Humbler days ahead for the physics enterprise?

A Short History of Physics in the American Century

David C. Cassidy
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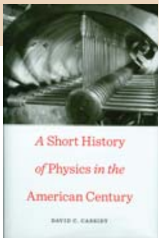

Reviewed by Benjamin Wilson

In 1883 Johns Hopkins University physics professor Henry Augustus Rowland was expressing cautious optimism about the state of physics in the US, telling an audience that "American science is a thing of the future, and not of the present or past." By 1900 there were signs that his vision was taking shape. In 1893 three physicists had founded what would become the nation's preeminent physics journal, the *Physical Review*, and in 1899 a few dozen more inaugurated the American Physical Society and elected Rowland as its first president.

A Short History of Physics in the American Century by David Cassidy presents a brisk but excellent institutional and political history of the discipline, ornamented by lucid descriptions of physics concepts and discoveries. Cassidy is a historian of science at Hofstra University and author of several noted books, including the celebrated *Uncertainty: The Life and Science of Werner Heisenberg* (W. H. Freeman, 1992; reviewed in PHYSICS TODAY, June 1992, page 79) and its update, *Beyond Uncertainty: Heisenberg, Quantum Physics, and the Bomb* (Bellevue Literary Press, 2009; reviewed in PHYSICS TODAY, January 2010, page 49). His latest offering deserves a wide audience, including physicists curious about their discipline's prominent role in modern US history.

This volume synthesizes more recent scholarly insights with an older generation of interpretations, most notably Daniel Kevles's 1978 classic *The Physicists: The History of a Scientific Community in Modern America* (reprinted by Harvard University Press, 1995). At just 169 pages of primary text, Cassidy's treatment of a large subject is necessarily swift, but his hand is sure. The book's brevity is among its strengths and weaknesses: A snappy and enjoyable read, it revisits familiar territory with a fresh perspective, even as it passes quickly over opportunities to integrate more thoroughly the content of physics with its institutional settings.

Rowland's elitist ideal of pure science, Cassidy argues, drove the professional development of physicists in the early decades of the century. In 1900 it was common to view physics as the handmaiden of engineering rather than as the pursuit of fundamental natural knowledge. But changes were afoot. A few scientist-administrators leading the National Research Council—a World War I–era experiment in the central coordination of research for military needs—developed a strategy for "pushing the peaks higher" in US physics. They channeled the preponderance of funding—much of it from private philanthropy—to a handful of topflight research institutions. In the flush years after the war, the Rockefeller Foundation paid for the best postdoctoral scholars to visit the major centers of European physics; they brought their experiences—and quantum mechanics—back to US soil. Young guns such as Arthur Compton, J. Robert Oppenheimer, and I. I. Rabi started making discoveries that won them admiration from their European colleagues. By the 1920s US physics had come of age.

As Cassidy shows, World War II vaulted US science to world dominance. The bond between physics and the federal government was cemented by the fantastic successes of the Manhattan Project and the development of radar technology. The discipline exploded in the postwar era in terms of funding, the size and scale of experiments, and numbers of trained researchers and graduate students. Physicists were now political insiders, advising the new atomic energy establishment and even the president. As the cold war grew colder during the 1950s and 1960s, the Pentagon disbursed the greatest fraction of federal R&D spending, with physics commanding by far the biggest share of the military's R&D budget.

Throughout every subfield, but especially in solid-state, nuclear, and high-energy particle physics, US research was the envy of the world. Yet the rising peaks of federal largesse did not lift all would-be climbers; as they had been for decades, women and other minorities were disproportionately excluded from new professional opportunities in physics. A measure of equality would only begin to arrive in subsequent decades. By the 1970s, the historic compact between physics and federal power had been chiseled apart by defense budget cuts, anti–Vietnam War activism, and a serious economic downturn. The result was a staggering employment crunch: Far more new physics PhDs competed for far fewer jobs, a reversal of the previous decade's trends.

In a fascinating final chapter, Cassidy charts the shifting patronage of physics in the 1980s and 1990s. In 1981 corporate outlays for industrial R&D surpassed federal funding for the first time since the late 1950s. Cassidy contends that as the sources of support shifted, so did the orientation of much of the profession, "from free research to product development." Physicists might well ponder Cassidy's observation that the profession today—more interdisciplinary and internationalized than at any time in recent memory—is also a chastened enterprise, occupying "a less transcendent intellectual status as one among many other intellectual disciplines." Will humility prove a better strategy for the 21st century than soaring confidence? Another hundred years will tell.

