PrismSPECT: Vi	ewing results from run <baseline_te5tr150ni15dl100_v1></baseline_te5tr150ni15dl100_v1>
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Setup: Plasma Elements Simulation Type	At. # Element # fraction Atomic Model Add 1 H 0.999 C:/files/physics_projects/photoionized_plasmas/simulations/F Add 6 C 0.001 C:/files/physics_projects/photoionized_plasmas/simulations/F Delete
Plasma Properties	
Atomic Processes Spectral Grid	Number fractions will be normalized to 1. Element Properties
Output	Element: C (Z = 6) Modify Name: Carbon
Run Simulation	Number Fraction: 0.001 At. Weight: 12.0112
View Results: Spectra	Atomic Model Model type: Detailed configuration accounting (DCA) C Tabular Data Default Model: Emission K-Shell Spectroscopy View
Ionization Line Intensities	Custom File: sct/carbon_v1/Z06_C_emis_kshell_spectra.atm Browse Edit Help Next >

D. Cohen 29 Feb 2008

Some simple PrismSpect tests of recombination spectra in photoionized plasmas

H: 99.9% at. C: 0.1% at.

 $n_i = 10^{15} \text{ cm}^{-3}$ $T_e = 5 \text{ eV}$

T_r = 150 eV T_spec = 500 eV

I used the canned K-shell emission atm files

I wanted a cold, highly ionized plasma of relatively low density to focus on the spectral signatures of recombination

Here's some of the set-up screens for the baseline PrismSpect simulation:

PrismSPECT: 🛽	liewing results from run	<baseline_te5tr150ni15dl100_v1< th=""><th></th><th></th></baseline_te5tr150ni15dl100_v1<>		
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	Help		< Back	Next >

lonization / Populations Viewer [baseline_Te5Tr150ni15DL100_v1]					
File Edit View Axes Text Graph Layers Help					
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Ion / Level Fraction]			
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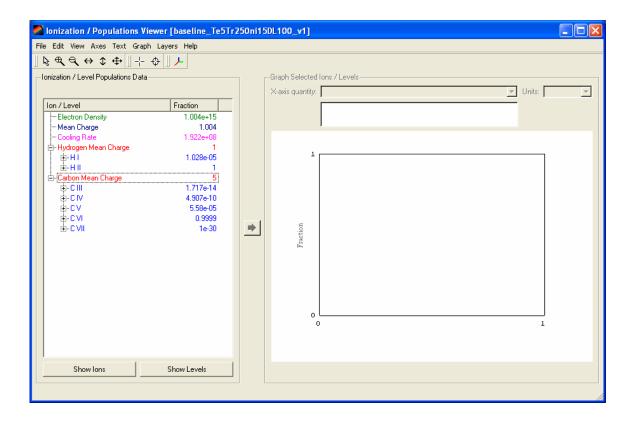
Note the carbon is nearly all H-like, but essentially none of it is bare.

