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HISTORY of Physics NEWSLETTER

Trolling with PROLA

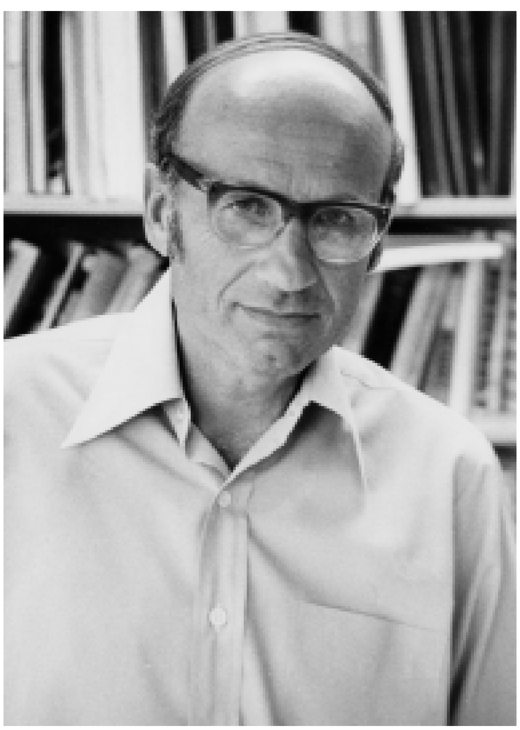
–Benjamin Bederson, Forum Chair

The history of physics and the practice of physics are closely intertwined, a not particularly surprising or original observation. There are many reasons for this connection, among them being the fact that physics as a modern scientific enterprise is young enough so that many physicists who are active today have had careers that stretch back to about half the duration of what one might call modern physics.

This relation is especially evident when we head to the library and start working our way back through the literature as we try to trace the precursors of some topic of current interest, acting in either a history or a research mode. Doing this by going to the stacks and pulling out older and older volumes eventually becomes more of an endurance challenge than a scholarly activity. Electronic journals and linkages will eventually change all this, provided such tricky matters as copyright protection and reprint fees can be worked out. That is, there are no fatal technical roadblocks to this wonderful future, although there are potentially serious ones of a nontechnical nature. Ignoring the nontechnical problems for the moment, it will become possible eventually to click on any reference and work one's way backwards through as many forks in the road, and as far, as we like, through any journal by any publisher which gives us permission to do so. We are not there yet, but there is a dramatic specific illustration of the shape of things to come, one for which APS physi-

FORUM ELECTION

Forum Councillor Election information is contained in this *Newsletter*. Please vote for a Forum representative to the APS Council for the next four years. If you have email registered with APS, you will have received a message inviting you to vote on the internet, as authorized by the FHP Executive Committee last year. If not, you should have received a paper ballot by mail. If you want a paper ballot but have not yet received one, please email your request, including your mailing address, to fhp_ballot@byu.edu or contact Prof. Bill Evenson, Department of Physics, Brigham Young University, Provo, UT 84602, 801 378-6078. **Ballots must be returned so they can be received by November 28**. Brief resumes and statements from the candidates are printed later in this *Newsletter*.



Walter Kohn, courtesy AIP Segre Photo Archives

Walter Kohn, recipient of the 1998 Nobel Prize in Chemistry, gave a beautiful talk on personal recollections of the history of density functional theory in a symposium organized by the Forum at the APS March 2001 Meeting in Seattle. See a report of the talk and the session in this issue.

INSIDE

cists should feel especially proud. This is the so-called PROLA archive, *Physical Review On-Line Archive,* which allows access to the entire *Physical Review* family of journals back to Volume 1, Number 1 of *Physical Review*, Series I, in 1893.

PROLA can be accessed either directly, via aps.org, or through one's own institution's online library. The sought article will appear either as a scanned image, Adobe PDF, or other equivalent means. Even without a subscription, anyone can call out abstracts and the citation list of referenced APS articles, and also articles appearing on the Los Alamos archives. By this means one can work one's way backward in time until citations to *Physical Review* journals run out. Eventually, we are promised, access will also be possible to *forward* articles of the authors, in addition to other mouth-watering enhancements.

Of course any scheme which repackages old information, such as PROLA, does not add new information. One could in principle accomplish anything PROLA can by using large amounts of shoe leather and some hefty carrying (though not some of the present or future search capabilities). But in practice exhaustion would eventually trump zeal. An additional bonus in using PROLA, I have found, is the surprising fact that a significant number of citations in references are incomplete or even wrong. Also, earlier editorial standards were much more relaxed than they are now; sometimes initials of authors in references are missing, sometimes even the authors' names are missing. PROLA makes it much easier to ferret out the correct reference, using its search capabilities. I have been playing a little game using PROLA – picking on a recent article of some particular interest to me, and working my way through linked references to see how far towards the first issue of *Phys Rev* Series I, published in 1893, I could go. I did not succeed in getting to the first issue, which did not contain especially memorable contributions. Recall that using APS journals alone we are severely handicapped by the fact that our journals only gradually became world-class. At first it reflected the level of physics activity in the US alone – with a few noteworthy exceptions. US physics only caught up with European physics relatively late in the game, aided of course by the exodus of European scientists before WWII. All of this is well-described in the informal but informative history of *Physical Review* by Paul Hartman, written to commemorate the Centenary of its founding in 1893 [*A Memoir on the Physical Review*, Paul Hartman, jointly published by APS and AIP, 1994].

Professor Hartman describes the scientific content of early issues. Many important discoveries are contained in these, but *Physical Review* did not really establish itself as a world-class physics journal until at least the second decade of the 20th century. It was then that such American physicists as Compton, Milliken, Michelson, Bridgman, Davisson, and Langmuir, to name but a few, began to publish regularly in *Physical Review*. As I worked my way backwards through citations, I found that I would end up almost invariably with a paper by one of these famous physicists, and in going to their first papers I would hit a blank wall – reference lists, which were sometimes quite long, almost all referred to other journals, even taking into account the youth of *Physical Review* at the time. Accordingly, we still have to wait for a more general version of PROLA if we are to successfully accomplish a complete literature search while remaining seated at our PC. Still, what we have already is a wonderful new tool.

Now for the bad news. The publishing industry, perhaps understandably, is far from enthusiastic about this glittering potential. The Association of American Publishers is taking a tough position on easy accessibility to already published books and articles. Commercial publishers are certainly more aggressive on this issue than non-profit, society publishers. For a short discussion of the developing confrontation between publishers and libraries, see the article "Looting the Library" by S. Shulman, *Technology Review* (MIT) **104**:37, 2001.

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. The Forum also has reciprocal arrangements with History of Science Society, Philosophy of Science Association, and HOPOS. Others who wish to receive it should make a donation to the Forum of $5 per year (+$3 additional for air mail). Each 3-year volume consists of six issues.

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Editor's Note

Perspective

An acquaintance with history, real history with its loose ends and blind alleys, brings perspective to any discipline. The history of physics is no exception. For example, studying the history of quantum mechanics has helped me gain perspective on the connections between quantum mechanics and optics and between quantum mechanics and classical mechanics, well beyond the usual physics textbook level. In addition to specific questions of physics, I have learned much of what I know about the practice of physics from careful attention to history of physics, and the history has influenced my own practice of physics.

Perspective is essential to progress, to seeing where to go and what paths might be productive. An example of its absence is shown in this amusing (but devastating) book review by E. A. Guggenheim, *Transactions of the Faraday Society* **38**:120 (1942) (quoted in *Seeking Ultimates* by Peter Landsberg; see review below).

Text-book of Physical Chemistry. By Samuel Glasstone. (Macmillan, 1940. Pp. 1289. 42s.)

In a certain city a councillor with grandiose ideas conceived the curious desire of having a picture of the whole city painted on a single canvas. The city indeed contained many fine modern buildings as well as older buildings of historical interest, of which good pictures already existed. But these did not satisfy the councillor, who insisted that he should have one complete canvas of the whole city; every building large or small, ancient or modern, beautiful or ugly had to be included. It is surprising that any painter could be found to attempt the task. Eventually, however, a certain traveling artist, who happened to be paying a visit to the town councillor, undertook the task of painting the whole city on a single canvas. He used a very large piece of canvas and he worked hard for two whole years, painting so many buildings each day and even working over weekends. At last his task was completed and true to his word every building, large or small, ancient or modern, beautiful or hideous, useful or useless, was included on his canvas, but the product of his toil was not a picture because he had omitted to pay any regard to perspective. The name of the city was physical chemistry and the name of the painter Samuel Glasstone.

-E. A.G.

Because history is so powerful in helping us gain perspective, it should be an important part of both teaching and research experience. And it must be history founded in reality, not in the cleaned up and idealized versions that we sometimes construct to bolster our self-importance. The Forum contributes significantly to that history of physics that brings perspective, through the symposia it sponsors and the reports in this *Newsletter*. These symposia sometimes stimulate writings by participants in the history. Some are recorded in audio or video. There is a journal, not associated with the Forum but available at a discounted rate to APS members, that is dedicated to, as its title declares, putting *Physics in Perspective*. I encourage all our readers to promote history of physics and explore the perspectives it brings in your own teaching, research, and other professional activities.

Note: I renew the invitation to readers to share particular experiences in which the history of physics has helped to make a course effective, has enhanced a research effort, or has contributed to communicating science to the public. And please continue to send brief notes about your current history of physics activities.

Anniversaries for 2002

1752 - Benjamin Franklin's invention of the lightning rod and d'Alembert's formulation of principles of hydrodynamics. Birth of Adrien-Marie Legendre.

1802 - William Herschel's discovery of a binary star system in constellation Castor, Gay-Lussac's demonstration of his law, Romagnosi's discovery that electricity passing through a wire will cause a magnetic needle to orient itself perpendicular to the wire, and Thomas Wedgwood's first photographic image.

1852 - Foucault's invention of the gyroscope, Joule and Thomson's demonstration of the Joule-Thomson effect, and George Stokes's coining of the term "fluorescence" for the glow observed in cathode-ray tubes. Birth of A. A. Michelson, Henri Becquerel, and John H. Poynting.

1902 - Marie Curie's purification of sufficient radium to establish its atomic weight, Rutherford and Soddy's demonstration of the radioactive decay families of uranium and thorium, and Lenard's experiments establishing the nature (but not yet the explanation) of the photoelectric effect. Birth of Dirk Brouwer. Death of Marie Alfred Cornu and Ogden Nicholas Rood.

1952 - Walter Baade's discovery of an error in the Cepheid luminosity scale, showing that other galaxies are about twice as far away as previously thought, Blaauw and Herbig's discovery of evidence for ongoing star formation in the Milky Way galaxy and Schwarzschild's investigations of signs of stellar evolution in globular clusters, Ghiorso and coworkers' discovery of the element einsteinium, Danysz and Pniewski's discovery of the K meson and the lambda particle, and the US detonation of the first hydrogen bomb (November 1, 1952). Death of A. A. Andronov and Hendrik A. Kramers.

Reports

New AIP Report Shows That Documenting Large-Scale Science Is Different

Those responsible for preserving the record of scientific research must take into account dramatic changes in its organizational structures. The multi-institutional collaboration has become the organizational structure of choice in a number of fields of science and engineering. Instead of evaluating the contributions of a scientist as an individual researcher, or the records of a research project conducted by one institution, archivists are confronted with the records of collaborations that may continue for a decade before disbanding and involve multiple institutions, disciplines and even nations. This does not necessarily mean more work for archivists and others responsible for records. But it does mean they need to understand how the new organizational structures affect the creation and use of records.

To help find solutions, the Center for History of Physics of the American Institute of Physics has issued *Documenting Multi-Institutional Collaborations*, the final report of its decade-long study of multi-institutional collaborations in physics and allied fields. The main goal of the project was to learn enough about these transient mini-institutions to be able to advise how to document them. The study was built on interviews with over 600 scientific collaborators; numerous site visits to archives, records offices, and federal agencies; and advice from working groups of distinguished scientists, archivists, records officers, historians and sociologists. The study group gathered and analyzed data on characteristics of collaborations such as their formation, decision-making structures, communication patterns, activities and funding.

The final report consists of three parts: Findings (Historical-Sociological and Archival) of Field Studies by AIP, Appraisal of Records Created, and Current Archival Practices and Project Recommendations. Archivists and records officers may find most valuable the fact that we provide three approaches to appraisal: a typology of collaborations, a functional analysis of records creation, and the more standard appraisal guidelines. The section on archival practices assesses the capability of saving adequate documentation of collaborations in academic archives, federal agencies, and corporate archives. Project recommendations are addressed to research centers, to federal funding agencies, and to the National Archives. The several appendices include a bibliography of selected readings.

The full final report, *Documenting Multi-Institutional Collaborations*, is accompanied by *Highlights and Project Recommendations*, which provides excerpts from the full report and a set of recommendations. Both reports are available upon request from the AIP History Center, One Physics Ellipse, College Park, MD 20740-3843; 301 209-3165, fax: 301 209-0882; chp@aip.org. These and other project reports will also be found at www.aip.org/historypubslst.htm#collabs.

The long-term study was funded by the AIP, the Andrew W. Mellon Foundation, the National Science Foundation, the National Historical Publications and Records Commission, and the Department of Energy.

Research Notes

Dan Greenberger (greenbgr@scisun.sci.ccny.cuny.edu) reports that an Austrian project is underway to produce a history of physics emigres from the 1930s to 1950s. They will consider what Austria lost with the emigration. They would be interested in collaborating with US historians regarding the US experience of emigres who came to this country.

Don Woessner (donald.woessner@utsouthwestern.edu) has written in support of the suggested need for work on the history of the development of MRI by an interested historian of physics (see February *Newsletter*). He published an article, "The Early Days of NMR in the Southwest," in the March 2001 issue of *Concepts in Magnetic Resonance* (**13**:77). A significant part of his history dealt with the most important driving force for the commercial development of NMR in the very early 1950s: the use of NMR to discover petroleum (NMR well logging) and the use of NMR to analyze mixtures of hydrocarbons in petroleum. (The first use resulted in the purchase for $370M in 1997 by Halliburton of the NMR well logging venture capital company NUMAR. This indicates that NMR well logging is probably, compared to MRI, the second most important single application of NMR technology, aside from the multitudinous routine chemical analytical uses.) The November 2001 issue of *Concepts in Magnetic Resonance* is a topical issue on "The History of NMR Well Logging" with Jasper Jackson as lead author, with a long set of articles describing much interesting NMR history, physics, and technology. For example, it gives the latest (licensed) development: an NMR machine that rotates at 180 rpm in an oil well on a drilling tool in a borehole (i.e., logging while drilling, a long sought-after capability) a mile or two beneath the earth's surface!

