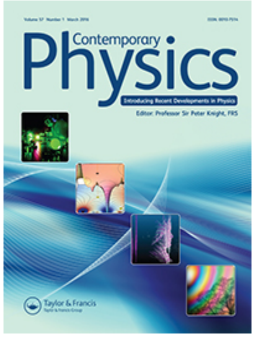

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Nonequilibrium statistical physics: a modern perspective

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BOOK REVIEW

Nonequilibrium statistical physics: a modern perspective, by R. Livi and P. Politi, Cambridge, UK, Cambridge University Press, 2017, 434 pp., £54.99 (hardback), ISBN 9781107049543. Scope: textbook. Level: advanced undergraduate, postgraduate, early career researcher, scientist.

Statistical physics is an important field of modern physics, and as it happens with thermodynamics it can be classified as equilibrium and non-equilibrium statistical physics. The most elementary equilibrium theory is the one typically taught in undergraduate courses, while the more advanced non-equilibrium theory is usually left for postgraduate courses, whenever the opportunity to teach it exists. However, there are rather few textbooks on the field, and the existing ones are somewhat specialised. Thus, the arrival of this book is highly welcome since this is certainly a textbook on the subject primarily designed for students. Its teaching is important and necessary since thermodynamics and statistical physics is at the foundations of various modern interdisciplinary ideas in physics ranging from astrophysics, geophysics, information physics, condensed matter physics, etc.

A key issue in writing a book on this subject, due to the lack of a canon, is the appropriate choice of its contents. The authors have organised the contents into three main parts, containing 7 chapters and 19 short appendices. The first part, including two chapters, dealing with basic topics. A second part, chapters three and four, including topics such as non-equilibrium phase transitions. And the third part, the last three chapters, describes some topics related to the personal research interests of the authors: kinetic roughening, phenomena of phase-ordering and pattern formation. Each chapter starts with an overview, followed by an introduction, which I have found truly helpful to have an idea of its contents. At the end of each chapter, there is a short section devoted to bibliographic notes, with an outstanding and careful selection of references with useful comments. The textbook is written with a pedagogical style and the authors have paid much attention to just mentioning certain key ideas, avoiding a detailed description that certainly would go beyond its scope.

The first chapter provides an excellent introduction to stochastic processes in physics, including Markov processes, the Langevin equation and the Focker–Planck equations. It also gives a historical overview, including a review of the Brownian motion, quite helpful to contextualise the subject. The second chapter describes the linear response theory, showing the Green–Kubo relations, and showing the connections between the linear response theory and the phenomenological equations of the thermodynamics of irreversible processes. A section describes a few different physical applications of the Onsager reciprocity relations, including well-known effects such as thermoelectric effects, the Seebeck effects, the Peltier effect, among others. Furthermore, some ideas are extended for quantum systems, assuming a knowledge of quantum physics and quantum field theory. I have liked all throughout the textbook, the brief comments on the main contributors to the theory, important to highlight some of the pioneers in statistical physics.

The second part explores non-equilibrium phase transitions and critical phenomena. One of the chapters reviews basic concepts from equilibrium phase transitions such as control parameters, order parameters and critical exponents, which are of much help for the remainder part devoted to non-equilibrium states and non-equilibrium phase transitions. The main elements of the Landau theory of phase transitions are sketched, rather appropriate to describe the critical phenomena. The other chapter is somehow more technical and focuses on out-of-equilibria critical phenomena, including a description of the self-organised criticality (SOC), absorbing phase transitions and non-equilibrium symmetry breaking.

The final part contains three chapters. Chapter five addresses the topic of stochastic dynamics of surfaces and interfaces. Special attention is given to the two most important local universality classes: Edwards–Wilkinson (EW) and Kardar–Parisi–Zhang (KPZ). And finally, to the diffusion limited aggregation (DLA), which is a non-local model and presents familiar fractal patterns. Chapter six is devoted to phase-order kinetics and addresses the question of relaxation to equilibrium from a disordered state. Two types of processes are involved in the ensuing dynamics: coarsening and nucleation, which is discussed in a rather simple and qualitative manner. The last chapter describes the topic of pattern formation out-of-equilibrium focusing mainly on Turing patterns and pattern formation in the Rayleigh–Bénard instability. This topic is also treated in monographs devoted to non-linear physics and its non-linear dynamics is modelled by partial differential equations.

Several advanced issues, some of them due to a more detailed mathematical treatment, are left for the appendices. Besides some mathematical techniques, a detailed description of the van der Waals equation, the Ising model, The

Rayleigh–Bénard instability and the Kardar–Parisi–Zhang equation can be found, among others.

The textbook can be highly beneficial for acquiring a good picture of non-equilibrium statistical physics. It can be used for different purposes, and the contents can be adapted to different levels of students. The first two chapters on stochastic processes and fluctuations can be quite useful even for advanced undergraduate students, besides postgraduate as well as newcomers to the field. The part of non-equilibrium phase transitions, somehow more technical, could be useful for graduate students, and the last part could be used as an introduction to some more specialised current research topics within the field.

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