OBSERVATIONAL ASTRONOMY

Astronomy is fundamentally an observational science, and as such it is important for astronomers and astrophysicists to understand how their data are collected and analyzed. This book is a comprehensive review of current observational techniques and instruments.

Featuring instruments such as Spitzer, Herschel, Fermi, ALMA, Super-Kamiokande, SNO, IceCube, the Auger Observatory, LIGO, and LISA, the book discusses the capabilities and limitations of different types of instruments. It explores the sources and types of noise and provides statistical tools necessary for interpreting observational data. Due to the increasingly important role of statistical analysis, the techniques of Bayesian analysis are discussed, along with sampling techniques and model comparison.

With topics ranging from fundamental subjects such as optics, photometry, and spectroscopy, to neutrinos, cosmic rays, and gravitational waves, this book is essential for graduate students in astronomy and astrophysics.

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OBSERVATIONAL ASTRONOMY

Techniques and Instrumentation

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Contents

List of illustrations *page* xiv
List of tables xx
Preface xxi
Acknowledgements xxiii

1 Astrophysical information 1
- 1.1 Electromagnetic radiation 1
- 1.2 Other carriers of information 2
- 1.3 Intervening regions 3
  - 1.3.1 Intergalactic/interstellar medium 3
  - 1.3.2 Interplanetary medium 5
  - 1.3.3 Earth's atmosphere 5
- Exercises 12

2 Photometry 14
- 2.1 Specific intensity (brightness) 14
- 2.2 Étendue 14
- 2.3 Moments of the specific intensity 16
- 2.4 Energy density 17
- 2.5 Flux from a surface of uniform brightness 17
- 2.6 Blackbody radiation 18
- 2.7 Atmospheric extinction (calibration) 20
- 2.8 Absolute calibration 22
- 2.9 Photometric magnitudes 23
- Exercises 25

3 Positional astronomy 28
- 3.1 Fundamental reference system 28
- 3.2 Time systems 28
  - 3.2.1 Atomic time 28

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3.2.2 Astronomical time scales 30
3.2.3 Sidereal time 31
3.2.4 Solar time 31
3.3 Spherical astronomy 32
3.3.1 Spherical coordinates (in general) 32
3.3.2 Latitude and longitude 33
3.3.3 Equatorial coordinates 33
3.3.4 Horizon coordinate system (alt/az) 34
3.3.5 Conversion formulae (alt/az ↔ ha/dec) 35
3.3.6 Ecliptic coordinates 35
3.3.7 Galactic coordinates 36
3.3.8 Spherical trigonometry 37
3.3.9 Rotation matrices 37
3.4 Epoch 39
3.5 Changes in equatorial coordinates 40
3.5.1 Proper motion 40
3.5.2 Precession 41
3.5.3 Nutation 41
3.5.4 Parallax 42
3.5.5 Aberration of starlight 42
3.5.6 Reduction of celestial coordinates (overview) 43
3.5.7 Gravitational deflection of light 44
3.5.8 Refraction 45
3.5.9 Parallactic angle 46
3.6 Astrometry 46
3.6.1 Historical techniques 46
3.6.2 Hipparcos 48
Exercises 49
4 Fourier transforms 52
4.1 Fourier series 52
4.2 Fourier integrals 54
4.2.1 Relationship to the Dirac delta (impulse) function 55
4.2.2 Parseval’s theorem (Rayleigh’s theorem) 56
4.2.3 Properties of Fourier transforms 57
4.2.4 Convolution 58
4.2.5 Autocorrelation (Wiener–Khinchin theorem) 58
4.2.6 Common functions and Fourier transform pairs 59
4.2.7 Aliasing and Shannon’s sampling theorem 60

