



# Ludwig Boltzmann

The Man Who Trusted Atoms

Carlo Cercignani

*Foreword by Sir Roger Penrose*



OXFORD

# Ludwig Boltzmann The Man Who Trusted Atoms

**M Walker**



## **Ludwig Boltzmann The Man Who Trusted Atoms:**

**Ludwig Boltzmann** Carlo Cercignani, 1998 The book presents the life and personality the scientific and philosophical work of Ludwig Boltzmann one of the great scientists who marked the passage from 19th to 20th century physics His rich and tragic life ending by suicide at the age of 62 is described in detail A substantial part of the book is devoted to discussing his scientific and philosophical ideas and placing them in the context of the second half of the 19th century The fact that Boltzmann was the man who did most to establish that there is a microscopic atomic structure underlying macroscopic bodies is documented as is Boltzmann s influence on modern physics especially through the work of Planck on light quanta and of Einstein on Brownian motion Boltzmann was the centre of a scientific revolution and he has been proved right on many crucial issues He anticipated Kuhn s theory of scientific revolutions and proposed a theory of knowledge based on Darwin His basic results when properly understood can also be stated as mathematical theorems Some of these have been proved others are still at the level of likely but unproven conjectures The main text of this biography is written almost entirely without equations Mathematical appendices deepen knowledge of some technical aspects of the subject *Ludwig Boltzmann* Carlo Cercignani, 1998 Ludwig Boltzmann (the Man Who Trusted Atoms) Cercignani C., **Boltzmanns Atom** David Lindley, 2015-12-19 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 si cle 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

Anxiety and the Equation Eric Johnson, 2022-11-01 A man and his equation the anxiety plagued nineteenth century physicist who contributed significantly to our understanding of the second law of thermodynamics Ludwig Boltzmann's grave in Vienna's Central Cemetery bears a cryptic epitaph  $S = k \log W$  This equation was Boltzmann's great discovery and it contributed significantly to our understanding of the second law of thermodynamics In Anxiety and the Equation Eric Johnson tells the story of a man and his equation the anxiety plagued nineteenth century physicist who did his most important work as he struggled with mental illness Johnson explains that  $S$  in Boltzmann's equation refers to entropy and that entropy is the central quantity in the second law of thermodynamics The second law is always on running in the background of our lives providing a way to differentiate between past and future We know that the future will be a state of higher entropy than the past and we have Boltzmann to thank for discovering the equation that underlies that fundamental trend Johnson accessibly and engagingly reassembles Boltzmann's equation from its various components and presents episodes from Boltzmann's life beginning at the end with Boltzmann Kills Himself and Boltzmann Is Buried Not Once But Twice Johnson explains the second law in simple terms introduces key concepts through thought experiments and explores Boltzmann's work He argues that Boltzmann diagnosed by his contemporaries as neurasthenic suffered from an anxiety disorder He was says Johnson a man of reason who suffered from irrational concerns about his work worrying especially about opposition from the scientific establishment of the day Johnson's clear and concise explanations will acquaint the nonspecialist reader with such seemingly esoteric concepts as microstates macrostates fluctuations the distribution of energy log functions and equilibrium He describes Boltzmann's relationships with other scientists including Max Planck and Henri Poincaré and finally imagines an alternative ending in which Boltzmann lived on and died of natural causes

*The Oxford Handbook of German Philosophy in the Nineteenth Century* Michael N. Forster, Kristin Gjesdal, 2015 The *Oxford Handbook of German Philosophy in the Nineteenth Century* is the first collective critical study of this important period in intellectual history The volume is divided into four parts The first part explores individual philosophers including Fichte Hegel Schopenhauer Marx and Nietzsche amongst other great thinkers of the period The second addresses key philosophical movements Idealism Romanticism Neo Kantianism and Existentialism The essays in the third part engage with different areas of philosophy that received particular attention at this time including philosophy of nature philosophy of mind philosophy of language philosophy of history and hermeneutics Finally the contributors turn to discuss central philosophical

