

Student days working on the super bomb

Building the H Bomb A Personal History

Kenneth W. Ford
World Scientific, 2015. \$24.00 paper
(221 pp.). ISBN 978-981-4632-07-2

Reviewed by Cameron Reed

The development of nuclear weapons remains one of the most dramatic events of 20th-century science and technology. With the publication of Ken Ford's *Building the H Bomb: A Personal History*, readers interested in the story have an engaging new first-hand account to add to their collections. This work is really three books in one: a history of the development of the first hydrogen bomb in its political context; a mini-textbook on nuclear physics and nuclear weapons; and a memoir of the author's experiences as a graduate student working in the H-bomb program.

In a brief introductory note, Ford shares that the US Department of Energy had reviewed the document prior to publication, claimed that some passages contain government secrets, and asked him to redact them—he did not. From my reading, Ford relates nothing that cannot be gleaned from numerous online sources or existing histories such as Richard Rhodes's monumental *Dark Sun: The Making of the Hydrogen Bomb* (Simon & Schuster, 1995). Ford's book is not a primer on how to build a hydrogen bomb.

Ford entered Princeton University's graduate program in physics in the fall of 1948 and studied under John Wheeler. After finishing his qualifying exam in the spring of 1950, Ford was courted by Wheeler and Edward Teller to join them in Los Alamos to work on the H-bomb project. The senior scientists were responding to President Harry S. Truman's directive to the Atomic Energy Commission (AEC) to continue work on all forms of atomic weapons, "including the hydrogen or

so-called super bomb." Ford arrived at Los Alamos in June 1950; his work involved calculations of the "thermonuclear burning" characteristics of putative bomb designs.

At the time, though, the H-bomb program was at an impasse. Calculations then were predicated on what would come to be called the "classical super" design, in which researchers anticipated that the temperature of the fusion fuel would have to greatly exceed that of the radiation in the explosion. Otherwise, too much energy would be lost from the fuel to the radiation field. But those calculations indicated that the fuel would cool too rapidly to maintain fusion reactions.

The breakthrough idea emerged early the following year when Stanislaw Ulam realized that a fuel-radiation temperature equilibrium could be tolerated if the fuel were compressed. Teller modified the idea to use radiation from a triggering fission weapon—not mechanical force—to achieve the compression; the configuration became known as the Teller-Ulam design. Debate continues as to how priority for the concept should be assigned between Ulam and Teller. Ford analyzes the various claims and chronicles Teller's evolving statements, which often denied Ulam any significant contribution. Whatever the circumstances of its genesis, the Teller-Ulam concept took center stage at Los Alamos.

In late 1950 Wheeler began relocating the computational effort—what became Project Matterhorn—to Princeton, and Ford moved back East. He programmed calculations of the propagation of the "thermonuclear flame" through cylinders of imploded deuterium and ran them on various card-fed and plug-board computers. The physics that was wrung out of machines having far less memory than a flash drive and operating at speeds less than a thousandth of that of today's desktop computers is a testimony to the ingenuity and perseverance of those involved.

Ford's calculations indicated that the Teller-Ulam design was feasible, and it was subsequently endorsed at a June 1951 meeting of the AEC's General Advisory Committee. Ford recalls passing Wheeler handmade graphs through the window of the meeting room following

an all-night work session. At Los Alamos, Richard Garwin was already busy designing the Ivy Mike device, which would be detonated at Enewetak atoll on 1 November 1952 (local time); it was the first full-scale test of the H bomb that used the Teller-Ulam design. Ford's predicted yield was 7 megatons; Garwin's design achieved 10.4 megatons, and Ford felt lucky to have calculated a number in the correct ballpark.

In the epilogue, Ford relates how he sincerely felt that having the H bomb in American hands would contribute to maintaining peace, but that view changed during the Vietnam War. In 1968 he declared at a meeting of Los Alamos scientists opposed to the war that he had decided to do no further weapons or classified work, a step he regarded as personally daring but satisfying.

