Contents

1. Introduction: Purpose and Scope of This Volume, and Some General Comments 1

2. Theoretical Foundations of the Monte Carlo Method and Its Applications in Statistical Physics 5

2.1 Simple Sampling Versus Importance Sampling 5

2.1.1 Models 5

2.1.2 Simple Sampling 7

2.1.3 Random Walks and Self-Avoiding Walks 8

2.1.4 Thermal Averages by the Simple Sampling Method . 13

2.1.5 Advantages and Limitations of Simple Sampling 14

2.1.6 Importance Sampling 17

2.1.7 More About Models and Algorithms 19

2.2 Organization of Monte Carlo Programs, and the Dynamic Interpretation of Monte Carlo Sampling 23

2.2.1 First Comments on the Simulation of the Ising Model 23

2.2.2 Boundary Conditions 26

2.2.3 The Dynamic Interpretation of the Importance Sampling Monte Carlo Method 28

2.2.4 Statistical Errors and Time-Displaced Relaxation Functions 33

2.3 Finite-Size Effects 35

2.3.1 Finite-Size Effects at the Percolation Transition 35

2.3.2 Finite-Size Scaling for the Percolation Problem 38

2.3.3 Broken Symmetry and Finite-Size Effects at Thermal Phase Transitions 41

2.3.4 The Order Parameter Probability Distribution and Its Use to Justify Finite-Size Scaling and Phenomenological Renormalization 44

2.3.5 Finite-Size Behavior of Relaxation Times 54

2.3.6 Finite-Size Scaling Without "Hyperscaling" 56

2.3.7 Finite-Size Scaling for First-Order Phase Transitions 57

2.3.8 Finite-Size Behavior of Statistical Errors and the Problem of Self-Averaging 64

2.4 Remarks on the Scope of the Theory Chapter 67

3. Guide to Practical Work with the Monte Carlo Method 68
3.1 Aims of the Guide 71
3.2 Simple Sampling 73
3.2.1 Random Walk 74
3.2.2 Nonreversal Random Walk 81
3.2.3 Self-Avoiding Random Walk 83
3.2.4 Percolation 87
3.3 Biased Sampling 94
3.3.1 Self-Avoiding Random Walk 95
3.4 Importance Sampling 97
3.4.1 Ising Model 97
3.4.2 Self-Avoiding Random Walk 112

Appendix 113
A1 Algorithm for the Random Walk Problem 113
A2 Algorithm for Cluster Identification 114

References 119

Subject Index 124