
Contents

<i>List of contributors</i>	ix
<i>List of abbreviations</i>	xi
<i>Preface</i>	xiii
1 Optical observations of nebulae <i>B. T. Lynds</i>	1
1.1 Discovery	1
1.2 Reflection nebulae and interstellar grains	5
1.3 Gaseous nebulae	12
1.4 Kinematics	28
References	33
2 Radio observations of H II regions <i>R. L. Brown</i>	35
2.1 Thermal equilibrium	35
2.2 Thermal bremsstrahlung radiation	37
2.2.1 <i>Observations and interpretation of the bremsstrahlung radiation from H II regions</i>	38
2.2.2 <i>Bremsstrahlung emission from inhomogeneous nebulae</i>	43
2.3 Radio recombination line emission	44
2.3.1 <i>Recombination line emission and absorption coefficients</i>	45
2.3.2 <i>Transfer of recombination line radiation</i>	47
2.3.3 <i>Approximations to the recombination line intensity</i>	47
2.3.4 <i>Departures from local thermodynamic equilibrium</i>	49
2.3.5 <i>Impact broadening</i>	51
2.3.6 <i>The relative abundance of helium and hydrogen</i>	53
2.3.7 <i>Radio recombination lines from atomic carbon</i>	54
2.3.8 <i>Stimulated radio recombination lines from distant galaxies</i>	55
2.4 Radio observations of H II regions in perspective	56
References	57
3 Quasars, Seyfert galaxies and active galactic nuclei	
<i>D. E. Osterbrock</i>	59
3.1 Introduction	59

3.2	Observational aspects	61
3.3	Narrow-line region	69
3.4	Broad-line region	78
3.5	High-energy photons	81
3.6	Ultraviolet spectra	82
3.7	Physical models	85
	References	86
4	Chemical abundances <i>L. H. Aller</i>	89
4.1	Introduction	89
4.2	Importance of composition studies	92
4.3	The Sun and the primordial solar system composition (PSSC)	93
4.4	Stellar abundance determinations, curve of growth	105
4.5	Breakdown of LTE and hydrostatic equilibria in stellar atmospheres	110
4.6	Abundances in gaseous nebulae	111
4.7	Summaries of some further perspectives on problems of elemental abundances	118
	References	123
5	The solar chromosphere <i>R. W. Noyes and E. H. Avrett</i>	125
5.1	Introduction: the nature of the solar chromosphere	125
5.2	The mean structure of the chromosphere	130
5.3	The three-dimensional structure of the chromosphere	148
5.3.1	<i>Plages and network: the role of magnetic fields</i>	149
5.3.2	<i>Small-scale chromospheric structure</i>	151
5.3.3	<i>Structure and dynamics of the high chromosphere</i>	153
5.3.4	<i>Magnetic fields in the chromospheres</i>	156
5.4	Conclusions	159
	References	162
6	Spectroscopy of the solar corona <i>J. B. Zirker</i>	165
6.1	Introduction	165
6.2	Coronal structures	166
6.3	Coronal temperature diagnostics	169
6.4	Electron density	173
6.5	Electron temperature and density in flares	179
6.6	Velocity	181
6.7	Magnetic field	182
6.8	Summary	183
	References	183
7	Spectroscopy of circumstellar shells <i>B. Zuckerman</i>	185
7.1	Overview	185
7.2	Observations of gas and dust grains	186
7.2.1	<i>Ultraviolet</i>	186

7.2.2	<i>Optical</i>	187
7.2.3	<i>Infrared</i>	188
7.2.4	<i>Microwave</i>	189
7.3	Analysis and interpretation	190
7.3.1	<i>Physical conditions</i>	190
7.3.2	<i>Chemical composition</i>	200
7.4	Some near future developments	205
	References	208
8	The gaseous galactic halo <i>B. D. Savage</i>	210
8.1	Introduction	210
8.2	Ultraviolet observations of halo gas	211
8.3	Interpretations of the observations	215
8.3.1	<i>Column densities</i>	215
8.3.2	<i>The z extent of galactic halo gas</i>	216
8.3.3	<i>Ionization and temperature</i>	218
8.3.4	<i>Densities</i>	220
8.3.5	<i>Abundances</i>	221
8.4	Origin of galactic halo gas	221
8.5	Implications for extragalactic astronomy	222
8.5.1	<i>The evolution of interstellar elemental abundances</i>	222
8.5.2	<i>Quasar absorption lines</i>	223
8.6	Future prospects	224
	References	225
9	Astrophysical shocks in diffuse gas <i>C. F. McKee</i>	226
9.1	The nature of astrophysical shocks	226
9.2	Shock jump conditions	228
9.2.1	<i>Derivation</i>	229
9.2.2	<i>Non-radiative jump conditions (J-shocks)</i>	231
9.2.3	<i>Radiative shocks (J- and C-shocks)</i>	233
9.2.4	<i>Effects of cosmic rays on J-shocks</i>	236
9.3	J-shocks	237
9.3.1	<i>Structure of the shock front</i>	237
9.3.2	<i>Radiative J-shocks: maximum velocity</i>	239
9.3.3	<i>Radiative J-shocks: structure and spectrum</i>	240
9.3.4	<i>Emission from non-radiative J-shocks</i>	244
9.4	C-shocks	245
9.4.1	<i>Physical conditions in C-shocks</i>	246
9.4.2	<i>Application to Orion</i>	249
	References	252
10	Coronal interstellar gas and supernova remnants <i>R. A. McCray</i>	255
10.1	Introduction	255
10.2	Thermally ionized gas: coronal approximation	256

10.3	Photoionized gas: nebular approximation	261
10.4	Thermal conduction	266
10.5	Supernova remnants, interstellar bubbles, and superbubbles	269
10.5.1	<i>Supernova remnants</i>	269
10.5.2	<i>Interstellar bubbles</i>	272
10.5.3	<i>Superbubbles</i>	274
	References	276
11	Diffuse interstellar clouds <i>J. H. Black</i>	279
11.1	<i>Introduction</i>	279
11.2	Observations: extinction	281
11.3	Observations: atomic and molecular absorption lines	283
11.4	Observations: radio lines	287
11.5	Theory and interpretation	288
11.6	Summary	299
	References	300
12	Laboratory astrophysics: atomic spectroscopy <i>W. H. Parkinson</i>	302
12.1	Introduction	302
12.2	Basic formulae and definitions	304
12.2.1	<i>Einstein probability coefficients</i>	304
12.2.2	<i>The oscillator strength or f-value</i>	307
12.2.3	<i>Electron impact excitation cross sections</i>	310
12.2.4	<i>Bound-free transition parameters</i>	311
12.3	Measurement of bound-bound radiative transition parameters	313
12.3.1	<i>Measurement of radiative lifetimes</i>	313
12.3.2	<i>Measurement of radiative lifetimes of metastable levels</i>	319
12.3.3	<i>Measurement of f-values</i>	322
12.3.4	<i>Measurement of electron impact excitation cross sections</i>	335
12.4	Measurement of bound-free transition parameters	341
12.4.1	<i>Measurement of photoionization cross sections</i>	341
12.4.2	<i>Measurement of autoionization parameter</i>	342
12.4.3	<i>Example of measurement of both photoionization and autoionization</i>	343
12.4.4	<i>Measurement of dielectric recombination cross sections</i>	345
	Compilations of atomic data	347
	Wavelength and multiplet tables	347
	Grotrian diagrams and energy levels	347
	Transition probabilities (oscillator strengths, line strengths)	348
	References	349
	<i>Index</i>	354

