Simple Brownian Diffusion: An Introduction to the Standard Theoretical Models FREE

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Smolin, a critic of the more extravagant pronouncements of string theorists, now declares that his view of time is "the key to the meaning of quantum theory and its eventual unification with space, time, gravity, and cosmology." He claims to show—not argue or contend, but show—that "no extension of the Newtonian paradigm can yield an acceptable theory of the universe as a whole.'' He asserts that "the only way to avoid the fallacy and the paradox of an improbable universe is to base our explanation . . . on time-asymmetric physics." In the book's last chapter, he finally steps back and confesses that he is merely "try[ing] to construct reasoned arguments." But that's too little, too late.

Again, experts will discount the hyperbole. But lay readers are liable to conclude that Smolin is clearly right and that other physicists are just being pigheaded in not following his lead, or, worse, that correctness in physics is essentially a matter of opinion.

Would I recommend the book? To a colleague, yes: While portions are irritating, it is valuable to have to think about the issues it raises, even if only to clarify one's disagreements. To a lay reader, only hesitantly: perhaps as part of a reading list that could also include Sean Carroll's *From Eternity to Here: The Quest for the Ultimate Theory of Time* (Dutton, 2010; reviewed in PHYSICS TODAY, April 2010, page 54); Julian Barbour's more difficult *The End of Time: The Next Revolution in Physics* (Oxford University Press, 1999); and, for an ambitious reader, Robert Geroch's wonderful *General Relativity from A to B* (The University of Chicago Press, 1978; reviewed in PHYSICS TODAY, May 1979, page 71).

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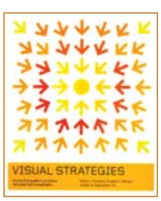
Visual Strategies
A Practical Guide to Graphics for Scientists and Engineers

Felice C. Frankel and
Angela H. DePace
Yale U. Press, 2012. $35.00 (160 pp.).
ISBN 978-0-300-17644-5



The production of figures, which have always been essential in physics publications, has undergone a revolution. A figure used to be an x-y plot, drawn by a draftsman, graphically showing the behavior of data. Now, figures illustrate so much more; x-y plots are supplemented by a plethora of figure types whose variety is driven by the increasing sophistication of computer graphics software and fed by ever-expanding data sets. For example, what used to be simple x-y plots are now in color or in three dimensions, and descriptions of experiments are now frequently supplemented by sophisticated "how-to" schematics. The design and production of computer graphics is much more complex and challenging than in days past.

Science photographer Felice Frankel and systems biologist Angela DePace offer a wonderful solution to the problem. *Visual Strategies: A Practical Guide to Graphics for Scientists and Engineers* is a how-to book on effectively utilizing modern computer graphics. Both authors have extensive experience in presenting complex data.

The book is focused on the use of drawings to illustrate structure and process, primarily in the life sciences, but the authors also give some attention to the physical sciences. Data sets are now so complex, the authors state, that they are better presented with structure-and-process drawings than with traditional x-y plots. And indeed, the most useful types of figures today are the ones that have benefited the most from advances in computer graphics. It is in introducing those that the book really shines.

Visual Strategies is intended to be a useful tool for scientists in their day-to-day graphics preparation. It is divided into sections with indented tabs for easy access. Rather than present a discussion of a theme or topic, the book instead is a compendium of specific examples chosen from the literature. In each case, the authors dissect a published graphic and make suggestions as to how it could be improved.

That approach is effective in getting specific about how graphics can be best presented, but it is less convenient for finding specific ideas for graphics than a more expository presentation would be. For that reason, the book is better suited to scientists already well-versed in data presentation who want to improve their skills—a target audience that probably includes the majority of scientists.

The presentation of basic concepts in the first three chapters reflects the authors' views on the goals and purposes of graphics. Chapter one covers form and structure. It is a primer on how to present such data as the shapes of complex biomolecules or atoms on a surface probed with a scanning tunneling microscope. The authors point out that shape information is like complex data structures, which, unlike simple x-y plots, involve more than two number sets.

Chapter two describes figures that represent the time evolution of a process; they can include a sequence of images from a movie or a depiction of how some process evolves, or a sequence of figures describing the how-to of an experiment. Because such figures are often essential and are becoming increasingly sophisticated, the authors' suggestions about them are of particular value.

Chapter three covers the comparing and contrasting of data sets, an essential step of organizing complex data. The key task addressed is how to take data subject to multiple interpretations and present them so that the author's conclusion comes through clearly. The fourth chapter is a collection of specific case studies that combine the material of the earlier chapters and offer additional concrete realizations of the strategies the authors have presented. The fifth chapter discusses computer graphics that allow viewers to interact with the data; those graphics are restricted to online papers.

