *The Quantum Theory*, first published in 1920. He was one of the last Jewish physicists to leave Germany during the Nazi period, in 1941. In his book *Heisenberg's War*, Thomas Powers relates that Reiche bore news of German work on nuclear fission, in a message from Friedrich Houtermans to Wigner and others in Princeton, where Reiche lived in Einstein's home during the summer of 1941. Reiche's son Hans later claimed that this incident played a significant role in convincing Einstein to write that letter to President Roosevelt. In this talk Bederson related the difficulties Reiche experienced, first in leaving Germany and then in reestablishing his physics career in the US. He finally obtained an adjunct position at NYU where he served until his retirement. The role played by the renowned Emergency Committee in Aid of Displaced Foreign Scholars was discussed. The particular role played by Ladenburg, who was instrumental in obtaining a small grant for Reiche permitting him to obtain a US visa, in helping many physicists leave Nazi Germany and occupied countries, was also described.

Harry Lustig (CUNY and APS, Emeritus) asked (and answered in some measure) *"Why did the Germans not produce an atomic bomb?"* The question has been examined and debated in books and articles by physicists and historians of science for the past half century. Since 2000, the controversy has been heightened by Michael Frayn's play *Copenhagen*. Was the reason for the failure that Werner Heisenberg, the leader of Germany's Uranium Project, for moral reasons, gave incomplete and misleading information to the Nazis, such as withholding the knowledge that fissionable plutonium can be produced in a uranium reactor? Was Heisenberg's science the cause, because it resulted in a critically wrong critical mass for fission of tons instead of kilograms? Did he not make the calculation at all because he was convinced, for practical reasons, that a bomb couldn't be assembled in time to be of use to anyone in World War II? And what about Hans Bethe's assertion that Walter Bothe's mistake in ruling out graphite as a moderator, which obliged the Germans to embark on the difficult, long range effort to obtain enough heavy water, doomed even Heisenberg's reactor program to failure? Can the different answers that have been given to these and other questions be reconciled? If not, which are likely to be correct and which should be abandoned? The talk gave a progress report on this investigation.

Margaret McMahan and David Clark (Lawrence Berkeley National Lab) spoke on *"Lawrence's Legacy: Seaborg's Cyclotron – The 88-Inch Cyclotron Turns 40."* In 1958, Sputnik had recently been launched by the Russians, leading to worry in Congress and increased funding for science and technology. Ernest Lawrence was director of the "Rad Lab" at Berkeley. Another Nobel Prize winner, Glenn Seaborg, was Associate Laboratory Director and Director of the Nuclear Chemistry Division. In this atmosphere, Lawrence was phoned by commissioners of the Atomic Energy Commission and asked what they could do for Seaborg, "because he did such a fine job of setting up the chemistry for extracting plutonium from spent reactor fuel" [1]. In this informal way, the 90-Inch (eventually 88-Inch) Cyclotron became a line item in the federal budget at a cost of $3M (later increased to $5M).

The 88-Inch Cyclotron achieved first internal beam on Dec. 12, 1961 and first external beam in May 1962. Forty years later it is still going strong. Pieced together from interviews with the retirees who built it, Rad Lab reports and archives from the Seaborg and Lawrence collections, the story of its design and construction – on-time and under-budget – provides a glimpse into the early days of big science.

[1] remarks made by Elmer Kelly, "Physicist-in-charge" of the project on the occasion of the 40th anniversary celebration.

The Seven Pines Symposium

by *Roger H. Stuewer* (U of Minnesota)

The Seven Pines Symposium is dedicated to bringing leading 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 seventh annual Seven Pines Symposium was held May 7-11, 2003, on the subject, "The Concept of the Vacuum 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 hiking and bird-watching. Its idyllic setting and superb cuisine make it an ideal location for small meetings. Its owner, Lee Gohlike, is the founder of the Seven Pines Symposium.

Unlike the typical conference, the talks are limited to 30 minutes, twice as much time is devoted to discussions following the talks, 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 that are distributed in advance to all of the participants. Twenty-one prominent historians, philosophers, and physicists were invited to participate in this year's symposium.

Each day the speakers set the stage for the discussions by addressing major historical, philosophical, and physical issues related to the concept of the vacuum in physics. After an introduction on the goals of the Seven Pines Symposium by Lee Gohlike, the morning and afternoon of Thursday, May 8, were devoted to the general topic of "Early Views on the Vacuum," with Don Howard (Notre Dame) speaking on "From the Pre-Socratics to Newton," Anne J. Kox (Amsterdam) speaking on "Lorentz and the Ether," and Simon Saunders (Oxford) speaking on "Dirac and the Negative Energy Sea." The morning and afternoon of Friday, May 9, were devoted to the general topic of "The Nature of the Vacuum State," with Ian J.R. Aitchison (Oxford) speaking on "Properties of the Vacuum State in Quantum Field Theory," Philip Stamp (British Columbia) speaking on "Structure of the Ground State in Condensed Matter Physics," William G. Unruh (British Columbia) speaking on "What is a Particle?" and Robert M. Wald (Chicago) speaking on "The Non-Uniqueness of the Vacuum." On Saturday morning, May 10, this topic continued with Vijay Balasubramanian (Pennsylvania) speaking on "The Nature of the Vacuum in String Theory." The general topic then became "Dark Energy and the Cosmological Constant," with Sean Carroll (Chicago) speaking on "The Energy of the Vacuum State" and, in the afternoon, John Earman (Pittsburgh) speaking on "History of the Cosmological Constant" and P. James E. Peebles (Princeton) speaking on "The Dark Energy Problem." The closing discussion on Sunday morning, May 11, 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 annual symposia, 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), Alan E. Shapiro (Minnesota), and Robert M. Wald (Chicago). Also participating in the seventh annual Seven Pines Symposium were Babak Ashrafi (MIT), Laurie M. Brown (Northwestern), Michel Janssen (Minnesota), Jürgen Renn (Berlin), Serge Rudaz (Minnesota), Laura M. Ruetsche (Pittsburgh), and Henrik Zinkernagel (Granada).

The eighth annual Seven Pines Symposium will be held May 5-9, 2004, on the subject, "Quantum Mechanics, Quantum Information, and Quantum Computation."

Forum News

FHP Sessions planned for the March and "April" 2004 APS Meetings

FHP will sponsor and/or co-sponsor some interesting sessions on the history of physics at the March and April 2004 APS meetings. At the March meeting, to be held March 22-26 in Montreal, there are three sessions:

Physics in Canada: Some Highlights, organized by **Robert Romer**; *Physics in Industrial Laboratories*, organized by **Chetan Nayak and William Brinkman**; *Monolayers and Multilayers*, organized by **Charles Knobler**. The invited speakers, their titles and scheduled times are given below. There are also three sessions at the "April" meeting, to be held May 1-4 in Denver. They are: *The Discovery of Black Holes*, organized by **Virginia Trimble**; *Scientists Advising Government*, organized by **Joel Primack**; and *History of the Mössbauer Effect*, organized by **Catherine Westfall**. These sessions promise very interesting discussions, as can be seen by the invited speakers' titles below.

The History of Physics in Canada: Some Highlights (2:30-5:30pm on Mon. March 22). Geoffrey W. Rayner: "Harriet Brooks: Canada's First Woman Physicist." Allan Griffin: "McLennan, Allen and Misener: Low temperature physics at

Toronto," Boris P. Stoicheff: "Gerhard Herzberg and The Temple of Science," Eric C. Svensson: "Physics at Chalk River."

Physics in Industrial Laboratories (8-11am, Tues. March 23), co-sponsored with Forum on Physics and Society. Roland Schmitt: "The History of Physics at G.E. Laboratories," Phillip Anderson: "The History of Physics at Bell Laboratories," Allen Fowler: "The History of Physics at IBM T.J. Watson Laboratories," Jennifer Chayes: "Physics at Microsoft Research."

Monolayers and Multilayers: Agnes Pockels and Katharine Blodgett (8-11am on Wed. March 24), co-sponsored with the Committee on the Status of Women in Physics. Christiane Helm: "Agnes Pockels: Life, Letters and Papers," Charles Knobler: "100 Years of Monolayers at the Air/Water Interface: Agnes Pockels' ...," Katharine Gebbie: "Katharine B. Blodgett: Aunt, Friend and Physicist," Daniel Schwartz: "70 Years of Built-Up Films: Katharine Blodgett's Scientific Legacy."

The Discovery of Black Holes (2:30-5:30pm on Sat. May 1) co-sponsored with the Division of Astrophysics. Werner Israel: "Theoretical Considerations and Deep History," Omer Blaes: "Active Galactic Nuclei," Jeffrey McClintock: "Black Hole X-Ray Binaries," Fulvio Melia: "The Black Hole in the Milky Way," M. Coleman Miller: "And All the Rest (Primordial, Intermediate, and Orphan Black Holes)."

Science Advising (8-11a on Tuesday, May 4) co-sponsored with Forum on Physics and Society. Gregg Herken: "Presidential Science Advising from the Atomic Bomb to SDI," Wolfgang Panofsky: "Science Advising Successes and Failures," D. Allan Bromley: "The President's Scientists: Reminiscences of a White House Science Advisor," Jack Gibbons: "Advising Congress and the President," Joel Primack: "The Congressional Science Fellow Program and Other Efforts to Help Congress and the Public Make Wiser Decisions on Technology."

Mössbauer Spectroscopy: Various Historical Perspectives. John Schiffer: "The Beginnings of the Iron Age," Hans Frauenfelder: "Early Developments at the University of Illinois," Catherine Westfall: "Between Basic and Applied: Forty-five Years of Mössbauer Spectroscopy," Hollis Wickman: "Mössbauer Hyperfine Relaxation Phenomena: From Berkeley to ...."

Contributed papers for the "April" 2004 meeting – Call for Papers

FHP invites scholars to present papers at the APS annual meeting which will be held May 1-4, 2004 in Denver, Colorado. Graduate students, young scholars and non-APS members are especially encouraged to attend; the APS meeting itself provides an opportunity to meet notable scientists and science managers. History talks are allowed twice the usual time for contributed papers: 20 + 4 minutes. Funding may be available to defray costs of travel and registration fees, especially for graduate students.

The deadline for abstract submissions is January 9, 2004. Scholars who wish to give papers that present the history of physics and its interaction with culture, education, and physics research should contact Patrick McCray (pmccray@history.ucsb.edu). This should be done well before the January deadline to ensure proper submission of abstracts via the APS's new web-based system. Non-APS members who wish to present papers are welcome and arrangements will be made on an individual basis to help with the abstract submission process. Additional information about the APS and its meetings is at www.aps.org.

Abraham Pais Award for History of Physics

The American Physical Society and the American Institute of Physics have established a major new award, the Abraham Pais Award for the History of Physics, which will recognize outstanding scholarly achievements in the history of physics. A renowned theoretical particle physicist and historian of physics, Pais died in July 2000. Among historians, he is best known for his book *Subtle is the Lord: The Science and the Life of Albert Einstein*, which won the 1983 American Book Award in Science.

