



Boltzmann's Atom: The Great Debate That Launched A Revolution In Physics

By David Lindley

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In 1900 many eminent scientists did not believe atoms existed, yet within just a few years the atomic century launched into history with an astonishing string of breakthroughs in physics that began with Albert Einstein and continues to this day. Before this explosive growth into the modern age took place, an all-but-forgotten genius strove for forty years to win acceptance for the atomic theory of matter and an altogether new way of doing physics. Ludwig Boltzmann battled with philosophers, the scientific establishment, and his own potent demons. His victory led the way to the greatest scientific achievements of the twentieth century.

Now acclaimed science writer David Lindley portrays the dramatic story of Boltzmann and his embrace of the atom, while providing a window on the civilized world that gave birth to our scientific era. Boltzmann emerges as an endearingly quixotic character, passionately inspired by Beethoven, who muddled through the practical matters of life in a European gilded age.

Boltzmann's story reaches from fin de siècle Vienna, across Germany and Britain, to America. As the Habsburg Empire was crumbling, Germany's intellectual might was growing; Edinburgh in Scotland was one of the most intellectually fertile places on earth; and, in America, brilliant independent minds were beginning to draw on the best ideas of the bureaucratized old world.

Boltzmann's nemesis in the field of theoretical physics at home in Austria was Ernst Mach, noted today in the term Mach I, the speed of sound. Mach believed physics should address only that which could be directly observed. How could we know that frisky atoms jiggling about corresponded to heat if we couldn't see them? Why should we bother with theories that only told us what would probably happen, rather than making an absolute prediction? Mach and Boltzmann both believed in the power of science, but their approaches to physics could not have been more opposed. Boltzmann sought to explain the real world, and cast aside any philosophical criteria. Mach, along with many nineteenth-century scientists, wanted to construct an empirical edifice of absolute truths that obeyed strict philosophical rules. Boltzmann did not get on well with authority in any form,

and he did his best work at arm's length from it. When at the end of his career he engaged with the philosophical authorities in the Viennese academy, the results were personally disastrous and tragic. Yet Boltzmann's enduring legacy lives on in the new physics and technology of our wired world.

Lindley's elegant telling of this tale combines the detailed breadth of the best history, the beauty of theoretical physics, and the psychological insight belonging to the finest of novels.

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Editorial Review

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Born in Austria and something of a bumpkin by nature, the 19th-century physicist Ludwig Boltzmann did not fit in easily in the highly cultured German universities at which he taught for many years. To add to his difficulties, Boltzmann stirred up controversy by proposing that scientists could make intelligent guesses about the behavior of atoms, which, though they moved randomly, could be described by certain probabilistic generalizations. His suggestion, hinging on novel interpretations of statistical theory, was not immediately acclaimed. "To an audience of physicists raised in the belief that scientific laws ought to encapsulate absolute certainties and unerring rules," writes scientist and journalist David Lindley, "these were profound and disturbing changes."

Opposed by the then-influential physicist and philosopher Ernst Mach, who urged that scientists stick to classical thermodynamics, Boltzmann was hard-pressed to convince his colleagues that the behavior of atoms could be explained by laws thought to apply only to the gaming table. Mach objected, and with some cause, that "the fact that the theory worked was not enough to prove that the assumptions on which the theory rested were true." It would take the next generation of scientists, among them Albert Einstein, to provide more solid proof for Boltzmann's hunches. And, while Mach's contributions to physics have largely been superseded, Boltzmann's endure in quantum mechanics and the Maxwell-Boltzmann distribution for the velocities of atoms in a gas. In this lively account, David Lindley tells the story of Boltzmann's many failures, and of his eventual success. --*Gregory McNamee*

From Publishers Weekly

In this well-researched study, Lindley (*The End of Physics*), a physicist and editor at *Science News*, follows the career of Ludwig Boltzmann, who played a quiet yet crucial role in physics in the late 19th and early 20th centuries. In 1897, Boltzmann proposed the then-controversial premise that matter consisted of atoms and molecules. At the time, no proof of atomic theory yet existed, and many people considered it only a fiction. Boltzmann was the first to pursue the idea that molecules in gases move with varying velocities and that these variations could be evaluated using statistical methods. Lindley describes the controversy surrounding Boltzmann's scientific publications and his angst when his theories failed to gain wide acceptance. His search for academic acceptance led him to professorships in Vienna, Graz, Munich and finally back to Vienna, sometimes these settings blur as the author jumps backward and forward in time. But Lindley's precise detailing of the inception of modern atomic theory does not falter, and he leads the lay reader along with straightforward analogies. In 1905, toward the end of Boltzmann's life, Einstein applied Boltzmann's techniques, but his results were largely overshadowed by his papers on relativity, published the same year. Boltzmann, meanwhile, had sunk into a clinical depression. In the fall of 1906 he took his own life. Within a few years, his fundamental tools would enable the development of quantum theory. Lindley offers a well-crafted blend of biography and science; readers who sought out David Bodanis's $E=mc^2$ will also enjoy this similar attempt to explain for laypeople the basis of modern physics. (Jan. 18)

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From [Booklist](#)

Now enshrined in scientific orthodoxy, the notion that such phenomena as heat and expansion derive from the motion of invisible atoms once attracted only the most adventurous minds. Lindley here recounts the life journey of one of the greatest of these minds, so rescuing from obscurity a great intellectual pioneer whose atomic theorizing gave new coherence to thermodynamics and whose statistical techniques paved the way to

a probabilistic redefinition of all physics. In Boltzmann's lifelong engagement with the atomic hypothesis, readers see how a single determined mind can slowly tease out the profound implications of a difficult idea. We also see how Boltzmann progressed from a daring extension of a single formula for calculating the velocity of atoms in a gas to the full development of atomic kinetics, so shaking the foundations of classical physics and opening the way for the quantum revolution effected by Planck and Einstein. While sparing us the mathematical complexities, Lindley conveys a fully nuanced sense of the obstacles--conceptual, personal, and professional--that Boltzmann had to surmount to frame his daring theory. Perhaps even more important, Lindley shows how Boltzmann's defeat of skeptical empiricism secured a new intellectual freedom in science for all future theorists. An engrossing portrait of an epoch-making thinker. *Bryce Christensen*
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