4.3 Higher-dimensional Fourier transforms 62
  4.3.1 Hankel (Fourier–Bessel) transforms 62
Exercises 63
5 Detection systems 66
5.1 Interaction of radiation and matter 66
5.2 Photoelectric effect 66
5.3 Compton scattering 67
5.4 Pair production 69
5.5 Electromagnetic wave interactions 70
5.6 Optical and ultraviolet detectors 70
  5.6.1 Photomultipliers 70
  5.6.2 Other electron multiplication devices 72
  5.6.3 Solid state detectors 74
5.7 Infrared astronomy 78
  5.7.1 Infrared photoconductors 80
  5.7.2 NICMOS 82
  5.7.3 Bolometers 83
  5.7.4 Spitzer 84
  5.7.5 Herschel 85
  5.7.6 WFIRST 85
Exercises 86
6 Orthodox statistics 87
6.1 Probability distributions 87
  6.1.1 Binomial distribution 88
  6.1.2 Poisson distribution 89
  6.1.3 Gaussian (normal) distribution 91
6.2 Moments of a probability distribution 92
6.3 Characteristic (moment-generating) function 92
6.4 Central limit theorem 94
6.5 Experimental data 95
6.6 Chi-squared (χ^2) distribution 97
6.7 Student's t-distribution 99
6.8 Robust estimation 100
6.9 Propagation of errors 102
Exercises 104
7 Stochastic processes and noise 105
7.1 Stochastic process 105
  7.1.1 Stationary process 106
7.2 Spectral density of a Poisson random process 106
7.3 Spectral density of a Gaussian random process 108

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Cambridge University Press
978-1-107-01046-8 — Observational Astronomy
Edmund C. Sutton
Frontmatter
More Information

7.4 The transformation $y = x^2$ 109
7.5 Filtering 110
  7.5.1 Low pass filtering 110
7.6 Estimation in the presence of Gaussian noise 112
7.7 Photon noise 112
7.8 Thermal noise 113
Exercises 115

8 Optics 117
8.1 Geometrical optics 117
  8.1.1 Paraxial optics (a first order theory) 119
  8.1.2 Seidel aberrations (a third order theory) 124
  8.1.3 Higher order terms 129
  8.1.4 Telescope design 130
  8.1.5 Other aspects of telescope design 132
  8.1.6 Gravitational lensing 133
8.2 Dispersion 134
  8.2.1 Origin of the refractive index 134
  8.2.2 Fresnel coefficients 135
8.3 Physical optics 138
  8.3.1 Vector and scalar diffraction 139
  8.3.2 Kirchhoff diffraction theory 139
  8.3.3 Fresnel and Fraunhofer approximations 143
  8.3.4 Diffraction with aberrations 149
8.4 Imaging 150
8.5 Addendum 153
Exercises 155

9 Interference 158
9.1 Mutual coherence function and complex degree of coherence 158
9.2 Quasi-monochromatic radiation 158
9.3 Young’s two-slit experiment 160
9.4 Michelson interferometer 162
9.5 Michelson stellar interferometer 163
9.6 Van Cittert–Zernike theorem 164
9.7 Étendue of coherence 166
  9.7.1 One approach 166
  9.7.2 An alternate approach 167
9.8 Aperture synthesis 168
  9.8.1 Arrays of antennas 168
9.9 Caveat 170

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9.10 Fourth order coherence 170
9.10.1 Intensity interferometry 171
Exercises 172
10 Spectroscopy 173
10.1 Multiple beam interference 173
10.1.1 Airy function 174
10.1.2 Anti-reflection coating 175
10.1.3 Enhanced reflection coating 176
10.1.4 Interference filters 177
10.2 Fabry–Perot interferometer (etalon) 178
10.3 Fourier transform spectrometer 180
10.4 Prism spectrograph 181
10.4.1 Prism applications 182
10.5 Diffraction gratings 183
10.5.1 Grating properties 184
10.5.2 Grating profiles 185
10.5.3 Czerny–Turner spectrograph 185
10.5.4 Echelle spectrograph 186
10.5.5 Grism spectroscopy 187
10.5.6 Fiber optic spectroscopy 187
Exercises 188
11 Ultraviolet, x-ray, and gamma ray astronomy 190
11.1 Telescopes and imaging 190
11.1.1 X-ray telescopes 190
11.1.2 Collimators 192
11.1.3 Tracking designs 192
11.1.4 Coded apertures 192
11.2 Detectors 194
11.2.1 Proportional counters 194
11.2.2 Solid state detectors 195
11.2.3 Scintillators 195
11.2.4 Spark chambers 196
11.3 Recent missions 196
11.3.1 ROSAT 196
11.3.2 Compton Gamma Ray Observatory 197
11.3.3 Extreme Ultraviolet Explorer 199
11.3.4 ASCA 200
11.3.5 Rossi X-ray Timing Explorer 200
11.3.6 BeppoSAX 201
11.3.7 FUSE 202

