

Contents

Part I *Reminiscences: Rolf Hagedorn and Relativistic Heavy Ion Research*

1	Spotlight on Rolf Hagedorn	3
	Johann Rafelski	
1.1	Working with Hagedorn	3
1.2	The Righteous Man	15
1.3	Rolf Hagedorn: Biographical Information	18
2	Rolf Hagedorn: The Years Leading to T_H	21
	Torleif Ericson	
2.1	CERN Theory Division in 1960s	21
2.2	Hagedorn's Path to and at CERN	23
2.3	Appreciation	26
3	Music and Science: Tribute to Rolf Hagedorn	27
	Maurice Jacob	
3.1	Personal Remarks	27
3.2	Contribution to Research	29
3.3	Active Retirement	32
4	On Hagedorn	33
	Luigi Sertorio	
4.1	In Times Past	33
4.2	Wide Field of Interests	35
4.3	Retrospective	36
5	Hungarian Perspective	37
	István Montvay and Tamás Biró	
5.1	Influence Spreads to Hungary	37
5.2	Memories by István Montvay	38
5.3	Tamás Biró Grows up with Hagedorn	39
5.4	Hagedorn Remembered	40

6	The Tale of the Hagedorn Temperature	41
	Johann Rafelski and Torleif Ericson	
6.1	Particle Production	41
6.2	The Statistical Bootstrap Model	42
6.3	Quark-Gluon Plasma	45
7	The Legacy of Rolf Hagedorn: Statistical Bootstrap and Ultimate Temperature	49
	Krzysztof Redlich and Helmut Satz	
7.1	Rolf Hagedorn	49
7.2	The Statistical Bootstrap	51
7.3	The Limiting Temperature of Hadronic Matter	55
7.4	Resonance Gas and QCD Thermodynamics	58
7.5	Resonance Gas and Heavy Ion Collisions	61
7.6	Particle Yields and Canonical Charge Conservation	64
7.7	Concluding Remarks	66
	References	67
8	The Hagedorn Spectrum and the Dual Resonance Model: An Old Love Affair	69
	Gabriele Veneziano	
8.1	A Surprise That Should Not Have Been One	70
8.2	From T_H to the String	71
8.3	Crisis, Reinterpretations	72
8.4	Many Years Later	73
9	Hadronic Matter: The Moscow Perspective	75
	Igor Dremine	
9.1	The Beginning	75
9.2	Hot Hadron Matter	77
9.3	Open Questions	78
	References	80
10	Hagedorn Model of Critical Behavior: Comparison of Lattice and SBM Calculations	81
	Ludwik Turko	
10.1	Rolf Hagedorn: Some Personal Impressions	81
10.2	Critical Behavior of Hadronic Matter	82
10.3	Conclusions	85
	References	86
11	Hagedorn's Hadron Mass Spectrum and the Onset of Deconfinement	87
	Marek Gaździcki and Mark I. Gorenstein	
11.1	Hadron Mass Spectrum and the Hagedorn Temperature	87
11.2	Discovery of the Onset of Deconfinement	88
	References	91

12	Begin of the Search for the Quark-Gluon Plasma	93
	Grazyna Odyniec	
12.1	The Beginning	93
12.2	Quark-Gluon Plasma Discovered	95
13	The Path to Heavy Ions at LHC and Beyond	97
	Hans H. Gutbrod	
13.1	Work at the Bevalac	97
13.2	... and at the SPS	100
13.3	How Heavy Ions Got into LHC and the ALICE Was Born	101
13.4	Future Facilities	104
13.5	Epilogue	105
14	A New Phase of Matter: Quark-Gluon Plasma Beyond the Hagedorn Critical Temperature	107
	Berndt Müller	
14.1	From Hagedorn to Quark-Gluon Plasma	107
14.2	Path to Discovery of the QGP	110
14.3	Outlook and Conclusions	114
	References	114
15	Reminscences of Rolf Hagedorn	117
	Emanuele Quercigh	
15.1	Many Years Ago	117
15.2	The Heavy Ion Era at CERN Begins	118
15.3	Experiments WA85–WA94–WA97–NA57	120
15.4	The Other Hagedorn	121
	References	122
 Part II The Hagedorn Temperature		
16	Boiling Primordial Matter: 1968	125
	Rolf Hagedorn	
16.1	The Large and the Small in the Universe	125
16.2	Highest Temperature = The Boiling Point of Primordial Matter?	131
16.3	Is the Question About the “Final Building Block” Meaningless?	134
17	The Long Way to the Statistical Bootstrap Model: 1994	139
	Rolf Hagedorn	
17.1	Introduction	139
17.2	From 1936 to 1965	141
17.3	The Statistical Bootstrap Model (SBM)	160
17.4	Some Further Remarks	167
17.5	Conclusion	173
	References	176