The award will be given annually and consists of $5,000, a certificate citing the recipient's contributions to the history of physics, and funds to travel to an APS meeting to receive the award and deliver an invited talk on the history of physics. The award is the first to be established specifically for the history of physics.

The first selection committee will be chaired by Roger H. Stuewer (U of Minnesota) and other members are Allan D. Franklin (U of Colorado), Lillian Hoddeson (U of Illinois), Anne J. Kox (U of Amsterdam), and Spencer R. Weart (AIP). The first award will be conferred in 2005. Nominations are due by 1 May 2004 and should be sent to Stuewer. For further information, see the website of the APS Forum on History of Physics, www.aps.org/units/fhp/pais.

The Pais award will usually be given to a single person but no more than three individuals and is open to scholars of all nationalities.

For the past two years, an award establishment committee has been working on both the concept and the fundraising. The initial goal of $100,000 to establish an endowment has been exceeded. A major contribution came from John and Elizabeth Armstrong, who gave $30,000 outright and provided another $30,000 in matching funds to challenge other donors. Fundraising to cover travel expenses and to perhaps raise the amount of the award is continuing, according to Benjamin Bederson, who chairs the award establishment committee. Other members are Stephen G. Brush (U of Maryland), Gloria B. Lubkin (AIP), Harry Lustig (APS Treasurer Emeritus), Michael Riordan (Stanford and UC-Santa Cruz), Stuewer, and Weart.

Call for Nominations for FHP Officers

Nominations are invited for Forum officers to be elected in early 2004 for terms beginning immediately following the Executive Committee meeting in April, or for future elections. Offices that will be open in 2004 are Vice-Chair, Secretary-Treasurer, and two Members-at-Large of the Executive Committee. In 2005 nominations will be needed for Vice-Chair, Forum Councillor, and two Members-at-Large of the Executive Committee. Send nominations to the chair of the Forum Nominating Committee: Hans Frauenfelder (frauenfelder@lanl.gov).

APS Fellow Nominations

Robert Romer is chair of the Forum's Fellowship Committee for 2003-04. Any Forum members who wish to nominate a candidate for Fellow in APS are invited to send him their suggestion(s), along with a c.v. and letter describing the candidate's achievements in history of physics. Send suggestions to Robert Romer, Department of Physics, Amherst College, Amherst MA 01002; 413-542-2258; rhromer@amherst. edu.

FHP Website

FHP officers have been working to keep the FHP Web site (www.aps.org/units/fhp) up to date and to expand its coverage. Comments from members who find errors or want to suggest additional material would be welcome, and should be sent to the FHP Secretary/Treasurer, Ken Ford, kwford@ verizon.net.

Forum Officers

Michael Riordan, UC-Santa Cruz (michael@slac.stanford.edu), became Chair in April 2003 at the end of Hans Frauenfelder's term. **Nina Byers**, UCLA (nbyers@ physics.ucla.edu), became Chair-Elect and will succeed to Chair in May 2004. **Robert Romer**, Amherst College (rhromer@ amherst.edu), was elected Vice Chair and will succeed to Chair-Elect in May 2004.

Patrick McCray, Center for History of Physics, AIP (pmccray@aip.org), was elected to fill Per Dahl's unexpired term which ends in April 2005. **Gerald Holton**, Harvard (holton@physics.harvard.edu), and **Michael Nauenberg**, UC Santa Cruz, (michael@mike.ucsc.edu) were elected to three-year terms on the Executive Committee. Their terms end in April 2006. Continuing members of the Executive Committee are **Daniel M. Greenberger**, CCNY (dansuzy@nyc.rr.com), and **Elizabeth Paris**, Argonne National Laboratory (eparis@anl.gov), whose terms expire in May 2004. **Daniel Siegel**, U of Wisconsin (dmsiegel@facstaff.wisc.edu) continues a term that ends in April 2005.

Kenneth Ford, retired Executive Director of AIP (kwford@verizon.net), continues as Secretary-Treasurer until May 2004. **Gloria Lubkin**, *Physics Today* (gbl2@aip.org), continues as Forum Councillor until December 2005. **Bill Evenson**, Brigham Young U (evenson@ byu.edu), as *Newsletter* Editor, will hand over this assignment to **Ben Bederson**, Department of Physics (Emeritus), New York University (ben.bederson@nyu.edu), in January 2004. **Spencer R. Weart**, Director of the AIP Center for History of Physics (sweart@aip.org), and the *Newsletter* Editor serve as *ex officio* members of the Executive Committee.

Many thanks to **Hans Frauenfelder**, Los Alamos National Laboratory (frauenfelder @lanl.gov), for his good work as Chair during 2002-2003, and to **Ben Bederson**, Department of Physics (Emeritus), New York University (ben.bederson@nyu.edu), for his continued help as Past Chair during 2002-2003. Thanks also to retiring members **Elizabeth Urey Baranger**, U of Pittsburg, and **Michael E. Fisher**, U of Maryland at College Park, and **Per F. Dahl**, Lawrence Berkeley National Laboratory (Emeritus) for their work on the Executive Committee during the past years.

Executive Committee

The annual meeting of the Executive Committee was held on April 4, 2003, at the APS April Meeting in Philadelphia. It was chaired by Hans Frauenfelder, who thanked the many Forum members who helped make the 2002-2003 activities successful. The Program Committee, led by Michael Riordan, planned an outstanding complement of 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 7.5%. Although there were exceptional expenses associated with FHP programs of about $3,000 beyond income for the year, FHP remains in good financial condition, with a small but adequate reserve fund. The FHP web site has been updated and improved. Members are invited to visit the site at www.aps.org/units/fhp. The Program Committee established a subcommittee to encourage more contributed papers in history of physics, especially from young scholars, at future meetings. The World Year of Physics 2005 was discussed with a view to FHP participation in the activities planned by APS. FHP will assist Alan Chodos (APS Associate Executive Officer) with the identification and labeling of physics historic sites in America. Michael Riordan will participate on a committee considering the creation of a "virtual journal" to reprint papers from APS journals that led to Nobel prizes. The Award Committee, chaired by Ben Bederson, reported the success of their fund raising so far and the approval by the APS Executive Board of the name, "Abraham Pais Award for History of Physics." Minutes have been posted on the FHP web site.

Electronic meetings of the Executive Committee were held in June, July, September, and October, 2003. In these meetings the Executive Committee approved the Pais Award Committee, confirmed the organization of a Committee on Historic Physics Sites, approved an FHP nomination for APS fellowship, approved a policy on support for speakers at FHP-sponsored invited sessions, and approved the appointment of a new *Newsletter* Editor to take office in January 2004.

Forum Committees

For 2003-04, the Standing Committees of the Forum are:

Program Committee: **Nina Byers** (chair), Laurie Brown, David Goodstein, Patrick McCrea, Cheten Nayak, Robert Romer, Ken Ford (*ex officio*), and Michael Riordan (*ex officio*)

Nominating Committee: **Hans Frauenfelder** (chair), Gordon Kane, Martin Klein, Gloria Lubkin, Elizabeth Paris

Fellowship Committee: **Robert Romer** (chair), Nina Byers, Elizabeth Paris, Dan Siegel

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

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

Award Selection Committee: **Roger H. Stuewer** (chair), Allan D. Franklin, Lillian Hoddeson, Anne J. Kox, Spencer R. Weart

Editorial Board and Publications Committee: **Bill Evenson** (chair), Laurie Brown, Ken Ford, Dan Greenberger, Michael Riordan, Spencer Weart

World Year of Physics 2005.

See www.physics2005.org for information about plans for the upcoming World Year of Physics 2005 and how to participate. FHP, along with APS as a whole, will be major participants.

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 Ben Bederson, 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.

Ben Bederson: Department of Physics, New York University, 4 Washington Place, New York, NY 10003; ben.bederson@nyu.edu.

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

APS AND AIP NEWS

Historic Physics Sites in America

Several suggestions have been made for the project to identify and label/memorialize historic physics sites in America. Those working on this project are looking for further suggestions in order to have a fairly comprehensive list as a starting point from which to begin the process of making selections and addressing the logistical (and possibly financial) problems associated with this project. FHP members are urged to send suggestions to Alan Chodos, APS Associate Executive Officer, The American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, chodos@aps.org.

AIP Center for History of Physics

Grants-in-Aid for History of Modern Physics and Allied Fields (Astronomy, Geophysics, etc.). NEW DEADLINES for receipt of applications: APRIL 15 and NOVEMBER 15 of each year.

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 part of the funds for travel and subsistence to use the resources of the Center's Niels Bohr Library in College Park, Maryland (easily accessible from Washington, DC), or to microfilm papers or to tape-record oral history interviews with a copy deposited in the Library. 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, 301-209-3174, fax: 301-209 0882,sweart @aip.org.

History of Physics Syllabi on the Internet – Call for Syllabi. As an aid to teaching and studying the history of physics, and as an introduction to the vast literature in the field, the AIP Center for History of Physics has put together a collection of syllabi. With the kind permission of their authors, sample syllabi are exhibited on the Internet at www.aip.org/history/syllabi/. They feature courses taught at a variety of universities, including "Scientific Revolutions," "History of Modern Physics," "Nuclear Age," "Science after WWII," and "Historical Experimentation." If you are teaching a course on the history of physics or a related science such as astronomy, please visit the site and send your comments. And please send a copy of your syllabus or reading list, in any paper or electronic format, to Spencer Weart, chp@aip.org.

AIP Center for History of Physics Grants to Archives. The Center for History of Physics of the American Institute of Physics has a regular program of Grants to Archives. The grants are intended to make accessible records, papers, and other primary sources which document the history of modern physics and allied fields (such as astronomy, geophysics, and optics). Grants can be used only to cover direct expenses connected with preserving, inventorying, arranging, describing, or cataloging appropriate collections. Expenses may include acid-free storage materials and staff salary/benefits but not overhead or other indirect costs. The AIP History Center's mission is to help preserve and make known the history of modern physics and allied fields, and the grant program is intended to help support significant work to make original sources accessible to researchers. Preference will accordingly be given to medium-size or larger projects for which the grant will be matched by the parent organization or other sources. For information about the 2004 program, see www.aip.org/history/grntann.htm or contact Joe Anderson, Center for History of Physics, American Institute of Physics, One Physics Ellipse, College Park, MD 20740; fax 301-209-0882; rja@aip.org.

New Web / CD Materials Teach Science with Firsthand Accounts of Discoveries. A new Web exhibit, "Moments of Discovery," uses the actual voices of leading scientists to explore how major discoveries are made, teaching some science along the way. The material is designed for classroom use (with presentation and discussion taking one or two days), but is also suitable for individual study. It is the latest addition to the award-winning online "Exhibit Hall" of the Center for History of Physics of the American Institute of Physics, www.aip.org/history/exhibit.htm, and is also available on CD-ROM. Extensive Teachers' Guides are included to help instructors use the modules, chiefly in science courses at the secondary-school or beginning college level.