11.3.8 Chandra 202
11.3.9 XMM-Newton 203
11.3.10 INTEGRAL 205
11.3.11 GALEX 206
11.3.12 Swift 206
11.3.13 Fermi gamma ray space telescope 207
11.4 Possible future missions 207
11.4.1 IXO 207
11.4.2 MAXIM or BHI 207
Exercises 208
12 Radio receivers, spectrometers, and interferometers 209
12.1 Astrophysical radio sources 209
12.2 Fundamentals of radio receivers 209
12.2.1 Linear systems 210
12.2.2 Quantum noise limit 211
12.2.3 Components in series 211
12.2.4 Low noise GaAs FET amplifiers 212
12.2.5 Radio frequency mixers 214
12.2.6 Detectors and the radiometer equation 217
12.3 Precision radiometry of the CMB 218
12.3.1 COBE 218
12.3.2 WMAP 218
12.3.3 Planck 220
12.3.4 Atacama Cosmology Telescope 220
12.4 Radio spectrometers 221
12.4.1 Autocorrelation spectrometers 221
12.4.2 Filter banks 222
12.4.3 Acousto-optical spectrometers 222
12.5 Radio antennas 223
12.5.1 Antenna patterns 223
12.5.2 Antenna temperature 225
12.5.3 Special antenna designs 226
12.6 Radio interferometry 226
12.6.1 Basic two-element interferometer 226
12.6.2 Interferometer arrays 228
12.6.3 Correlators 229
12.6.4 Fourier inversion 230
13 Modern statistical methods 233
13.1 Bayes’ theorem 233
13.2 Maximum likelihood 235

13.3 So what is Bayesian inference? 236
13.3.1 Example 1 236
13.3.2 Example 2 237
13.4 Maximum entropy 239
13.5 Uninformative priors 241
13.5.1 Location priors 241
13.5.2 Scale priors 241
13.5.3 Positive, additive distributions 241
13.6 Inverse problems 242
13.7 Sampling the posterior 243
13.7.1 Rejection sampling 244
13.7.2 Metropolis–Hastings algorithm 245
13.7.3 Gibbs sampling 246
13.7.4 Mixing behavior 247
13.8 Model comparison 247
13.9 Malmquist (truncation) bias 250
13.10 Censoring 251
13.11 Confidence limits 253
Exercises 255
14 Neutrino detectors 257
14.1 Neutrinos 257
14.2 Solar neutrino production 258
14.3 Supernova production 260
14.4 Atmospheric neutrinos 260
14.5 Neutrino oscillations 262
14.5.1 Vacuum oscillations 262
14.5.2 Matter oscillations 264
14.5.3 Conclusions 264
14.6 Radiochemical (transmutational) detectors 265
14.6.1 Chlorine 265
14.6.2 Gallium 267
14.6.3 Other targets 268
14.7 Čerenkov detectors 269
14.7.1 Kamiokande and Super-Kamiokande 271
14.7.2 Sudbury Neutrino Observatory 276
14.7.3 IceCube 279
14.8 Scintillation detectors: Borexino 282
14.9 Cosmological implications 283
14.10 Background of supernova neutrinos 283
Exercises 284

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Cambridge University Press
978-1-107-01046-8 — Observational Astronomy
Edmund C. Sutton
Frontmatter
More Information

15 Cosmic ray detectors **285**
- 15.1 Properties of cosmic rays 285
- 15.2 Intervening regions 287
  - 15.2.1 Magnetic fields 287
  - 15.2.2 Spallation reactions 289
  - 15.2.3 Interstellar ionization losses 290
  - 15.2.4 Bremsstrahlung 290
  - 15.2.5 Synchrotron losses 292
  - 15.2.6 Inverse Compton losses 293
  - 15.2.7 Pair production 294
  - 15.2.8 GZK effect 294
  - 15.2.9 Decays 295
  - 15.2.10 Atmospheric interactions 295
- 15.3 Detectors 295
  - 15.3.1 Ionization detectors 296
  - 15.3.2 Bremsstrahlung 297
  - 15.3.3 Čerenkov radiation 300
  - 15.3.4 Transition radiation 300
- 15.4 Balloon-borne and spacecraft missions 301
  - 15.4.1 1990s and early 2000s 301
  - 15.4.2 TRACER and CREAM 301
  - 15.4.3 PAMELA 303
  - 15.4.4 Alpha Magnetic Spectrometer 303
- 15.5 Extensive air showers 303
  - 15.5.1 High Resolution Fly's Eye 307
  - 15.5.2 Pierre Auger Observatory 309
  - 15.5.3 Telescope Array (TA) project 310
  - 15.5.4 Atmospheric Čerenkov Telescope Array 311
  - 15.5.5 JEM-EUSO 311
- 15.6 Particle acceleration 312
- Exercises 313

