Preface to the Second Edition

The first edition of this book was written on purpose in a very concise, booklet format, to make it easily accessible to a broad interdisciplinary readership of science students and research scientists with an interest in the theoretical modeling of complex systems. Readers were assumed to typically have some bachelor level background in mathematical methods, but no a priori knowledge in statistical physics.

A few years after this first edition, it has appeared relevant to significantly expand it to a full—though still relatively concise—book format in order to include a number of important topics that were not covered in the first edition, thereby raising the number of chapters from three to six. These new topics include non-conserved particles, evolutionary population dynamics, networks (Chap. 4), properties of both individual and coupled simple dynamical systems (Chap. 5), as well as probabilistic issues like convergence theorems for the sum and the extreme values of a large set of random variables (Chap. 6). A few short appendices have also been included, notably to give some technical hints on how to perform simple stochastic simulations in practice.

In addition to these new chapters, the first three chapters have also been significantly updated. In Chap. 1, the discussions of phase transitions and of disordered systems have been slightly expanded. The most important changes in these previously existing chapters concern Chap. 2. The Langevin and Fokker–Planck equations are now presented in separate subsections, including brief discussions about the case of multiplicative noise, the case of more than one degree of freedom, and the Kramers–Moyal expansion. The discussion of anomalous diffusion now focuses on heuristic arguments, while the presentation of the Generalized Central Limit Theorem has been postponed to Chap. 6. Chapter 2 then ends with a discussion of several aspects of the relaxation to equilibrium. Finally, Chap. 3 has also undergone some changes, since the presentation of the Kuramoto model has been deferred to Chap. 5, in the context of deterministic systems. The remaining material of Chap. 3 has then been expanded, with discussions of the Schelling model with
two types of agents, of the dissipative Zero Range Process, and of assemblies of active particles with nematic symmetries.

Although the size of this second edition is more than twice the size of the first one, I have tried to keep the original spirit of the book, so that it could remain accessible to a broad, non-specialized, readership. The presentations of all topics are limited to concise introductions, and are kept to a relatively elementary level—not avoiding mathematics, though. The reader interested in learning more on a specific topic is then invited to look at other sources, like specialized monographs or review articles.

Grenoble, France                      Eric Bertin
May 2016
Preface to the First Edition

In recent years, statistical physics started raising the interest of a broad community of researchers in the field of complex system sciences, ranging from biology to social sciences, economics or computer sciences. More generally, a growing number of graduate students and researchers feel the need for learning some basics concepts and questions coming from other disciplines, leading for instance to the organization of recurrent interdisciplinary summer schools.

The present booklet is partly based on the introductory lecture on statistical physics given at the French Summer School on Complex Systems held both in Lyon and Paris during the summers 2008 and 2009, and jointly organized by two French Complex Systems Institutes, the “Institut des Systèmes Complexes Paris Ile de France” (ISC-PIF) and the “Institut Rhône-Alpin des Systèmes Complexes” (IXXI). This introductory lecture was aimed at providing the participants with a basic knowledge of the concepts and methods of statistical physics so that they could later on follow more advanced lectures on diverse topics in the field of complex systems. The lecture has been further extended in the framework of the second year of Master in “Complex Systems Modelling” of the Ecole Normale Supérieure de Lyon and Université Lyon 1, whose courses take place at IXXI.

It is a pleasure to thank Guillaume Beslon, Tommaso Roscelde and Sébastien Grauwin, who were also involved in some of the lectures mentioned above, as well as Pablo Jensen for his efforts in setting up an interdisciplinary Master course on complex systems, and for the fruitful collaboration we had over the last years.

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