

SPECTRAL SERIES EMISSION AND ATOMIC
POPULATIONS IN SOLAR ASTROPHYSICAL AND
LABORATORY FUSION PLASMAS

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Abstract

This thesis seeks to provide spectroscopic diagnostic tools through the advancement of atomic modelling techniques. Issues of opacity (and its consistent treatment from bound to free states), excited state population modelling and spectral feature generation are dealt with. The escape factor technique is used to account for opacity in emergent flux and atomic population calculations. A thorough treatment of low series member opacity is given in the code ADAS 214, which modifies adf04 files for subsequent population processing via ADAS collisional-radiative routines. The escape factor expressions are analytically extended from bound to free states, allowing opacity to be dealt with smoothly across the ionisation threshold. The continuity approach of this thesis is contrasted with the usual technique of introducing an ionising plasma microfield which gradually ‘dissolves’ the highly excited quantum shells into the continuum. A comprehensive plan is outlined which will allow collisional-radiative modelling of arbitrary heavy species. This scheme works in a new coupling picture, for which new Gaunt factors have been developed. The bundled- $(J_p)nl$ and bundled- $(J_p)n$ block primitives of this model have been developed, as has a test module for a single n-shell of the bundled- $(J_p)nlj$ block primitive. A scheme for automatic determination of bundling cut-offs has also been demonstrated. The new model is designed in a modular manner to allow future developments to be performed in testable steps and to take advantage of modern high performance computers. The population, opacity and continuity modelling are then brought together in the generation of a synthetic spectrum for series limit wavelengths of hydrogenic systems. A specific code is written to allow JET divertor Balmer series limit observations to be analysed, returning diagnostic information on plasma electron density, temperature and recombination state. The code is shown to provide good fits to typical divertor spectra and will be developed into an ADAS spectral fitting procedure. The future directions for application of the work are outlined.

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Contents

Contents	v
List of Figures	ix
List of Tables	xiii
1 Introduction	1
1.1 Aims and objectives	1
1.2 Background theory	11
1.2.1 Escape factor basic definitions	11
1.2.2 Escape probability and emergent flux	12
1.2.3 Absorption factor and populations	15
1.2.4 Continuum opacity	17
1.2.5 Line broadening	19
1.2.6 Population modelling	27
1.3 Examples of opacity and spectral series in astrophysical and laboratory plasmas	36
1.3.1 The solar atmosphere : branching line ratios as a diagnostic for deducing optical depth	36
1.3.2 Low hydrogen series member opacity : Fusion divertor plasma	41
1.3.3 High hydrogen series member opacity: Solar prominence Ly- man lines, Lyman continuum and Balmer line radiation	45
1.3.4 High series observations : Fusion divertor plasma	49

2	Opacity modelling of low series members for population and emergent flux calculations : The escape probability and absorption factor approach	51
2.1	Introduction	51
2.2	Basic Theory	52
2.3	Spatial variation in the emission coefficient	57
2.4	Proof that generic $\Lambda(b)$ and Θ vs optical depth curves are valid . . .	59
2.5	Profile Theory	62
2.6	Evaluation of Λ	62
2.7	Computation of populations using absorption factors	63
2.8	Using the code as a line ratio diagnostic	64
2.9	Example of the use of the code for He line identification using CDS quiet sun observations	66
2.10	Further theory and code development : Inclusion of a background radiation field	73
2.10.1	Theory	73
2.11	Conclusions	75
3	Continuity of high series opacity	76
3.1	Introduction	76
3.2	Analytic continuity	76
3.2.1	Continuity of emission coefficient	78
3.2.2	Continuity of absorption coefficient	84
3.3	Contrast with the occupation probability formalism	86
3.4	The use of continuous escape and absorption expressions	88
3.4.1	Some illustrations	89
3.5	Conclusions	93
4	Population modelling and computation	94
4.1	An overview of the model	94
4.1.1	Definition of block structures for advanced computation	97
4.2	Gaunt factors revisited	99

4.2.1	Background	99
4.2.2	Gaunt factor evaluated for j-j coupling	99
4.2.3	Cross coupling Gaunt factors evaluated	100
4.3	The new collisional-radiative code	102
4.3.1	nl and n resolution	102
4.3.2	nlj resolution	103
4.4	Automatic detection of the bundling cut-offs	111
4.4.1	Energy level investigation	111
4.4.2	Collisional redistribution evaluated	122
4.5	Conclusions	132
5	Special feature synthesis for continuum edge spectral analysis	133
5.1	Series limit spectral modelling background	133
5.2	General components of the series limit feature	134
5.2.1	Atomic populations	134
5.2.2	Opacity	135
5.2.3	Line profile evaluation	139
5.2.4	Bound-free, bremsstrahlung and impurity contributions	139
5.3	A specific code for modelling the Balmer emission in the JET divertor.	141
5.3.1	Details of the physical problem	141
5.3.2	Modelling work	142
5.3.3	Fitting the JET data and diagnostic results.	147
5.4	Conclusions	152
6	General conclusions and future work	154
6.1	General conclusions and summary	154
6.2	Areas for future work	155
6.2.1	Extensions to ADAS 214	156
6.2.2	Future work for the series limit code	156
6.2.3	Population extension for heavy species	158
	Bibliography	161

