of no interest to the military. The switch allowed him to leave a lasting influence on yet another fundamental science and enjoy the relative freedom of academic research and informal discussions with colleagues. Zeldovich clearly valued that freedom more than administration or other official business as a high-ranking member of the USSR Academy of Sciences. He tried to keep politics at arm's length; for example, he collaborated with Sakharov on science, but abstained from making any public statement, positive or negative, about Sakharov's political actions.

Many of the sources that provide background information for Hargittai's biographies are close to the oral tradition: eulogies, personal recollections, and stories told and retold in the scientific community. In some cases, such as Zeldovich's, I can confirm the essence of his depiction in *Buried Glory* from my personal experience as one of Zeldovich's last students. The surviving archival documents can sometimes correct or support the folklore tradition, though often they simply lack sufficient information. But as Thomas Kuhn once said about George Gamow's personalized account of the 30 years that revolutionized physics: Even if some anecdotes cannot be fully verified, they are still important because they circulate in the academic profession and tell much about its culture.

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A Course in Mathematical Methods for Physicists

Russell L. Herman
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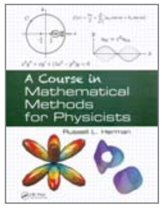
In *A Course in Mathematical Methods for Physicists*, Russell Herman advocates for and successfully practices an example- and application-based introduction to the subject.



In that regard, the book is a welcome and refreshing addition to a rich body of literature. For two decades, I have taught a math methods course to advanced undergraduates and incoming graduate students who need a refresher; it uses a more advanced text, *Mathematical Methods for Physicists* (6th edition, Academic Press, 2005) by George Arfken and Hans Weber.

As Herman, a mathematical physicist, states in the prologue, his book is intended for "undergraduate students who have completed a year-long introductory course in physics," so a two-semester course based on it should fit into the sophomore or junior year of a typical physics undergraduate curriculum. The text is designed for and will easily accommodate such a course. Engineers and chemistry majors, too, would benefit from taking such an intermediate-level course, perhaps even more so than from a higher-level one. Our own department at Howard University is considering a mid-level math methods course, and I would definitely recommend this textbook as well suited.

A Course in Mathematical Methods for Physicists includes plenty of interesting worked-out examples, many of them quite realistic, and uses them to introduce concepts in a reasonable progression. The book offers a good selection of material, most of which I would expect to be included in a math methods text. I was also pleasantly surprised by the 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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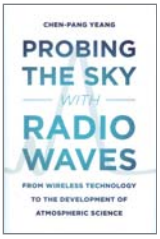
Probing the Sky with Radio Waves
From Wireless Technology to the Development of Atmospheric Science

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