

BOOKS

Boltzmann Bio: Solid, Readable, With Reservations

Boltzmann's Atom: The Great Debate that Launched a Revolution in Physics

▶ David Lindley
Free Press, New York, 2001.
\$24.00 (260 pp.).
ISBN 0-684-85186-5

Reviewed by Clayton A. Gearhart

The Austrian theoretical physicist Ludwig Boltzmann shaped much of the physics of the 20th century. His influence was central to Max Planck's 1900–1901 papers on blackbody radiation, to Josiah Willard Gibbs's 1902 formulation of statistical mechanics, and to Albert Einstein's 1905 papers on the light quantum and on Brownian motion. Boltzmann was not only one of the most creative and influential physicists of the 19th century, but one of its most colorful personalities as well. His amusing account of his visit to California in 1905, "Journey of a German Professor to Eldorado," has been widely reprinted, and the number and variety of Boltzmann stories rival those told about Richard Feynman!

David Lindley's new popular biography is thus a welcome addition to the Boltzmann literature. Lindley is a physicist with wide experience as an editor and science writer. He gives a solid account of Boltzmann's life, one that makes good use of the collections of Boltzmann's correspondence that have appeared in recent years. There are also thumbnail sketches of such figures as Ernst Mach, James Clerk Maxwell, and Gibbs.

It is no easy matter to present Boltzmann's scientific achievements to general readers, and here the record is mixed: Lindley gives a good account of the 1877 paper that related entropy to probability—the principle that Planck later wrote down in the famous equation $S = k \log W$. The

section on the H -theorem is perhaps a little less successful (hardly a criticism in view of its difficulty). There is also a fine account of Boltzmann's visit to England for the 1894 British Association meeting, where he found the reception of the H -theorem and kinetic theory generally to be considerably more favorable than elsewhere in Europe. There is, however, only a brief mention of Boltzmann's papers of 1871 and later, in which he developed the formalism of equilibrium statistical mechanics that Gibbs later put to such good use.

Lindley does a good job of describing the uneven reception of kinetic theory in Germany. The criticisms of Josef Loschmidt and Ernst Zermelo, based respectively on the time-reversibility of Newton's laws and on Poincaré's recurrence theorem, forced Boltzmann to clarify the probabilistic nature of both the H -theorem and the second law of thermodynamics. Other objections from the energeticists and from Mach were less fruitful. Boltzmann found all of them discouraging.

These criticisms, along with failing eyesight and other health problems (including increasingly serious if intermittent depression), plagued his later years. Lindley shows how the controversy over kinetic theory, and more generally over the role and scope of theoretical physics, eventually led Boltzmann to write and lecture on the philosophy of science. Here again, however, the author's discussion is a little too brief to give a comprehensive picture. Readers looking for a more detailed and nuanced account of Boltzmann's scientific and philosophical writings may wish to consult the recent works of Carlo Cercignani (*Ludwig Boltzmann: The Man Who Trusted Atoms*, Oxford U. Press, 1998) and John Blackmore, editor, (*Ludwig Boltzmann, His Later Life and Philosophy, 1900–1906*, Kluwer, 1995).

There are some questionable statements and interpretations that readers should be aware of. For example, there were no "later editions" of Boltzmann's 1896–1898 *Lectures on Gas Theory*. The Franco-Prussian War of 1870–71 was considerably more than

a "skirmish." Lindley's account of Maxwell's religion and his statement that Maxwell "kept science and religion separate" struck me as dubious, as did his suggestion that Gibbs was in some sense neutral in the late 19th-century controversy over the existence of atoms and molecules. One could cite other examples. None is particularly serious—general readers will not be badly misled, and others will readily encounter corrections—but they are in sum unfortunate.

These problems should in no way discourage readers from a well-written and informative popular biography that fills a real gap in the Boltzmann literature. It serves as a fine account for general readers and a good starting point for those who want to go more deeply into Boltzmann's life and thought.

Atom: An Odyssey from the Big Bang to Life on Earth . . . and Beyond

▶ Lawrence M. Krauss
Little, Brown, New York, 2001.
\$26.95 (320 pp.).
ISBN 0-316-49946-3

Lawrence Krauss is a physicist who works on cosmological problems and who has been led by this interest to work on such astrophysical topics as the ages of globular clusters. He has written *Atom: An Odyssey from the Big Bang to Life on Earth . . . and Beyond* for the well-educated lay reader. It is the story of the universe from the distant past to the distant future, with many topics of interest to the human race in the middle. When I was asked to review this book, I thought I would seek an opinion from someone interested in science but with no training in physics. I quickly concluded however, that you really do need to understand physics at the level of a college course or two to appreciate the book. In other words, this is not a tutorial; it makes little attempt to describe the underlying

CLAYTON A. GEARHART is a professor of physics at St. John's University in Collegeville, Minnesota. His research interests include the history of thermodynamics and statistical mechanics.

physical processes in the events that unfold as the universe evolves.

