

inclusion of nonlinear dynamics in chapter 4 and the very nice discussion of solving inhomogeneous equations in chapter 6.

In chapter 3, Herman introduces and develops linear algebra (matrices, eigenvalues, eigenvectors) and finds nice applications of 3×3 and bigger matrices. Then, somewhat unexpectedly given the chapter title, “Linear Algebra,” the presented applications seamlessly turn to systems of linear differential equations and their solutions. The connection between linear algebra and differential equations provided by that fusion is indeed useful, and it highlights the benefits of Herman’s emphasis on examples and applications. It is a pity that the analysis does not go beyond two linear differential equations for two functions, although Herman does find a successful and interesting application of the analysis in the following chapter.

An application-based approach inevitably seems to cause a few closely related concepts (or even one and the same concept) to turn up at distant places in the text. For example, the Bessel equation and its solutions turn up in chapter 6 to introduce the Fourier–Bessel series as an example of a nonsinusoidal harmonic. The reader will have to wait until chapter 11 to be reintroduced to the Bessel equation and its solutions; there Herman provides much more detail, a proper physical motivation, and several concrete and amusing applications to solving the wave equation and the diffusion equation.

I would have expected some of the introduced concepts to be employed further. For example, the gamma function is introduced briefly in chapter 6 and used in chapter 8, but Herman misses the opportunity to show how to use it to compute Gaussian integrals of the form $\int dx x^n \cdot \exp\{-a \cdot x^2\}$, which frequently occur in statistical and quantum physics. Finally, and I have the same qualm with several other textbooks on mathematical physics, Herman introduces the index notation in the vector analysis section of chapter 9, but essentially ignores the difference between covariant and contravariant quantities; the distinction is made only in the last two pages of the chapter.

Although the subject of mathematical methods has inspired many valuable texts, Herman’s approach, motivated by the physics applications, is novel, seldom used by other authors. The myriad well-chosen worked-out examples and other strengths have

earned my firm endorsement, and they convincingly outweigh the few shortcomings.

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Probing the Sky with Radio Waves

From Wireless Technology to the Development of Atmospheric Science

Chen-Pang Yeang
U. Chicago Press, 2013. \$60.00
(361 pp.). ISBN 978-0-226-01519-4

Other than the commercial distribution of electric power, perhaps no other 20th-century technical development has had a greater impact on society than the opening of the radio-frequency spectrum for communication, position location, and entertainment broadcasting. Chen-Pang Yeang’s *Probing the Sky with Radio Waves: From Wireless Technology to the Development of Atmospheric Science* weaves together the multifaceted development of the commercial, amateur, and military use of radio waves with the experimental and theoretical research on radio-wave propagation in the atmosphere and ionosphere. Yeang is a faculty member at the University of Toronto’s Institute for the History and Philosophy of Science and Technology; in addition to work in that field, he also has a background in electrical engineering and radio-wave propagation.

The first military and commercial radio communications, which started around 1900, have developed into a wide range of personal and commercial mobile services. Similarly, from the earliest commercial radio broadcasts in 1920, broadcasting—first radio then TV—has grown to report up-to-the-minute onsite news in high-definition color, using satellites to link homes to remote parts of the globe. The recognition that radio waves are reflected from aircraft and ships was critical to the development of commercial airplane navigation and has led to a revolution in warfare.

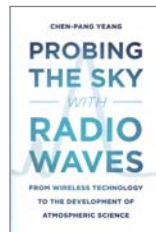
On a more peaceful front, scientists today study radio emission from the most distant parts of the universe and use radio waves and radar to probe Earth’s atmosphere, oceans, and land surfaces. Remarkably accurate weather

predictions not only help us plan our daily activities, but save untold numbers of lives by warning us of violent weather conditions such as hurricanes, typhoons, and tornadoes. All of those applications follow from James Clerk Maxwell’s classical synthesis of electricity and magnetism; his recognition of light as an electromagnetic wave; Heinrich Hertz’s generation of radio-frequency radiation; and Guglielmo Marconi’s 1901 demonstration of transatlantic propagation of radio waves, followed by his vigorous promotion of the technology’s commercial uses.

