Voigt profile fitting and Ionisation modelling results

April 22, 2024

System plots

- Velocity taken to be 0 at z_{abs} given on the title of the plots
- Blue dashed curves are the individual components and orange dashed curves are the contamination

Ionisation modelling

- PI CLOUDY models with varying log n_H (cm^{-3}) from -5 to 1 at constant metallicity of log Z = -1
- Column densities are scaled with metallicity
- This approximation is valid for metallicities less than around log Z < 1
- If solution from MCMC gives metallicity of around or above log Z = 1, in such cases CLOUDY models are run at base metallicity of log Z = 1
- n_H and Z values are reported for both excluding and including O VI cases.
- In case if some component doesn't have O VI, column density of O VI from other component is taken for the sake of solution
- CI : collisional ionisation, PI : photoionisation


System-Plots/3C263_z=0.140756_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
Si III	-18 ± 8	35 ± 11	12.39 ± 0.09
C IV	-10 ± 3	33 ± 0	13.71 ± 0.04
O VI	0 ± 2	26 ± 4	13.63 ± 0.04
H I	-14 ± 1	87 ± 10	13.49 ± 0.06
H I	0 ± 1	28 ± 1	14.49 ± 0.02

N(H I)=13.49

log Z_{ref} = -1

Excluding O VI : n_H = -3.88 ± 0.04 Z = 1.06 ± 0.05
Including O VI : n_H = -4.13 ± 0.02 Z = 0.99 ± 0.04

log Z_{ref} = 1

Excluding O VI : n_H = -4.14 ± 0.04 Z = 1.69 ± 0.08
Including O VI : n_H = -4.45 ± 0.01 Z = 1.30 ± 0.05

Figure 1: N(H I)=13.49, log Z_{ref}=-1

Figure 2: N(H I)=13.49, log Z_{ref}=1

Non-detections

Figure 3: N(H I)=13.49, log Z_{ref}=1

Comments

- All 3 ions couldn't be explained together
- O VI is underproduced when excluded
- Reference metallicity was initially used as logZ=-1, resulted in metallicity to be around 1, so later modelled with reference metallicity of logZ=1.
- Ionisation : CI
- BLA : +ve

System-Plots/PKS0637-752_z=0.161064_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
N V	-42 ± 6	40 ± 9	13.37 ± 0.07
Si III	11 ± 4	30 ± 7	12.37 ± 0.06
O VI	0 ± 3	48 ± 5	14.02 ± 0.03
H I	-13 ± 2	162 ± 21	13.6 ± 0.06
H I	-1 ± 1	45 ± 1	15.01 ± 0.02

N(H I)=13.60

log Z_{ref} = -1

Excluding O VI : n_H = -4.05 ± 0.03 Z = 1.20 ± 0.05
Including O VI : n_H = -4.12 ± 0.01 Z = 1.30 ± 0.04

log Z_{ref} = 1

Excluding O VI : n_H = -4.29 ± 0.02 Z = 1.64 ± 0.05
Including O VI : n_H = -4.42 ± 0.01 Z = 1.69 ± 0.04

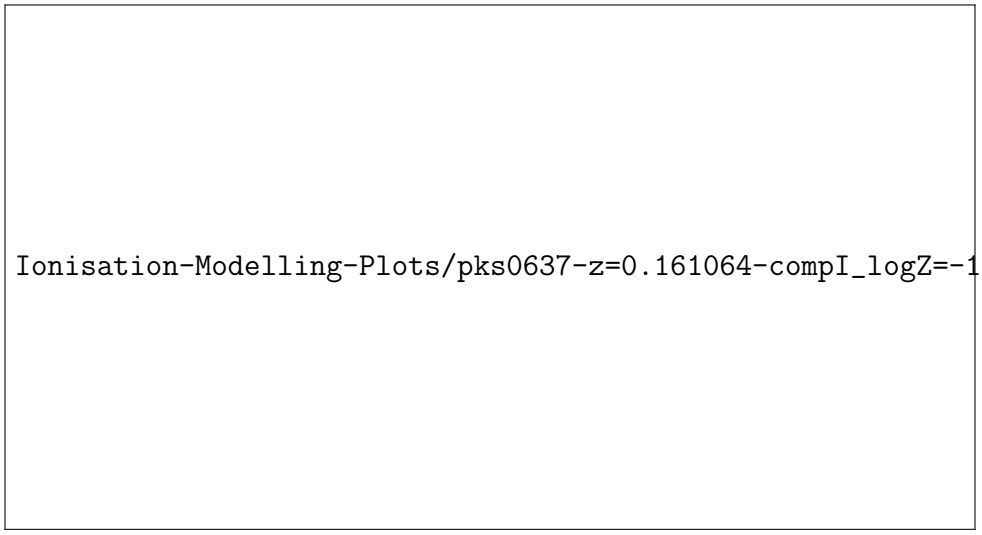


Figure 4: N(H I)=13.60, log Z_{ref}=-1

Figure 5: N(H I)=13.60, log Z_{ref}=1

Non-detections

Figure 6: N(H I)=13.60, log Z_{ref}=1

Comments

- large b value
- All 3 ions couldn't be explained together
- When excluded O VI is underproduced, but not significantly less, about an order of magnitude
- Modelled using both logZ=1 and logZ=-1
- Ionisation : CI
- BLA : +ve

System-Plots/PKS0637-752_z=0.417539_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
Si III	-5 ± 4	35 ± 7	12.74 ± 0.06
C III	-4 ± 1	24 ± 2	14.44 ± 0.15
O VI	0 ± 1	42 ± 6	14.19 ± 0.05
H I	-17 ± 1	30 ± 1	15.41 ± 0.03
H I	20 ± 1	46 ± 4	14.61 ± 0.07

N(H I)=15.41

Excluding O VI : n_H = -3.54 ± 0.11 Z = -0.49 ± 0.11
Including O VI : n_H = -3.74 ± 0.02 Z = -0.23 ± 0.04

NOTE : MCMC walkers initialised near the solution for excluding O VI case.

Ionisation-Modelling-Plots/pks0637-z=0.417539-compI.png

Non-detections

Figure 7: N(H I)=15.41 , log Z_{ref}=-1

Comments

- All 3 ions couldn't be explained together
- When excluded O VI is underproduced
- Ionisation : CI
- BLA : +ve

System-Plots/PG1424+240_z=0.147104_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
C IV	-81 ± 2	11 ± 4	13.58 ± 0.09
C IV	-18 ± 2	20 ± 3	14.06 ± 0.05
Si III	-78 ± 2	15 ± 3	12.58 ± 0.05
Si III	-9 ± 1	16 ± 2	12.87 ± 0.03
Si IV	-82 ± 4	13 ± 7	12.69 ± 0.1
Si IV	-11 ± 2	11 ± 5	12.88 ± 0.07
O VI	-56 ± 9	39 ± 13	13.77 ± 0.11
O VI	4 ± 4	16 ± 6	13.73 ± 0.11
H I	-454 ± 3	27 ± 5	13.16 ± 0.05
H I	-87 ± 3	23 ± 2	14.88 ± 0.05
H I	0 ± 3	29 ± 2	15.44 ± 0.14
H I	216 ± 2	40 ± 3	13.49 ± 0.02

N(H I)=15.44

Excluding O VI : n_H = -3.81 ± 0.03 Z = -0.46 ± 0.03
Including O VI : n_H = -3.88 ± 0.02 Z = -0.42 ± 0.02

N(H I)=14.88

Excluding O VI : n_H = -3.74 ± 0.05 Z = -0.22 ± 0.04
Including O VI : n_H = -3.96 ± 0.03 Z = -0.07 ± 0.04

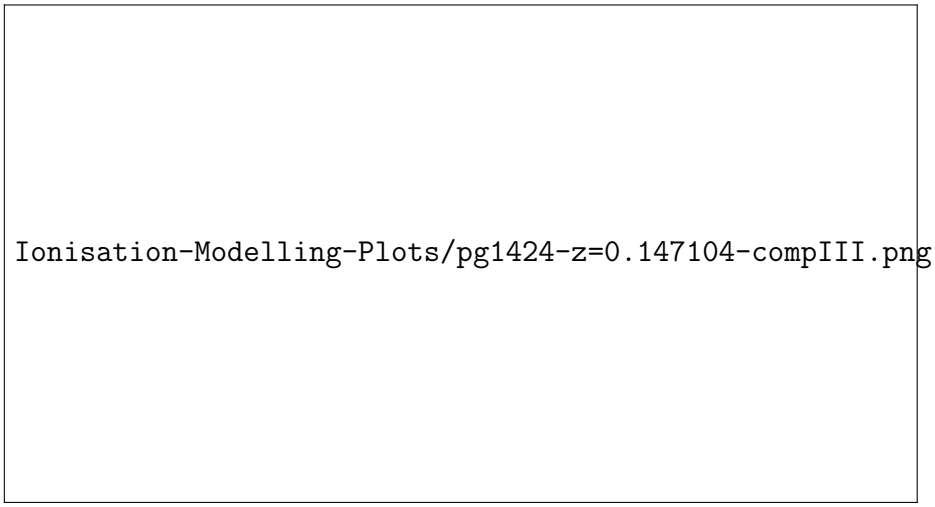


Figure 8: N(H I)=15.44

Figure 9: N(H I)=14.88

Non-detections

Figure 10: N(H I)= 15.44, log Z_{ref}=-1

Figure 11: N(H I)=14.88 , log Z_{ref}=-1

Comments

- Smaller b values 23 and 29 km/s
- All 4 ions couldn't be explained together
- Ions excluding O VI could be explained together for both the components
- Ionisation : CI
- BLA : tentative - small b value but collisionally ionised


System-Plots/PG0003+158_z=0.386089_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
O III	-18 ± 2	9 ± 5	13.93 ± 0.08
C III	-11 ± 1	13 ± 2	13.35 ± 0.05
N V	-7 ± 1	33 ± 11	13.49 ± 0.11
O VI	0 ± 2	25 ± 3	13.87 ± 0.04
O VI	54 ± 3	25 ± 4	13.71 ± 0.06
H I	-10 ± 1	29 ± 0	14.81 ± 0.03
H I	40 ± 9	40 ± 4	14.1 ± 0.05

N(H I)=14.81

Excluding O VI : n_H = -4.12 ± 0.06 Z = -0.65 ± 0.04
Including O VI : n_H = -4.07 ± 0.02 Z = -0.68 ± 0.03

Ionisation-Modelling-Plots/pg0003-z=0.386089-compI.png

Non-detections

Figure 12: N(H I)=14.81 , log Z_{ref}=-1

Comments

- Not a good solution
- Ionisation : can't comment
- BLA : +ve


System-Plots/PG0003+158_z=0.421923_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
C III	-9 ± 1	13 ± 1	13.35 ± 0.04
O III	-1 ± 2	7 ± 5	13.83 ± 0.13
O VI	0 ± 1	27 ± 1	14.27 ± 0.02
H I	-272 ± 6	66 ± 10	13.37 ± 0.05
H I	-16 ± 1	64 ± 3	14.17 ± 0.04
H I	-2 ± 1	26 ± 1	14.71 ± 0.02

N(H I)=14.17

Excluding O VI : n_H = -2.66 ± 0.22 Z = 0.42 ± 0.23
Including O VI : n_H = -4.24 ± 0.02 Z = -0.09 ± 0.03

NOTE : Convergence is not good for excluding O VI case

Ionisation-Modelling-Plots/pg0003-z=0.421923-compII.png

Non-detections

Figure 13: N(H I)=14.17 , log Z_{ref}=-1

Comments

- All 3 ions couldn't be explained together
- When excluded O VI is heavily underproduced
- Convergence is not good for excluding O VI case
- Ionisation : CI
- BLA : +ve


System-Plots/PG1216+069_z=0.282286_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
Si III	0 ± 1	14 ± 3	12.92 ± 0.05
C III	-51 ± 3	32 ± 5	13.33 ± 0.05
C III	5 ± 1	16 ± 2	13.76 ± 0.07
O VI	-64 ± 6	58 ± 9	13.93 ± 0.05
O VI	19 ± 2	12 ± 5	13.54 ± 0.09
H I	-31 ± 1	52 ± 3	15.1 ± 0.05
H I	7 ± 1	22 ± 1	16.4 ± 0.03
H I	169 ± 22	53 ± 10	13.15 ± 0.18

N(H I)=15.10

Excluding O VI : n_H = -2.13 ± 0.15 Z = 0.65 ± 0.22
Including O VI : n_H = -3.86 ± 0.02 Z = -0.37 ± 0.03

NOTE : Convergence is not much good for excluding O VI case

N(H I)=16.40

Excluding O VI : n_H = -2.08 ± 0.43 Z = -0.37 ± 0.59
Including O VI : n_H = -3.68 ± 0.02 Z = -1.55 ± 0.04