16 Gravitational waves **314**
- 16.1 Characteristics of gravitational radiation 314
- 16.2 Sources of gravitational waves 316
- 16.3 Ground-based interferometric detectors 320
  - 16.3.1 Fabry–Perot 323
  - 16.3.2 Recycling interferometers 325
  - 16.3.3 Lasers 325
  - 16.3.4 Seismic noise 326

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Cambridge University Press
978-1-107-01046-8 — Observational Astronomy
Edmund C. Sutton
Frontmatter
More Information

16.3.5 Quantum limit, shot noise, and radiation pressure fluctuations 328
16.3.6 Thermal noise 330
16.3.7 Other factors 330
16.3.8 Performance 331
16.3.9 Squeezed states 332
16.4 Space-based interferometric detectors 333
16.5 Other systems 336
16.6 Data analysis 336
Exercises 337
17 Polarimetry 340
17.1 Sources of polarized radiation 340
17.1.1 Synchrotron radiation 340
17.1.2 Zeeman effect 340
17.1.3 Thermal emission 343
17.1.4 Scattering 343
17.1.5 Primordial polarization 344
17.2 Propagation effects 345
17.3 Polarization-sensitive devices 345
17.4 Analysis of polarization states 346
17.4.1 Stokes parameters 346
17.4.2 Mueller matrices 348
17.4.3 Jones vectors and matrices 349
17.5 Polarization measurement 350
17.5.1 Analysis of weak field splittings 351
17.6 Optical polarimetry 351
17.7 Radio polarimetry and calibration 352
Exercises 353

Appendix A Physical constants and units 355
Appendix B Acronyms 356
Appendix C Additional reading 363

References 369
Index 378

The color plates will be found between pages 232 and 233.

Cambridge University Press
978-1-107-01046-8 — Observational Astronomy
Edmund C. Sutton
Frontmatter
More Information

Illustrations

1.1 Atmospheric transmission from 10 to 1000 GHz *page* 6
1.2 Atmospheric transmission from 480 to 500 GHz 7
1.3 Scattering from bound electrons 10
1.4 Seeing and scintillation 11
2.1 Geometry defining the specific intensity 15
2.2 Conservation of étendue 15
2.3 Changes in image size and solid angle 15
2.4 Flux through an aperture 16
2.5 Relation between energy density and mean intensity 17
2.6 Integrated flux from a surface of uniform brightness 18
2.7 Opacity of Earth's atmosphere 21
2.8 Sky-dip method for calculating zenith opacity 22
2.9 Sidelobes of a radio telescope 22
2.10 Filter response of standard photometric systems 24
3.1 Cesium clock 29
3.2 Sidereal time 31
3.3 Spherical coordinates 32
3.4 Latitude and longitude on Earth 33
3.5 Fixed and rotating equatorial coordinate systems 34
3.6 Rotating and fixed meridians 34
3.7 Horizon coordinate system 35
3.8 Ecliptic coordinate system 36
3.9 Galactic coordinate system 36
3.10 Relationship between galactic and equatorial coordinates 38
3.11 Spherical trigonometry 39
3.12 Rotation matrices 39
3.13 Precession 41
3.14 Parallax Π for a star at distance D 42
3.15 Aberration of starlight 43
3.16 Gravitational deflection of light at the limb of the Sun 44
3.17 Refraction in a plane-parallel atmosphere 45
3.18 Wide field astrometric errors 47

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Cambridge University Press
978-1-107-01046-8 — Observational Astronomy
Edmund C. Sutton
Frontmatter
More Information