Oddly, the rapid growth of the military and commercial uses of radio outpaced the understanding of how it all worked. The earliest experiments clearly showed that, contrary to expectation, radio waves propagated well beyond the horizon, apparently by means of what was referred to as surface diffraction. Extensive tests indicated that the maximum distance reached depended on the radiated power and wavelength; but they were not consistent with various complex diffraction models developed to explain radio-wave propagation. The breakthrough in understanding did not come about from refinements in the theory. It came from observation and experimentation after the amateur radio operators, who were relegated to the “useless” spectral region, unexpectedly demonstrated radio communication over global distances using only modest power at wavelengths as short as 10 meters.

Experiments at the Carnegie Institution of Washington, the US Naval Research Laboratory, the National Bureau of Standards (now NIST), and the Universities of Cambridge and Manchester in the UK showed how radio propagation changed with frequency, time of day and year, and polarization. At high frequency, the received signal strength initially diminishes with increasing distance, but beyond some point it again increases. Observations of the frequency-dependent fading suggested constructive and destructive interference arising from multiple signal paths. The existence of “skip zones” in which transmissions could not be received implied that radio waves are reflected from a layered, ionized medium and reach distant receivers after one or more “hops”; the insight led to a new application of radio technology to probe the ionosphere. But detailed understanding of the complex underlying theory took many years and was at times controversial.

Yeang’s book contains much of that



history and will be of value to historians interested in the sociology and the century-long development of radio technology. Some sections, though, require a good understanding of partial differential equations, electromagnetism, and magneto-ionic theory. Those discussions that are treated in great depth and quantitative detail will be appreciated more by scientists working in atmospheric and ionospheric physics, but may be distracting to those more interested in the historical aspects of radio communication and broadcasting.

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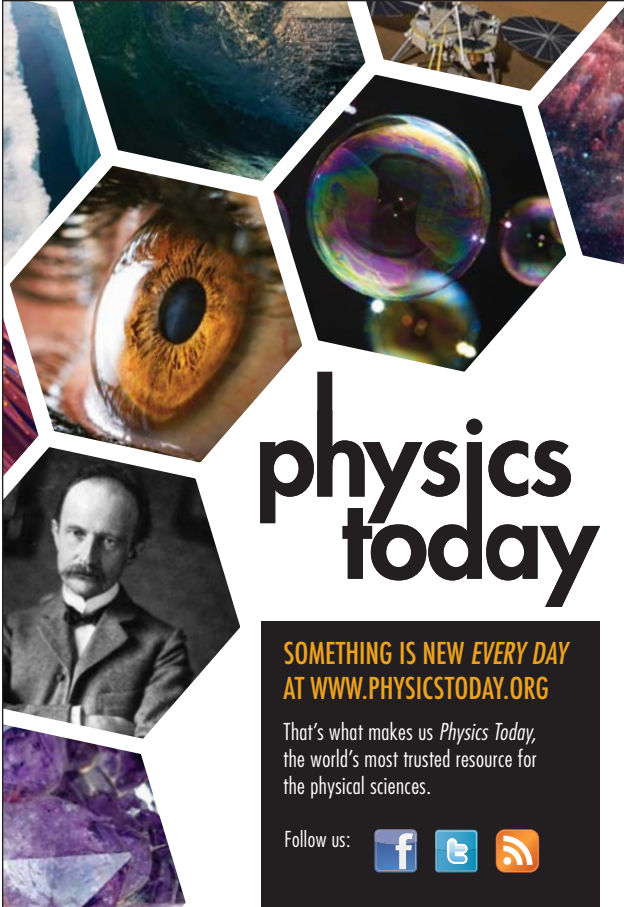
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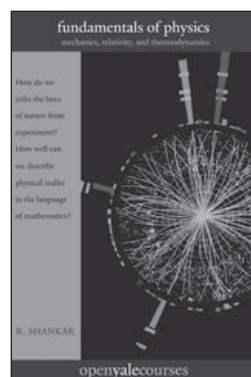
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