Book Review: *Nonequilibrium Phase Transitions in Lattice Models*

Nonequilibrium Phase Transitions in Lattice Models.
Joaquín Marro and Ronald Dickman, 327 pp., Cambridge University Press, 1999.

Kinetics of processes far from equilibrium is a challenging problem, for the classical approaches which work so well for systems at equilibrium seem then irrelevant. In recent years, much effort has been devoted to the study of kinetic phase transitions, that is, transitions between different kinds of *nonequilibrium*, stationary behavior in kinetic models. The goal of these studies is, ideally, to achieve an understanding similar to that of equilibrium phase transitions, where we know for example that the type (universality class) of transitions is decided by the symmetry of the order parameter, the range (short or long) of the interactions, and the dimensionality of space. To date, numerous models of kinetic phase transitions have been analyzed, but there have been relatively few attempts to put the conclusions together, and a coherent picture has not yet emerged.

In their book "Nonequilibrium Phase Transitions in Lattice Models", J. Marro and R. Dickman make a bold effort to summarize what's been achieved so far, and to distill some general guiding principles out of the plethora of existing results. They argue most convincingly that many of the concepts associated with equilibrium phase transitions have useful counterparts in the study of nonequilibrium phase transitions. A large number of the models studied so far fall within relatively few universality classes, and in some instances (notably, the directed percolation conjecture) it seems clear what features of a model determine its class, though a complete understanding of the subject remains an elusive goal.

The book opens with a description of two toy-models: a birth-death process which undergoes a kinetic phase transition, and a simplified anisotropic lattice gas model which illustrates the concepts of dynamic competition and pattern formation. These main themes are further developed through the remainder of the book. The driven lattice gas model (DLG) is a particularly good example where experimental efforts, especially regarding super-ionic conductors, parallel the many existing theoretical studies. An excellent account of both research activities is given in chapter 2. Chapter 3 focuses on theoretical approaches (mean-field, hydrodynamic, and Ω-expansions) as applied to a series of increasingly complex DLG models, and the findings are compared to Monte-Carlo simulations and to experimental results. Chapter 4 introduces reactions in lattice gas models, and demonstrates how the competition between reactions and diffusion drives such systems away from equilibrium. The Ziff-Gulari-Barshad model and related models of heterogeneous catalysis are reviewed in chapter 5. Chapter 6 deals with the contact process—perhaps the simplest example belonging to the very robust class of kinetic phase transitions of directed percolation. The next two chapters (6 and 7) discuss the timely question of the effects of various types of disorder, while chapter 8 explores the effects of conflicting dynamics. Chapter 9 concludes with a brief survey of miscellaneous reaction models which have attracted some recent attention.

The book is written in review style, though it does much more than simply summarizing the bulk of relevant research. The material is skillfully arranged so as to emphasize those aspects of universality which are now well established, while the richness of the problem and the obstacles remaining on our way to a more global understanding of kinetics phase transitions are carefully indicated. If there is one main theme to this work, it is the fact that, in spite of the obvious difficulties, concepts from the theory of equilibrium phase transitions still come in handy in the study of their nonequilibrium counterparts. In particular, the usefulness of mean-field approaches (hydrodynamic equations, cluster expansions) is demonstrated time and again throughout the book's many examples. "Nonequilibrium Phase Transitions in Lattice Models" is sure to become a standard reference guide for the field, and it will hopefully motivate much of the future research.

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