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Book Review: *Ludwig Boltzmann: The Man Who Trusted Atoms*

Ludwig Boltzmann: The Man Who Trusted Atoms. Carlo Cercignani, Foreword by Sir Roger Penrose, Oxford University Press, New York, 1998.

Since the Austrian physicist Ludwig Boltzmann (1844–1906) was one of the founders of statistical physics, any book about him should be of at least passing interest to readers of this *Journal*. Carlo Cercignani's book is much more: a thorough analysis of Boltzmann's scientific achievements by an expert on modern kinetic theory, who has also made an effort to read the original papers in "dense German" and has surveyed some of the extensive biographical material. The result is a book that can be highly recommended to all physical scientists and mathematicians, including graduate students.

Cercignani, who is Professor of Theoretical Mechanics at the Politecnico di Milano, is well known for his research on the Boltzmann equation and is credited with several notable results, such as establishing the Boltzmann–Grad limit hierarchy. So it is not surprising that the core of the book is a description and critique of Boltzmann's famous 1872 paper in which he introduced the transport equation and attempted to derive irreversibility by means of (what was later known as) the "H theorem," followed by an account of subsequent debates about the reversibility and recurrence paradoxes, the statistical interpretation of entropy, and specific heats of polyatomic molecules. (Several appendices survey mathematical aspects of kinetic theory from a modern viewpoint.) But this technical material is preceded by well-written chapters on Boltzmann's life and times and on the early history of thermodynamics and kinetic theory, and followed by chapters on his philosophical views, his relations with his contemporaries, his dispute with the anti-atomists, and his influence on 20th century science. The text concludes with a (previously-published) translation of Boltzmann's satirical account of his trip to California.

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For many readers the only controversial part of this book will be the claim (Chap. 7) that Boltzmann rather than J. Willard Gibbs should be credited with the invention of statistical mechanics. Cercignani correctly points out that Boltzmann was the first to publish the basic ideas of the theory (e.g., the concept of ensembles) but he overlooks the historical fact that it was Gibbs who presented those ideas in a form that turned out to be comprehensible and useful to physical scientists in the 20th century. This was one of the times when Boltzmann turned off many readers (especially British and American scientists) with his long-winded, somewhat pedantic discussions of minute details.

Cercignani avoids another controversy when he discusses the relation between Boltzmann's kinetic theory of gases and Max Planck's theory of black body radiation. Even though he cites with approval Thomas Kuhn's book on this subject, he ignore Kuhn's bold claim that Planck in his 1900 paper did not introduce a *physical* discontinuity in energy but, like Boltzmann, used the "quantum hypothesis" only as a convenient mathematical device to calculate the number of microstates. Cercignani states that Planck introduced the quantum hypothesis in 1901, but does not clearly explain why there is some reason to doubt that he did so in 1900, as the traditional story asserts.[1]

When productive scientists take time out from their own research to analyze and interpret the work of their predecessors, we cannot evaluate the result by the same criteria we would use in judging a book written by a professional historian of science. I could question several of Cercignani's statements on points of historical detail, but that would not be appropriate here. Instead I will give just one example of his disinterest in historical scholarship. He asserts that Boltzmann wanted to publish his transport equation in a short paper in Poggendorff's *Annalen der Physik* to ensure his priority, but "since Stefan was against publishing the same material twice, we are left with just the memoir of almost 100 pages." Now this is a very interesting claim; such a short paper might have helped publicize Boltzmann's theory to a wider audience and led to fruitful discussions by other physicists like Maxwell (who, as Cercignani points out elsewhere, generally ignored the H theorem). But where is the evidence? Cercignani fails to cite any document to support his assertion, and I have not seen such a document myself. In view of the many myths and unverified anecdotes about Boltzmann that still circulate in the physics community, I must remain skeptical about this story.

Cercignani also ignores many of the books and articles published about Boltzmann in the past decade. This is not a criticism, since he does not claim to give a comprehensive account for historians, but rather an accurate and readable exposition of Boltzmann's achievements for scientists

and philosophers—which he in fact succeeds in doing. For those who want to delve more deeply into the scholarly literature, I list below a number of recent works probably *not* cited by Cercignani in his extensive list of references—not to substitute for his book but to complement it.[2]

