

# Contents

## Part I Physical Processes

<b>1</b>	<b>The Framework</b>	3
1.1	Sources	3
1.2	The Parameter Space of High-Energy Astrophysics	4
1.3	High-Energy Space Instrumentation and Their Limitations	9
1.3.1	Basic Principles of X-Ray Detectors	9
1.3.2	Spectral and Image Extraction, Fitting	10
1.3.3	Optics	12
1.3.4	Some Recent High-Energy Astrophysics Instruments and Satellites	14
1.4	Historical Remarks	15
1.5	Bibliography	20
	References	20
<b>2</b>	<b>Radiation of an Accelerated Charge</b>	21
2.1	Energy Loss by a Non-relativistic Accelerated Charge	21
2.2	Spectrum of the Radiation	23
2.3	Radiation of a Relativistic Accelerated Particle	25
2.4	Relativistic Aberration	27
2.5	Bibliography	29
	References	29
<b>3</b>	<b>Bremsstrahlung</b>	31
3.1	Emission from Isolated Electron–Ion Pairs	32
3.2	Electron Distribution: The Impact Parameter	33
3.3	Electron Distributions: Thermal Bremsstrahlung	34
3.4	Line Emission	36
3.5	Example: Clusters of Galaxies	39
3.6	Bibliography	44
	References	46

<b>4</b>	<b>Cyclotron Line Emission</b> .....	47
4.1	Gyro Frequency .....	47
4.2	Emitted Power .....	49
4.3	Observed Cyclotron Features .....	51
4.4	Bibliography .....	55
	References .....	55
<b>5</b>	<b>Synchrotron Emission</b> .....	57
5.1	Power Emitted by a Single Electron in a Magnetic Field .....	57
5.2	Synchrotron Characteristic Frequency .....	58
5.3	Spectrum Emitted by a Population of Electrons .....	62
5.3.1	Synchrotron Self-absorption .....	63
5.4	Examples .....	65
5.4.1	The Infrared Emission of the Quasar 3C 273 .....	65
5.4.2	Far Infrared Emission of Radio-Quiet Active Galaxies ...	66
5.4.3	The Crab Nebula .....	70
5.5	Bibliography .....	73
	References .....	73
<b>6</b>	<b>Compton Processes</b> .....	75
6.1	Thomson Cross Section .....	75
6.2	Compton Scattering .....	77
6.3	Power Emitted by a Single Electron .....	82
6.4	Power Emitted by a Distribution of Electrons .....	83
6.5	Energy Gains Per Scattering .....	84
6.5.1	Non-relativistic Electrons .....	84
6.5.2	Relativistic Electrons .....	85
6.6	Multiple Scattering in an Optically-Thin Limit .....	86
6.7	Example: X-Ray Emission of AGN .....	86
6.8	Bibliography .....	89
	References .....	89
<b>7</b>	<b>Comptonisation</b> .....	91
7.1	Compton Temperature .....	91
7.2	The $y$ Parameter .....	92
7.3	The Kompaneets Equation .....	93
7.4	Solutions to the Kompaneets Equation .....	94
7.4.1	Equilibrium Solution .....	94
7.4.2	Saturated Comptonisation: $y \gg 1$ .....	95
7.4.3	Intermediary Case, $y \simeq 1$ .....	96
7.4.4	Low Optical Depth .....	96
7.5	The Sunyaev–Zeldovich Effect .....	96
7.6	Bibliography .....	103
	References .....	103

<b>8</b>	<b>Pair Processes</b> .....	105
8.1	Pair Creation .....	105
8.2	Pair Annihilation .....	108
8.3	Bibliography .....	109
	References .....	109
<b>9</b>	<b>Particle Acceleration</b> .....	111
9.1	Second-Order Fermi Acceleration .....	114
9.2	Diffusive Shock Acceleration .....	116
9.3	Highest Energy Particles .....	119
9.4	Bibliography .....	123
	References .....	123
<b>10</b>	<b>Accretion</b> .....	125
10.1	Eddington Luminosity and Accretion Rate .....	125
10.2	Spherically-Symmetric Accretion .....	127
10.3	Geometrically-Thin Optically-Thick Accretion Disks .....	130
10.3.1	Conservation of Mass .....	131
10.3.2	Conservation of Angular Momentum .....	132
10.3.3	Stationary Disks .....	134
10.3.4	Spectrum of the Disk .....	136
10.3.5	Viscosity .....	138
10.4	Observational Evidence for Geometrically-Thin Optically-Thick Accretion Disks .....	139
10.5	Bibliography .....	143
	References .....	143
<b>11</b>	<b>Radiation Inefficient Accretion Flows</b> .....	145
11.1	Advection-Dominated Accretion Flows (ADAFs) .....	145
11.2	Spectrum of an ADAF .....	148
11.3	The Galactic Centre and the Source Sgr A* .....	148
11.4	Bibliography .....	154
	References .....	154