One of the exhibit's two modules, "The Discovery of Fission," weaves together excerpts from oral history interviews and other tape recordings of the voices of Albert Einstein, Otto Hahn, Lise Meitner, Enrico Fermi, and many others, in a professionally narrated story of the historical turning-point when nuclear energy first came into view. It emphasizes the social process: how an odd phenomenon was glimpsed by experimenters, tentatively explained by theorists, and confirmed around the world. The other module, "A Pulsar Discovery," focuses on a few days of intellectual ferment. A narration by physicist-educator Philip Morrison is interwoven with excerpts from tape-recorded interviews with the two astronomers who first detected a pulsar in ordinary light. Students can witness the moment of discovery itself, for during that night at the telescope, the two young scientists happened to run a tape recorder, and it preserved their excitement and their arguments as they struggled to find out if what they were seeing was real.

Users with slow internet connections who wish to hear the voices without tedious delays can get both modules at cost on a CD-ROM. "Moments of Discovery" may be viewed at www.aip.org/history/mod (where there is also information on how to purchase the CD-ROM, or you can write to: Moments of Discovery, Center for History of Physics, One Physics Ellipse, College Park, MD 20740 USA).

AIP Center for History of Physics Begins Project to Document the History of Physicists in Industry. The Center for History of Physics at the American Institute of Physics has launched a three-year effort to create a national documentation strategy to identify and preserve the historically valuable records of physicists in industry. Supported by funding from NHPRC, NSF, the Andrew Mellon Foundation, and other sources, the study represents the first systematic investigation of records-keeping practices and needs in high-tech industry. The project got underway in November 2002 and field work began in March 2003. The study is a continuation in an especially complex area of the Center's ongoing work to develop strategies for saving hard-to-preserve records in physics and allied fields. Approximately one-third of all the physicists in the U.S. today are employed in industry, and the country's economic dominance rests on a brilliant century of corporate research and innovation. Industrial R&D is, however, one of the least documented areas in our society.

The study's key activities will consist of interviews with more than 100 corporate scientists and R&D managers at IBM, Xerox, General Electric, Kodak and 11 other high-tech corporations; interviews with archivists and records managers responsible for industrial records in the U.S. and abroad; and records surveys to identify extant corporate records, laboratory notebooks and other sources. A principal product of the study will be published reports that present our findings and endeavor to outline new frameworks for identifying, appraising, and preserving historically valuable industrial R&D records, both past and present. For additional information on the project, contact project director Joe Anderson (rja@aip.org, 301-209-3183).

2004-2005 APS/AIP Congressional Science Fellowship Programs

The American Institute of Physics and the American Physical Society are now seeking applicants for the 2004-2005 Congressional Science Fellowships. Spend a year providing S&T expertise to Congress. Application deadline: January 15, 2004. Send all materials to: APS and AIP Congressional Science Fellowship Programs, c/o Jackie Beamon-Kiene, APS Executive Office, One Physics Ellipse, College Park, MD 20740-3844. For more information, call 301-209-3094 (AIP); 301-209-3269 (APS) or visit www.aip.org/pubinfo or www.aps.org/public_affairs/fellow.

2004-2005 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 November 1, each year. For more information, visit www.aip.org/mgr/sdf.html.

NOTES AND ANNOUNCEMENTS

I. Bernard Cohen, an important historian of physics who was especially well-known for his work on Newton, died at his home in Waltham, MA on June 20, 2003 at age 89. A memorial service was held at Harvard Memorial Church on 19 November 2003.

Bethe-Mermin video. The video interview of Hans Bethe, conducted by David Mermin at Cornell University on February 25, 2003 and shown at the APS March Meeting (see report above), is available from Cornell University for $12.50 per cassette in NTSC format, plus tax and shipping. Other formats are $5 more (i.e. $17.50) – PAL or SECAM. Tape copies can be ready to ship within a week of the receipt of the order. Orders should be made to: Mr. Glen Palmer, Media & Technology Services, 1156 Comstock Hall, Ithaca, NY 14853-2601, fax: 607-255-1563, grp2@cornell.edu

Michael Riordan, current FHP Chair, received the **2002 Andrew W. Gemant Award** from the American Institute of Physics "for skillfully conveying the excitement and drama of science and for clarifying important scientific ideas through his books, articles and many television programs. Riordan's work has enhanced the public's appreciation of physics as a source of beneficial applications and as an integral part of our intellectual life." The Andrew Gemant Award, made possible by a bequest of Andrew Gemant, is awarded by AIP to individuals who have linked physics to the arts and humanities. Past awardees include A. Pais, G. Holton, S. Weinberg, F. Dyson, P. Morrison, S. Hawking, and J. Bernstein.

New NASA Chief Historian. Dr. Steven J. Dick has been appointed Chief Historian of NASA. Dr. Dick has worked as an astronomer and historian of science at the U. S. Naval Observatory since 1979. He obtained his B.S.in astrophysics (1971), M.A. and Ph.D. (1977) in history and philosophy of science from Indiana University. He is a well-known expert in the field of astrobiology and its cultural implications. He spent three years at the Naval Observatory's Southern Hemisphere station in New Zealand. He served as the first Historian of the Naval Observatory, and has most recently been the Acting Chief of its Nautical Almanac Office. He has authored more than 100 publications, including: *Plurality of Worlds: The Origins of the Extraterrestrial Life Debate from Democritus to Kant* (Cambridge University Press, 1982); *The Biological Universe: The Twentieth Century Extraterrestrial Life Debate and the Limits of Science* (Cambridge University Press, 1996); and *Life on Other Worlds* (1998), the latter translated into four languages. He was also editor of *Many Worlds: The New Universe, Extraterrestrial Life and the Theological Implications* (2000).

The 2002 Singer Prize of the British Society for the History of Science was awarded to Simone Turchetti, University of Manchester, for his essay "Atonic secrets and government lies: nuclear science, politics and security in the Pontecorvo case."

The winner of the 2003 Dingle Prize for the book that best brings history of science to a broad readership is Ken Alder's *The Measure of All Things*.

Cushing Prize in History and Foundations of Physics. An annual 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 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. Information 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.

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.

Marc-Auguste Pictet Prize. The Société de Physique et d'Histoire Naturelle (SPHN) de Genève invites applications for the Marc-Auguste Pictet Prize. This Prize, in principle intended for a young researcher, will reward a significant contribution to the history of science, which is as yet unpublished or has only recently appeared. Application is open to both Swiss and foreign candidates at the university level. Notification of candidature should be sent by 29 February 2004 to Président de la SPHN, Muséum d'Histoire Naturelle, Case Postale 6434, CH-1211, Genève 6, Switzerland.

The Singer Prize, of up to £300, is awarded by the British Society for the History of Science (BSHS) every two years to the writer of an unpublished essay based in original research into any aspect of the history of science, technology or medicine. The Prize is intended for younger scholars or recent entrants into the profession. The Prize may be awarded to the writer of one outstanding essay, or may be divided between two or more entrants. Candidates must be registered for a postgraduate degree course or have completed such in the last two years. Entry is not limited to British nationals. For further information, contact Paula Gould, BSHS Media Officer; Tel/Fax: 01244 680044; Paula.Gould@absw.org.uk; www.man.ac.uk/Science_Engineering/CHSTM/bshs/bshssin2.htm.

The American Philosophical Society Library Resident Research Fellowships 2004-2005. The American Philosophical Society Library offers short-term 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 8 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, his 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.

Eligibility: The fellowships, funded by a number of generous benefactors, 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 examinations, and independent scholars. Applicants in any relevant field of scholarship may apply.

Award, duration: 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, 2004 and May 31, 2005. Fellowships are usually of one month in duration, and seldom exceed two months. Fellows are expected to be in residence at the Library for four to twelve consecutive weeks, depending upon the length of their award. Awards are taxable income, but the Society is not required to report payments. It is understood that recipients will discuss their reporting obligations with their tax advisors.

Deadline, notification: Applications are due no later than **March 1**. This is a postmark deadline. Applicants will be informed by mail whether all materials were received. For additional information call 215-440-3443 or send an email inquiry to jjahern@amphilsoc.org. Notification is sent in May.

Applications: Completed applications include **six collated sets (clipped, not stapled)** of: a) the *cover sheet*, b) the *project statement*, 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; type your last name in the upper left of each page; c) your *C.V.*, and d) two *letters of support*; if the applicant is a graduate student, one of the letters must be from the dissertation supervisor. The letters can be included with the proposal in sealed envelopes, signed across the flap. The postmark deadline is **March 1**.

The Andrew W. Mellon Travel Fellowship Program is intended to assist scholars at both pre-doctoral and post-doctoral levels. The program is designed to provide travel expenses and a reasonable per diem to researchers who reside outside the central Oklahoma area, and who have well-defined research projects that can be served by the holdings of the History of Science Collections. Support is available for qualifying projects for periods ranging from two to eight weeks. It is expected that pre-doctoral applicants will be graduate students actively engaged in projects for the M.A. thesis or Ph.D. dissertation that are formally approved at the student's home institution. For information, please contact: The Andrew W. Mellon Travel Fellowship Program, The University of Oklahoma, Bizzell Library, 401 West Brooks, Room 521, Norman, OK 73019; mogilvie@ou.edu, kmagruder@ou. edu; libraries.ou.edu/depts/histscience/mellon. Proposals will be evaluated three times each year, with deadlines for submission October 15, February 15, and May 15.

Bakken Visiting Research Fellowships and Research Travel Grants: The Bakken Library and Museum in Minneapolis offers visiting research fellowships and research travel grants for the purpose of facilitating scholarly research in its collection of books, journals, manuscripts, prints, and instruments. The focus of the Bakken's collection is on the history of electricity and magnetism and their applications in the life sciences and medicine. Significant holdings include the writings of natural philosophers, scientists, physicians, electrotherapists, and electrophysiologists of the 18th, 19th, and early 20th centuries. The instrument collection includes electrostatic generators, magneto-electric generators, induction coils, physiological instruments, recording devices, and accessories. See www.thebakken.org for more details of the collections. Visiting research fellowships up to a maximum of $1,500 are to be used to help to defray the expenses of travel, subsistence, and other direct costs of conducting research at the Bakken. The minimum period of residence is two weeks. Preference is given to researchers who are interested in collaborating with the Bakken on exhibits or other programs. Research Travel Grants up to a maximum of $500 (domestic) and $750 (foreign) are to be used to help to defray the expenses of travel, subsistence, and other direct costs of conducting research at The Bakken. The minimum period of residence is one week. The deadline for all 2004 applications is February 16, 2004. For further details and application guidelines, contact Elizabeth Ihrig, Librarian, The Bakken Library and Museum, 3537 Zenith Avenue South, Minneapolis, MN 55416 (612-926-3878, ext. 227; fax: 612-927-7265; ihrig@thebakken.org; www. thebakken.org).

Smithsonian Institution Libraries Resident Scholar Programs 2005: The Smithsonian Institution Libraries (SIL) offers two programs for scholars to use SIL Special Collections for the calendar year 2005. Each program awards stipends of $2,500 per month for up to six months. Historians, librarians, doctoral students, and post-doctoral scholars are welcome to apply. Scholars must be in residence at the Smithsonian.

