REVIEW

Chancing Time Again

By Craig Callender

David Albert, *Time and Chance*. Cambridge, Mass.: Harvard University Press, 2000. Pp. ix + 172. US$29.95 HB.

Suppose that we that we have a sample of a light poisonous gas under pressure in a small flask. Put it in a room and open the cover. What should we do? Answer: run. We know from thermodynamics that such gases will expand throughout their available volume. Opening the flask frees the gas to expand spontaneously. Lest we desire a premature end, we had better leave the room and close the door rather quickly. And we had better not return without chemical suits on, because in no one's experience has a gas that has dispersed throughout a room ever spontaneously evolved back into a smaller volume, e.g., the original flask.

Thermodynamics captures this fact—and an amazing assortment of similar ones in a variety of substances and circumstances—with a law to the effect that the entropy of systems always increases with time. This law is manifestly time-asymmetric. And one of the great philosophical and physical problems of the last 150 years has been to reconcile this time-asymmetric macroscopic regularity with the time symmetry of the fundamental dynamical laws of classical mechanics; for in the case described, it is possible according to classical mechanics for the poison gas to evolve, spontaneously and completely, from the large room into the small flask. In fact, if left to itself for eternity, it will so evolve. Statistical mechanics reconciles the apparent conflict between classical mechanics and thermodynamics by saying, loosely, that the transition we experience is likely and the reversed one is tremendously unlikely—but not impossible. But what is the precise meaning of 'likely' here, and what exactly is needed for this explanation to work? Albert's *Time and Chance* is a significant contribution to these and related questions.

Albert's book has seven chapters and an appendix. It is written in the style familiar to readers of his previous work: many clear and clever examples, few equations and scholarly references, lots of spirited discussion and argumentation. Like his *Quantum Mechanics and Experience*

(Cambridge, Mass., 1992), the book doubles as an advanced contribution to the field and as an introduction to the area accessible to undergraduate students. Thus it contains elementary presentations of the science of thermodynamics in Chapter 2 and the appendix, and more limited presentations of statistical mechanics and quantum mechanics within Chapters 3 and 7, respectively. But it also has original and unorthodox claims within perhaps every chapter.

The central theme of the book is the desire to discover what laws of nature or rules need to be added to the fundamental laws of mechanics in order to explain the success of statistical mechanics. The book proceeds with the reasons for positing two extra laws, the successive sharpening of them, and the eventual claim that one can be dropped if a particular interpretation of quantum mechanics is correct. Along the way solutions to the problems of Maxwell's Demon (why he can or can't exist) and the knowledge asymmetry (why we know more about the past than future) are offered.

The two additions we need in addition to the Newtonian laws of motion, Albert claims, are the 'Past Hypothesis' and the 'Statistical Hypothesis'. The 'Past Hypothesis' states that the world came into being in whatever particular low-entropy macrocondition it is that cosmology requires. The need for this time asymmetric posit—essentially to account for why our above gas never spontaneously re-enters the flask—was clearly seen by Boltzmann. Albert, however, provides a novel discussion of the evidence we have for this posit. The second addition to the Newtonian laws of motion is a statistical postulate that grounds the meaning of the word 'likely' in the above explanation of the gas's behaviour. Albert begins with the idea that a true thermodynamical law to the effect that macrocondition **A** will evolve into macrocondition **B** will be understood as follows: 'most' of the microconditions that could realize **A** will evolve according to Newton's equations to states that will realize **B**. Our poisonous gas will expand throughout the room because most of the trajectories for its state take it there. Albert then confronts this rough idea with various objections and offers refinements until he is eventually satisfied. His final chapter then claims that if the GRW interpretation to quantum mechanics is true, there will be no need for a separate postulate about statistics. If GRW is true, he claims, the statistical postulate will essentially follow as a corollary to the fundamental laws of nature.

