

I was wrong. *The Disordered Cosmos* is more than your usual popular-science book, and the sections about physics are well worth the read, even for someone in the field. Among other things, they illuminate flaws in our physics terminology. Take, for example, dark matter. Why do we call it dark? Does that usage align with the physics of dark objects? Having gotten many questions about that terminology at lectures in the past, I have enjoyed being able to cite *The Disordered Cosmos* when asked about it during talks. In fact, I have started using several details from the book in my presentations, which my audience has greatly appreciated.

A far more troubling case she points out is that we call the $SU(3)$ -charged particles “colored.” In the US that word has a loaded, racialized meaning, one that the individuals who coined the terminology were surely aware of. Because my

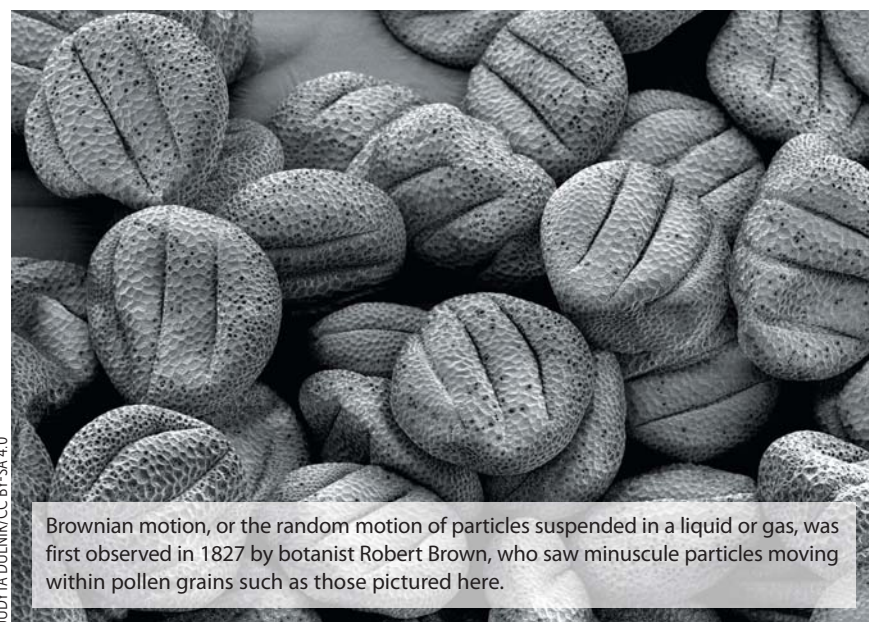
native tongue, Turkish, does not have a direct equivalent of the word colored, the word *renkli*, which literally means “colorful,” is used to describe such particles. One happy consequence of that slight change in literal meaning is that in Turkish the racialized context is lost. A similar language issue I was not attuned to is the way physicists use the word “dark” when we name particles or concepts. In Turkish, the word used is *karanlık*, which one might use to describe the color of the night sky, but never to describe dark skin. But that ambiguity exists in the English word “dark,” and it is a lot more obvious to a Black person than to a white person.

Prescod-Weinstein’s writing has compelled me and my collaborators to be more mindful about language when writing papers. I also found some wonderful historical gems in the book that

will help make my physics teaching more nuanced: I’m looking forward, for example, to bringing up Black physicist Elmer Imes in my quantum-mechanics class.

The Disordered Cosmos is the rare book that one returns to again and again. It is so interesting and varied that I almost hope Prescod-Weinstein writes several sequels that each expand on different aspects of the book. But I’m guessing she’d prefer it instead if the scientific world made space for more people who come from untraditional backgrounds—so that those individuals could enrich our worldview by shining their own unique light on the physics we do. Let us work so that her dream is realized sooner rather than later.

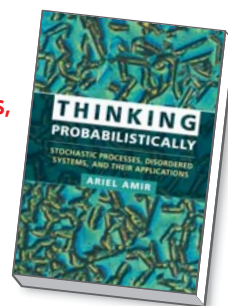
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Brownian motion, or the random motion of particles suspended in a liquid or gas, was first observed in 1827 by botanist Robert Brown, who saw minuscule particles moving within pollen grains such as those pictured here.

Thinking Probabilistically Stochastic Processes, Disordered Systems, and Their Applications

Ariel Amir
Cambridge U. Press,
2021. \$105.00



limit theorem, and percolation. Each of those subjects has applications in several fields, which means that the book will appeal to students and researchers in a wide variety of disciplines.