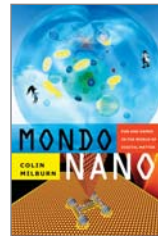
Ford's book is a valuable resource for anyone interested in the history of the H bomb and its role in the Cold War, and in how that work affected the life and career of an individual involved.

Mondo Nano Fun and Games in the World of Digital Matter

Colin Milburn
Duke U. Press, 2015. \$28.95 paper
(424 pp.). ISBN 978-0-8223-5743-8

The term "nanotechnology" elicits differing responses. Novelists warn it may destroy us; moviemakers invoke it to explain the incredible wonders on-screen; and politicians and other scientific laity ascribe to it a litany of coming miracles, from robotic soldiers to self-healing steel.

Nanotechnology's current reality, while impressive, is less sensational. Many trades meet the late Richard Smalley's definition of nanotechnology as "the art and science of making stuff on the nanometer scale." Brewers and bakers adding yeast to carbohydrates, or cheesemakers mixing milk with cow-gut enzymes, have long functioned as nanotechnological empiricists, taking for granted the unseen molecules that underpin



Cameron Reed is the Charles A. Dana Professor of Physics at Alma College in Alma, Michigan, and author of *The History and Science of the Manhattan Project* (Springer, 2013).

their work. Increasingly, however, instruments such as scanning tunneling microscopes and high-resolution scanning electron microscopes are imaging and manipulating the constituent atoms of metallurgy, chemistry, and even life. Physicists and engineers have synthesized simple machines, as well as immensely strong carbon allotropes such as nanotubes and buckyballs, on the nanoscale.

Building on that incremental progress, Colin Milburn, in *Mondo Nano: Fun and Games in the World of Digital Matter*, discusses nanotechnology both before and beyond its current state. He looks to the past to summarize the initial speculations that sparked the nanorevolution, and he looks to the future to sketch new realities that today's conjectures may yet catalyze. Based at the University of California, Davis, Milburn is the very model of a modern interdisciplinary scholar; he is a professor not only of English but also of cinematographic technology and science and technology studies (STS). In addition, he is a talented author who usefully reminds us that academic writing need not be dull.

Milburn examines nanotechnology through various conceptual filters, such as history, military technology (both offensive weaponry and defensive armor), speculative fiction, and play. His main theme, however, is the close and productive association that has arisen between nanotechnology and video games. Games, he argues, let us explore nanotechnology through the relaxed, loosely structured, intensive creativity we call fun.

Throughout his book, Milburn emphasizes the role of games, especially massive, multiplayer, online role-playing games, to forecast the likely development of nanotechnology over the next few decades. By using interactive multimedia to manifest the wildest imaginaries of nanotechnology, experts and nonexperts alike can rub shoulders to explore the possibilities of new ideas such as combat exoskeletons and artery-cruising nanotherapeutics. Milburn offers concrete examples based on games such as *Crysis* and *Second Life*, in which his avatar Colin Dayafter appears as a winged adventurer. Gamers and politicians (in particular, the prophetic ones introduced up front) may have more in common than either group believes.

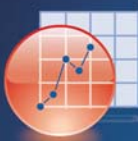
Readers with scientific training should note that Milburn's scholarly methods are not precisely those of the natural sciences. The discipline of STS

examines how scientific knowledge is imagined and created and how scientists use that knowledge to achieve consensus and to communicate their findings to the world; it is not used to evaluate data or hypotheses per se but to investigate their contexts. For example, an STS conference I attended this past April featured a paper on late 19th-century ectoplasmic photography. The presenter's point was to discuss not the likelihood of fairies at the bottom of the garden—the pre-Photoshop evidence is ludicrously faked—but rather the influence of a literal belief in the

supernatural on mainstream science a century ago.

