Atomic Warrior

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Ludwig Boltzmann: Man, Physicist, Philospher
by Engelbert Broda
Ox Bow Press, 1983

There are three things that students of physics usually know about Ludwig Boltzmann: that he has a 'constant' named after him, that he committed suicide, and that the formula '$S = k \log W$' is inscribed on his gravestone.

Do they need to know more? Well, yes, for Boltzmann was certainly one of the most interesting physicists of the late 19th and early 20th centuries, standing out even in an age when pioneering physicists with strong personalities and revolutionary ideas were aplenty. He was one of the founders of the field of statistical mechanics, applying the laws of probability to the motion of large collections of objects (atoms). Though he saw himself as a classical physicist, tying up the loose ends and clarifying the concepts of classical physics, his work paved the way for quantum mechanics (in which probability and statistics play a vital role), and it has even been suggested that he anticipated some of the ideas of quantum theory and special relativity. Boltzmann's was also an interesting personality. Not only was he involved passionately in scientific debates, but he also drew packed houses to his lectures on the philosophy of science, and even wrote a humorous book about his travels to America.

I feel that there are two reasons why students should be encouraged to read histories of science and biographies of scientists: first, to appreciate that scientists are also human beings (which, alas, is not always as obvious as it ought to be!); and second, to understand how scientists developed their ideas. A good book makes dry formulae and drier scientists come alive, and gives a better understanding of the science itself. Engelbert Broda's book *Ludwig Boltzmann: Man, Physicist, Philosopher* succeeds better at the former than the latter. After reading the book, one is intrigued and impressed by Boltzmann the man, but left feeling a little vague about his role in physics, unless one was already familiar with it.

This is perhaps a little surprising, given that Broda is a professor of physical chemistry at the University of Vienna, and the book is structured and written somewhat in the style of a scientific paper – Broda's own opinions are stated formally ('the author of the present work would like to remark that ...'). Unlike most biographies, no attempt is made to develop Boltzmann's life and work chronologically; instead, the book is subdivided into three parts: 'Man', 'Physicist' and 'Philosopher', and each section is further subdivided. This means that the interconnections between these different aspects of Boltzmann are never explicitly made, but after reading the book one has accumulated a collection of disjoint (but interesting) pieces of information about Boltzmann.

The first and most interesting section, 'Man' is quaintly subdivided into categories such as 'Human Contact', 'Love of Beauty, 'Humor', 'Naivete' and 'Tragic Death'. From the collection of anecdotes in these sections, supplemented by quotations from speeches about and by Boltzmann (mostly obituaries that he wrote for his friends and scientific colleagues!), an interesting picture emerges of a man and physicist who combined a serious and possibly fatal passion for physics with a sense of humour.

Ludwig Boltzmann was born in Austria in 1844, to a comfortable middle-class family. After obtaining his PhD in Vienna, he began a restless career, moving several times between various jobs in Germany and Austria, in part because of the serious scientific arguments that he got into with his colleagues. The big battle of Boltzmann's life was that of the 'atomists' (whose most impassioned spokesman he was) versus the 'energists', who were fiercely hostile to the hypothesis of the existence of atoms. Boltzmann probably took these fierce arguments too seriously, attempting to kill himself after one set of arguments with Ostwald (it has been suggested that he may have been manic-depressive), and it is generally assumed that Boltzmann's suicide was prompted at least in part by his fear that an era of 'barbaric energism' was beginning.

Boltzmann was equally passionate about things outside physics; after travelling by ship, he wrote "I cried when I saw the colour of the sea; how can a mere colour make one cry?". He titled an attack on the philosopher Schopenhauer "Proof that Schopenhauer is a Mindless, Ignorant Philosophaster who Peddles Nonsense, and Through his Empty Verbiage, Is a Thoroughly and Forever Degenerating Influence on Others." However, he did not take himself seriously, making fun of himself in articles and his book about his travels to America, *Journey of a German professor to Eldorado*. Admittedly, his sense of humour was often of the nerdy physicist variety, as when in his memorial address for his friend Loschmidt (who determined the size of the atom) he stated: "Now Loschmidt's body is disintegrated into atoms. Just how many we can calculate on the basis of the principles established by him. I have the number in question written on the blackboard [1 followed by 25 zeroes] so that this address in honour of an experimental physicist does not entirely lack demonstration." This lack of formality seems to have hurt his career, as the rumpled Boltzmann did not conform to the cold, stern stereotype of the German/Austrian professor of his day. He once recalled: "When I harmlessly adopted my usual tone on the first day in the Berlin laboratory, a single glance from Helmholtz made it clear that cheerfulness and humour did not befit the scholar"!

