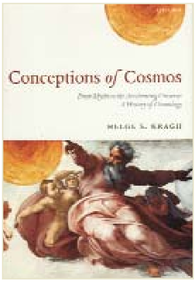
of Cardiff University, who wrote in 2000 that the "most unhealthy aspect of cosmology is its unspoken parallel with religion. Both deal with big but probably unanswerable questions. The rapt audience, the media exposure, the big booksale, tempt priests and rogues, as well as the gullible, like no other subject in science."



Kragh, however, is less interested in dissecting the arguments of cosmology's critics than exploring what he sees as the remarkable achievements of natural philosophers and scientists who have tackled cosmological questions. The author, a professor of history of science at the University of Aarhus, Denmark, is well known for his range of works on the history of physics and cosmology. Most of them, such as *Cosmology and Controversy: The Historical Development of Two Theories of the Universe* (Princeton U. Press, 1996) and *Quantum Generations: A History of Physics in the Twentieth Century* (Princeton U. Press, 1999), are centered on the 20th century. In *Conceptions of Cosmos*, Kragh goes farther afield. The book is focused chiefly on the history of cosmology in the Western tradition since ancient times. It is a skillful mix of narrative and analysis that draws on a very large collection of literature, including a significant body of work by Kragh himself.

The book is divided into five main chapters, each treating a distinct time period. In the first, Kragh covers ancient cosmologies to the Copernican revolution. He identifies the second period as the one in which Isaac Newton's theory of universal gravitation held sway; it stretched from the late 17th century until the advent of Albert Einstein's general relativity.

For Kragh, Einstein's invention of general relativity, covered in chapter 3, was pivotal, and most of the book is devoted to developments after its creation. Kragh recounts, for example, how the meshing of general relativity with the observations of the redshifts of galaxies led to the establishment around 1930 of the expanding universe, surely one of the greatest discoveries in the history of science.

At the heart of the book is what Kragh calls the curious early history of the hot Big Bang model of the universe. He argues that it was proposed, largely independently, three times over some three decades. Although Georges Lemaître, on the strength of his primeval atom hypothesis of 1931, should, in Kragh's opinion, be definitely viewed as the originator of Big Bang cosmology, it was George Gamow, Ralph Alpher, and Robert Herman who first developed the theory in a quantitative and physical fashion.

The next major elaborations of Big Bang theory came in the 1960s at the hands of Robert Dicke, James Peebles, and others; the 1965 discovery of the cosmic microwave background radiation by Arno Penzias and Robert Wilson earned them a share of the 1978 Nobel Prize in Physics. By the early 1970s, Big Bang cosmology had become much the dominant theory, and the steady-state model, a serious rival for two decades, had slumped to marginal status. In Kragh's interpretation, by the mid-1970s cosmology was well on the way to becoming what Thomas Kuhn would have called a "normal" science, with its paradigm being the Big Bang model.

Kragh also describes recent concepts and observations, including the anthropic principle and the accelerating universe. He also takes a step back from his detailed narrative to consider some broader issues that run through more than one of the periods he describes, such as the problem of creation in cosmology. In a mere 276 pages he examines thousands of years of history. He must have encountered, then, numerous difficult choices of what to omit or include. Yet, overall, he has done an excellent job in keeping the reader's attention on the big picture while providing enough detail to ensure that the discoveries and changes are intelligible.

Conceptions of Cosmos is aimed at a relatively broad audience, though some background in the physical sciences will be useful for the 20th-century sections. The book will certainly be enjoyed by working scientists and historians of science; its superb overview of the history of cosmology is unrivalled in terms of reliability and range of coverage.

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Random Processes in Physics and Finance

Melvin Lax, Wei Cai, and Min Xu
Oxford U. Press, New York, 2006. $98.50 (327 pp.). ISBN 978-0-19-856776-9

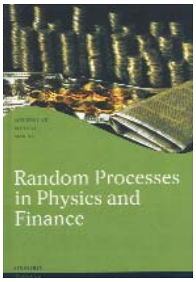
The term "econophysics" was introduced just 14 years ago, but the tradition of physicists being fascinated by random processes in finance has a history much older than that. In fact, both Nicolaus Copernicus and Isaac Newton invested considerable intellectual energy in attempting to understand the economic problems of their day.

