

Contents

1	Introduction	1
	Mauro D’Onofrio and Carlo Burigana	
2	Fundamental Cosmological Observations and Data Interpretation	7
	Contributions by Matthias Bartelmann, Charles L. Bennett, Carlo Burigana, Cesare Chiosi, Mauro D’Onofrio, Alan Dressler, Isabella Gioia, Günther Hasinger, Juan Francisco Macias-Perez, Piero Madau, Paola Marziani, John Mather, Francesca Matteucci, Keith Olive, John Peacock, Wolfgang Reich, Pierre-Marie Robitaille, Michael Rowan-Robinson, Gary Steigman, Matthias Steinmetz, Jack W. Sulentic, Massimo Turatto, and Simon D.M. White	
2.1	Outline of the Chapter	7
2.2	From CDM to Λ CDM Paradigm	10
2.3	Type Ia SNe as Probe of the Paradigm Shift	12
2.4	SNe Physics and the Λ CDM Scenario	16
2.5	Cosmology with Quasars	22
2.5.1	The Challenge	22
2.5.2	Exploiting Quasar Variability	25
2.5.3	Quasar Diversity and Quasar Evolution	26
2.5.4	The Baldwin Effect	27
2.5.5	Exploiting the Luminosity-to-Mass Ratio	29
2.5.6	Guessing Further... ..	30
2.6	The Heretical View on Cosmological Redshifts	33
2.6.1	On the Wolf Effect	36
2.6.2	Anomalies with Quasars?	37
2.7	Cosmological Nucleosynthesis	42
2.7.1	Theory of Cosmological Nucleosynthesis	42
2.7.2	Tests of Cosmological Nucleosynthesis	51
2.7.3	Alternatives to Standard BBN	56
2.8	CMB Observations and Main Implications	56
2.8.1	The COBE Legacy	56
2.8.2	WMAP	65

2.8.3	Balloon-borne Experiments	75
2.8.4	Far-IR Foreground	77
2.8.5	Interstellar Medium	85
2.8.6	Radio Foregrounds	87
2.8.7	A Radically Different Point of View on the CMB	93
2.9	Cosmological Information from X-Ray Astronomy	108
2.9.1	Evolution of LSS and Nucleosynthesis	108
2.9.2	Coeval Evolution of Galaxies and Their Supermassive BHs	110
2.10	First Structures	114
2.10.1	Preamble	115
2.10.2	The Dark Age and the Emergence of Cosmic Structure ..	117
2.10.3	High Redshift Quasars and BH Feedback	122
2.11	Galaxy Clusters, The Largest Self-gravitating Structures of the Universe	124
2.12	A Multifrequency View of Galaxy Clusters	131
2.12.1	Clusters of Galaxies: An Introduction	132
2.12.2	Clusters of Galaxies in X-Rays	133
2.12.3	Clusters of Galaxies as Cosmological Tools	137
2.13	Dark Matter in Modern Cosmology	144
2.13.1	Issues of the CDM Scenario	146
2.14	Lensing	152
2.15	Constraints on the Universe Age from Stellar Evolution	159
2.15.1	The Very First Generation: PopIII	160
2.15.2	Ages from Star Clusters	160
2.15.3	Ages from Integrated Properties	166
2.16	The Distance Scale, A Road Towards Modern Cosmology	171
2.16.1	HST Key Program	174
2.16.2	Type Ia Supernovae	174
	References	179
3	Astrophysical Cosmology	203
	Contributions by Amedeo Balbi, Charles L. Bennett, Martin Bucher, Carlo Burigana, Peter Coles, Mauro D’Onofrio, Ruth Durrer, John Mather, Pavel Naselsky, Francesca Perrotta, Lucia A. Popa, David Spergel, Kandaswamy Subramanian, and Nicola Vittorio	
3.1	Outline of the Chapter	203
3.2	Inflation	205
3.3	Topological Defects	211
3.3.1	Imprints on the CMB	215
3.3.2	Non-Gaussian Anisotropies	220
3.4	Adiabatic vs. Isocurvature Perturbations	222
3.5	CMB Theory	225
3.5.1	Implications of CMB Spectrum Observations	225