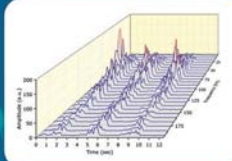
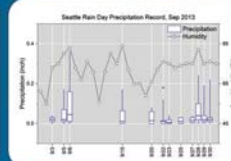
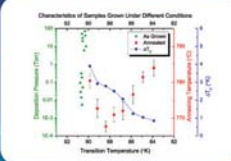
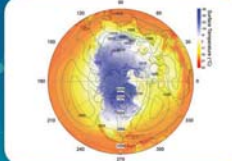
Thus when Milburn discusses such early godfathers of nanotechnology as K. Eric Drexler, he ignores Drexler's naive treatment of the nanoworld as nothing but the macroworld with shrunk dimensions. In the Drexlerian view, nanoscale machinery such as cranes and conveyor belts can be cobbled up with little regard for the nanoscale's vastly different context, where water is more viscous than toothpaste and Brownian motion makes the average environment as chaotic as a

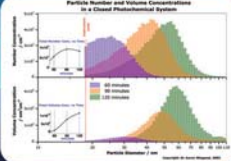
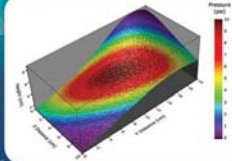
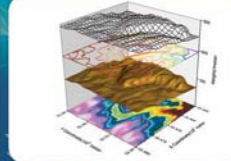
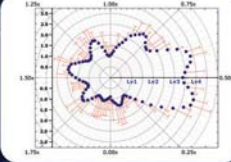
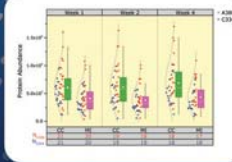
NEW VERSION



ORIGIN® 2015

Graphing & Analysis


Over 100 new features & improvements in Origin 2015!

FOR A FREE 60-DAY EVALUATION,
GO TO ORIGINLAB.COM/DEMO
AND ENTER CODE: 2876



Over 500,000 registered users worldwide in:

- 6,000+ Companies including 120+ Fortune Global 500
- 6,500+ Colleges & Universities
- 3,000+ Government Agencies & Research Labs



20+ years serving the scientific & engineering community

storm-wracked sea. Nor does Milburn ridicule Drexler for touting nanotechnology as a road to physical immortality—a near-religious zealotry that has today convinced mainstream nanoscience to banish Drexler to its margins.

Milburn's profession isn't about judging the truth of nanotechnological hypotheses; it is about teasing out their technoscientific origins and effects. And Drexler, like Richard Feynman a generation before him, was undeniably instrumental in sparking a rigorous scientific scrutiny of the nanocosm. Readers bearing that in mind will find *Mondo Nano* a thoroughly researched, thought-provoking read that offers many points to ponder as well as a few observations that might make some professional scientists grind their teeth.

William Atkinson
York University
Toronto

Plasma Physics An Introduction

Richard Fitzpatrick
CRC Press, 2015. \$79.95 (281 pp.).
ISBN 978-1-4665-9426-5

Plasma physics has come of age. Thanks to the impetus from fusion physics, space science, and plasma astrophysics, the core principles of the subject are sufficiently well developed that researchers now routinely make predictions for many configurations and objects, either manmade or naturally occurring. Those predictions are tested by experiments that make use of ground-based instruments, *in situ* detectors aboard satellites, telescopes, and sophisticated diagnostics in the laboratory. Given the highly nonlinear nature of plasma processes, experimental realities often challenge theoretical predictions. Nonetheless, a core of theoretical models at both fluid and kinetic levels of description provides useful points of departure for problems of broad, interdisciplinary interest.

In recent years graduate and advanced undergraduate students with a suitable background in classical mechanics and electromagnetic theory have had the luxury of choosing between several very good textbooks that present the core principles of plasma physics. In that crowded field, Richard Fitzpatrick's *Plasma Physics: An Introduction* distinguishes itself by its excellence. For those of us who have admired Fitzpatrick for his seminal

contributions to the subject of magneto-hydrodynamic (MHD) instabilities in fusion plasmas, his book is as much a source of pleasure as his papers are for their clarity and rigor.

