



*See the great Newton, He who first Survey'd
The Plan, by which the Universe was made;
Saw Nature's Temple, yet Suspended—Saw
And provid'd the Offices tho' not explain'd the Cause.*

*O wondrous Man! in whom the heavenly Mind
Shines forth distinguish'd, and above Mankind;
Which here on Earth, have humble joys and good!
In Heav'n a Star of the first Magnitude.*

London Published May 6th 1727 by Robert Sayer 55 Fleet Street.

103

This reprint of a 1732 line engraving of Isaac Newton by the English printmaker George Bickham the Elder features astronomical and mythological imagery and a laudatory poem.

Popular science, with equations

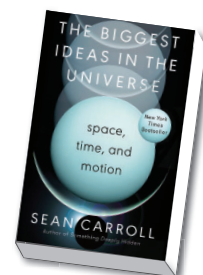
It's easy for a popular-science book to jump into the glamorous, flashy physics of seemingly paradoxical concepts like relativity, time travel, and black holes. So it might seem odd that Sean Carroll focuses on classical motion in his latest book, *The Biggest Ideas in the Universe: Space, Time, and Motion*, the first volume of a promised trilogy based on his similarly titled YouTube series. (As he sug-

gests, trilogies have proved to be successful.) But I'm glad Carroll starts with the old, established—a nicer word for boring—Newtonian mechanics because it presents to his audience the underlying historical developments that led to Einstein's theory of relativity. Once you appreciate $F = ma$, you gain a deeper understanding of $E = mc^2$.

Carroll's research areas span cosmol-

The Biggest Ideas in the Universe Space, Time, and Motion

Sean Carroll
Dutton, 2022. \$23.00



ogy, relativity, the foundations of quantum mechanics, and philosophy of science. His 2004 textbook *Spacetime and Geometry: An Introduction to General Relativity* is greatly appreciated by graduate students in that field. He's also an admirably prolific science communicator: Along with authoring several other popular-science works, Carroll served as a consultant for the Marvel films *Avengers: Endgame* and *Thor: The Dark World*. Although I'd never read any of Carroll's popular-science books before, I'm glad I picked up the latest one, because I simply love it!

What makes *The Biggest Ideas in the Universe* different from other similar titles is how much Carroll wants readers to understand physics. At the risk of sounding curmudgeonly, I think the current era of podcasts is doing science a disservice by watering down a bit too much the mathematics behind many of the biggest ideas in physics. (Yes, I know Carroll has a podcast too!) Even the physics majors in my classes today are sometimes of the mindset that if they just get the basic concepts, they can understand topics as challenging as quantum mechanics. We academics face a similar difficulty when we want to communicate our science to the public: Can we do it without the math? The overarching view is that we must not show the complicated equations behind our results lest we scare our audience.

Carroll is aware that you need to understand the math to truly comprehend the physics that underpins our greatest brainchildren. He diligently explains the concept of infinitesimal changes, for example, so that readers understand why Isaac Newton had to (co)invent calculus to explain planetary orbits. Over the course of the book, readers go from learning how to take a derivative to gaining an appreciation of the metric tensor that describes spacetime. That is also the path from Newtonian gravity to Einstein's theory of general relativity. Along the way,

readers also learn how to take the shortest path between two points, which can have both physical consequences on a plane flight and metaphorical implications in life.

I don't want to make it sound like *The Biggest Ideas in the Universe* is solely a book about math, because it isn't. But it's just so refreshing to read a popular-science book that doesn't hide the math. Instead of shying away from the nitty-gritty calculations that led to the biggest leaps in our physical understanding of the universe, Carroll leans on the beauty of the

math to show readers why it's an integral part of the physics we do. And he does so in a remarkably unpretentious manner: At one point, he explains that guessing is a respectable path to a breakthrough. (My students don't believe me when I tell them that sometimes you just need to guess the solution. Of course, physical intuition helps.)

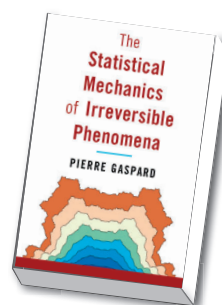
The Biggest Ideas in the Universe reminds me of popular mathematics books that I read in high school when I was deciding between a career in physics or mathematics. (I settled on theoretical physics, which

uses a lot of math!) I'm sure Carroll's book will inspire many math-inclined students to pursue science, and I'm looking forward to the next two volumes. I recommend it to all students who are interested in physics so that they can get an idea of what it's like to work in science. If it gets translated into Turkish, I would love to give it to my family so that I can finally explain to them what I actually do at work.

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The Statistical Mechanics of Irreversible Phenomena

Pierre Gaspard
Cambridge U. Press,
2022. \$99.99



complex systems and statistical physics at the Free University of Brussels in Belgium.

Nearly 25 years after the publication of his first book, Gaspard has written a follow-up, *The Statistical Mechanics of Irreversible Phenomena*. An advanced-level textbook, it presents an overview of a broad range of nonequilibrium phenomena, including traditional subjects—such as Langevin dynamics, chemical reactions, and the kinetic theory of rarefied gases—and more novel topics like transport in open quantum systems and the motion of active particles and molecular motors.

Such a huge amount of material could easily fill several volumes. But Gaspard's clear, concise writing presents all the important ideas and their theoretical formalism in only 15 neat chapters and six appendices. For example, the first three chapters, which cover thermodynamics, statistical mechanics, and hydrodynamics, not only lay out those fundamental theories and settle on notation conventions but also include discussions of research areas where developments have been made in the past few decades, including fluctuations, nonequilibrium steady states, ergodicity, and coarse graining.



One famous source of fluctuations—both financial and emotional—is the stock market, as illustrated in this 1799 etching by the English caricaturist Thomas Rowlandson, who based it on a drawing by the caricaturist George Moutard Woodward.

The power of fluctuation relations

During his long career, Pierre Gaspard has made a name for himself as a leader in the field of nonlinear dy-

namics: His highly cited 1998 book *Chaos, Scattering and Statistical Mechanics* is a classic, and he heads the unit that studies