In 1996 the *Encyclopedia of NMR* was published by Wiley (eight big volumes). The first volume was a very brief history by Ted Becker of the technological development of NMR, followed by several hundred autobiographical articles by the early NMR researchers, a gold mine of historical information about the field. Woessner notes that much remains to be written of this history, not the least of which is the history of MRI.

Memorial Session honoring Louis Néel, 31 May-1 June, 2001, Grenoble. This memorial session, held at the Louis Néel Laboratory, featured a talk by Bernard Barbara, Director of Research at Louis Néel Laboratory, "The Work of Louis Néel," eulogies by Daniel Bloch and Michel Soutif, "Louis Néel and the training of engineers at Grenoble" by Eric Robert, and "Louis Néel and the industrialists" by Roger Moret and Eric Robert. Some summary information is available on the web at ln-w3.polycnrsgre.fr/neel.html. The talks (in French) have been printed, and copies may be available from the Louis Néel Laboratory (see their web site).

Foundations of Chemistry, a journal for philosophical, historical, educational, and interdisciplinary studies of chemistry, published a special issue on the periodic system of the elements, Vol. 3, No. 2, 2001. Articles include "Argon and the Periodic System: the Piece that Would not Fit" by Carmen J. Giunta, "The First Subatomic Explanations of the Periodic System" by Helge Kragh, "What and How Physics Contributes to Understanding the Periodic Law" by V. N. Ostrovsky, and "Bibilography of Secondary Sources on the Periodic System of the Chemical Elements" by Eric R. Scerri and Jacob Edwards.

FHP Symposia

History of Electronic Structure Theory in Atoms, Molecules, and Solids. APS March Meeting, Seattle, 14 March 2001. This symposium was cosponsored by the Division of Materials Physics and featured four talks by leading participants in electronic structure theory, with emphasis on density functional theory. It was highlighted by a beautiful talk by Walter Kohn. The session was chaired by John Perdew and attended by more than 500 meeting participants.

The first talk was *"The History of Density Functional Theory – Some Personal Recollections"* by **Walter Kohn** (UCSB). Kohn spoke about the early history of DFT and then explored the reception DFT received in the theoretical physics and chemistry communities. He came to this problem from an attempt to understand the electronic structure of alloys. There was an apparent conflict between the localized picture of alloys and the delocalized picture. The localized picture was used by metallurgists and was based on the ground state electron density, $n(\mathbf{r})$. The basic picture was the lattice gas/Bragg-Williams model accompanied by Friedel impurity screening. The delocalized picture, on the other hand, led to the rigid band model and an average periodic potential, with no Friedel screening. So Kohn wondered whether a theory might be developed based on $n(\mathbf{r})$, an *exact* formulation of the theory of electronic structure *without* the approximations of Thomas-Fermi theory.

With hindsight, Kohn framed the question as "Can electronic structure *in principle* be formulated *exactly* in terms of the ground state density $n(\mathbf{r})$ (and nothing else)?" There were seemingly good arguments both ways: No, because $n(\mathbf{r})$ is too simple; we need $\Psi_0(\mathbf{r}_1,\mathbf{r}_2, \ldots ,\mathbf{r}_N)$. No, because chemists had tried with $n_1(\mathbf{r},\mathbf{r}')$ and $n_2(\mathbf{r}_1,\mathbf{r}_2)$ and failed. Yes, because there *is* a mapping from the interparticle potential $v(\mathbf{r})$ to $n(\mathbf{r})$, namely the Schrödinger equation. Why not the inverse, $n(\mathbf{r}) \rightarrow v(\mathbf{r})$? And $v(\mathbf{r})$ then gives the complete Hamiltonian and hence, in principle, everything. Yes, because it could be shown explicitly in two examples: arbitrary one-body problems and arbitrary small deviations from the uniform electron gas. These considerations led to a general proof by Hohenberg and Kohn in 1964. Levy and Lieb provided a better treatment in 1979.

In the early development of DFT, Kohn and coworkers provided both formal, exact results *and* practical approximations. The Hohenberg-Kohn variational principle was, in effect, an "exactified" Thomas-Fermi theory. Slow variation in $n(\mathbf{r})$ is no longer needed. The Kohn-Sham equations were developed from the Hohenberg-Kohn variational principle and inspired by Hartree's equations. These were "exactified" Hartree equations. In this process the theory moved from $\Psi_0(\mathbf{r}_1, \mathbf{r}_2, \ldots, \mathbf{r}_N)$ (Schrödinger) to $n(\mathbf{r})$(Hohenberg-Kohn) to $\Psi_j(\mathbf{r})$ (Kohn -Sham). Essential approximations were developed, including Local Density Approximation (LDA), GE, GGA, etc. A finite temperature extension was developed by Mermin.

As to the reception of the theory by the theoretical physics and chemistry communities, Kohn presented and discussed the following table:

	Physics	Chemistry
1964-65	$\in$	0
1966-90	Yes* ("Standard Model")	Mostly No**
1990	Yes	Turning Point†
1998	Yes	Nobel Prize in Chemistry
2001	Yes	Most of the "interesting"†† Quantum Chemistry

* Except "exotica" (heavy fermions, etc.)
** Major exceptions: Parr and associates
† Becke and Pople
†† A chauvinist statement

Kohn was followed by **A. J. Freeman** (Northwestern) on *"Impact of Band Theory: Past, Present and Future."* He reviewed the evolution of quantum theory from the beginnings of band theory, starting with Hartree's 1928 paper and Fock in 1930. The 1930s saw Wigner-Seitz theory (1933-34) and considerable progress with cellular models, work with nearly free electron models (Jones, 1934), and Slater's introduction of the APW method (1937). The decade closed with Gombas's work in 1939 using pseudo-potentials. Highlights of the 1940s included Herring and Hill's OPW method (1940), continuing progress with cellular methods, and important electronic structure calculations using the tight-binding method. In addition to continuing, and often innovative, progress with the methods developed earlier, the 1950s brought $\mathbf{k}\cdot\mathbf{p}$ (Silverman, 1952) and KKR (Korringa, 1947; Kohn and Rostocker, 1954).

Early energy band studies "provided an understanding of electrons in metals, semiconductors and insulators – and laid the foundation for the theory of optical and magnetic properties of solids." One example of the impact of these studies is reflected in the statement thought to have been made by William Shockley in 1965: "The invention of the transistor was the outgrowth of the pioneering theoretical work of John C. Slater and a few other academics in solid state physics." Further impact is shown in the fact that "band theory accounts for the non-integral atomic magnetic moments in Fe, Co, and Ni metals and transition metal alloys." Freeman showed the Slater-Pauling curve for these magnetic materials, interpreted on the basis of a rigid band model.

Chodrow's 1939 APW calculation for Cu paved the way to future systematic studies of bands and Fermi surfaces in metals. He created a semi-empirical muffin-tin potential from solutions of the Fock equations for Cu^+ ($l = 2$). His potential partially took into account the exchange interaction of a *d* electron with the other electrons. He could solve the APW equations only for high symmetry points, but his potential was later used by Segall (1961) with KKR and by Burdick (1961) with APW to establish the validity of the band approach with detailed predictions of the Fermi surface. This led to the age of Fermiology.

The electronic structure and properties of *f* electron metals were studied by Freeman and his students in the 1960s and 70s. Band structures of the rare-earth metals (Dimmock & Freeman, 1964) "completely transformed previous understanding of 'anomalous' electronic, optical and magnetic properties of rare earths as free electron metals. [This work] demonstrated that they are like transition metals (5*d* and 6*s*-*p* conduction bands) but with localized 4*f* electrons." Calculations for the actinide metals (Koelling & Freeman, 1970) "gave the first picture of the correct ordering and separation of the band electrons and made the distinction between the *light actinides* as complex transition metals (itinerant 5*f* electrons) and *heavy actinides* as a second rare-earth series (localized 5*f* electrons)."

Freeman characterized the historical stages of band theory in terms of pre-and post - DFT, with revolutionary changes beginning about 1976, pre-andpost-super computing, with a transition about 1967, and pre- and post-E_{tot}, with the ability to calculate total energies beginning in about 1976, allowing the calculation of equilibrium structures, cohesive energies, elastic constants, phonon frequencies, and thermodynamic quantities.

Freeman made the point that all materials properties originate in electronic structure, so the progress in band theory is now enabling the calculation and prediction of properties of real materials. A new class of materials, half-metallic ferromagnets, was predicted on the basis of electronic structure calculations by de Groot, Mueller, van Engen and Buschow in 1983. Properties of layered magnetic structures, including giant magnetoresistive materials, have been predicted (e.g. Cu-Ni, Jarlborg & Freeman, 1980, 1983). Band theory has also come to play an essential role in understanding correlated electron systems, including the rare earths, the actinides, heavy fermion systems, high T_c superconductors, and colossal magnetoresistive materials.

Freeman concluded his talk by reviewing the wide range of DFT implementations now in use and reporting the status of his FLAPW code. He listed achievements of first-principles calculations in magnetic materials, in ferroelectric materials, and in semiconductors. He pointed out that the theory continues to develop new capabilities, thanks to synergism between new algorithms, methods, and computing power, making it possible to calculate ever more complicated systems.

Leonard Kleinman (U of Texas) explained *"Why I Love Pseudopotentials."* He traced the beginnings of pseudopotential theory back to Enrico Fermi (*Il Nuov. Cim.* **11**:157, 1934), then Hellman (1935-36), and Gombas (1938-56). Other early contributors include Antončík (1954-59), Callaway (1958), and Phillips (1958). Kleinman began his work with pseudopotentials in 1957. He reviewed strengths and weaknesses of various approaches and refinements, leading to the first principles justification of empirical pseudopotentials by Marvin Cohen et al., the cancellation theorem of Morrel Cohen and V. Heine (1961), and rapid advances that Walter Harrison brought together in his important book, *Pseudopotentials in the Theory of Metals*, 1966.

Heine and Abarenkov, Ashcroft, and Ziman contributed to the development of model pseudopotentials in the 1960s. Hamann, Schlüter, & Chang developed norm-conserving pseudopotentials (1979), and Kleinman extended this work to the Dirac equation (1980). Additional progress was described, down to the present status of pseudopotential theory, with careful citation of the many important contributors to this field. Kleinman concluded with a listing of "Pseudopotential Firsts" (shown below) and a comparison with other methods. The comparison showed that pseudopotentials are still remarkably competitive with full potential methods.

Pseudopotential Firsts

• Non–Wigner-Seitz total energy, elastic constants, Goroff & Kleinman, 1970 (OPW); Ihm, Cohen, & Zunger, 1979

• Self–consistent thin films, Alldredge & Kleinman, 1972-74

• Car-Parrinello *ab initio* molecular dynamics (1983)

• Semiconductor quasiparticle energies in Hedin's GW approximation, Hybertsen & Louie (1986)

• Semiconductors with *exact* Kohn-Sham exchange potential, Städele, Majewski, Vogl, & Gorling (1997)

The final talk of the session was given by **Bernard Delley**, (Paul Scherrer Institut, Switzerland) on *"Density Functional Calculations of Molecules: History and Outlook."* The prehistory of density functional calculations of molecules started about fifty years ago with a quick and dirty approximation based on an idea borrowed from solid state physics. Early successes with transition metal compounds demonstrated the usefulness of the approximations.

Highlights of this early history included the work of Hartree (1928), Fock (1930), and Slater (1951), with additional important contributions by Boys (1950), who introduced Gaussian basis functions, Gaspar (1954), Pople & Nesbet (1954), Herman & Skillman (1961-62), and Korriga (1947), Kohn & Rostoker (1954), who introduced the KKR method.

The history of orbital-based density functional theory began in earnest with the work of Kohn and Sham, in the "dawn" of DFT. This period extended from the mid 60s to the late 70s and included the work of Hohenberg & Kohn in 1964, Kohn & Sham in 1965, with additional developments and implementations by Herman, van Dyke, & Ortenburger (1969), Hedin & Lundqvist (1971), van Barth and Hedin (1972), and Slater & Wood (1971). The first DFT molecular codes appeared in the early 1970s, when leading contributors included Ellis, O. K. Andersen, Pople, and others. In early work, Jones (1979) calculated electronic properties of alkaline earth diatomic molecules.

Improved density functional approximations can be constructed and have since been designed in an ongoing process. A lot of progress has been made with methods for solving these equations computationally. Delley mentioned applications in molecular magnetism, vibrational properties, thermochemistry and metastable states. A recent calculation explains the complex atomistic behavior of an inorganic molecular crystal under light irradiation. Theory has shown that light-induced reversible structural switching of a NO ligand occurs, which leads to metastable states with extremely long lifetime. In this application, density functional theory acts as a unified theory that explains optical, vibrational, Mössbauer and thermodynamic properties.

In the 90s DFT became the method of theoretical chemistry. A milestone was the "Density Functional Methods in Chemistry" Workshop in Columbus, Ohio, 1990, and the book, *DFT of Atoms and Molecules*, by Parr and Yang, 1989. In the early 90s work on the molecules HF and FOOF led to great progress. Molecular magnetism was studied in organic molecules by DFT calculations (1991). Transition metal clusters and metal organic compounds were calculated; for example, Fe was shown to be the active site in Fe(II)tetraphenyl-porphine. In a calculation of thermochemically well-known enthalpies of formation, as a test of the predictive accuracy of theoretical bond energies, using 148 molecules, Curtiss & Pople and coworkers showed excellent agreement between DFT and experiment (1991). DFT calculations of vibrational spectra became routine and in very close agreement with experiment.

Since the mid 90s, much progress has been made on O(N) (order N) calculation scaling, surface studies, time-dependent DFT, non-collinear spin systems, quantum Monte Carlo, and quantum nuclear motion studies.

Density functional calculations of molecules, surfaces and solids have become a useful tool to treat quantum properties of complex materials systems. This is also appreciated in industry, where density functional calculations have become one of the means to fill in data that are hard to obtain otherwise. Such input can be important to select the most promising options in industrial research. For the future it is expected that density functional calculations for weakly correlated electron systems will continue to predict more properties reliably and become applicable to increasingly complex systems.

NIST at the Millenium: Condensed Matter and Measurement Science. APS March Meeting, Seattle, 13 March 2001. Cosponsored by the Topical Group on Instrument and Measurement Science, this symposium heard speakers report on the history of polarized electron research, fundamental constants and standards, neutron physics, and polymer physics at NBS-NIST in its first 100 years. It was chaired by Katharine Gebbie (NIST).