The scope and layout of the book are fairly standard. Fitzpatrick includes chapters on charged-particle motion, collisions, fluid models, MHD fluids, and kinetic treatments of linear waves and instabilities. Nonetheless, the book has some unique features that make it especially attractive to both students and researchers. Examples include systematic and readable accounts of the Braginskii equations and the Chapman–Enskog method for weakly collisional plasmas. Nice physical explanations for the transport effects that emerge from the baroque complexity of orderings and expansions will help students see the forest for the trees. Another useful chapter deals with wave propagation through inhomogeneous plasmas. Using the WKB (Wentzel–Kramers–Brillouin) method, Fitzpatrick offers a concise treatment of cutoffs, resonances, and pulse propagation, including elegant, self-contained discussions of the relevant mathematical tools.

The various applications of core theoretical principles are drawn primarily from space science and fusion; they make the book an attractive choice for graduate plasma-physics courses taught in a broad range of physics and engineering departments. The Van Allen radiation belts and the ring current in Earth's magnetosphere are discussed in the chapter on charged-particle motion, and Eugene Parker's classic solar-wind theory is handled nicely in the chapter on MHD.

The treatment of MHD dynamo theory is somewhat idiosyncratic. Fitzpatrick provides rigorous treatments of the somewhat dated homopolar disk and Ponomarenko dynamo models, but he does not discuss mean-field turbulent dynamo theory, the dominant focus of the dynamo community for the past two decades. The first-rate sections on magnetic reconnection theory deal with both linear and nonlinear steady-state models based on resistive MHD, but they don't even mention the collisionless reconnection models that have preoccupied the reconnection community during the past 25 years.

I was also quite surprised not to find a longer discussion on the Rutherford theory of tearing modes with applications to fusion plasmas—a subject to

which Fitzpatrick has made striking contributions and on which he has given instructive lectures in various summer and winter schools. Fitzpatrick's may be one of a very small number of textbooks in plasma physics that does not carry a single reference to the author's own research papers, an act of self-effacement that is uncharacteristic of the times.

Over the many years that I have taught plasma physics, I have made use of Fitzpatrick's lecture notes, which were posted on his website. Often I wondered why he hadn't published the notes as a textbook, because they read like one. I am glad to see those notes finally out in print in the form of an excellent and compact textbook—complete with problem sets and references—that has earned a permanent place on my bookshelf. Thanks to the several useful and well-presented topics, I would expect the book to endure as a standard text in colleges and universities all over the world.

Amitava Bhattacharjee
Princeton University
Princeton, New Jersey

new books

acoustics

Acoustics, Information, and Communication. N. Xiang, G. M. Sessler, eds. Springer, 2015. \$229.00 (461 pp.). ISBN 978-3-319-05659-3

Adaptive Identification of Acoustic Multichannel Systems Using Sparse Representations. K. Helwani. Springer, 2015. \$129.00 (113 pp.). ISBN 978-3-319-08953-9

The Helmholtz Legacy in Physiological Acoustics. E. Hiebert. Springer, 2014. \$129.00 (269 pp.). ISBN 978-3-319-06601-1

Rock and Pop Venues: Acoustic and Architectural Design. N. W. Adelman-Larsen. Springer, 2014. \$139.00 (470 pp.). ISBN 978-3-642-45235-2

history and philosophy

Achievements, History and Challenges in Geophysics: 60th Anniversary of the Institute of Geophysics, Polish Academy of Sciences. R. Bialik, M. Majdański, M. Moskalik, eds. Springer, 2014. \$129.00 (417 pp.). ISBN 978-3-319-07598-3

Arts, Sciences, and Economics: A Historical Safari. 2nd ed. T. Puu. Springer, 2015. \$129.00 (189 pp.). ISBN 978-3-662-44129-9

Bionics by Examples: 250 Scenarios from Classical to Modern Times. W. Nachtigall, A. Wisser. Springer, 2015. \$179.00 (325 pp.). ISBN 978-3-319-05857-3

Carl Friedrich von Weizsäcker: Major Texts in Philosophy. M. Drieschner, ed. Springer, 2014. \$54.99 paper (187 pp.). ISBN 978-3-319-03670-0

Carl Friedrich von Weizsäcker: Major Texts