

CONTENTS

INTRODUCTION

I

CHAPTER 1 THE MILKY WAY – OUR GALAXY

3

1.1	Introduction	3
1.2	An overview of the Milky Way	4
1.3	The mass of the Milky Way	14
1.4	The disc of the Milky Way	20
1.5	The stellar halo and bulge of the Milky Way	33
1.6	The evolution of the Milky Way	44
1.7	Summary of Chapter 1	49

CHAPTER 2 NORMAL GALAXIES

53

2.1	Introduction	53
2.2	The classification of galaxies	53
2.3	The determination of the properties of galaxies	65
2.4	The determination of the distances of galaxies	72
2.5	The formation and evolution of galaxies	87
2.6	Summary of Chapter 2	106

CHAPTER 3 ACTIVE GALAXIES

111

3.1	Introduction	111
3.2	The spectra of galaxies	112
3.3	Types of active galaxies	124
3.4	The central engine	134
3.5	Models of active galaxies	143
3.6	The origin and evolution of active galaxies	152
3.7	Summary of Chapter 3	155

CHAPTER 4 THE SPATIAL DISTRIBUTION OF GALAXIES

159

4.1	Introduction	159
4.2	The Local Group of galaxies	159
4.3	Clusters of galaxies	161
4.4	The large-scale distribution of matter	178
4.5	The formation of clusters and large-scale structure	190
4.6	Summary of Chapter 4	192

CHAPTER 5 INTRODUCING COSMOLOGY – THE SCIENCE OF THE UNIVERSE

195

5.1	Introduction	195
5.2	The nature of the Universe	195
5.3	Modelling the Universe	203
5.4	The key parameters of the Universe	222
5.5	Summary of Chapter 5	236

CHAPTER 6 BIG BANG COSMOLOGY – THE EVOLVING UNIVERSE	239
6.1 Introduction	239
6.2 The thermal history of the Universe	241
6.3 The early Universe	252
6.4 Nucleosynthesis and the abundance of light elements	266
6.5 Recombination and the last scattering of photons	275
6.6 Gravitational clustering and the development of structure	284
6.7 Summary of Chapter 6	289
CHAPTER 7 OBSERVATIONAL COSMOLOGY – MEASURING THE UNIVERSE	293
7.1 Introduction	293
7.2 Measuring the Hubble constant, H_0	294
7.3 Measuring the current value of the deceleration parameter, q_0	301
7.4 Cosmology from the cosmic microwave background	307
7.5 The concordance cosmology	326
7.6 Summary of Chapter 7	335
CHAPTER 8 QUESTIONING COSMOLOGY – OUTSTANDING PROBLEMS ABOUT THE UNIVERSE	337
8.1 Introduction	337
8.2 The nature of dark matter	338
8.3 The nature of dark energy	343
8.4 The horizon and flatness problems	347
8.5 The origin of structure	350
8.6 The matter of antimatter	352
8.7 The very early Universe	353
8.8 The anthropic Universe	356
8.9 Epilogue	358
8.10 Summary of Chapter 8	359
ANSWERS AND COMMENTS	361
APPENDIX	398
GLOSSARY	401
FURTHER READING	420
ACKNOWLEDGEMENTS	421
FIGURE REFERENCES	427
INDEX	432