That is the book in barest outline. But it is packed with fresh examinations and controversial claims about the foundations of statistical mechanics. Since this field is, in my opinion, in dire need of clear thinking and straight talking, I found Albert's more provocative claims very welcome—even if I didn't always agree with them. In a short review like this, I will perhaps best serve the prospective reader if I simply mention some of the more interesting claims. These will perhaps provoke the reader into studying the book further.

Chapter 1 on time-reversal invariance contains the claim that, contrary to what all the physics textbooks say, neither classical electromagnetism nor quantum mechanics is in fact time reversal invariant when one has a proper understanding of what this symmetry involves. "[T]here have been dynamical distinctions between past and future written into the fundamental laws of physics of a century and a half now" (p. 21).

Chapter 3 challenges the idea that entropy is a feature of one's knowledge of a system, the idea that the laws and predicates of thermodynamics apply to probability distributions, and the idea that equilibrium corresponds to the properties of a system not varying with time. All of this is, in Albert's words, "sheer madness" (p. 70).

Chapter 4 tackles the so-called reversibility objections of Loschmidt and Zermelo. (Albert erroneously attributes the same objection to both Zermelo and Loschmidt, when in fact Zermelo made what is known as the recurrence objection.) Here Albert criticises much of the literature surrounding these objections, and the theories of Gibbs, Schrödinger, Horwich, Davies, Reichenbach, and Gold.

Chapter 5 contains an original counter-example to the long history of attempts to show that there can't be a Maxwell Demon. It is perfectly compatible with Newtonian and statistical mechanics, he asserts, that there exist physical systems that can reliably lower the entropies of some larger isolated systems of which they form parts (p. 108). If this is right, scores of 'proofs' to the contrary are wrong-headed.

Chapter 6 contains a sophisticated discussion of what exactly the 'knowledge asymmetry' is and why it occurs, as well as a related discussion of why the future but not the past counterfactually depend on what we do now.

And Chapter 7 contends, as mentioned above, that the GRW interpretation of quantum mechanics (and GRW alone) will obviate the need for a statistical postulate in addition to the laws of the fundamental physics.

Despite the novelty of the above claims, with which I mostly sympathise, perhaps the one I found most surprising is an idea running throughout the book. This is the belief that statistical mechanics applies, or ought to apply, to just about everything. It ought to turn out to be true, Albert thinks, that the postulate about statistics, plus Newton's laws, plus the Past Hypothesis, make it likely that spatulas are found in kitchen drawers rather than bathtubs (p. 95), that upon finding one eighteenth-century boot with an 'N' (for Napoleon) on it, it is likely that we will find another (p. 94). This expansion of the domain over which statistical mechanics concerns itself struck me as odd. But it does have a pedigree precedent: Boltzmann himself wrote that a 'wide perspective' opens up 'if we think of applying this science to the statistics of living beings, human society, sociology and so on, instead of only to mechanical bodies'.

In sum, I heartily recommend this book. It challenges the foundations of a field that sorely need challenging. I am confident that the book will take its place alongside Reichenbach's *Direction of Time* as one of the most stimulating on this topic.

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With Friends Like This, Who Needs Enemies?

By Steve Fuller

Alexander Bird, *Thomas Kuhn*. Princeton: Princeton University Press, 2000. Pp. xii + 308. US$16.95 PB.

Anyone interested in reading Bird's book will already know that I am no friend of Thomas Kuhn (see my *Thomas Kuhn: A Philosophical History for Our Times*, Chicago, 2000). But with friends like Bird, Kuhn has no need for people like me! Bird's is the sort of book that is published only once the subject is no longer around to object to the way his project has been dragooned into someone else's holy war. Here we find Bird customising Kuhn as the standard-bearer, albeit imperfect, for the currently fashionable naturalistic approach to epistemology and the philosophy of science. Bird does this by inventing a new field for Kuhn's work—'theoretical history' (p. viii)—that is sufficiently close to philosophy for Bird to draw from it as he pleases, yet sufficiently distant for Bird not to have to deal with all, or even most, of it. Too bad Kuhn himself thought he was always doing philosophy, albeit in a