NOTE : Convergence is not much good for excluding O VI case

Figure 14: N(H I)=15.10

Figure 15: N(H I)=16.40

Non-detections

Figure 16: N(H I)=15.10, log Z_{ref}=-1

Figure 17: N(H I)=16.40, log Z_{ref}=-1

Comments

- Results similar for both the components
- All 3 ions couldn't be explained together
- When excluded O VI is heavily underproduced
- Convergence is not much good for excluding O VI case
- Ionisation : CI
- BLA : +ve

System-Plots/SDSSJ135712.61+170444_z=0.097869_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
Si III	-62 ± 2	17 ± 3	12.94 ± 0.05
Si III	4 ± 1	13 ± 10	14.67 ± 2.87
C IV	-74 ± 6	33 ± 1	13.82 ± 0.09
C IV	-7 ± 8	32 ± 12	13.63 ± 0.12
Si IV	-66 ± 4	18 ± 6	13.02 ± 0.08
Si IV	0 ± 4	29 ± 5	13.3 ± 0.05
C II	-79 ± 8	19 ± 14	13.17 ± 0.16
C II	-1 ± 2	22 ± 3	13.92 ± 0.04
O VI	-96 ± 10	43 ± 16	14.3 ± 0.11
H I	-536 ± 3	29 ± 5	13.36 ± 0.05
H I	-66 ± 0	29 ± 8	16.49 ± 0.12
H I	0 ± 0	46 ± 4	15.01 ± 0.16
H I	424 ± 3	34 ± 4	13.52 ± 0.04

N(H I)=16.49 (log Z_{ref}=-1)

Excluding O VI : n_H = -3.76 ± 0.05 Z = -1.49 ± 0.04
Including O VI : n_H = -4.06 ± 0.02 Z = -1.32 ± 0.04

N(H I)=15.01

log Z_{ref}=-1
Excluding O VI : n_H = -3.25 ± 0.04 Z = 0.93 ± 0.04
Including O VI : n_H = -3.84 ± 0.03 Z = 0.75 ± 0.03

log Z_{ref}=1
Excluding O VI : n_H = -3.7 ± 0.03 Z = 1.35 ± 0.04
Including O VI : n_H = -4.30 ± 0.03 Z = 1.00 ± 0.03

NOTE : Using O VI column density from other component to compare.

Figure 18: N(H I)=16.49, log Z_{ref}=-1

Figure 19: N(H I)=15.01, log Z_{ref}=-1

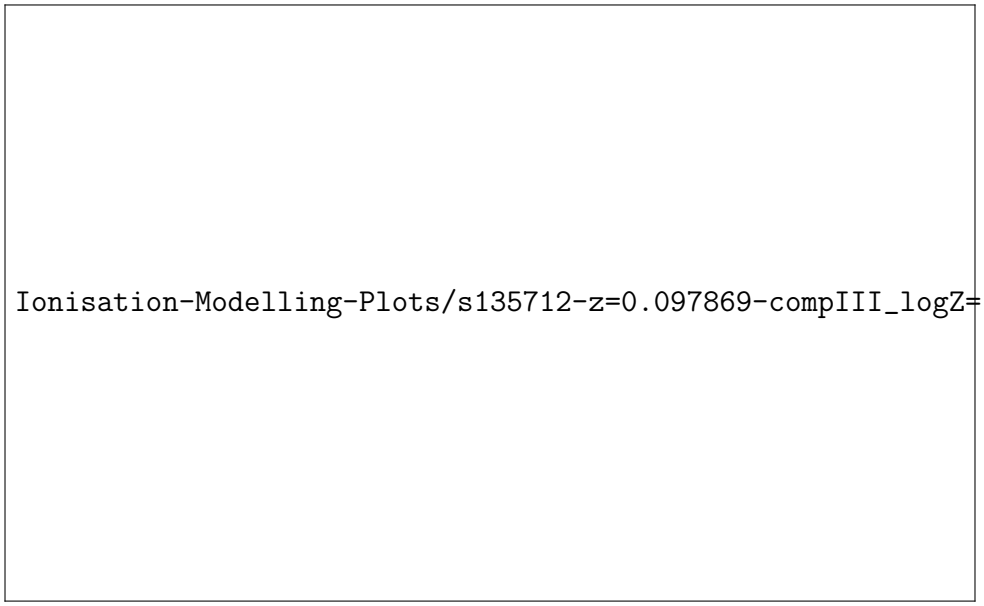


Figure 20: N(H I)=15.01, log Z_{ref}=1

Non-detections

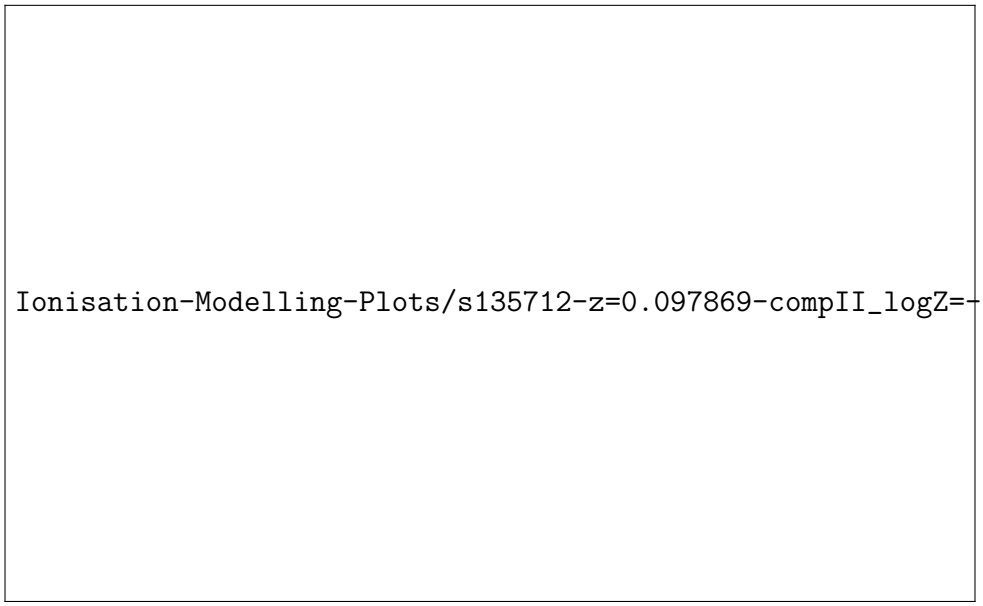


Figure 21: N(H I)=16.49, log Z_{ref}=-1

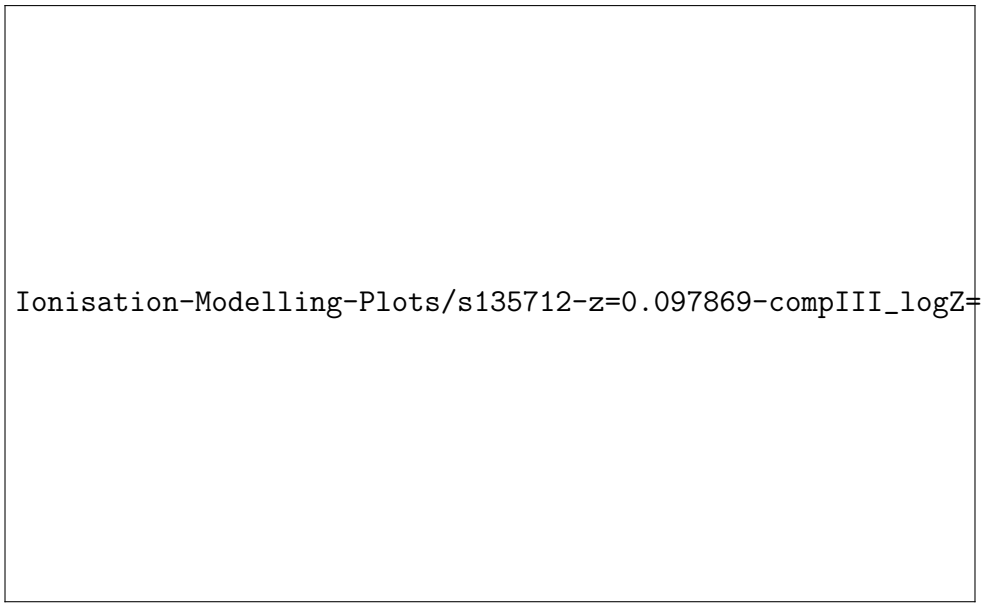


Figure 22: N(H I)=15.01, log Z_{ref}=1

Comments

- Good solution II component (N(H I)=16.49) : small b value - 29 km/s
- All other 4 ions could be explained together except O VI
- When excluded O VI is heavily underproduced
- For III component (N(H I)=15.01), model can't predict column density of Si III for the excluding O VI case.
- Ionisation : CI
- BLA : +ve


System-Plots/1ES1553+113_z=0.187764_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
C III	-46 ± 1	5 ± 4	13.17 ± 0.46
C III	-6 ± 1	13 ± 2	13.21 ± 0.03
N V	-47 ± 2	17 ± 0	13.43 ± 0.05
N V	-5 ± 2	16 ± 4	13.33 ± 0.06
O VI	-42 ± 1	3 ± 1	14.23 ± 0.33
O VI	0 ± 1	15 ± 3	13.71 ± 0.03
O VI	511 ± 3	28 ± 5	13.49 ± 0.05
H I	-52 ± 3	8 ± 6	12.76 ± 0.15
H I	-28 ± 1	51 ± 1	13.88 ± 0.01
H I	425 ± 3	25 ± 5	13.02 ± 0.07
H I	496 ± 2	37 ± 3	13.46 ± 0.03

N(H I)=12.76

Excluding O VI : n_H = -4.62 ± 0.04 Z = 1.37 ± 0.06
Including O VI : n_H = -4.63 ± 0.03 Z = 1.37 ± 0.06

NOTE : Reference metallicity at log Z = 1. Low N(H I), and error for column density for C III and O VI for component I were obtained from χ^2, else they were large and convergence was not good. Nearly similar solution for both the cases.

N(H I)=13.88

Excluding O VI : n_H = -4.6 ± 0.04 Z = 0.03 ± 0.03
Including O VI : n_H = -4.44 ± 0.02 Z = -0.06 ± 0.02

Figure 23: N(H I)=12.76

Figure 24: N(H I)=13.88

Non-detections

Figure 25: N(H I)=12.76, log Z_{ref}=1

Figure 26: N(H I)=13.88, log Z_{ref}=-1

Comments

- Same solution for I component (N(H I)=12.76) : all ions explained in both the cases : PI
- For II component (N(H I)=13.02), all 3 ions couldn't be explained together, O VI is overproduced.
- Ionisation : PI in component I and CI for component II
- BLA : +ve


System-Plots/SBS1108+560_z=0.463207_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
O I	25 ± 2	18 ± 4	14.13 ± 0.05
Si III	-23 ± 9	39 ± 12	13.26 ± 0.12
Si III	21 ± 2	13 ± 15	14.61 ± 0.24
C II	12 ± 9	31 ± 4	14.15 ± 0.05
C II	34 ± 2	12 ± 5	14.67 ± 0.1
C III	-48 ± 3	15 ± 1	13.66 ± 0.08
C III	-10 ± 3	26 ± 7	14.16 ± 0.07
C III	28 ± 3	24 ± 1	13.95 ± 0.05
N III	-22 ± 59	67 ± 61	13.77 ± 0.1
N III	32 ± 2	26 ± 4	14.49 ± 0.09
Si II	25 ± 1	15 ± 1	13.57 ± 0.08
O VI	0 ± 6	45 ± 10	13.71 ± 0.07
H I	-48 ± 0	22 ± 2	15.77 ± 0.02
H I	-10 ± 2	16 ± 0	15.79 ± 0.11
H I	28 ± 1	16 ± 1	18.1 ± 0.12

log Z_{ref}=-1
N(H I)=18.10

Excluding O VI : n_H = -1.88 ± 0.03 Z = 1.07 ± 0.04
Including O VI : n_H = -2.83 ± 0.02 Z = 0.89 ± 0.03

NOTE : Using O VI from other component to compare

N(H I)=15.79

Excluding O VI : n_H = -2.65 ± 0.22 Z = 1.6 ± 0.22
Including O VI : n_H = -3.56 ± 0.03 Z = 1.16 ± 0.05

log Z_{ref}=1
N(H I)=18.10

Excluding O VI : n_H = -2.55 ± 0.03 Z = -0.83 ± 0.04
Including O VI : n_H = -3.49 ± 0.01 Z = -0.92 ± 0.03

N(H I)=15.79

Excluding O VI : n_H = -3.33 ± 0.10 Z = -0.02 ± 0.12
Including O VI : n_H = -3.99 ± 0.02 Z = -0.44 ± 0.05