3.19 Altitude/azimuth coordinate system 49
4.1 Square wave as a finite Fourier series 54
4.2 An exponentially decaying wave and its power spectrum 56
4.3 Aliasing 60
4.4 Sampling theorem 61
4.5 Gibbs’ phenomenon 64
5.1 X-ray total absorption cross section for Xe 67
5.2 Compton scattering 68
5.3 Compton cross sections 69
5.4 Pair production cross section in lead 70
5.5 Schematic view of a photomultiplier 71
5.6 A Multi-Anode Microchannel Array (MAMA) 73
5.7 Silicon with donors and acceptors 74
5.8 PN junction 75
5.9 Metal-oxide-semiconductor (MOS) device 77
5.10 CCD readouts 78
5.11 Thermal backgrounds for infrared telescopes 79
5.12 Intrinsic and extrinsic photoconductors 80
5.13 Photoconductive gain 81
5.14 Thermal circuit for a bolometer 83
6.1 Probability density and cumulative probability 88
6.2 Binomial distribution 89
6.3 Poisson distributions for $a = 1, 1.5$, and 2 90
6.4 Poisson statistics based on binomial distribution 90
6.5 Gaussian distribution 92
6.6 Convergence in central limit theorem 95
6.7 Rainfall statistics for Urbana, Illinois 96
6.8 Probability density function for Student’s t-distribution 101
6.9 Outliers and robust estimation 101
6.10 Outliers and least-squares fitting 102
7.1 Autocorrelation of a Poisson random process 107
7.2 The transformation $y = x^2$ 109
7.3 Filtering 110
7.4 Ideal low pass filter 111
7.5 Thermal noise passed by a low pass filter 114
7.6 Johnson noise 114
8.1 Law of reflection 118
8.2 Snell’s law 119
8.3 Paraxial optics and refraction 120
8.4 Paraxial optics and reflection 121
8.5 Transverse and angular magnification 122
8.6 Thin and thick lenses 123
8.7 Spherical aberration for a mirror 125
8.8 Spherical aberration for a lens 126
8.9 Coma 126
8.10 Coma in the tangential and sagittal planes 127

Cambridge University Press
978-1-107-01046-8 — Observational Astronomy
Edmund C. Sutton
Frontmatter
More Information

8.11 Astigmatism 128
8.12 Astigmatism in the tangential and sagittal planes 128
8.13 Pincushion and barrel distortion 129
8.14 Petzval field curvature 130
8.15 Classical Cassegrain telescope 130
8.16 Schmidt telescope 132
8.17 Drude–Lorentz model of the refractive index 134
8.18 Dispersion relation 136
8.19 Fresnel coefficients 136
8.20 S-polarization 137
8.21 Application of Green’s theorem to Kirchhoff diffraction 140
8.22 Kirchhoff diffraction for an opaque screen with a hole 141
8.23 Huygens–Fresnel principle 142
8.24 Geometry of the Poisson spot 142
8.25 Intensity distribution along the axis for the Poisson spot 143
8.26 Geometry for the Fresnel approximation 144
8.27 Cylindrical coordinates for diffraction from a circular aperture 145
8.28 The Airy pattern: diffraction from a circular aperture 146
8.29 Diffraction by a straight edge 147
8.30 The Cornu spiral: the Fresnel integrals S(u) and C(u) 148
8.31 Diffraction pattern for a point source and a straight edge 149
8.32 Point spread function 150
8.33 Modulation transfer function 151
8.34 A rectangular pixel 153
8.35 Nyquist sampling with a grid of pixels 154
8.36 Marginal and paraxial rays 155
9.1 Electric fields separated in time and space 159
9.2 Quasi-monochromatic radiation 159
9.3 Gaussian power spectral density and autocorrelation functions 159
9.4 Coherence length of quasi-monochromatic radiation 160
9.5 Young’s two-slit experiment 161
9.6 Fully modulated fringes 161
9.7 Loss of coherence 162
9.8 Michelson interferometer 162
9.9 Michelson stellar interferometer 163
9.10 Fringes from two point sources being washed out 164
9.11 Coherence of radiation 165
9.12 Radiation pattern of a radio telescope 167
9.13 Radio interferometer 169
9.14 Linear array of dipoles 169
9.15 Antenna pattern of a linear array 170
10.1 Interference between plane-parallel dielectric interfaces 174
10.2 Airy function 175
10.3 Anti-reflection coating 176
10.4 Enhanced reflectivity coating 177
10.5 Fabry–Perot interferometer 178

