Contents

Preface  IX
Abbreviations and Acronyms  XI
Astronomical and Physical Constants  XV
Color Plates  XVII

1 The Observational Picture of AGN  1
1.1 From Welteninseln to AGN  1
1.2 Broad Lines, Narrow Lines, and the Big Blue Bump  3
1.3 Jets and Other Outflows  4
1.4 X-ray Observations: Probing the Innermost Regions  5
1.5 Up, Up and Away: from Gamma-Rays toward the TeV Range  7

2 Radiative Processes  11
2.1 Scattering of Photons  11
2.1.1 Thomson Scattering  11
2.1.2 Compton Scattering  12
2.1.3 Inverse Compton Scattering  15
2.1.4 Thermal Bremsstrahlung  17
2.1.5 Pair Production  20
2.2 Synchrotron Emission  21
2.2.1 Synchrotron Emission of a Particle Plasma  25
2.2.2 Polarization  27
2.2.3 Faraday Rotation  28
2.2.4 Synchrotron Self-Absorption  29
2.2.5 Synchrotron Self-Compton  32

3 The Central Engine  35
3.1 The Black Hole  35
3.1.1 Approaching a Black Hole  36
3.1.2 Evidence for Black Holes in AGN  37
3.1.3 Gravitational Field Near a Black Hole: the Schwarzschild Metric  42
3.1.4 Rotating Black Holes: the Kerr Metric  43
3.2 Accretion Processes  44
5.7 VHE: the Evolving Domain 182
5.7.1 The High-Energy End of the Spectrum 188
5.8 The Whole Picture: the Spectral Energy Distribution 188
5.8.1 SED of Blazars: a Whole Different Story 191
5.8.1.1 The One-Zone Model 193
5.8.1.2 External Compton Scattering 197
5.8.2 The Spectral Energy Distribution of Nonbeamed Sources 200
5.8.2.1 The Synchrotron Branch 201
5.8.2.2 Dust in the SED 202
5.8.2.3 The Disk Component 203
5.8.2.4 The Inverse Compton Branch 205

6 AGN Variability 209
6.1 Variability in Radio-Quiet AGN 209
6.2 Analysis Methods for Variability Studies 212
6.3 Variability of Radio-Loud AGN 220
6.4 Quasiperiodic Oscillations in AGN 225
6.5 Rapid Variability 228

7 Environment 231
7.1 Host Galaxies of AGN 231
7.1.1 Are There Naked Black Holes? 232
7.1.2 Morphological Classification of Galaxies 232
7.1.3 Host Galaxy and Black Hole Mass 237
7.1.4 AGN-Host Galaxy Feedback 240
7.2 The AGN–Starburst Connection 242
7.2.1 Estimating the Star-Formation Rate 243
7.2.2 AGN–Starburst Feedback 244
7.3 Merging 247
7.4 AGN in Clusters of Galaxies 252

8 Quasars and Cosmology 259
8.1 The Universe We Live in 259
8.1.1 Geometry and Distances 260
8.1.2 Measuring Fluxes 265
8.1.3 The Three-Component Universe 267
8.1.4 From the Big Bang to the Cosmic Microwave Background 269
8.1.5 The Dark Matter Universe 271
8.2 AGN and the Distribution of Matter on Large Scales 272

9 Formation, Evolution and the Ultimate Fate of AGN 281
9.1 The First AGN: How Did They Form? 281
9.2 Tools to Study AGN Evolution 286
9.2.1 The Number-Flux Relation 286
9.2.2 The $V/V_{\text{max}}$ Test 288
9.2.3 Luminosity Function 290
9.3 Luminosity Functions of AGN 294
9.4 AGN and the Cosmic X-ray Background  300
9.5 The Late Stages of an AGN’s Life and Reignition SMBH  304

10 What We Don’t Know (Yet)  307
10.1 The Central Engine  307
10.2 Environment, Interaction, and Feedback  311
10.3 Origin, Evolution, and Fate  312
10.4 Continuing the Quest  313

References  315

Index  347