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Book Review: *Statistical Dynamics*

Statistical Dynamics, A Stochastic Approach to Nonequilibrium Thermodynamics. R. F. Streater, Imperial College Press, London, 1996.

"Statistical dynamics" refers to dynamical rules which are stochastic (or random) rather than strictly deterministic. For many physical situations such a modeling is a necessity, since only a small subset of degrees of freedom is relevant, the rest being taken into account in the form of noise. If applied with some care, the noise is approximately independent and the stochastic dynamics is Markovian. As a consequence the reader learns about random variables, correlations, Markov chains, and the like. A Boltzmann-type approximation, leading to a nonlinear transport equation, is introduced and studied extensively. Given the scientific background of the author, it is not so surprising that he spends a considerable portion of the book to extend the classical notions to quantum systems. This leads then to completely positive maps, quantum dynamical semigroups, nonlinear quantum transport equations, and a brief chapter on infinite systems. The text is well written, careful in its explanations, and supplemented by many exercises. The presentation is mathematically concise, but sticks to a solid graduate level by intention.

In many places I find the selection of the material somewhat limited. For example, in his book *Probability and Related Topics in Physical Sciences*, M. Kac discusses at length how the nonlinear transport equation is derived from a stochastic many-particle system. Not even a hint in this direction is offered to the reader of the book under review. The stochastic modeling of chemical reactions has reached such a sophisticated level that it can explain the kinetic mechanisms behind spatial pattern formation. Instead the reader learns only about the simplest examples of spatially uniform chemical kinetics. The author claims that no flow terms can be included in the transport equation. As discussed in the literature on lattice gases, one considers particles with, say, a discrete set of velocities. According to its current velocity a particle performs then a biased random walk. On the level of the transport equation this systematic motion is reflected by flow terms.

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On p. 162 (and somewhat less explicitly at several other places) one reads, "Thus we have the same problem as in classical statistical dynamics, that the microscopic theory does not lead to dissipation." What is the evidence? As proven a few lines above the citation, the "entropy" $-\mathrm{tr}[\rho \log \rho]$ does not change under the unitary time evolution generated by the Schrödinger equation. It is amazing how this two-line computation is weighed against the vast experimental and theoretical evidence which consistently points precisely to the opposite, namely that the dissipation which we observe around us is very well accounted for by microscopic Hamiltonian dynamics. As a reviewer I might take the opportunity to recall a conservative observation: While $-\mathrm{tr}[\rho \log \rho]$ is of extreme importance for thermal equilibrium and serves as a very useful Lyapunov functional for stochastic dynamics and transport equations, it is simply not a functional which reflects the dissipation going on in Hamiltonian dynamics. For this purpose $-\mathrm{tr}[\rho \log \rho]$ is too fine-grained.

In conclusion: while the book offers interesting reading, it is biased toward the research work of the author.

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