	View Axes Text Graph Lay		L100_v1]							
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						30	Wavelength (40 (A)		
	Spectral components.									
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C VI	5p(1)	2P	1s(1)	guration	2S [1/2]	470.398	26.3564	0.01394		-
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CVI CVI CV CVI	5p(1) 4p(1) 3p(1)3d(1) 3p(1)	2P 2P av 2P	1s(1) 1s(1) 1s(1)3s(1) 1s(1)	guration	2S [1/2] 2S [1/2] 1S 2S [1/2]	470.398 459.375 436.724 435.558	26.3564 26.9888 28.3886 28.4646	0.01394 0.02896 0.0327 0.079		<u> </u>
CVI CVI CV CVI CVI	5p(1) 4p(1) 3p(1)3d(1)	2P 2P av	1s(1) 1s(1) 1s(1)3s(1)	guration	2S [1/2] 2S [1/2] 1S	470.398 459.375 436.724	26.3564 26.9888 28.3886	0.01394 0.02896 0.0327		
CVI CVI CVI CVI CV CV CV	5p(1) 4p(1) 3p(1)3d(1) 3p(1)3d(1) 3s(1)3d(1) 3p(1)3d(1) 3p(1)3d(1)	2P 2P av 2P av	1s(1) 1s(1) 1s(1)3s(1) 1s(1) 1s(1)3p(1) 1s(1)3s(1) 1s(1)3s(1)	guration	2S [1/2] 2S [1/2] 1S 2S [1/2] 1P 3S 1D	470.398 459.375 436.724 435.558 434.385 433.288 431.808	26.3564 26.9888 28.3886 28.4646 28.5415 28.6138 28.7118	0.01394 0.02896 0.0327 0.079 0.0253 0.01297 0.06589		
lon CVI CVI CV CVI CV CV CV CV CV	5p(1) 4p(1) 3p(1)3d(1) 3s(1)3d(1) 3s(1)3d(1) 3s(1)3d(1) 3p(1)3d(1) 3d(2)	2P 2P av 2P av av av av	1s(1) 1s(1) 1s(1)3s(1) 1s(1) 1s(1)3p(1) 1s(1)3s(1) 1s(1)3s(1) 1s(1)3d(1) 1s(1)3p(1)	guration	2S [1/2] 2S [1/2] 1S 2S [1/2] 1P 3S 1D 1P	470.398 459.375 436.724 435.558 434.385 433.288 431.808 430.315	26.3564 26.9888 28.3886 28.4646 28.5415 28.6138 28.7118 28.8115	0.01394 0.02896 0.0327 0.079 0.0253 0.01297 0.06589 0.05589 0.01137		
CVI CVI CVI CVI CV CV CV CV CV	5p(1) 4p(1) 3p(1)3d(1) 3s(1)3d(1) 3s(1)3d(1) 3p(1)3d(1) 3p(1)3d(1) 3d(2) 3p(1)3d(1)	2P 2P av 2P av av av av	1s(1) 1s(1) 1s(1)3s(1) 1s(1) 1s(1)3p(1) 1s(1)3s(1) 1s(1)3s(1) 1s(1)3d(1) 1s(1)3d(1)	guration	2S [1/2] 2S [1/2] 1S 2S [1/2] 1P 3S 1D 1P 3D	470.398 459.375 436.724 435.558 434.385 433.288 431.808 430.315 429.785	26.3564 26.9888 28.3886 28.4646 28.5415 28.6138 28.7118 28.8115 28.847	0.01394 0.02896 0.0327 0.079 0.0253 0.01297 0.06589 0.01137 0.06943		<u> </u>
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CVI CVI CVI CV CV CV CV CV CV CV CV Filter Tr Filter	5p(1) 4p(1) 3p(1)3d(1) 3p(1) 3p(1)3d(1) 3p(1)3d(1) 3p(1)3d(1) 3d(2) 3p(1)3d(1) 3s(1)3p(1) 3s(1)3p(1) 3s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3d(1	2P 2P av 2P av av av av av av av	1s(1) 1s(1)3s(1) 1s(1)3s(1) 1s(1)3b(1) 1s(1)3b(1) 1s(1)3b(1) 1s(1)3b(1) 1s(1)3c(1) 1s(1)3c(1) 1s(1)3c(1)		2S [1/2] 2S [1/2] 1S 2S [1/2] 1P 3S 1D 1P 3D 1S 3S	470.398 459.375 436.724 435.558 434.385 433.288 431.808 430.315 429.785 429.658 429.623 429.701	26.3564 26.9888 28.3886 28.4646 28.5415 28.6138 28.7118 28.8115 28.8115 28.847 28.8555 28.8579 29.0100	0.01394 0.02896 0.0327 0.079 0.0253 0.01297 0.06589 0.01137 0.06943 0.0396 0.05907	Min. osc. strength	
DVI DV DV DV DV DV DV DV DV DV Filter Tr. Filter	5p(1) 4p(1) 3p(1)3d(1) 3p(1) 3p(1)3d(1) 3p(1)3d(1) 3p(1)3d(1) 3d(2) 3p(1)3d(1) 3s(1)3p(1) 3s(1)3p(1) 3s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3p(1) 2s(1)3d(1	2P 2P av 2P av av av av av av av	1s(1) 1s(1)3s(1) 1s(1)3s(1) 1s(1)3b(1) 1s(1)3b(1) 1s(1)3b(1) 1s(1)3b(1) 1s(1)3c(1) 1s(1)3c(1) 1s(1)3c(1)		2S [1/2] 2S [1/2] 1S 2S [1/2] 1P 3S 1D 1P 3D 1S 3S	470.398 459.375 436.724 435.558 434.385 433.288 431.808 430.315 429.785 429.658 429.623 429.623	26.3564 26.9888 28.3886 28.4646 28.5415 28.6138 28.7118 28.8115 28.8115 28.847 28.8555 28.8579 29.0100	0.01394 0.02896 0.0327 0.079 0.0253 0.01297 0.06589 0.01137 0.06943 0.0396 0.05907	Min. osc. strength	•

Note: The C VI K-edge is at 25.3 Angstroms; the edge that's visible here, near 32 Angstroms, is the C V edge/RRC. This reflects the fact that for a pure recombination spectrum, the strong features are from the i-1 ionization state.

The lines at 40+ A are the resonance and intercombination lines of C V. Presumably the forbidden line is absent because of the relatively high density, but I'm surprised that the intercombination line isn't stronger, as G > 1 for photoionized plasmas.

