Contents

Preface v

Classical Statistical Dynamics **1**

1. Introduction 3

2. Probability Theory 13
   - 2.1 Sample Spaces and States 13
   - 2.2 Random Variables, Algebras 24
   - 2.3 Entropy 34
   - 2.4 Exercises 39

3. Linear Dynamics 43
   - 3.1 Reversible Dynamics 43
   - 3.2 Random Dynamics 48
   - 3.3 Convergence to Equilibrium 60
   - 3.4 Markov Chains 66
   - 3.5 Exercises 69

4. Isolated Dynamics 73
   - 4.1 The Boltzmann Map 73
   - 4.2 The Heat-Particle 87
   - 4.3 The Hard-Core Model of Chemical Kinetics 94
     - 4.3.1 Isomers and Diffusion in a Force-Field 95
     - 4.3.2 Markov Dynamics 100
     - 4.3.3 Entropy Production 102

STATISTICAL DYNAMICS - A Stochastic Approach to Nonequilibrium Thermodynamics(Second Edition)
© Imperial College Press
http://www.worldscibooks.com/physics/p576.html

4.3.4 Osmosis . . . 103
4.3.5 Exchange Diffusion . . . 104
4.3.6 General Diffusions . . . 105
4.4 Chemical Reactions . . . 106
4.4.1 Unimolecular Reactions . . . 106
4.4.2 Balanced Reactions . . . 107
4.5 Energy of Solvation . . . 111
4.6 Activity-led Reactions . . . 111
4.7 Exercises . . . 119

5. Isothermal Dynamics 123
5.1 Legendre Transforms . . . 124
5.2 The Free-energy Theorem . . . 126
5.3 Chemical Kinetics . . . 130
5.4 Convergence in Norm . . . 137
5.5 Dilation of Markov Chains . . . 146
5.6 Exercises . . . 149

6. Driven Systems 151
6.1 Sources and Sinks . . . 151
6.2 A Poor Conductor . . . 152
6.3 A Driven Chemical System . . . 155
6.4 How to Add Noise . . . 162
6.5 Exercises . . . 165

7. Fluid Dynamics 167
7.1 Hydrostatics of a Gas of Hard Spheres . . . 168
7.2 The Fundamental Equation . . . 171
7.3 The Euler Equations . . . 177
7.4 Entropy Production . . . 178
7.5 A Correct Navier-Stokes System . . . 181

Quantum Statistical Dynamics 187

8. Introduction to Quantum Theory 189

9. Quantum Probability 197

STATISTICAL DYNAMICS - A Stochastic Approach to Nonequilibrium Thermodynamics(Second Edition)
© Imperial College Press
http://www.worldscibooks.com/physics/p576.html

9.1 Algebras of Observables 197
9.2 States 204
9.3 Quantum Entropy 213
9.4 Exercises 217

10. Linear Quantum Dynamics 221

10.1 Reversible Dynamics 221
10.2 Random Quantum Dynamics 224
10.3 Quantum Dynamical Maps 228
10.4 Exercises 236

11. Isolated Quantum Dynamics 237

11.1 The Quantum Boltzmann Map 237
11.2 The Quantum Heat-Particle 240
11.3 Fermions and Ions with a Hard Core 256
11.4 The Quantum Boltzmann Equation 272
11.5 Exercises 281

12. Isothermal and Driven Systems 283

12.1 Isothermal Quantum Dynamics 283
12.2 Convergence to Equilibrium 289
12.3 Driven Quantum Systems 292
12.4 Exercises 296

13. Infinite Systems 297

13.1 The Algebra of an Infinite System 299
13.2 The Reversible Dynamics 300
13.3 Return to Equilibrium 302
13.4 Irreversible Linear Dynamics 306
13.5 Exercises 309

14. Proof of the Second Law 311

14.1 von Neumann Entropy 311
14.2 Entropy Increase in Quantum Mechanics 312
14.3 The Quantum Kac Model 314
14.4 Equilibrium 315
14.5 The ϵ-Limit 316
14.6 The Marginals and Entropy 316

STATISTICAL DYNAMICS - A Stochastic Approach to Nonequilibrium Thermodynamics(Second Edition)
© Imperial College Press
http://www.worldscibooks.com/physics/p576.html

14.7 The Results 317

15. Information Geometry 319

15.1 The Jaynes-Ingarden Theory 319
15.2 Non-Linear Ising Dynamics 322
15.3 Ising Model Close to Equilibrium 327
15.4 Non-linear Heisenberg Model 329
15.5 Estimation; the Cramér-Rao Inequality 333
15.6 Efron, Dawid and Amari 337
15.7 Entropy Methods, Exponential Families 340
15.8 The Work of Pistone and Sempi 341
15.9 The Finite-Dimensional Quantum Info-Manifold 346
15.10 Araki's Expansionals and the Analytic Manifold 352
15.11 The Quantum Young Function 354
15.12 The Quantum Cramér Class 359
15.13 The Parameter-Free Quantum Manifold 360
15.14 Exercises 364

Bibliography 367

Index 377

STATISTICAL DYNAMICS - A Stochastic Approach to Nonequilibrium Thermodynamics(Second Edition)
© Imperial College Press
http://www.worldscibooks.com/physics/p576.html