
Contents

Preface	xi
List of Contributors	xiii
Chapter 1. Introduction	
<i>A. Greven, G. Keller, G. Warnecke</i>	1
1.1 Outline of the Book	4
1.2 Notations	14
PART 1. FUNDAMENTAL CONCEPTS	17
Chapter 2. Entropy: a Subtle Concept in Thermodynamics	
<i>I. Müller</i>	19
2.1 Origin of Entropy in Thermodynamics	19
2.2 Mechanical Interpretation of Entropy in the Kinetic Theory of Gases	23
2.2.1 Configurational Entropy	25
2.3 Entropy and Potential Energy of Gravitation	28
2.3.1 Planetary Atmospheres	28
2.3.2 Pfeffer Tube	29
2.4 Entropy and Intermolecular Energies	30
2.5 Entropy and Chemical Energies	32
2.6 Omissions	34
References	35
Chapter 3. Probabilistic Aspects of Entropy	
<i>H.-O. Georgii</i>	37
3.1 Entropy as a Measure of Uncertainty	37
3.2 Entropy as a Measure of Information	39
3.3 Relative Entropy as a Measure of Discrimination	40
3.4 Entropy Maximization under Constraints	43
3.5 Asymptotics Governed by Entropy	45
3.6 Entropy Density of Stationary Processes and Fields	48
References	52

PART 2. ENTROPY IN THERMODYNAMICS	55
Chapter 4. Phenomenological Thermodynamics and Entropy Principles	
<i>K. Hutter and Y. Wang</i>	57
4.1 Introduction	57
4.2 A Simple Classification of Theories of Continuum Thermodynamics	58
4.3 Comparison of Two Entropy Principles	63
4.3.1 Basic Equations	63
4.3.2 Generalized Coleman–Noll Evaluation of the Clausius–Duhem Inequality	66
4.3.3 Müller–Liu’s Entropy Principle	71
4.4 Concluding Remarks	74
References	75
Chapter 5. Entropy in Nonequilibrium	
<i>I. Müller</i>	79
5.1 Thermodynamics of Irreversible Processes and Rational Thermodynamics for Viscous, Heat-Conducting Fluids	79
5.2 Kinetic Theory of Gases, the Motivation for Extended Thermodynamics	82
5.2.1 A Remark on Temperature	82
5.2.2 Entropy Density and Entropy Flux	83
5.2.3 13-Moment Distribution. Maximization of Nonequilibrium Entropy	83
5.2.4 Balance Equations for Moments	84
5.2.5 Moment Equations for 13 Moments. Stationary Heat Conduction	85
5.2.6 Kinetic and Thermodynamic Temperatures	87
5.2.7 Moment Equations for 14 Moments. Minimum Entropy Production	89
5.3 Extended Thermodynamics	93
5.3.1 Paradoxes	93
5.3.2 Formal Structure	95
5.3.3 Pulse Speeds	98
5.3.4 Light Scattering	101
5.4 A Remark on Alternatives	103
References	104
Chapter 6. Entropy for Hyperbolic Conservation Laws	
<i>C. M. Dafermos</i>	107
6.1 Introduction	107
6.2 Isothermal Thermoelasticity	108
6.3 Hyperbolic Systems of Conservation Laws	110
6.4 Entropy	113
6.5 Quenching of Oscillations	117
References	119

Chapter 7. Irreversibility and the Second Law of Thermodynamics	
<i>J. Uffink</i>	121
7.1 Three Concepts of (Ir)reversibility	121
7.2 Early Formulations of the Second Law	124
7.3 Planck	129
7.4 Gibbs	132
7.5 Carathéodory	133
7.6 Lieb and Yngvason	140
7.7 Discussion	143
References	145
Chapter 8. The Entropy of Classical Thermodynamics	
<i>E. H. Lieb, J. Yngvason</i>	147
8.1 A Guide to Entropy and the Second Law of Thermodynamics	148
8.2 Some Speculations and Open Problems	190
8.3 Some Remarks about Statistical Mechanics	192
References	193
PART 3. ENTROPY IN STOCHASTIC PROCESSES	197
Chapter 9. Large Deviations and Entropy	
<i>S. R. S. Varadhan</i>	199
9.1 Where Does Entropy Come From?	199
9.2 Sanov's Theorem	201
9.3 What about Markov Chains?	202
9.4 Gibbs Measures and Large Deviations	203
9.5 Ventcel–Freidlin Theory	205
9.6 Entropy and Large Deviations	206
9.7 Entropy and Analysis	209
9.8 Hydrodynamic Scaling: an Example	211
References	214
Chapter 10. Relative Entropy for Random Motion in a Random Medium	
<i>F. den Hollander</i>	215
10.1 Introduction	215
10.1.1 Motivation	215
10.1.2 A Branching Random Walk in a Random Environment	217
10.1.3 Particle Densities and Growth Rates	217
10.1.4 Interpretation of the Main Theorems	219
10.1.5 Solution of the Variational Problems	220
10.1.6 Phase Transitions	223
10.1.7 Outline	224
10.2 Two Extensions	224
10.3 Conclusion	225