NOTE : With log $Z_{ref} = 1$, logZ is coming -ve for both the components

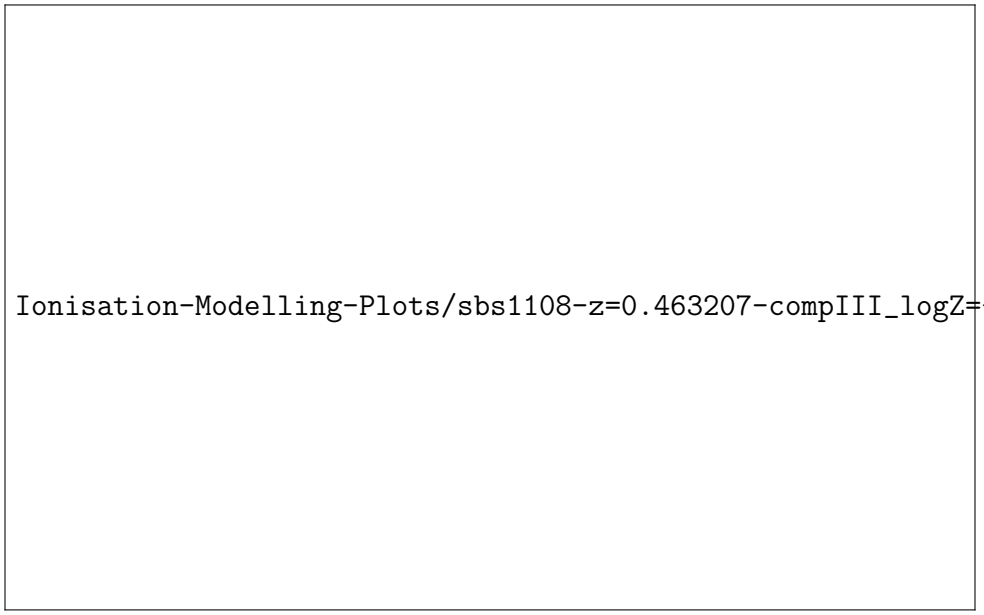


Figure 27: N(H I)=18.10, log Z_{ref}=-1

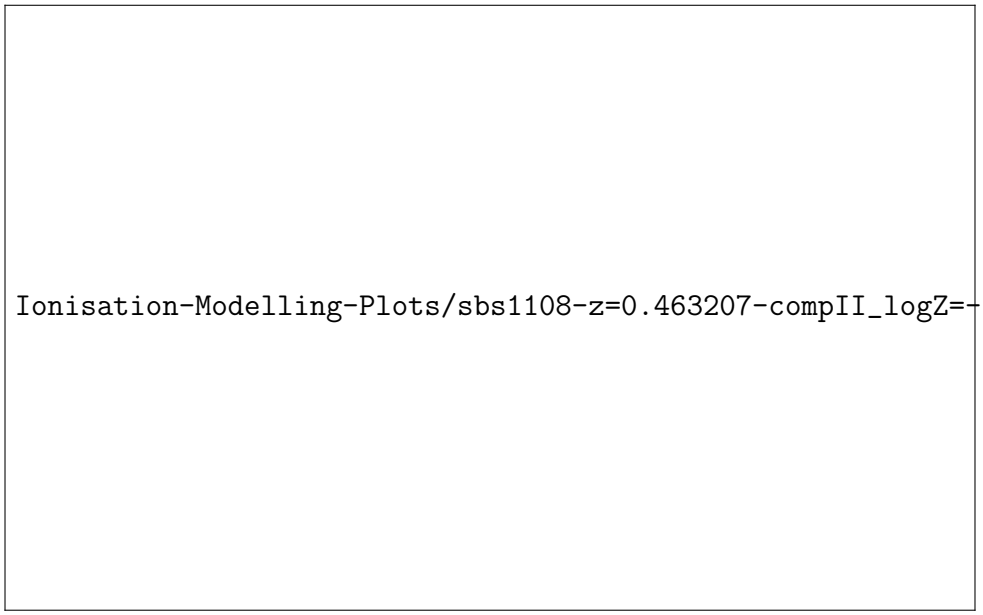


Figure 28: N(H I)=15.79, log Z_{ref}=-1

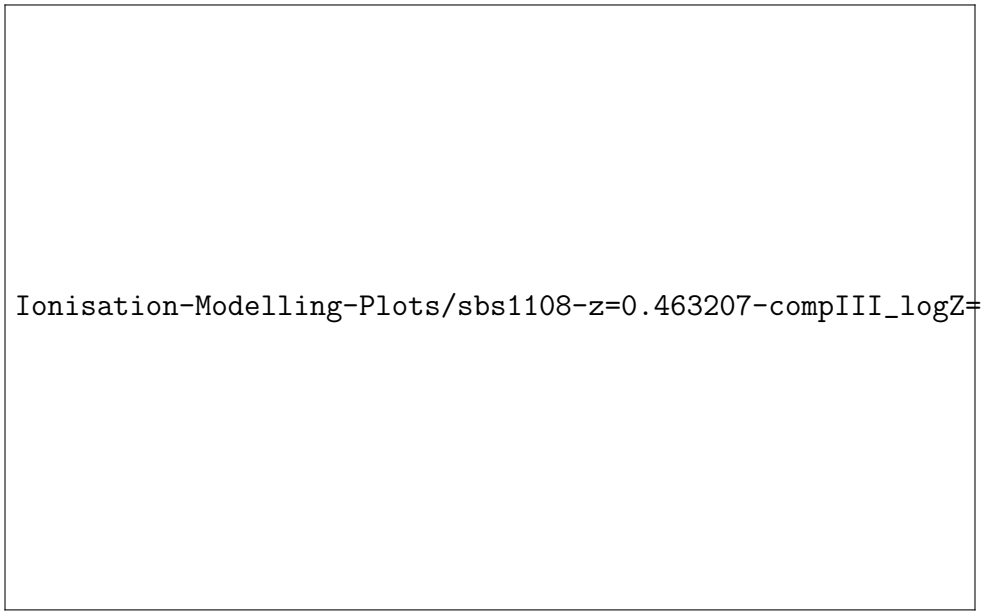


Figure 29: N(H I)=18.10, log Z_{ref}=1

Figure 30: N(H I)=15.79, log Z_{ref}=1

Comments

- Smaller b values for all 3 components
- Not much good solution for component III ((N(H I)=18.10)), as there are many ions. Only few can be explained.
- Modelled using both logZ=-1 and logZ=1 for both the components
- For component II ((N(H I)=15.79)), when using logZ=1 model, the metallicity is coming -ve. And the solution is better when logZ=-1 model is used.
- Ionisation : CI
- BLA : tentative


System-Plots/PG1222+216_z=0.378389_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
O III	7 ± 5	61 ± 8	14.51 ± 0.04
Si III	0 ± 2	30 ± 3	12.98 ± 0.03
C III	-261 ± 3	17 ± 5	13.54 ± 0.06
C III	-215 ± 5	22 ± 6	13.40 ± 0.08
C III	0 ± 2	32 ± 3	13.79 ± 0.02
C III	63 ± 3	13 ± 6	13.12 ± 0.07
O VI	-439 ± 3	28 ± 5	13.42 ± 0.06
O VI	-264 ± 6	24 ± 6	13.75 ± 0.2
O VI	-223 ± 14	34 ± 13	13.68 ± 0.24
O VI	-24 ± 12	14 ± 18	13.00 ± 0.11
O VI	13 ± 4	29 ± 13	13.95 ± 0.16
O VI	59 ± 6	18 ± 7	13.42 ± 0.23
H I	-455 ± 3	26 ± 4	13.40 ± 0.06
H I	-353 ± 9	64 ± 19	13.54 ± 0.11
H I	-268 ± 1	16 ± 6	13.70 ± 0.14
H I	-227 ± 5	52 ± 4	14.34 ± 0.05
H I	-27 ± 2	23 ± 1	14.73 ± 0.08
H I	31 ± 2	43 ± 1	15.43 ± 0.04

N(H I)=15.43

Excluding O VI : n_H = -2.66 ± 0.05 Z = -0.25 ± 0.06
Including O VI : n_H = -3.16 ± 0.03 Z = -0.66 ± 0.02


Ionisation-Modelling-Plots/pg1222-z=0.378389-compVI.png

Comments

- All ions couldn't be xplained together
- When excluded, O VI is underproduced. However, column density of O III is also off by around 0.5 dex from predicted value
- Ionisation : CI
- BLA : +ve

System-Plots/PG1116+215_z=0.138527_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
N V	-7 ± 3	12 ± 6	12.84 ± 0.09
N II	-5 ± 1	6 ± 3	13.62 ± 0.11
N II	33 ± 6	8 ± 13	12.85 ± 0.15
P II	-44 ± 5	19 ± 8	12.94 ± 0.09
Si II	-13 ± 1	9 ± 1	12.46 ± 0.06
Si II	13 ± 1	23 ± 3	12.31 ± 0.04
Si III	-9 ± 1	10 ± 1	12.92 ± 0.04
Si IV	-13 ± 2	4 ± 3	12.84 ± 0.09
O VI	-1 ± 1	35 ± 3	13.84 ± 0.02
C IV	-10 ± 3	13 ± 4	13.17 ± 0.07
C II	-7 ± 1	9 ± 1	13.85 ± 0.04
H I	-8 ± 3	27 ± 2	14.97 ± 0.05
H I	-5 ± 9	71 ± 14	13.6 ± 0.23
H I	31 ± 2	6 ± 2	16.04 ± 1.77

N(H I)=13.60

log $Z_{ref} = -1$

Excluding O VI : n_H = -3.24 ± 0.03 Z = 1.92 ± 0.03
Including O VI : n_H = -3.88 ± 0.01 Z = 1.87 ± 0.02

log $Z_{ref} = 1$

Excluding O VI : n_H = -3.92 ± 0.02 Z = 2.0 ± 0.0
Including O VI : n_H = -4.35 ± 0.0 Z = 2.0 ± 0.0

NOTE : logZ coming near 2 for both the cases and for logZ=1 also, P II is not Included

Figure 31: N(H I)=13.60, log $Z_{ref} = -1$

Figure 32: N(H I)=13.60, log $Z_{ref} = 1$

Comments

- Not good solution as there are many ions.
- metallicity is coming 2, which is the upper bound taken in flat priors
- Ionisation : tentative CI (since O VI can't be explained, even though the solution is not good)
- BLA : +ve


System-Plots/H1821+643_z=0.170006_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
Si III	7 ± 3	17 ± 5	12.05 ± 0.07
Si III	52 ± 6	14 ± 10	11.62 ± 0.17
N V	47 ± 3	31 ± 5	13.29 ± 0.05
N V	122 ± 7	21 ± 11	12.74 ± 0.14
O VI	3 ± 28	152 ± 20	13.94 ± 0.06
O VI	107 ± 9	48 ± 12	13.29 ± 0.11
H I	-92 ± 1	36 ± 1	13.85 ± 0.02
H I	0 ± 2	63 ± 3	13.68 ± 0.02
H I	120 ± 1	28 ± 1	13.35 ± 0.02

log Z_{ref} = -1
N(H I)= 13.68

Excluding O VI : n_H = -4.10 ± 0.02 Z = 0.91 ± 0.04
Including O VI : n_H = -4.14 ± 0.02 Z = 0.94 ± 0.04

N(H I)= 13.35

Excluding O VI : n_H = -4.07 ± 0.06 Z = 0.75 ± 0.11
Including O VI : n_H = -4.11 ± 0.05 Z = 0.79 ± 0.10

log Z_{ref} = 1
N(H I)= 13.68

Excluding O VI : n_H = -4.33 ± 0.02 Z = 1.30 ± 0.05
Including O VI : n_H = -4.43 ± 0.01 Z = 1.25 ± 0.05

N(H I)= 13.35

Excluding O VI : n_H = -4.30 ± 0.05 Z = 1.18 ± 0.13
Including O VI : n_H = -4.41 ± 0.02 Z = 1.15 ± 0.12

