

studies of filaments and voids in large-scale distribution of galaxies in astronomy, and detection of gravitational waves, to name a few.

There is a broader picture, which takes longer to digest but is intellectually very satisfying. In this picture, wavelets lie at the confluence of a wide range of schools of thought about multiscale processes, capturing the essence of key ideas arising in areas as diverse as fractal analysis, the study of human vision, renormalization group analysis, and computer-aided design and manufacturing. As Yves Meyer first showed in his celebrated "Review of Two Books on Wavelets," (*Bull. Amer. Math. Soc.*, April 1993, p. 350), wavelets provide a common language for multiscale thinking in 16 different fields scattered throughout the mathematically inclined science and engineering disciplines. The story of wavelets and their relationships to similar multiscale ideas in a multitude of fields gives an intriguing picture of some interactions of mathematics, science, and technology in the late 20th century.

Stéphane Jaffard, Yves Meyer, and Robert D. Ryan take this "big picture" viewpoint in *Wavelets* and tell the story admirably, with flair and charm. While the spirit animating the discussion is clearly mathematical, the book will surprise readers who expect mathematics books to be dry and abstract. The book's approach has much in common with intellectual histories familiar to physicists; it constructs a thread linking ideas of key scientists in various eras, describes their ideas, and shows how these ideas have come together to create a coherent modern multiscale viewpoint and set of tools. This "key-scientist" approach mentions the work of many well-known mathematical scientists, including J. E. Littlewood, Alberto Calderón, Dennis Gabor, and Eugene Wigner, and it suggests linkages to the work of key scientists who were active more recently—David Marr's work in human vision, for example. Such suggested linkages arise from a scientific vision that perceives vital links between applied mathematics and science and technology. These links run not through the traditional avenue of analysis of differential equations, but rather through applied mathematicians' roles in devising ways to represent, transform, and process information rapidly as digital data.

The first seven chapters of the book set up a frame of reference: What are wavelets? Where did they come from?

What are they related to? These chapters establish background terminology in signals and transforms, describe historical trends in mathematics leading up to the development of modern wavelet transforms, and discuss parallel developments in image and speech coding and contrasting developments in time-frequency representations. Later chapters link wavelets to the study of vision, to the study of turbulence, to delicate mathematical analysis of some classic nondifferentiable functions, to data compression and noise removal, and to astronomical image processing. Each topic is treated briefly but engagingly, providing just enough mathematical content to make clear where further study can be directed and to point to interesting developments that are very recent or still in progress.

While an intellectually exciting story has its place, students inevitably need to learn details in a systematic way. Albert Boggess and Francis J. Narcowich, in their *A First Course in Wavelets with Fourier Analysis*, provide an undergraduate course in which Fourier analysis and wavelet analysis are developed simply, without such advanced mathematical tools as measure theory. While the book gives only a sketch of some applications of wavelets, it provides a thorough foundation that culminates in the discussion of Daubechies wavelets and their construction. The text also uses MATLAB® scripts to illustrate the computations underlying basic wavelet analysis. This text breaks with the traditional undergraduate introduction to Fourier analysis, which is typically presented primarily as a tool for understanding differential equations. The book's approach suggests that understanding the structure of a key information-processing tool—the wavelet transform—can be an important component of a college education. Such nuts-and-bolts understanding should be supplemented by an attempt to convey the spirit and significance of wavelet applications. The instructor might, for example, want to master Jaffard, Meyer, and Ryan, supplementing textbook instruction with remarks and examples inspired by their visionary book.

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Theoretical Astrophysics

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Volume I: Astrophysical Processes

Cambridge U. Press, New York, 2000. \$120.00, \$44.95 paper (622 pp.). ISBN 0-521-56240-6, ISBN 0-521-56632-0 paper

Volume II: Stars and Stellar Systems

Cambridge U. Press, New York, 2001. \$120.00, \$44.95 paper (575 pp.). ISBN 0-521-56241-4, ISBN 0-521-56631-2 paper

Theoretical astrophysics is a curious discipline, more like a classification than a unified field of study. A "theoretical astrophysicist" might study the dynamics of planetary rings, or the microphysics of interstellar dust, or the formation of stars, or the evolution of the universe. Although many theorists confine their attention to a single corner of the cosmos, some have worked on phenomena spanning incredible ranges of physical conditions. No matter what he or she studies, no theoretical astrophysicist can be absolutely certain what specific piece of fundamental physics might be needed to explain the problem at hand, so a formidable arsenal of weapons and the courage to delve into unfamiliar territory are essential to success. For most students entering this field, graduate study invariably includes numerous physics courses to provide the basics, as well as astronomy courses designed to introduce the phenomenology. For students and researchers alike, frequent trips to previously unexplored sections of the physics library fill in the blanks left by courses that could not quite pinpoint the right physics needed to ply the trade.