The first speaker was **Daniel T. Pierce** (Electron Physics Group, NIST) on *"Spin-Polarized Electrons: How Measurement Development Advances Science and Technology."* This talk described the development of measurement techniques involving spin-polarized electrons and illustrated the use of these techniques in the investigation of surface and thin film magnetism.

NBS was organized in 1901 with a mission to engage in measurement research, provide standard reference data, national and international standards, and calibrations and tests. The Electron Physics Group worked under the direction of L. L. Marton in the 1940s and 50s on geometrical and physical electron optics. In the 1960s and early 70s J. A. Simpson and C. E. Kuyatt developed electron guns and studied scattering resonances in gases. In the 1970s and 80s R. D. Young, E. W. Plummer, and J. D. Gadzuk studied field emission energy distributions.

The work on spin-polarized electrons began with the development of an electron gun and an electron spin polarization analyzer. The spin-polarized electron gun was based on photoemission from GaAs, which produced an intense beam of spin-polarized electrons suitable for sensitive surface magnetometry measurements such as polarized electron scattering and spin-polarized low-energy electron diffraction (SPLEED). This type of electron gun was then used to enable spin-polarized versions of inverse photoemission spectroscopy (SPIPES), electron energy loss spectroscopy (SPEELS), low energy electron microscopy (SPLEEM), Auger electron spectroscopy (SPAES), and secondary electron emission. The spin-polarized electron gun also facilitated the development of new compact, efficient spin analyzers for use in various electron spectroscopies. In particular, such a spin analyzer is well suited to measure the spin polarization of secondary electrons emitted from magnetic samples in a scanning electron microscope. This measurement technique, known as scanning electron microscopy with polarization analysis (SEMPA), provides high-resolution images of surface magnetization. SEMPA measurements have proven powerful for investigating both fundamental problems, such as interlayer exchange coupling of magnetic multilayers, and technological questions, such as the magnetic microstructure of small magnetic device elements.

The first surface magnetization measurement with SPLEED was taken in 1979. It was verified that a true magnetic effect was being observed by measuring the magnetic field and the temperature dependence of the SPLEED surface magnetization. SPLEEM then gave a magnified magnetization image. Spin polarized electron scattering allowed the measurement of low temperature surface magnetization and the observation of the thermal excitation of spin waves. This measurement required an extension of the theory to take account of the weaker coupling at the surface compared to the bulk. This technique also measured the surface critical exponent β for Ni, finding a value of 0.8.

SPIPES enabled the measurement of the spin-dependent band structure of unfilled states in ferromagnetic Ni. Spin polarized secondary electron emission gave the valence band electron polarization. SEMPA, developed in 1984 in Japan and 1985 at NIST, provided high resolution magnetization imaging. NIST is now working with a third generation SEMPA machine, with surface sensitivity of 10 nm diameter beam and one monolayer, i.e. about 1000 Fe atoms. They studied interlayer exchange coupling with a Cr wedge whose thickness ranged from 0 to 20 nm, seeing the coupling alternate between ferromagnetic and antiferromagnetic, according to the thickness of the spacer. Magnetic depth profiling has been done for Co/Cu multilayers in the study of the relationship of magnetoresistance and domain structure, observing interlayer domain correlations. Magnetic nanostructures have been studied, starting with Fe nanowires.

Pierce briefly reviewed technological applications. Both technological and scientific progress are closely tied to the development of tools like the spin polarized electron gun and the resulting spin polarized probes.

Peter Mohr (NIST) followed with a review of *"Adjustment of the Fundamental Constants at NBS/NIST."* He explained the role NBS/NIST has played in measurements and adjustments of the fundamental physical constants, emphasizing recent work on the adjustment of the constants which produced the 1998 values recommended by the Committee on Data for Science and Technology (CODATA) for international use. This work was begun by Raymond Birge in Berkeley in 1929. CODATA was formed in 1966, and NBS became the US site for analysis and recommendations in 1973.

The recommended values of the constants, such as the fine-structure constant, the Rydberg constant, the Planck constant, the electron charge and mass, and many others, are determined by a broad range of experimental measurements and theoretical calculations involving many fields of physics and metrology. For example, the value of the mass of the electron in kilograms is based mainly on the combined information from experiments that involve classical mechanical and electromagnetic measurements, the highest precision optical laser spectroscopy, electrons in a trap, and condensed matter quantum phenomena, together with condensed matter theory and extensive calculations in quantum electrodynamics (QED). Mohr described the physical basis for the constants and procedures used at NIST to combine the results of disparate measurements, taking account of the interconnectedness of the various constants.

"Polymer Research at NBS-NIST" was presented by **Charles Han** (NIST). Research on polymers at NBS-NIST can be traced back to the World War I era, having begun in 1915 in the Miscellaneous Materials Division (organized 1914). The Organic and Fibrous Materials Division was organized in 1926, and the Polymers Division, finally, in 1963.

In the early days paper testing was a big part of organic materials research. Then impact testing and uv degradation of plastic parts became more important in NBS work. During World War II, rubber and other organic materials testing and characterization started to play an important role in the nation's war effort. Since the 1940s, the rubber and plastics industry has transformed our lives. Rubber and plastic have become a part of nearly every aspect of our daily life, including clothing, housing, transportation, and even food.

Textile impact behavior for the development of bulletproof materials has been another part of the work of this division.

In 1950 they undertook the first restoration of the Declaration of Independence, then the preservation of the Constitution of Puerto Rico, and the second restoration of the Declaration of Independence in 1999.

In 1959 NBS developed the absolute light-scattering photometer to determine the molecular weight of polymers. In 1966 they developed homogeneous anionic polymerization. They have a large effort in rheology. They study polymer adsorption on surfaces using ellipsometry, and polymer crystallization. In the 1960s they began simulation and modeling studies. They also study dental materials and tools as well as biomaterials. With the advent of the high flux reactor in 1966, they undertook experimental studies of spinodal decomposition, providing quantitative verification of Kahn-Hilliard Cook theory. They also measured shear suppression of the critical temperature, verifying Onuki-Kawasaki theory.

Now the Polymers Division does mass spectroscopy of synthetic polymers, studies materials for microelectronics, biomaterials, multi-phase materials, rheology and processing, and combinatorial measurements methods.

The standards, testing methods, and basic physics research results produced at NBS-NIST have had extensive influence and impacts on science and technology development during the post-WWII period. Although sometimes controversial, the research in polymer crystallization, in linear and non-linear viscoelasticity, in surface adsorption, in piezoelectrical and pyroelectrical properties, in light scattering and neutron scattering, in polymer blends and alloys, and in dental applications, has made important contributions to the establishment of the current technology base.

J. J. Rush (NIST) discussed *"Neutron Research at NIST-NBS."* The NIST Center for Neutron Research (NCNR) is currently the major neutron facility in the United States, particularly in the area of cold neutron research. Rush reviewed the interesting genesis of the NBS reactor project forty years ago and its role in the rapid development of thermal neutron research in many disciplines in ensuing decades. Many groups were interested in research reactors at the end of the 1950s. Director Astin decided in 1959 to build a big reactor at NBS. In 1962 the Reactor Design Team proposed a new idea, based on an Argonne design: large beam tubes with a split core. This design made prescient allowance for a large cold source thimble that is important in present use. The new reactor achieved first criticality in December 1967. However, funding problems due to the Viet Nam war complicated development of research on the reactor.

During the period 1970-85 neutron scattering research was dominant at the NBS Reactor, focusing on studies of magnetism, hydrogen in metals, catalysis, powder diffraction, and protein structures. The reactor, originally designed at 10 MW, was brought up to 20 MW about 10 years after startup. In 1984 the US was far behind Europe in cold neutron studies. The Seitz-Eastman committee placed highest priority on a large cold source. The Cold Neutron Research Facility was inaugurated in 1990. This gave the opportunity to do new science, including in situ chemical trace analysis, non-destructive testing, and high resolution cold neutron spectroscopy.

Rush emphasized the impact of new U.S. cold neutron scattering capabilities at NIST over broad areas of research in new materials, chemistry and biology. He also discussed his expectations for future applications of neutrons, ranging from condensed matter science to nanotechnology.

The final talk in this session was on the subject *"Electrical Measurements of Fundamental Constants at NBS/NIST"*, by **Edwin Williams** (NIST). Williams reviewed the history of measurements of the constants c, α, and h. In 1907 Rosa and Dorsey carried out an electrical measurement of c, $c^2 = 1/\epsilon_0\mu_0$, that helped to give US scientists credibility in precision measurement. In 1910, Rosa, Dorsey, and Miller established the NBS Ampere. 1950 saw the precision measurement of the proton gyromagnetic ratio using a high B technique by Thomas, Driscoll, and Hipple. Then in 1958 Driscoll and Bender measured the proton gyromagnetic ratio with a low B technique.

Some of these early measurements, which have been updated numerous times, set the stage for recent standards for c, α, and h. In 1969 Taylor, Parker, and Langenberg (U. of Penn) measured α using the Josephson effect. This was the first time that condensed matter physics had an impact on the fundamental constants. Since then, condensed matter physics has had a dramatic impact on the way electrical units are maintained and the role electrical measurements play in physics. The Josephson and quantum Hall effects have revolutionized NIST's calibration program and, at the same time, allowed the traditional measurements of current, voltage and resistance to contribute to an accurate measurement of many fundamental constants. We now have a calculable capacitor of 0.5 pF, a Josephson voltage standard, a Quantum Hall effect resistance standard, and a single electron transistor (SET) capacitance standard.

This talk emphasized the experiments that have allowed the measurement of the fine-structure and the Planck constants. Williams showed how these measurements relate to other areas of physics and how electrical measurements will help replace the artifact Kilogram as the base unit of mass.

100 Years at NBS-NIST. APS April Meeting, Washington, DC, 29 April 2001. Cosponsored by DAMOP, this session was chaired by Charles Clark (NIST). The first talk was by **David DeVorkin** (Smithsonian Institution) on *"H. N. Russell and Atomic Spectra."* "I would rather analyze spectra than do cross-word puzzles or do almost anything else" Henry Norris Russell wrote to William F. Meggers in 1927. Meggers, chief of the spectroscopy division at the NBS, had been surprised that an astrophysicist could be so keen about the analysis of complex spectra. But Russell was a new type of astrophysicist, one who made physics the core of his research. Spectra, for Russell, held the "master key" to knowledge about the universe, and of the atom. He was first attracted by the challenge of detecting and explaining anomalies, which he hoped would lead to new knowledge about the structure of matter. Then, influenced by physicists such as Meggers, he devoted himself to filling in the picture of the structure of atoms from their characteristic spectra as completely as possible. De Vorkin reviewed how Russell worked with Meggers and became the nucleus of an ever-widening circle of spectroscopists devoted to the analysis of complex spectra.

Lewis M. Branscomb (Harvard, emeritus) spoke on *"Political Controversy and Scientific Integrity at NBS-NIST."* Branscomb joined the scientific staff of NBS in 1951 because Harvard University could not match the Bureau's capability to perform absolute measurements under very difficult conditions. At NBS he and his colleagues were able to observe the photodetachment cross section for the hydrogen negative ion and verify Wildt's theory that H^- was the source of visible opacity in the sun. He became Director of NBS in 1969 and served until 1972. During his years there, Branscomb came to appreciate that the greatest asset of the NBS was its reputation for scientific integrity. As the steward of the nation's system of measurements, NBS had to be trusted. Its scientific program required the performance of absolute measurements, which require quantification of the limits of systematic as well as statistical errors. As a result, that skill and trust were tested repeatedly. The talk included a number of fascinating examples. Some involved consumer products: the Battery Additive ADX-2 case in the 1950s, the Flammable Fabrics challenge in the 1970s. Others involved scientific data on which major presidential decisions turned (the SST in the early 1970s). Branscomb concluded that NBS, in his experience, was true to its commitment and remains today, as NIST, a model of the commitment to trusted research.

"A Century of Fundamental Constants Work at NBS-NIST" was presented by **Edwin Williams** (NIST). The National Institute of Standards and Technology (NIST) was founded as the National Bureau of Standards (NBS) on March 3, 1901 by the 56th Congress of the United States. From its earliest beginnings, NBS-NIST has carried out important work related to improving our knowledge of the values of the fundamental physical constants. As the national metrology institute of the United States, one of the basic responsibilities of NBS-NIST has been to develop, maintain, and retain custody of the national standards of measurement. Since such standards should be highly reproducible and constant in time, the fundamental constants, which are Nature's true invariants, have played an important role in helping NBS-NIST meet this responsibility. Further, adding another digit to the value of a constant is never trivial; it invariably requires advancing the state-of-the-art in a particular field of metrology, and such advances generally have much broader application. Williams gave an overview of NBS-NIST's century of work in the fundamental constants field, including the role of NBS-NIST during the last 30 years in providing sets of recommended values of the constants through the Committee on Data for Science and Technology (CODATA).

Mitio Inokuti (Argonne) spoke on *"The Scientific Legacy of Ugo Fano."* In 1934 Fano received an Sc.D. degree in mathematics at University of Turin, Italy (the city of his birth in 1912). He was then led to physics by his cousin Giulio Racah, and received postdoctoral training from Fermi at Rome and from Heisenberg at Leipzig. He worked at institutions near Washington, D.C. during the war, and joined the staff of the National Bureau of Standards in 1946. He became a professor of physics at The University of Chicago in 1966. His contributions to radiation physics, atomic and molecular physics, and statistical physics are extensive and were recognized by many honors such as the Fermi Award of the DOE, and terms such as the Beutler-Fano profile of certain spectral lines, the Fano factor characterizing the fluctuations of radiation-induced ionization, the Fano-Lichten mechanism for inelastic atomic collisions, and the Fano effect leading to spin-polarized photoelectrons. His work follows a style inherited from Fermi and is characterized by incisive insight into the physics behind experimental data, penetrating mathematical analysis, and close communication with many colleagues. Because he took a leading role in developing new areas of research and in nurturing young scientists, his influence now permeates many topics of physics. They include far uv and soft x-ray spectroscopy with synchrotron radiation and fundamental radiological physics, both stemming from his time at NBS, as well as multichannel quantum-defect theory and the hyperspherical-coordinate approach, both pioneered at Chicago. More complete accounts of his life and science are seen in M. Inokuti, in *Fundamental Processes of Atomic Dynamics*, J. S. Briggs et al. (eds.), (Plenum, New York, 1988); A. R. P. Rau, *Comments At. Mol. Phys.* **33**, 181 (1997), and a forthcoming special issue of *Physics Essays* in his honor.