Figure 33: N(H I)=13.68, log Z_{ref} = -1

Figure 34: N(H I)=13.35, log Z_{ref} = -1

Figure 35: N(H I)=13.68, log $Z_{ref} = 1$

Figure 36: N(H I)=13.35, log $Z_{ref} = 1$

Non-detections

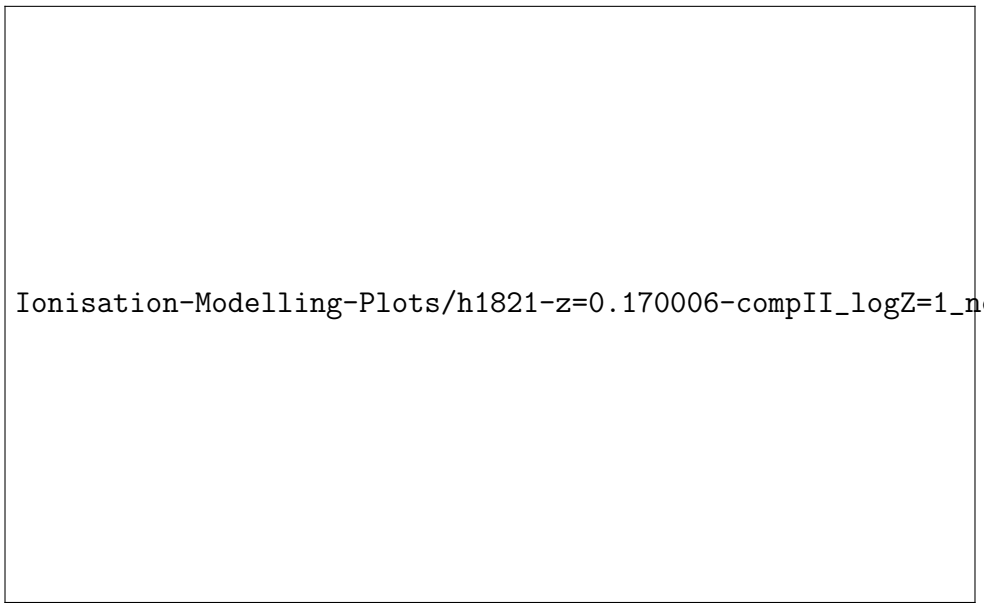


Figure 37: N(H I)=13.68, log Z_{ref}=1

Figure 38: N(H I)=13.35, log Z_{ref}=1

Comments

- For component II (N(H I)=13.68), solution very close to explaining all 3 ions but not exactly when using logZ=-1 models, but clearly, can't explain the 3 ions together when logZ=1 models are used.
- Similarly, for component III (N(H I)=13.68), all 3 ions can be explained when using logZ=-1 models, but not with logZ=1 models.
- Ionisation : CI
- BLA : +ve

System-Plots/H1821+643_z=0.224981_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
Si III	-59 ± 13	31 ± 18	12.23 ± 0.15
Si III	-1 ± 6	22 ± 9	12.71 ± 0.13
C III	-31 ± 1	24 ± 2	13.36 ± 0.07
C III	12 ± 1	36 ± 2	13.84 ± 0.02
C III	81 ± 3	15 ± 5	12.6 ± 0.09
C III	335 ± 7	20 ± 10	12.13 ± 0.11
O VI	0 ± 1	45 ± 1	14.24 ± 0.01
O VI	57 ± 2	3 ± 3	13.12 ± 0.1
O VI	330 ± 1	13 ± 2	13.42 ± 0.03
H I	-109 ± 3	33 ± 0	13.87 ± 0.09
H I	-38 ± 1	30 ± 1	15.16 ± 0.02
H I	-19 ± 10	84 ± 13	13.64 ± 0.11
H I	18 ± 1	19 ± 1	15.13 ± 0.03
H I	276 ± 7	62 ± 11	13.48 ± 0.06

N(H I)= 15.16

Excluding O VI : n_H = -3.29 ± 0.08 Z = -0.95 ± 0.07
Including O VI : n_H = -4.36 ± 0.02 Z = -0.81 ± 0.04

N(H I)= 15.13

Excluding O VI : n_H = -3.29 ± 0.03 Z = -0.44 ± 0.03
Including O VI : n_H = -3.83 ± 0.04 Z = -0.77 ± 0.03

NOTE : Solution using χ^2, MCMC didn't converge good, shows hint of two solution, another solution with high density and metallicity for both the components

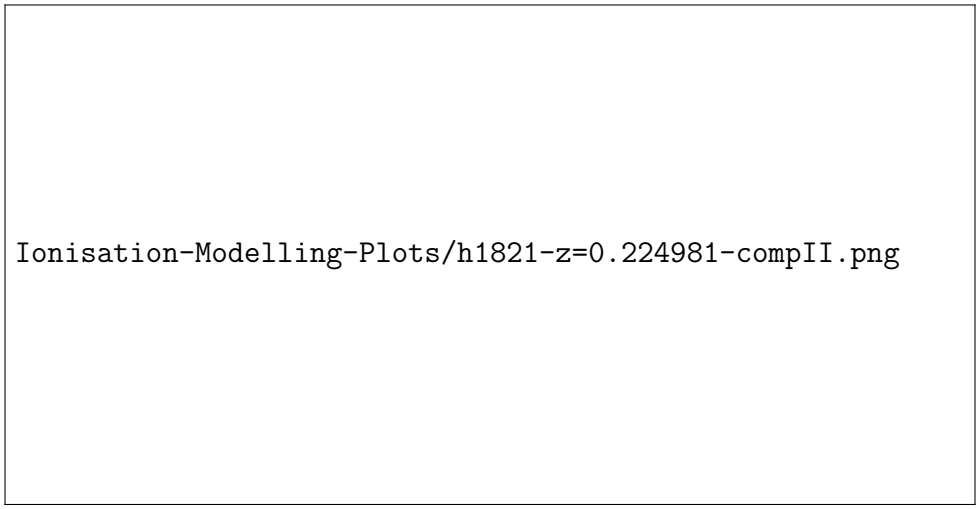


Figure 39: N(H I)=15.16

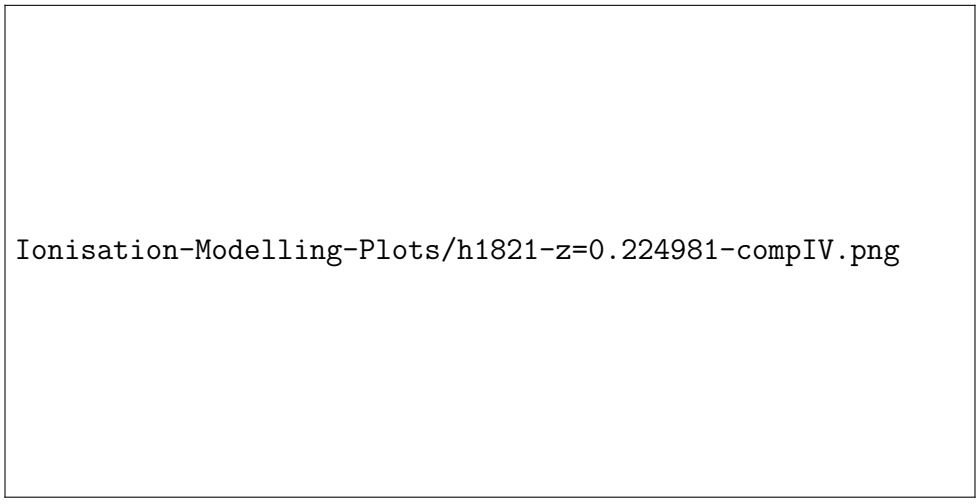


Figure 40: N(H I)=15.13

Non-detections

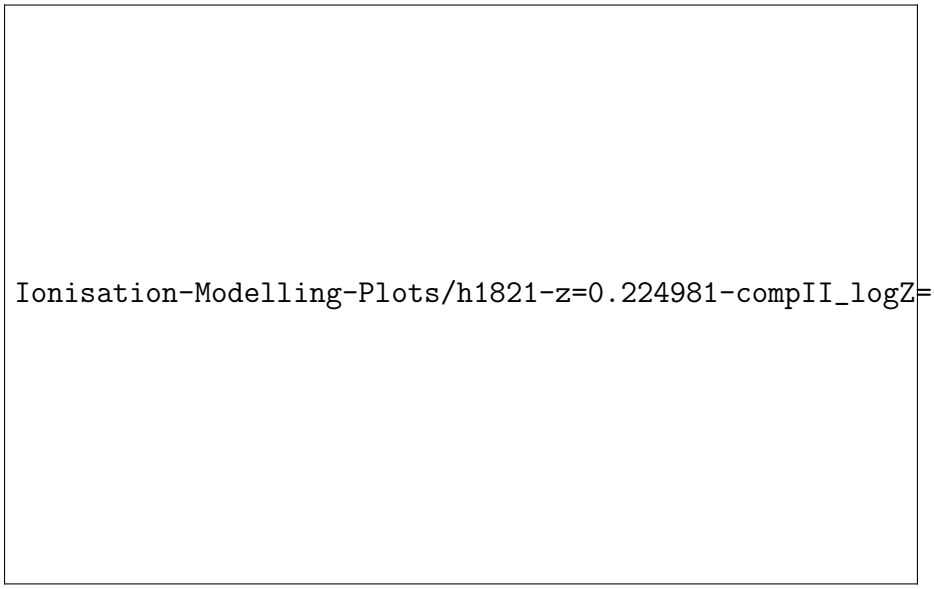


Figure 41: N(H I)=15.16, log Z_{ref}=-1

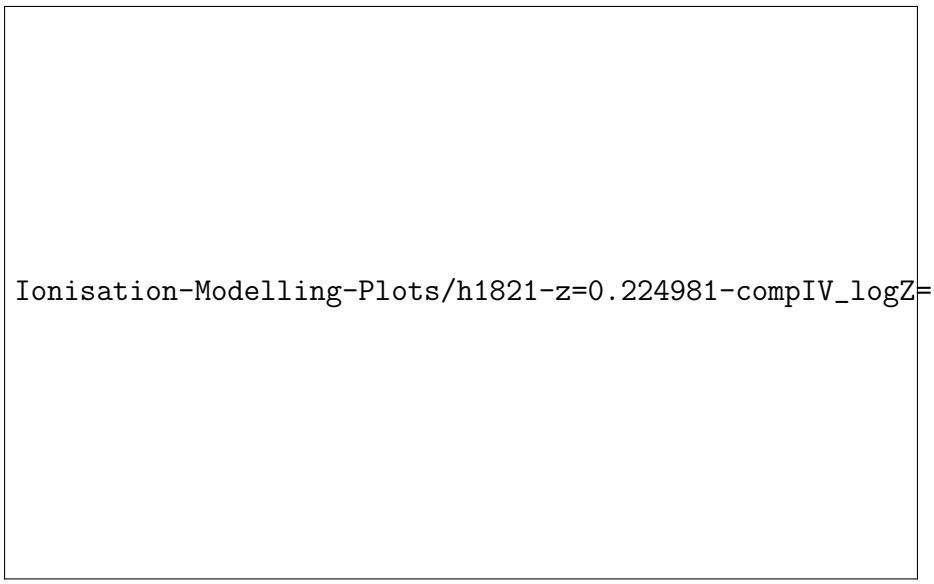


Figure 42: N(H I)=15.13, log Z_{ref}=-1

Comments

- All 3 ions couldn't be explained for both component II (N(H I)=15.16) and IV (N(H I)=15.13)
- Ionisation : CI
- BLA : +ve

System-Plots/PG1121+422_z=0.192393_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
Si III	-11 ± 13	10 ± 3	12.62 ± 0.10
Si III	9 ± 13	18 ± 4	13.14 ± 0.04
C III	-26 ± 10	10 ± 7	13.04 ± 0.09
C III	8 ± 5	18 ± 6	13.74 ± 0.11
C II	-9 ± 3	17 ± 5	13.69 ± 0.08
C II	9 ± 2	16 ± 3	13.93 ± 0.05
Si IV	10 ± 7	22 ± 11	12.86 ± 0.13
Si II	-3 ± 1	15 ± 2	13.04 ± 0.06
Si II	27 ± 19	42 ± 1	12.48 ± 0.23
O VI	-7 ± 13	11 ± 16	12.84 ± 0.19
O VI	20 ± 3	3 ± 4	13.37 ± 0.12
H I	1 ± 2	60 ± 6	14.34 ± 0.09
H I	5 ± 1	19 ± 1	17.7 ± 0.11

N(H I)=14.34

log Z_{ref} = -1
Excluding O VI : n_H = -1.78 ± 0.05 Z = 1.97 ± 0.04
Including O VI : n_H = -3.00 ± 0.04 Z = 1.25 ± 0.04

log Z_{ref} = 1
Excluding O VI : n_H = -3.12 ± 0.07 Z = 1.62 ± 0.07
Including O VI : n_H = -3.7 ± 0.03 Z = 1.33 ± 0.04

N(H I)= 17.70
Excluding O VI : n_H = -2.35 ± 0.05 Z = -1.66 ± 0.06
Including O VI : n_H = -3.08 ± 0.04 Z = -2.08 ± 0.05

NOTE : Since very high N(H I), so low metallicity. And solutions aren't much good.