3.5.2	CMB Anisotropy	228
3.5.3	Cosmological Parameters from WMAP	238
3.5.4	Geometry of the Universe	240
3.6	The Ionization History	245
3.6.1	Recombination	246
3.6.2	Reionization	254
3.6.3	Alternative Ionization Histories	256
3.7	Large Scale Structure	262
3.7.1	Baryon Acoustic Oscillations	268
3.7.2	Large Scale Structure Through Simulations	270
3.8	Neutrino Physics and Its Cosmological Implications	273
3.9	Cosmic Magnetism	278
3.9.1	The Magnetic Universe	279
	References	289
4	From Galileo to Modern Cosmology: Alternative Paradigms and Science Boundary Conditions	301
	Contributions by Carlo Burigana, Salvatore Capozziello, Cesare Chiosi, Mauro D’Onofrio, Malcolm Longair, Philip Mannheim, Paola Marziani, Moti Milgrom, Keith Olive, Thanu Padmanabhan, John Peacock, Francesca Perrotta, Luisa Pigatto, Rafael Rebolo, Luigi Secco, Jack W. Sulentic, Gerard t’Hooft, and Simon D.M. White	
4.1	Outline of the Chapter	301
4.2	Remembering Galileo	303
4.3	Galileo’s Lesson Today	316
4.4	Tests of General Relativity	319
4.5	Cosmological Constant	323
4.5.1	Historical Overview	323
4.5.2	The Problem of Theoretical Physics	324
4.6	Dark Energy Models	333
4.6.1	Dark Energy Candidates	336
4.6.2	Dark Energy and Inflation Analogies?	342
4.7	Alternatives to Standard Gravity Theories	343
4.7.1	MOND	344
4.7.2	$f(R)$ Theories	353
4.7.3	DE as a Curvature Effect	354
4.7.4	DM as a Curvature Effect	359
4.7.5	Conformal Gravity	365
4.8	Early Universe: Connecting Particle Physics and Cosmology	382
4.9	Constants in Physics?	386
4.10	On the Anthropic Principles	391
4.10.1	Cosmological Principle	391
4.10.2	Modern Cosmology and Center of the Universe	392
4.10.3	The Large Numbers Puzzle	393

4.10.4	Anthropic Principle	394
4.10.5	Growth of Complexity	396
4.10.6	The Fine Tuned Expansion	397
4.10.7	Carbon and Oxygen Nucleosynthesis	398
4.11	Many-Universes	399
4.12	Science and Society and Self-Organization of Astrophysical Community	401
4.12.1	Comments on Sociological and Economical Influences ..	401
4.12.2	Comments on Astrophysical Community Self-Organization	405
4.13	Boundary Condition for Astrophysics Development: A Modern Example	413
4.13.1	Astronomy in the Canaries	415
4.13.2	Cosmology in the Canaries	418
	References	420
5	Next Challenges	429
	Contributions by Matthias Bartelmann, Charles L. Bennett, Martin Bucher, Carlo Burigana, Massimo Capaccioli, Mauro D’Onofrio, Ruth Durrer, Isabella Gioia, Günther Hasinger, Charles Lawrence, Giuseppe Longo, Juan Francisco Macias-Perez, Piero Madau, John Mather, John Peacock, Lucia A. Popa, Rafael Rebolo, Wolfgang Reich, Matthias Steinmetz, Massimo Turatto, and Simon D.M. White	
5.1	Outline of the Chapter	429
5.2	New Perspectives from Radio Astronomy	431
5.2.1	New Radio Telescopes Trace the Epoch of Reionization .	432
5.3	New Perspectives in CMB Cosmology	435
5.3.1	Ideas for New Spectrum Experiments	435
5.3.2	The Future of CMB Experiments: Ground vs. Space?	438
5.3.3	<i>Planck</i> , A Forthcoming Space Mission	439
5.3.4	Surveys to Map Dust Foreground Emission	451
5.3.5	Beyond Planck	452
5.4	Perspectives from New Galaxy Surveys	458
5.4.1	Ground-based Optical Surveys and Related Technological Aspects	461
5.5	New Key Observations Dedicated to the First Structures	473
5.6	N-Body Simulations	474
5.7	Future Perspectives from SNe	478
5.8	New Perspectives in High Energy Astrophysics and Galaxy Clusters.....	480
5.9	Cosmological Expectations from Lensing	486
5.10	Future Tests for Topological Defects.....	489
5.10.1	What are the Characteristics of Lensing by Cosmic Strings?	490

5.10.2	Would Cosmic Strings Lead to an Observable Gravitational Wave Background?	491
5.11	New Perspectives for Neutrino from Astrophysical Cosmology ...	493
	References	496
6	Concluding Remarks	503
	Mauro D’Onofrio and C. Burigana	
	Web Pages	515
	Further Reading	521
	Index	525



<http://www.springer.com/978-3-642-00791-0>

Questions of Modern Cosmology

Galileo's Legacy

D'Onofrio, M.; Burigana, C. (Eds.)

2009, XXX, 530 p., Hardcover

ISBN: 978-3-642-00791-0