topics from skepticism to materialism from dialectics to ideas of historical and cultural Otherness and from the reception of antiquity to atheism Written by a team of leading experts this Handbook will be an essential resource for anyone working in the area and will lead the direction of future research      *Jožef Stefan: His Scientific Legacy on the 175th Anniversary of His Birth* John C. Crepeau, 2013-02-20 Most scientists and engineers are familiar with the name Josef Stefan primarily from the Stefan Boltzmann law which relates the amount of energy transferred by radiation to the absolute temperature raised to the fourth power Stefan determined this law from experimental data and it was later theoretically verified by his former student Ludwig Boltzmann However it is interesting to know that this is the same Stefan who lent his name to the solid liquid phase change problem and concepts related to molecular diffusion and convective motion driven by surface evaporation or ablation Stefan counted among his students Sigmund Freud who was so inspired by his physics instructor that he incorporated scientific methods into psychoanalysis This invaluable book details not only Josef Stefan's original contributions in these areas but the current state of the art of his pioneering work      **Philosophy of Physics** Jeremy Butterfield, John Earman, 2007 The ambition of this volume is twofold to provide a comprehensive overview of the field and to serve as an indispensable reference work for anyone who wants to work in it For example any philosopher who hopes to make a contribution to the topic of the classical quantum correspondence will have to begin by consulting Klaas Landsman's chapter The organization of this volume as well as the choice of topics is based on the conviction that the important problems in the philosophy of physics arise from studying the foundations of the fundamental theories of physics It follows that there is no sharp line to be drawn between philosophy of physics and physics itself Some of the best work in the philosophy of physics is being done by physicists as witnessed by the fact that several of the contributors to the volume are theoretical physicists viz Ellis Emch Harvey Landsman Rovelli t Hooft the last of whom is a Nobel laureate Key features Definitive discussions of the philosophical implications of modern physics Masterly expositions of the fundamental theories of modern physics Covers all three main pillars of modern physics relativity theory quantum theory and thermal physics Covers the new sciences grown from these theories for example cosmology from relativity theory and quantum information and quantum computing from quantum theory Contains special Chapters that address crucial topics that arise in several different theories such as symmetry and determinism Written by very distinguished theoretical physicists including a Nobel Laureate as well as by philosophers Definitive discussions of the philosophical implications of modern physics Masterly expositions of the fundamental theories of modern physics Covers all three main pillars of modern physics relativity theory quantum theory and thermal physics Covers the new sciences that have grown from these theories for example cosmology from relativity theory and quantum information and quantum computing from quantum theory Contains special Chapters that address crucial topics that arise in several different theories such as symmetry and determinism Written by very distinguished theoretical physicists including a Nobel Laureate as well as by philosophers      **Statistical Mechanics And The Physics Of**

**Many-particle Model Systems** Alexander Leonidovich Kuzemsky, 2017-02-24 The book is devoted to the study of the correlation effects in many particle systems It presents the advanced methods of quantum statistical mechanics equilibrium and nonequilibrium and shows their effectiveness and operational ability in applications to problems of quantum solid state theory quantum theory of magnetism and the kinetic theory The book includes description of the fundamental concepts and techniques of analysis following the approach of N N Bogoliubov's school including recent developments It provides an overview that introduces the main notions of quantum many particle physics with the emphasis on concepts and models This book combines the features of textbook and research monograph For many topics the aim is to start from the beginning and to guide the reader to the threshold of advanced researches Many chapters include also additional information and discuss many complex research areas which are not often discussed in other places The book is useful for established researchers to organize and present the advanced material disseminated in the literature The book contains also an extensive bibliography The book serves undergraduate graduate and postgraduate students as well as researchers who have had prior experience with the subject matter at a more elementary level or have used other many particle techniques

*Approaches to Entropy* Jeremy R. H. Tame, 2018-08-30 This is a book about thermodynamics not history but it adopts a semi historical approach in order to highlight different approaches to entropy The book does not follow a rigid temporal order of events nor it is meant to be comprehensive It includes solved examples for a solid understanding The division into chapters under the names of key players in the development of the field is not intended to separate these individual contributions entirely but to highlight their different approaches to entropy This structure helps to provide a different view point from other text books on entropy

**Arthur E. Haas - The Hidden Pioneer of Quantum Mechanics** Michael Wiescher, 2021-09-23 The book highlights the personal and scientific struggles of Arthur Erich Haas 1884 1941 an Austrian Physicist from a wealthy Jewish middle class family whose remarkable accomplishments in a politically hostile but scientifically rewarding environment deserve greater recognition Haas was a fellow student of both Lise Meitner and Erwin Schrödinger and was also one of the last doctoral students of Ludwig Boltzmann Following Boltzmann's suicide Haas was forced to submit a more independent doctoral thesis in which he postulated new approaches in early quantum theory actually introducing the idea of the Bohr radius before Niels Bohr It is the lost story of a trailblazer in the fields of quantum mechanics and cosmology a herald of nuclear energy and applications of modern science This biography of Haas is based on new and previously unpublished family records and archived material from the Vienna Academy of Science and the University of Notre Dame which the author has collected over many years From his analysis of the letters documents and photos that rested for nearly a century in family attics and academic archives Michael Wiescher provides a unique and detailed insight into the life of a gifted Jewish physicist during the first half of the twentieth century It also sheds light on the scientific developments and thinking of the time It appeals not only to historians and physicists but also general readers All appreciate the record of Haas interactions with many of the key