In the final talk, **Eric Cornell** (JILA) told *"The story of Bose-Einstein condensation."*

Perspectives on Major High Energy Physics Projects. APS April Meeting, Washington, DC, 29 April 2001. This symposium was chaired by Laurie Brown and cosponsored by the Forum on Physics and Society. *"LEP, LHC and European Perspectives on the SSC"* was addressed by **Herwig Schopper** (CERN & U of Hamburg). Schopper, former Director-General of CERN, discussed the importance of international cooperation in major high energy physics projects. Talks about the possibility of realizing large facilities for elementary particle physics as worldwide projects started in the International Committee for Future Accelerators (ICFA). While this was a time of plenty, nations were willing to give up many national projects to support large international projects at CERN and elsewhere. There was concern about duplication of resources, with many overlapping, complementary machines. Openness and cooperation with the competition were essential. Joint projects could produce very interesting physics and make efficient use of resources.

An electron-positron collider ring was considered as a first candidate, and such an installation was realized as the European project LEP at CERN in the 1980s. This facility was opened to groups from non-CERN Member States, and with the participation of the US, Japan, China, Soviet Union, India, and many other countries, LEP experiments became worldwide cooperations. There was a finance committee for each experiment, working with an association of funding agencies. It was envisaged from the beginning that the LEP tunnel, with a circumference of 27 km, could later house a proton-proton collider.

The HERA model extended the possibilities for participation to allow international contributions in kind.

When the SSC was proposed in the US, negotiations started among scientists (e.g. ICFA) and at high political levels (High Energy Committee of the G7 summit meetings and hearings in the US Congress) with the aim of exploring whether this facility could be realized as an international project. These negotiations failed. Why? Ambiguity was a problem. Was this an international facility or a facility to establish the leadership of the USA? Europe and Japan were already overcommitted. There was a lack of a commonly agreed inter-regional long-term program.

When the SSC was abandoned, the LHC project in the LEP tunnel became the only possible realization of a proton-proton collider with the highest achievable energies. Intensive negotiations with non-European countries resulted in agreements that these partners would contribute not only to the experimental installations, as in the LEP case, but also to the storage rings and the infrastructure itself. Solutions were found to allow those partners to participate in important decisions concerning the project.

Schopper discussed the conditions necessary to realize the next large facilities:

1. Scientific arguments for the machines and parameters must be based on science, not politics.

2. The scientific community must agree on priorities.

3. Existing labs should be used as hosts, taking advantage of a big savings in infrastructure.

4. They should be announced as international projects from the beginning.

5. Convince the public, but also other fields of science of the importance of the projects.

6. Develop existing models further.

7. In-kind contributions should be accepted for high technology; the host country must also provide the civil engineering, so the host will make a higher contribution.

8. Be aware that scientific recognition will not be coupled to the site.

9. A fair distribution over continents remains important.

10. US participation is essential for the future.

Michael Riordan (UC-Santa Cruz) spoke on *"The Rise and Fall of the Superconducting Super Collider."* The largest scientific project ever attempted, the Superconducting Super Collider fell to the axe of Congressional budget cutters in 1993, after ten years and almost two billion dollars had been spent on its design and construction.

In 1981 George Keyworth was named Science Advisor to President Reagan. He had access to Reagan, was a strong science advisor, and a strong supporter of basic research. The SSC proposal took form at the 1982 Snowmass meeting. The first budget estimate was $750M. In 1983 the HEPAP subpanel on new facilities recommended the SSC, with a price tag now of $2B. In 1986 the conceptual design had an SSC of 40 TeV, $3.01B.

The Domestic Policy Council decided in 1987 to proceed with the maximum possible cost sharing from other countries, current cost estimate $4.4B. However, the political motivation for support of the SSC was to maintain US supremacy in high energy physics. This made it very difficult for Europe and others to buy in. No international site was considered, although a New York-Canada site was proposed.

In early 1989 Congress authorized construction of the SSC, with a current cost of $5.9B, including inflation. But in November, 1989 design changes introduced a $1-2B cost increase. This caused the Secretary of Energy (Watkins) to get directly involved. January, 1991 saw a revised budget of $8.25B, and a national coalition was developed including universities, users, and industry.

However, in 1992 there was a reversal of power balance in the Congress, as the Texas-based SSC became a "Rust Belt" vs. "Sun Belt" issue. President Bush became an active supporter. Senator J. Bennett Johnson (LA) saved the project that year in Congress.

Foreign support never materialized. Japan waited for President Bush to ask for their money, but Bush lost the election, and Clinton was lukewarm. Because of Clinton's slow engagement with the project, the cost grew to >$10B. The press began to criticize it due to cost.

Finally, there were three major reasons for the demise of the SSC in 1993:

1. Continuing cost growth and widespread perceptions in Congress that the project was out of control.

2. Lack of any significant foreign contributions.

3. The end of the Cold War, which led to major transformations in American politics and science policy.

Thomas B. W. Kirk (Brookhaven) identified *"Success Factors in Management of Large Projects."* Large Projects in science have now regularly reached the size where formal project management methods and tools are needed for successful execution of the work. High tech projects must be carried out in an environment of shared communities: the Big Science Community, the Defense Community, and the Industrial Community. These three communities share technologies and expertise, to some extent, but have disparate cultures.

Sponsors have focused on cost management, schedule, and technical performance, in that order. But Users place these in precisely the opposite priority. It is a basic management principle that you can optimize one factor, improve two, but you cannot optimize, or even improve, all three. So the opposite sense of priorities is an almost insuperable barrier to confidence between Sponsors and Users.

Vital additional management considerations include communications, management technical expertise, management stability, technical stability, and funding stability. The SSC had serious problems in all these areas, especially in communications and management stability.

The SSC experienced much greater total project cost growth with respect to the initial total project cost compared to other science projects. It was politically visible in a much wider forum due to the multi-billion dollar price tag. There was a cultural mismatch in the management, ignorance of the two widely divergent cultures that had to be addressed. The project had problems with communications and management technical expertise. All this led to termination by Congress on October 19, 1993.

David Goldston, Staff Director for the House Science Committee and former Legislative Director for Rep. Sherwood Boehlert, provided *"An Historical and Policy Perspective on the Plight of the SSC."* The Superconducting Super Collider (SSC) has come to represent the epitome of big science gone awry. In the late 80s and early 90s the SSC was the dream next machine of the US high energy physics community, representing our efforts to discover the Higgs particle as well as to demonstrate the US commitment to scientific leadership and exploration. While the scientific merits of the SSC were strong, from a policy perspective the project was beset with problems. As with any big science project, these problems were based, to first order, in cost, but the complexity of the policy issues went beyond cost.

There are four major lessons from this project:

1. Large science projects need to be internationally funded.

2. Both a broad and a deep consensus of the scientific value of the project is needed.

3. Management counts.

4. Agreement is needed across and within scientific disciplines.

The Department of Energy was not much interested early on in international funding or involvement. There was a thin consensus in Congress. The elaborate process for site selection was very political; the early sales job brought the message, "This could be good for your state." Management was cast into doubt by continually escalating costs. Finally, the SSC was seen as a threat by many scientists.

Then the atmosphere changed. There were budget deficits, a new Congress, a new President. The old ethic that you don't touch pork in another district changed.

The demise of the SSC should not be taken as a message that Congress is anti-science. Look at science funding since that event. The issues should be seen as specific to the SSC, but the lessons are more general and apply to the next big science project.

History of Atomic Collision Physics. APS April Meeting, Washington, DC, 1 May 2001. Cosponsored by DAMOP, the Topical Group on Few Body Systems, and the Topical Group on Fundamental Constants, this symposium was chaired by Ben Bederson (NYU). The following report was prepared by Dr. Bederson.

The symposium consisted of four talks. The first, by our own **Michael Nauenberg** (UC Santa Cruz), was entitled "The quantum-classical correspondence: What happened to Kepler-Bohr orbits in quantum mechanics?" Nauenberg offered a clear exposition of the way in which Schrödinger, following Bohr, developed his quantitative wave-mechanical description of electron orbits to replace the classical model. This new view at first seemed to be unsatisfactory since it is generally assumed that wave functions spread with time, so that the quantum model would be unable to explain the localization of probability, in apparent contradiction to the Bohr correspondence principal. He then reported on both theoretical and recent experimental results that indeed show that bunching, i.e., localization, occurs in Rydberg states.

The second talk was by **Alexander Dalgarno** (Harvard-Smithsonian Center for Astrophysics). Dalgarno gave a detailed presentation of the developing understanding of the crucial role played by atomic collision processes in the evolution of gaseous nebulae and other astronomical bodies, starting with the work of Menzel and others in the early part of the twentieth century, motivated primarily by the need to explain observational line spectra. There followed a notable line of collision theorists, primarily in the UK, starting with H S W Massey, followed by successive generations of his students, from D R Bates, then M J Seaton, P Burke, and Dalgarno himself (although he did not include himself in this pantheon). Ever more sophisticated laboratory experiments then played crucial roles in being able to identify important reactions of many types in the astronomical environment.

This was followed by a talk by **Tim Gay** (U of Nebraska) on "the quest for the perfect collision experiment." By "perfect" he meant experiments that provided all the parameters that, properly combined, determine the complete behavior of the collision partners. For example in elastic scattering of an electron by a one-electron atom (hydrogen or alkalis) three parameters, two scattering amplitudes and phase between them, are required. Such an experiment, or a combination of suitably chosen experiments, require measurements of angular distributions, spin and angular momentum information both before and after the collision. More complicated systems require ever larger numbers of such parameters. Starting with the first collision experiment (the Franck-Hertz experiment) he went through a series of measurements performed over the past fifty or more years, showing how this goal is being approached, although actually only being realized at this time in one or two very simple cases.

Finally, **Thomas Gallagher** (U of Virginia) gave a history of the use of lasers in atomic collisions. In the relatively short time since the advent of the laser age, and especially upon the appearance of tunable dye lasers, the laser has become an essential tool in a vast array of collision experiments. It was first used extensively as a tool for the preparation of selected atomic ground and excited states to permit measurements that were far more refined than formerly allowed. More recently, pulsed lasers have been used to produce electromagnetic fields strong enough so that they can themselves influence collisions – "laser-assisted collisions." And most recently, "cold atom" collision phenomena have opened up new areas of collision studies, these being made possible by the various present techniques for laser cooling and trapping.

History of Physics Contributed Papers. APS April Meeting, Washington, DC, 28 April 2001. This second FHP Contributed Session was chaired by Gloria Lubkin. It included three history talks, supplemented by two education papers. The talks in this session were allotted twice the usual time for contributed papers, in recognition of the nature of history papers, so each had 24 minutes, including the question period. A brief report is given here on the three history talks in the session.

The first talk was *"Cosmonumerology, Cosmophysics, and the Large Numbers Hypothesis: British Cosmology in the 1930s"* by **Ian Durham** (U of St. Andrews, Scotland). A number of unorthodox cosmological models were developed in the 1930s, mainly by British theoreticians. Three of the most notable of these theories were Eddington's cosmonumerology, Milne's cosmophysics, and Dirac's large numbers hypothesis (LNH). Dirac's LNH was based partly on the other two, and it has been argued that modern steady-state theories are based partly on Milne's cosmophysics.

Eddington's fundamentalism (cosmo numerology) was an early attempt at unification of general relativity and quantum mechanics. It was purely deductive, deliberately referencing Pythagoras and Kepler. The work began with a desire to formulate Dirac's wave equation for the electron (1928) in tensor form. It asserted that the fine structure constant was the reciprocal of a whole number, with no fractional part. Eddington was apparently superstitious about the meanings of numbers, and in this case ascribed significance to the facts that Arthur Stanley Eddington could be numerically equated to 2×137 and that Pauli died in Room 137. General relativity and quantum mechanics had a common meeting point in a state of equilibrium of a radiationless self-contained system of a very large number of particles. The solutions must produce an Einstein universe with zero pressure and temperature and a quantized system in its ground state. To make the solutions from general relativity and quantum mechanics agree, a ratio of constants, *N* (Eddington's cosmical number), had the value $3(136 \cdot 2^{256})/2$. *N* is about 10^{79}, which is the total number of electrons in the observable universe. Eddington also related *N* to other constants of nature, the highest energy of an Einstein universe, the masses of the electron and proton, etc. His model suggested that gravity was a consequence of the exclusion principle.

Milne's cosmophysics, by contrast, was not motivated by a desire for unification, but like Eddington, Milne used purely deductive reasoning. In this theory, space was merely a system of reference without structure. Milne thought relativity was too obtuse and called his theory "kinematic relativity." He made no appeal to dynamic or gravitational assumptions, and he considered the existence of a particle horizon to be an argument against relativistic cosmology. Cosmophysics was based on two principles: constancy of the speed of light and the cosmological principle (universe is homogenous and isotropic on a large scale). With these two principles and *without* general relativity, Milne derived a uniformly expanding universe. *G* was no longer constant, but increasing in time. He showed for the first time that the Hubble law was trivial, that the Friedmann-Lemaître equation for the expansion rate can be derived using elements of Newtonian mechanics, and he introduced the terms "cosmological principle" and "Einstein's cosmological principle." He judged that the nonconstancy of *G* was unobservable, so he proposed two time scales: kinematic time and dynamical (Newtonian) time. Milne's interpretation of the two time scales was that there existed two versions of the same reality, and that "reality" itself was a scientifically illegitimate concept.

Dirac's large numbers hypothesis (LNH) was a mix of Eddington's fundamentalism and Milne's cosmophysics. It was based on large dimensionless numbers, 10^{39} and 10^{78}. These dimensionless numbers are taken to be interconnected and functions of the age of the universe, i.e. of time. 10^{39} was about the then-assumed age of the universe (2 billion years) in units of time given by e^2/mc^3. It is also a ratio of electrostatic and gravitational forces between an electron and a proton. The equality of these two quantities required *G* to change with time, but Teller pointed out that a decreasing *G* would make the Sun's age too young compared to the evidence. Dirac used Milne's two time scales to avoid this problem. 10^{78} is about the number of particles in the universe, also Eddington's cosmic number, and the square of the period in atomic time, which led Dirac to the conclusion that the number of particles will increase with time as t^2, implying continuous matter creation!

In 1938 Dirac reversed his stance and changed the theory to conserve matter. Dirac held that the fine structure constant, being dimensionless, could be derived from general principles. Thus only *e* or *h* can be fundamental, but if *h*, then *e* would contain a square root, which is unlikely. So Dirac concluded that *h* was a derived quantity, which completely altered the view of the uncertainty principle. Dirac's two time scales, adapted from Milne's, both corrected the continuous matter creation problem and resolved the problem of the Moon's orbital age not matching its geologic age. In addition, LNH predicted a slower decrease of average temperature of the universe with time so the radiant temperature extrapolates back to a value $m_p c^2 /k_B$ at a time close to the origin, which obviates the need for late decoupling between matter and radiation. Dirac claimed that the discovery of the cosmic microwave background radiation confirmed this and thus affirmed LNH. LNH also predicted an inward spiral of planetary orbits that should be close to observational possibility.

