

The procession of a profession

The Neutron's Children Nuclear Engineers and the Shaping of Identity

Sean F. Johnston
Oxford U. Press, 2012. \$62.99
(313 pp.). ISBN 978-0-19-969211-8

Reviewed by Audra J. Wolfe

Let no one say that Sean Johnston can't commit to a metaphor. His book, *The Neutron's Children: Nuclear Engineers and the Shaping of Identity*, recounts the history of nuclear engineering in the US, Canada, and the UK as a story of marriage, birth, and childhood development. The neutron "spawned" nuclear workers who were "gestated" in the bellies of wartime industrial plants such as those at Hanford, Washington, and at Chalk River, Ontario, Canada.

Born in a culture of postwar secrecy, nuclear engineering came of age in an era of loosening security restrictions and close partnerships between industry and academia. A series of traumatic experiences—among them Three Mile Island, Chernobyl, and Fukushima—suggests that the profession perhaps suffers from "arrested development, . . . weak communication skills, and poor socialization." One metaphor deserves another: A profession is a strange fruit for a subatomic particle.

Johnston, a professor of science, technology, and society at the University of Glasgow in the UK, has written extensively on the history of professionalization, so he is well qualified to consider the emergence of nuclear engineering as a 20th-century discipline. The focus on working engineers rather than either scientists or managers distinguishes Johnston's account from the small library of books on the history of the atomic bomb and nuclear power. His attention to the experiences of British and Canadian workers instead of just the more famous Americans is another welcome change from the usual approach. Nuclear engineers in all three countries, working in very different social and political environments, strug-

gled to define their particular knowledge base and occupational authority in environments flush with cash but short on experience.

Johnston's account hews closely to sociologist Andrew Abbott's "theory of professions," developed in *The System of Professions: An Essay on the Division of Expert Labor* (University of Chicago Press, 1988). That book describes professionalization as a series of jurisdictional struggles for recognition and status. As Johnston puts it, the central question for the nascent field of nuclear engineering was whether it was "a straightforward extension of existing disciplines, or the seed of a new one." Nuclear engineers' distinct disciplinary identity depended on their interactions with the nuclear reactor, a new technology that presented unique challenges to would-be nuclear experts.

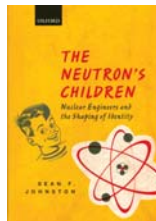
Largely in isolation from one another, atomic workers at several of the early nuclear research facilities used skills derived from chemistry, physics, materials science, and chemical and mechanical engineering to develop ways to generate, sustain, and control nuclear chain reactions. But at least at first, secrecy measures limited nuclear engineers' ability to convert that specialized knowledge into a recognized field. Not until the easing of security measures in the mid 1950s could nuclear engineers establish some of the standard markers of disciplinary identity: university departments, journals, learned societies, standard procedures for training and certification, and so on.

Reactors designed for generating electrical power posed especially daunting challenges. The continuous heat that they required to produce steam was inevitably accompanied by intense levels of radiation, which threatened workers and surrounding communities alike; much of nuclear engineers' sense of professional identity came from their attempts to balance safety with cost. They have not, of course, been uniformly successful at that task. As a student of professional identity, Johnston is more interested in how accidents like Three Mile Island have affected the public's perception of nuclear engineers than in the systems of expertise, risk management, and regu-

lation that have allowed such accidents to occur. The first generation of nuclear engineers projected an image both heroic and terrifying, but lately their successors ("the neutron's grandchildren") have been reduced to the likes of Homer Simpson.

As with most works of genealogy, *The Neutron's Children* has a hard time keeping track of the cousins even a couple of generations down the line. The same "forced marriage" of academic science and industrial engineers that produced nuclear engineering created a range of new disciplinary specialties from radiobiology to nuclear-weapons engineering; the stories of those other "divergent nuclear breeds" fades in the second half of Johnston's telling, as nuclear engineers' expertise crystallized around the reactors rather than their products.

The Neutron's Children will undoubtedly be the standard work on the professionalization of nuclear engineers for some time to come. The larger family history remains to be told.

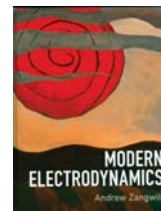


Modern Electrodynamics

Andrew Zangwill
Cambridge U. Press, 2013. \$85.00
(977 pp.). ISBN 978-0-521-89697-9

In *Modern Electrodynamics*, Andrew Zangwill and Cambridge University Press have created a hefty, readable modern textbook on classical electrodynamics aimed at advanced students of the subject. Author and publisher set an ambitious goal, given the formidable competition from existing, well-deserved classics on the subject; the result is a worthy addition to the literature.