Dibner Library Resident Scholars will do research in the Dibner Library of the History of Science and Technology. The Dibner Library specializes in the physical sciences and technology, and contains books and manuscripts from the 15th to the 20th centuries. Subject areas include mathematics, astronomy, classical natural philosophy, theoretical physics (up to the early 20th century), experimental physics (especially electricity and magnetism), engineering technology (from the Renaissance to the late 19th century), and scientific apparatus and instruments. This award is supported by The Dibner Fund.

Baird Society Resident Scholars will do research in other SIL Special Collections located in Washington, DC and New York City. This award is supported by the Smithsonian Libraries Spencer Baird Society.

Deadline for applications is March 1, 2004. For application materials and further information about SIL Special Collections visit: www.sil.si.edu, write to Smithsonian Institution Libraries Resident Scholar Programs, P.O. Box 30712, NMAH 1041 MRC 672, Washington, DC 20013-7012 (202-357-1568), or email: libmail@sil.si.edu.

Jet Propulsion Laboratory Historian. JPL is currently looking to fill a $52,312-$105,664 salary range Historian position. The job is posted on the JPL Career site, careerlaunch.jpl.nasa.gov under requisition number 509. The JPL Historian is responsible for working with the JPL Archivist to preserve JPL's rich history, overseeing JPL's historical research program, participating in the NASA History historical research program, and supporting the JPL oral history program.

The **Space History Division of the National Air and Space Museum** is currently looking to fill a GS 11/12 curatorial position. The job is posted on www.usajobs.opm.gov under announcement number 03MH-1372.

The **National Air and Space Museum, Smithsonian Institution**, provides three residential fellowships to support research in aerospace history: **the Guggenheim Fellowship for predoctoral and recent postdoctoral scholars, the A. Verville Fellowship, open to academic and non-academic historians, and the Ramsey Fellowship in Naval Aviation History, which is similarly open.** Stipends range from $20,000 to $45,000 a year, plus money for travel and miscellaneous expenses. The application deadline for the academic year 2004-2005 is 15 January 2004, and successful applicants will be notified in mid-April. Further information can be found at www.nasm.si.edu/getinvolved/fellow/

index.cfm. Potential applicants are also encouraged to investigate the Smithsonian Institution's Office of Fellowships program. Information can be found at web1.si.edu/ofg.

The National Air and Space Museum is also offering Aviation/Space Writer Award grants of $5,000 to support research toward publication on aerospace topics. Funds may be used to support research travel and expenses, or the publication of research. Applicants for NASM or Smithsonian Fellowships are encouraged to apply for the Aviation/Space Writers Award, but recipients of the award need not be in residence at the National Air and Space Museum. The deadline for submission is 15 January 2004. For more information, see www.nasm.si.edu/getinvolved/fellow/writer_grant.cfm.

The Museum also offers the Charles A. Lindbergh Chair in Aerospace History. Senior scholars with distinguished records of publication who are working on, or anticipate working on, books in aerospace history, are invited to write letters of interest for the academic year 2005-2006 or later. The Lindbergh Chair is a one-year appointed position; support is available for replacement of salary and benefits up to a maximum of $100,000 a year. Please visit www.nasm.si.edu/getinvolved/fellow/lindfellow.cfm.

***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).

***Hydrogen: The Essential Element* by John S. Rigden** has been published in a new paperback edition by Harvard University Press.

Éditions numériques, scientifiques, et universitaires VIGDOR (www.vigdor.com, contact@vigdor.com) provides out of print books in electronic format that can be downloaded at a reasonable price from their web site. Among other subject areas, they have a selection in history and philosophy of science including books like Pierre-Simon LaPlace: *Essai philosophique sur les probabilités*.

Celebrating a Century of Flight (NASA SP-2002-09-511-HQ). This very attractive and informative 32-page, 8 1/2 x 11", color publication was edited by Tony Springer, the NASA Centennial of Flight coordinator, with input from the NASA History Office and many other organizations including the U.S. Air Force and the U.S. Centennial of Flight Commission. It was designed by Melissa Kennedy. It is an excellent introduction to aerospace history since the Wright brothers' historic flight in December 1903. It is available in hard copy by sending a self-addressed stamped envelope to the NASA Information Center, Code CMI-1, NASA Headquarters, 300 E Street SW, Room 1H23, Washington, DC 20546-0001, (202) 358-0000, please order NASA SP-2002-09-511-HQ. Alternately, it can also be found at history.nasa.gov/centtimeline in an attractive Web exhibit.

NASA's Nuclear Frontier: the Plum Brook Research Reactor (NASA SP-2003-4532), by Mark Bowles, is a short, heavily illustrated monograph about this unique Glenn Research Center facility. It is scheduled for distribution in February 2004.

"The Wright Brothers & the Invention of the Aerial Age" exhibit has opened at the National Air and Space Museum. The exhibit contains artifacts, interactive exhibits, photographs, and the Wright Flyer. For more information, see www.nasm.si.edu/galleries/gal209/wrights.htm.

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 at www.hq.nasa.gov/office/pao/History/nltrc.html.

Meetings

The **American Astronomical Society** will hold a meeting 4-8 January 2004, in Atlanta, Georgia. Their Historical Astronomy Division conducts numerous sessions during the meeting. For more information, please visit www.aas.org/meetings/aas203.

The **American Institute of Aeronautics and Astronautics** will hold an aerospace sciences meeting and exhibit 5-8 January, 2004, in Reno, Nevada. For additional information, see www.aiaa.org/calendar/index.hfm?cal=5&luMeetingid=665. The meeting will include sessions on History of Aeronautics, History of Space Flight, and Science in Space: Achievements of STS-107 and ISS Increment 6.

The **American Historical Association** will hold their annual meeting 8-11 January

2004 in Washington DC. For more information, see www.theaha.org/ANNUAL/index.cfm.

Interdisciplinary Workshop on Eddington, 11 March 2004. Contact Kate Price, kep26@cam.ac.uk.

Oppenheimer as Scientific Intellectual, April 23-24, 2004, at University of California, Berkeley, Office for History of Science and Technology, ohst.berkeley.edu/oppenheimer/conference. J. Robert Oppenheimer sensed that his life would be lived as an example – in how many ways, he could not have guessed. Raised in a cultivated Jewish milieu and shaped by the intellectual left of 1930s Berkeley, the theorist was remade as a large-scale scientific leader, a political insider, and the mid-century scientist par excellence. Coming out of the Manhattan Project, Oppenheimer's ascendancy marked a turn in American conceptions of the promise and power of intellectuals and science. Then just as his postwar apotheosis symbolized the physicists' entry into positions of power, the 1954 stripping of his security clearance defined their political bounds.

In all its dimensions, Oppenheimer's unsettled career tracks deep-lying changes in modern science. To mark the centennial of Oppenheimer's birth, the Office for History of Science and Technology at the University of California, Berkeley, is hosting a scholarly conference on April 23-24, 2004. Open to a broad range of Oppenheimer scholarship, the meeting takes as its theme his role as a scientific intellectual.

Other Oppenheimer centennial events at Berkeley include a distinguished public lecture by Daniel J. Kevles and a program in the Department of Physics. Opening concurrently with the conference are major exhibits in the Bancroft Library gallery and the Brown Gallery of the Doe Library, featuring Berkeley and Berkeleyans in the history of physics.

The Oppenheimer centennial program is open to the public.

The Canadian Society for History and Philosophy of Science will meet in Winnipeg, 4-6 June 2004. See www.fedcan.ca/english/congress/congress.html.

HOPOS 5th International Conference, San Francisco, June 24-27, 2004. HOPOS, now the International Society for the History of Philosophy of Science (no longer Working Group), will hold its fifth international congress at the University of San Francisco, in cooperation with Stanford University and the University of California, Berkeley. The conference is open to scholarly work on the history of philosophy of science from any disciplinary perspective. Submissions of abstracts of papers of approximately 30 minutes' reading length, and of symposia of three to four thematically related papers will be considered for the program.

Guidelines for Submissions: Abstracts of individual paper submissions should be between 250 and 500 words in length. Panel proposals should include one panel abstract, names and addresses of all participants, and abstracts of 250 words for each of three to four papers. All submissions should arrive by January 1, 2004. Notification of acceptance of submissions will be provided by March 1, 2004.

Preferred format for all submissions is plain ASCII text or RTF attachment submitted by e-mail to hopos2004@umkc.edu with "HOPOS 2004 Submission" in the subject line of the email. Other submissions should include one paper copy and one copy in plain ASCII or RTF format on a 3.5" DOS diskette and be sent to: Menachem Fisch, Co-Chair, HOPOS 2004 Program Committee, The Cohn Institute for the History and Philosophy of Science and Ideas, Tel Aviv University, Ramat Aviv 61390, ISRAEL

For more information about HOPOS, please visit www.umkc.edu/scistud/hopos.

***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 or to express interest, contact Frank Manasek, francis.j.manasek@dartmouth.edu.

British Society for the History of Science Annual Meeting at Liverpool Hope University, 25-27 June 2004. Contact Geoff Bunn, bunng@hope.ac.uk.

Vienna International Summer University / Scientific World Conceptions 2004: The Quest for Objectivity, 19-30 July, 2004. For information, contact Friedrich Stadler: friedrich.stadler@univie.ac.at, or see ivc.philo.at/VISU on the web.

The 2004 Meeting of the 3 Societies: HSS, BSHS, and CSHPS. Every four years, the Canadian Society for the History and Philosophy of Science, the British Society for the History of Science, and the History of Science Society come together for a special meeting. The 5th meeting of the "3 Societies" will be 5-7 August 2004 in Halifax, Nova Scotia. Proposal Deadline: December 15, 2003. Decision notices will be sent at the end of February, 2004. Primary Meeting

Email: 3Societies@hssonline.org. Program Chairs: Geoff Bunn (BSHS), Lesley Cormack (CSHPS), and Jan Golinski (HSS). Local Organizer: Gordon McOuat, University of King's College.

SHOT, Society for the History of Technology, 2004. The annual meeting in 2004 will be 7-10 October in Amsterdam. See shot.press.jhu.edu/annual.htm for more information. In 2005 SHOT will meet with HSS, 3-6 November, in Minneapolis.

History of Science Society, 2004. The HSS Annual Meeting in 2004 will be 18-21 November in Austin, TX. This is a joint meeting with Philosophy of Science Association. Information can be found at www.hssonline.org. In 2005 HSS will meet in Minneapolis, 3-6 November, colocated with SHOT. In 2006 HSS will again meet jointly with PSA, this time in Vancouver, BC, 2-5 November.

The Atomic Bomb and American Society. To mark the 60th anniversary of the detonation of the first atomic bomb, this three-day conference, 15-17 July 2005, will assess how nuclear weapons' development affected American society and culture. The conference will convene in Oak Ridge. For more information contact Prof. G. Kurt Piehler, gpiehler@utk.edu. Proposals are due April 1, 2004.

22nd International Congress of History of Science: 24-30 July, 2005, Beijing, China. See 2005bj.ihns.ac.cn on the web.

