

especially in those branches of fluid dynamics whose rapid progress has led to the incorporation of their techniques into modern physics.

A notable example is the solitary wave in shallow water, whose stable exemplar, the KdV soliton, has mathematical properties that leave one speechless on first hearing of them. Still, wonderful as they are, the solitons arise in a system that is free from real-world problems, such as the instability and dissipation that enrich the lives of fluid dynamicists with difficult but fascinating challenges. Adding these features to the study of the dynamics of thin fluid layers brings us into the kaleidoscopic world of fluid dynamical pattern formation.

At the turn of the century, Henri Bénard produced his famous picture of the hexagonal flow pattern observed in a thin layer of spermaceti heated from below. More than 50 years later it was realized that the nature of this particular pattern owed more to the temperature dependence of the surface tension than to the influence of the gravitational acceleration, which was the key ingredient in the theoretical analysis by Lord Rayleigh. (Rayleigh's theory and some subsequent elaborations are detailed in Subrahmanyan Chandrasekhar's *Hydrodynamic and Hydromagnetic Instability*, Oxford, 1961.) The surface tension operates on only the top surface, and so it breaks the symmetry underlying Rayleigh's theory. This is enough to modify the expected form of the convective cells.

Bénard and his students soon appreciated that his first experimental results were atypical of ordinary fluids. They went on to attempt "to define and to measure in a horizontal liquid layer heated from below, the convection currents that prevail, considered as near as possible to their state of greatest stability." The problem so formulated is at the center of modern convective pattern research, and the work of Bénard's students anticipated some important modern discoveries and methods. Surprisingly, their early grasp of the basic issues is generally overlooked in the current literature.

Though *Rayleigh-Bénard Convection: Structures and Dynamics* by Alexander V. Getling does not dispel this general misimpression, it does give a careful account of work on the patterns of convective motions performed in the second half of this century. Getling, of the Institute of Nuclear Physics at Moscow State University, describes the recent addition of such cell shapes as bull's-eyes, spirals, and labyrinths to the more traditional structures of convective motions, rolls, and hexagons. His account of this growth in the ex-

perimental and theoretical understanding of convective pattern dynamics during the past 30 or 40 years follows the presentation of the original research papers closely.

In his admirably slim volume, Getling attempts no grand synthesis and is driven by no current fads. We do not find the words "complexity" or "chaos" in the index of his book, though they are normally to be heard in many discussions of this subject—even the second edition of Landau and Lifshitz's *Fluid Mechanics* describes the transition to chaos by period doubling. Getling confines himself to the results of convective pattern theory, and one need not look for more.

Yet similar pattern studies have occurred in other subjects, such as oscillating chemical reactions and biological structure formation. The subject has gained a universality that is attractive to physicists because pattern formation exemplifies concepts from such other branches of physics as condensed matter. These connections have developed in the 30 years since the Ginzburg-Landau equation first appeared in theoretical discussions of convection. This discovery set off a wave of cultural diffusion that brought the Navier-Stokes equations of fluid dynamics back into physics, even as fluid dynamicists and applied mathematicians have learned to speak of disclinations, order parameters, and Goldstone modes.

Physicists who want a global vision of where the study of patterns has gone in the past decade or two will need to decide whether they want to follow Getling's straight and narrow path through convection or seek a wider view, like that provided in the prodigious review article by Michael C. Cross and Pierre C. Hohenberg (*Rev. Mod. Phys.*, **65**, 581–621, 1993). Or perhaps they would prefer the more mathematical outlook afforded by Paul Manneville's *Dissipative Structures and Weak Turbulence* (Academic, 1990). Those who favor the applied mathematical outlook may find it interesting to see how the technique once known as slowly varying wave theory has made a successful reappearance in this seemingly waveless terrain, as described in the review by Alan N. Newell, Thierry Passot, and Jocelyn Lega (*Ann. Rev. Fluid Mech.*, **25**, 399–453, 1993). Still, there is no denying that the convective regime of moderate amplitude, where pattern theory works well, is well worth a book of its own, and Getling's is of about the right thickness.