Benjamin Wilson is a doctoral student in the history of science at MIT. He is writing a dissertation on the history of US physicists' nuclear arms control efforts during the cold war.

Modeling Nanoscale Imaging in Electron Microscopy

Edited by Thomas Vogt, Wolfgang Dahmen, and Peter Binev
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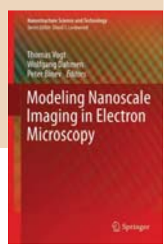

Imaging with electrons, in particular scanning transmission electron microscopy (STEM), is now in widespread use in the physical and biological sciences. And its importance will only grow as nanotechnology and nanobiology continue to flourish. Many applications of electron microscopy are testing the limits of current imaging capabilities and highlight the need for further technological improvements. For example, high throughput in the combinatorial chemical synthesis of catalysts demands automated imaging. The handling of noisy data also calls for new approaches, particularly because low electron doses are used for sensitive samples such as biological and organic specimens.

Modeling Nanoscale Imaging in Electron Microscopy addresses all those issues and more. Edited by Thomas Vogt and Peter Binev at the University of South Carolina (USC) and Wolfgang Dahmen at RWTH Aachen University in Germany, the book came out of a series of workshops organized by the Interdisciplinary Mathematics Institute and the NanoCenter at USC. Those sessions took the unusual but innovative approach of bringing together electron microscopists, engineers, physicists, mathematicians, and even a philosopher to discuss new strategies for image analysis in electron microscopy.

In six chapters, the editors tackle the ambitious challenge of bridging the gap between high-level applied mathematics and experimental electron microscopy. They have met the challenge admirably. I believe that high-resolution electron microscopy is at a point where it will benefit considerably from an influx of new mathematical approaches, daunting as they may seem; in that regard *Modeling Nanoscale Imaging in Electron Microscopy* is a major step forward. Some sections present a level of mathematical sophistication seldom encountered in the experimentally focused electron-microscopy literature.

The first chapter, by philosopher of science Michael Dickson, looks at the big picture by raising the question of how we perceive nanostructures and suggesting that a Kantian approach would be fruitful. The book then moves into a review of the application of STEM to nanoscale systems, by Nigel Browning, a leading experimentalist in the field, and other well-known experts. Using case studies, the authors show how beam-sensitive samples can be studied with high spatial resolution, provided one controls the beam dose and establishes the experimental parameters that allow for the optimum dose.

The third chapter, written by image-processing experts Sarah Haigh and Angus Kirkland, addresses the reconstruction, from atomic-resolution images, of the wave at the exit surface of a specimen. The exit surface wave is a fundamental quantity containing not only amplitude (image) information but also phase information that is often intimately related to the atomic-level structure of the specimen. The next two chapters, by Binev and other experts, are based on work carried out using the experimental and computational resources available at USC. Examples in chapter four address the mathematical foundations of compressed sensing as applied to electron microscopy, and in particular high-angle annular dark-field STEM. That emerging approach uses randomness to extract the essential content from low-information signals. Chapter five eloquently discusses the efficacy of analyzing several low-dose images with specially adapted digital-image-processing techniques that allow one to keep the cumulative electron dose low and still achieve acceptable resolution.

The book concludes with a wide-ranging discussion by mathematicians Amit Singer and Yoel Shkolnisky on the reconstruction of a three-dimensional object via projected data taken at random and initially unknown object orientations. The discussion is an extension of the authors' globally consistent angular reconstitution approach for recovering the structure of a macromolecule using cryo-electron microscopy. That work is also applicable to the new generation of x-ray free-electron lasers, which have similar prospective applications, and illustrates nicely the importance of applied mathematics in the physical sciences.

Modeling Nanoscale Imaging in Electron Microscopy will be an important resource for graduate students and researchers in the area of high-resolution electron microscopy.

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Eruptions That Shook the World

Clive Oppenheimer
Cambridge U. Press, New York, 2011.
$30.00 (408 pp.).
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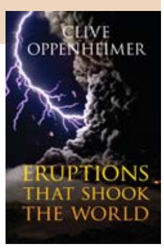

Geological and biological evolution and epic myth are punctuated by such catastrophic events as massive volcanic eruptions that shake Earth, change the