What influenced Eddington and Milne? Both were products of the late Victorian education system in Britain and could conceivably have been influenced by Victorian thought, which, in addition to its strict (though technically unofficial) social caste system, had a flair for the unusual. Victorianism was filled with a fascination for the occult and the supernatural, and science was not insulated from this trend (witness the Henry Slade trial in 1877). It is conceivable that the normally strict mentality of the scientific process in their minds was affected, indirectly, by this trend for the unusual, possibly pushing them into thinking "outside the box" as it were. In addition, cosmonumerology and the LNH exhibit signs of Pythagorean and Aristotelian thought. The personal influence of Sir Ralph Fowler on all three men seems also to have been important to each.

Michael A. Day (Lebanon Valley College, Annville, PA) discussed "*Oppenheimer on the Nature of Science: 1945-1954.*" He reviewed Oppenheimer's views on the nature of science and its relations to society as developed between 1945 and 1954, then, with this review in mind, provided some general guidelines for interpreting his views and works on the nature of science. 1945 was the date of Oppenheimer's first public writing on the nature of science. Day cautioned that most of Oppenheimer's writings on this topic are actually transcribed lectures and talks, which require some caution in the reading.

Three topics were seen as central in Oppenheimer's thought in this area: science as community, the spiritual and material fruits of science, and complementarity of atomic physics. He made a distinction between science and technology. For Oppenheimer, the aim of science is knowledge and understanding, while the aim of technology is power and control. He also presented a communitarian view of science. He advocated the scientific community as a worthy prototype for other fields of endeavor, because of the spiritual and material fruits of science. Here he discussed science as a source of ideas, contrasting science and philosophy (science much more fruitful), science as a mode of action, enriching our society, and science education and history of science as models for education and history. His discussions of complementarity focused on the character of complementary descriptions, examples in physics, and social and philosophical examples. His motivation in talking about the nature of science seems to have been to provide explanations to the public at a time of crisis and his sense of responsibility to both science and society.

The reception of his views was mixed. The largest audience was achieved for the Reith Lectures in 1953, published as *Science and the Public Understanding.* He received considerable criticism at that time, but continued his attempts to explain science, and especially complementarity, to the public. The loss of his security clearance in 1954 did not affect his views. He continued to have substantial interaction with other intellectuals on his ideas.

To understand Oppenheimer's views in context, it is essential to see their relation to other works, to consider interactions between Oppenheimer and other intellectuals, and the very important influence of Niels Bohr. Bohr's philosophical influence on Oppenheimer was overarching and dominant. It molded his commitment to complementarity, and it is reflected in his 1963 biographical sketch of Bohr. Oppenheimer gave a talk about Einstein in 1965 that mixed praise and criticism in a way that he never did of Bohr. For more information, see Michael Day, *Oppenheimer on the Nature of Science,* Centaurus, forthcoming 2001.

Paul Forman (Smithsonian Institution) gave the third talk: *"Rabi, the proton magnetic moment, and the '2-wire' magnet, 1931-34."* The following report was prepared by Dr. Forman.

Guiding cold neutral atoms with magnetic fields produced by two, closely spaced, parallel wires carrying equal and opposite electric currents is today a hot topic. (See E.A. Hinds et al., *Phys. Rev. Lett.* **86**:1462, 2001; N.H. Dekker et al., *Phys. Rev. Lett.* **84**:1124, 2000). From these recent papers, however, it is not evident that physicists now exploiting this concept are aware that it originated seven decades ago (I. I. Rabi, J. M. B. Kellogg, and J. R. Zacharias, *Phys. Rev.* **46**:157, 1934), and, still less, that it functioned as the enabling technique for a unique and important program of experimental research in the early years of nuclear physics: I. I. Rabi's molecular beam determinations of nuclear moments.

In the summer of 1929, Rabi returned to Columbia after two years of postdoctoral study in Europe – spent chiefly with Otto Stern, in Hamburg, learning the technique of magnetic deflection of molecular beams. That same summer Gregory Breit came to NYU. Each was expected to promote at his institution the quantum theory and its application in experimental research. That autumn they began a joint "quantum seminar" that would continue the five years that Breit remained in New York City, and Rabi's dependence upon Breit's theoretical insight and calculational strength would continue long after.

Late in 1930 Rabi conceived the idea of using the molecular beam technique to study the 'Paschen-Back' transition in the coupling between nuclear and electronic angular momentum in atoms, and recognized that in the weak-field regime, where the coupling was unbroken, the electronic magnetic moment provided a 'handle' on the thousand-fold smaller nuclear magnetic moment. With Breit he worked out a quantitative theory of that effect (G. Breit and I. I. Rabi, *Phys. Rev.* **38**: 2082, 1931). But there seemed no prospect of making this a more than semi-quantitative experimental procedure, one capable, at best, of evaluating the quantized quantity nuclear spin – Rabi got sodium's 3/2•$\hbar$ in spring 1933, and cesium's 7/2•$\hbar$ in spring 1934 – but incapable of measuring nuclear magnetic moments, largely because of the infeasibility of mapping the relatively weak, spatially very extended magnetic deflecting fields that that experimental procedure required.

When the sensational result, $\mu_p = 2.5\ \mu_{Bohr}\ (m_e/m_p)$, from Otto Stern's deflection of a beam of hydrogen molecules in a strong magnetic field became known late in 1932, its confirmation by another laboratory, preferably by another method, seemed urgent. No one else had the refined technique to reproduce Stern's experiment. But because the hydrogen electronic wave function was known, the Breit-Rabi technique was susceptible of extension in this case to the measurement of the magnetic moment of the proton – but only with accurate knowledge of the relatively long, because necessarily weak, magnetic field and field gradient traversed by the atomic hydrogen beam.

To this end Rabi introduced the '2-wire' magnet, producing a weak field and uniform gradient that could be calculated rather than measured – and confirmed Stern's result (*PR* **46**:157, 1934). This field configuration quickly came to be used in all magnetic deflection experiments in Rabi's laboratory, first as produced directly by electric currents, and subsequently as emulated in iron electromagnets in order to achieve the higher magnetic fields required by molecular beam magnetic resonance experiments from 1937 onward.

As mementos of that pre-1937 era in which Rabi and collaborators so laboriously ascertained nuclear spins and magnetic moments, Rabi held onto one of the earliest, and also the very largest of the 'parallel-wire' magnets used in his laboratory. These are now in the Modern Physics Collection of the National Museum of American History.

The Seven Pines Symposium

by Roger H. Stuewer (University of Minnesota)

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

The fifth annual Seven Pines Symposium was held from May 30-June 3, 2001, on the subject, "The Quantum Nature of Gravitation, Space, and Time." It was held at the Outing Lodge at Pine Point near Stillwater, Minnesota, a beautiful facility surrounded by spacious grounds with many trails for walking and hiking. Its idyllic setting and superb cuisine make it an ideal location for small informal meetings. It is owned and operated by Lee Gohlike, the founder of the Seven Pines Symposium.

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

Each day the speakers set the stage for the discussions by addressing major historical, philosophical, and physical issues related to the quantum nature of gravitation, space, and time. In the morning of Thursday, May 31, Nick Huggett (Illinois at Chicago) spoke on "Classical Notions of Space and Time" and John D. Norton (Pittsburgh) spoke on "Spacetime in General Relativity." In the afternoon, Robert M. Wald (Chicago) spoke on "Observables and Singularities in Classical General Relativity" and Helge Kragh (Aarhus) spoke on "Historical Roots of Quantum Gravity." In the morning of Friday, June 1, Jeffrey Harvey (Chicago) and Amanda Peet (Toronto) spoke on "The Nature and Status of String Theory." In the afternoon, Donald Marolf (Syracuse) spoke on "Spacetime Structure in String Theory" and Carlo Rovelli (Marseille) spoke on "Spacetime Structure in Loop Quantum Gravity." In the morning of Saturday, June 2, Karel V. Kuchar (Utah) and John Earman (Pittsburgh) spoke on "The Problem of Time." In the afternoon, William G. Unruh (British Columbia) spoke on "Black Holes in Quantum Gravity" and Raphael Bousso (UC Santa Barbara) spoke on "Holography and Complementarity." A closing discussion on Sunday morning, June 3, was chaired by Roger H. Stuewer (Minnesota).

Lee Gohlike, the founder of the Seven Pines Symposium, has had a life-long interest in the history and philosophy of physics, which he has furthered through graduate studies at the Universities of Minnesota and Chicago. To plan the symposia, which will be held annually, he established an advisory board consisting of Roger H. Stuewer (Minnesota), Chair, Jed Z. Buchwald (MIT), John Earman (Pittsburgh), Geoffrey Hellman (Minnesota), Don Howard (Notre Dame), and Alan E. Shapiro (Minnesota). Also participating in the fifth annual Seven Pines Symposium were Abhay Ashtekar (Penn State), Jeremy Butterfield (Oxford), Michel Janssen (Minnesota), Serge Rudaz (Minnesota), and Rafael D. Sorkin (Syracuse).

The sixth annual Seven Pines Symposium will be held from May 15-18, 2002, on the subject, "Symmetry and Symmetry Breaking in Physics."

Forum Officers

Benjamin Bederson, Department of Physics (emeritus), New York University (ben.bederson@nyu.edu), became Chair in April 2001 at the end of Laurie Brown's term. **Hans Frauenfelder**, Los Alamos National Laboratory (frauenfelder@lanl.gov), became Chair-elect and will succeed to Chair in April 2002. **Michael Riordan**, SLAC (michael @slac.stanford.edu), was elected Vice-Chair and will succeed to Chair-Elect in April 2002. **Kenneth Ford**, retired Executive Director of AIP (kwford@bellatlantic.net), was elected Secretary-Treasurer for a three-year term.

Daniel M. Greenberger, CCNY (greenbgr@scisun.sci.ccny.cuny.edu), and **Elizabeth Paris**, Dibner Institute, MIT (eparis@dibinst.mit.edu), were elected to three-year terms on the Executive Committee. Their terms end in April 2004. In addition, **Michael Nauenberg**, UC-Santa Cruz (michael@mike.ucsc.edu), and **Allan Needell**, National Air and Space Museum, Smithsonian Institution (allan.needell@ nasm.si.edu) were elected by the Executive Committee to fill the remaining year of the terms of Michael Riordan, who became Vice-Chair, and A.P. French, who resigned for personal reasons. Their terms end in April 2002. The remaining members of the Executive Committee are **Elizabeth Urey Baranger**, University of Pittsburgh (eub@pitt.edu) and **Michael E. Fisher**, University of Maryland at College Park, whose terms expire April 2003.

Gloria Lubkin, *Physics Today* (gbl2@aip.org), continues as Forum Councillor until December 2001. **Bill Evenson**, Brigham Young University(evenson@byu .edu), as *Newsletter* Editor, and **Spencer R. Weart**, Director of the AIP Center for History of Physics (sweart@aip.org), serve as *ex officio* members of the Executive Committee.

Many thanks to **Laurie M. Brown**, Department of Physics and Astronomy (emeritus), Northwestern University (brown@lotus.phys.nwu.edu), for his good work as Chair during 2000-2001, and to **Allan D. Franklin**, Department of Physics, University of Colorado(Allan.Franklin@ colorado.edu), for his continued help as Past Chair during 2000-2001. Thanks also to **Alanna Connors** and **Martin C. Gutzwiller** for their work on the Executive Committee during the last three years.

Executive Committee

The annual meeting of the Executive Committee was held on April 29, 2001, at the APS April Meeting in Washington. It was chaired by Laurie Brown, who thanked the many Forum members who helped with FHP projects this year, especially the Program Committee, the Award Committee, and the Nominating Committee. It was determined that an election for Forum Councillor will be held this fall since Gloria Lubkin's term expires on December 31. This election will be held electronically, to the extent possible. Because Michael Riordan was elected Vice-Chair and A. P French resigned for personal reasons, the Executive Committee elected Michael Nauenberg and Allan Needell to fill the unexpired terms. Both new appointees will serve until April 2002. The proposed Forum Award was approved conditionally by APS Council, allowing fund raising to move forward. The Forum Award Committee is focusing on raising the money to make the award available within the next two years. Financial status and membership of the Forum are similar to last year. With electronic voting, the number of members participating in the election increased significantly to 10.3% of FHP membership (310). Proposed revisions to update the bylaws were considered and passed to APS Council for their review.

Forum Committees

For 2001-02, the Standing Committees of the Forum are:

Program Committee: **Hans Frauenfelder** (chair), Michael Nauenberg, Elizabeth Paris, Michael Riordan

Nominating Committee: **Laurie Brown** (chair), Elizabeth Baranger, Anne Kox, Fritz Rohrlich, Virginia Trimble

Fellowship Committee: **Michael Riordan** (chair), Laurie Brown, Michael Fisher, Hans Frauenfelder, Martin Gutzwiller

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

Award Committee: **Ben Bederson** (chair), Ken Ford, Gloria Lubkin, Harry Lustig, Michael Riordan

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

Call for nominations

Nominations are invited for Forum officers to be elected in early 2002 for terms beginning immediately following the Executive Committee meeting in April. Offices that will be open are Vice-Chair and two Members-at-Large of the Executive Committee. Send nominations to the chair of the Forum Nominating Committee: Prof. Laurie M. Brown, Department of Physics and Astronomy, Northwestern University, Evanston, IL 60208;brown@lotus.phys. nwu.edu.

Fall 2001 Election for Forum Councillor

Gloria Lubkin's term as Forum Councillor ends December 31, 2001. An election will be held this fall for Forum Councillor for a four-year term beginning January 1, 2002.

APS Fellow Nominations

Michael Riordan is chair of the Forum's Fellowship Committee for 2001-02. 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 Dr. Michael Riordan, MS 80, SLAC Director's Office, Stanford, CA 94309; michael@slac.stanford.edu.

Contributed papers for the April 2002 meeting

Because of the success of the Forum's contributed paper sessions in 2000 and 2001, the Executive Committee has voted and obtained approval to continue these sessions annually in the 20-minute contributed paper format. The next FHP contributed paper session will be at the 2002 April APS meeting in Albuquerque. The deadline for submitting abstracts for this session is January 11, 2002. *Members are strongly encouraged to consider submitting abstracts on their current work.*

Request for Information about Memorial Sessions for Prominent Physicists

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

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

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

APS and AIP News

2002-2003 APS/AIP Congressional Science Fellowship Programs

The American Institute of Physics and the American Physical Society are accepting applications for their 2002-2003 Congressional Science Fellowship programs. Fellows serve one year on the staff of a Member of Congress or congressional committee,learning the legislative process while lending scientific expertise to public policy issues. Application deadline is January 15, 2002. For more information, visitwww.aip.org/pubinfo orwww.aps.orgpublic_affairs/fellow/index.shtml.