Turning up the radiation field (Tr=250) – still no bare C:



Spectra Viewer [baseline_Te5Tr250ni15DL100	0_v1]	
File Edit View Axes Text Graph Layers Help		
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Spectra units Plot: Intensity	1e+9 $1e+7$ $1e+7$ $1e+6$ $1e+7$ $1e+4$ $1e+3$ $1e+4$ $1e+2$ 30 32 34 36 Wavelength (A)	5
C VI 5p(1) 2P 1s(B-B▼ ⊣ Hide satellites ⊽ Hide levels not in atomic model Min. osc. strength:	

Maybe the electron temperature is just too low. Try Te=15eV. But still Tr=250. ni=1e15.

Pionization / Populations Viewer [baseline_Te15Tr250ni15DL100_v1]				
Ionization / Level	Fraction		Graph Selected Ions / Levels	
	1.005e+15 1.005 4.047e+08 1 1.793e-06 1 6 8.301e-24 1.442e-17 2.418e-11 1.156e-05 1	*	Lation	
Show lons	Show Levels			
			L	

OK, this made a huge difference; now bare C is dominant.

Though I'm somewhat surprised that it went from nothing to completely dominant going from just $T_e=5eV$ to 15eV.

Here's the synthetic spectrum from this simulation:

Spectra Viewer [baseline_Te15Tr250ni15DL100_v1]	
File Edit View Axes Text Graph Layers Help	
<u> </u>	
units Plot: Intensity Intensity Add Delete Delete <td></td>	
Ion Upper Configuration Term Lower Configuration Term Photon Energy Wavelength C VI 5p(1) 2P 1s(1) 2S [1/2] 470.398 26.3564 ✓ Filter Transition Table Data Filter Elements: All ✓ Ions: All Transitions: B-B ✓ Hide satellites ✓ Hide levels not in atomic model Min. osc. strength: 0.07	
Help Close	

The RRC (at 25.3 A) is still very weak compared to Ly-alpha (near 33 A).

Let's convolve down to R=800

Spectra Viewer [baseline_Te15Tr250ni15DL10	00_v1]	
File Edit View Axes Text Graph Layers Help		
<u></u>		
units Plot: Intensity reg/cm2/ster/s/eV rs: Wavelength Add Delete Delete All Resolution 800 Selected Plot Resolution: 800 Apply to all Spectral components	le+9 le+8 le+7 le+6 le+4 25 Wavelength (A)	
C VI 5p(1) 2P 1s(1	B-B▼ ⊣ Hide satellites ⊽ Hide levels not in atomic model Min. osc. strength:	<u> </u>

Doesn't make much difference

But, when I integrate the power in a band around Ly-alpha and then around the RRC, I get just a factor of 4 ratio in integrated power:

Line Intensity Viewer [baseline_Te15Tr250ni1	5DL100_v1]	
File Edit View Axes Text Graph Layers Help		
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Select line/band type:	Graph Selected Line Intensities / Ratios	
Freq-Integrated Power in Band	X-axis quantity: Units:	T
Select plot quantity:		
Intensity reg/ster/cm^2/s		
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- Lines / Bands		
Line / Bands		
Intensity_1 2.866e+07	0.5-	
Intensity_2 7.731e+06		
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Ratios		
Ratio ID Ratio Value	-1.0 -0.5 0.0 0.5 1.0	0
Add Edit Delete	Show in Spectral Viewer-	
Add Edit Delete	🗖 Line/Band ranges 🗖 Fitted lines 🗖 Background con	tinuum fit
Help		Close

Hmmm... so there's significant integrated power in the RRC... but it's not highly peaked (though in linear space, it looks plausibly to have a width of \sim kT.

See what difference it makes to lower T to 10eV:

Ionization / Populations Viewer [baseline_Te10	Tr250ni	15DL100_v1]		
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		X-axis quantity:	Units:	Ψ.
Ion / Level Fraction				
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Cooling Rate 1.349e+08				
🕀 Hydrogen Mean Charge 1				
i∰HI 3.33e-06 i∰HII 1		1		
Er-Carbon Mean Charge 5				
±-CV 1.21e-05				
	-	Fraction		
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Show lons Show Levels				

Wow, Ionization completely different – back down to no bare C at all.

Ionization / Populations Viewer [baseline_Te10T	r 250 ni	0ni13DL100_v1]	
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<u> </u>			
Ionization / Level Populations Data	1	Graph Selected Ions / Levels	
		X-axis quantity: Units:	~
Ion / Level Fraction			
Electron Density 1.004e+13 Mean Charge 1.004			
Cooling Rate 1.275e+06			
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i∰HI 3.439e-08 i∰HII 1			
🖻 - Carbon Mean Charge 5			
CVI 1			
i≟-CVII 1e-30	•	Faction	
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		0 1	
Show lons Show Levels			

same thing – still no bare C at all.