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Book Review: *A Guide to Monte Carlo Simulations in Statistical Physics*

A Guide to Monte Carlo Simulations in Statistical Physics. D. P. Landau and K. Binder, Cambridge University Press, 2000, pp. 384 + xiii.

This book comes from two well-known practitioners of the Monte Carlo arts. Because of the great breadth of the subject the authors focus on material relevant to the statistical physics community, thus the title accurately reflects the contents. The book is aimed at the graduate student level and beyond; while some parts of the material will be accessible to beginning graduate students, others assume a certain familiarity with subjects such as critical phenomena.

The first of the initial three chapters provide a general introduction. This is followed by a summary of background material covering relevant topics in thermodynamics and statistical mechanics, phase transitions, probability, and the all-important issue of random number generation. The subject of Monte Carlo (MC) methods based on a simple sampling approach is covered in the next chapter, with examples of applications such as percolation and random walks.

The following group of four chapters forms the core of the book and occupies roughly half the overall page count. The first deals with importance sampling MC (this is what makes MC so effective for problems in statistical mechanics); the subject matter includes the Ising and other discrete spin models, finite-size scaling and phase transitions, sources of error (of which there are more than a few) and how to deal with them, relaxation effects, polymers on lattices, and some useful practical advice for the simulator. More material on importance sampling as applied to lattice systems occupies the next chapter, which covers cluster methods for

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accelerating convergence, specialized techniques such as multispin coding, continuous spin models, quenched randomness, free energy methods, surfaces and interfaces, and finally a discussion of the pathological aspects of (pseudo-)random number generators- –caveats all MC practitioners should be aware of. A chapter is devoted to off-lattice models, including the theory behind the techniques for fluids in different thermodynamic ensembles, and studies of monolayers and polymers in the continuum. The last of these chapters deals with reweighting methods, including umbrella sampling, and histogram and multicanonical methods.

By the time the reader has progressed this far she will have been exposed to a range of techniques, models and case studies. Examples of using many of the techniques are given, often based on the authors' own research over the years, although the descriptions of the algorithms themselves are sometimes rather concise. The types of models introduced reflect the tendency of statistical physicists to focus on simplified systems designed to capture the essence of a problem—typified by Ising models and self-avoiding walks— rather than dealing with more detailed molecular structures and heavily parameterized potentials. Thus the computations are easier while the essential behavior is preserved; sometimes even these simple models can be tailored to fit experiment, but where the goal is the examination of general phenomena such as second-order phase transitions (a topic prominent in this book), the simpler the representation the better.

MC methods are also used for quantum mechanical problems, and the next chapter discusses a number of the more popular techniques, including path integral methods, ways of dealing with lattice quantum spin systems and fermions, and methods for ground states. This is followed by a chapter on MC renormalization group methods; the basic theory is summarized and various approaches outlined. Nonequilibrium and irreversible processes can also be treated by MC, and the next chapter discusses examples of such applications, including crystal growth, gels, DLA and thin film growth.

The final three chapters provide a very short introduction to MC for lattice gauge models, a survey of other simulation methods, and a brief look to the future. An appendix lists several programs related to material in the text—in Fortran, and exhibiting a variety of programming styles—but these only address a fraction of the material in the book. Problems for the enthusiastic reader to solve are located throughout the text, but for solutions one must look elsewhere. References are placed at the end of each chapter.

Monte Carlo has played an important role over the past half century. As should be apparent from the above outline, this volume succeeds in describing a broad collection of techniques and their contribution to problems in statistical physics. The book will serve as a useful introduction to those entering the field, while for those already versed in the subject it provides a timely survey of what has been achieved.

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