2002-2003 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, 2001. For more information, visit www.aip.org/mgr/sdf.html.

AIP Center for History of Physics

Syllabi and bibliographies for teaching history of physics

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

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

The AIP Center for History 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 $2500 each. They can be used only to reimburse direct expenses connected with the work. Preference will be given to those who need funds for travel and subsistence to use the resources of the Center's Niels Bohr Library (near Washington, DC), or to microfilm papers or to tape-record oral history interviews with a copy deposited in the Library. Applicants should name the persons they would interview or papers they would microfilm, or the collections at the Library they need to see; you can consult the online catalog at www.aip.org/history, and please feel free to make inquiries about the Library's holdings.

Applicants should either be working toward a graduate degree in the history of science (in which case they should include a letter of reference from their thesis adviser), or show a record of publication in the field. To apply, send a vitae, a letter of no more than two pages describing your research project, and a brief budget showing the expenses for which support is requested to: Spencer Weart, Center for History of Physics, American Institute of Physics, One Physics Ellipse, College Park, MD 20740; 301-209-3174, fax:301-209-0882;sweart@aip.org. Deadlines for receipt of applications are June 30 and December 31 of each year.

Notes and Announcements

***Rabi, Scientist and Citizen* by John Rigden** has been reissued in paperback by Harvard University Press with a new preface.

Position announcement: HSS Bibliographer and Associate Editor of *Isis*, History of Science Society and Term Faculty Appointment, Department of the History of Science, University of Oklahoma. The History of Science Society and the University of Oklahoma invite nominations and applications for the History of Science Society Bibliographer and Associate Editor of *Isis* and a term faculty appointment in the Department of the History of Science, each with a commitment of 50 percent time through December 31, 2003. Starting date is negotiable, but with a preference for appointment as soon as possible. This appointment covers the Current Bibliography for the years 2000 through 2003, with the possibility of 5-year renewal. Review of applications will begin immediately and will continue until the position is filled. For information contact Steven J. Livesey, Search Committee Chair, Department of the History of Science, University of Oklahoma, 601 Elm, Room 622, Norman, OK 73019-3106, 405-325-2213; fax: 405-325-2363; slivesey@ou.edu.

Ivan Slade Prize

The first Slade Prize, administered by the British Society for the History of Science, was awarded last summer. First prize was awarded to Sander Gliboff, now at Northwestern University, for the essay, "Gregor Mendel and the Laws of Evolution." Joint second prize winners were John Henry, University of Edinburgh, for "Animism and Empiricism: Copernican Physics and the Origins of William Gilbert's Experimental Method," and David Kaiser, now MIT, for "Stick Figure Realism: Conventions, Reification, and the Persistence of Feynman Diagrams, 1948-1964."

The British Society for the History of Science invites entries for the 2001 Slade Prize. The Slade Prize of £300 is awarded biennially to the writer of an essay (published or unpublished) that makes a critical contribution to the history of science. Examples would be scholarly work that critically engages a prevalent interpretation of a historical episode, scientific innovation or scientific controversy. Entry is open to people of any age or nationality. The Prize may be awarded to the writer of one outstanding essay, or may be divided between two or more entrants. The Prize(s) will be presented at a BSHS meeting. Any winning essay(s) not yet placed with a publisher will be considered for publication in the British Journal for the History of Science at the discretion of the Editor.

General Rules: There is no age limit. Entry is not limited to members of BSHS or UK citizens. Entries should be in English, and should have been published or written in the two years prior to 31 December 2001. Essays should not exceed 10,000 words in length (excluding footnotes) and must be accompanied by an abstract of 500 words. Entries without an abstract will not be considered.

Three copies of the essay and abstract should be sent to arrive not later than 31 December 2001. Essays should not bear any reference to the author, either by name or department. Submissions by email will not be accepted. Entries should be sent to BSHS Secretary, Dr. Sally Horrocks, Department of Economic and Social History, University of Leicester, Leicester, LE1 7RH; tel: + 44 116 252 5070; fax: +44 116 2525081;smh4@le.ac.uk. Enquiries by email are welcome.

Pictet Prize

The Société de Physique et d'Histoire Naturelle (SPHN) de Genève has announced details of its 2002 Marc-Auguste Pictet Prize. This Prize, worth at least 12,000 Sfr, is intended for young researchers to reward outstanding work, unpublished or recently published in the field of the history of science. The prize is open to both Swiss and foreign candidates at the university level. Notification of candidature should be sent by 31 December 2001 to Président de la SPHN, Museum of Natural History, Caisse Postale 6434, CH-1211 Geneva 6, Switzerland. Two full copies of the work, accompanied by a summary and a curriculum vitae should be submitted before 31 December 2001. The texts may be written in French, German, Italian, or English. In the last three instances, the summary should be translated into French and be approximately 12 pages in length, i.e. 4000 words. The theme for the 2002 prize is the history of meteorology and climatology.

Pfizer Prize

Crosbie Smith was awarded the Pfizer Prize of the History of Science Society for his book *The Science of Energy* (reviewed in the September 2000 issue of this *Newsletter*).

Fermi Centenary

Numerous celebrations have taken place in honor of Enrico Fermi, born September 29, 1901. Physicists and historians of physics may be interested in the associated web sites: Fermilab (www.fnal.gov/pub/events/special_fermi.html), the University of Chicago (fermi_remembered.uchicago.edu), and the University of Pisa (docenti.ing.unipi.it/dimnp/fermi2001). A US Department of Energy website (www.osti.gov/accomplishments/fermi.html) summarizes some of the accomplishments of this great physicist. His name is also preserved on element 100, a unit of distance (10^{-15} m), one of the two broad categories of particle (fermion), an energy level (condensed matter physics), a type of interaction, a constant, a temperature, a gas, Fermilab, a Presidential award, an institute at the University of Chicago, and now a brand new US postage stamp.

A symposium, "The Life and Times of Enrico Fermi," will be held at UCLA, November 29-December 1. Contact Cludio Pellegrini (pellegrini@physics.ucla.edu) for more information.

Faraday Archive

Most of the manuscripts of Michael Faraday in the archives of the Royal Institution, Institution of Electrical Engineers, and the Guildhall Library have been microfilmed and are available, with a guide by Frank A. J. L. James, from Microform Academic Publishers, Main Street, East Ardsley, Wakefield, WF3 2AT, West Yorkshire, UK; info@microform.co.uk;www.microform.co.uk

J.J. Thomson Collection

The J.J. Thomson papers in Trinity College, Cambridge, have been catalogued and deposited by the National Cataloguing Unit for the Archives of Contemporary Scientists. Further details are available from P. Harper, NCUACS, University of Bath, Claverton Down, Bath, BA2 7AY, UK; www.bath.ac.uk/Centres/NCUACS

Bakken Library and Museum (Minneapolis) Visiting Research Fellowships.

The Bakken Library and Museum offers visiting research fellowships to facilitate research in its collection of books, journals, manuscripts, prints, and instruments. The focus of the collections is the history of electricity and magnetism and their applications in the life sciences and medicine. The fellowship is a maximum of $1300 and is to be used for travel, subsistence, and other direct costs of conducting research at the Bakken. The minimum period of residence is one week. The grants are open to all researchers. Contact David J. Rhees, Executive Director, The Bakken Library and Museum, 3537 Zenith Avenue South, Minneapolis, MN 55416; rhees@thebakken.org.

The Sackler Archive Resource

Developed by the Royal Society Library and funded by the Raymond and Beverly Sackler Trust, the Resource is a biographical database of Fellows of the Royal Society from its inception in 1660 to the present (excluding the current Fellowship) and includes some 8,000 figures in the history of science. See www.royalsoc.ac.uk/library

History and Technology

This is an international journal that encourages submissions from both graduate students and more established scholars interested in the mutual shaping of technology and society in an historical perspective. To date considerable emphasis has been given to work dealing with the twentieth century. The journal comes out four times a year and usually includes three articles and a small book review section. Guest editors sometimes take responsibility for a single number dealing with a coherent theme. The time to publication is relatively brief as the journal works on a flow system, i.e. when there is enough material available they proceed to publication. Interested authors should submit articles to: Dr. John Krige, School of History, Technology and Society; Georgia Institute of Technology; Atlanta, GA 30332-0345; 404-894-7765; fax 404-894-0535.

Literary and Scientific Cultures of Early Modernity

A new series from Ashgate Publishing Company was announced recently. Series Editors are Mary Thomas Crane, Boston College and Henry S. Turner, University of Wisconsin-Madison. Ashgate's new series provides a forum for groundbreaking work on the relations between literary and scientific discourses in Europe, during a period when both fields were in a crucial moment of historical formation. They welcome proposals that address the many overlaps between modes of imaginative writing typical of the sixteenth and seventeenth centuries – poetics, rhetoric, prose narrative, dramatic production, utopia – and the vocabularies, conceptual models, and intellectual methods of newly emergent "scientific" fields such as medicine, astronomy, astrology, alchemy, psychology, mapping, mathematics, or natural history. In order to reflect the nature of intellectual inquiry during the period, the series is interdisciplinary in orientation and will publish monographs, edited collections, and selected critical editions of primary texts relevant to an understanding of the mutual implication of literary and scientific epistemologies. More information is available from Erika Gaffney, Editor, Ashgate Publishing Company, 131 Main Street, Burlington, VT 05401-5600; egaffney@ashgate.com

Exploring the Cosmos

The fifth volume of *Exploring the Unknown*, has just been published by NASA. This is one of an ongoing series of reference books essential for anyone interested in the history and development of the U.S. civil space program. Selected documents of interest to those involved in both space history and space policy are grouped into three thematic chapters with an introductory essay for each subject. Chapter one is devoted to the origins and early organization of space science; chapter two covers NASA's planetary exploration efforts; and the third chapter details space-based astronomy and astrophysics. The book is for sale from the U.S. Superintendent of Documents and from the NASA Information Center. Details on ordering the volume are available at history.nasa.gov/what.html.

Meetings

On 8-11 November 2001 the **History of Science Society** will hold its annual meeting in Denver, Colorado. Contact: History of Science Society Executive Office, University of Washington, Box 351330, Seattle WA 98195-1330, 206-543-9366;depts.washington.edu/hssexec; hssexec@u.washington.edu.

"The Life and Times of Enrico Fermi," a symposium at the centenary of Fermi's birth, will be held at UCLA, November 29-December 1. This symposium is sponsored by several UCLA departments and centers: the Physics Department, the Center for History of Physics, the Center for Modern and Contemporary Studies, and the Department of Italian. Contact Claudio Pellegrini (pellegrini@physics.ucla.edu) for more information.

An Online Symposium – Science and the Developing World: Past, Present, and Future, Sponsored by *ScienceWeek*, www.scienceweek.com. Closing date for submission of papers: December 15, 2001. All papers to be published on the SW website, January 2002. Online access to the symposium will be completely free. Maximum length 2500 wds. Language: English. Both new and previously published papers are acceptable. Send papers via email to Dan Agin, PhD, *ScienceWeek*, dpa@scienceweek.com. Please note: All material must be sent by Email as plain ASCII text. Please convert any word processing formats to plain text. We will format your paper for the SW website. Hypertext inclusions of images and graphics on other sites are acceptable. PDF files are not acceptable. Printed or typewritten papers are not acceptable.

The following additional Online Symposia are also in preparation: Perspectives on the Origin of Life (closes 15 Jan), Revolutions in Physics: Past, Present, and Future (closes 15 Feb).

The 116th annual meeting of the **American Historical Association** will be held in San Francisco, 3-6 January 2002. The Program Committee invites proposals from all members of the Association (academic and nonacademic), from affiliated societies, and from scholars in foreign countries and in related disciplines. In planning the program, the committee seeks presentations that address the entire community of historians and provide opportunities to examine the larger concerns of the profession. Information on proposing may be obtained from the AHA office at 2002 Materials, AHA, 400 A St., SE, Washington, DC 20003-3889. (202) 544-2422, ext. 104, fax (202) 544-8307; aha@theaha.org. All materials may also be found on the AHA's website: www.theaha.org.

Faces of anti-Newtonianism, 1672-1832, will be held 24-25 May 2002 at Center for History and Philosophy of Science, Department of Philosophy, University of Paris-X (Nanterre), France. ***Call for Papers***: Historians have often regarded the opposition encountered by Newtonianism during its triumphal progress in the 18th and 19th centuries as little more than conservative reaction or temporary misunderstanding. Yet from Leibniz and Berkeley to Goethe and the Naturphilosophen, powerful critics manifested profound dissatisfaction with both the scientific content and the philosophical foundations of Newtonianism. The aim of the colloquium is to engage in a critical reexamination of anti-Newtonianism by exploring its diverse origins, the content of its arguments and practices, and its scientific and philosophical consequences. The colloquium will be organized around four major themes (subthemes listed are indicative, not exhaustive): 1. The principles of Newtonian mechanics. Cartesian reactions to the publication of the *Principia Mathematica*; critiques by Leibniz, Huygens, Fontenelle, and others of central Newtonian concepts (attraction, force, relative and absolute motion, space and time). 2. Theories of matter. Reception of and resistance to the research program of the Queries in Newton's *Opticks*; the encounter of Newtonianism with established research traditions in chemistry. 3. Hypothesis and experiment. The 18th century epistemological debate regarding the legitimacy of the experimental method and inductive generalization, the proscription of hypotheses, the relation of mathematics to experience, and the validity of the method of fluxions; competing forms of experimental practice in the work of Rizetti, Mariotte, Goethe, and others. 4. Scientific knowledge and human culture. The evolving (post-*Principia*) image of the cultural role of natural science; philosophical (Berkeley) and poetical (Swift, Coleridge, Blake, Goethe)critiques of the Newtonian conception of nature; theological objections to Newtonianism. To propose a paper (30 minutes, either in French or English), please send a short abstract and a c.v. to either: Philippe Hamou (Philippe Hamou@aol.com) or Neil Ribe (ribe@ ipgp.jussieu.fr). More information is available from either of these organizers.

