Book Review: Delores Knipp's Understanding Space Weather and the Physics Behind It

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Understanding Space Weather and the Physics Behind It
By Delores Knipp
McGraw-Hill, 2011; 744 pp.; ISBN: 978-0073408903; $93.33

Delores Knipp's textbook *Understanding Space Weather and the Physics Behind It* provides a comprehensive resource for space physicists teaching in a variety of academic departments to introduce space weather to advanced undergraduates. The book benefits from Knipp's extensive experience teaching introductory and advanced undergraduate physics courses at the U.S. Air Force Academy. The fundamental physics concepts are clearly explained and are connected directly to the space physics concepts being discussed. To expand upon the relevant basic physics, current research areas and new observations are highlighted, with many of the chapters including contributions from a number of leading space physicists.

The textbook is written in the style of university physics texts, such as *Halliday et al.* [2005], in that each chapter is filled with color diagrams, photos, callouts, and sidebars that contain brief digressions on real-life examples of the concepts being discussed, worked problem examples, and Pause for Inquiry questions that help students assess their understanding.

Space physics, as we know, is the field of space science that studies the structure and dynamics of the Sun's atmosphere and its interaction with everything inside the solar system (from planetary atmospheres and magnetospheres to asteroids, comets, and dust) as well as its interaction with the local interstellar medium. The Sun's supersonically flowing magnetized solar wind carves out a bubble in the local interstellar medium called the heliosphere. Understanding the physical processes important for the heliosphere requires knowledge of plasma physics, a field that is often not taught at the undergraduate level. With our increasing reliance on space technology, global communication and navigation systems, and continental-scale power grids, we now realize that the Sun significantly influences the Earth's space environment, with societal and technological implications. Because of all of these factors, space weather has emerged from the field of space physics as an independent area of study.

The goal of the textbook is extremely ambitious, and the scope of topics covered is comprehensive. Each chapter begins with a list of concepts that students should already understand and a list of concepts discussed in the text. At the end of each chapter is a list of keywords and equations that were introduced, answers to the Pause for Inquiry questions posed throughout the chapter, and references and suggestions for further reading.

Although students are expected to have studied calculus, mechanics, thermodynamics, and electricity and magnetism, the text provides background on all of the undergraduate-level physics pertaining to space weather concepts. The textbook is clearly designed for advanced undergraduates in that much of the fundamental physics is reviewed as opposed to being assumed knowledge. In addition, many of the fundamental plasma physics topics normally included in graduate textbooks are introduced but are not fully developed or derived. For example, in the chapter that introduces the solar wind structure, an outline of Eugene Parker's theory is presented, but instead of doing the full derivation of the solar wind structure (as is often done in graduate space physics texts), the path to the solution is provided by a flow chart diagram with the final results (such as the class of solutions of the solar wind velocity for different temperatures as a function of radial distance from the Sun) given as figures. This deliberate target of advanced undergraduate students and the book's organization for that audience clearly distinguish *Understanding Space Weather* from other hybrid audience advanced-undergraduate- and beginning-graduate-level introductory space physics textbooks.

The textbook's three sections are presented in a logical order. The first section describes the structure and physics of the space environment, including the quiescent Sun; the solar wind; and Earth's magnetosphere, ionosphere, and atmosphere. Along the way, the important concepts of radiation,

electric and magnetic fields, and plasma physics are introduced specifically as they pertain to the space environment. The second section examines the dynamics of the space environment, from solar storms to geomagnetic storms. The third section explores how these space weather storms directly affect society and technology. Essentially all of the technological space weather impacts are described in detail, including ramifications for space electronics, satellites, ground systems, radio communication, and navigation, as well as airline crews and astronauts.

The encyclopedic, 14-chapter textbook is clearly a labor of love and is a wonderful addition to the space physics library. However, the work is designed to be taught in one 15-week semester, but with more than 700 pages, 560 keywords, and 200 Pause for Inquiry questions, it is a significant task for an undergraduate student to read, understand deeply the concepts, and take full advantage of the pedagogical sections in the text. Working through the Pause for Inquiry problems and reading the text carefully took this reviewer 3 to 4 hours per chapter. From education research on how undergraduate students use introductory physics textbooks [e.g., *Podolefsky and Finkelstein*, 2006] it is known that a majority of students do not read the textbook unless they are required to submit reading exercises, and most skip over sidebars, text boxes, and inquiry questions [e.g., *Benbassett et al.*, 2008] unless these features are emphasized by the instructor. The textbook also suffers from a lack of end-of-chapter problem sets.

Despite the density of the text, this textbook is the most comprehensive and well-written advanced undergraduate introduction to space physics on the market and provides the opportunity to introduce space physics at the undergraduate level using the relevance and importance of space weather to engage and excite the next generation of scientists and engineers. I highly recommend it.

References

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