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Nonlinear Optics: Basic Concepts

Douglas L. Mills
Springer-Verlag, New York, 1998.
2nd edition. 263 pp. \$42.50 pb
ISBN 3-540-64182-3

Douglas L. Mills's *Nonlinear Optics* is the second edition of a well-known text first published in 1991. In the preface to the first edition, the author states clearly what his intended audience is: students who have completed a year of graduate-level electricity and magnetism (and quantum mechanics) and who wish to learn something about nonlinear optics. He attempts specifically to introduce the competent graduate student in physics or electrical engineering to nonlinear optics, but does not try to cover the field in the kind of detail of, say, Amnon Yariv's *Quantum Optics* (Wiley, 1975, 2nd edition). In short, Mills has produced a high-level "overview" text.

The strength and the weakness of this book in both of its editions flow from the author's aim. The text covers virtually all of the main research areas in modern nonlinear science, and the style and presentation are inviting to the general reader. In this sense, it serves a valuable purpose, for it offers a broad, easily accessible introduction to one of the most important research topics using lasers. The second edition includes an emphasis on nonlinear optics at the surfaces of materials, a subject of great activity over the last 10 years and, combined with the sections on nonlinear optics in fibers, it offers the reader a real sense of the excitement and opportunities in nonlinear optics.

The downside is that while Mills takes pains to express many of the equations in their correct form and even derive in detail some of the results, he is not consistent in the depth with which he goes into individual topics. For example, he spends multiple pages deriving phase-matching conditions yet leaves much to the reader in developing fundamental equations in optical fibers. Accepting that this disparity is a necessary risk in any overview text, *Nonlinear Optics* comes close, but not close enough, to being useful as a main text for the course Mills wishes to offer. Anyone planning to use this book as a guide for a second-year graduate course in nonlinear optics would have to include a great deal of outside reading, or supplement it with one of the more established texts in the field (for example, Yariv's).

As a note on structure, I would have appreciated a much more detailed index, and especially an author index

with cross references to the subject index. Given the audience Mills is attempting to address, these additions would add greatly to its usefulness.

I recommend this book to any first-year graduate student who may wish to learn about the opportunities of this exciting field. But to really learn what is going on, or what is involved in the subject, the student will need to be guided by a book that goes into greater details.

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Galaxy Formation

▶ Malcolm S. Longair
Springer-Verlag, New York, 1998.
536 pp. \$64.95 hc
ISBN 3-540-63785-0

The discipline of cosmology—extragalactic astronomy is one of the most rapidly evolving fields in astronomical research. During the last three decades it evolved from the search for three numbers—the Hubble constant (H_0), the density parameter (Ω_0), and the deceleration parameter (q_0)—to a full-fledged quantitative science with considerable predictive power and substantial impact on such other topics in physics as particle physics.

Of these three decades, the most recent one has probably been the most fruitful, mainly because of the breathtaking images captured by the Hubble Space Telescope, but also because of the advent of other superb research facilities during that time. Those facilities include the Keck 10 m telescopes and space probes such as ROSAT (Roentgen (x-ray) Satellite) and COBE (Cosmic Background Explorer) to name only a few. Actually, one could argue that a similar if not even larger boost still lies ahead, triggered by the large number of 8 m telescopes that are going to be dedicated in the next few years and such new satellites as SIRTf (Space Infrared Telescope Facility) and MAP (Microwave Anisotropy Probe), and, in the somewhat more distant future, the Planck and the NGST (Next Generation Space Telescope).

To write a textbook at the graduate level on such a rapidly evolving subject is a formidable challenge. This challenge has been met by about a half-dozen textbooks, all of them excellent and none older than about five or six years. Some appeared as recently as 1998.