The Canadian Society for the History and Philosophy of Science (CSHPS) is holding its annual conference at the University of Toronto, 26-28 May 2002. The program committee invites historians, philosophers and other scholars of the social sciences and humanities to submit paper, panel or session proposals. The proposals and papers may be in English or French, and should have a title, a brief abstract of 150 to 250 words, and the complete information for correspondence. They strongly encourage email submissions. Information about Congress registration and accommodation can be found at www. er.uqam.ca/nobel/r20430/schps_toronto _2002. Canadian Society for History and Philosophy of Science: www.ukings. ns.ca/cshps.

HOPOS 2002, the Fourth Congress of the International Working Group in History of Philosophy of Science, will be held in Montreal, June 21-23, 2002. The congress is being held in cooperation with Concordia University, McGill University, the Université de Montréal, and the Université du Québec à Montréal. The conference is open to scholarly work in French or English on the history of philosophy of science from any disciplinary perspective. Submissions of abstracts, in French or English, of papers of approximately 30 minutes' reading length, and of symposia of three to four thematically related papers will be considered for the program. Plenary speakers will be Francois Duchesneau (Université de Montréal) and Don Howard (University of Notre Dame). 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 contact addresses of all participants, and abstracts of 250 words for each of three to four papers. All submissions should arrive by 1 January 2002. Notification of acceptance of submissions will be provided by 1 March 2002. Preferred format for all submissions is plain ASCII text or RTF attachment submitted by electronic mail to hopos2002@arts.ubc.ca with "HOPOS 2002 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: Alan Richardson, Co-Chair, HOPOS 2002 Program Committee, Department of Philosophy, 1866 Main Mall - E370, University of British Columbia, Vancouver, BC V6T 1Z1, Canada.

Karl Popper 2002 Centenary Congress, 3-7 July 2002, Vienna. The work of the Congress will be arranged in seven sections: 1. Philosophy of the physical sciences, 2. Philosophy of the biological sciences, 3. Philosophy of the social sciences, 4. Moral & political philosophy, 5. Logic & scientific method, 6. Epistemology & metaphysics, 7. Life & times of Karl Popper. Invited lectures and symposia are planned for all sections. Contributed papers relevant to Popper's work will be invited in all sections (though papers tackling problems appropriate to more than one section will be welcome). Potential contributors are asked to bear in mind that a period of 30 minutes will be allotted to each contributed paper, including discussion. The deadline for the submission of abstracts will be early in 2002. All abstracts will be refereed. Letters of acceptance will be mailed not later than 1 April 2002. The Congress languages are English and German. For more information, please contact Gerhard Budin at the University of Vienna, Department for Philosophy of Science, Sensengasse 8/10, A-1090 Vienna; fax: +43-1-4277-9476; preferably by email:karlpopper2002.econ @univie.ac.at.

The Congress website situated at www.univie.ac.at/karlpopper2002 will be kept up to date.

A Robert Hooke Tercentenary Conference will be held at Birkbeck College, London, 7-9 July, 2003. Contact julie.jones6 @btinternet.com.

Web Resources

Medieval and Renaissance Scientific Instruments. The Museum of the History of Science, Oxford, Instituto e Museo di Storia della Scienza, Florence, The British Museum, London, and Museum Boerhaave, Leiden, have announced the online version of "Epact: Scientific Instruments of Medieval and Renaissance Europe:"www.mhs.ox. ac.uk/epact. This is an electronic catalogue of all the Medieval and Renaissance scientific instruments in the four museums.

Archive Gateway: www.archiveshub. ac.uk is very useful for researching history of UK science. The Archives Hub provides a single point of access to descriptions of archives held in UK universities and colleges. At present these are primarily at collection-level, although where possible they are linked to complete catalogue descriptions. The Archives Hub forms one part of the UK's National Archives Network, alongside related networking projects. A Steering Committee which includes representatives of the Public Records Office, the Historical Manuscripts Commission and the other archive networks guides the progress of the project. The service is hosted at MIMAS on behalf of the Consortium of University Research Libraries (CURL) and is funded by the Joint Information Systems Committee (JISC). Systems development work is undertaken at the University of Liverpool.

Online tutorial 'Internet for History and Philosophy of Science': A free user-friendly guide to virtual resources in history and philosophy of science, technology and medicine is now available at www.humbul.ac.uk/ vts/hps. This tutorial was prepared by James Sumner, a PhD student at the University of Leeds, as one of 29 new such 'virtual training suites' supported by the Resource Discovery Network for HUMBUL in a wide range of disciplines. A complete list of these suites with hyperlinked gateways can be found at www.vts.rdn.ac.uk. The complete range of humanities suites, including specialist tutorials for history and for philosophy, can also be accessed at www.humbul.ac.uk/vts.

Navigational Aids for the History of Science, Technology and the Environment (NAHSTE): This RSLP project has relaunched its website at www.nahste.ac.uk.

The new pages contain, among other things: a detailed breakdown of the project's methodology, information about the collections being catalogued, sample ISAD and ISAAR records, abstracts from academic papers read at dissemination events, and the online newsletter.

Project Orion: A Design Study of a System for Detecting Extrasolar Planets (NASA SP-436, 1980) is now online at history.nasa.gov/SP-436/sp436.htm. This book was edited by David C. Black and addresses the question "Why is a search for other planetary systems important?"

New materials regarding SETI (The Search for Extraterrestrial Intelligence) are posted at history.nasa.gov/seti.html. This page includes a brief outline of SETI history, as well as a variety of links, including to a journal article describing the circumstances behind the Congressional cancellation of NASA's formal SETI program and an on-line version of *The Search for Extraterrestrial Intelligence* (NASA SP-419, 1977).

New book on the history of Sputnik and associated web site: Writer Paul Dickson is publishing a new book on the history of Sputnik. *Sputnik: The Shock of the Century* (New York: Walker & Co., 2001) is a book chronicling the events and developments leading up to and emanating from Sputnik 1's launch. It has a fine web site that features details about the book, Paul Dickson's thoughts on how the book came to be written, the full text of the introduction and first chapter, a gallery of historical photographs of people and events surrounding Sputnik's launch and the race for space, advance comments and reviews, unique audio and video clips recorded at the time, and links to other sources of information on the internet. See sputnikbook.com/home.php.

Dibner Institute for the History of Science and Technology: Fellows Programs 2002-2003

The Dibner Institute for the History of Science and Technology invites applications to its two fellowship programs for the academic year 2002-2003: the Senior Fellows program and the Postdoctoral Fellows Program. Some twenty-five Dibner Fellows are resident at the Institute each year. The Dibner Institute is an international center for advanced research in the history of science and technology, established in 1992. It draws on the resources of the Burndy Library, a major collection of both primary and secondary material in the history of science and technology, and enjoys the participation in its programs of faculty members and students from the universities that make up the Dibner Institute's consortium: The Massachusetts Institute of Technology, the host institution; Boston University; and Harvard University. The Institute's primary mission is to support advanced research in the history of science and technology, across a wide variety of areas and a broad spectrum of topics and methodologies. The Institute favors projects that address events dating back thirty years or more.

The deadline for receipt of applications for 2002-2003 is December 31, 2001. Fellowship recipients will be announced in March 2002. 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 2001-2002

The Dibner Institute for the History of Science and Technology has appointed sixteen Senior, nine Postdoctoral, and six Graduate Student Fellows and reappointed six Postdoctoral Fellows. They 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 full listing of all Dibner Institute Fellows with information about their backgrounds and projects can be found at www.aps.org/FHP/news.html as a web supplement to this*** **Newsletter.**

Senior Fellows:

Domenico Bertoloni Meli is Professor of History and Philosophy of Science, Indiana University. He is the author of *Marcello Malpighi, Anatomist and Physician* and *Equivalence and Priority: Newton versus Leibniz, including Leibniz's Unpublished Manuscripts on the "Principia."* At the Dibner Institute he expects to complete his book on motion and mechanics in the seventeenth century.

Richard Creath, Professor, Department of Philosophy, Arizona State University, is the editor of the volume, *Dear Carnap, Dear Van: The Quine-Carnap Correspondence and Related Work* and the co-editor, with Jane Maienschein, of *Biology and Epistemology*. His most recent article is "The Linguistic Doctrine and Conventionality: The Main Argument in 'Carnap and Logical Truth,'" forthcoming in *Logical Empiricism in North America*. He will continue his work on the volume, "Analyticity: Carnap, Quine, and the Structure of Scientific Knowledge," while at the Dibner Institute.

Elaheh Kheirandish, Research Associate at the Center for Middle-Eastern Studies, Harvard University, is the author of the two-volume work, *The Arabic Version of Euclid's Optics* and the forthcoming "Sources for the History of Mathematical Sciences in the Islamic World," to be published by the Institute for Humanities and Cultural Studies. At the Dibner Institute she will continue her work titled "The Optical Traditions of Ancient Alexandria and Their Transmission within Near Eastern and European Lands: 300 BC - 1300 AD."

Volker Remmert is Professor, University of Mainz, Germany. He is the author of the volume, *Ariadnefäden im Wissenschaftslabyrinth. Studien zu Galilei: Historiographie - Mathematik - Wirkung* and "Mathematicians at War. Power Struggles in Nazi Germany's Mathematical Community: Gustave Doetsch and Wilhelm Süss" in *Revue d'histoire des Mathématiques* **5** (1999). His research project at the Dibner Institute is titled "Picturing the Scientific Revolution: Frontispieces as Second Language of the Seventeenth-Century Mathematical Sciences."

Michael B. Schiffer is Professor of Anthropology and Director, Laboratory of Traditional Technology, at the University of Arizona. He is the author of *Technological Perspectives on Behavioral Change* and, with Andrea Miller, *The Material Life of Human Beings: Behavior, Artifacts, and Communication*. He has also written two books on consumer electrical and electronic technologies. His current project focuses on the process of "technological differentiation" or "technology transfer" as related to electrical technologies of the 18th century.

George E. Smith, Professor, Department of Philosophy, Tufts University, is the author of "J.J. Thomson and the Electron, 1897-1899," to appear in the forthcoming volume, *The Electron and the Birth of Microphysics* and "From the Phenomenon of the Ellipse to an Inverse-Square Force: Why Not?" to appear in a Festschrift for Howard Stein. He plans to work on two projects at the Dibner Institute: (1) exploration of how Newton's *Principia* provided a new way for the development of high-quality evidence in science and (2) the study of works in the history of chemistry from Lavoisier to the emergence of the periodic table and the development of organic chemistry in the second half of the 19th century.

Postdoctoral Fellows:

Elizabeth Cavicchi received her Ed.D. from the Harvard Graduate School of Education, where she was a Lecturer and developed courses in teaching science. She is the author, with P. Lucht and F. Hughes-McDonnell, of "Playing with Light," *Educational Action Research* **9**(1) (2001) and of "Experimenting with Magnetism: Ways of Learning of Joann and Faraday," *American Journal of Physics* **65** (9) (1997). For her Dibner Institute research project, she plans to study the experimental practices and knowledge resulting from the experiments of Jonathan Hearder and other amateurs in making and using induction coils.

Andrew Janiak will receive his Ph.D. Spring 2001 from Indiana University and is currently a Tutor in Philosophy at the University of California, Berkeley. He is the author of "The Continuing Strength of Newtonianism," and of "Space, Atoms and Mathematical Divisibility in Newton," in *Studies in History and Philosophy of Science*, **31**,2 (2000). His research project while at the Dibner Institute will focus on the philosophical response to Newtonian physics in the writings of Kant, Leibniz and Berkeley.

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

Manolis Patiniotis received his Ph.D. from the University of Athens, where he is now an Associate Researcher. He is the author of "When Eugenios Voulgaris Prefaces Theofilos Korydalleas," *Neusis, Journal for the History and Philosophy of Science and Technology*, **8** (1999) and, with Dimitris Dialetis and Kostas Gavroglu, "The Sciences in the Greek-Speaking Regions During the 17th and 18th Centuries: The Process of Appropriation and the Dynamics of Reception and Resistance," *Archimedes*, **2** (1999). During his year at the Dibner Institute he will continue his study of the works of natural philosophy written by Greek-speaking scholars of the 18th century, writings that tried to synthesize elements of the new natural philosophy with the Aristotelian tradition.

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

Postdoctoral Fellows Appointed to a Second Year:

Tara Abraham received her Ph.D. from the University of Toronto. She is the author of the article "(Physio)logical Circuits: Mathematical Biology and the Intellectual Origins of the McCulloch-Pitts Neural Networks," forthcoming in the *Journal of the History of the Behavioral Sciences* and the paper, "Styles of Visualization: Representing Neurons in the 1930s," to be presented at the Spring 2001 meeting of the Canadian Society for the History and Philosophy of Science. At the Dibner Institute, she is continuing to investigate mathematical and cybernetic methods in twentieth-century biology. Her current project examines the work of mathematical biophysicist Nicolas Rashevsky.

Elizabeth Paris received her Ph.D. from the University of Pittsburgh and was previously a lecturer in the History of Science Department at Harvard. She is the author of the forthcoming article, "Lords of the Ring: The Fight to Build the First U.S. Electron-Positron Collider," in *Historical Studies in the Physical and Biological Sciences*. Her research project at the Dibner Institute focuses on Italian high energy physics instrumentation in the 1960s.

Graduate Student Fellows:

Tongdong Bai is a student in the Department of Philosophy, Boston University. He studied at Peking University, where he earned a B.S. in nuclear physics and an M.S. in philosophy of science. For his dissertation he is exploring the EPR interpretation of quantum mechanics, focusing on Niels Bohr and also on Wolfgang Pauli and Richard Feynman.

FORUM COUNCILLOR ELECTION

Please vote for Forum Councillor. If you have email registered with APS, you will have received a message inviting you to vote on the internet, as authorized by the FHP Executive Committee last year. If not, you should have received a paper ballot by mail. If you want a paper ballot but have not yet received one, please email your request, including your mailing address, to fhp_ballot@byu.edu or contact Prof. Bill Evenson, Department of Physics, Brigham Young University, Provo, UT 84602, 801 378-6078. **The closing date of the election is November 28 – ballots must be received by that date to be valid**. Brief resumes and statements from the candidates begin on this page. The candidates on the ballot are

Forum Councillor:

Gloria Lubkin

Sam Schweber

Nominees

Gloria Lubkin received her A.B. degree in physics from Temple University and her M.S. from Boston University. After two years as a nuclear physicist in industry, Lubkin joined *Physics Today* as Associate Editor (1963-69). Since then she has been Senior Editor (1970-84), Editor (1985-94), Editorial Director (1994-00), and is currently Editor at Large. She has emphasized physics history in the magazine's coverage of recent events, in historical articles, and special issues. In the 1960s, she was involved in oral history interviews with Feynman, Serber, Weisskopf, Wheeler, and Van Vleck. She was on the APS History Forum's Executive Committee (1983-86 and 1992-95), was associate Editor of the *History of Physics Newsletter* (1983-87), Member of the Publications Committee (1993), and served as a member (and one year as chair) of many Nominating Committees. She has represented the Forum on the APS Council (1998-01) and was elected to a two-year term on the APS Executive Board (2000-01). She helped found the Theoretical Physics Institute at the University of Minnesota, and has served as co-chair of its advisory committee since 1987. In 1990, Minnesota named a chair in her honor.

