

Table of Contents

QCD thermodynamics from the lattice	1
<i>C.E. DeTar and U.M. Heller</i>	
1 Introduction	2
2 Thermodynamics in lattice gauge theory	2
2.1 Quantum partition function.....	2
2.2 Feynman path integral partition function.....	2
2.3 Scalar field example.....	3
2.4 QCD on the lattice	3
2.5 Cutoff effects	7
3 Determining the transition temperature	8
3.1 Polyakov loop and the free energy of color screening	8
3.2 Chiral condensate.....	9
3.3 Other observables	10
3.4 Setting the temperature scale	13
4 QCD phase diagram at zero density	13
4.1 General outline of the phase diagram	13
4.2 Order of the phase transition for physical quark masses.....	14
4.3 Order of the phase transition for two massless flavors	14
4.4 The phase transition with a physical strange quark	15
5 QCD Phase diagram at nonzero densities.....	16
5.1 Phenomenology	16
5.2 Lattice methods for nonzero densities	16
5.3 Curvature of the critical surface.....	20
6 Equation of state	20
6.1 Derivative method	20
6.2 Standard integral method.....	21
6.3 Temperature integral method.....	22
6.4 Step scaling method.....	22
6.5 Equation of state at nonzero densities.....	23
7 In-medium properties of hadrons.....	25
7.1 Spatial string tension.....	25
7.2 Screening masses	25
7.3 Charmonium	26
8 Transport coefficients	28
8.1 Shear and bulk viscosities.....	28
8.2 Dilepton emission and related quantities	28
9 Outlook	29
References	30
 Hadronic parity violation and effective field theory	 35
<i>B.R. Holstein</i>	
1 Introduction	35
2 Parity-conserving NN scattering.....	36
2.1 Conventional analysis.....	36
2.2 Coulomb effects.....	37
2.3 Effective field theory analysis	38

2.4	Coulomb effects in EFT.....	39
2.5	Parity-violating NN interaction: potential model description.....	40
2.6	Parity-violating NN interaction: EFT description.....	42
3	Danilov parameters.....	44
4	Experimental program.....	48
5	Future initiatives.....	52
6	Conclusions.....	52
	References.....	53
Cosmic microwave background and first molecules in the early Universe.....		55
<i>M. Signore and D. Puy</i>		
1	Elements of cosmology.....	56
1.1	Space-time geometry of cosmological models.....	58
1.2	Dynamics of cosmological models.....	58
1.3	Some Friedmann models.....	59
1.4	Inflation: a solution to the problems of the standard big-bang model.....	60
2	Decoupling particles in the early universe.....	62
2.1	Thermal equilibrium in the early universe.....	63
2.2	Thermal relics.....	65
3	Primordial nucleosynthesis.....	67
3.1	Standard big-bang nucleosynthesis.....	67
3.2	Observations of primordial abundances.....	70
3.3	On non-standard BBN models.....	73
3.4	Conclusions.....	73
4	The cosmic microwave background spectrum.....	73
4.1	On the thermal nature of the CMB spectrum.....	73
4.2	On observations of the CMB spectrum.....	75
4.3	Thermalization.....	77
4.4	Spectral distortions of CMB radiation.....	78
5	Cosmological recombination.....	79
5.1	Recombination of hydrogen and deuterium.....	79
5.2	Recombination of helium.....	80
5.3	Recombination of lithium.....	80
6	Standard chemistry.....	80
6.1	Helium chemistry.....	80
6.2	Hydrogen chemistry.....	81
6.3	Deuterium chemistry.....	81
6.4	Lithium chemistry.....	81
6.5	Equations of evolution.....	81
6.6	Results of thermochemistry.....	82
7	The CMB dipole anisotropy.....	86
7.1	The prediction of the dipole anisotropy.....	86
7.2	The observation of the dipole anisotropy.....	87
7.3	The physical origin of the dipole anisotropy.....	88
7.4	Conclusions.....	88
8	Cosmic microwave background anisotropies (CMBA).....	89
8.1	CMB observables.....	89
8.2	Thomson scattering.....	90
8.3	Acoustic oscillations in the photon–baryon fluid.....	91
8.4	Polarization anisotropies.....	94
8.5	Secondary anisotropies.....	95

9	Cosmic microwave background anisotropies and primordial molecules.....	97
9.1	Imprint from primordial chemistry on CMB	97
9.2	On the primordial molecular clouds	99
9.3	Observational situation	100
10	Past and future observations: COBE, WMAP, PLANCK	100
10.1	The Cosmic Background Explorer COBE.....	100
10.2	The balloon observations of millimetric extragalactic radiation and geophysics BOOMERANG.....	101
10.3	The Wilkinson Microwave Anisotropy Probe WMAP	103
10.4	The future: the PLANCK satellite	104
10.5	The HERSCHEL and ODIN satellite.....	105
11	Summary.....	106
	References.....	107
The 2009 world average of α_s		111
Siegfried Bethke		
1	Introduction	111
2	Theoretical basics	112
2.1	Energy dependence of α_s	112
2.2	Quark threshold matching.....	113
2.3	Perturbative predictions of physical quantities	115
2.4	Renormalisation.....	115
2.5	Non-perturbative methods	116
3	Measurements of α_s	117
3.1	α_s from τ -lepton decays.....	117
3.2	α_s from heavy quarkonia.....	118
3.3	α_s from deep inelastic scattering.....	118
3.4	α_s from hadronic event shapes and jet production in e^+e^- annihilation.....	119
3.5	α_s from electroweak precision data	120
4	The 2009 world average of $\alpha_s(M_Z^0)$	121
4.1	Numerical procedure.....	121
4.2	Determination of the world average	122
5	Summary and discussion	123
	References.....	124