Modern Electrodynamics is large: more than 900 pages of text, examples, and hundreds of problems, organized into 24 chapters. Given the imposing size, I was reassured to find at the top of the very first page a quotation attributed to physicist Kenneth Johnson: "A textbook, as opposed to a treatise,



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should include everything a student must know, not everything the author does know." Anyone with the good taste to select that epigram, from such a great teacher, is well worth reading.

Among the other interesting quotations that spice up *Modern Electrodynamics* is Richard Feynman's answer to why one should write a new textbook on such a well-covered subject: "Why repeat all this? Because there are new generations born every day. Because there are great ideas developed in the history of man, and these ideas do not last unless they are passed purposely and clearly from generation to generation."

The first chapter summarizes mathematical tools. That unconventional start makes sense. Most readers will be familiar with the mathematical preliminaries; it is helpful to establish standard nomenclature early to keep the focus on physics later. And collecting the mathematical tools at one location enhances the book's reference value. Mathematical topics crucial to electromagnetism—solving Laplace's and Poisson's equations—are each covered in their own chapter. Chapter two, "The Maxwell Equations," is a delightful whirlwind tour. It touches on history, on Zangwill's choice of Lorentz averaging to relate macroscopic sources and fields to rapidly varying microscopic values, and on the role of classical electrodynamics in our real world of atoms interacting through electric and magnetic forces and subject to the rules of quantum mechanics.

The meat of the book, chapters 3 to 23, proceeds in a conventional order: electrostatics—from vacuum to conductors to dielectric materials; followed by steady currents, magnetostatics, and magnetic matter; then building up to dynamic fields and electromagnetic waves in various media; and then on to radiation, scattering, diffraction, special relativity, and fields from moving charges.

Modern Electrodynamics makes good use of certain modern elements of page layout and manages to avoid the more annoying ones. Most chapters have several sidebar "Applications" that relate the material being developed in the chapter to classic electricity and magnetism problems, research-level examples, or technical devices. In a helpful touch, those applications have their own table of contents. The book also contains sample problems presented in screen-tinted text boxes. Generally, the examples are well stated, as are the actual homework problems, and their so-

lutions are developed clearly and concisely. Each chapter concludes with a detailed and informative section on sources, references, and additional reading.

I enjoyed examining this handsome book, finding favorite topics described in fresh ways and learning about other topics. Zangwill's writing and mathematical demonstrations are crisp and to the point, and they generally complement each other well. Sprinkled throughout are various gems of historical and scientific interest, such as the stories of the operation of a vacuum-

tube triode and the "miller of Nottingham," George Green of Green function fame (see the article on George Green in *PHYSICS TODAY*, December 2003, page 41). The high points for me are chapters 5, 6, and 13, on materials, and chapter 14, "Dynamic and Quasistatic Fields," in which Zangwill addresses the pesky issues of dissipation, skin effect, and eddy currents before moving into full-blown electrodynamics in subsequent chapters.

The book's weakest part is its treatment of special relativity. Uncharacteristically, *Modern Electrodynamics* largely

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misses the grandeur of Lorentz invariance, embedded in electrodynamics from its inception but hidden from full view until Albert Einstein recognized its implications and replaced Newton's concepts of space and time with spacetime. Zangwill's choice of Minkowski's imaginary component in four-vectors is strange; given the straightforward mathematics of special relativity, that choice adds unnecessary complexity and heightens the potential for confusion. Also, numerical methods are not addressed in this book.

I sometimes advise advanced undergraduates to begin building their own physics libraries with classic advanced textbooks, even before the books are assigned in class. Such texts can broaden perspectives on core subjects and would be readily accessible as the student advances in his or her studies and work. Where shall I put *Modern Electrodynamics* on such a reading list? It has a lot to offer, so I think it should be somewhere pretty high up, but after John David Jackson's *Classical Electrodynamics* (3rd edition, Wiley, 1998), David Morin's update of Edward Purcell's *Electricity and Magnetism* (3rd edition, Cambridge University Press, 2013; reviewed in PHYSICS TODAY, August 2013, page 48), and the timeless classic, Lev Landau and Evgeny Lifshitz's *Classical Theory of Fields* (Addison-Wesley Press, 1951).

