

Contents

	<i>Acknowledgements</i>	<i>page vii</i>
1	Introduction	1
2	Early history of the dark matter hypothesis	11
	2.1 Prehistory	11
	2.2 Zwicky and the modern concept of dark matter	12
	2.3 Dark matter on galaxy scales	15
	2.4 Radio astronomy: a new tool for galactic astronomy	20
	2.5 Finzi sums it up	23
3	The stability of disk galaxies: the dark-halo solution	26
	3.1 Building disk galaxies: too hot to be real	26
	3.2 Dark halos to the rescue	30
	3.3 Larger implications	34
4	Direct evidence: extended rotation curves of spiral galaxies	38
	4.1 Radio telescopes: single-dish and interferometers	38
	4.2 Early results of single-dish neutral hydrogen observations	44
	4.3 Early observations of spiral galaxies with radio interferometers	48
	4.4 Flat rotation curves: perception approaches reality	51
5	The maximum-disk: light traces mass	57
	5.1 Reaction follows revolution	57
	5.2 The anomaly exists beyond the visible disk	62
	5.3 Low-surface-brightness galaxies and sub-maximal disks	65
	5.4 Reflections on observations of rotation curves	67
6	Cosmology and the birth of astroparticle physics	69
	6.1 A brief history of modern cosmological models	69
	6.2 Structure formation: dark matter again to the rescue	72
	6.3 Some like it hot, most like it cold, all like it in the pot 10 billion years old	76

6.4	What is the matter?	80
6.5	A new paradigm: standard CDM	84
7	Clusters revisited: missing mass found	87
7.1	The reality of the cluster discrepancy	87
7.2	Hot gas in clusters of galaxies	88
7.3	Gravitational lensing: a new method for probing cluster mass distribution	93
7.4	The Bullet	98
8	CDM confronts galaxy rotation curves	101
8.1	What do rotation curves require of dark matter?	101
8.2	Global scaling relations	105
8.3	Structure formation in a CDM universe	106
8.4	The mass distribution in CDM dark halos	109
8.5	Substructure in CDM halos	113
8.6	The Tully–Fisher law	115
8.7	Can CDM be falsified by galaxy phenomenology?	117
9	The new cosmology: introducing dark energy	119
9.1	The accelerated expansion of the Universe	119
9.2	COBE finds the primordial fluctuations	124
9.3	What do we see in the CMB?	125
9.4	Boomerang to WMAP: the age of precision cosmology	127
9.5	Reflections	130
10	An alternative to dark matter: modified Newtonian dynamics	132
10.1	Naive modifications of Newtonian attraction	132
10.2	MOND	133
10.3	MOND and hot galaxies	138
10.4	MOND and rotation curves	140
10.5	The problem of clusters	143
10.6	Relativistic MOND: TeVeS	144
10.7	Summing up: MOND vs. dark matter	147
11	Seeing dark matter: the theory and practice of detection	150
11.1	Non-gravitational detection of dark matter	150
11.2	The practice of direct detection	152
11.3	Indirect detection of dark matter	159
11.4	Light on dark matter: the story so far	165
12	Reflections: a personal point of view	166
	<i>Appendix Astronomy made simple</i>	173
	<i>References</i>	195
	<i>Index</i>	202