Web Resources

The Newton Project, a joint effort based at the University of London, aims gradually to post all of the scientist's previously unpublished work at a Web site (www.newtonproject.ic.ac.uk), including thousands of pages of alchemical and theological writings and, eventually, some of his optical studies. The material, which may take 15 to 20 years to finish transcribing, will be accompanied by high-resolution images of the manuscripts. The enterprise was founded in 1998 by a small group of Newton scholars who had grown tired of seeing the complete writings of other important thinkers published only as expensive multivolume editions that would invariably languish in a few academic libraries.

A new source of manuscript material concerning **Henri Poincaré** is now available on the web at www.univ-nancy2.fr/ACERHP.

The European Physical Society has a new interdivisional group on the history of physics: www.eps.org/divisions/ historyof physics.html.

The History of Science Society maintains a **guide to science history online** at www.hssonline.org/guide. This guide enables users to access information about publications, institutions, individuals, and organizations interested in science.

The **Historical Astronomy Division** of the American Astronomical Society examines science history and its implications. The organization publishes a newsletter online at www.aas.org/had hadnews.html.

The American Institute of Physics maintains an online database of collections called the **International Catalog of Sources for the History of Physics and Allied Sciences**. Interested parties may access the catalog by visiting www.aip.org/history/icos. Individuals wishing to access documents within the collections should contact the repository.

History of Physics links: The AIP Center for History of Physics posts a diverse set of web links and updates them regularly at www.aip.org/history/web-link.htm.

AAAS History and Archives Website: The American Association for the Advancement of Science has launched a new AAAS History and Archives website at archives.aaas.org.

The British Society for the History of Science has a newly redesigned and expanded website at www.bshs.org.uk. 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. An updated BSHS Guide to History of Science Courses in the UK can be found at www.bshs.org.uk/courses.

An online student guide to the History of Science titled *Horus Gets in Gear: A Beginner's Guide to Research in the History of Science*, by Professor Ronald Tobey of the University of California-Riverside is at www.horuspublications.com/guide/tp1.html. Send any corrections or suggestions to Professor Tobey at the University of California-Riverside, Department of History, Riverside, CA 92521-0204.

Nixon Administration science files, chronicling significant events in earth science, exploration, engineering, and other science fields are stored at the National Archives and Records Administration II facility in College Park, Maryland. Individuals interested in these files should visit www.archives.gov/nixon/about_nixon/historical_materials.html.

Science in Orbit: The Shuttle & Spacelab Experience: 1981-1986 (NASA NP-119, Marshall Space Flight Center, 1988) is now available at history.nasa.gov/NP-119/NP-119.htm.

Online Exhibit of Wright Brothers Papers and Images. The Library of Congress has released an online Wright brothers exhibit including diaries detailing glides and powered flight, family correspondence, scrapbooks, and drawings. The exhibit may be accessed at memory.loc.gov/ammem/wrighthtml/wrighthome.html.

NASA Educational Material Online. NASA's Spacelink website has a new Educator Focus article, this time dealing with the Wright brothers. This article provides educational materials and resources in support of the celebration of the 100th anniversary of the Wright brothers' historic flight on 17 December 1903. The article is a guide for educators and includes background material about the historic flight, and can be found at spacelink.nasa.gov/Educator.Focus/Articles/012_Wright_Brothers.

New website for Philosophy of Science Association (PSA): philosophy.wisc.edu/psa.

Dibner Institute for the History of Science and Technology

Fellows Programs 2004-2005. The Dibner Institute for the History of Science and Technology invites applications to its two fellowship programs for the academic year 2004-2005: 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: MIT, 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 2004-2005 is December 31, 2003. Fellowship recipients will be announced in March 2004. 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 2003-2004. The Dibner Institute for the History of Science and Technology is pleased to announce the appointments of the Dibner Institute Fellows for 2003-2004. The Institute will welcome fourteen Senior Fellows, seven Postdoctoral Fellows, five reappointed Postdoctoral Fellows, and eight Graduate Student Fellows. 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: dibinst.mit.edu.

<u>Dibner Institute Senior Fellows</u>

John P. Britton is President of Gryphon Research, Inc. He is the author of the articles "On Corrections for Solar Anomaly in Babylonian Lunar Theories," to appear in the volume of *Centaurus* (in press), "Remarks on a System A Text for Venus: ACT 1050," *Archive for History of Exact Sciences* 2001 (55), and, with Alexander Jones, "A New Babylonian Planetary Model in a Greek Source," *Archive for History of Exact Sciences*, 2000 (54). At the Dibner Institute he will be working on a comprehensive book about Babylonian lunar theory that includes consideration of all the more recently discovered cuneiform sources along with the previously available sources.

Ofer Gal is Head, Division of the History and Philosophy of Science, Ben Gurion University, Israel. He is the author of the book, *Meanest Foundations and Nobler Superstructures: Hooke, Newton and the Compounding of the Celestial Motions of the Planets*, 2002, the forthcoming article, "Constructivism for Philosophers," *Perspectives* and the entry, "Robert Hooke," in *Dictionary of Seventeenth Century British Philosophers*, 2000. His research proposal while at the Dibner Institute is titled "The Imperfect Universe," a continuation of his previous studies of Robert Hooke and his influence on Newton.

Robert Iliffe, Reader in History, Imperial College, U.K., is the Editorial Director of the Newton Manuscript Project. With Peter Spargo and John Young, he edited *A Catalogue of Isaac Newton's non-Scientific Papers*, 2001 and has contributed the following chapters to forthcoming works: "Persecution Complexes: the Historiography of Newton's Science and Religion," in *New Directions in the History of the Relationship between Science and Religion*, 2003, edited by J. Brooke and "An Electronic Newton" in *Recent Newtonian Research*, 2003, edited by J. Force and S. Hutton. He plans to work on two projects while at the Dibner: first, complete his book on Newton's theological writings between 1670 and 1700; and second, integrate the Newton manuscripts presently at the Dibner and the Smithsonian into the online resource managed at Imperial College by the Newton Project.

Myles Jackson, Associate Professor, Willamette University, is the author of the book, *Spectrum of Belief: Joseph von Fraunhofer and the Craft of Precision Optics*, 2000 and the forthcoming articles, "Harmonious Investigators of Nature: Music and the Persona of the German Naturforscher in the 19th Century," *Science in Context*, 2003 and "Can Artisans be Scientific Authors?" in *Scientific Authorship*, 2002. His research project at the Dibner Institute will explore the role of physicists and scientific instrument-makers in the standardization of musical pitch in 19th century Germany.

Elzbieta Jung-Palczewska is a Visiting Scholar in the Theology Department, Boston College and was a recipient of a Fulbright Foundation Fellowship, 2002-2003. She is the author of "Walter Burley, Tractatus secundus de intensione et remissione formarum accidentalium," forthcoming in *The British Academy* and "Richard Kilvington on Local Motion," in *Essays in Honor of Zenon Kaluza*, 2002. Her work at the Dibner Institute will be a study titled "Walter Charleton: Concept of the Science of Mechanics. A Transmission of Ideas from Galileo to Newton."

Irina O. Luther is a Senior Research Associate, Institute for the History of Science and Technology, Russian Academy of Sciences, Moscow. She is the author of "Metaphysics of Aristotle and kinematical-geometrical Investigations of al-Tusi and al Shirazi," *Arabic Science and Philosophy* (in press), "Incommensurability of the Circumference and Diameter of a Circle in the Context of Aristotle's Doctrine: the Works of al-Tusi and al Shirazi," *Istoriko-Matematicheskie Issledovaniya*, 2002 (7/42) (in Russian). At the Dibner Institute she will prepare a critical edition with complete English translation of the treatise, *On the Motion of Rolling and the Relation between the Plane and the Curve*, by the Iranian astronomer, mathematician and philosopher, al-Shirazi.

Rhonda Martens, Associate Professor, University of Manitoba, Canada, is the author of *Kepler's Philosophy and the New Astronomy*, 2000 and the articles "A Commentary on Genesis: Plato's 'Timaeus' and Kepler's Astronomy" in *Plato's Timaeus as Cultural Icon*, edited by Gretchen Reydam-Schils, 2001 and "Kepler's Solution to the Problem of a Realist Celestial Mechanics," *Studies in History and Philosophy of Science* 1999 (30/3). The title of her project while at the Dibner Institute is "The Best Of All Possible Worlds: Kepler's Influence on Leibniz."

Edith Sylla, Professor of History at North Carolina State University, Raleigh, is the author of the forthcoming chapters: "Creation and Nature," in *Cambridge Companion to Medieval Philosophy*, "Business Ethics, Commercial Mathematics, and the Origins of Mathematical

Probability, to be published in *Oeconomies in the Age of Newton*, and, with Alfonso Maierù, "Daughter of her Time: Anneliese Maier (1905-71) and the Study of 14th Century Philosophy," in *Women Medievalists in the Academy*. Her project at the Dibner Institute is titled "Mathematics and the Scientific Revolution: Leibniz and the Bernoullis."

Dibner Institute Postdoctoral Fellows (First Year)

Babak Ashrafi received the Ph.D. in Physics at the Institute for Theoretical Physics, SUNY, Stonybrook. His dissertation for MIT's Program in Science, Technology, and Society is titled "Interrogatory Structures in the Production of Quantum Field Theory." He has been Co-Principal Investigator and Project Manager for the Sloan/Dibner History of Recent Science and Technology Project since May 2000. For his project as a Fellow, he proposes to build on his thesis, exploring alternative attempts to reconcile relativity and quantum mechanics in the context of renormalization theory.

Peter Bokulich successfully defended his dissertation, "Horizons of Description: Black Holes and Complementarity" in December, 2002 at the University of Notre Dame. He is currently Assistant Director for the Center for Philosophy and History of Science at Boston University. At the Dibner Institute he will be working on a project titled, "The Debate Over the Consistency of (Un-) Quantized Fields, 1929-1963."

David Pantalony, who received his Ph.D. from the Institute for the History and Philosophy of Science and Technology, University of Toronto, is the Visiting Curator of Historical Scientific Instruments at Dartmouth College. He is the author of the following articles in press: "Americans in Europe: the Purchasing Trip of Ira and Charles Young in 1853," *Bulletin of the Scientific Instrument Society* and "Do Collections Matter to the History of Science?" *Bulletin of the Scientific Instrument Society* and is working on an article on the history of the standard tuning fork. At the Dibner Institute he will continue writing a book titled, "The Instruments and Workshop of the 19th-Century Parisian Instrument Maker, Rudolph Koenig (1832-1901)."

Second-Year Postdoctoral Fellows

François Charette wrote the book, *Mathematical Instrumentation in Fourteenth-Century Egypt and Syria. The Illustrated Treatise of Najm al-Din al-Misri*, 2003. A work on the descriptions of the Islamic astrolabes in the National Maritime Museum (Greenwich, U.K.) will be printed by Oxford University Press, 2004. His project while at the Dibner Institute is titled "The Visual Language of Science in Islam".

H. Darrel Rutkin, received the Ph.D. at Indiana University (2002). He is the author of the article, "Celestial Offerings: Astrological Motifs in the Dedicatory Letters of Galileo's *Sidereus Nuncius* and Kepler's *Astronomia Nova*," in *Secrets of Nature: Astrology and Alchemy in Early Modern Europe*, eds. Newman and Grafton (2001). At the Dibner Institute he proposes to develop a book on the place of astrology in premodern western science, c.1250-1750.

