



Advanced population modelling

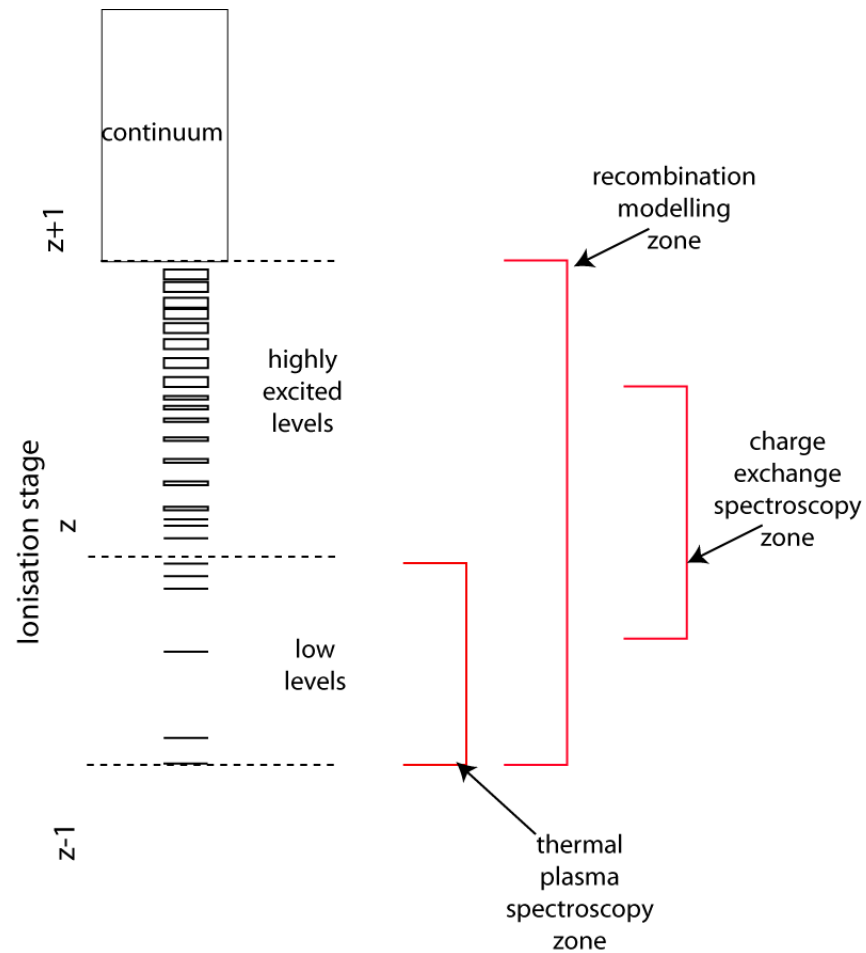
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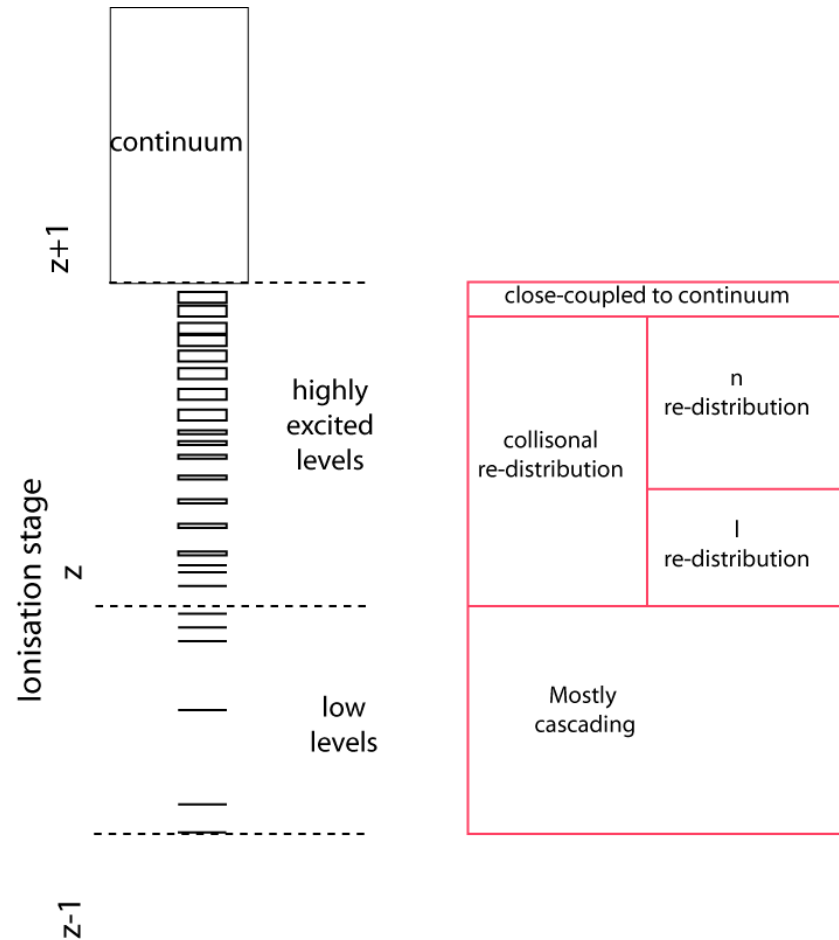
Contents