A	Gaunt factor evaluation	168
A.1	Basic rules for graphical expression and manipulation of Clebsch-Gordan coefficients	169
A.2	Application of the graphical manipulation method for Clebsch-Gordan coefficients	173
A.2.1	Gaunt factors for j-j coupled initial and final states	173
A.2.2	Gaunt factors for cross-coupling	180

List of Figures

1.1	EIT He 304 Å observation of the solar chromosphere	2
1.2	An image of the inside of the JET tokamak	3
1.3	Diagram of the line of sight used in the escape probability formalism	13
1.4	Range of validity of broadening approximations for $H\alpha$	22
1.5	Ion-microfield plotted for various plasma parameters	24
1.6	Example of the hydrogen 9-2 Balmer series spectral line profile as evaluated by the PPP code	26
1.7	Illustration of an opacity modified line profile	28
1.8	Spectrum of the C II multiplet used in the branching ratio study . . .	37
1.9	Plot of the C II line ratio used in the deduction of optical depth	39
1.10	Schematic of JET divertor showing the target plates and cryopump .	42
1.11	Absorption factor results from ADAS 214 for divertor conditions . . .	43
1.12	Opacity modified line ratio results for L_β/H_α from ADAS 214 for divertor conditions	44
1.13	Solar prominence $H\alpha$ observation taken by the Big Bear Solar observatory in 1970	46
1.14	Lyman series limit observation of a solar prominence, taken from the data in Schmieder et al. (1999b)	46
1.15	Balmer series limit observation of the JET divertor region	50
2.1	Example of the processing options screen in ADAS 214	53
2.2	Schematics of the disk geometry considered by ADAS 214	53
2.3	Schematics of the cylindrical geometry considered by ADAS 214 . . .	54

2.4	Diagrams of the spatial distribution of the emission coefficient as considered by ADAS 214	56
2.5	Example of the generic Θ and Λ curves produced by ADAS 214 . . .	60
2.6	Example of various hydrogen profiles as calculated by the ADAS 214	63
2.7	Example of the emergent flux line ratio evaluation vs column density from ADAS 214	65
2.8	Example of the observed CDS spectrum used in the line identification work	67
2.9	$G(T_e)$ function for helium evaluated using ADAS 412	69
2.10	Escape factor plot generated using ADAS 214 for the helium line identification work	70
2.11	Line ratio plot generated using ADAS 214 for the helium line identification work	71
3.1	Diagram illustrating the contribution of overlapping profiles to the integration in eqn (3.12)	79
3.2	Emission coefficient for the Balmer series plotted across the series limit	83
3.3	Absorption coefficient for the Balmer series plotted across the series limit	86
3.4	Continuous escape probability plotted for the case of the Balmer series in the fusion divertor	89
3.5	Continuous escape probability plotted for the case of the Lyman series in solar prominence conditions	90
3.6	Absorption factor plotted for the Lyman series limit	92
4.1	The details of the bundling scheme proposed for the new model . . .	95
4.2	Population results from the hydrogen module of the new C-R code . .	104
4.3	b_{nlj} results for $n=3$ as a function of density for $z_0 = 36$ and $T_e = 1.05 \times 10^8 K$	109
4.4	Plot showing the fine structure nlj splitting in the $n = 3 \rightarrow 2$ transition for $z_0 = 28, 36$ & 44	110
4.5	$E_{2P_{1/2}}$ separation from $E_{2P_{3/1}}$ centroid - z_1 dependence	114
4.6	$E_{2P_{1/2}}$ separation from $E_{2P_{3/1}}$ centroid - n dependence	114

