

models, and hypothetical mechanisms to infer general rules, as Sommerfeld did in developing atomic theory.

Sommerfeld is best known for his 1916 relativistic generalization of Bohr's model of the atom, his introduction of the fine-structure constant, and his analysis of the effects of electric and magnetic fields on atomic spectra. He is also known for writing some of the first atomic- and quantum-physics textbooks. *Atombau und Spektrallinien (Atomic Structure and Spectral Lines)*, Sommerfeld's problem-oriented treatise on the old quantum theory, first published in 1919, was revised almost annually until 1924. He published his last text on quantum physics, *Wellenmechanischer Ergänzungsband (Wave Mechanical Supplement)*, in 1929, after the emergence of Schrödinger's wave mechanics; Paul Dirac's aptly named *The Principles of Quantum Mechanics* followed in 1930. Sommerfeld's multi-volume *Lectures on Theoretical Physics* featured a number of technical applications. In the 1940s I studied his excellent textbooks on classical mechanics and electromagnetic theory.

A significant portion of *Crafting the Quantum* is devoted to a discussion of what is now known as the Sommerfeld school of theoretical physics. Nearly one-third of all full professors of theoretical physics at German-speaking European universities in 1928 were former doctoral students of Sommerfeld, who was the "doctoral father" to four Nobel Prize winners: Werner Heisenberg, Wolfgang Pauli, Peter Debye, and Hans Bethe. Many American physicists, including Linus Pauling, I. I. Rabi, and Edward Condon, went to work with him. (In recognition of his impact on the teaching of physics, the American Association of Physics Teachers awarded Sommerfeld its Oersted Medal in 1949.)

Crafting the Quantum can be approached on two different levels: For the historian, it is a monograph on the practice of early-20th-century theoretical physics and a commentary on Thomas Kuhn's much-debated views on the way science advances; for the general reader, it is an account of the transition from the old "quantum-number mystique" to modern quantum mechanics based on general symmetry principles and invariance. From the latter vantage point, the book should be of interest to anyone who has studied quantum mechanics.

Eugen Merzbacher
Chapel Hill, North Carolina

Optical Metamaterials

Fundamentals and Applications

**Wenshan Cai and
Vladimir Shalaev**
Springer, New York, 2009. \$129.00
(200 pp.). ISBN 978-1-4419-1150-6

From the late 1960s through the early 1980s, those of us who worked on materials and devices did not use the terms "nano-" and "meta-." Nor did we have sophisticated tools like the atomic force

microscope (AFM), or the bells and whistles of fine-resolution, automated techniques for the manipulation of materials on the nanoscale.

But Wenshan Cai and Vladimir Shalaev do. These authors of *Optical Metamaterials: Fundamentals and Applications* are highly accomplished in the field of metamaterials, which are used to make such devices as invisible cloaks that bend electromagnetic waves around a shrouded object or superlenses that permit spatial resolution below the diffraction limit. Metamaterials constitute a complex subject: Researchers and students alike need a critical

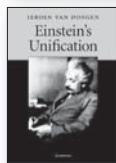
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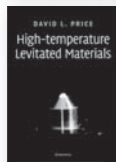
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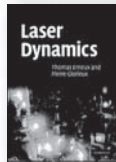
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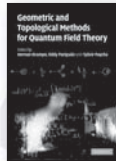
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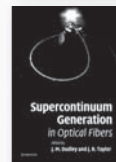
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understanding of how the unique properties and applications of those devices depend on the physics, chemistry, and overall properties of optical and electromagnetic components, and on how such components are designed and fabricated.

Optical Metamaterials begins with a brief introduction stuffed with ample references; the remaining chapters extensively cover selected topics: optical properties of metal-dielectric composites; experimental techniques and data treatment; electric and magnetic metamaterials; negative-index materials; applications of nonlinear optics; super resolution with meta-lenses; and optical cloaking.

One stated goal of the authors is to write a textbook for senior undergraduate and graduate courses; indeed, that is quite a commendable and lofty goal for this highly interdisciplinary field! A useful text for advanced undergraduates should, in my opinion, be self-contained, particularly in its presentation of introductory material and unique aspects of a field. It should also systematically develop basic concepts and then elaborate on specific engineering challenges, with worked-out examples. For instance, properties of both exotic and run-of-the-mill metamaterials that might result in a working device must be identified before issues relating to fabrication and characterization are considered.

