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Book Review: *Time's Arrow; The Origin of Thermodynamic Behavior*

Time's Arrow: The Origin of Thermodynamic Behavior. M. C. Mackey, Springer-Verlag, Berlin, 1992, 175 pp.

The title of this book arouses curiosity. Since the days of Boltzmann the problem of irreversibility has perplexed scientists. It has been discussed repeatedly and its multifaceted aspects have been scrutinized in many learned articles and books. Should there suddenly be new vistas opening up? A first quick browsing through the pages shows that the reader can relax. Mackey's book is not about physics. In fact none of the standard model systems of theoretical physics is introduced. Rather, Mackey explains the long-time behavior for a large variety of dynamical systems and does so on a very readable introductory level.

To have a unified framework, Mackey studies the time evolution of probability densities on phase space (R^d or some bounded subset of it). The dynamics is either induced by a deterministic flow or given directly through a Markov transition probability. In the large-time limit the system should settle down to a stationary probability distribution. Since it is required to have a density, dissipative dynamics with strange attractors is unfortunately a subject beyond the scope of the textbook. Various types of behavior are illustrated: invertible and noninvertible dynamics, asymptotic periodicity, mixing, day of correlations, and weak and strong convergence as $t \to \infty$. Sufficient criteria are provided under which the dynamics converges in the long-time limit to a stationary distribution independent of initial conditions. The associated increase of the relative entropy is explained. In the case of weak convergence, some coarse graining is needed to achieve the desired result. The final chapter studies Markov evolutions corresponding to additive, external noise.

Mackey makes a careful and pedagogical presentation of the material in a concise mathematical language without being unnecessarily formal. The text should be accessible on a graduate student level. The strength of

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the book lies in the many examples given. What I miss is some additional perspective on topics which for lack of space or some other reason the author did not include. Only two examples: The Sinai billiard would have been an appropriate illustration for K-systems. Discussing properties of Fokker–Planck equations (Chapter 11), the condition of uniform ellipticity is introduced. Even in the simplest physical applications such a condition is typically not satisfied. A hint pointing in the direction of the Hörmander theory would have been helpful here. Apart from these qualifications I enjoyed reading the book.

Herbert Spohn
Theoretische Physik
Ludwig-Maximilians-Universität
8000 München 2, Germany