

physics, astrophysics, geophysical sciences and engineering. *Turbulence* is also aimed at readers such as myself, who would like to learn something of the subject at a sophisticated level.

The title reveals an immediate advantage of this book: It is not a book on fluid dynamics with a chapter or so on turbulence; it is instead a modern, physics-oriented discussion of a difficult subject about which surprisingly little can be said to be known with confidence. The author discusses Andrei Kolmogorov's 1941 work on turbulence, employing in the process concepts from dynamical-systems studies such as symmetry breaking and deterministic chaos not developed until decades later. For instance, Frisch carefully rederives the main results of Kolmogorov's three 1941 papers, using assumptions of symmetries of the turbulent flow instead of Kolmogorov's assumption of "universality." There is an impressive chapter on the problem of intermittency and a final chapter that reflects the author's intuition as to where the field is heading. Examples include dynamical systems, fractals and turbulence, and two-dimensional turbulence. Discussions of almost all topics are linked to modern experimental data. Indeed, key experimental data are reproduced in the book.

This is a work of great scholarship. The author includes a number of illuminating historical discussions, something I find most helpful in learning a new subject. For example, I can recall Lars Onsager telling me about his own derivation of the Kolmogorov theory and the efforts of Werner Heisenberg and Carl von Weizsäcker along similar lines. The short historical discussion in section 6.5 is the first place I ever encountered the actual sequence of events. There are also complete citations to papers, including authors, titles and page ranges, as well as both an author and a subject index. All of these time-consuming labors of the author certainly make it easier for the reader.

This book belongs in the library of any college or university where physics is taught. It can productively be used as a reference in advanced undergraduate courses or as a text for a one-semester course on turbulence itself. For US physics students at least, a prior course in fluid mechanics would probably be a necessity if the book is to be covered substantially in 30 or so lecture hours. It would help the reader if, in a future edition, Kolmogorov's papers were included in some appropriate form in an appendix.

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Theory of Electron-Atom Collisions Part I: Potential Scattering

Philip G. Burke
and Charles J. Joachain
Plenum, New York, 1995. 293 pp.
\$69.50 hc ISBN 0-306-44546-8

This monograph is the first part of a three-volume set. Part II is to deal with the general theory at low energies and Part III with the general theory at high energies. Such a partition is completely natural, not only by virtue of the sharp division of methods in the two energy regimes, but because the two authors have themselves specialized in the respective energy domains and associated methodologies. How necessary the present volume (Part I) will be in the context of those future volumes one can only surmise.

The authors, Philip G. Burke and Charles J. Joachain, have each written a previous book in the field, Burke's *Potential Scattering* (Plenum, 1977) and Joachain's *Quantum Collision Theory*, (North Holland, 1983). The present volume is more detailed than Burke's but significantly less comprehensive than Joachain's.

The central theme of the four chapters and five appendixes of *The Theory of Electron-Atom Collisions, Part I*, is the scattering of a particle (think electron) in a fixed external potential. Although all of the material is available from many other sources, I found the current text to be sufficiently detailed to be reasonably self-contained yet sufficiently selective so as not to be unwieldy. The first chapter (general theory), for example, contains a nice derivation of the optical theorem wherein the relationship between the imaginary part of the forward scattering amplitude and the total cross section arises from the interference between the incoming and scattered waves. In most texts this relationship is rather formally derived, and one really does not appreciate the physics underlying its origin.

In the second chapter (approximation methods), the section on the R-matrix method is rather longer than one might think necessary. However, that method is the basis for an elaborate suite of calculational programs—initiated by Burke and now widely used—for electron scattering from many-electron targets (and related processes such as photoionization). As such, it will undoubtedly be an essential chapter of Part II, so the presence of the fundamentals of the approach here is well justified.

If there is one major flaw in this book, it is the absence of a section devoted to separable *nonlocal* potentials in chapter 3 (analytic properties of the scattering amplitude). Not only is that material less well known than the local potential results (which constitute the core of the included material), but nonlocal potentials reveal a much richer analytical structure of the amplitude on the negative real energy axis and would thus have served as an excellent introduction to the (still unsolved) problem of electron-atom dispersion relations (also likely to be dealt with in Part II).

Chapter 4 deals with spin and relativistic effects; all of its six subsections, especially those devoted to the Dirac equation, its nonrelativistic limit and density matrices, are clearly delineated, and will be useful in both Parts II and III.

Some of the appendixes are dispensable, in my view. This is especially true of Appendix E on Clebsch-Gordan and Racah coefficients, because that material is contained in so many places and is primarily of use in the many-particle situation which, as stated, is not properly the domain of Part I. Its inclusion here is clearly an attempt to make the book self-contained, its use being confined to the coupling of spin and orbital angular momentum for the total angular momentum (j) components characterizing the solutions of the Dirac equation. But Racah coefficients ($6-j$ symbols) are not used at all. Appendix C, on Dalitz integrals, is pedagogically superior to a similar appendix in Joachain's previous book.

The above criticisms notwithstanding, I found this book to be an excellent one, of considerable potential utility, particularly to those entering the field.

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Galaxies and Cosmology

Françoise Combes, Alain Mazure,
Patrick Boissé and Alain Blanchard
Springer-Verlag, New York, 1995.
407 pp. \$69.95 hc
ISBN 3-540-58933-3

Galaxies and Cosmology is intended as a graduate-level introduction to extragalactic astrophysics and cosmology. The first 7 of its 13 chapters, those dealing with normal galaxies and their interactions, are followed by chapters on radio galaxies and on quasars; the final section covers large-scale structure and galaxy formation and rapidly reviews Friedmann cosmologies and

the early universe. The authors, Françoise Combes, Alain Mazure, Patrick Boissé and Alain Blanchard, have tried hard to convey the current state of both observations and understanding: The 1991 French text was partially revised for this English-language translation, and almost all of the 192 figures are taken from recent research publications. The book has many strengths, but it is definitely not for beginners.