In its present form, *Optical Metamaterials* is not self-contained, and I would not recommend it as a textbook, even for graduate courses. Less experienced readers will be forced to rely on cited references to develop an understanding of the structural details of unit cells in metamaterials composites or to derive the design equations that characterize such unit cells. When introducing various design equations and performance trends in optical metamaterials, the book merely references certain seminal papers. It barely touches on the design and synthesis of metastructures that meet specific applications—for example, or those involving two- and three-dimensional arrays, input/output interfaces, packaging—nor does it discuss their reliability and performance in benign and adverse environments.

Readers will also need additional background to understand the book's comparison of different techniques or processes that are not common knowledge to graduate students or even to nonexpert researchers. The authors fre-

quently mention the AFM and other modern high-resolution characterization and fabrication tools, whose purpose is to correlate a metamaterial's properties with its micro- and nanostructures; a focus on that correlation was sorely missing in this book. Another concern is the book's presentation of commercial simulation software: The authors used such programs in their research to elucidate the performance of sought-after metamaterials and devices, but fail to present the codes that were used or to follow up their illustrations with worked-out problems. Such details would have helped the reader grasp the concepts and understand the implications of material choices.

I did enjoy reading *Optical Metamaterials* for the purpose that best suits it: a useful overview that could encourage researchers new to this multidisciplinary field to dig deeper in pursuing their goals. The chapters are short and well written: They read like summaries of research papers and not like a textbook. Especially well presented and concise are the chapters on negative-index materials and optical cloaking. The book is unnecessarily brief and sketchy at times, though, and may not be as useful for students and researchers who lack sufficient background in materials science and engineering; such readers will need additional resources to acquire a comprehensive understanding of optical metamaterials. That said, a course textbook even for simple, well-developed subjects carries enormous requirements; for a complex interdisciplinary topic like optical metamaterials, with its novel applications, writing such a text is a very tall order indeed.

Dilip K. Paul

*Advanced Concepts in
Engineering & Sciences Inc
Bethesda, Maryland*

The Hancocks of Marlborough

**Rubber, Art, and the
Industrial Revolution:
A Family of Inventive Genius**

**John Loadman and
Francis James**

Oxford U. Press, New York, 2010.

\$49.95 (274 pp.).

ISBN 978-0-19-957355-4

Thomas Hancock (1786–1865) has often been accused of stealing the British patent for vulcanized rubber from

under the nose of Charles Goodyear. He is exonerated by John Loadman and Francis James in their lively biography of him and his brothers, *The Hancocks of Marlborough: Rubber, Art, and the Industrial Revolution—A Family of Inventive Genius*. The book also reveals how Thomas's unrivaled understanding of the technology of rubber production facilitated his independent invention of the vulcanizing process.

The Hancock family story is essentially the story of the British rubber industry. Few important industries have suffered such neglect by historians, which is surprising since Thomas Hancock handed us an unusually coherent and intimate source of information in his *Personal Narrative of the Origin and Progress of the Caoutchouc or India-Rubber Manufacture in England* (1857). His brother Walter was equally helpful in publishing his *Narrative of Twelve Years' Experiments (1824–1836) . . . of Employing Steam-Carriages on Common Roads . . .* (1838), which detailed technical successes that ended in commercial failure when the smart money abandoned the roads and took to the rails.

However, *The Hancocks of Marlborough* is not the book for readers who want an up-to-date history of the British rubber industry. The authors tacitly admit as much in their appendix, "The Evolution of the Rubber Industry Today," a 12-page summary of two centuries of technical and business developments, for which there was insufficient space in their chapters. A more comprehensive account is found in Loadman's earlier monograph, *Tears of the Tree: The Story of Rubber—A Modern Marvel* (Oxford University Press, 2005). The book is also not an orthodox business history of the type that takes a single company as its subject and scrutinizes everything from its balance sheets to its markets and labor relations.

This book is something both less and more than those. It's an intriguing family-business history—great-aunts and all, across five generations (one of the authors, James, belongs to the sixth)—that illuminates the impact of business dealings on fraternal relationships. Brothers and nephews cooperated with and supported—and sometimes competed against and deceived—each other. *The Hancocks of Marlborough* reminds us that talent is a necessary but not sufficient condition for success. Many would have described Thomas and his five young brothers, who left Marlborough for London, as skilled, enterprising, and creative. Thomas, John, and Walter were all mechanically adept