18	About ‘Distinguishable Particles’	179
	Johann Rafelski	
	18.1 Withdrawn Manuscript	179
	18.2 Note by Rolf Hagedorn of 27 October 1964	180
	18.3 From Distinguishable Hadrons to SBM	181
	18.4 Hagedorn Temperature as a General Physics Concept	182
19	Thermodynamics of Distinguishable Particles: A Key to High-Energy Strong Interactions?	183
	Rolf Hagedorn	
	19.1 Introduction	184
	19.2 Statistical Thermodynamics of Distinguishable Particles	187
	19.3 The Interpretation of the Model	191
	19.4 Speculations on a More Realistic Model	200
	19.5 Summary and Conclusions	214
	Appendix 1	217
	Appendix 2	218
	References	221
20	On the Hadronic Mass Spectrum	223
	Rolf Hagedorn	
	References	228
21	On the Hadronic Mass Spectrum: 2014	229
	Johann Rafelski	
	21.1 Data and Hadron Mass Spectrum	229
	21.2 Quarks and QCD	232
	References	234
22	SBM Guide to the Literature as of June 1972	235
	Rolf Hagedorn	
	References	238
23	Thermodynamics of Hot Nuclear Matter: 1978 in the Statistical Bootstrap Model	241
	Johann Rafelski and Rolf Hagedorn	
	23.1 Introduction	242
	23.2 The Statistical Bootstrap Method in Particle and Nuclear Physics	244
	23.3 Thermodynamics	254
	23.4 Properties of Nuclear Matter in the Bootstrap Model	261
	23.5 Summary	269
	References	270
24	On a Possible Phase Transition Between Hadron Matter and Quark-Gluon Matter: 1981	271
	Rolf Hagedorn	
	24.1 Introduction	271
	24.2 The Grand Canonical Pressure Partition Function	274

24.3	The Hadron Gas	278
24.4	Conclusions	285
	References	286
25	How We Got to QCD Matter from the Hadron Side: 1984	287
	Rolf Hagedorn	
25.1	Introduction	287
25.2	Pre-bootstrap	288
25.3	Early Bootstrap	289
25.4	The Phase Transition: Hadron Matter–Quark Matter	299
	References	304
Part III Melting Hadrons, Boiling Quarks Heavy Ion Path to Quark-Gluon Plasma		
26	How to Deal with Relativistic Heavy Ion Collisions	309
	Rolf Hagedorn	
26.1	Introduction	309
26.2	Collective Motions	310
26.3	Statistical Bootstrap Thermodynamics	319
26.4	Is There Equilibrium in the Relativistic Heavy Ion Collision?	332
26.5	Conclusions	338
	References	339
27	Extreme States of Nuclear Matter: 1980	343
	Johann Rafelski	
27.1	Overview	343
27.2	Thermodynamics of the Gas Phase and the SBM	347
27.3	The Hot Hadronic Gas	353
27.4	The Quark–Gluon Phase	356
27.5	Nuclear Collisions and Inclusive Particle Spectra	361
27.6	Strangeness in Heavy Ion Collisions	367
27.7	Summary	371
	References	373
28	Hot Quark Plasma in ISR Nuclear Collisions: January 1981	375
	Johann Rafelski	
	References	378
29	Possible Experiments with Heavy Ions at the PS/SPS: CERN SPC 1982	379
	Johann Rafelski	
29.1	The Participants	379
29.2	On Formation of QGP in Heavy Ion Collisions	380
29.3	Experimental Opportunities to Study QGP	381
29.4	Discussion on Relativistic Heavy Ion Collisions	383

30 What Happened to ‘Strangeness in Quark-Gluon Plasma: 1982’ 387
 Johann Rafelski

31 Strangeness in Quark–Gluon Plasma – 1982 389
 Johann Rafelski

31.1 Overview 389

31.2 Strangeness Production in the Quark–Gluon Plasma 392

31.3 Equilibrium Chemistry of Strange Particles
 in Hot Nuclear Matter 397

31.4 Discussion 398

References 400

32 Strangeness and Phase Changes in Hot Hadronic Matter – 1983 401
 Johann Rafelski

32.1 Phase Transition or Perhaps Transformation: Hadronic
 Gas and the Quark-Gluon Plasma 401

32.2 Strange Particles in Hot Nuclear Gas 404

32.3 Quark-Gluon Plasma 408

32.4 Strange Quarks in Plasma 412

32.5 How to Discover the Quark–Gluon Plasma 413

References 416

33 Melting Hadrons, Boiling Quarks 417
 Johann Rafelski

33.1 The Concepts: Hadron Side 417

33.2 The Concepts: Quark Side 420

33.3 Quark-Gluon Plasma and Relativistic Heavy Ion Collisions 424

33.4 Hadrons and Quark-Gluon Plasma 427

33.5 Conclusions 437

References 438

Erratum to: Chapter 6: The Tale of the Hagedorn Temperature E1