However, though Boltzmann may have been a martyr to the atomist cause, his was not the sad life of an unacknowledged genius; he had a fan following of loyal students, was academically successful and received many awards, including an honorary doctorate from Oxford University.

Broda's book is unashamedly laudatory of Boltzmann, and doesn't mention anything even mildly negative about him ... for example, other scientists have suggested that a part of the reason why Boltzmann's ideas about physics were not immediately appreciated was that he wrote bad papers that became too lengthy in his attempt to be precise. Maxwell said that Boltzmann didn't understand his papers because they were too short, while Maxwell didn't understand Boltzmann's papers because they were too long! Yet at the same time, Boltzmann was considered a brilliant and sympathetic teacher, to whose lectures about everything from calculus and number theory to hydrodynamics 'countless came because of the radiant power of his incomparable personality'.

The 'Man' section of the book could perhaps have been expanded further. For example, one learns nothing about his family, except that his fiancee called him her "sweet fat darling", that he built his wife an electric sewing machine, and bought pet rabbits for his youngest daughter! Also, though it is not directly relevant to his physics, I would have liked to know where Boltzmann stood on some of the thorny and disturbing issues of his day (such as anti-Semitism, or the controversial ideas of another influential intellectual in the Vienna of his days, the psychoanalyst Sigmund Freud). Of course, the odd choice of categories for this section makes one wonder sometimes about the classification: are Boltzmann's operatic description of Maxwell's work ('ever higher the chaos of equations surges until suddenly four words resound: 'Put $N = 5$'....') and his fondness for 'ultramodern' [phonetic] spelling really examples of his 'Love of Beauty' rather than 'Humour'?! And I suppose it is alright to list under 'Naivete' the anecdote about Boltzmann buying a cow and then asking the professor of zoology at the university for advice about how to milk cows, but is it really naive to 'not mind wearing torn shoes when lecturing'? (Admittedly, the 'author of the present article' has a vested interest in this question, having given her first lecture at the Indian Institute of Science wearing only one shoe, since the other one broke just before the talk began!)

The 'Physicist' section shows that Boltzmann was both a talented experimentalist and a brilliant theoretician. In addition to work on electromagnetism (where he favoured a rather mechanistic interpretation of electricity and magnetism), he developed statistical mechanics, at the same time as Willard Gibbs in America. Amongst his more famous works are what we now know as the Maxwell–Boltzmann distribution law, the Stefan–Boltzmann Law for black body radiation, the Boltzmann transport equation and the H theorem. He also introduced the idea of statistical ensembles, proved the equipartition of energy (Maxwell called this 'the Boltzmann theorem') and developed the relation between the entropy S and the statistical weight of W of configurations, that is found on his gravestone (in the form later stated by Planck). In other words, much of the foundations of

statistical mechanics is due to Boltzmann.

This section would perhaps have benefited from a clearer exposition of what the situation was in the field of thermodynamics before Boltzmann, and exactly why his ideas were novel and significant. As it stands, it is perhaps more suited to a curious statistical mechanician than a beginning student of physics, though there are a couple of nice explanations of probabilistic concepts illustrated through throws of dice.

The final section of the book deals with Boltzmann's philosophical ideas. These were largely confined to the philosophy of science, and it is difficult to separate his philosophy from his physics, as the two were intertwined. In his views on the progress of scientific research, Boltzmann anticipated some of the ideas of later philosophers of science such as Karl Popper and Thomas Kuhn.

I think this book will be enjoyed both by students and scientists. However, those looking for greater insight into Boltzmann's personality and life-history, and a better understanding of his physics, might also like to read two more recent biographies, '*Ludwig Boltzmann: The Man Who Trusted Atoms*' by Carlo Cercignani (Oxford University Press, 1998) and '*Boltzmann's Atom: The Great Debate That Launched a Revolution in Physics*' by David Lindley (Free Press, 2001). An article by Dieter Flamm about some of Boltzmann's 'modern' ideas in physics is also available on the web at http://xxx.lanl.gov/abs/physics/9710007.

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"In the case of light, most people confidently speak of the wave as an electromagnetic wave, like a radio wave but with a much shorter wavelength. The associate particle, called a photon, is not so confidently visualized, perhaps only because it is a newer idea. Conversely, most people have little difficulty visualizing the electron as a bit of stuff, while the nature of the associated wave seems rather obscure."

Alan Holden
The Nature of Solids
Columbia University Press, New York
1965, p.139