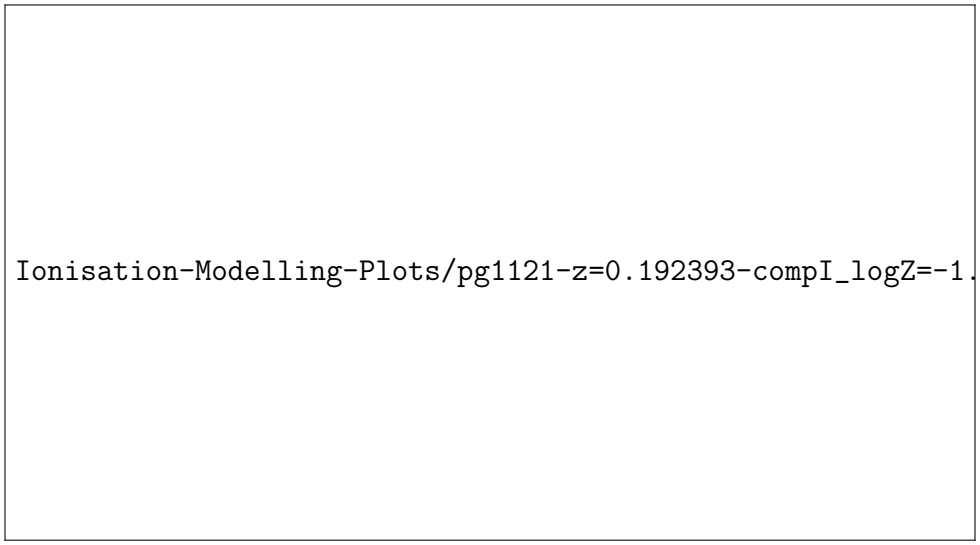


Figure 43: N(H I)=14.34, log Z_{ref}=-1

Figure 44: N(H I)=14.34, log Z_{ref}=1

Figure 45: N(H I)=17.70, log Z_{ref}=-1

Non-detections

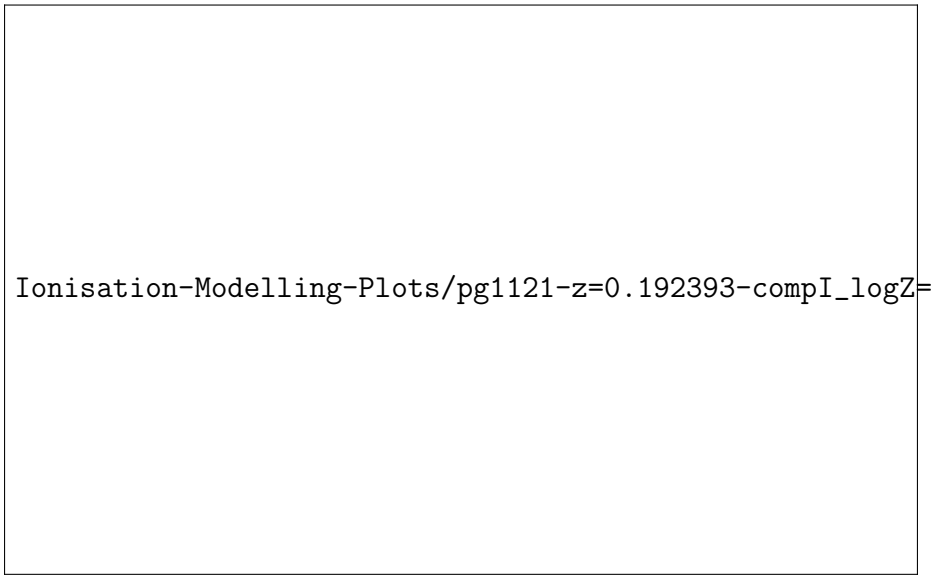


Figure 46: N(H I)=14.34, log Z_{ref}=1

Figure 47: N(H I)=17.70, log Z_{ref}=-1

Comments

- For component I (N(H I)=14.34), solution is little better when logZ=-1 model is used, where other ions than O VI could be explained upto some level. And solution is not good in case of logZ=1 model
- For component II (N(H I)=17.70), no good solution is obtained, possibly due to more no. of ions.
- All the solutions underproduce O VI
- Ionisation : CI
- BLA : +ve


System-Plots/PKS0405-123_z=0.167125_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
O I	-14 ± 5	23 ± 7	13.52 ± 0.08
C II	-37 ± 2	16 ± 2	13.76 ± 0.02
C II	-1 ± 1	6 ± 1	16.27 ± 0.12
C III	-136 ± 2	32 ± 2	13.45 ± 0.02
C III	-26 ± 0	37 ± 2	14.33 ± 0.04
N II	-27 ± 6	44 ± 5	13.47 ± 0.09
N II	-7 ± 1	12 ± 1	14.11 ± 0.02
N III	-7 ± 0	9 ± 4	14.06 ± 0.08
N III	5 ± 0	50 ± 2	14.43 ± 0.02
N V	-276 ± 3	30 ± 0	13.25 ± 0.05
N V	-116 ± 0	59 ± 9	13.32 ± 0.08
N V	-79 ± 13	24 ± 12	12.77 ± 0.19
N V	-3 ± 2	43 ± 3	13.89 ± 0.03
Si III	-41 ± 3	13 ± 4	12.66 ± 0.10
Si III	-1 ± 2	22 ± 2	13.28 ± 0.03
Si IV	-128 ± 0	25 ± 5	12.61 ± 0.06
Si IV	2 ± 1	31 ± 2	13.25 ± 0.02
Si II	-48 ± 5	26 ± 8	12.54 ± 0.09
Si II	-4 ± 1	15 ± 0	13.24 ± 0.02
O VI	-268 ± 0	74 ± 5	14.05 ± 0.02
O VI	-129 ± 8	41 ± 3	14.05 ± 0.10
O VI	-64 ± 5	32 ± 2	14.11 ± 0.17
O VI	-2 ± 4	43 ± 3	14.49 ± 0.05
H I	-158 ± 0	56 ± 9	13.09 ± 0.06
H I	-127 ± 4	26 ± 3	13.46 ± 0.04
H I	-80 ± 1	18 ± 2	13.54 ± 0.04
H I	-30 ± 0	18 ± 2	15.98 ± 0.34
H I	8 ± 49	19 ± 0	17.53 ± 0.07
H I	54 ± 90	30 ± 2	13.66 ± 0.04

N(H I)= 13.46

Excluding O VI : n_H = -3.98 ± 0.03 Z = 0.62 ± 0.02
Including O VI : n_H = -4.17 ± 0.02 Z = 0.63 ± 0.02

N(H I)= 15.98

Excluding O VI : n_H = -2.73 ± 0.04 Z = -0.18 ± 0.02
Including O VI : n_H = -3.27 ± 0.03 Z = -0.33 ± 0.02

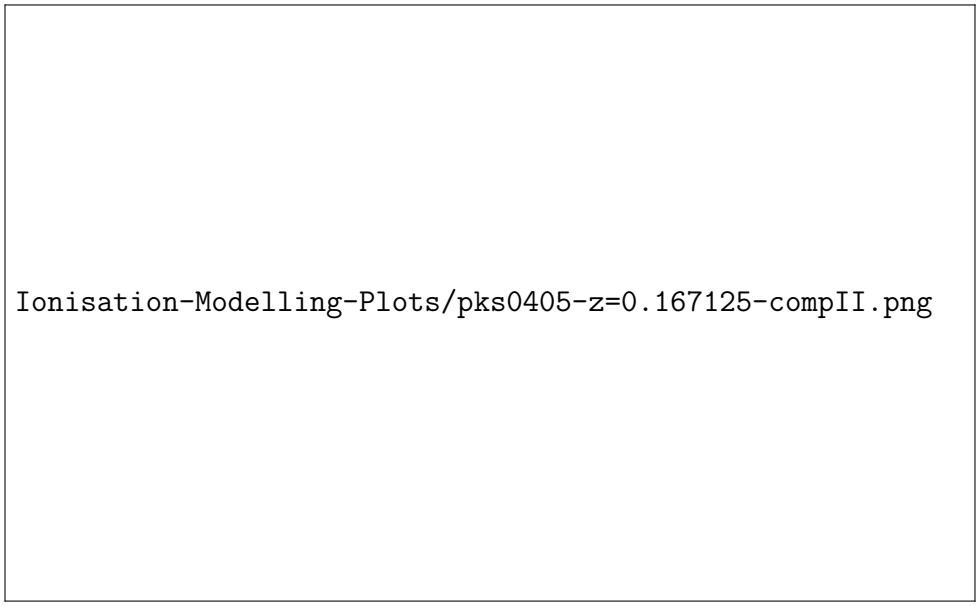


Figure 48: N(H I)=13.46

Figure 49: N(H I)=15.98

Comments

- Not a good solution for component II (N(H I)=13.46)
- For component IV (N(H I)=15.98), excluding O VI case explains all ions except Si III and O VI is underproduced in this case.
- Ionisation : CI
- BLA : +ve

Non O vi absorbers

System-Plots/HE0056-3622_z=0.043265_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
Si III	27 ± 6	34 ± 9	12.37 ± 0.07
N V	-26 ± 4	1 ± 8	13.42 ± 0.46
C IV	30 ± 2	31 ± 0	13.64 ± 0.03
H I	0 ± 3	85 ± 6	14.02 ± 0.07
H I	12 ± 1	32 ± 4	15.3 ± 0.1

Ionisation modelling to be done.


System-Plots/PG1216+069_z=0.006328_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
O I	8 ± 2	7 ± 5	14.07 ± 0.16
O I	25 ± 12	50 ± 13	14.0 ± 0.11
C II	0 ± 3	7 ± 5	13.98 ± 0.08
C II	24 ± 19	17 ± 6	13.43 ± 0.09
Si II	-68 ± 4	21 ± 6	12.51 ± 0.06
Si II	6 ± 1	18 ± 0	13.2 ± 0.02
H I	-233 ± 110	95 ± 15	13.56 ± 0.06
H I	-68 ± 0	81 ± 8	14.76 ± 0.12
H I	0 ± 0	106 ± 15	14.79 ± 0.08
H I	24 ± 0	20 ± 12	19.09 ± 0.03

N(H I) = 14.79

Solution : n_H = -1.90 ± 0.07 Z = 1.97 ± 0.05

NOTE : logZ near 2

Tried excluding O I also, still not good solution.

Excluding O I : n_H = -2.10 ± 0.25 Z = 1.84 ± 0.14
Including O I : n_H = -1.90 ± 0.07 Z = 1.97 ± 0.05
log Z_{ref}=1

Solution : n_H = -2.69 ± 0.05 Z = 1.97 ± 0.04

Excluding O I : n_H = -2.87 ± 1.32 Z = 1.82 ± 0.29
Including O I : n_H = -2.69 ± 0.05 Z = 1.97 ± 0.04

Figure 50: N(H I)=14.79, shows solution excluding O I, log Z_{ref}=-1

Figure 51: N(H I)=14.79, log Z_{ref}=-1

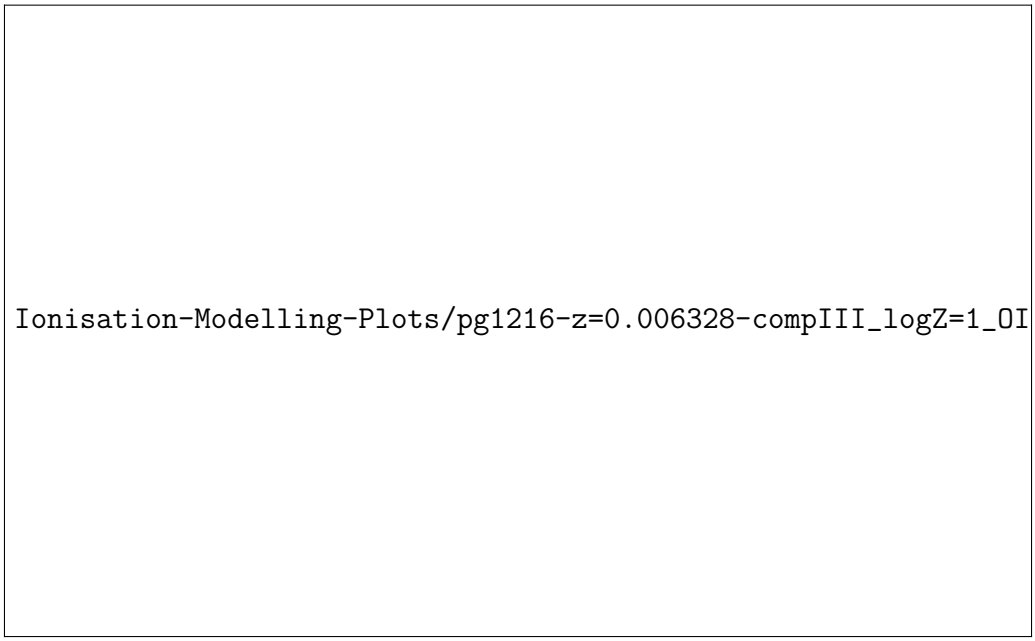


Figure 52: N(H I)=14.79, shows solution excluding O I, log Z_{ref}=1

Figure 53: N(H I)=14.79, log Z_{ref}=1

System-Plots/3C263_z=0.063397_sys_plot.png

∞

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
Si II	26 ± 2	8 ± 4	12.29 ± 0.06
Si III	-39 ± 1	21 ± 2	12.64 ± 0.03
Si III	34 ± 1	12 ± 1	12.91 ± 0.04
Si IV	25 ± 1	22 ± 0	13.57 ± 0.02
C IV	-35 ± 1	12 ± 3	13.42 ± 0.06
C IV	0 ± 2	13 ± 3	13.63 ± 0.06
C IV	38 ± 2	17 ± 2	13.86 ± 0.04
C II	34 ± 2	17 ± 3	13.37 ± 0.04
H I	-146 ± 2	25 ± 2	13.87 ± 0.04
H I	-35 ± 0	50 ± 6	14.88 ± 0.12
H I	0 ± 0	54 ± 6	14.42 ± 0.2
H I	38 ± 0	12 ± 3	16.46 ± 0.13

N(H I) = 16.46

Solution : n_H = -3.72 ± 0.02 Z = -0.99 ± 0.02

Figure 54: N(H I)=16.46, log Z_{ref}=-1

System-Plots/PG1222+216_z=0.054479_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
Si III	-12 ± 3	20 ± 3	13.19 ± 0.05
Si III	40 ± 5	27 ± 5	13.04 ± 0.07
Si IV	0 ± 1	25 ± 8	12.89 ± 0.08
Si IV	41 ± 4	10 ± 7	12.39 ± 0.13
C IV	-2 ± 1	29 ± 6	13.55 ± 0.1
C IV	41 ± 8	34 ± 6	13.5 ± 0.11
C IV	182 ± 10	26 ± 15	12.86 ± 0.15
C II	7 ± 4	26 ± 6	13.51 ± 0.07
C II	51 ± 4	10 ± 6	12.98 ± 0.09
H I	-12 ± 23	74 ± 11	14.08 ± 0.15
H I	5 ± 4	24 ± 3	17.91 ± 0.15
H I	0 ± 0	23 ± 1	17.9 ± 0.14
H I	41 ± 0	13 ± 2	17.22 ± 0.19

In table last two rows are from fits without BLA (fixed redshift).