Thinking Probabilistically assumes its readers have an undergraduate background in physics, that they are familiar with calculus and linear algebra, and that they have some background in probability theory and complex analysis. In that sense, the level of mathematical understanding required is on par with that of well-known textbooks such as *Mathematical Methods of Physics* (2nd ed., 1970) by Jon Mathews and R. L. Walker. Throughout, Amir is careful to prioritize physical intuition over mathematical rigor, and the author gives plenty of heuristic hints. For those who need help, the appendix contains brief reviews of probability theory, linear algebra, contour integration and Fourier transforms, some basic mechanics and statistical mechanics, and functional derivatives and Lagrange multipliers.

Randomness unbound

The typical undergraduate statistical-mechanics course does not usually delve into advanced topics that require probabilistic reasoning to understand, such as extreme-value statistics, anomalous diffusion, and random-matrix theory. Nevertheless, many of those topics are closely linked to ongoing research trends in various fields. Ariel Amir, a professor at Harvard University, aims to remedy that situation in *Thinking Proba-*

bilistically: Stochastic Processes, Disordered Systems, and Their Applications, a book of about 200 pages intended for advanced undergraduates and graduate students.

Amir’s own work is at the vanguard of complex-systems theory, and his experience shows: One of *Thinking Probabilistically*’s main strengths is how it introduces many interesting and inspiring advanced topics, including barrier-escape problems, generalizations of the central

The book is a suitable springboard for self-study because it introduces a wide variety of topics and contains many references to current work. In the classroom, the book can function either as the basis for a course in special topics or as a source of material to spice up more traditional statistical-mechanics courses.

Chapters 1 through 3 cover random walks and the Langevin and Fokker-Planck equations. Because those topics lay the groundwork for the rest of the book, that portion should probably be read first. After that, the rest of the chapters can be digested independently. Many of the real-world examples presented in the later chapters come from physics, but Amir also includes interesting cases from other fields such as finance, biology, computer science, and even hydrology. It's not often that you see topics like the Black-Scholes equation for option pricing and the Google PageRank algorithm discussed in a physics textbook, but *Thinking Probabilistically* covers both in depth.

Amir has chosen exercises inspired by research questions to support and deepen the arguments made in the main

text. They are designed to invite readers to think outside—sometimes far outside—the box. For that reason, they are more open-ended than those one would find in standard textbooks.

There are two minor points of criticism that I feel compelled to mention. First is that the level of technical detail is a bit overwhelming at several points, including, for example, the discussion of random-matrix theory at the end of chapter 8. In fairness, Amir does warn the reader that things are going to get tricky before he delves into such topics, but the difficulty spike is still notable.

Second, when describing Brownian motion, the author propagates a common error found in many physics textbooks: that Robert Brown observed the motion of pollen grains. But pollen grains are far too large to exhibit visible Brownian motion. What Brown actually observed in 1827 was the motion of small particles within pollen grains. It is pedagogically important to correct that error because, as David Layton noted in a 1965 article in the *Journal of Chemical Education*, failing to do so “fosters a misleading impression of the scale of the phenomenon.”

Making the correct statement also shows our friends in the life sciences that we physicists at least know a little bit of biology.

One of the book's explicit goals is to bridge the gap between the world of active research and the sanitized treatment of random phenomena found in the typical textbook, thereby enabling readers to follow contemporary research papers. The book succeeds in that aim, but making that leap will require hard work on the part of a reader not already familiar with the techniques being presented. A necessary consequence of the book's brevity is that the conceptual and technical jumps in reasoning are often quite large, and the reader will have to fill in many of the details.

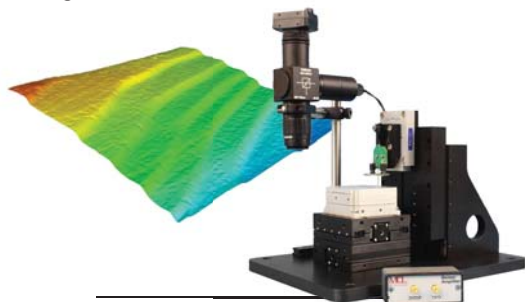
Nevertheless, the methods for studying random phenomena introduced in *Thinking Probabilistically* will help readers understand reasoning techniques that may not be terribly familiar to physicists. Moreover, following the author's arguments is a rewarding intellectual exercise in its own right.

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