Malcolm Longair's *Galaxy Formation* is a very nice addition to that pool of textbooks. Despite its title, the book actually covers pretty much all of extragalactic astronomy and cosmology. Among the smallest textbooks by mass

(it's still suitable for your carry-on luggage), it nonetheless offers one of the most comprehensive descriptions of the topic, in particular where observational data are concerned. For example, it gives a 20-page crash course on general relativity, but one also finds the Hubble Galaxy classification scheme, mass estimates of galaxy clusters using lensing and x-ray data, linear and nonlinear theory of structure formation, and the physics of the cosmic microwave background.

Although many topics are covered, Longair never fails to place the results within the big picture. Of course, one cannot expect every topic to be derived with the depth and rigor of a theoretical physics textbook, but Longair knows how to use physical intuition to comfort the reader who is stepping into unfamiliar terrain.

Besides completeness, it is also the most up-to-date textbook. Even very recent developments are included, such as supernova projects to measure cosmological parameters, the Hubble Deep Field, the clustering of the so-called Lyman-break galaxies (a galaxy population at redshift 3), and the paradigm shift in explaining the Lyman-alpha forest based on the outcome of large hydrodynamical simulations.

The only weakness I could identify is, ironically, in the topic of galaxy formation itself, which is discussed somewhat too briefly. Some recent developments that involve numerical simulations using N-body and gas dynamical techniques, as well as the so-called semianalytical or phenomenological galaxy formation models, are hardly mentioned, even though these topics have made up a fair share of the literature of the last couple of years.

I very much enjoyed reading this book, and I am sure I will make use of it the next time I teach a cosmology graduate course, as both a textbook for the students and a guide in preparing my lectures.

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Physics of the Space Environment

▶ Tamas I. Gombosi
Cambridge U. P., New York, 1998.
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ISBN 0-521-59264-X

Space physics, narrowly defined as the study of Earth's plasma environment, has had an identity crisis throughout its relatively brief existence as a discipline: ▶ The limited and often serendipitous nature of the data requires the re-

search style of an astrophysicist.

▶ However, the *in situ* observations and instrumentation that are central to the field are quite different from the remote observations and instrumentation of astronomers.

▶ Compared to neutral gases, the wealth of additional phenomena and the complexity associated with magnetized plasmas and their interaction leave the space physicist little in common with the atmospheric scientist.

▶ Although the phenomena studied in space physics are ultimately important to astrophysics, the intimate measurements of plasma properties provide a greater commonality with the methods of the plasma physicist.

Tamas I. Gombosi's *Physics of the Space Environment* cuts through this diversity to deal with the interpretation of space physics observations. The book is intended for well-motivated graduate students and research scientists and engineers. It is based upon graduate-level courses taught by the author in the College of Engineering at the University of Michigan. Although the book does not delve into numerical modeling, the author's interest in this area is evident throughout.

The book emphasizes physical processes rather than phenomenology. In particular, it stresses the application of transport theory to the space environment. The reader is assumed to be proficient in undergraduate physics and mathematics through tensor algebra, complex variables, statistics, and the solution of basic ordinary and partial differential equations. Knowledge of elementary chemistry and astronomy is also helpful. Terms that are not part of the standard physics curriculum, such as "spectral type G2V" and "type IV radio emission," are sometimes used without explanation.

The text is divided into three parts. There is no overview or historical introduction. (A reader will have to look elsewhere for historical perspective.) Part I presents the theory of gases and plasmas. This includes single-particle orbit theory, the Boltzmann equation and collision terms, the fluid and magnetohydrodynamic equations, basic MHD and plasma waves, shock waves and discontinuities, and energetic particle transport. Part II is devoted to aeronomy, the physics and chemistry of Earth's upper atmosphere. The neutral atmosphere, the ionosphere, the aurora, and airglow are covered. Part III addresses the Sun, the solar wind, cosmic rays and energetic particles, and Earth's magnetosphere. Four appendices contain physical constants and summaries of vector and tensor identities and some special functions.

Each of the 14 chapters concludes