N(H I) = 14.08
Solution : n_H = -3.45 ± 0.06 Z = 1.25 ± 0.05

log Z_{ref} = 1 :

Solution : n_H = -3.85 ± 0.04 Z = 1.92 ± 0.06

N(H I) = 17.91
Solution : n_H = -3.86 ± 0.08 Z = -2.91 ± 0.07

With Non-BLA fits :

N(H I) = 17.90
Solution : n_H = -3.62 ± 0.06 Z = -2.47 ± 0.06

N(H I) = 17.91
Solution : n_H = -3.73 ± 0.08 Z = -2.36 ± 0.06

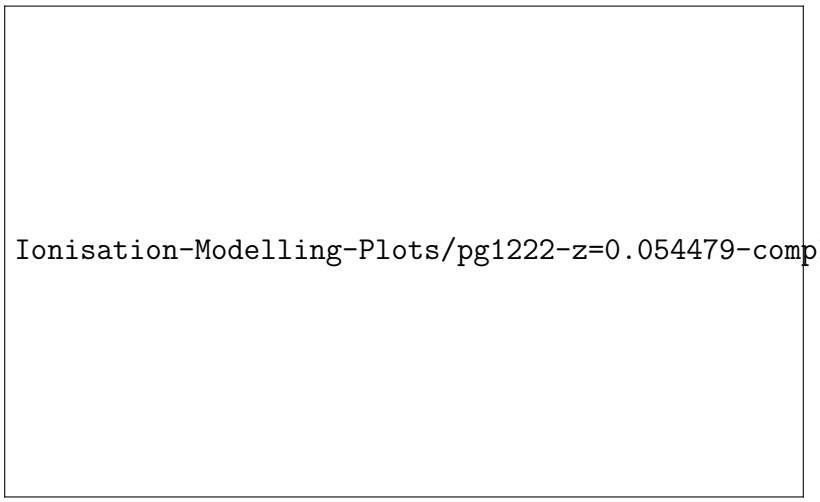


Figure 55: N(H I)=14.08, log Z_{ref}=-1

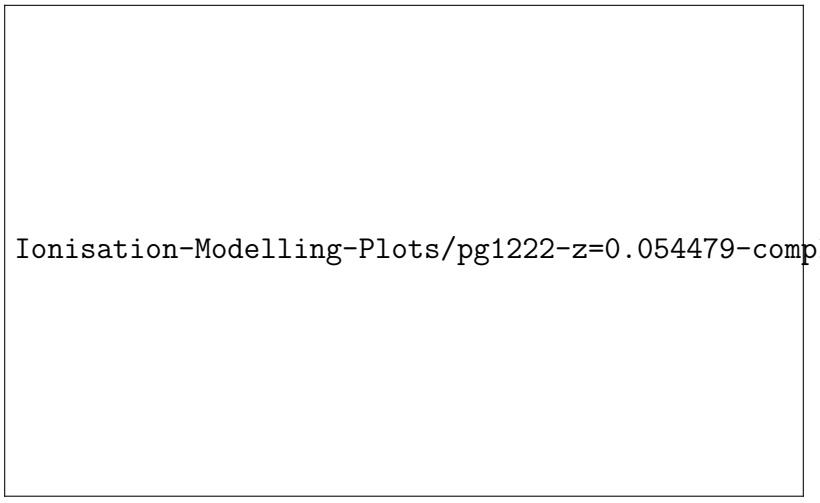


Figure 56: N(H I)=14.08, log Z_{ref}=1

Figure 57: N(H I)=17.91, log Z_{ref}=-1

With non-BLA fits

Figure 58: N(H I)=17.90, log Z_{ref}=-1

Figure 59: N(H I)=17.91, log Z_{ref}=-1


System-Plots/RXJ0439.6-5311_z=0.005568_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
Si III	16 ± 1	11 ± 3	13.01 ± 0.12
Si IV	-3 ± 4	20 ± 6	12.77 ± 0.08
C IV	4 ± 3	13 ± 5	13.5 ± 0.07
H I	0 ± 2	53 ± 6	14.3 ± 0.09
H I	5 ± 3	15 ± 6	16.11 ± 0.26

N(H I)= 16.11

Solution : n_H = -3.69 ± 0.07 Z = -1.07 ± 0.1

Ionisation-Modelling-Plots/rxj0439-z=0.005568-compII_logZ=-1.png

Figure 60: N(H I)=16.11, log Z_{ref}=-1

System-Plots/UKS0242-724_z=0.063850_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
Fe II	-90 ± 4	9 ± 9	13.49 ± 0.14
C II	-84 ± 2	7 ± 5	13.46 ± 0.11
C II	0 ± 3	3 ± 7	13.55 ± 0.16
C II	24 ± 5	9 ± 6	13.32 ± 0.1
Si II	-78 ± 3	25 ± 5	12.6 ± 0.05
Si II	10 ± 2	15 ± 4	12.52 ± 0.06
H I	-84 ± 0	30 ± 5	14.61 ± 0.06
H I	0 ± 0	46 ± 6	15.17 ± 0.1
H I	24 ± 0	19 ± 6	15.34 ± 1.33

N(H I) = 14.61

Solution : n_H = -1.28 ± 0.12 Z = 1.96 ± 0.06

NOTE : logZ near 2 and density also coming higher than usual.

Tried with excluding Fe II also

Excluding Fe II : n_H = -1.8 ± 0.55 Z = 1.54 ± 0.32
Including Fe II : n_H = -1.28 ± 0.11 Z = 1.96 ± 0.07

NOTE : Excluding Fe II MCMC hints towards 2 sol. Didn't converge satisfactorily.

log Z_{ref} = 1 :

Solution : n_H = -2.23 ± 0.13 Z = 1.92 ± 0.10

Excluding Fe II : n_H = -2.42 ± 0.58 Z = 1.69 ± 0.42
Including Fe II : n_H = -2.23 ± 0.13 Z = 1.92 ± 0.10

NOTE : Same note as above.

