the book lacks narrative cohesion; it is full of diversions that add little to its main themes. Does the reader really need to know which administrative staff member at Caltech's seismological laboratory was acutely afraid of lizards? Why is there a chapter at the end of the book about seismological controversies that occurred decades after Richter's death and that seem to have little to do with any of Richter's scientific ideas?

Richter's Scale is not the book about seismological history that I wanted to read. Perhaps those who have personal connections to the Caltech seismology community will find it interesting and revealing. But I think that the meatier parts of this material plus some scientific content could make a much better book. I hope that someone will write it.

James S. Langer
University of California, Santa Barbara

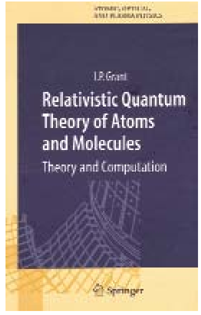
Relativistic Quantum Theory of Atoms and Molecules

Theory and Computation

I. P. Grant
Springer, New York, 2007. $199.00 (797 pp.). ISBN 978-0387-34671-7

Ian Grant, a professor emeritus of mathematical physics at Oxford University, is well known in the atomic-physics community for his seminal contributions to relativistic atomic physics, his excellent review articles on relativistic atomic-structure methods, and his role in creating the widely used software codes for GRASP, the General-purpose Relativistic Atomic Structure Program. Until now only a few complete and up-to-date reference books on relativistic calculations of structure and scattering in atoms and molecules have been published. Grant's *Relativistic Quantum Theory of Atoms and Molecules: Theory and Computation* fills the gap admirably.

Studies of the structure of multielectron atoms based on the Dirac equation can be traced back to 1935, when Bertha Swirles, later coauthor of *Methods of Mathematical Physics* (University Press, 1946) with her husband Harold Jeffreys, formulated relativistic, self-consistent field equations for atoms. Because of the complexity of Swirles's equations, now referred to as Dirac-Hartree-Fock equations, little early progress was made on the computational front. From 1940 through 1960, numerical solutions of the DHF equations without the interactions involving electron exchange were obtained for the copper ion and for several heavy, neutral atoms.



Grant reexamined the relativistic, self-consistent theory in 1961 and, with the aid of Racah algebra, brought the DHF equations into a compact and easily used form. Numerical solutions to the DHF equations with exchange were published by various authors between 1960 and 1980. General purpose multiconfiguration DHF codes, including codes written by Grant and his associates, became publicly available from the Computer Physics Communications Program Library, which was established in 1969 and contains more than 2000 programs in computational physics and chemistry. Since 1980, relativistic atomic-structure calculations have become a matter of course; they are now standard, even for light atoms for which relativistic effects are small, because they automatically account for fine-structure phenomena. Moreover, relativistic calculations of elastic and inelastic electron–atom and electron–ion scattering, photoionization, and other continuum processes are now quite common, as are relativistic studies of molecular structure.

Grant's book is divided into three parts. Part 1 is an overview of atomic physics, aimed at helping the reader identify the signatures of relativistic effects. It is a standalone introduction to relativistic atomic physics and could reasonably be used for the atomic-physics part of a graduate course on modern physics. Part 2 details the theoretical foundations of the field, starting from relativistic wave equations and quantum electrodynamics. Grant offers a concise introduction to QED, culminating with an informative discussion of the "no virtual-pair approximation." He also discusses relativistic versions of density functional theory.

Part 3, which makes up more than half of the book, is devoted to computational methods; it examines atomic structure, molecular structure, transitions, scattering, and photoionization. Chapter 7, on computation of atomic structure, emphasizes the DHF method as realized in the GRASP codes; however, liberal reference is made to alternative methods, such as many-body perturbation theory. The section in chapter 9 that describes relativistic scattering calculations emphasizes the Dirac atomic *R*-matrix code, or DARC. Again, Grant presents liberal reference to and discussion of alternatives, such as relativistic close-coupling methods and the relativistic random-phase approximation.

The book also contains two useful appendices. The first contains a collection of formulas, with their derivations, that are frequently encountered in atomic-structure studies and a description of available software packages. The second is a kind of minicourse on mathematical physics that includes a complete discussion of the angular momentum theory needed in atomic-structure calculations. Material on numerical methods, such as finite-difference schemes, is also included in the second appendix.

Relativistic Quantum Theory of Atoms and Molecules is a book that should be on the desk of every atomic-physics student and research scientist. Written by a master of the field, it contains a wealth of information about relativistic atomic and molecular structures. The progress on relativistic structure of many-electron atoms detailed in the book brings to mind a comment by Richard Feynman in the final section of his *Theory of Fundamental Processes: A Lecture Note Volume* (W. A. Benjamin, 1961). Feynman states that readers could now do many, but not all, physics problems by themselves, and he gives the many-electron atom as an example of a problem beyond their grasp.

Feynman may well have been impressed by the progress that has been made on the many-electron-atom problem in the nearly half century since that comment was written.

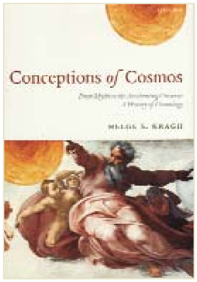
Walter Johnson
University of Notre Dame
Notre Dame, Indiana

Conceptions of Cosmos

From Myths to the Accelerating Universe—A History of Cosmology

Helge S. Kragh
Oxford U. Press, New York, 2007. $70.00 (276 pp.). ISBN 978-0-19-920916-3

In 1882 the philosopher John Stallo pooh-poohed theories that purported to apply physical and dynamical laws to the entire universe. But attacks on cosmology as unscientific did not end in the 19th century. In *Conceptions of Cosmos: From Myths to the Accelerating Universe—A History of Cosmology*, Helge Kragh cites (page 249), in addition to Stallo, a prominent British astronomer, Mike J. Disney 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.

Robert W. Smith
University of Alberta
Edmonton, Canada

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