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Electromagnetic and Optical Pulse Propagation, by Kurt E. Oughstun, Springer, Dordrect, Volume 1: 2006, 460 pages, ISBN 978-0387345994; Volume 2: 2009, 831 pages, ISBN 978-1441901484.

Prof. Kurt Oughstun of the University of Vermont has remarkably combined mathematical rigor and the presentation of cutting-edge engineering applications with a captivating and eloquent writing style in this thorough two-volume treatise on the theory of pulse propagation in temporally dispersive media. This is an advanced graduate textbook. It provides a substantial extension on the theory side and a refreshing update on the applications side to its successful predecessor, *Electromagnetic Pulse Propagation in Causal Dielectrics*, by Oughstun and Sherman. Both volumes are addressed to a wide audience of students and researchers in electromagnetics and optics, especially those involved with either guided or radiated ultra-wideband pulse fields and their interaction with natural or artificial media. Not only does this work provide a solid theoretical foundation for ultra-wideband pulse-propagation studies, but it also points to interesting directions of applied research in the second volume. However, by itself the first volume is an excellent resource for electromagnetic theory fundamentals. It can well serve as a reference text for a one-semester advanced electromagnetic theory course at the graduate level. In the following, a more detailed overview of the subjects included in the two volumes is presented.

1. Volume 1: *Spectral Representations in Temporally Dispersive Media*

The first volume is occupied with the development of the basic tools for the representation of pulsed fields in temporally dispersive media. In the process of assembling the theoretical tools that lead to the angular-spectrum representation of pulsed fields in dispersive media, the author discusses the whole range of electromagnetic theory fundamentals, carefully developing the macroscopic field equations from the microscopic Maxwell equations. The latter are presented in Chapter 2, along with conservation principles for energy, linear and angular momentum, Poynting's theorem, and the principle of uniqueness. Notably, Chapter 2 also discusses the invariance of Maxwell's equations under special-relativity transformations.

In Chapter 3, the microscopic theory of radiated fields is developed through the introduction of potentials (Hertz and Lienard-Wiechert). Hence, the fundamental problems of determining radiated fields produced by a moving charge and a general dipole oscillator are rigorously resolved.

With microscopic electromagnetic theory in place, Chapter 4 proceeds with the connection of microscopic to the more familiar macroscopic electromagnetics. This is one of the most important and interesting chapters of the two volumes. The spatial averaging process that is used to connect the microscopic to the macroscopic equations is fundamental, yet omitted by most textbooks. With the recent surge of interest in homogenization theories in the area of metamaterials, this chapter serves as a sound reference for relevant studies. Moreover, the constitutive relations are introduced and connected to causality, leading to the presentation of causal models for material dispersion.

Chapter 5 focuses on the time-harmonic case to illustrate fundamental relations for fields in temporally dispersive media. In particular, the complex form of Poynting's theorem and energy conservation are discussed, along with the concept of energy velocity. In addition, boundary conditions for dielectric-dielectric and dielectric-conductor interfaces are presented. Up to this point, the book has covered fundamentals of electromagnetic theory that are not necessarily particular to the topic of pulse propagation: they are in general useful for any advanced student of electromagnetics.

The next three chapters enter the subtitle topic of this volume, namely, the angular-spectrum representation of pulsed fields in temporally dispersive media. Chapter 6 lays the groundwork, providing the basic strategy for the field-integral representation through the well-known plane-wave expansion. Introducing polar-coordinate transformations, the author discusses Weyl's, Sommerfeld's, and Ott's integral representations. Chapter 7 proceeds to solve the boundary-value problem of the fields in a half-space produced by known tangential fields on its terminal plane, and to investigate the polarization properties of the associated field solutions. Finally, Chapter 8 deals with the source-free case, and offers an insightful discussion on field propagation.