Figure 61: N(H I)=14.61, shows solution with excluding Fe II, log Z_{ref}=-1

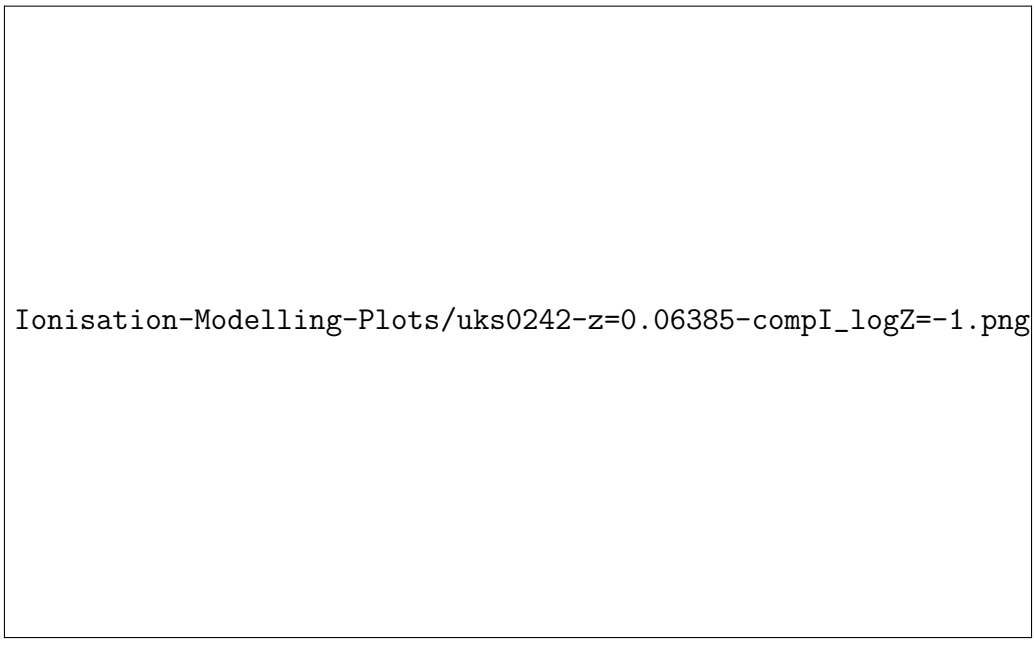


Figure 62: N(H I)=14.61, log Z_{ref}=-1

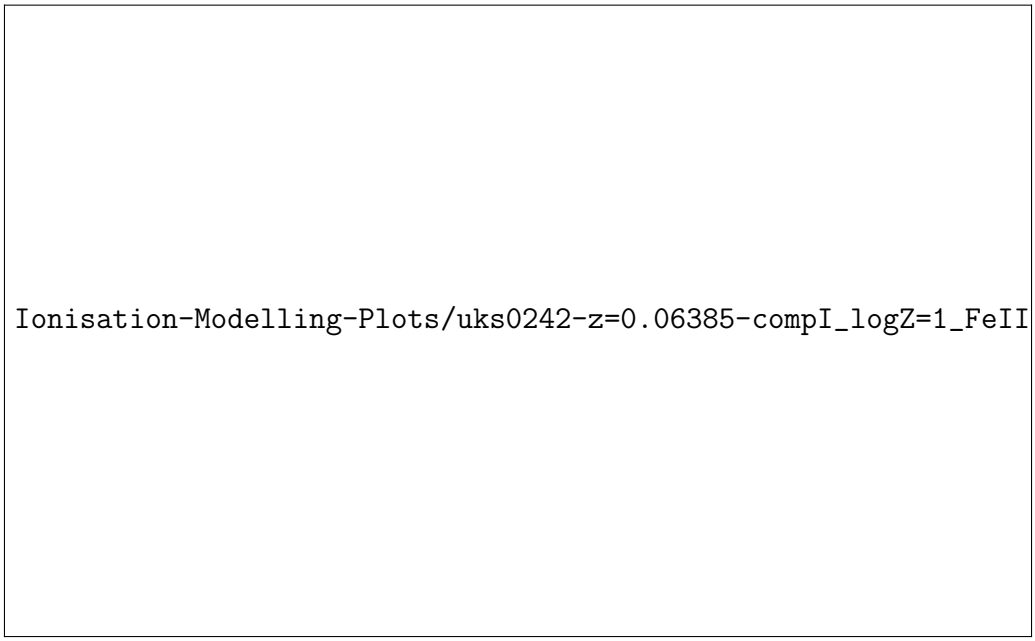


Figure 63: N(H I)=14.61, shows solution with excluding Fe II, log Z_{ref}=1

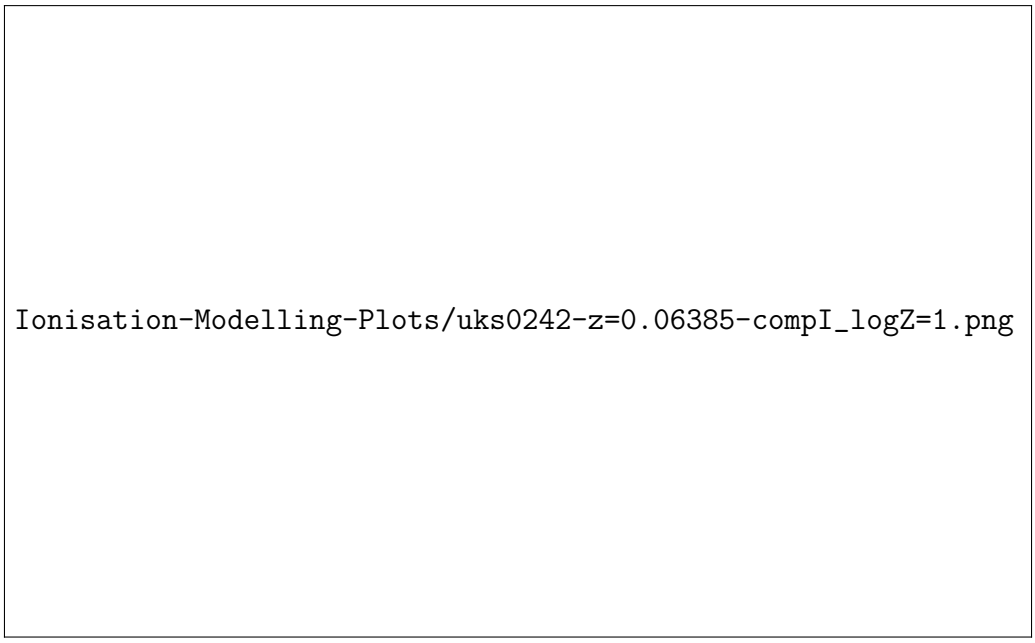
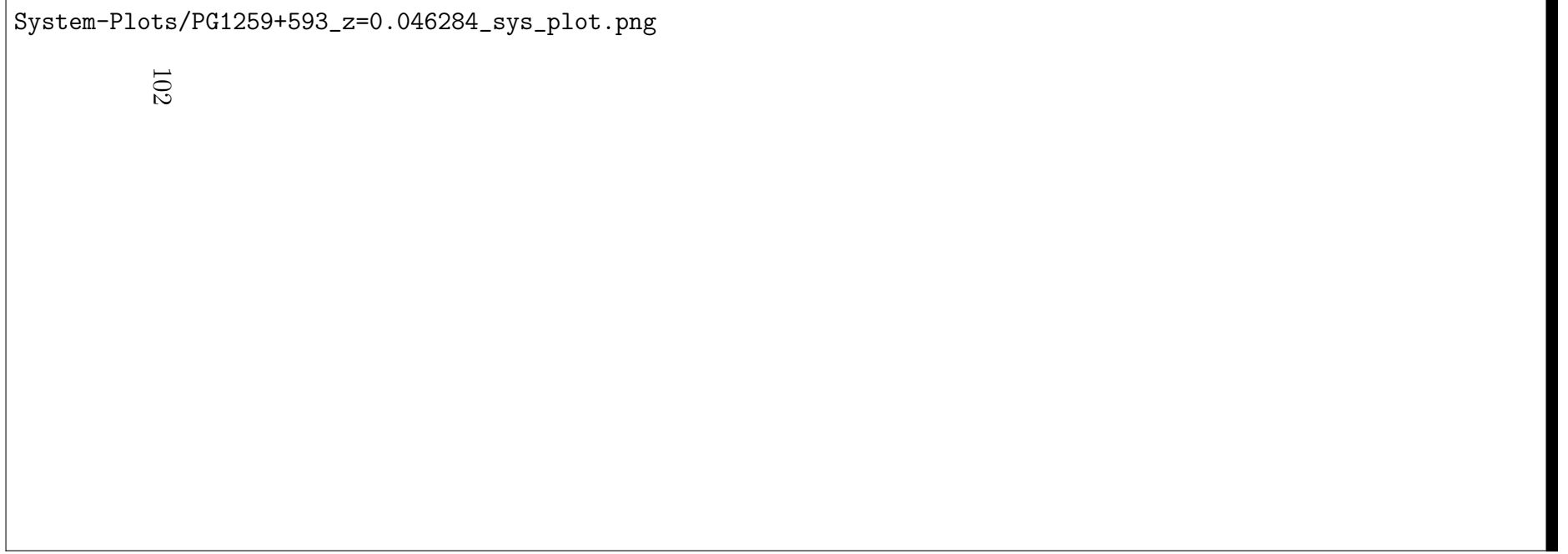


Figure 64: N(H I)=14.61, log Z_{ref}=1


System-Plots/PG1259+593_z=0.046284_sys_plot.png

Ion	v (km s^{-1})	b (km s^{-1})	log [N cm^{-2}]
C IV	-34 ± 2	31 ± 3	13.7 ± 0.03
C IV	42 ± 2	16 ± 3	13.56 ± 0.05
Si IV	-43 ± 4	35 ± 6	12.67 ± 0.05
Si III	-50 ± 2	29 ± 3	12.87 ± 0.03
Si III	67 ± 3	40 ± 5	12.78 ± 0.04
H I	-590 ± 8	47 ± 12	12.79 ± 0.08
H I	-23 ± 7	26 ± 3	17.79 ± 0.07
H I	0 ± 5	61 ± 7	14.86 ± 0.06
H I	140 ± 3	27 ± 4	13.43 ± 0.07

N(H I) = 17.79

Solution : n_H = -4.23 ± 0.04 Z = -3.18 ± 0.04

NOTE : Used logZ range from -4 because of low Z

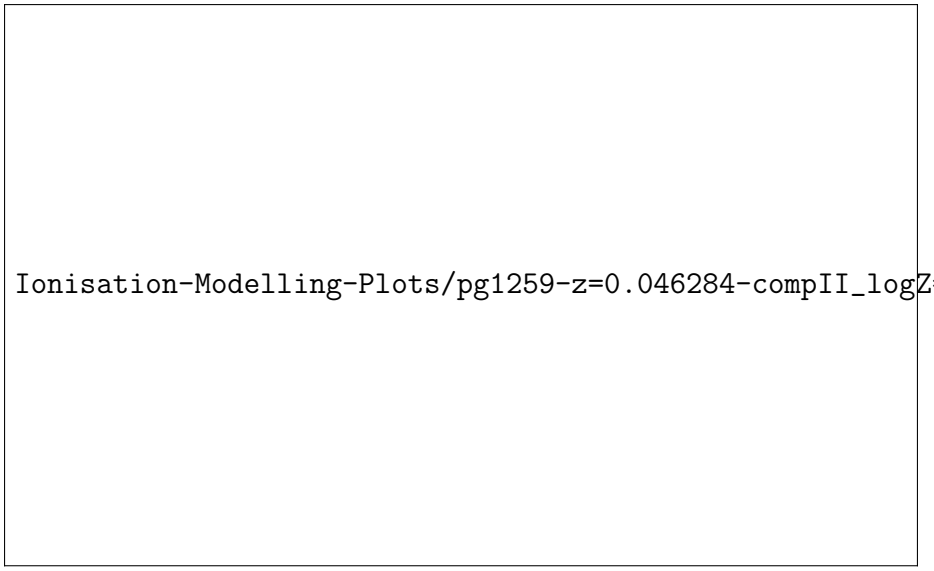


Figure 65: N(H I)=17.79, log Z_{ref}=-1

System-Plots/PKS1302-102_z=0.094839_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
Si III	0 ± 2	22 ± 3	12.82 ± 0.04
Si III	45 ± 3	16 ± 4	12.48 ± 0.08
Si II	11 ± 5	34 ± 7	12.48 ± 0.06
C II	7 ± 8	21 ± 8	13.27 ± 0.09
C II	46 ± 4	10 ± 5	13.25 ± 0.09
H I	-229 ± 1	29 ± 2	14.81 ± 0.14
H I	0 ± 0	46 ± 2	14.96 ± 0.1
H I	45 ± 0	31 ± 4	14.25 ± 0.14

N(H I) = 14.96

Solution : n_H = -2.65 ± 0.06 Z = 0.62 ± 0.06

log Z_{ref} = 1

Solution : n_H = -4.14 ± 0.04 Z = 0.64 ± 0.03

NOTE : Density changed considerably in the two cases.