Statement: The historical sessions our Forum organizes for APS meetings are well attended, and I believe we should try to arrange even more each year. At present, Federal support for physics has dropped, industrial support hasn't taken up the slack, and some scholars are questioning whether scientists are objective. In such a climate, the Forum can make important contributions – dealing with the history of science policy; helping identify the benefits (and sometimes risks) of past physics research; providing insight and intellectual resources for physics teaching, and communicating physics to the public. Meanwhile, if we are successful in fundraising to establish the History of Physics Award, we have an opportunity to honor significant scholarly work in the history of physics.

Sam Schweber got his PhD in physics in 1952 at Princeton University. After postdoctoral fellowships at Cornell and at Carnegie Tech he joined the faculty of Brandeis University in 1955, and has been there ever since. He is the author of a textbook on relativistic quantum field theory which was published in 1962. Since the late 1970s his research activities have been in the history of science and he has written an account of the post World War II developments in quantum electrodynamics, *QED and the Men who Made It*, and he is presently at work on a biography of Hans Bethe. His book on Oppenheimer and Bethe, *In the Shadow of the Bomb*, was published in 2000.

Statement: I believe that one of the important functions of the Forum is to make both the Society and the public at large more sensitive to the importance of the context in which physics is carried out. And by context I mean not only the economic, political, sociological and social environment but also the hopes and aspirations that motivate the activities, and the responsibilities these entail. I believe that such views ought to be represented within the Council of the Society; that persons who have been actively engaged in disseminating the advances in the various fields of physics in a cogent, dependable and understandable manner to both scientists and the public at large ought to be on the Council of the Society; and that the Council have more women on it.

Book Reviews

Allan Franklin, *Are There Really Neutrinos?: An Evidential History* (Perseus Books, Cambridge, MA, 2001). 371+xii pages, ISBN: 0738202657, $45

Reviewed by William E. Evenson, Brigham Young University.

This is a time of great excitement in the study of neutrinos, with recent data greatly strengthening the case that neutrinos have mass. So Franklin's excellent book is especially welcome and timely. The book tells us much about the history of the neutrino and related physics (beta decay, weak interactions and associated theories, experiments to observe neutrinos, multiple types of neutrinos, neutrino mass and oscillations, missing solar neutrinos). It is up to date, dealing with experimental results obtained right up to the final revisions of the text (tau neutrino, 2000) and describing experiments that were underway but not yet completed for the study of neutrino oscillations and the missing solar neutrino question.

Yet the theme and aims of this book are not so much the history and properties of the neutrino as to show by case study that "science is a reasonable enterprise, which produces knowledge of the physical world based on valid experimental evidence and reasoned, critical discussion." By looking at the history of the neutrino in careful detail, examining the experiments, the dead-ends in both theory and experiment and the eventually successful interpretations of the slowly accumulating data, Franklin argues that we do have good grounds for belief in the existence and properties of this elusive particle. He then concludes that since science has, by its normal practice, developed knowledge of a particle as difficult to observe as the neutrino, then the normal practice of science can reasonably be relied upon to provide us with knowledge of the physical world.

Franklin brings in both data and summaries of theoretical arguments to make the case for the neutrino. The book is not technically specialized, but it requires some physics background to follow the arguments. This reviewer sees that level of technical detail as a strength of the book, because the arguments are laid out fully enough to assess and consider.

The book begins with an introduction to the history, laying out the line of argument and its main features. The second half of the introduction is then composed of two philosophical sections: "A. Postmodernism, Constructivism, and Science," and "B. A Brief Philosophical Digression: Scientific Realism." In the philosophical introduction, Franklin outlines the modern philosophical challenges to science as a producer of knowledge and his approach to answering these questions. He returns briefly to these issues in each chapter (with discussion and commentary in most chapters) and summarizes in the final pages: "Conclusion: There Are Neutrinos." The philosophical implications of the practice of science that is being explored and the knowledge that is attained are the central message of this book, but it is the thorough examination of the experimental and theoretical history that makes the arguments compelling. Not the least of the insights into the practice of science is the demonstration of its self-correcting nature, with scientists admitting error and previous misinterpretation as new evidence comes to light.

Chapter one carefully lays out the background which led to the discovery of the neutrino: the discovery of radioactivity and of the electron, then the difficult work of establishing the nature of the beta-decay energy spectrum. Contrary to what I learned as a student, it was not evident in the early days that the beta-decay energy spectrum is continuous. Because of experimental artifacts and errors, it was not until the 1927 work of Ellis and Wooster that the evidence for a continuous spectrum became compelling to most physicists.

Subsequent chapters deal with "The Neutrino Hypothesis," "Toward a Universal Fermi Interaction," "Fermi's Theory: The Final Act," "'Observing' the Neutrino: The Reines-Cowan Experiments," "How Much? The Mass of the Neutrino," "How Many? Whose?" (on the types of neutrino and Majorana's vs. Dirac's neutrino), "The Missing Solar Neutrinos," and "Neutrino Oscillations."

This book can be recommended strongly on at least two levels: as a very interesting history of neutrino physics and as an extended argument for the validity of science. It deserves a wide readership.

Robert T. Lagemann, *To Quarks and Quasars: A History of Physics and Astronomy at Vanderbilt University* (Vanderbilt University Department of Physics and Astronomy, Nashville, TN, 2000) ISBN: 0967927102, $25+$5 postage & handling (available for purchase from Department of Physics and Astronomy, Vanderbilt University, Nashville, TN 37235; (615) 322-2828; fax: (615) 343-7263; physics-astronomy@vanderbilt.edu).

Reviewed by Ronald E. Mickens, Distinguished Fuller E. Callaway Professor of Physics at Clark Atlanta University. Mickens received the Ph.D. in physics from Vanderbilt in 1968.

This book gives a detailed history of the Department of Physics and Astronomy at Vanderbilt University from its genesis in 1875 to about 1995. It is authored by Robert Theodore Lagemann and is a presentation of his-story of the development of the Department, its faculty and chairs, their research and educational philosophies, and the influence of particular faculty on regional, national and international scientific research and related policy and organizational issues. An analysis is also provided of the impact that various Vanderbilt administrations had on the Department's evolution. With Lagemann's death in 1994, the task of insuring the publication of Lagemann's "substantially completed manuscript" was taken up by a colleague, Wendell G. Holladay.

The text is arranged chronologically, beginning with the main reasons for the founding of Vanderbilt University and the hiring of its first chancellor, Landon Garland, who was also named Professor of Physics and Astronomy. Over the next hundred years, a number of eminent scientists would join the department. Among these individuals were Edward E. Barnard (1883-87), discoverer of numerous comets and the person to correctly explain the gegenshein phenomenon in astronomy, and Max Delbruck (1940-47), a future Noble Prize winner in molecular biology (1969).

This is a thoroughly researched book with ample documentation. In addition to its twelve chapters, there are ninety-four photographs and illustrations, forty-four pages of chapter notes, and thirteen appendices covering topics from "List of Experiments in Daniel's Physical Laboratory Course Beginning in the Fall of 1888," to "Chairmen of the Department and Directors of the Observatory (1875-1994)." The twenty-five page index is excellent and reflects the careful editorial work of Holladay.

An important, although implicit, feature of the book is the insight that it provides into the nature of physics education and research in the southeastern region of the country. This is due in large measure to the major influence that the Department exerted in physics research and related activities in the region. For example, the Southeastern Section of the American Physical Society has been chaired by a large number of its faculty and former students. During the period 1954-64, its faculty and students dominated the number of university-based presentations given at the SESAPS annual meetings.

A particular strength of the Department has been its work in nuclear physics. Through the efforts of Joseph Hamilton and colleagues, several major facilities were constructed in the southeastern region: UNISOR (University Isotope Separator Oak Ridge), JIHIR (Joint Institute for Heavy Ion Research), and HHIRF (Holifield Heavy Ion Research Facility). Other current significant research programs in the Department include high energy physics, astronomy using robotic telescopes, research at its Free Electron Laser Center, and living state physics. The book gives a good summary of these programs along with the particular activities of participating faculty.

Another critical feature of the book is its detailed presentation of the impact that undergraduate teaching and graduate training had on the evolution of the Department. During its early history, the Department's main goal was providing students with a general background in physics and astronomy. However, after rapid growth in the early 1970s, the Department's future was seemingly in peril due to a precipitate decrease in the numbers of new graduate students and an essentially static undergraduate enrollment. While this situation was quite common nationally during the 1970s and 1980s, the manner in which this problem and related issues were resolved at Vanderbilt University makes for interesting reading.

One of Lagemann's purposes in writing this book was to "... help student and colleague alike gather a fuller appreciation for the accomplishments of those who have gone before them and enlightened us all by their insights into and applications of the great laws and principles that describe the operation of the physical world."

Through the splendid editorial efforts of Wendell Holladay, for whom we all owe a great debt of gratitude, this book was completed and published. I am certain that Lagemann would be pleased with what was done. This fine book not only gives a history of the Department of Physics and Astronomy at Vanderbilt University, it also provides a model that can be productively copied by others wishing to write the history of their particular science department.

Peter T. Landsberg, *Seeking Ultimates: An Intuitive Guide to Physics* (Institute of Physics Publishing, Bristol & Philadelphia, 2000). 314+xii pages, ISBN: 0750306572, $34.99 (£19.99), paper.

Reviewed by William E. Evenson, Brigham Young University.

This book has remarkable breadth, dealing with physics as a human activity of wide interest and summarizing much of what we know about physics and its broader implications. The historical background of many developments in physics is described, with historical vignettes and a "hero" in each chapter, to give the science a human face.

Landsberg's exploration of the limits of scientific knowledge, written for a general audience, is interesting. He points to the gaps in our knowledge and asks what we can learn from them. In the introductory chapter, “What this book is about,” he discusses intuition, incompleteness, and human aspects of science, but so briefly that he only opens a window on these topics without exploring them in a way that could lead nonscientists to serious insights. In fact, I fear that brief comments like, “Research can be a cut-throat activity. . . . This is just human nature and the general public must be made aware of it, and then make allowance for it. But for others, including this author, research can be an outcome of teaching. . . ,” (p. 6) can leave the general reader with a distorted picture of science. It is not that we should avoid discussing the interference of human nature with the practice of science, but that we must explain that practice in enough depth so the general reader is able to see how it can survive bad behavior. On the positive side, Landsberg does come back to some of these issues in his comments in the various physics chapters.

The body of the book deals with important ideas and directions in physics. Chapter 2, “There is no free lunch. Temperature and energy: science for the environment (Hero: Count Rumford),” is about thermodynamics, energy conservation, perpetual motion, and energy supply. The section “A marriage of energy and mass” does not give insight into the relation between mass and energy (that comes later) but ends with an anecdotal account of the marriage of Rumford and Lavoisier’s widow (p. 20). The anecdote gives important insight into neither physics nor its history, and given the small size of the book, I have to wonder how such a note helps meet the author’s goals. Unfortunately, throughout the book the historical notes are often too cryptic to be sure what the message is.

Chapter 3 deals with the chemical elements, the periodic table, atoms, nuclei, and particles (“Painting by numbers. Elements and particles: science as prediction (Hero: Dmitri Mendeleev).” I was surprised at the claim that “elements like oxygen, . . . were, of course, well known from the times of the alchemists” (p. 30). Chapter 4 is “Why you cannot unscramble an egg. Time and entropy: science and the unity of knowledge (Hero: Ludwig Boltzmann).” Chapter 5: “How the butterfly caused a tornado. Chaos and life: science as synthesis (Hero: Charles Darwin).” Chapter 6: “Now you see it, now you don’t. Quantum theory: science and the invention of concepts (Hero: Max Planck).” Chapter 7: “The galactic highway. Cosmology: science as history (Hero: Albert Einstein).” Chapter 8: “Weirdness or purity. Mathematics: science as numbers (Hero: Arthur Eddington).”

The final two chapters are “The last question: Does God exist? (Hero: Blaise Pascal)” and “Love of my life. Science as human activity.” In dealing with the question of whether physics leaves place for God, Landsberg is careful and thoughtful (although sometimes terse to the point of cryptic). He argues that this question is a Gödelian proposition, undecidable in physics, but worthy of discussion. He reviews the hints of a designer found in thermodynamics, cosmology, and quantum mechanics. He is careful to point out the dangers of “God of the gaps” type arguments, where God is postulated to fill any convenient gap in scientific knowledge, but when theories or observations change, grounds for belief change or even disappear. So he leaves the existence of God an open question, unanswerable in physics and the subject of faith.

The last chapter closes with a delightful page about the joys of doing science, whether in the forefront or making small contributions with the large group of lesser scientists. This concludes a chapter that briefly touches on some very big issues: what is the basis of human happiness? what are the limits of science? how is science distorted when dramatized for the public? or distorted by self-promotion? are there things to be learned from sociology of science? from postmodernism? More questions than answers here.

The book is intriguing, but I did not find it satisfying. Perhaps it is inevitable that a short book that tries to describe the whole field of physics, including a glimpse of the historical background, will leave the reader feeling that too many concepts “drop from the sky,” without adequate understanding of their foundations. I can recommend it more strongly to scientists than to the general reader, since the scientist can fill in much of what is skipped over, but even for me the book did not read easily; I expected it to flow more smoothly given Landsberg’s extensive previous writing.

So, finally, I am ambivalent about this book. Since I very much like the project that is attempted in this work, I wish I could be more positive about it, as some other reviewers have been.

Briefly Noted:

Mara Beller, *Quantum Dialogue: The Making of a Revolution* (University of Chicago Press, 2001). 365+xvi pages, ISBN: 0226041824, $20 (£13), paper.

Mara Beller’s splendid book, *Quantum Dialogue*, has just been issued in paper. This book won the 1999 Morris D. Forkosch Prize of the *Journal of the History of Ideas* for Best Book on Intellectual History, 1999. The original hardback edition was reviewed in *History of Physics Newsletter* **7**(6, February 2000). It is a careful study of the dialogue and conversations, as well as the rhetorical strategies, involved in the development of quantum mechanics. Beller also outlines, tentatively but suggestively, her proposal for a “Dialogical Historiography.”

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