BOOK REVIEWS

Gerald Holton and Stephen G. Brush, *Physics, the Human Adventure: From Copernicus to Einstein and Beyond* (Rutgers University Press, New Brunswick, NJ, 2001) 582 + xv pages, ISBN: 0813529085, $39, paper; ISBN: 0813529077, $75, hard.

Reviewed by Daniel M. Siegel, University of Wisconsin-Madison

Originally published in 1952, Gerald Holton's *Introduction to Concepts and Theories in Physical Science* (Addison-Wesley) was a groundbreaking contribution to the use of historical materials in teaching physics. A second edition, substantially reworked, and with Stephen G. Brush as coauthor, appeared in 1972; and *Physics, the Human Adventure* is the third edition, again substantially revised. The lead review in *Physics Today* of October 2001 judged that, "In spite of its imperfections, this book, in its three editions spanning half a century, is one of the great textbooks of our time....It is a grand thing to have the new edition available." I heartily concur, and the task I shall undertake here will be not to present another full review, but rather to discuss some salient examples of the pedagogical use of historical materials, including examples from *Physics, the Human Adventure*, as well as some further suggestions.

Historical materials are helpful to science teaching in a variety of ways. In particular, historical materials can be useful in clarifying scientific concepts for students, in two ways: First, the originators of these concepts often supplied excellent expositions of their new ideas, which may be very helpful to the present-day student (either quoted or paraphrased). Second, in the assimilation of scientific concepts, it may be helpful for ontogeny to recapitulate phylogeny – that is, it may be helpful for the student to go through the same stages in the development of his or her understanding that the scientific community went through in the historical development of the concept.

An instructive example of successful use of the originator's own exposition is supplied by Holton and Brush's treatment of Newton's Third Law of Motion, using an example from the *Principia*: "If a horse draws a stone tied to a rope, the horse will (so to speak) also be drawn back equally towards the stone, for the rope, stretched out at both ends, will urge the horse toward the stone and the stone toward the horse by one and the same endeavor to go slack and will impede the forward motion of the one as much as it promotes the forward motion of the other" (p. 118). This example speaks to an issue that often puzzles students, namely, if A exerts a force on B, how does B know (as it were) how much force to exert back on A? The answer, in real-world situations, is that B undergoes an elastic deformation, which proceeds until the elastic restoring force exerted by B on A is equal to the force exerted by A on B. Newton's example is a bit complicated, involving at least three bodies – horse, rope, and stone; to simplify, one can have students consider instead a heavy object on a mattress, the key point in clarifying the concept being the introduction of elasticity. In this respect, Newton's exposition – and Holton and Brush's – is far superior to many a modern textbook account of the third law.

The ontogeny-recapitulates-phylogeny pedagogical strategy is quite fruitfully employed in Holton and Brush's treatment of the energy concept. The pedagogical problem addressed here is that the modern energy concept is forbiddingly abstract: The contemporary definition of energy as *the capacity for doing work* is not very helpful to the beginning student in coming to terms with this idea. Historically, however, the scientific community came to understand the energy concept, in mid-19th century, by way of two much more concrete, partial conservation laws (which in turn dated from the 18th century). The law of conservation of *vis viva* (i.e., kinetic energy, and – more generally – mechanical energy) was very concrete, measured by the power to move bodies, as in collisions; to raise bodies, as in the case of the pendulum; and to penetrate or damage bodies, as in the cases of sledgehammers, pile drivers, or cannonballs. The parallel law of conservation of heat was also understood in very concrete terms: There was the theory of a heat substance, caloric, made up of little particles, and heat flow and accumulation were visualized in terms of the flow and accumulation of these little particles. When the two partial conservation laws, for mechanical energy and for heat, were put together in the 19th century, yielding the modern, completely general energy conservation law, a much more abstract energy concept resulted; attention, however, to the roots of the abstract general law in its more concrete precursors can be most helpful to the modern student, just as it was helpful to the scientific community in the 19th century. Holton and Brush give full attention to the more concrete precursors of the general energy law, in this way helping the student to approach the more abstract modern energy law by easy stages.

By way of further suggestions of pedagogically useful historical materials, consider first the issue of centripetal and centrifugal forces in circular motion (here using "centrifugal" to designate the reaction force to the centripetal force constraining the moving body). The question of the directionality of the forces involved is perennially puzzling to students, and the usual derivations of the mv^2/r magnitude of the force tend to be quite opaque to the beginning student. Newton, in his manuscript writings, and in an alternative derivation of the centripetal force law in the *Principia*, considered the case of a ball bouncing around in a hoop, describing a polygonal path that approaches a circle as the number of sides of the polygon increases without limit. The impulsive forces that the ball exerts on the hoop at the vertices of the polygon are directed outward, and the reaction forces that the hoop exerts on the ball are directed inward; this is the picture that Newton had in mind when he was disentangling centrifugal and centripetal forces, and it is helpful to the present-day student as well. As for the magnitude of the force: one can easily see (either from the formalism or from intuition) that each impact of the ball with the hoop, at each corner of the polygon, will generate an impulsive force proportional to the product mv; the number of impacts per unit time will be proportional to v, and inversely proportional to the distance between impacts, which scales as the radius r of the hoop, yielding a proportionality to v/r for number of impacts per unit time. Composing the two proportionalities, mv and v/r, the force will be proportional to mv^2/r.

A final example, which includes a use of historical materials by Holton and Brush as well as a further suggestion: As is well known, the pre-relativistic theory of H.A. Lorentz and others, in which the behavior of bodies traveling at speeds approaching that of light was understood in terms of the behaviors of their constituent electrical particles, was an important step along the way to relativity theory; Holton and Brush discuss this, again making good pedagogical use of the recapitulation strategy. What is not so well known (and not mentioned by Holton and Brush) is that Einstein himself (for example, in the manuscript account of special relativity that Holton and Brush reproduce, in part, on their front cover) considered treatments of relativistic phenomena in terms of the behavior of electrical particles as complementary to, rather than completely superceded by, a macroscopic, relativistic account. (*The Collected Papers of Albert Einstein*, Vol 4 [Princeton U. Press, 1995], p. 64.) To the student who is mystified, for example, by the Lorentz-Fitzgerald contraction – and begs to know, What is happening inside the meter stick to make it contract? – there is precedent, in Einstein's own expository strategy, for saying, Yes, one can look at the electromagnetic forces between the particles that make up the meter stick, and by understanding how those forces are affected by motion, one can give an account of the contraction. (One would use the reasoning that goes into the Liénard-Wiechert potentials, simplified as appropriate for the given student audience.) Einstein, in his own expositions of relativity theory, was not completely inflexible concerning the supercession of electron theory by his own relativistic formalism, and students can still benefit from this more pluralistic expository strategy in approaching relativity theory. (Cf. N. David Mermin, *Space and Time in Special Relativity* [McGraw-Hill, 1968], pp. 225-227.)

In sum, Holton and Brush, in *Physics, the Human Adventure*, take a giant step forward in the utilization of historical materials in teaching physics; it is incumbent upon the rest of us to take their accomplishment as a stimulus toward the further development of this approach, rather than as the last word.

Leila Belkora. *Minding the Heavens: the story of our discovery of the Milky Way*. (Institute of Physics Publishing, Bristol & Philadelphia, 2003) x + 406 pages, notes, references, index, and B&W figures and drawings with color plate section, ISBN: 0750307307, $21.99, paper.

Reviewed by Virginia Trimble, UC-Irvine and U of Maryland

Leila Belkora's book on the discovery of our galaxy and others takes its name from a phrase used by William Herschel (1738-1822), who said that, if he were called away from the telescope, his sister, Caroline, could "mind the heavens" for him. Not surprisingly, the seven people through whose lives and works the author has chosen to tell her story are all men. The core seven are Thomas Wright (1711-1786, disk-like shape for the Milky Way), Herschel (distances to stars, types of nebulae), William Struve (1793-1874, measurement of parallax), William Huggins (1824-1920, applications of spectroscopy to astronomy), Jacobus Kapteyn (1851-1922, stellar dynamics), Harlow Shapley (1885-1972, non-centrality of the solar system in the galaxy), and Edwin Hubble (1889-1953, existence of other galaxies and expansion of the universe). Caroline Herschel and Margaret Murray Huggins (wife of William, and born the year, 1848, that Caroline died) receive extended discussions, while other women are mentioned as astronomers

(Henrietta Leavitt, Martha Betz Shapley, Annie Cannon, Williamina Fleming, and Cecilia Payne Gaposchkin) or as, mostly supportive, wives (Mary Herschel, Grace Hubble, Elise Kalshoven Kapteyn, and Emilie and Johanna Struve).

Professional astronomers should probably not be allowed to read books like this. It is simply too easy to focus in on the glitchs of arithmetic and physical principles, saying, "Merciful heavens (this is a euphemism), what on earth was she thinking of to write this?" and "Crikey (another), was I really one of the people consulted during the writing of this?" (Yes, I was, but not, I hope, on the most worrisome items.) And it is correspondingly easy to forget how many years we have put in mastering oddities like the magnitude system and the enormous dynamic range of astronomical phenomena: well, the energy of a typical supernova is 10^{68} in units of 21 cm photons. And we too make mistakes. It took me three tries during a lunchtime presentation for graduate students today to get right the ratio of neutrino to photon luminosity of a supernova progenitor just before and just after core collapse sets in (about 10^3 and 10^6, in case you should ever need this for anything).

So, yes, the wavelength shift (Doppler effect) due to a typical stellar motion is wrong by a factor 1000. The range of spectral types of normal stars is attributed to differences in abundances of trace constituents, while the real cause is differences in surface temperature. And two magnitudes of absorption is described as twice as much as one magnitude; but they are logarithmic units, in base 2.51 (the fifth root of 100). Well, I warned you one had to spend years mastering these things.

What is right in the book rather than wrong? Some ripping good stories of how parallaxes were first measured, the gaseous nature of some of the nebulae demonstrated, existence of other galaxies proven, and much else. There is one great analogy: Belkora compares aberration of starlight to raindrops hitting the windows of your forward-moving car (lots in front, few in back) rather than to the usual tipping of an umbrella forward as you walk into the storm. If you hate getting wet as much as I (and probably she – the family name is Moroccan) do, you are much more likely to have noticed the apparent direction of raindrops from inside your car than from under your umbrella.

A flock of factoids were new, at least to me. Betelgeuse might originally have meant "house of the twins" (compare Hebrew "beth") in Arabic, rather than "arm pit of the giant," as many elementary stars books say. OED, incidentally, is silent on the topic. The Baltic republics of Estonia and Latvia were called Livland when Wilhelm Struve surveyed them (1815 or thereabouts). Alexander von Humboldt coined the phrase "Island Universe" (or perhaps the German equivalent) for galaxies. The reason that heliometers (originally meant for measuring the diameter of the sun) led to successful determinations of parallax for the first time was that they could measure much larger angles than could wire micrometers, with comparable accuracy. Willem de Sitter (of de Sitter space, now popular in higher-dimensional cosmologies) was the first graduate student of Jacobus Kapteyn (whose Kapteyn universe is metonymous for old fashioned astronomy). Yerkes, who paid for Yerkes Observatory, made his money in street cars, or rather by constructing them; somehow we suspect he didn't often ride them. Radcliffe College was called something else when Henrietta Leavitt was a student there (but what?). The idea that the center of the Milky Way galaxy might be where the globular clusters seemed to concentrate, toward Sagittarius, rather than near the solar system, was advanced by Swedish astronomer Karl Bohlin (when, we wonder?) before Harlow Shapley (1918), who gets the credit, but rightly, since he made it quantitative.