## Part II Astrophysical Objects

<b>12</b>	<b>Black Holes and Accretion Efficiency</b> .....	157
12.1	Metric and Index Gymnastics .....	158
12.2	Relativistic Hydrostatic Equilibrium .....	159
12.3	Schwarzschild Metric .....	163
12.4	Particle Motion Around Schwarzschild Black Holes .....	165
12.5	Trajectories of Massive Particles in the Schwarzschild Geometry .....	169
12.5.1	Radial Geodesics of Massive Particles .....	170
12.5.2	Non-radial Orbits .....	173
12.6	Kerr Black Holes .....	177
12.6.1	Relativistically-Broadened Emission Lines .....	183

12.7	Energy Gain from a Kerr Black Hole .....	185
12.8	Black Hole Radiation .....	186
12.9	Bibliography .....	188
	References .....	189
<b>13</b>	<b>Neutron Stars .....</b>	<b>191</b>
13.1	Neutron Star Equation of State .....	192
13.1.1	The Harrison–Wheeler Equation of State .....	194
13.1.2	Structure of Neutron Stars .....	199
13.1.3	The Maximum Mass of a Neutron Star .....	199
13.2	Bibliography .....	201
	References .....	203
<b>14</b>	<b>Pulsars .....</b>	<b>205</b>
14.1	Basic Observational Facts .....	205
14.1.1	Periods and their Derivatives .....	205
14.1.2	The Nature of Pulsars .....	206
14.1.3	Glitches .....	209
14.1.4	Distances to Pulsars .....	209
14.1.5	Pulsar Distribution in the Galaxy .....	212
14.2	Magnetic Dipole Model .....	212
14.2.1	Pulsar Ages .....	215
14.3	The Aligned Rotator and the Pulsar Magnetosphere .....	217
14.3.1	Maximum Particle Energy .....	219
14.4	Radio Quiet Pulsars .....	222
14.5	Bibliography .....	224
	References .....	224
<b>15</b>	<b>The Hulse–Taylor Pulsar and Gravitational Radiation .....</b>	<b>225</b>
15.1	Binary Pulsar Systems .....	226
15.2	Direct Detection of Gravitational Waves .....	230
15.3	Bibliography .....	232
	References .....	233
<b>16</b>	<b>X-Ray Binaries .....</b>	<b>235</b>
16.1	Populations of X-Ray Sources .....	235
16.2	Classification of X-Ray Binaries .....	237
16.3	High-Mass X-Ray Binaries, the X-Ray Pulsars .....	240
16.4	Low-Mass X-Ray Binaries (LMXB) .....	246
16.4.1	Bursts .....	249
16.5	Black Hole Candidates .....	255
16.5.1	Dynamical Evidence in X-Ray Binaries .....	255
16.5.2	Intrinsic Signatures .....	257
16.5.3	Micro-quasars .....	260
16.6	Bibliography .....	263
	References .....	263

<b>17 X-Ray Binaries Evolution</b> .....	265
17.1 Millisecond Pulsars .....	266
17.2 The Eclipsing Pulsar .....	269
17.3 Bibliography .....	274
References .....	274
<b>18 Relativistic Jets</b> .....	275
18.1 Relating the Observed Jet Properties to the Intrinsic Conditions ..	277
18.2 Superluminal Motion .....	280
18.3 Bibliography .....	283
References .....	283
<b>19 Gamma Ray Bursts</b> .....	285
19.1 Short History .....	285
19.2 Homogeneous Distribution of Events .....	289
19.3 Interpretation .....	290
19.4 Afterglows .....	291
19.5 GRBs as Cosmological Probes .....	295
19.6 Bibliography .....	295
References .....	295
<b>20 Active Galactic Nuclei</b> .....	297
20.1 Introduction to Active Galactic Nuclei (AGN) .....	297
20.2 Basic Physical Properties of AGN .....	298
20.3 Categories of Active Galactic Nuclei .....	300
20.4 The Emission Components .....	301
20.4.1 Continuum Emission .....	301
20.4.2 Line Emission .....	305
20.5 Seyfert 1 and Seyfert 2 Galaxies .....	308
20.6 Radio Galaxies .....	311
20.6.1 Extended Lobes of Radio Galaxies .....	312
20.7 AGN Statistics and Evolution .....	315
20.8 Link of AGN with Host Galaxies .....	317
20.9 Bibliography .....	319
References .....	319
<b>21 The Diffuse X-Ray Background and Other Cosmic Backgrounds</b> ....	321
21.1 The Diffuse X-Ray Background .....	321
21.2 The Different Diffuse Extragalactic Backgrounds .....	324
References .....	327
<b>Index</b> .....	329



<http://www.springer.com/978-3-642-30969-4>

High Energy Astrophysics

An Introduction

Courvoisier, T.J.-L.

2013, XVI, 332 p., Hardcover

ISBN: 978-3-642-30969-4