

# Contents

<b>1</b>	<b>Balancing Detail and Completeness in Collisional-Radiative Models</b>	<b>1</b>
	Stephanie B. Hansen	
1.1	Introduction	1
1.2	State-Space Completeness	2
1.3	Degree of State Detail	6
1.4	Application-Driven Approaches to Balancing Detail and Completeness	9
1.4.1	Coronal Fine-Structure Models	10
1.4.2	General Models for Moderate-Density Plasmas	10
1.4.3	Self-consistent Field Models for Dense Plasma	13
1.5	Conclusions	14
	References	15
<b>2</b>	<b>Self-consistent Large-Scale Collisional-Radiative Modeling</b>	<b>17</b>
	Christopher J. Fontes, James Colgan and Joseph Abdallah Jr	
2.1	Introduction	18
2.2	Large-Scale Collisional-Radiative Modeling	20
2.2.1	The Los Alamos Suite of Atomic Physics Codes	20
2.2.2	Selecting a List of Configurations	22
2.2.3	Selecting the Level of Refinement	26
2.2.4	Constructing the Rate Matrix	28
2.2.5	Steady-State Solutions Versus Time-Dependent Solutions	29
2.2.6	Boundary Conditions for the Steady-State CR Equations	29
2.2.7	Different Methods of Solving the Steady-State CR Equations	31
2.3	An Illustrative Example	33
2.4	Summary and Outlook	40
	References	42

<b>3 Generalized Collisional Radiative Model Using Screened Hydrogenic Levels</b>	51
H.-K. Chung, S.B. Hansen and H.A. Scott	
3.1 Introduction	52
3.2 Formalism	53
3.2.1 Generalized Collisional-Radiative Atomic Levels.	53
3.2.2 Atomic Transition Rates.	58
3.2.3 Plasma Effects.	64
3.2.4 Spectroscopic Emissivity and Opacity	66
3.3 Applications	68
3.3.1 Steady-State Plasmas Generated by Long-Pulse Lasers.	68
3.3.2 Two-Temperature Plasmas Generated by Short-Pulse Lasers	69
3.3.3 Photoionization Equilibrium Plasmas	70
3.3.4 Photo-Ionized Plasmas Generated by X-Ray Free Electron Lasers	71
3.3.5 Radiative Loss Rates of Heavy Elements	73
3.4 Validities and Limitations	73
3.4.1 Completeness	74
3.4.2 Improvement on SH Model Spectra.	75
3.4.3 Dielectronic Recombination	76
3.4.4 Radiative Power Losses	76
3.4.5 Continuum Lowering.	77
3.4.6 CR Models in High-Energy-Density Radiation-Hydrodynamic Simulations.	78
3.5 Summary	78
References	78
<b>4 Collisional-Radiative Modeling for Radiation Hydrodynamics Codes</b>	81
Howard A. Scott	
4.1 Introduction	81
4.2 Governing Equations	83
4.3 Non-LTE Material Response.	87
4.4 High Density Effects	91
4.5 Detailed Balance, Energy Conservation and Discretization	98
4.6 Conservation and Consistency in Non-LTE Thermal Radiation Transport	101
4.7 Summary	104
References	104
<b>5 Average Atom Approximation in Non-LTE Level Kinetics.</b>	105
Vladimir G. Novikov	
5.1 Introduction	105
5.2 Level Kinetics Equations	106

5.3	The Rates of Collisional and Radiative Processes. . . . .	108
5.3.1	Excitation by Electron Impact . . . . .	108
5.3.2	Electron-Impact Ionization and Three-Body Recombination . . . . .	111
5.3.3	Autoionization and Dielectronic Capture. . . . .	113
5.3.4	Rates of Radiative Processes. . . . .	114
5.4	Configuration Accounting in the Extended CR-AA Model . . . . .	116
5.5	Reducing Detailed Level Kinetics to Extended CR-AA Model. . .	117
5.6	The Calculation Algorithm . . . . .	120
5.7	Results of Calculation for Tin Plasma . . . . .	121
	References . . . . .	125
<b>6</b>	<b>Collisional-Radiative Modeling and Interaction of Monochromatic X-Rays with Matter . . . . .</b>	<b>127</b>
	O. Peyrusse	
6.1	Introduction . . . . .	127
6.2	Atomic Model Construction for the Modeling of X-Ray Interaction with Matter. . . . .	128
6.3	Interaction with Gas. . . . .	130
6.4	Interaction with Small Objects. . . . .	135
6.5	Interaction with Solids . . . . .	136
6.5.1	Population Kinetics and Atomic Structure at Solid Density . . . . .	137
6.5.2	Temperature and Population Evolution. . . . .	139
6.5.3	Energy Deposition. . . . .	144
6.5.4	Modeling of Al, V and Ag Samples Irradiated in the X-UV or X-Ray Range. . . . .	146
6.6	Conclusion . . . . .	150
	References . . . . .	150
<b>7</b>	<b>Spectral Modeling in Astrophysics—The Physics of Non- equilibrium Clouds . . . . .</b>	<b>153</b>
	G.J. Ferland and R.J.R. Williams	
7.1	Introduction . . . . .	154
7.2	Working with Real Nebulae: The Observational Questions We Are Trying to Answer . . . . .	155
7.3	Approaches to Astronomical Spectral Modelling . . . . .	162
7.4	Spectral Calculations . . . . .	166
7.4.1	The Ionization Balance in the ISM Limit . . . . .	166
7.5	The Physics of the Astronomical Problem. . . . .	173
7.6	Future Opportunities and Challenges . . . . .	174
7.6.1	New Spectroscopic Opportunities . . . . .	174
7.6.2	And the Grand Challenges to Exploiting Them . . . . .	177
	References . . . . .	178

<b>8 Validation and Verification of Collisional-Radiative Models . . . . .</b>	<b>181</b>
Yu. Ralchenko	
8.1 Introduction . . . . .	181
8.2 Tests and Uncertainty Analysis of CR Models. . . . .	182
8.3 Overview of NLTE Code Comparison Workshops . . . . .	186
8.4 Code Comparison Parameters . . . . .	188
8.4.1 List of Parameters for Steady-State Cases . . . . .	188
8.4.2 Global Parameters . . . . .	190
8.4.3 Ion Parameters . . . . .	192
8.4.4 Data for Atomic States. . . . .	197
8.5 Concluding Remarks . . . . .	205
References . . . . .	207
<b>Index . . . . .</b>	<b>209</b>

Modern Methods in Collisional-Radiative Modeling of  
Plasmas

Ralchenko, Y. (Ed.)

2016, X, 212 p. 76 illus., 52 illus. in color., Hardcover

ISBN: 978-3-319-27512-3