10.4	Appendix: Sketch of the Derivation of the Main Theorems	226
10.4.1	Local Times of Random Walk	226
10.4.2	Large Deviations and Growth Rates	228
10.4.3	Relation between the Global and the Local Growth Rate	230
	References	231
Chapter 11. Metastability and Entropy		
	<i>E. Olivieri</i>	233
11.1	Introduction	233
11.2	van der Waals Theory	235
11.3	Curie–Weiss Theory	237
11.4	Comparison between Mean-Field and Short-Range Models	237
11.5	The ‘Restricted Ensemble’	239
11.6	The Pathwise Approach	241
11.7	Stochastic Ising Model. Metastability and Nucleation	241
11.8	First-Exit Problem for General Markov Chains	244
11.9	The First Descent Tube of Trajectories	246
11.10	Concluding Remarks	248
	References	249
Chapter 12. Entropy Production in Driven Spatially Extended Systems		
	<i>C. Maes</i>	251
12.1	Introduction	251
12.2	Approach to Equilibrium	252
	12.2.1 Boltzmann Entropy	253
	12.2.2 Initial Conditions	254
12.3	Phenomenology of Steady-State Entropy Production	254
12.4	Multiplicity under Constraints	255
12.5	Gibbs Measures with an Involution	258
12.6	The Gibbs Hypothesis	261
	12.6.1 Pathspace Measure Construction	262
	12.6.2 Space-Time Equilibrium	262
12.7	Asymmetric Exclusion Processes	263
	12.7.1 MEP for ASEP	263
	12.7.2 LFT for ASEP	264
	References	266
Chapter 13. Entropy: a Dialogue		
	<i>J. L. Lebowitz, C. Maes</i>	269
	References	275

PART 4. ENTROPY AND INFORMATION	277
Chapter 14. Classical and Quantum Entropies: Dynamics and Information	
<i>F. Benatti</i>	279
14.1 Introduction	279
14.2 Shannon and von Neumann Entropy	280
14.2.1 Coding for Classical Memoryless Sources	281
14.2.2 Coding for Quantum Memoryless Sources	282
14.3 Kolmogorov–Sinai Entropy	283
14.3.1 KS Entropy and Classical Chaos	285
14.3.2 KS Entropy and Classical Coding	285
14.3.3 KS Entropy and Algorithmic Complexity	286
14.4 Quantum Dynamical Entropies	287
14.4.1 Partitions of Unit and Decompositions of States	290
14.4.2 CNT Entropy: Decompositions of States	290
14.4.3 AF Entropy: Partitions of Unit	292
14.5 Quantum Dynamical Entropies: Perspectives	293
14.5.1 Quantum Dynamical Entropies and Quantum Chaos	295
14.5.2 Dynamical Entropies and Quantum Information	296
14.5.3 Dynamical Entropies and Quantum Randomness	296
References	296
Chapter 15. Complexity and Information in Data	
<i>J. Rissanen</i>	299
15.1 Introduction	299
15.2 Basics of Coding	301
15.3 Kolmogorov Sufficient Statistics	303
15.4 Complexity	306
15.5 Information	308
15.6 Denoising with Wavelets	311
References	312
Chapter 16. Entropy in Dynamical Systems	
<i>L.-S. Young</i>	313
16.1 Background	313
16.1.1 Dynamical Systems	313
16.1.2 Topological and Metric Entropies	314
16.2 Summary	316
16.3 Entropy, Lyapunov Exponents, and Dimension	317
16.3.1 Random Dynamical Systems	321
16.4 Other Interpretations of Entropy	322
16.4.1 Entropy and Volume Growth	322
16.4.2 Growth of Periodic Points and Horseshoes	323
16.4.3 Large Deviations and Rates of Escape	325
References	327

Chapter 17. Entropy in Ergodic Theory	
<i>M. Keane</i>	329
References	335
Combined References	337
Index	351