

CONTENTS

List of symbols and abbreviations	ix
1 Introduction	1
1.1 Historical background and outline of the book	1
1.2 Various plasmas	12
1.3 Nomenclature and basic constants	13
1.4 z-scaling	14
1.5 Neutral hydrogen and hydrogen-like ions	15
1.6 Non-hydrogen-like ions	19
2 Thermodynamic equilibrium	22
2.1 Velocity and population distributions	22
2.2 Black-body radiation	25
3 Atomic processes	30
3.1 Radiative transitions	31
3.2 Radiative recombination	42
3.3 Collisional excitation and deexcitation	48
3.4 Ionization and three-body recombination	59
*3.5 Autoionization, dielectronic recombination, and satellite lines	64
*3.6 Ion collisions	72
Appendix 3A. Scaling properties of ions in isoelectronic sequence	76
*Appendix 3B. Three-body recombination “cross-section”	79
4 Population distribution and population kinetics	83
4.1 Collisional-radiative (CR) model	83
4.2 Ionizing plasma component	96
4.3 Recombining plasma component – high-temperature case	111
4.4 Recombining plasma component – low-temperature case	120
4.5 Summary and concluding remarks	131
*Appendix 4A. Validity of the statistical populations among the different angular momentum states	134
*Appendix 4B. Temporal development of excited-level populations and validity condition of the quasi-steady-state approximation	136
5 Ionization and recombination of plasma	150
5.1 Collisional-radiative ionization	151
5.2 Collisional-radiative recombination – high-temperature case	157
5.3 Collisional-radiative recombination – low-temperature case	163

5.4	Ionization balance	167
5.5	Experimental illustration of transition from ionizing plasma to recombining plasma	182
	Appendix 5A. Establishment of the collisional-radiative rate coefficients	188
	Appendix 5B. Scaling law	190
*Appendix 5C.	Conditions for establishing local thermodynamic equilibrium	191
*Appendix 5D.	Optimum temperature, emission maximum, and flux maximum	202
6	Continuum radiation	205
6.1	Recombination continuum	205
6.2	Continuation to series lines	207
6.3	Free-free continuum – Bremsstrahlung	211
*7	Broadening of spectral lines	213
7.1	Quasi-static perturbation	214
7.2	Natural broadening	218
7.3	Temporal perturbation – impact broadening	219
7.4	Examples	224
7.5	Voigt profile	233
*8	Radiation transport	236
8.1	Total absorption	236
8.2	Collision-dominated plasma	240
8.3	Radiation trapping	245
	Appendix 8A. Interpretation of Figure 1.5	252
*9	Dense plasma	257
9.1	Modifications of atomic potential and level energy	257
9.2	Transition probability and collision cross-section	261
9.3	Multistep processes involving doubly excited states	266
9.4	Density of states and Saha equilibrium	277
	Index	286