

CONTENTS

FOREWORD	v
CHAPTER 1. THE STANDARD COSMOLOGICAL MODEL	1
1.1 The Cosmological Principle	3
1.2 Einstein's equations	6
1.3 Some results from Relativistic Kinetic Theory	16
1.4 Thermal history of the universe	19
References 1	30
CHAPTER 2. DETERMINATION OF THE COSMOLOGICAL PARAMETERS	31
2.1 The red-shift	32
2.2 The determination of the Hubble constant and the deceleration parameter	34
2.3 Determination of the density parameter	41
References 2	51
CHAPTER 3. THE COSMIC MICROWAVE BACKGROUND	53
3.1 The spectrum of the cosmic microwave background	54
3.1.1 Standard cosmological model predictions	54
3.1.2 Observations	59
3.2 Angular distribution of the microwave background	61
radiation	
3.2.1 The peculiar velocity of the observer	61
3.2.2 The horizon problem	64
3.2.3 Observations	66
References 3	70

CHAPTER 4. THE STANDARD BIG-BANG NUCLEOSYNTHESIS	71
4.1 The primordial nucleosynthesis process in standard cosmologies	72
4.2 Predicted abundances and their uncertainties	79
4.3 Observed abundances	84
4.3.1 Deuterium	84
4.3.2 Helium 3	88
4.3.3 Helium 4	89
4.3.4 Lithium 7	93
4.4 Primordial abundances and consistency theory/ astronomical data	94
References 4	101
CHAPTER 5. LARGE SCALE STRUCTURE FORMATION	103
5.1 Characteristic masses	104
6.1.1 Jeans mass for a photon, baryon, electron and massless neutrino gas	105
5.1.2 Silk mass	106
5.1.3 Joann mass for massive collisionless particles ..	109
6.2 Observations	118
5.3 Linear theory of perturbation% to FRW model	128
5.3.1 Equations for the perturbations	129
5.3.2 Ideal fluid	132
5.3.3 Collisionless gas	135
5.3.4 Photon gas near the recombination	137
5.3.5 General resolution method and normalization	138
6.4 Transfer functions and coherence lengths	143
6.5 Cosmic microwave background anisotropies	147
5.5.1 Small scale anisotropies	148
5.5.2 Large scale CMB fluctuations: gauge invariant formalism	150
5.6.3 Results	163
5.6 Large scale peculiar velocities	155
5.7 N-body simulations	157
5.8 Biased structure formation scenario	162
References 5	165

CHAPTER 6. SOME COSMOLOGICAL LIMITS ON THE PARAMETER OF EXOTIC PARTICLES 168

6.1 Evolution of the concentration of massive particles 169

6.2 Light element yields with noni-standard particles content 177

6.3 Distortion of the cosmic background radiation by decaying particles 182

6.4 Cosmological bounds on massive neutrinos 186

 6.4.1 The mean density of the universe 186

 6.4.2 Massive neutrinos and light element abundances . . 188

 6.4.3 Cosmic microwave background distortions 192

6.5 Cosmological limits on the microphysical parameters of light particles 192

 6.5.1 Bounds on the number of weakly interacting particles 192

 6.5.2 Bounds on the mass of light neutrinos 195

 6.5.3 The chemical potential of neutrinos 196

6.6 Cosmological limits for supersymmetric particles 200

References 6 207

CHAPTER 7. FINITE TEMPERATURE EFFECTIVE POTENTIAL AND PHASE TRANSITIONS 209

7.1 General formalism 210

7.2 Finite temperature Green functions 213

 7.2.1 Spinless fields 213

 7.2.2 Fermion fields 216

 7.2.3 Feynman rules 217

7.3 Finite temperature effective potential for spinless particles 218

7.4 Finite temperature effective potential for fermion fields 223

7.5 Finite temperature effective potential for gauge fields 229

7.6 Finite temperature effective potential for a general theory 232

7.7	Phase transitions in field theories	234
7.7.1	A toy model	235
7.7.2	SU(5) Coleman-Weinberg potential	239
	Reference 7	243
CHAPTER 8.	PROBLEMS OF THE STANDARD BIG-BANG MODEL	244
8.1	Introduction	244
8.2	The flatness (oldness) problem	245
8.3	The horizon problem	249
8.4	A solution to the flatness and horizon problems: inflationary universe scenarios	254
8.4.1	Inflation solves the horizon problem	257
8.4.2	Inflation solves the flatness problem	259
8.5	Other problems of the standard cosmological model	262
8.5.1	Small-scale inhomogeneity and galaxy formation	262
8.5.2	The domain wall problem	264
8.5.3	The baryon number of the universe	265
8.5.4	The cosmological constant problem	270
8.6	Baryogenesis	272
8.6.1	The standard out-of-equilibrium decay scenario	275
8.6.2	Baryogenesis in Grand Unified Theories	282
	References 8	294
CHAPTER 9.	THE DYNAMICS OF INFLATION	297
9.1	Introduction	297
9.2	The Hawking temperature	300
9.3	The dynamics of first-order phase transitions	308
9.3.1	Semiclassical theory of false vacuum decay	309
9.3.2	Gravitational effects on false vacuum decay	322
9.3.3	The Hawking-Moss transition	329

9.4	The slow rollover regime	336
9.5	Coherent field oscillations and reheating	342
9.6	Energy density perturbations and galaxy formation	350
	References 9	366
CHAPTER 10. INFLATIONARY MODELS		368
10.1	Nearly Coleman-Weinberg models	368
10.2	Inflation cries out for supersymmetry	377
10.3	Primordial inflation in supergravity	380
	10.3.1 Inflationary models in minimal supergravity	386
	10.3.2 Inflationary models in no-scale supergravity	392
10.4	Chaotic inflation	406
10.5	Double inflation	411
	References 10	420
APPENDIX		422
	Conversion factors in natural units and some cosmological constants	