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The Universe in the Rearview Mirror

How Hidden Symmetries Shape Reality

Dave Goldberg
Dutton, 2013. \$27.95 (352 pp.).
ISBN 978-0-525-95366-1

In *The Universe in the Rearview Mirror: How Hidden Symmetries Shape Reality*, Dave Goldberg expounds on the important role of symmetries in the fundamental laws of physics. He starts with the discrete operations of charge conjugation, parity, and time inversion—and their combinations. Then, after introducing readers to mathematician Emmy Noether and her work connecting symmetries with conservation laws, Goldberg discusses continuous symmetries, homogeneity and isotropy, and Lorentz in-

variance. Later chapters deal with gravity, gauge symmetries, and symmetry breaking; the book's finale considers proposals beyond the standard model of particle physics, grand unification, supersymmetry, and the missing theory of quantum gravity.

Goldberg does a remarkably good job of conveying technical topics in non-technical terms and with only a handful of equations (yes, $E = mc^2$ is among them). He works mostly with analogies and writes in an engagingly colloquial way. The bibliography and the guide to further reading provide helpful references for readers who want more details. The book also has a brief glossary.

Symmetries that “shape reality,” as mentioned in the subtitle, cover a vast subject area, of course. Except for offering one brief analogy, Goldberg does not touch on the broad topic of emergent symmetry and order in condensed-matter, biological, and other systems. His focus on fundamentals has the benefit of keeping the book relatively lean and maintaining its momentum, but the description on the cover could have been more explicit.

Unfortunately, *The Universe in the Rearview Mirror* is somewhat confusingly organized, and readers who do not possess sufficient prior knowledge might become frustrated. In several instances, Goldberg refers to concepts that he has not previously discussed; he gives other explanations repeatedly. For example, he introduces “the elusive dark matter particle” in chapter 9 without so much as mentioning what dark matter is or what evidence we have for it. He uses the Planck length in chapter 6, but he doesn't explain what it is until chapter 10. The graphics that have been produced specifically to accompany the text are well done and helpful, but the book also contains a number of images that are only loosely connected to the text and come without caption or explanation.

Parts of the book are just too superficial to be of much use. For example, Goldberg mentions that cosmic inflation was proposed “to get around the horizon problem,” but readers are not actually told how inflation solves the problem. The evidence he provides for inflation amounts to “we're reasonably certain that it is [correct].” He elaborates on the multiverse and later on the compactified dimensions of M-theory, but he does not connect the two topics. The *Wilkinson Microwave Anisotropy Probe* mission and the cosmic microwave background are mentioned twice before the actual explanation and the

relevant image of the CMB temperature anisotropies appear. Those are just some places that might trip up readers who have little prior knowledge of the subject.

For the most part, Goldberg is to be credited for making his text timely by referring to recent research; in particular, he includes a good summary of the discovery of the Higgs particle and the relevance of that finding (see also page 10 and the article by Joseph Lykken and Maria Spiropulu, page 28, in this issue). He mentions Erik Verlinde's contribution to entropic gravity. That reference—the only one on the topic—appears in a section on the arrow of time, though for all I can tell, the only connection is that both have something to do with entropy. Goldberg presents Max Tegmark's proposed “level” structure of the multiverse. And in the last chapter on physics beyond the standard model we meet Garrett Lisi, the surfer without university affiliation who stunned everybody by proposing a unified theory of matter and gravity—it somehow goes unmentioned in the book that Lisi has a PhD in physics.

The Universe in the Rearview Mirror is valuable for its selection of topics and for inspiring a sense of awe for the relevance and power of symmetries in the laws of nature. But the execution leaves one wanting. Readers who do not have a background in modern physics will learn a great deal more from the didactic approach of Sean Carroll in his books *From Eternity to Here: The Quest for the Ultimate Theory of Time* (Dutton, 2010; reviewed in PHYSICS TODAY, April 2010, page 54) and *The Particle at the End of the Universe: How the Hunt for the Higgs Boson Leads Us to the Edge of a New World* (Dutton, 2012; reviewed in PHYSICS TODAY, July 2013, page 50). Together, those books cover a substantial part of the physics shaped by hidden symmetries.

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What Editors Want

An Author's Guide to Scientific Journal Publishing

Philippa J. Benson and Susan C. Silver
U. Chicago Press, 2013. \$55.00
(192 pp.). ISBN 978-0-226-04313-5

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