- Overview of atomic level structure, zones and nomenclatures
- Techniques – representative levels, condensation, projection
- ADAS population models
- A universal baseline of charge exchange data for heavy species

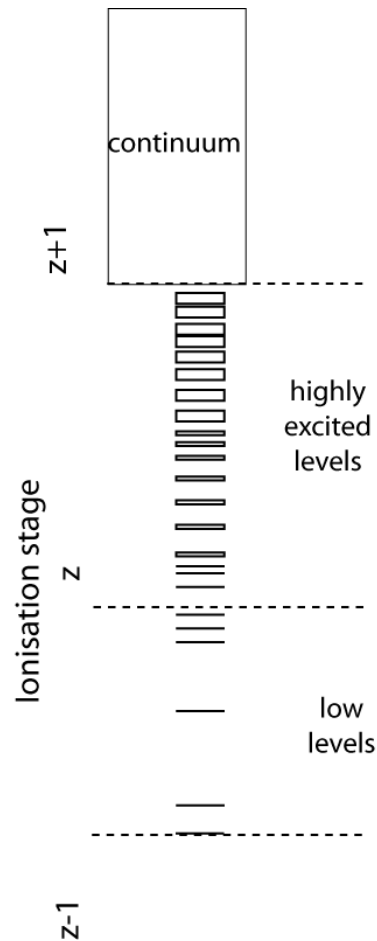
Level zones and relevance



Collisionality regimes

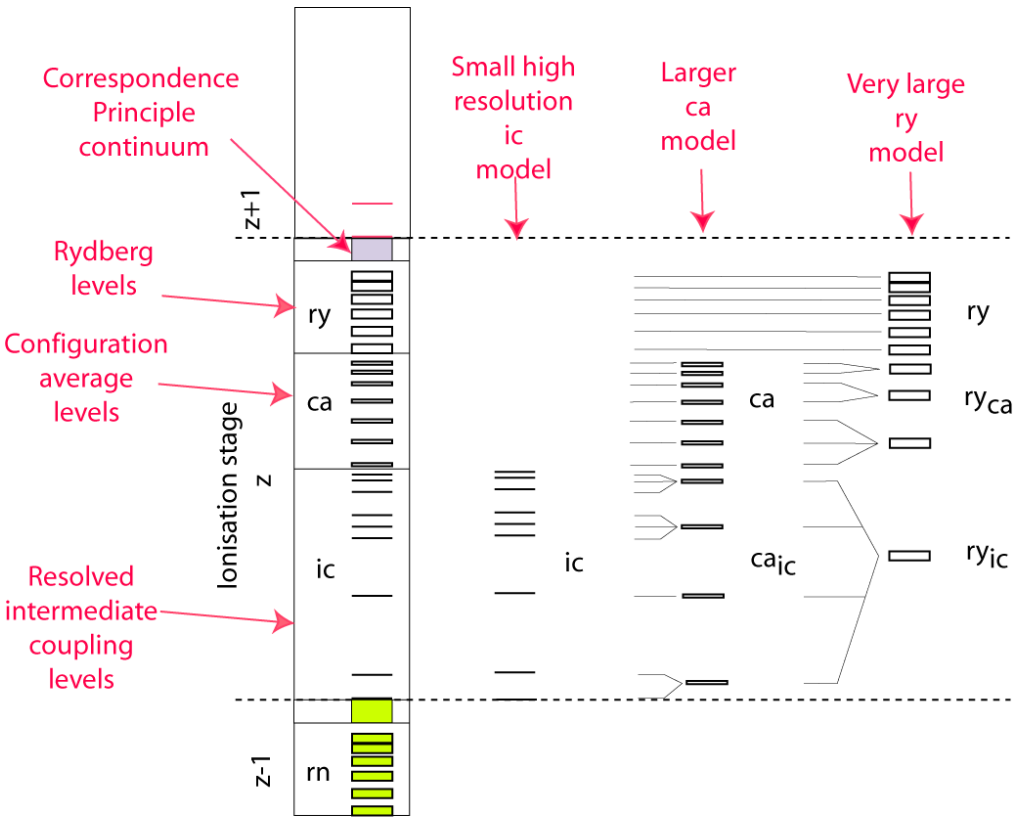


Level nomenclatures and mnemonics



$(2S_{p+1}L_p) n$	bundle-n ry	
$(2S_{p+1}L_p) nl$ $n_1 l_1^{q_1} \dots n_m l_m^{q_m}$	bundle-nl ca	
$(2S_{p+1}L_p) nl \ 2S+1L$ $n_1 l_1^{q_1} \dots n_m l_m^{q_m} \ 2S+1L$ $n_1 l_1^{q_1} \dots n_m l_m^{q_m} \ 2S+1L_J$	terms ls levels ic	

Collisional-radiative models



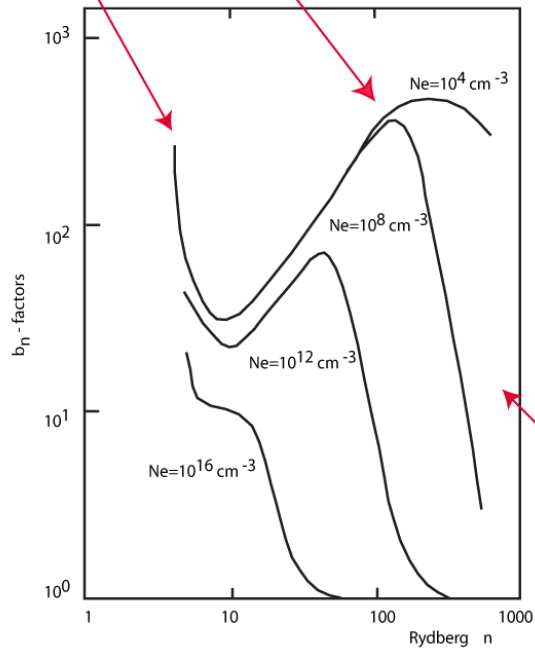
Yields a series of population calculations of varying resolution and span