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10.6 Fabry–Perot interferometers in series 179
10.7 Fourier transform spectrometer 180
10.8 Angular deflection by a prism 181
10.9 Prism spectrograph 182
10.10 Objective prism 183
10.11 Principle of a grating 184
10.12 Blazed grating 185
10.13 Czerny–Turner spectrograph 186
10.14 Echelle grating 186
10.15 Grism 187
11.1 Examples of total internal reflection 191
11.2 Wolter type-I telescope with nested optics 191
11.3 Illustration of a pinhole camera and a coded aperture mask 193
11.4 Photoionization within a gas proportional counter 194
11.5 Gas proportional counter 195
11.6 COMPTEL detector on CGRO 199
11.7 EGRET detector on CGRO 200
11.8 Proportional counter unit from RXTE PCA 201
11.9 Chandra ACIS imaging and spectroscope arrays 203
11.10 Chandra HRC 204
11.11 Coded aperture masks for SPI and IBIS 205
12.1 Thermal bremsstrahlung and synchrotron emission 210
12.2 Examples of linear systems 210
12.3 Amplifiers connected in series 212
12.4 FET amplifier 213
12.5 Mixer frequencies 215
12.6 Schottky diode 215
12.7 SIS tri-layer 216
12.8 Simple radiometer system 217
12.9 WMAP results 219
12.10 Polarization-sensitive bolometers 220
12.11 Autocorrelation spectrometer 221
12.12 Bragg reflection 222
12.13 Acousto-optical spectrometer 223
12.14 Ruze theory 224
12.15 Radio antenna pattern 224
12.16 Radio interferometer 227
12.17 Baseline variation due to Earth’s rotation 228
13.1 Probabilty of a neutrino detection 238
13.2 Bayesian posterior 239
13.3 Example of rejection sampling 244
13.4 Metropolis algorithm 246
13.5 Model comparison 248
13.6 Evidence comparison 249
13.7 Example of Malmquist bias 251
13.8 Example of censoring 252

14.1 SSM neutrino flux predictions 259
14.2 Atmospheric neutrinos 261
14.3 System of two coupled pendulums 263
14.4 Neutrino mixing parameters 265
14.5 Ray Davis during construction of his neutrino detector 266
14.6 DUSEL laboratory 269
14.7 Neutrino–electron elastic scattering 270
14.8 Geometry of Čerenkov radiation 270
14.9 Inner portion of Super-K detector 272
14.10 Outer portion of Super-K detector 272
14.11 Super-K event topology 273
14.12 Electron-like and muon-like Super-K events 274
14.13 Neutrino cross sections for light and heavy water 275
14.14 Creighton mine 276
14.15 Artist's conception of SNO 277
14.16 SNO detector during construction 277
14.17 Solar neutrino fluxes 278
14.18 Photomultiplier deployed into antarctic ice 279
14.19 IceCube photomultiplier strings 280
14.20 Simulated muon event in IceCube 281
15.1 Cosmic ray spectrum 286
15.2 Cosmic ray deflection 288
15.3 Cosmic ray components 291
15.4 Electron impact parameter 292
15.5 Ionization energy losses 297
15.6 Energy loss for light nuclei 298
15.7 Isotope mass resolution 299
15.8 Ionization tracks in plastic 299
15.9 TRACER 302
15.10 X_{max} 305
15.11 Shower particles arrive at ground array stations 305
15.12 HiRes air shower event 308
15.13 GZK cutoff 308
15.14 Pierre Auger Observatory 309
16.1 Linear polarization states of gravitational waves 316
16.2 Possible sources of gravitational radiation 318
16.3 Chirp signal 319
16.4 Images of interferometers 322
16.5 Locations and orientations of interferometers 323
16.6 LIGO optical layout 324
16.7 Mode cleaner 326
16.8 Quadruple pendulum prototype 327
16.9 LIGO sensitivity 331
16.10 Sensitivity goals for Einstein Telescope 332
16.11 Configuration of LISA satellites 333
16.12 Estimated LISA sensitivity 334