A reader unfamiliar with the arcana of the astronomical magnitude system, the life cycles of stars or the methods for extracting physical information from the spectra of stars and interstellar gas will have a difficult time with this book. The authors appear to assume a solid undergraduate preparation in astronomy. They frequently offer insufficient detail for reconstruction of a standard argument and fail to provide references to more basic texts. There is almost no discussion of measurement techniques, and the first chapter gives neither the usual comprehensive illustrations of the various galaxy morphologies nor information on sizes, masses and physically relevant time scales. Even the crucial conversion between luminosity measured in solar units and the absolute magnitude system seems to be missing.

The best features of this book are its breadth of coverage and the authors' insistence on using real observational data in illustrations. Although the emphasis is at redshifts $z < 3$ and weighted towards radio and optical observations of galaxies near enough to us that we can resolve details of their structures, there are also very good summaries of what is known on active galactic nuclei, which are generally almost ignored in texts on galaxies, and on quasar absorption lines and large-scale structure. Although Marc Lachièze-Rey's 130-page *Cosmology: A First Course* (Cambridge U. P., 1995) reads slightly more smoothly than the final two chapters of this book, it lacks the observational illustrations; I know of no other textbook offering a comparably concise and current treatment of quasars and radio galaxies.

I was more enthusiastic about the second half of the book; the first, by comparison, appears at times hurried and somewhat disorganized. In a second edition, it might be helpful to include discussion of our Milky Way, which would allow a treatment in an early chapter of distance measurements (always contentious in astronomy) and inclusion of the best available information on stellar and gaseous content about two-thirds of the way out in a galaxy disk. The chapter on interstellar gas gives an excellent ac-

count of information from radio observations, but I am sorry that the authors did not use their chance to bring us up to date on, for example, irregular and dwarf galaxies, the chemical evolution of galaxies, the central regions of normal galaxies and infrared, ultraviolet and x-ray emission from normal galaxies. On the other hand, I suspect that our students do not need to know as much about the theory of spiral waves in disks as most of us keep trying to tell them.

The figures, however, are not particularly well coordinated; each illustrates only a single point, and some important ones are missing—no Magellanic irregulars, no luminosity profile of a cD galaxy (an elliptical galaxy with an extended outer envelope), no full view of M31 (the Andromeda galaxy) to prepare for the later partial views.

This book would provide a good skeleton for a graduate course, to be supplemented perhaps by *The Milky Way as a Galaxy* by Gerry Gilmore, Ivan King and Piet van der Kruit (University Science Books, 1990) and James Binney and Scott Tremaine's *Galactic Dynamics* (Princeton U. P., 1987), but at \$69.95 for this hardback volume alone, the students would be in for an expensive semester.

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Analysis of Observed Chaotic Data

Henry D. I. Abarbanel

Springer-Verlag, New York, 1996.

272 pp. \$39.95 hc

ISBN 0-387-94523-7

The problem of extracting useful information from chaotic data is a deep and challenging one. The potential objectives are varied: to characterize a data source quantitatively, to place constraints on possible models, to devise quantitative models useful for short-term prediction, to separate chaotic data from measurement noise that contaminates a signal, or to modify chaotic systems so that they exhibit stable periodic motion. The issues involved are subtle, because the fluctuations manifested in chaotic data can be either intrinsic or extrinsic. The effort has now reached a point of stability, where the main ideas seem clear although applications continue to develop rapidly.

While there have been many books on chaotic dynamics, previous works have not focused exclusively or in depth on problems related to the analysis of chaotic data. Henry Abarbanel has published extensively on this topic and

has (with students and coauthors) contributed many innovative methods. A good example is the method of "false nearest neighbors," which can be used to determine the dimension of the embedding phase space required for the reconstruction of chaotic data from a time series. This method is described with great care in his *Analysis of Observed Chaotic Data*, and the reader will understand clearly how one can use the method to distinguish between low-dimensional chaos and high-dimensional noise, as well as to see what happens when both factors are important.

Abarbanel presents precise mathematical descriptions of each method, so that their rationales are clear, and he applies them to both numerical and (relatively clean) experimental data sets, so that one can see how they work in practice. The strengths and limitations of each approach are evaluated explicitly, and the (often very useful) opinions of the author are clearly labeled.

In addition to presenting methods for phase-space reconstruction of chaotic data, Abarbanel considers the important topic of devising models from chaotic data for use in forecasting. He compares methods that are local in phase space to those that are global, and he shows that powerful short-term prediction is possible (to the extent compatible with the long-term exponential growth of small perturbations). A detailed look at the analysis of chaotic laser-intensity fluctuations (work done in collaboration with Raj Roy's group at the Georgia Institute of Technology) will probably augment the appeal of this book to physicists. The methods really do work for some physical systems and can yield useful insights about appropriate models.

The weakness of this entire enterprise, of course, is that many noisy signals of great practical importance are not low-dimensional, or at least not exclusively so, so that the appropriateness of these methods (to spatially extended fluids, physiological systems or financial forecasting, for example) is often debatable. Still, the chaotic paradigm may contribute significantly to data analysis even in some situations of this type.

Abarbanel's monograph defines the state of the art in analysis of low-dimensional chaotic data. The book is extremely well written and accessible to anyone with a basic knowledge of chaotic dynamics. The glossary will not be needed by this probable audience and will be too brief for others. *Analysis of Observed Chaotic Data* belongs in the collections of individuals working with chaotic data and in institutional libraries in physics, applied mathematics and engineering that