however, the author also destroys the validity of his own point of view, for what he writes is simply not historically true. Only (b) and (c) make valid starting points, for (a) neglects the fact that the real world simply is not the same for everyone. Relativity, for example, imposes itself on physicists; it does not have any effect on most other people. Nor, for that matter, did it impose itself on Laplace or Gauss, although it was certainly a part of nature during their lives. Empirical facts are often the result of wild hypotheses, which can arise from anywhere and make it seem that certain empirical facts ought, in consequence, to exist. The source of these hypotheses is not without relevance to the history of science.

There is a central distinction between the reason physicists may wish to study their past and the reason historians want to know about it. Physicists are interested in nature; historians of science are interested in science. The two are not the same. Put simply, physicists focus on what was discovered and historians focus on the process of discovery. In short, physicists and historians are not talking about the same thing.

The process of discovery tends to look, historically, like a relatively straight line. To understand how physics developed from Newton to Einstein is like asking the AAA how to get from New York (Newton) to San Francisco (Einstein). The agent will draw a direct route likely to get from here to there in the most efficient way. Historians of science tend to be more interested in the process by which San Francisco came to be. San Francisco was built by people from all over the world, has a unique geology and a climate suitable for its flourishing. These too are empirical facts, but it is their blending in a peculiar and particular society that makes San Francisco what it is. So, too, is modern physics more than the steady advance implied by focusing only on success and progress towards modernity.

Having said all this, it is only fair to point out that Purrington's text is one of the best of its kind. He understands fully the architecture of a physics that has been erected on empirical facts molded by mathematical analysis and synthesis. This overview of the subject will be of great use to students and practitioners. He takes his readers carefully from the middle of the 18th century to the end of the 19th by focusing on two limited and relatively well-known evolutions—those of electricity and magnetism and of heat and thermodynamics. The route followed is clearly marked with excellent bibliographical and explanatory footnotes. The whole would make an excellent supplementary text for a beginning course in physics, for it would allow students to see the forest while still trudging through the trees.

There are some minor flaws and simple mistakes, but they do not seriously detract from the main purpose of the book. The physical chemist, Pierre Duhem, for instance, was a victim of the anti-Catholicism of the Third Republic, not the Second Empire. William Whewell did not write the *Metaphysical Foundations of Natural Science*. William Rowan Hamilton was not a member of the Cambridge group, although he did attend Trinity College—but the one in Dublin, not Cambridge. Proofreading of proper names is bad: Priestly for Priestley, Wein for Wien, Morely for Morley, and so on. Proofreading is an essential part of writing for public consumption and should not be slighted—for whatever reason.

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Encyclopedia of Acoustics

Edited by Malcolm J. Crocker
Wiley, New York, 1997. 2017 pp. $395.00 hc ISBN 0-471-80465-7

The four-volume *Encyclopedia of Acoustics*, edited by Malcolm Crocker, is perhaps the greatest concentration of writing about acoustics since Lord Rayleigh wrote his *Theory of Sound*. The encyclopedia's more than 200 authors, the great majority of whom are fellows of the Acoustical Society of America, have contributed a total of 166 articles, which offer a clear statement of where acoustics stands as we approach the new millennium. Crocker, a professor of engineering at Auburn University, has performed a valuable service to the acoustics community in organizing this massive effort and bringing it to a successful conclusion.

Crocker divides the field of acoustics into 18 parts, largely paralleling the division of acoustics in the Physics and Astronomy Classification Scheme. Generally, each part is introduced by a review article. These articles were written by such well-known figures in acoustics as Per Bruel, James Flanagan, David Green, Manfred Heckl and James Lighthill, and alone they constitute a remarkable summary of our present knowledge.

The level of quality of the articles is high; there are ample illustrations, tables of formulas and more than enough equations to demonstrate that acoustics still contains a large mathematical physics component, despite the affiliation of the field with architecture, engineering, music and the life sciences.

Volume 1 includes linear acoustics, nonlinear acoustics and cavitation, aeroacoustics and underwater sound. Much of the material is traditional and classical, but the most modern of topics, such as sonoluminescence, cavitation, acoustic modeling and infrasound are given their fair share of space.

Volume 2 includes quantum acoustics, mechanical shock and vibration, statistical methods and noise, both its effects and its control. Here again we find a comfortable mixture of the traditional and the modern. There are articles on phonons in crystals, wave modes in liquid helium and thermoacoustic engines, but there are also all sorts of articles on vibrations—their analysis, monitoring and control, including the very modern area of active vibration control. Under noise, we find the traditional studies of industrial, transportation and airport noise, but also one on active noise control, a field that parallels the field of active vibration control.

Consideration of the human-related portions of acoustics begins in volume 2 with the articles on noise and continues throughout volume 3. The section on architectural acoustics includes practical details on the acoustics of room design and noise control for rooms and their ventilating systems. After a brief look at signal processing, the volume concludes with coverage of physiological acoustics and psychological acoustics.

The fourth and final volume covers a variety of topics. Speech articles include those on models of speech production, speech perception, speech coding and machine recognition of speech. Coverage of music and musical acoustics extends through different types of musical instruments and includes a chapter on electronic and computer music and one on the human voice. Bioacoustics, a most difficult field to define but one that is growing rapidly, is handled in articles on the acoustical characteristics of biological media, the biological effects of ultrasound, medical diagnosis and imaging (two chapters) and the effects of vibration and shock on people. Animal bioacoustics forms a separate part, with an article on the hearing of other vertebrates and articles on insect, amphibian and bird acoustics, as well as one on echolocation by bats. The final two parts of volume 4 are devoted, respectively, to acoustical measurements and instrumentation and to transducers, perhaps because there was no other clear place to put them. If this encyclopedia had been produced in the 1930s or 1940s, these final two parts would have dominated the coverage; now they are reduced almost to an afterthought, so far has the field of acoustics come in the last half century.