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16.13 Possible configuration of LISA spacecraft 335
17.1 Polarization of synchrotron radiation 341
17.2 Longitudinal and transverse Zeeman effect 341
17.3 Hyperfine splitting of OH 342
17.4 Zeeman doublet and triplet showing π and $\sigma^{\pm}$ components 343
17.5 Scattering of unpolarized light 344
17.6 Wollaston prism 346
17.7 Right circular polarization 348

Cambridge University Press
978-1-107-01046-8 — Observational Astronomy
Edmund C. Sutton
Frontmatter
More Information

Tables

1.1 Characteristic photon energies and temperatures *page* 2
2.1 Johnson–Cousins–Glass photometric system 25
2.2 SDSS bands 25
3.1 Hipparcos precision 48
4.1 Symmetry properties of Fourier transform pairs 55
4.2 Properties of Fourier transforms 57
4.3 Symbols for common functions 59
4.4 Fourier transform pairs 59
6.1 Reduced chi-squared 98
6.2 Chi-squared 99
6.3 Student's t-distribution 100
13.1 One-dimensional confidence limits 253
13.2 Two-dimensional confidence limits 254
15.1 Characteristic magnetic fields and gyroradii 288
15.2 Radioactive isotopes replenished from cosmic rays 290
16.1 Gravitational wave interferometers 320
A.1 Physical constants 355
A.2 Other units 355

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978-1-107-01046-8 — Observational Astronomy
Edmund C. Sutton
Frontmatter
More Information

Preface

This book is based on a required course for graduate students in Astronomy which I taught for a number of years at the University of Illinois. The premise of the course is that both theoretical astronomers and observers should have a basic understanding of the techniques of observational astronomy. The emphasis is on the underlying physics of the methods of detection and analytical tools (statistical and otherwise) that astronomers find useful. The great variety of current instruments and the rapid introduction of new instruments preclude an in-depth treatment of the peculiarities and idiosyncrasies of many instruments. But every instrument has its own idiosyncrasies and its own ways of corrupting the data and deceiving the observer. The topics in this book, I believe, cover the minimum which is required of anyone attempting to understand or interpret observational astronomy data.

Throughout the book equations are given in mks (SI) units so that it is easy to relate the discussion to practical quantities such as volts and watts. This is true even in the chapter on gravitational waves, a subject for which many texts and references use geometrized units ($c = 1$, $G = 1$). I prefer to keep c and G around rather than having to figure out where to put them when I need to calculate power. I also like being able to check equations using dimensional analysis. In the text other units are freely worked in. Among astronomers, the gauss remains firmly fixed as the unit of magnetic flux density. And astronomers frequently use other cgs units. For example, cross sections are always in cm^2. And of course there is a plethora of astronomical units such as pc, AU(!), and $M_\odot$. An appendix is provided with physical constants in both mks and cgs units and with a list of other units used and their equivalents in mks and cgs units.

The reader will note that the chapters on neutrinos, cosmic rays, and gravitational waves are of a different nature than other parts of the book. These fields are sufficiently specialized that it is difficult to separate purely observational issues from the underlying science, Therefore, in these chapters I freely go back and forth between design and scientific goals.

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Edmund C. Sutton
Frontmatter
More Information

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I am well aware of other topics that I could have included in this book. In particular, I regret not being able to include a thorough discussion of adaptive optics and not covering topics in astroparticle physics.

The outlook for possible future instruments has changed markedly since much of this text was written, largely due to budgetary constraints. A funding increment for DUSEL (Chapter 14) by the National Science Foundation was recently rejected by the US National Science Board. The fate of DUSEL currently rests with its remaining US sponsor, the Department of Energy. WFIRST (Chapter 5) remains a high priority project for NASA. If ESA assigns a similarly high priority to its Euclid mission, a merger of these projects is likely to be considered. The US commitments to IXO (Chapter 11) and LISA (Chapter 16) are very much in doubt. These international collaborations are expected to continue, but reduced financial support could lead to delays and reductions in scope. In any event, these instrument concepts are the current state of the art. Astronomers constantly need to readjust their plans in light of financial realities. If better ways can be found to pursue some of these scientific objectives, now is certainly the time for them.

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