Bundle-n (ry) and bundle-nl (ca) populations

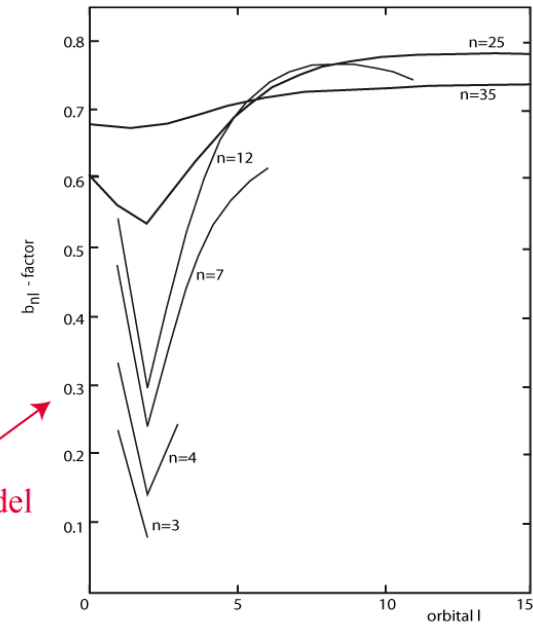
b_i - factor defined in term of population $N_i = N_i(\text{Saha})$ $b_i = 8 (\pi a_0^2 I_H / k T_e)^{3/2} (\omega_i / 2 \omega_+) \exp(I_i / k T_e) b_i$
 $c_i = b_i - 1$, $\exp b_i = \exp(I_i / k T_e) b_i \rightarrow b_i, c_i, \exp b_i$ representations