In an attempt to make the story of the universe accessible to the reader, Krauss uses an oxygen atom to give a microscopic point of view to the evolutionary processes. In the early universe, this oxygen atom exists simply as its constituent nucleons, which become 12 hydrogen atoms and a helium atom as a result of Big-Bang nucleosynthesis. Then these constituents participate in star formation, but Krauss takes them through several scenarios before they become fully synthesized into ^{16}O . The oxygen atom is presented during the formation of the solar system and manages to be part of the processes occurring in Earth's atmosphere, oceans, and rocks. But this participation is somewhat limited, until Earth develops its oxygen atmosphere and the atom can participate in life's respiratory cycles. In the long run, the Sun heats up, expands, and the atom is blown into space, where it can participate in further adventures. A remarkably versatile atom!

Viewing the course of the universe through the eyes of an atom is a clever idea, but I don't think Krauss carries it out as successfully as he had hoped. Krauss concentrates on telling the story of universal evolution, and from time to time he tells us in a paragraph or two how this affects his atom. Thus the atom is not really central to the theme of the book. In fact I found it a distraction, partly because the participation of the atom in the events is artificially contrived, and I found the events themselves—from creation to extinction—much more interesting. In the book these events just happen, for the most part, and I think many readers would like a little more explanation of why they happen. Why does a star expand when it finishes burning hydrogen in the core, for example? At the level of physics understanding assumed by Krauss, I think that some indication could have been given of how physical processes like this work. But I will be interested in a review of this book by someone who has had just those one or two courses of college physics, to see if that reader feels the same way.

The book contains only three illustrations, diagramming the gathering of a dense gas of quarks into bound clumps as the gas expands. Although Krauss exhibits a mastery of smooth, vivid, and colorful language in his word pictures, many of his explanations would have been much clearer if they had been accompanied by real illustrations.

Despite such carping, I must endorse this book as a good example of the attempts that should be made to educate the public in scientific matters, to show that science is interesting in its own right, and to deal with the complexities of modern science in all of their interdisciplinary glory. Krauss tells us of his efforts to expand his own understanding of the planetary, geological, and life sciences as he prepared to write the book. As far as I can tell, he became, in the process, quite current on the thinking at the frontiers of these subjects. The only area in which I found his work deficient concerned the attempts to date the events in the formation of the solar system, including Earth, using the extinct radioactivities. There are many more of these radioactivities now known than Krauss describes, and some of them indicate that things went much faster than he indicates.

It is said that the future of physics lies in understanding complexity. But there is no magic shortcut. The physicist must identify all the important processes and find which ones govern the behavior of a system. Then the principal properties of that system will usually become clear. To a considerable extent that is what Krauss has done here, but the physical reasoning is in the background, and only the conclusions are presented as an entertaining story.

ALASTAIR G. W. CAMERON
*University of Arizona
Tucson*

Solar and Stellar Magnetic Activity

Carolus J. Schrijver
and Cornelis Zwaan
*Cambridge U. Press, New York,
2000. \$80.00 (384 pp.).
ISBN 0-521-58286-5*

The study of solar and stellar activity is currently one of the most vibrant and interesting fields of astronomy. Solar physics is being revolutionized by many surprising discoveries from the SOHO (Solar and Heliospheric Observatory) space satellite, launched jointly by the European Space Agency and NASA, and from NASA's Transition Region and Coronal Explorer (TRACE) mission. The observations from these missions are being eagerly examined, interpreted, and modeled by a new generation of lively young solar researchers, especially in Europe, but also in the US.

Stellar observations are becoming not only more numerous but also

increasingly sophisticated, leading to the discovery of many solarlike phenomena (such as spots, flares, prominences, activity cycles, and global oscillations) on other stars. The detailed properties of these processes are being investigated in parameter regimes that are quite different from those on the Sun.

It is, however, astonishing that many fundamental properties of the Sun are not yet understood. These include the generation of magnetic fields by dynamos; the heating of the outer atmosphere (the corona); the acceleration of the solar wind (the particle outflow from the Sun); the power source of solar flares; and the trigger mechanism of great solar eruptions—coronal mass ejections. Study of each of these basic phenomena is crucial to an understanding not only of how they occur on other stars but also how our dynamic universe works in all its richness and diversity.

The key factor at the root of all these processes is the magnetic field and its subtle nonlinear interaction with the matter of the universe, most of which is in the plasma state.

In *Solar and Stellar Magnetic Activity*, Carolus J. Schrijver and his former thesis supervisor, Cornelis Zwaan, have produced a splendid book that reviews our current understanding of many key topics in solar and stellar activity. Tragically, Zwaan died soon after the manuscript was finished. He had been one of the leading figures in forging the so-called solar–stellar connection and understanding how solar phenomena occur on other stars. Schrijver is one of the leading solar–stellar physicists in the US.

The strength of the book lies in the clear overview it provides of activity both on the Sun and on other stars, from an observer's viewpoint. It describes the physical processes at work without going into the mathematical details. Its particular forte is in its detailed description of the complex behavior of magnetic fields in the solar surface; that behavior drives a host of dynamic phenomena in the overlying corona. The book also reviews authoritatively the various components of stellar activity, such as starspots, activity cycles, and the evolutionary stages of stellar activity.

The area to be covered by any overview of this subject is enormous; inevitably, a few topics cannot be fully treated. For in-depth accounts of stellar magnetic field theory, the reader is advised to complement the Schrijver–Zwaan book with Leon Mestel's *Stellar Magnetism* (Oxford U. Press, 1999),