Thanu Padmanabhan, an eminent astrophysics theorist at the Inter-University Centre for Astronomy and Astrophysics in Pune, India, attempts to bring all of theoretical astrophysics under a single tent in a projected three-book series titled *Theoretical Astrophysics*. The first two volumes, *Astrophysical Processes* and *Stars and Stellar Systems*, have appeared. Volume 3—*Galaxies and Cosmology*—is due later this year. His goal for the series is to write "something analogous to the famous Landau–Lifshitz course in theoretical physics, but focused to the subject of theoretical astrophysics at a fairly advanced level."

Volume I deals with the fundamentals, and is a dizzying romp through subfields of physics ranging

from general relativity to optics to nuclear physics. As such, it resembles CliffsNotes™ more than Landau and Lifshitz, but, as many “readers” of the classics can attest, CliffsNotes™ can be enormously useful. Although one shouldn’t open this book to find in-depth studies of any particular field of physics, one can find almost anything an astrophysicist needs, summarized succinctly and accurately, if not always profoundly.

Want to learn about the quantum theory of radiation? Open to section 4.5; in about 15 pages, you can learn how to quantize the electromagnetic field, couple it to matter, and derive the dipole radiation formula. Higher-level topics, like relativistic effects, are presented but not derived, later on, in section 6.4. If subtleties like radiative corrections or renormalization trouble you, go read another book; this one will prepare you for modeling cosmic phenomena, without extraneous philosophical adornments. Theoretical astrophysics often requires a “shut up and calculate” approach, more like cosmic engineering than the more reflective branches of theoretical physics; this book zooms through physics in that can-do, get-the-job-done spirit.

The second volume applies many of the fundamentals developed in Volume I to the physics of “Stars and Stellar Systems.” The title actually understates the scope of the book, which ranges over normal stars, white dwarfs, neutron stars, black holes, star formation, stellar collapse and explosions, the interstellar medium, and globular star clusters. Once again, the material is presented in a no-nonsense manner that is, for the most part, clear and accurate. However, topics are sometimes treated so concisely that underlying subtleties are not apparent. For example, the “intuitive” explanation in chapter 2 of the equation of radiative transport based on radiation pressure and radiation force is familiar from freshman-level texts. But the explanation is somewhat misleading, as it obscures the deep connection between the resulting formula and the diffusion approximation, not to mention that the opacity in the equation is a particular average over frequencies (the Rosseland mean).

Several fine textbooks deal with the material collected in Volume II, although no *single* text contains *all* of the topics covered here. Admittedly, one can gain a global perspective by seeing a collective presentation of diverse problems generally related to stars. However, most topics in Volume

II have been treated in a similar manner, and usually in much greater depth, elsewhere—frequently in texts listed in the references. Given its vast scope, Volume II might have been distinguished by elucidating the links among the disparate topics treated, but those connections are not always apparent. For example, millisecond pulsars are introduced, along with the idea that they are spun up to fast rotation by mass accretion, in section 7.6, and globular clusters are discussed in chapter 10. But the existence of many millisecond pulsars in globular clusters is not discussed.

The intended audience for the three-volume series includes first-year graduate students and their teachers, as well as researchers in virtually any area of theoretical astrophysics or cosmology. Volume I is a good backbone for the projected series. Its first chapter, which is more like a preface to the course, unifies the field with numerous order-of-magnitude estimates of the scales of different astronomical phenomena. Many teachers of courses like stellar structure to first year graduate students will recognize the wisdom of beginning with a broad-brush overview.

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The alternative, an immediate plunge into the basic physics needed to understand the course subject, often obscures the point for students, even though it touches all the bases eventually. While the rest of the book does not seem to follow any obvious roadmap through physics, the opening gambit shows the author's underlying master plan for the series.

Volume II takes up where Volume I leaves off, and delivers many of the applications for which the groundwork is laid in Volume I.

One has to admire the considerable erudition evident in both books, even while wondering what the hurry is to get through so many interesting topics. Where, then, do these books fit in the library of astrophysics texts, and how might they be used most profitably? By itself, Volume I could form the basis of a course on astrophysical processes, although considerable augmentation of the material would be needed in several areas. The presentation is unquestionably at the right level for first- or second-year graduate students, but professors should caution those students against substituting this book for more detailed texts. Volume II could be used as the basic text for a survey course in stellar astrophysics for beginning graduate students. The book falls short of being a first-rate text for any of the individual topics it presents, but the sheer range of material encompassed could make it useful for quick-and-dirty, one-or-two-lecture minicourses.

Two obvious criticisms can be leveled against both volumes. The less serious one is the relative sparsity of references provided by the author, who seems to subscribe to the same aversion to cult of personality that pervades the Landau-Lifshitz series. Given the sketchiness of some of the treatments presented in the text, more references would have been helpful. In Volume I, the most consistent references are to material in Landau and Lifshitz, which, although just right for some, are notoriously terse for most students. In Volume II, the references are more extensive, and are usually to competing, more narrowly focused—but also more complete—texts that treat the same material.

More serious is the complete lack of discussion of even the most rudimentary principles of numerical simulation as applied to astrophysics. Volume II gives references here and there to publicly available computer codes, but these are not enough. This lack is particularly evident in the various sections that deal with radiative

transport and spectral line formation, which leave the misleading impression that calculations in this highly technical, computationally intensive field require only a relatively trivial set of analytical tools.

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