

Contents

Quark Matter Production in Heavy-Ion Collisions

Carlos Lourenço	1
1 Introduction	1
2 Overview of Heavy-Ion Collisions at the SPS	4
3 Strangeness Production	9
4 Evolution of the Final State	12
5 Low-Mass Dilepton Production	14
6 Intermediate-Mass Dilepton Production	17
7 Charmonia Production and Suppression	21
8 Open-Charm Production	27
9 Future Prospects	27
10 Summary and Conclusions	34
References	35

Theory of High-Energy A+A at RHIC

Miklos Gyulassy	37
1 Introduction	37
2 Geometry and Dynamics in A+A	39
3 Preliminary Results from RHIC	45
3.1 Global Constraints on Initial Conditions	45
3.2 Global Barometric Observable E_T/N_{ch}	49
3.3 Discovery of Jet Quenching	50
3.4 Where Have All the Baryons Gone?	53
3.5 Quenching of Elliptic Flow	58
3.6 Where Did the Slowly Burning Plasma Log Vanish?	59
4 Jet Quenching: Theory	62
4.1 GLV Formalism	63
4.2 Non-Abelian Energy Loss at Finite Opacity	67
4.3 The Opacity of the QGP at RHIC	69
4.4 Jet Tomography from Quenched Elliptic Flow	72
5 Summary	74
References	76

Dense Quark Matter in Compact Stars

Mark Alford	81
1 Introduction	81
1.1 The Fermi Surface and Cooper Instability	81
1.2 The Gap Equation	83
2 Two Massless Quark Flavors	86
3 Three Massless Quark Flavors	88
4 Two Massless + One Massive Quark Flavors	91
4.1 Description of the Phase Diagram	93
4.2 Quark-Hadron Continuity	97
5 Color-Flavor Unlocking and the Crystalline Color Superconducting Phase	98
5.1 The (Un)locking Transition	99
5.2 The Crystalline Color-Superconducting Phase	100
6 Compact Stars and Color-Superconducting Quark Matter	103
6.1 The Mixed Phase	103
6.2 Cooling by Neutrino Emission	105
6.3 The Neutrino Pulse at Birth	106
6.4 r-Mode Instability	107
6.5 Magnetic Field Decay	109
6.6 Glitches and the Crystalline Color Superconductor	110
7 Conclusions	112
References	112

Theory of the Quark-Gluon Plasma

Jean-Paul Blaizot	117
1 Introduction	117
2 The Quark-Hadron Transition in the Bag Model	118
3 Quantum Fields at Finite Temperature	121
3.1 Finite Temperature Calculations	121
3.2 Free Propagators	123
3.3 Classical Field Approximation and Dimensional Reduction	125
4 Effective Theories for the Quark-Gluon Plasma	128
4.1 Scales and Degrees of Freedom in Ultrarelativistic Plasmas	129
4.2 Effective Theory at Scale gT	132
5 Kinetic Equations for the Plasma Particles	133
5.1 One-Loop Polarization Tensor from Kinetic Theory	133
5.2 Kinetic Equations for Quantum Particles	135
5.3 QCD Kinetic Equations and Hard Thermal Loops	138
6 Collective Phenomena in the Quark-Gluon Plasma	140
6.1 Collective Modes	141
6.2 Debye Screening	142
6.3 Landau Damping	143
7 The Entropy of the Quark-Gluon Plasma	143

7.1	Results from Perturbation Theory	144
7.2	Skeleton Expansion for Thermodynamic Potential and Entropy	147
7.3	A Simple Model	149
7.4	Comparison with Thermal Perturbation Theory	152
7.5	Approximately Self-consistent Solutions	155
7.6	Some Results for QCD	156
	References	158

Thermal Gauge Field Theories

	Anton Rebhan	161
1	Overview	161
2	Basic Formulae	162
3	Complex Time Paths	164
	3.1 Imaginary-Time (Matsubara) Formalism	165
	3.2 Real-Time (Schwinger-Keldysh) Formalism	166
4	Gauge Theories – Feynman Rules	168
	4.1 Path Integral – Faddeev-Popov Trick	169
	4.2 Covariant Operator Quantization	170
	4.3 Frozen Ghosts	173
5	Gauge Dependence Identities	174
	5.1 Gauge Independence of the Partition Function	174
	5.2 Gauge Dependence of Green Functions	176
	5.3 Gauge Independence of Propagator Singularities	180
6	Quasiparticles in HTL Perturbation Theory	187
	6.1 Long-Wavelength Plasmon Damping	189
	6.2 NLO Correction to Gluonic Plasma Frequency	189
	6.3 NLO Correction to the Non-Abelian Debye Mass	190
	6.4 Dynamical Damping and Screening	194
	6.5 NLO Corrections to Real Parts of Dispersion Laws	197
7	Conclusions	204
	References	205