figures who helped to found modern physics      *Entropy Demystified* Arieh Ben-Naim,2008 This book has a two pronged message first that the second law of thermodynamics is not infinitely incomprehensible as commonly stated in most textbooks on thermodynamics but can be comprehended through sheer common sense and second that entropy is not a mysterious quantity that has resisted understanding but a simple familiar and easily comprehensible concept p 4 of cover      **Entropy Demystified: The Second Law Reduced To Plain Common Sense (Revised Edition)** Arieh Ben-naim,2008-06-18 In this unique book the reader is invited to experience the joy of appreciating something which has eluded understanding for many years entropy and the Second Law of Thermodynamics The book has a two pronged message first that the second law is not infinitely incomprehensible as commonly stated in most textbooks on thermodynamics but can in fact be comprehended through sheer common sense and second that entropy is not a mysterious quantity that has resisted understanding but a simple familiar and easily comprehensible concept Written in an accessible style the book guides the reader through an abundance of dice games and examples from everyday life The author paves the way for readers to discover for themselves what entropy is how it changes and most importantly why it always changes in one direction in a spontaneous process In this new edition seven simulated games are included so that the reader can actually experiment with the games described in the book These simulated games are meant to enhance the readers understanding and sense of joy upon discovering the Second Law of Thermodynamics      *Remarkable Physicists* Ioan James,2004-01-12 Sample Text      **Entropy Demystified: The Second Law Reduced To Plain Common Sense** Arieh Ben-naim,2007-05-04 In this unique book Arieh Ben Naim invites the reader to experience the joy of appreciating something which has eluded understanding for many years entropy and the Second Law of Thermodynamics The book has a two pronged message first that the Second Law is not infinitely incomprehensible as commonly stated in textbooks of thermodynamics but can in fact be comprehended through sheer common sense and second that entropy is not a mysterious quantity that has resisted understanding but a simple familiar and easily comprehensible concept Written in an accessible style the book guides the reader through an abundance of dice games and examples from everyday life The author paves the way for readers to discover for themselves what entropy is how it changes and most importantly why it always changes in one direction in a spontaneous process      **Energy, the Subtle Concept** Jennifer Coopersmith,2015-05-14 Energy is at the heart of physics and of huge importance to society and yet no book exists specifically to explain it and in simple terms In tracking the history of energy this book is filled with the thrill of the chase the mystery of smoke and mirrors and presents a fascinating human interest story Moreover following the history provides a crucial aid to understanding this book explains the intellectual revolutions required to comprehend energy revolutions as profound as those stemming from Relativity and Quantum Theory Texts by Descartes Leibniz Bernoulli d Alembert Lagrange Hamilton Boltzmann Clausius Carnot and others are made accessible and the engines of Watt and Joule are explained Many fascinating questions are covered including Why just kinetic and potential energies is one more

fundamental than the other What are heat temperature and action What is the Hamiltonian What have engines to do with physics Why did the steam engine evolve only in England Why S klogW works and why temperature is IT Using only a minimum of mathematics this book explains the emergence of the modern concept of energy in all its forms Hamilton's mechanics and how it shaped twentieth century physics and the meaning of kinetic energy potential energy temperature action and entropy It is as much an explanation of fundamental physics as a history of the fascinating discoveries that lie behind our knowledge today

*50+ Years of AIMETA* Giuseppe Rega, 2022-06-04 The book retraces the history of the Italian Association of Theoretical and Applied Mechanics AIMETA since its establishment in 1965 AIMETA is the official Italian association of mechanics adhering to IUTAM International Union of Theoretical and Applied Mechanics which organizes and coordinates a meaningful number of research activities the most important of which are the biennial National Congress and the internationally renowned journal *Meccanica* published by Springer Besides collecting and organizing all related important data and information as far as possible by distinguishing among the five scientific areas general mechanics solids structures fluids machines encompassed by AIMETA the history of the association is assumed as a proper perspective to overview the evolution of theoretical and applied mechanics in Italy over about the last fifty years This is accomplished in the first part of the book with also a specific focus on the mechanics of solids and structures where the biographies of a meaningful number of recognized Italian scholars of mechanics in all areas are also provided along with testimonials and memories by a few senior people meaningfully involved with AIMETA and Italian mechanics The second part gives an account although unavoidably incomplete of recent developments of mechanical sciences in Italy as reflected also in the activities of AIMETA and with reference to the international context Contributions by a number of invited senior scholars still very active consist of overviews on some scientific themes in the various areas summaries of achievements of research groups expressions of research viewpoints prospects for future developments

**Pathways to Modern Chemical Physics** Salvatore Califano, 2012-05-26 In this historical volume Salvatore Califano traces the developments of ideas and theories in physical and theoretical chemistry throughout the 20th century This seldom told narrative provides details of topics from thermodynamics to atomic structure radioactivity and quantum chemistry Califano's expertise as a physical chemist allows him to judge the historical developments from the point of view of modern chemistry This detailed and unique historical narrative is fascinating for chemists working in the fields of physical chemistry and is also a useful resource for science historians who will enjoy access to material not previously dealt with in a coherent way

**Theory of Heat** James Clerk Maxwell, Peter Pesic, 2001-01-01 This classic sets forth the fundamentals of thermodynamics clearly and simply enough to be understood by a beginning student yet with enough subtlety and depth of thought to appeal also to more advanced readers It elucidates fundamentals of kinetic theory and illustrates the Second Law of Thermodynamics with Maxwell's demon

[The Analysis of Selected Algorithms for the Stochastic Paradigm](#) Abdo Abou Jaoudé, 2019-08-30 This



book analyses selected algorithms for random and stochastic phenomena in the areas of basic probability random variables mathematical expectation special probability and statistical distributions random processes and Markov chains It also presents a novel approach titled the Complex Probability Paradigm and applies it to the Brownian motion As such the book will be of interest to all scholars researchers and undergraduate and graduate students in mathematics computer science and science in general

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