4.7	E_{nlj} separation from E_{nl} centroid - z_1 dependence	116
4.8	E_{nlj} separation from E_{nl} centroid - n dependence	116
4.9	E_{nlj} separation from E_{nl} centroid for ${}^2P_{1/2}$ parent - l dependence . . .	117
4.10	E_{nlj} separation from E_{nl} centroid for ${}^2P_{3/2}$ parent - l dependence . . .	117
4.11	E_{nljJ} separation from E_{nlj} centroid for ${}^2P_{1/2}$ parent - z_1 dependence .	118
4.12	E_{nljJ} separation from E_{nlj} centroid for ${}^2P_{3/2}$ parent $j = (l - 1/2)$ - z_1 dependence	118
4.13	E_{nljJ} separation from E_{nlj} centroid for ${}^2P_{3/2}$ parent $j = (l + 1/2)$ - z_1 dependence	118
4.14	E_{nljJ} separation from E_{nlj} centroid for ${}^2P_{1/2}$ parent - n dependence .	119
4.15	E_{nljJ} separation from E_{nlj} centroid for ${}^2P_{3/2}$ parent $j=l-1/2$ state - n dependence	119
4.16	E_{nljJ} separation from E_{nlj} centroid for ${}^2P_{3/2}$ parent $j=l+1/2$ state - n dependence	119
4.17	E_{nljJ} separation from E_{nlj} centroid for ${}^2P_{1/2}$ parent - l dependence . .	120
4.18	E_{nljJ} separation from E_{nlj} centroid for ${}^2P_{3/2}$ parent - l dependence . .	120
4.19	$\Delta E_{nljJ}/\Delta E_{nlj}$ for ${}^2P_{1/2}$ parent, $j=l-1/2$	121
4.20	$\Delta E_{nljJ}/\Delta E_{nlj}$ for ${}^2P_{3/2}$ parent, $j=l-1/2$	121
4.21	$\Delta E_{nljJ}/\Delta E_{nlj}$ for ${}^2P_{1/2}$ parent, $j=l+1/2$	121
4.22	$\Delta E_{nljJ}/\Delta E_{nlj}$ for ${}^2P_{3/2}$ parent, $j=l+1/2$	121
4.23	A-values for the range of physical parameters that the autostructure code was run, n and z_1 dependence	126
4.24	Ion quadrupole collisional rates as a function of temperature and n-shell	126
4.25	Ion quadrupole collisional rates as a function of n-shell and z_1	127
4.26	Critical density at which the ion quadrupole collisions balance the spontaneous emission rates from the $j=l-1/2$ set of levels	128
4.27	Critical n-shell plot showing the critical value at which the ion collisions balance the spontaneous emission rates from the $j=l-1/2$ set of levels	128
4.28	$\langle A_J \rangle$ evaluated for the C-like system for the $1s^2 2s^2 2p : nd$ set of levels	130
4.29	$\langle\langle q_{nlJ \rightarrow nl \pm 1J}^{(z\text{eff})}(T^{(z\text{eff})}) \rangle\rangle$ evaluated for the C-like system for the $1s^2 2s^2 2p : nd$ set of levels	130

4.30	$\langle A_J \rangle / (\langle\langle q_{nlJ \rightarrow nl \pm 1J'}^{(z\text{eff})}(T^{(z\text{eff})}) \rangle\rangle)$ evaluated for the C-like system for the $1s^2 2s^2 2p : nd$ set of levels	131
4.31	$\langle A_J \rangle / (\langle\langle q_{J \rightarrow J'}^{(z\text{eff})}(T^{(z\text{eff})}) \rangle\rangle N_{ion})$ evaluated for the C-like system for the $1s^2 2s^2 2p : nd$ set of levels	131
5.1	Example of the population datafile produced by the hydrogen collisional-radiative code	136
5.2	Continuum absorption factors for the Lyman series	138
5.3	Continuum averaged Λ for the Lyman continuum plotted as a function of plasma length	138
5.4	A comparison of PPP profiles with Griem's expression	140
5.5	Illustration of the lines of sight of the KT3 instrument in the Balmer series limit observations	143
5.6	Population results for typical divertor conditions	144
5.7	Analytically continuous escape probabilities and absorption factors evaluated for typical divertor conditions	145
5.8	Optically thick and thin populations for typical divertor conditions	146
5.9	Contributions to the emission coefficient from the different hydrogen components	148
5.10	Contributions to the total intensity from all the hydrogen and impurity emitters	148
5.11	Diagnostic fit to pulse 43735, Balmer series limit spectrum	149
5.12	Diagnostic fit to pulse 43738, Balmer series limit spectrum	150
A.1	Graphical representation of the Clebsch-Gordan coefficient	170
A.2	Graphical representation of the Wigner 6-j coefficient	171
A.3	Change in cyclic order of Wigner 3-j symbol	171
A.4	Combining Wigner 3-j symbols	172

List of Tables

1.1	Summary of the data for the C II $2s^22p\ ^2P_{3/2} - 2s2p^2\ ^2S_{1/2}$ transition for each raster scan position	40
1.2	Summary table of typical prominence physical properties	47
1.3	Summary table of typical mean free paths of hydrogen photons in a solar prominence	48
2.1	Observed and calculated solar atmosphere helium line ratios with and without the effects of opacity	73
4.1	$(j - j)$ coupling to $(j' - j')$ coupling Q and R values evaluated for various levels of resolution	101
5.1	The diagnostic values returned from the fit shown in figure 5.11	150
5.2	Diagnosed electron densities from the FWHM analysis of Meigs	150
5.3	The diagnostic values returned from the fit shown in figure 5.12	151
5.4	Diagnosed electron densities from the FWHM analysis of Meigs	151
A.1	$(j - j)$ coupling to $(j' - j')$ coupling Q and R values evaluated for various levels of resolution	179