Stephen G. Brush
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NOTES

1. Thomas S. Kuhn, *Black-Body Theory and the Quantum Discontinuity, 1894–1912* (Oxford University Press, New York, 1978). Max Planck, Zur Theorie des Gesetzes der Energieverteilung im Normalspektrum, *Verhandlungen der Deutschen Physikalischen Gesellschaft* **2**:237–245 (1900); Ueber die Elementarquanta der Materie und der Elektricität, *Annalen der Physik* [series 4] **4**:564–566 (1901). In his 1900 paper, at the end of the paragraph where he apparently postulates that the total energy E of a group of oscillators is an integer multiple P of energy elements ε, he says that if the ratio E/ε "is not an integer, we take for P an integer in the neighbourhood." This sentence does not appear at the corresponding place in the 1901 paper. Kuhn's thesis does not rely on single sentences like this but on a more general analysis of Planck's views expressed in several papers.
2. The following works were published in the most recent 5-year period, 1994–1998; most of them can be located in a few minutes by using the *Isis Current Bibliography* or the electronic database RLIN/Eureka (HST file) (keyword search on "Boltzmann"). Since Cercignani's index does not cover his references, I can't be certain that he does not cite any of them. Enrico Bellone, Il "quantum" classico e la matematica, *Rivista di Filosofia* **87**:193–202 (1996). John Blackmore, *Ludwig Boltzmann: His Later Life and Philosophy, 1900–1906* (Boston, Kluwer, 1995), 2 vols. [Blackmore has also edited a collection of essays on Boltzmann for a special issue of the journal *Synthese* (forthcoming).] Craig Callender, The view from no-when, *British Journal for the Philosophy of Science* **49**:135–159 (1998) [see also the discussion of Boltzmann's views on irreversibility by J. Lebowitz and others, cited in his note 2]. Carlo Cercignani, *Ludwig Boltzmann e la Meccanica Statistica* (Goliardica Pavese, 1997) [the Italian version of the book under review]. E. G. D. Cohen, Boltzmann and Statistical Mechanics, in *Boltzmann's Legacy 150 Years after his Birth* (Accademia Nazionale del Lincei, 1997), pp. 9–23. Henk W. De Regt, Philosophy and the Kinetic Theory of Gases, *British Journal for the Philosophy of Science* **47**:31–62 (1996). William R. Everdell, *The First Moderns: Profiles in the Origins of Twentieth-Century Thought* (University of Chicago Press, Chicago, 1997) [chapter on Boltzmann]. Ilse Fasol-Boltzmann and Walter Höflechner, eds., *Ludwig Boltzmann, Vorlesungen über Experimentalphysik in Graz* (Akademische Druck- und Verlagsanstalt, Graz, 1998). Dieter Flamm, Scientific discussion and friendship between Loschmidt and Boltzmann, in *Pioneering Ideas for the Physical and Chemical Sciences*, W. Fleischhacker and T. Schönfeld, eds. (Plenum Press, New York, 1997), pp. 277–281 [the book is a collection of essays on Josef Loschmidt]. C. Garola and A. Rossi, eds., *The Foundations of Quantum Mechanics—Historical Analysis and Open Questions* (Kluwer, Boston, 1995) [articles by P. Campogalliani and P. Cerreta on Boltzmann, Planck, and the birth of quantum physics]. Erwin

N. Hiebert, The reduction of thermodynamics to mechanics: Historical-philosophical problem, in *Memorial Symposium for Lorenz Krüger* (Max–Planck-Institut für Wissenschaftsgeschichte, Berlin, 1995), pp. 43–60. Walter Höflechner, ed., *Ludwig Boltzmann, Leben und Briefe*, Akademische Druck- und Verlagsanstalt (Graz, 1994). Maria Ianniello, Il contributo di Boltzmann alla teoria dei fenomena di elasticà "con memorial," *Giornale di Fisica* **36**:121–149 (1995). Karl von Meyenn, Boltzmann y la mecánica estadistica, *Arbor: Ciencia, Pensamiento y Cultura* **148**(581):51–79 (1994). Jürgen Renn, Einstein's controversy with Drude and the origin of statistical mechanics: A new glimpse from the "love letters," *Archive for History of Exact Sciences* **51**:315–354 (1997) [Einstein's 1902 statistical mechanics "was the result of a reinterpretation of already existing results by Boltzmann."] Erhard Schiebe, L'origin du réalisme scientifique: Boltzmann, Planck, Einstein, in *Les Savants et l'Epistémologie vers la Fin du XIXe Siècle*, M. Panza and J.-C. Pont, eds. (Blanchard, Paris, 1995). Gianni Zanarini, *Ludwig Boltzmann: Una Passione Scientifica* (CUEN, Napoli, 1996).