The level of all of the articles is close to uniform, and there appears to be a minimum of duplication, which is often the bane of multiauthored volumes.

In his 1879 review in *Nature* of volume 2 of Rayleigh's book on sound, Herman von Helmholtz expressed the hope that there would be a third volume, taking up a number of topics that von Helmholtz found lacking in the first two volumes. So I would hope for the later appearance of a volume 5 to the *Encyclopedia of Acoustics* to include such topics as cochlear implants, concert-hall acoustics, speech perception in the young and voice identification, as well as more material on signal processing. But for what is here, the book is a magnificent compendium of acoustical knowledge.

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Electronic Imaging in Astronomy: Detectors and Instrumentation

Ian S. McLean
Wiley, New York, 1997. 472 pp.
$82.95 hc ($44.95 pb)
ISBN 0-471-96971-0 hc
(0-471-96972-9 pb)

Until the 1970s, optical astronomers had to make do with two imperfect detectors: the photographic plate and the photomultiplier. The former could cover large focal-plane areas, but detected less than 1% of the incident starlight and were quickly saturated by background skylight. Photomultipliers were two orders of magnitude more sensitive, but only single-channel and bulky.

In the late 1960s and early 1970s, several groups married the panoramic and sensitivity advantages of television cameras to the emerging power of digital technology for space probes and ground-based telescopes. The Voyager images are perhaps among the best remembered. Then, in the 1970s, arrays of solid-state sensors based on doped silicon technology began to appear. In these, electrons released by photons accumulate at photo sites (pixels) until sensed by an on-chip amplifier and converted to a digital signal. Self-scanned diode arrays came first, followed by CCD's (charge-coupled devices).

Over the years, CCDs have grown from a few hundred pixels to several million on a single chip. Coupled with innovations in thinning and ultra-low-noise amplification, the stable format, large charge-storage capacity, high conversion efficiency of photons to charge (quantum efficiency) and panchromatic response make them almost perfect astronomical detectors. CCDs on four-meter and other optical telescopes have increased precision and sensitivity a thousandfold and, with the Hubble Space Telescope, have ushered in an exciting new era for observational astronomy. Even more dramatic has been the improvement in low-noise infrared arrays.

The remarkable, parallel development of CCDs and infrared arrays is celebrated by Ian McLean in *Electronic Imaging in Astronomy*, in which he provides an informal history and a veritable gold mine of basic information on all of these solid-state devices and the powerful auxiliary instruments into which they have been incorporated. McLean has played an important part in this story. He was involved in building infrared instrumentation at the Royal Observatory in Edinburgh for the United Kingdom Infrared Telescope, and more recently, as a professor at UCLA, he has built CCD cameras and is helping develop infrared instruments for the two ten-meter Keck telescopes.

This is more of a how-to book than a scientific monograph. McLean gives us the benefit of his considerable experience, with extensive and invaluable discussions of such things as cryogenics, data acquisition and image processing. He also knows most of the key players in the field, and there is a liberal sprinkling of anecdotes, with occasional sermons on how to run an instrumentation team. In addition, there are important chapters on detection techniques at other wavelengths, from ultraviolet to radio, and McLean finishes with a summary of the new, very large optical–infrared telescopes, now complete or under construction, which, with their carefully engineered auxiliary instruments and the emerging technology of adaptive optics, will provide unprecedented precision and sensitivity for astronomers by the year 2000. One caution: You might be left with the impression that large, scientific-grade CCDs and infrared arrays are available off the shelf at reasonable cost. In fact, their fabrication is still a fragile art, and the best devices are expensive and their delivery uncertain.

There are useful references and suggestions for further reading (not all readily available) at the end of each chapter. The sets of exercises and their answers didn't seem really necessary to me, but that may be personal taste. The only real shortcoming is an inadequate index. Important topics appear in several different places in the book, but most don't appear at all in the index. For example, try to find such fundamentals as cold stops or thermal emission from the sky and the telescope.

The book will be an invaluable resource for engineers and other groups building instruments. Parts of it will be vital reading for graduate and other students who need to understand fully the idiosyncrasies of detectors, reduction software and observing routines. It could well form an important part of an undergraduate or graduate course in astronomical techniques. Certainly no astronomical institution should be without a copy.

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Relativity and Gravitation

Philippe Tourrenc
Translated by Andrew King
Cambridge U. P., New York, 1997.
242 pp. $64.95 hc ($29.95 pb)
ISBN 0-521-45075-6 hc
(0-521-45685-1 pb)

I am frequently on the lookout for a slim, straightforward, no-frills text on relativity. Not to teach my graduate-level course in general relativity. For that I rely upon some combination of Bernard Schutz's *A First Course in General Relativity* (Cambridge U. P., 1985) and the "telephone book": Charles Misner, Kip Thorne and John Wheeler's *Gravitation* (Freeman, 1973). For teachers who are of a more field-theoretical bent, there's Steven Weinberg's *Gravitation and Cosmology* (Wiley, 1972), while for the more mathematically oriented, there's Robert Wald's *General Relativity* (U. Chicago, P., 1984). But sometimes you just need a book to assign to a good undergraduate who wants to do a one-semester or one-quarter reading course for credit. The book should not be so encyclopedic that the student makes no noticeable progress. It should also avoid overlong development of formalism (such as tensor calculus or differential geometry), so that the student soon gets into the stuff that really interests him or her.

Philippe Tourrenc's *Relativity and Gravitation* nicely fills the bill. The author, a professor of physics at the Université Pierre et Marie Curie in Paris, has produced a condensed accounting of special and general relativity rather than a full textbook, yet he packs a remarkable amount into its 240 pages. The absence of problems