Perhaps the best way to judge this how-to book is to ask whether it can actually help you. Indeed, one example was chosen from a paper by my research group, which presented data that were quite difficult to convey. The postdoc who did that work is quite artistic and made what I thought was a good figure. Still, *Visual Strategies* made excellent suggestions that would have greatly improved our figure.

I think others will find similar value in this excellent book.

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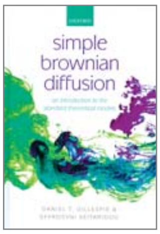
Simple Brownian Diffusion
An Introduction to the Standard Theoretical Models

Daniel T. Gillespie and
Effrosyni Seitaridou
Oxford U. Press, 2013. $84.99
(273 pp.). ISBN 978-0-19-966450-4

Diffundere, the Latin origin of the word "diffusion," means "to spread out." Diffusion is practically ubiquitous and takes place in solids, liquids, and gases.

Because it is so pervasive in physical phenomena, students in all branches of science and engineering should be exposed to diffusion theory. And for that reason, *Simple Brownian Diffusion: An Introduction to the Standard Theoretical Models* by Daniel Gillespie and Effrosyni Seitaridou is a welcome addition to the existing literature.

The authors intend the book to be a "self-contained, tutorial introduction to simple Brownian diffusion for scientists." Familiarity with calculus is the only prerequisite for performing the mathematical calculations within. Chapters 2 and 7 cover some of the essential concepts of stochastic processes, which undergraduate students not majoring in mathematics may not normally be exposed to. I think most diffusion theorists would agree with the



authors that numerical simulations provide deep insight into stochastic processes generally and diffusion in particular. The principles of such numerical-simulation algorithms and the methods of their implementation are presented in considerable detail throughout the book. Thus, in relation to the mathematical and numerical toolkit required to understand simple Brownian diffusion, this book is indeed self-contained.

In a lively tutorial style, the authors discuss some of the most widely used mathematical formulations of diffusion. They have endeavored to organize and present the subject matter "from a purely logical perspective." They emphasize the basic physical assumptions and the conditions for the validity of each of the mathematical formalisms. No subtlety is bypassed, and no limitation of the theory is swept under the carpet.

Physical diffusion of matter, for example, is generally described in terms of a diffusion equation for the local density of matter. That equation combines Fick's law with the equation of continuity that captures the conservation of matter. The one-dimensional examples worked out in chapter 1 provide physical insight into the nature of diffusion phenomena. Those examples also illustrate a few elementary mathematical techniques for solving the diffusion equation under different sets of initial and boundary conditions.

Historically, diffusion theory developed along two separate lines (see the article by T. N. Narasimhan, PHYSICS TODAY, July 2009, page 48). The heat diffusion equation, first formulated by

Joseph Fourier, is an example of physical diffusion. By contrast, the diffusion equation for a probability, developed by Pierre Simon Laplace, results in the continuum limit of a random walk. Einstein's theory, which essentially unified the two approaches in the context of Brownian motion, is covered in chapters 3 and 4.

In chapter 5, the authors, by discretizing the diffusion equation, prepare the foundation for Markov jump processes; in chapter 6, they derive the corresponding master equations. In that chapter, readers also get a firsthand introduction to the powerful numerical technique called Gillespie's algorithm. The book's first author developed it many years ago for exact numerical simulations of the trajectories that follow from the master equation.

Three years after Einstein developed his theory of Brownian motion, Paul Langevin formulated an alternative approach based on a stochastic differential equation that extends Newton's deterministic equation. The logical foundation of Langevin's theory and its implications are discussed in chapters 8 and 9.

Chapter 10 presents, at an elementary level, the extension of the equations for diffusion in the presence of a time-independent conservative external force—in the chapter, the authors work out the example of a constant force. It is a pity, however, that the chapter only mentions in a footnote Kramers's diffusion model of chemical reactions, which treats the decay of a metastable state.

Simple Brownian Diffusion will certainly be used to form the core content of my senior undergraduate course on diffusion and related phenomena. However, I would hesitate to recommend this excellent exposition as a standalone textbook for two main reasons: Few examples are explicitly worked out, and no exercises are given. Nevertheless, I do recommend this book to all serious students who seek to have a thorough understanding of the conceptual subtleties in the theory of diffusion. The authors emphasize that "developing that understanding is the limited aim of this book." In that endeavor they have been remarkably successful.

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