Lattice QCD at High Temperature and Density

	Frithjof Karsch	209
1	Introduction	209
2	The Lattice Formulation of QCD Thermodynamics	210
	2.1 The Basic Steps from the Continuum to the Lattice	210
	2.2 ... and Back from the Lattice to the Continuum	213
3	The QCD Phase Diagram at Finite Temperature	215
4	Deconfinement versus Chiral Symmetry Restoration	218
	4.1 Deconfinement	220
	4.2 Chiral Symmetry Restoration	222

5	Screening at High Temperature – Short- Versus Long-Distance Physics	226
6	The QCD Equation of State	228
6.1	High-Temperature Limit of the QCD Equation of State	230
6.2	Thermodynamics of the SU(3) Gauge Theory	231
6.3	Flavour Dependence of the QCD Equation of State	233
7	The Critical Temperature of the QCD Transition	238
8	Finite Density QCD	242
8.1	Quenched Limit of Finite Density QCD	243
9	Conclusions	244
	References	248

Nonperturbative Phenomena and Phases of QCD

	Edward V. Shuryak	251
1	Introduction	251
1.1	An Outline	251
1.2	Scales of QCD	252
2	Chiral Symmetry Breaking and Instantons	253
2.1	Brief History	253
2.2	General Things About Instantons	254
2.3	Zero Modes and the $U(1)_A$ Anomaly	256
2.4	The Effective Interaction Between Quarks	257
2.5	The Quark Condensate in the Mean Field Approximation	259
2.6	The Qualitative Picture of the Instanton Ensemble	260
2.7	Interacting Instantons	263
3	Hadronic Structure and the QCD Correlation Functions	264
3.1	Correlators as a Bridge Between Hadronic and Partonic Worlds	264
3.2	Vector and Axial Correlators	265
3.3	Spin-Zero Correlation Functions	269
3.4	Baryonic Correlation Functions	272
4	The Phases of QCD	274
4.1	The Phase Diagram	274
4.2	Finite-Temperature Transition and Large Number of Flavors .	275
4.3	High Density and Color Superconductivity	277
5	High-Energy Collisions of Hadrons and Heavy Ions	279
5.1	The Little Bang: AGS, SPS and Now the RHIC Era	279
5.2	Collective Flows and EoS	281
5.3	How QGP Happened to Be Produced/Equilibrated So Early?	285
	References	288

The Color Glass Condensate and Small- x Physics

Larry McLerran	291
1 General Considerations.....	291
1.1 Introduction	291
1.2 Total Cross-Sections at Asymptotic Energy	293
1.3 How Are Particles Produced in High-Energy Collisions?	293
1.4 Some Useful Variables	294
1.5 Deep Inelastic Scattering	297
1.6 Heavy-Ion Collisions	302
1.7 Universality	305
2 A Very-High-Energy Nucleus	305
2.1 Approximations and the Color Glass	306
2.2 Light Cone Quantization	309
2.3 Light Cone Gauge QCD	312
2.4 Distribution Functions	313
2.5 The Classical Gluon Field.....	313
2.6 The Structure of the Gluon Field	316
3 Hadron-Hadron Collisions	
and the Initial Conditions for Heavy-Ion Collisions	317
3.1 Phenomenology of Mini-Jets	317
3.2 Classical Description of Hadron Collisions.....	320
3.3 The Form of the Classical Field.....	321
3.4 Numerical Results for Mini-Jet Production.....	323
3.5 pA Scattering	324
3.6 Thermalization	326
4 The Renormalization Group	327
4.1 How to Compute the RG Effective Hamiltonian.....	328
4.2 Quantum Diffusion.....	330
4.3 Some Generic Features	
of the Renormalization Group Equation	331
4.4 Some Limiting Solutions	
of the Renormalization Group Equations.....	331
4.5 Some Speculative Remarks	332
5 Concluding Comments	333
References	334



<http://www.springer.com/978-3-540-43234-0>

Lectures on Quark Matter

Plessas, W.; Mathelitsch, L. (Eds.)

2002, XIV, 338 p., Hardcover

ISBN: 978-3-540-43234-0