Perhaps you didn't actually want to know any of these things, and, indeed (like Sherlock Holmes and the Copernican hypothesis), now that you do know them, perhaps you will do your best to forget them. Never mind, I promise there are other things in *Minding the Heavens* that will be new to you and that you will want to know.

Another subtext has just crept in, of the form "more information needed." I noted a good many of these. Some are arithmetic. Why does a parallax of 0.287 arc second correspond to a distance of 10 light years? Well, we use distances in parsecs, for which $d = (\text{parallax})^{-1}$. Some involve astronomical processes. For instance, the reader is told that stars in the arms of spiral galaxies tend to be bright, but with no indication why. The answer is that bright stars have short lifetimes and have no opportunity to wander far from their birthplaces, which are in the arms where the dense gas is. And why would one of these clouds of dense gas be called BN-KL? Becklin-Neugebauer and Kleinmann-Low, for the discoverers. Some other passages in my copy are now marked "incomprehensible," for instance the sentence saying that bar structure in spiral galaxies is "more pronounced when the galaxy is imaged using a colored filter." Yes, the color matters, and the best "color" for this purpose is near infrared.

If you are contemplating authorship of a book for real people, there is one definite action item to be found here. Many classic images and graphs have been redrawn (perhaps to avoid copyright problems?), and redrawn very badly, making the Doppler shifts of stars look like a redshift of about two (Fig. 6.5), completely obscuring the fact that the globular clusters are concentrated toward the center of the Milky Way, which is what allowed Shapley to reach his conclusions (Fig. 10.3), and many others. Do not let the publisher do this to your book!

Should professional historians of science be allowed to read books like this? Also probably not, for they will be equally distressed by careless errors in their domain (even I caught several handfuls). And they are less likely to be enchanted by the storytelling than we who come with the naive feeling that what really matters is getting the right answer to scientific questions so as to be able to go on to the next. In this case, perhaps it is "What happened before the big bang?" And the author is, I believe, young enough that one of her subsequent books might well be able to incorporate the story of answering that question. I look forward to reading it!

Per F. Dahl. ***From Nuclear Transmutation to Nuclear Fission, 1932-1939***. (Institute of Physics Publishing, Bristol & Philadelphia, 2002) xii + 304 pages, notes, bibliography, 2 indexes, and black and white figures and drawings, ISBN: 0750308656, $75, hard.

Reviewed by Jean-François S. Van Huele, Brigham Young University

Maybe one day the twentieth century will be known as the century of nuclear physics. It is certainly difficult to name one area of physics that has done so much over the last hundred years to catch the attention of everyone from scientists, politicians, journalists, authors and thinkers to the general public.

It was the nucleus that brought the news of the relativistic and the quantum revolutions to the world. The nucleus confronted physicists with their responsibilities and modified their role in society significantly. For better or for worse the nucleus propelled physicists into the limelight and it has turned the story of their life and work into a topic of scrutiny and fascination ever since. Not surprisingly, a great many books have been written and will continue to be written on the subject.

Nuclear physics of course is a vast topic with many interesting subfields. From the discovery of radioactivity just before 1900, through Rutherford's actual discovery of the nucleus, and the phenomenal advances in our understanding of nuclear structure and nuclear reactions, nuclear physics has given us new insights from particle physics to stellar evolution and many applications in imaging, medicine, energy production, and warfare, leaving the world in 2003 with critical nuclear issues to be dealt with. For this to happen, scientists at some point had to take control of nuclear physics by switching from passive experimentation using available radioactive sources to the activation of particle accelerators with high enough energies to cause nuclear reactions.

This critical transition, Per F. Dahl tells us in his book *From Nuclear Transmutation to Nuclear Fission, 1932-1939*, happened on April 14, 1932 when John Cockroft and Ernest Walton spotted scintillation flashes of alpha particles whilst bombarding a lithium target with 252 kV protons in Cambridge's Mond Laboratory:

> Cockroft (...) rang up Rutherford, who arrived shortly afterward. With difficulty he manoeuvred in the little hut, and he, too, had a look at the scintillations (p. 114). *He shouted out such instructions as "Switch off the proton current! Increase the accelerating voltage!, etc. but he said little or nothing of what he saw. He ultimately came out of the hut, sat down and said something like this: "Those scintillations look mighty like alpha-particle ones. I should know an alpha-particle scintillation when I see one for I was in at the birth of the alpha-particle and I have been observing them ever since."*

In the last (italicized) statement Dahl quotes Mark Oliphant's 1972 *Recollections of the Cambridge Days* (Elsevier).

In the Prologue of Dahl's book, this momentous event is related to the opening of the play "Wings over Europe" in London a few days earlier. In the play the release of atomic energy by a young physicist has far-reaching philosophical implications and political consequences. Dahl's further story illustrates how in this case the reality not only paralleled but surpassed the fiction in dramatic effect.

If nuclear physics has a rich and well documented history full of major breakthroughs, fascinating anecdotes and important insights, how does a scholar who competes for the time and attention of potential readers select a unique subject and find the appropriate niche?

For the book reviewed here, there is no clear choice.

The title refers explicitly to the years 1932-1939, the period when physicists studied nuclear reactions with accelerators as well as radioactive sources. It is ironic that whereas physicists at the time may have perceived this period as a race for creating transuranic elements, it turned out after the fact to have been a struggle for the discovery of fission. An interesting analysis of this surprising discovery process can be found in Ruth Lewin Sime's article (*Physics in Perspective* **2**:48-62, 2000). The protagonists in that story (Lise Meitner and Otto Hahn in Berlin, Irène and Frédéric Joliot-Curie in Paris, and Fermi's group in Rome) are also present in Dahl's book in later chapters but mostly (although not exclusively) for the purpose of discussing the reaction of American laboratories to the fission news.

The book's jacket and the author's preface present the central theme as an earlier race (~1928-1932) between four different laboratory teams: John Cockroft and Ernest Walton in Cambridge, Ernest Lawrence in Berkeley, Merle Tuve in Washington, and Charles Lauritsen in Pasadena, in their search for high voltage accelerators to overcome Coulombic and nuclear repulsion and penetrate the nucleus in a bold move to verify George Gamov's prediction of tunnelling.

The book itself starts much earlier still with Marsden and Rutherford's 1919 achievement of artificial transmutation and discovery of the presence of hydrogen ions inside nuclei, a result of Rutherford, Marsden and Geiger's 1909 celebrated alpha particle investigation of gold foils.

From the towering presence of Rutherford, his many students and collaborators in Cambridge, to the presentation of the members of the American teams, the book follows the evolution of nuclear physics in general and the rapid development of mostly experimental physics in America in the twenties.

The *annus mirabilis* of nuclear physics, 1932, which witnessed, besides Walton and Cockroft's experiment, the discovery of the positron by Carl Anderson, the publication of the discovery of deuterium by Harold Urey, and the discovery of the neutron by James Chadwick, is covered in dramatic detail.

Once the different types of accelerators were operational, they could be used for fundamental research and many applications were found and discoveries confirmed, fission being just one of them. Finally the last two chapters of the book deal with what happened after 1932 to the people, the teams and their machines.

In fourteen chapters Dahl gives us a coverage of nuclear physics that stretches in space and time far beyond what the reader might have expected. If there is a focus in the book, it would have to be the dynamics of the research teams: we learn how they were formed, how they interacted, and ultimately achieved or didn't achieve what they set out to do. The teams take precedence over the individual scientists, but teams only exist as a result of the machines that they build or dream of. Therefore the author goes into some very detailed descriptions of the apparatus used in the different experiments. His priority is appropriately reflected in his choice of illustrations for the book. We only find two traditional portraits of physicists, but we discover six pictures of physicists in the proximity of their (impressively large) apparatus, and also one (uranium fission) group picture which is nicely analyzed in the text (p. 202). Sixteen drawings of the experimental designs are included. Some sketch the principles behind the apparatus and some are detailed illustrations taken from the relevant publications. A large quantity of apparatus specification is given in the text and whereas some of it, like the cyclotron diameter, is critically important, it is not always clear to the reader why certain facts were selected over others. As one example, we learn in the epilogue (p. 217) that the optical components of a solar observatory that Odd Dahl worked on after the war were provided by Zeiss in West Germany. Does the author mention this because it has some deeper significance? The accumulation of what seems to be disconnected trivia does eventually detract from the story line. Presumably a lot of this information could have been made available in comparative tables and charts in a series of appendices. Such a compilation would probably have led to further insight and would certainly have facilitated the retrieval of the information.

Of course team members were also individuals and Dahl gives us some biographical data and some character description of the main players: we learn, for example, about Rutherford's constant penny-pinching and about Lawrence's touchiness when embroiled in scientific controversy. We encounter quite a few funny (or maybe not so funny) anecdotes such as the story of the two Berkeley mice: The first mouse was fed a most expensive cocktail of heavy water for the purpose of studying the effect of isotopes on living organisms. It survived against all odds. The second mouse, housed in a little box of the cyclotron wall, died after five minutes of neutron bombardment due to ... lack of air in the box!

An intriguing facet of this book is the presence of a large number of physicists of Scandinavian origin whose major contributions to nuclear and accelerator physics in America are either not very well-known or whose Scandinavian origin is not generally recognized.

The main protagonists, Lawrence and Tuve, share Norwegian origins and a South-Dakota childhood, and we discover many more physicists (Lauritsen, Anderson, Rolf Wideröe, whose original ideas led to the cyclotron, team members Odd Dahl, Philip Abelson, Lawrence Hafstad) as well as several less important characters with Scandinavian roots.

However the author does not tell us whether he sees any significance in this concentration of Scandinavian talent in American nuclear physics or whether it is just coincidental. Indeed the scientists comprise a mix of second generation and first-generation Americans, immigrants and temporary immigrants, and it is not clear to what extent their common Scandinavian background created bonds or facilitated their collaboration. Neither does Per Dahl choose to acknowledge in the text or in the preface his relationship to the Washington team member Odd Dahl ("a curious fellow, indeed", p. 43) or any precious insight that this connection may have added to the manuscript.

The author has consulted a vast literature of primary and secondary sources listed in forty-three pages of notes and references at the end of the book. His previous books covering related topics, *Flash of the cathode ray. A history of J.J. Thomson's electron*, (I.O.P. Publishing, Bristol, 1997), and *Heavy water and the Wartime race for Nuclear Energy* (I.O.P. Publishing, Bristol, 1999) and his colloquial writing style ("What about our British friends in all of this?" p. 211) make it clear that he is very comfortable with his subject and emotionally engaged. The eighteen-page name index and the twelve-page subject index will certainly help in locating the information.