$\exp b_i$ representation
 required for
 very low T_e

c_i representation
 required

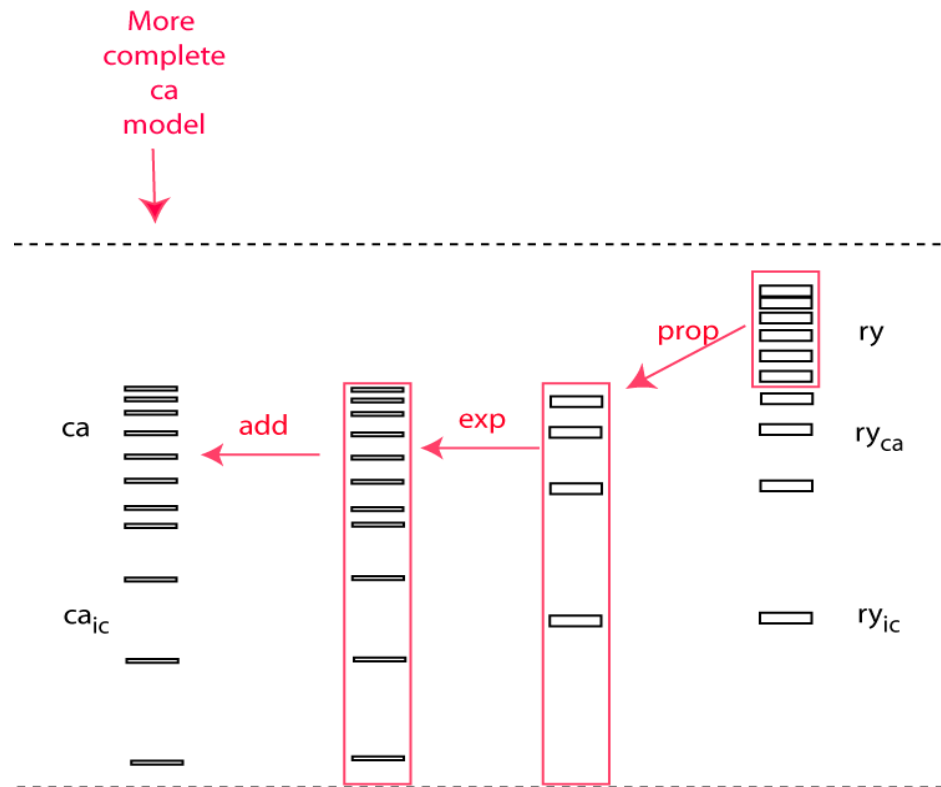


iron population structure Fe^{+14}



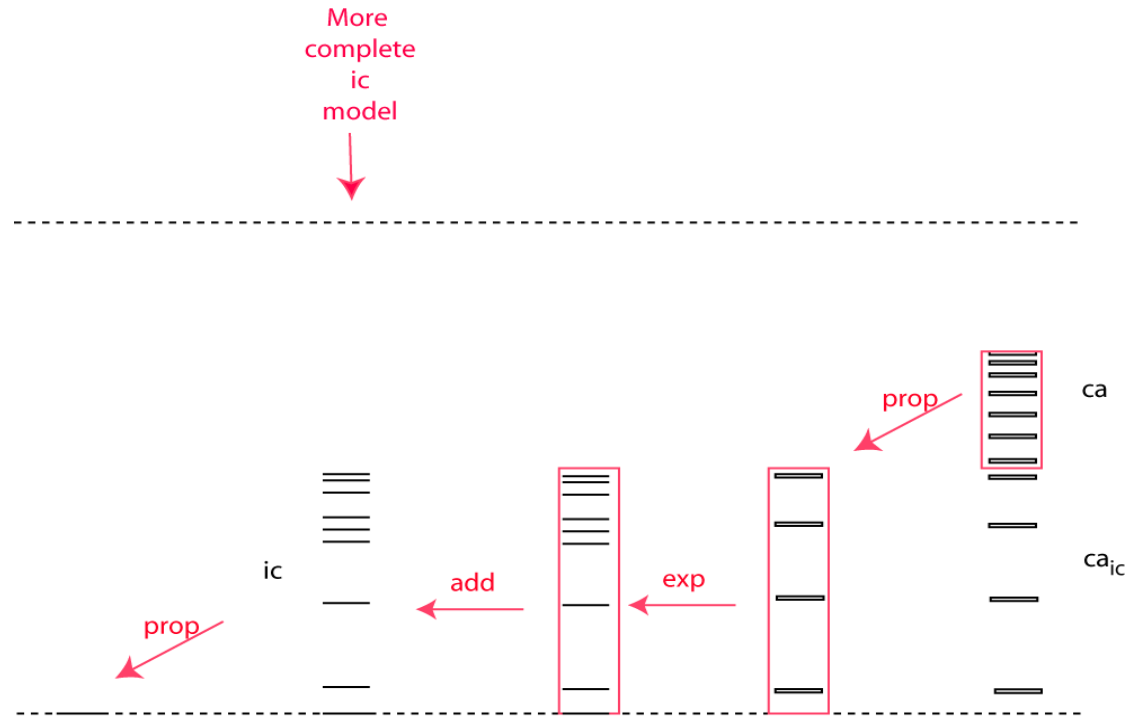
Hydrogen population structure. Case B depopulated, $N_e = 10^4 \text{ cm}^{-3}$ $T_e = 1 \text{ eV}$

Lifting CR models: propagated top-up



ry collisional-radiative matrix propagated onto the $ry_{ca} + ry_{ic}$ manifold, expanded over the higher resolution $ca + ca_{ic}$ manifold and added to the direct $ca + ca_{ic}$ collisional-radiative matrix.

Lifting CR models: propagated top-up



ca collisional-radiative matrix propagated onto the ca_{ic} manifold, expanded over the higher resolution *ic* manifold and added to the direct *ic* collisional-radiative matrix.

Repeat similar process to obtain α_{cd} and S_{cd} coefficients

Suitable approach for higher precision spectroscopy and GCR modelling

Population model use in ADAS

	bundle-n		bundle-nl single and spin separated system	(Jp)nlj-bundled single system	nkm (and mixed fields)	low level balance ic, ls, ca
	single system	spin system separated				
ADAS use	heavy element $\alpha_{cd} \cdot S_{cd}$			heavy element prop. for full ic-resol. GCR ADAS2XX		all element ADAS205 ADAS206
		light element prop. for full ls-resol. GCR ADAS204	light element prop. for full ls-resol. GCR ADAS2XX			all element with proj. ADAS208 ADAS810
	heavy element universal CXS q_{eff} ADAS316		light element CXS q_{eff} (l-redist/cascade version) ADAS308 ADAS309	light element CXS q_{eff} (l-redist/cascade version) ADAS306 ADAS307		
			heavy element CXS q_{eff} ADAS317		hydrogen beam emission (restricted level model) ADAS305	
	hydrogen beam stopping and emission ADAS310	helium beam stopping and emission ADAS311	helium beam stopping and emission ADAS311		hydrogen beam stopping and emission ADAS3XX	
	thermal hydrogen emission ADAS310	thermal helium emission ADAS311	thermal H and He very low temperature emission ADAS311			

■ Operational
 ■ Final development/test
 ■ Development
 ■ Rework