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BOLTZMANN'S ATOM

The Great Debate That Launched a Revolution in Physics

By David Lindley

Free Press. 260 pp. $ 24

Painful as it may be, think back on the revelations of our recent presidential election. A process once thought by the public to be fully determinable was unveiled as something far more muddled, subject to the statistical whims of hanging chads and butterfly ballots (and dare I say fuzzy math?). That queasiness you felt -- that sudden shift in your world view -- is similar to the anxiety that scientists felt in the closing decades of the 19th century, when Ludwig Boltzmann introduced his startling new equations of thermodynamics. His insights served as a harbinger for the atomic age. It was he, not Werner Heisenberg, who first introduced uncertainty into the hallowed halls of physics.

At first glance, thermodynamics -- the laws of heat and energy -- might seem like an odd topic for a popular science book, but David Lindley, an editor at Science News, has made an inspired choice, especially for the physics aficionado. By focusing on this Austrian physicist, Lindley has chronicled the preliminary steps leading to the great revolutions of modern physics in an accessible and engaging fashion. In many ways, this book serves as a nice prequel to Lindley's earlier book on quantum mechanics, Where Does the Weirdness Go?

Though little known to the lay public, Boltzmann looms large in the world of physics. He trained at the University of Vienna and held prestigious academic posts in both Germany and Austria. By 1877, at the age of 33, he had arrived at his most important conception. For decades, scientists toyed with the notion of atoms but largely considered them mere hypothetical objects -- not real but useful for bookkeeping when figuring out chemical experiments. Boltzmann, however, took a leap of faith and came to believe in the tiny motes' existence. While the laws governing the behavior of heat and gases were already well established, in a tour de force Boltzmann showed why those revered formulas held true. Like a few visionaries before him, he argued that the many atoms pushing on a container worked collectively. But he realized something far more important than his predecessors did: The behavior of those innumerable atoms could not be derived exactly but only by approximation, using the laws of probability. This horrified physicists long content with the Newtonian world of precise predictions. Probability was all very well for games of chance, they said, but it certainly did not apply to physics.

Throughout the book, Lindley describes the new atomic perspective of Boltzmann and others in imaginative ways. "An atom would make its way . . . not by cruising unimpeded along a straight path," he writes, "but by battling through all the other atoms like an opera-goer trying to push through the crush to get out of the theater at the end of the show."

Boltzmann was so far ahead of his colleagues that his insights went unappreciated for years. He was asking his fellow physicists to believe in minuscule particles they could not see. At the time, this was unheard of in physics. Atoms are a fiction, declared Boltzmann's chief rival, Ernst Mach. An Austrian philosopher of science then lionized by Europeans, Mach demanded that science deal only with phenomena it could directly observe. Boltzmann, on the other hand, was offering an entirely new approach to science: developing theories that lead to a deeper understanding of how a physical process occurs and then predicting new phenomena yet to be revealed.

This great debate with Mach dominated Boltzmann's professional and personal life for years. Sometimes he sabotaged himself. In the highly formal atmosphere of physics in the 19th century, this brilliant but clumsy nerd came across as terribly undiplomatic. His scientific papers were often dense and inscrutable. It was also his bad luck to live where he did. British scientists, more open to the idea of atoms, feted Boltzmann. Germany and Austria, on the other hand, recognized his genius but pushed him to the side as the lone, misguided atomist of the continent.

Often prone to nervous disorders, Boltzmann committed suicide in 1906, just as atomic theories were gaining respect. Many histories of science point to the discovery of X-rays, electrons, radioactivity, and to Max Planck's invention of the quantum, as ushering in the new physics. Lindley shows that it goes back further. In arriving at his idea that energy comes in discrete packets, Planck directly applied the mathematical techniques that Boltzmann first used. If Planck is the father of quantum mechanics, Boltzmann is assuredly its grandfather. His work, writes Lindley, "loosened the soil."

With Boltzmann's Atom, Lindley gives us a unique look at science in the raw. Truth in science does not always triumph immediately. Radical concepts often need time to stew and percolate. "Sometimes scientific ideas, like strange musical compositions or surrealistic dreams, need a ready audience as well as a creator," writes Lindley. His highly readable blend of human drama and scientific explanation offers a means of better understanding how science arrives at its esoteric laws. If the standard textbooks regularly provided information in this way, we might get more students majoring in science. *

Marcia Bartusiak writes regularly on physics and astronomy. Her latest book is "Einstein's Unfinished Symphony."

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