2. Volume 2: *Temporal Pulse Dynamics in Dispersive, Attenuative Media*

The second volume draws from many years of research conducted by Prof. Oughstun and his coworkers on the time-domain pulse dynamics in temporally dispersive, attenuating media, and, especially, the evolution of precursor fields. The origins of this topic date back to Sommerfeld and Brillouin. Their work on the propagation of a sinusoidally modulated step signal in a semi-infinite, single-resonance, passive Lorentzian medium led to the observation that the main part of the signal is preceded by two "forerunners" or "precursors." The first precursor, named after Sommerfeld, contains high-frequency components, whereas the second precursor, named after Brillouin, contains low-frequency components of the signal. Prof. Oughstun has updated and expanded this early steepest-descent-based derivation, using modern asymptotic-analysis techniques. The first two chapters of the second volume (Chapters 9 and 10) offer the preliminaries for such an analysis. They start from classical stationary-phase approximations on the angular-spectrum representation (in Chapter 9), followed by advanced saddle-point techniques, such as Olver's method, in Chapter 10.

Chapter 11 can attract the interest of a broad audience in electromagnetics, as it treats the basic question of what is the appropriate definition for group velocity when an ultra-wideband pulse is considered. The classical group-velocity definition fails in this case, as expected. This is also shown with several simple and convincing examples. Instead of the classical group-velocity approximation, the author presents a reasonably accurate alternative, due to Brabec and Krausz.

The pulse dynamics in causally dispersive dielectrics can be determined by studying the phase function (in particular, its saddle points) in the spectral representation of the field. Chapter 12 discusses the saddle-point location and dynamics for single/multiple-pole Lorentzian and Rocard-Powles-Debye, Drude model conductors and semiconductors. This paves the way for the detailed study of the evolution of the Sommerfeld and Brillouin precursors, as well as the main signal in such media, in Chapters 13 and 14, respectively.

The author then turns his attention to the dependence of these wave phenomena on the source excitation signal. Chapter 15 studies several cases of wideband pulse-excitation functions and the fields they produce. Among those, the case study of the Brillouin precursor presenting an optimally low attenuation rate in a Rocard-Powles-Debye dielectric stands out as a candidate for intriguing applications. In the same chapter, one can find an overview of the total field evolution, with the transition from the precursor-field stage to the main-signal stage thoroughly described. Perhaps the most enjoyable part of this chapter – if not of the whole volume – is the section entitled "The Myth of Superluminal Pulse Propagation." In this section, the preservation of relativistic causality throughout the evolution of a pulse signal in a causal, dispersive dielectric is made abundantly clear by straightforward yet elegant mathematical arguments.

The group-velocity question is revisited in Chapter 16, in light of the asymptotic analysis that illustrated the pulse evolution in dispersive dielectrics. It is shown that the classical group velocity holds for small propagation distances in the combined presence of attenuation and dispersion, "small" being defined in comparison to the skin depth. To address this problem, the "extended group velocity" is presented, with validity extended up to distances greater than the skin depth.

The last chapter (Chapter 17) is dedicated to applications, mainly of precursor fields. The low-attenuation property of the Brillouin precursor is naturally appealing for radar and underwater communications. The flip side of the optimal-penetration properties of the precursor fields is also presented: safety issues, stemming from the inadequate consideration of the presence of precursors in various radiated emissions.

Both volumes are complemented by useful appendices. Each chapter ends with a series of practice problems. On the other hand, both volumes are missing solved examples, which would have certainly enhanced their quality as course textbooks.

The author has also devised a creative solution to bridge the divide between those using the MKS system and those preferring cgs: all formulas can be read in both systems by including or omitting a factor in brackets.

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Recent Books

The following is a list of recently published books that have been received by the Associate Editor since the last issue of the *Magazine* was published. Reviewers are sought for these books, so readers are encouraged to let the Associate Editor know if they are interested in reviewing a particular book.

Small Antennas: Miniaturization Techniques and Applications, John L. Volakis, Chi-Chih Chen, and Kyohei Fujimoto (McGraw-Hill, 2010)

Numerical Methods for Engineering: An Introduction Using MATLAB and Computational Electromagnetics Examples, Karl F. Warnick (SciTech, 2010)

Practical Applications of Asymptotic Techniques in Electromagnetics, Francisco Saez de Adana, Oscar Gutiérrez, Iván González, Manuel F. Cátedra, Lorena Lozano (Artech House, 2010)

http://www.springer.com/978-0-387-34599-4

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