Now, centuries later, Wall Street appears to hire as many physicists as economists. (See the article "Is Economics the Next Physical Science?" by Doyne Farmer, Martin Shubik, and Eric Smith, PHYSICS TODAY, September 2005, page 37.) One wonders why. Is it because physicists are trained to solve the problems that are so difficult that knowing where to begin is unclear? Whatever the reason, just as physics departments in the US now prepare students for possible careers at the interface between physics and biology, they may want to emulate several excellent examples of departments at European institutions that prepare physics students for possible careers at the interface between physics and economics.

One challenge in adequately preparing physics students to contribute to economics has been the absence of a comprehensive and rigorous monograph that presents the physical laws governing random processes, which, in turn, provide the starting point for understanding economic fluctuations. *Random Processes in Physics and Finance*, by the late Melvin Lax and completed by coauthors Wei Cai and Min Xu, rises admirably to the challenge. One could certainly find no finer teacher than Lax to pen an introduction to the random-process techniques used in finance today. Lax was a Distinguished Professor of Physics at the City College of New York. I first came to admire his pedagogical gifts more than 30 years ago when he, with Robert Brout, Freeman Dyson, Mark Kac, and Leo Kadanoff, taught a statistical physics summer-school institute at Brandeis University in Massachusetts.

Chapter 1 is a 43-page summary of probability, the theory of random events. On page 1 Lax makes the humbling statement that there are three approaches to the very definition of probability. In chapter 2 he introduces the concept of random processes, a sequence of random events extended over a period of time, and emphasizes the simplifying ideas that underlie stationary, Gaussian, and Markovian processes. The following is an example of the liveliness of his prose: "Markovian processes are the analog of students who can remember only the last thing they have been told."

Chapter 4 covers the concept of the noise spectrum and how it is measured. It is one of the nicest treatments I have seen on the subject; the development of the Wiener–Khinchine theorem relating the spectrum to the autocorrelation function is especially impressive. The Langevin treatment of the Fokker–Planck process, covered in chapter 10, differs from the stochastic differential equation approach, which incorporates Ito's calculus lemma, a mathematical



tool used in financial quantitative analysis. Other departures from traditional mathematical finance texts make Lax's book a refreshing and much clearer read. For example, delta functions are used to avoid the need for abstract Lebesgue measures and Stieltjes integrals.

Throughout the book Lax emphasizes experimental measurement, an approach sadly missing from some traditional texts on mathematical finance. The numerous examples from experimental physics, such as noise in homogeneous semiconductors and the random walk of light in turbid media, allow the heavily abstract formalisms to come alive.

Examples from finance occupy only the last 30 or so pages, chapters 16 and 17, which are about 10% of the book. Lax covers some topics that are standard in mathematical finance texts, such as the Black–Scholes differential equation, as well as subjects that are new to me, for example, the Slepian functions. Not discussed, presumably for lack of space, is the rather large set of empirical facts that has emerged in recent years and has challenged the degree to which the assumptions that underlie the tractable mathematical models are valid. That the well-known "fat tail phenomena" are not simple perturbations on a Gaussian distribution calls into question the validity of many current economic models. But that omission is not so serious because the empirical facts are already discussed in other recent books on econophysics. Examples include the second edition of *Theory of Financial Risk and Derivative Pricing: From Statistical Physics to Risk Management* (Cambridge U. Press, 2003) by Jean-Philippe Bouchaud and Marc Potters and *An Introduction to Econophysics: Correlations and Complexity in Finance* (Cambridge U. Press, 2000), which Rosario Mantegna and I wrote.

Sadly, Lax passed away in 2002 at age 80, and his almost completed manuscript was brought to its present form as a labor of love by his tremendously capable and dedicated former students, Cai and Xu. One hopes that this text will inspire other physics students to continue Lax's legacy and contribute to this growing, diverse field.

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