We are fortunate that Dahl has collected so many facts and sources of information about a truly fascinating period in the development of modern physics. His lively writing and the many surprising turns of the story will help the reader navigate through the abundance of detail. The book should be keenly enjoyed by everyone who likes to view progress in physics as one big (and mostly friendly) competitive team game.

In the final four paragraphs of the text, the author summarizes his opinion as to why the Cambridge team was first to produce nuclear reactions using man-made accelerators. It is left to the readers to analyze the significance of this race and indeed of this whole tale of scientific discovery. In closing the book, thoughtful readers will reflect on the changes that have occurred in the scientific enterprise since the days of Rutherford and Lawrence, and they may wonder how many similarly dramatic developments physics has in store for the twenty-first century.

Tony Jones. *Splitting the Second*. (Institute of Physics Publishing, Bristol & Philadelphia, 2000) 216 pages, 50 cartoons, 15 photos, ISBN: 0750306408, $22.99, paper.

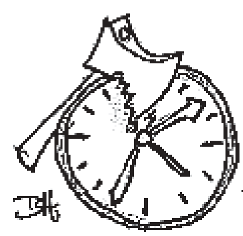
Reviewed by Donavan Hall, Assistant Editor, Physical Review Letters

Most of us take time for granted. If we need to know what time it is, we look at a convenient clock. Whatever that clock says is what time it is – unless we have some way of comparing that clock with some other clock. If two clocks read different times, we must decide which one to trust. In our low temperature lab we would joke that an experimenter with two thermometers never knows what temperature it is. The situation is similar with clocks. We have at least ten clocks throughout our house and none of them read the same time.

About ten days ago, my wife and I drove a friend to the train station in Port Jefferson. We were in my wife's car which has an analog clock built into the dashboard. I remarked, after consulting that clock, that we were "cutting it close." My wife then cast doubt on the accuracy of the clock. "It runs about five minutes fast," she said. My reply was that the Long Island Rail Road seemed to run about five minutes slow, so my friend was in no danger of missing his train.

My wife and I might be able to live with a five minute error in our clocks. However, in various laboratories throughout the world, scientists and engineers take great pains to determine and keep the time accurately to 3 parts in 10^{15}. Who needs that kind of accuracy?

Historically, determining and keeping the time has been the purview of the astronomers. After all, the changings of the days, months, and seasons were signaled or accompanied by corresponding changes in the heavens. The astronomical monopoly on time keeping began to crumble when mechanical clocks were developed to solve the problem of "taking time with you." Readers of Dava Sobel's incredible book *Longitude* [1] will be aware that John Harrison's sea clocks were both accurate enough and stable enough to solve a longstanding problem in naval navigation. The end of the astronomical standard for timekeeping came in the twentieth century, when physicists started applying their knowledge of the atom to the problem of accurate time keeping.

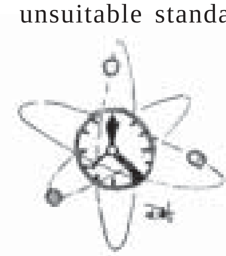


Tony Jones' book entitled *Splitting the Second: The Story of Atomic Time* is (as he announces on the first page) "not primarily a history of the atomic clock but an account of timekeeping today." [2] Indeed the first two chapters give a fascinating account of how time has been measured and the problems with the timekeeping methods that drove the development of better clocks. Jones' discussion of the geophysical mechanisms that conspire to speed up and slow down the Earth's rate of rotation is captivating. Each advance in timekeeping led to some new insight about the physics of our spinning planet. He establishes the theme that runs through his book – that accurate clocks are measurement tools that help scientists discover new and understand known physical phenomena. I might not need to know the time to better than five minutes, but by determining time to 3 parts in 10^{15} I could (amongst other things) do a number of experiments to check the special and general theories of relativity. Jones provides plenty of examples of how accurate measurement of time has led to a better understanding of physical phenomena.

One of the issues raised in Jones' book that puzzled me the most was the problem of establishing standards for measurement. Determining just how long a second really is (once one begins to appreciate the subtleties) can begin to seem like the Munchausenian task of lifting oneself by one's own bootstraps.

How long is a day? Every culture throughout the history of humanity has agreed that a day is the length of time it takes for the Earth to undergo one complete rotation. Simple? Not really. As Jones shows, the length of the solar day varies by as much as 30 seconds (either fast or slow) throughout the year. Not a big deal if you are like me and have clocks that are five minutes off anyway. But 60 second swings in the length of the day translate into significant timekeeping errors when those errors are compounded over many years.

The seasonal variation of the length of the solar day is only one of many factors that make the rotation of the Earth an unsuitable standard for accurate time keeping. Jones carefully explains them all. However, abandoning the Earth as the time standard introduces additional problems. When the second was defined in terms of the transition between two hyperfine levels and the ground state of the cesium-133 atom, this "atomic time" and solar time would always be out of step, so measures had to be taken periodically to insert (or, in principle, remove) seconds as necessary to keep atomic time and solar time in some agreement. Jones devotes an entire chapter to this issue of inserting "leap seconds" to keep atomic time and solar time in rough agreement.



The motivation for accurately determining the time is clear in terms of our human need for improving technologies. As in John Harrison's day, accurate time keeping is essential to navigation. The famous GPS or global positioning system is a system of satellites that broadcast accurate time. By determining the delay between the signals from several GPS satellites, one can determine one's position on the Earth's surface to with a few meters. While human desires and needs drive the development of time keeping technology, the standards we have adopted for measuring time tell us more about humanity than about nature. Ken Alder in his book *The Measure of All Things*, an account of the effort to establish the meter as a length standard, writes: "Our methods of measurement define who we are and what we value." [3] The modern movement (beginning with the Enlightenment Philo-sophes) to establish natural standards demonstrates a remarkable shift in how we humans view ourselves.

Units of measurement prior to the 17th century could be highly idiosyncratic and arbitrary. Establishing a natural standard for measurement was thought to be less arbitrary and more democratic – as Jones says, units "for all people, for all time." But the shift from an astronomical timekeeping standard to an atomic standard represents an even more radical shift in human self perception. Physics came of age in the twentieth century with advances in recognizing and understanding the nucleus and the atom. This understanding was demonstrated clearly and powerfully to the world in August of 1945. From that time on, it is tempting to speculate that the shift to an atomic standard for timekeeping was inevitable.

Jones sets out to tell the story of modern timekeeping. On the whole, Jones successfully informs the reader about the sequence of technological advances in timekeeping and what issues drove those advances, but Jones never ventures too far into human concerns. Unlike many of the more popular accounts of horology and metrology (like Sobel's *Longitude* and Alder's *Measure of All Things*), Jones avoids telling us anything about the people who were behind the technological advances. We learn from Jones all about atomic clocks, but not much about what makes the scientists themselves tick. Not that this is a major defect. This fact reveals the intended audience for *Splitting the Second*. For someone with a Ph.D. in physics, Jones' book is a quick and interesting read. He succinctly presents physical explanations for the workings of different kinds of atomic clocks and weaves a compelling, detailed account of the difficulties of keeping accurate time. Jones' explanation of how to "transfer time" from one place to another prompted me to leap up out of my armchair and dig my old shortwave radio out of the basement so that I could tune into WWV for an up to the minute update of the US version of Universal Coordinated Time. For the first time in my life I actually understood what UTC was and how it was determined.

Jones' book probably will not interest the casual reader who is easily put off by technical descriptions. Although the technical descriptions themselves tend not to be detailed enough for the reader trained in physics to attempt any calculations of their own. Jones provides a taste of the physics – without the equations. I don't want to give the impression that the casual reader would not be able to follow Jones' book. Jones has written his story of timekeeping in a way that is accessible to the general public, but the presentation lacks those human interest elements that make for a popular science bestseller (if there is such thing).

[1] Dava Sobel, *Longitude* (Walker Publishing Co., 1998).

[2] Tony Jones, *Splitting the Second: The Story of Atomic Time* (Institute of Physics Publishing, 2000).

[3] Ken Alder, *The Measure of All Things: The Seven-Year Odyssey and Hidden Error that Transformed the World* (The Free Press, 2002), p. 2.

Sean F. Johnston, *A History of Light and Colour Measurement: Science in the Shadows* (Institute of Physics Publishing, Bristol & Philadelphia, 2001) xi + 281 pages plus (sparse) drawings and B&W photographs, ISBN: 0750307545, $56 hard.

Reviewed by Virginia Trimble, UC-Irvine and U of Maryland

Johnston begins with Astronomer Royal George Airy (the guy who failed to look for Neptune) on the Ides of March 1858, urging his fellow countrymen to find out by how much sunlight is reduced during an annular eclipse by trying to read *The Times* at various distances from their eyes before, during, and after the event. He ends with an "Undisciplined Science" of "Declining

Fortunes" in 1980, when the Illuminating Engineering Society of London merged with the Chartered Institution of Building Services. A few items come from both earlier and later times, but his focus is on the period from the 1890s to World War II, when commercial and then military interests drove the need for improved, repeatable measurements of the properties of light and color. If you were buying a certain amount of illuminating gas for your factory or dye stuffs to continue producing successful camouflage uniforms, you wanted to be sure you would get what you were paying for. The author has worked as a physicist in industry, but is now primarily engaged in history of science.

The frustrations of reading the book are surely a good match to the frustrations experienced by the practitioners of photometry, colorimetry, and radiometry over the past 150 years. Both as an astronomer and as the daughter of a color cinematographer, I expected a much more quantitative treatment than is given. It may annoy you every time you are reminded that the radio astronomer's unit, the Jansky, is 10^{-26} W m^{-2} Hz^{-1} sr^{-1}, but at least we can think it probably means that they know what they are measuring. "Quantity of light", defined as "the light reaching either the human eye or the variety of physical detectors that have come into use since 1870" and similarly purely verbal definitions of illuminance, radiance, and spectral flux leave me much less certain about the author. The three standard attributes of color (hue, saturation, and brilliance or intensity) are neither defined in any obvious place nor indexed for the hunt.

Interesting surprises included how large a role astronomy played in the early years of photometry and how very similar all international scientific unions seem to be. Nearly half the indexed names belong to recognizable members of our astronomical tribe. The compromise definitions adopted by the Commission International de l'Eclairage (reconvened after World War I, without the Germans, of course) could have come from any resolution adopted by the International Astronomical Union over the past 85 years. And William Henry Fox Talbot (the inventor of the photographic negative) was a very clever chap indeed.

An enormous amount of hard-gained information has gone into this volume, as exemplified by more than 900 footnotes, many of them extracted from industrial sources, whose history we are all just beginning to appreciate. But, like the poet, I have come back out the entrance door, not having replaced Father's definition of "white" (a clean piece of paper outdoors on a sunny day) by anything more quantitative. (cf. J.M. Overduin, AJP **71**:216-219, 2003). Anyhow I do now understand why, as late as the 1950s, the purveyors of colored gels for theatre and sound stage lighting sent booklets of swatches, rather than lists of the available colors!