

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.

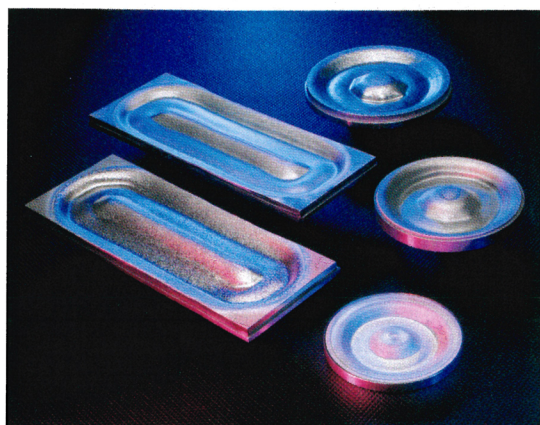
In addition to presenting methods for phase-space reconstruction of chaotic data, Abarbanel considers the important topic of devising models from chaotic data for use in forecasting. He compares methods that are local in phase space to those that are global, and he shows that powerful short-term prediction 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

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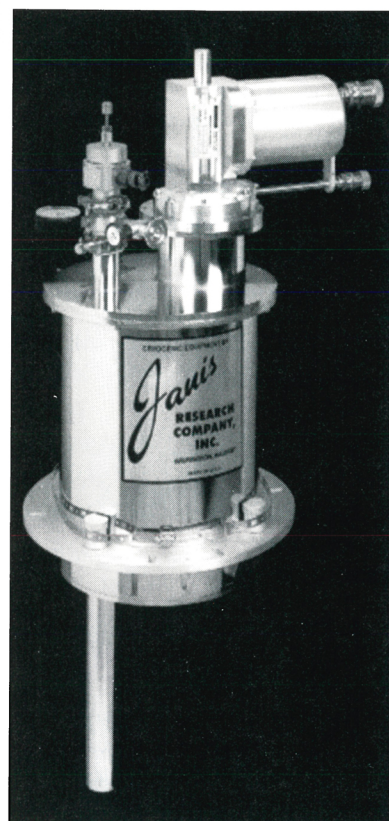
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maintain a selective collection in non-linear dynamics and its applications. Looking carefully at chaotic data is an excellent way to deepen one's understanding of chaos.

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Cataclysmic Variable Stars

Brian Warner

Cambridge U. P., New York, 1995.

572 pp. \$100.00 hc

ISBN 0-521-41231-5

Disk accretion powers many astronomical objects, including the youngest known stars and the most distant quasars. The nearest and best-studied examples of accretion disks are the cataclysmic variable stars (CVs), in which a tidally distorted red dwarf star loses material into a disk surrounding a white dwarf star. Modern analyses of CV brightness variations—on time scales from seconds to centuries—led directly to a physical model for every other accreting system. The CVs still provide the best tests of the model, but this success has been tempered by extreme disappointments. In 1897, the irregular outbursts of the CV U Geminorum led John Parkhurst of Yerkes Observatory to lament, "Predictions with regard to it can better be made after the fact." This frustration continues today with T Pyxidis, a recurrent nova long overdue for its next eruption.

In *Cataclysmic Variable Stars*, Brian Warner sets out to review our current understanding of these complex binary systems. After a brief summary of early history, Warner explains the basic physical picture of a cataclysmic binary and introduces observations across the electromagnetic spectrum. The middle chapters of the book systematically describe the many CV subclasses, including dwarf novae, nova-like variables, classical novae and magnetic systems. The main text concludes with a comprehensive discussion of the long-term evolution of cataclysmic variables. The volume includes an extensive list of references and a fine index.

Warner has studied CVs for over a quarter-century, and his expertise shines throughout each chapter. His descriptions of individual CV subclasses are thorough. Each section includes a variety of new and published results to illustrate the many facets of CV behavior. The 70-odd light curves—including nearly 100 years of data from SS Cygni—are a marvelous resource. Warner also develops the es-