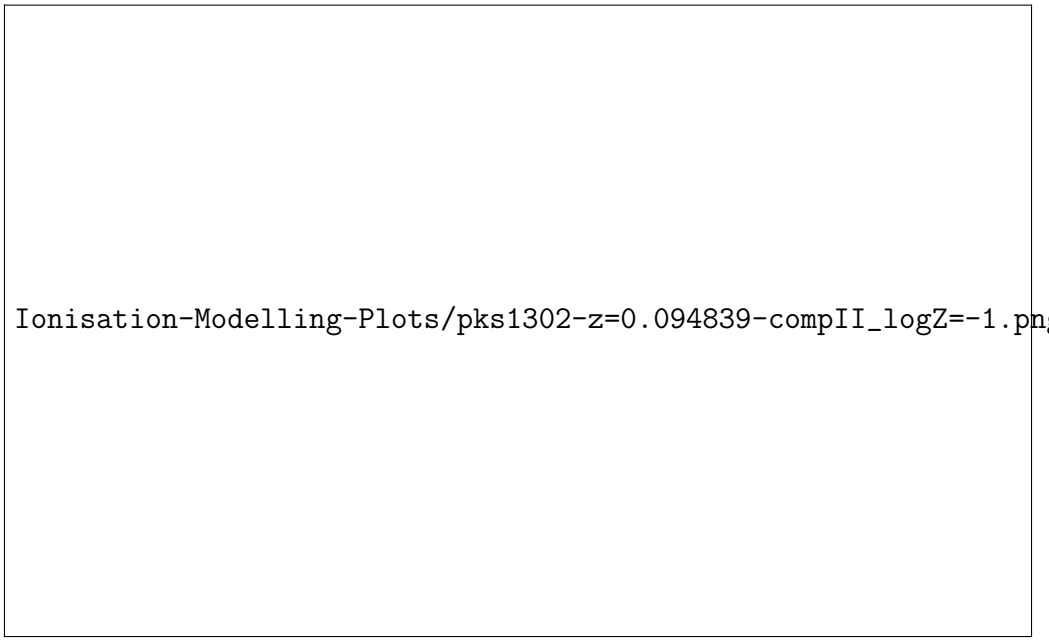


Figure 66: N(H I)=14.96, log Z_{ref}=-1

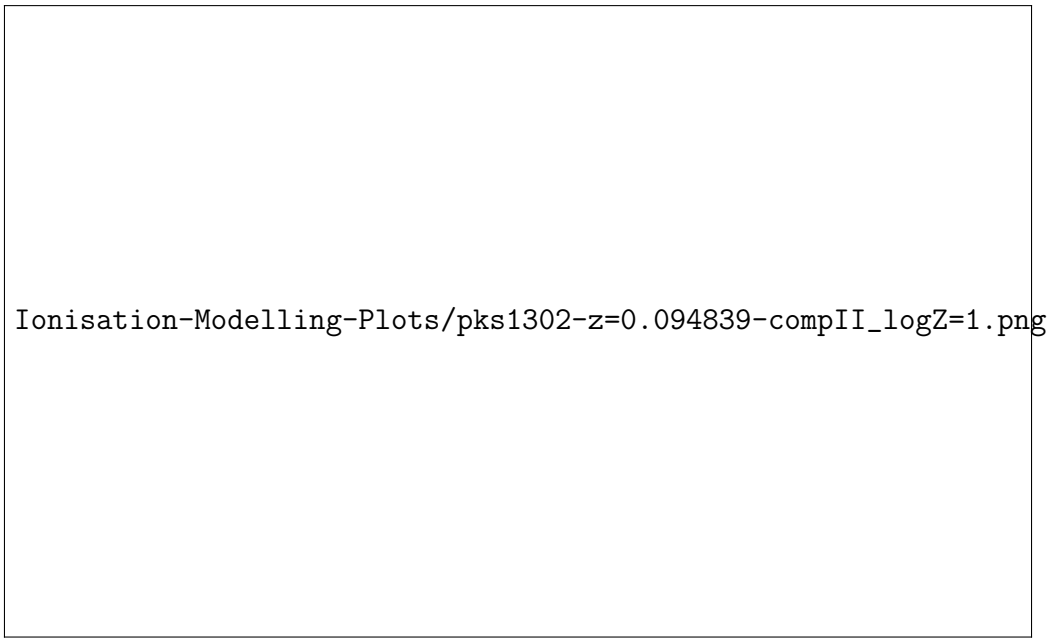
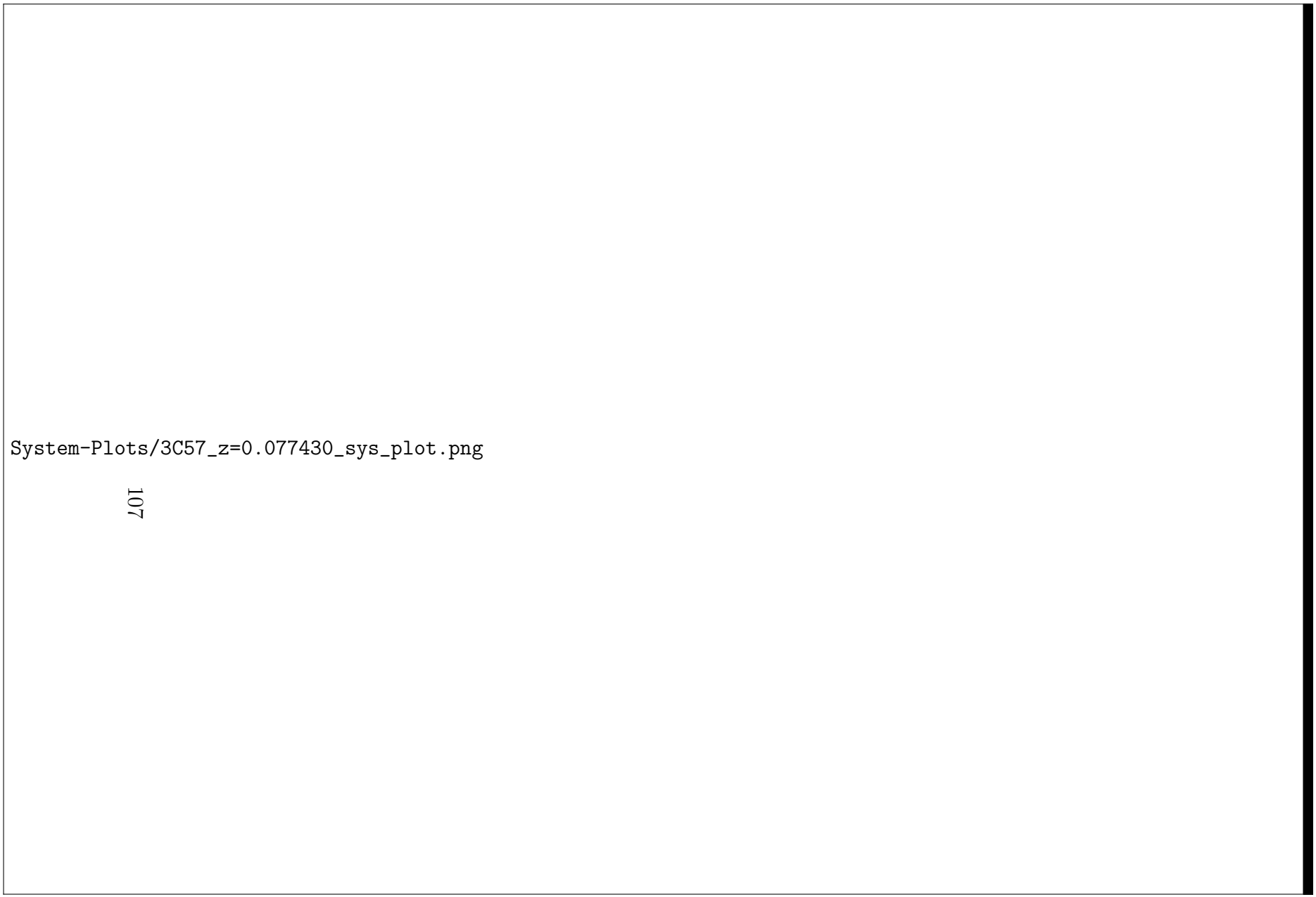


Figure 67: N(H I)=14.96, log Z_{ref}=1


System-Plots/3C57_z=0.077430_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
C IV	-12 ± 6	32 ± 9	13.43 ± 0.08
Si IV	-4 ± 4	7 ± 6	12.54 ± 0.09
Si IV	37 ± 4	22 ± 6	12.92 ± 0.07
Si III	-38 ± 5	34 ± 7	12.67 ± 0.06
H I	-50 ± 2	8 ± 4	13.3 ± 0.08
H I	0 ± 4	50 ± 4	13.86 ± 0.04

N(H I) = 13.30

Solution : n_H = -3.73 ± 0.05 Z = 1.38 ± 0.05

log Z_{ref} = 1

Solution : n_H = -4.04 ± 0.04 Z = 1.98 ± 0.03

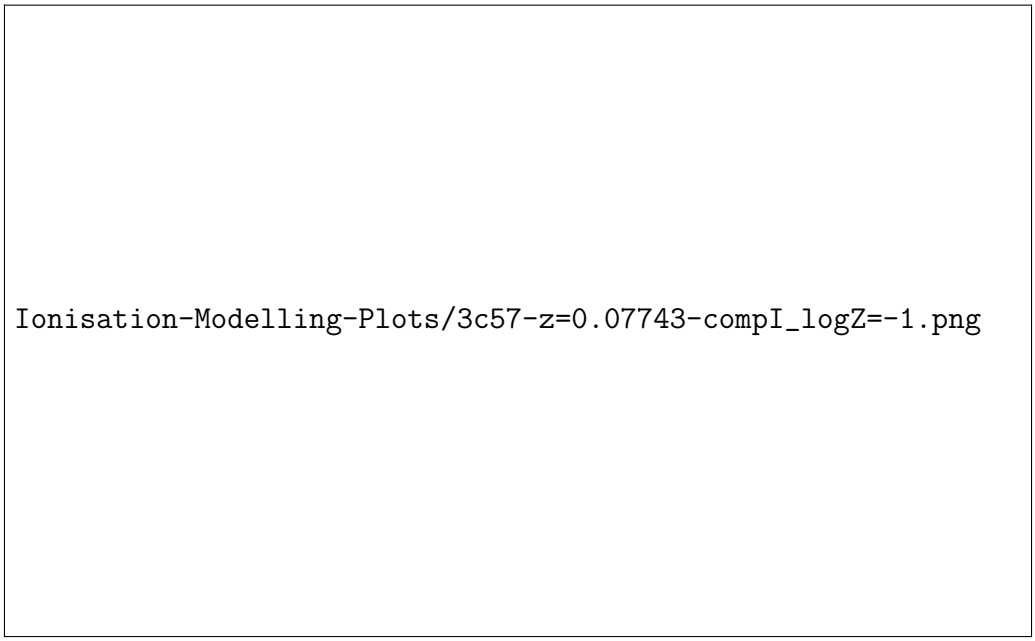


Figure 68: N(H I)=13.30, log Z_{ref}=-1

Figure 69: N(H I)=13.3, log Z_{ref}=1


System-Plots/PMNJ1103-2329_z=0.003934_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
Si III	23 ± 3	4 ± 3	15.02 ± 0.22
Si IV	13 ± 3	23 ± 5	12.96 ± 0.06
N V	22 ± 5	52 ± 8	13.65 ± 0.05
C IV	10 ± 1	24 ± 2	14.26 ± 0.04
H I	-68 ± 6	10 ± 7	13.37 ± 0.09
H I	0 ± 12	19 ± 2	16.29 ± 0.19
H I	60 ± 27	28 ± 4	13.95 ± 0.05

N(H I) = 16.29

Solution : n_H = -4.17 ± 0.03 Z = -1.08 ± 0.04

Tried excluding Si III also

Excluding Si III : n_H = -4.24 ± 0.03 Z = -1.19 ± 0.04
Including Si III : n_H = -4.17 ± 0.03 Z = -1.08 ± 0.04

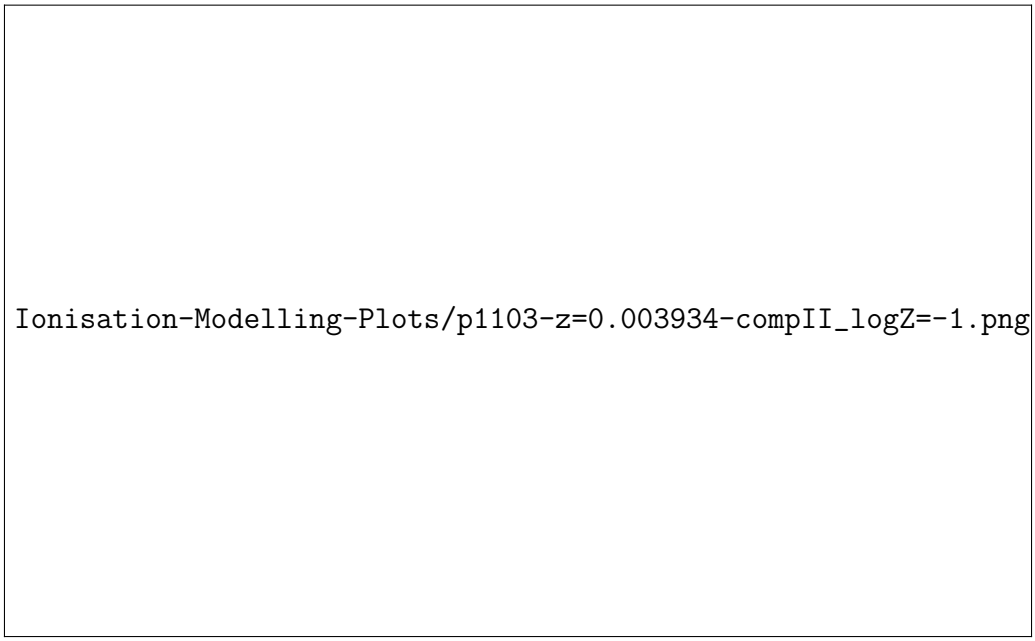


Figure 70: N(H I)=16.29, log Z_{ref}=-1

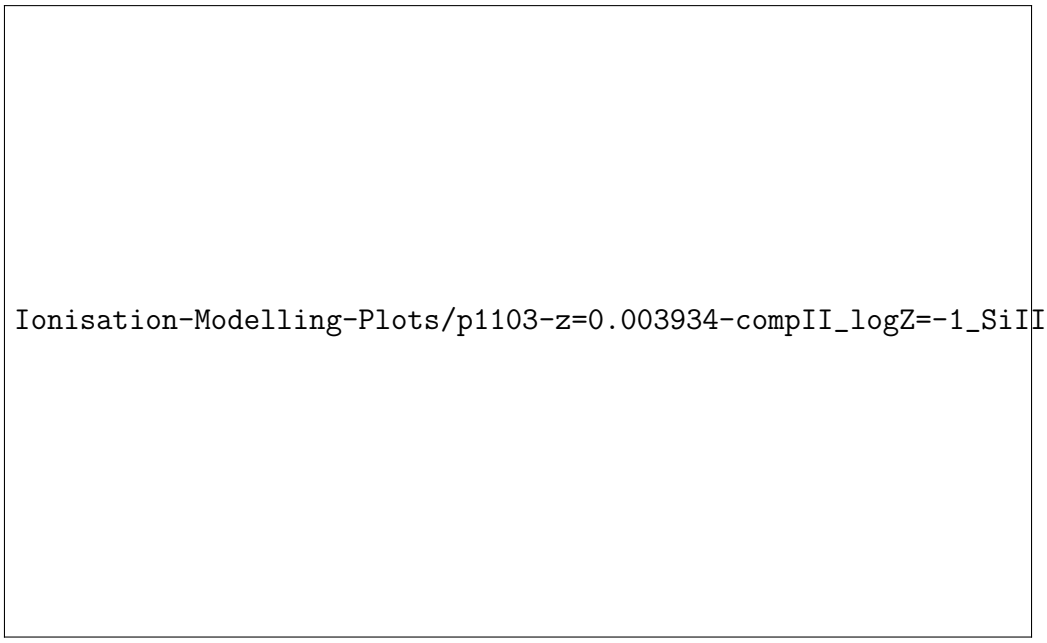


Figure 71: N(H I)=16.29, shows excluding Si III case, log Z_{ref}=-1

System-Plots/PHL1811_z=0.080928_sys_plot.png

Ion	**v (km s^{-1})**	**b (km s^{-1})**	**log [N cm^{-2}]**
O I	-6 ± 1	15 ± 2	14.29 ± 0.05
C II	-1 ± 1	16 ± 1	14.15 ± 0.02
N II	-1 ± 1	13 ± 1	14.06 ± 0.03
C IV	-49 ± 2	16 ± 3	13.38 ± 0.04
C IV	-1 ± 1	11 ± 1	13.93 ± 0.04
Si IV	-2 ± 1	11 ± 1	13.46 ± 0.03
Fe II	-4 ± 1	7 ± 3	13.7 ± 0.07
Si II	-10 ± 1	3 ± 1	14.24 ± 0.07
Si II	7 ± 1	4 ± 1	13.33 ± 0.08
H I	-875 ± 1	32 ± 1	14.6 ± 0.06
H I	-528 ± 0	30 ± 2	15.38 ± 0.05
H I	-34 ± 1	29 ± 1	18.02 ± 0.11
H I	0 ± 19	126 ± 23	13.62 ± 0.07

N(H I) = 18.02

Using all ions :
Solution : n_H = -3.11 ± 0.01 Z = -1.28 ± 0.01

Using C II, C IV, Si II and Si IV :
Solution : n_H = -3.44 ± 0.02 Z = -1.7 ± 0.02

Figure 72: N(H I)=18.02, all ions, log Z_{ref}=-1

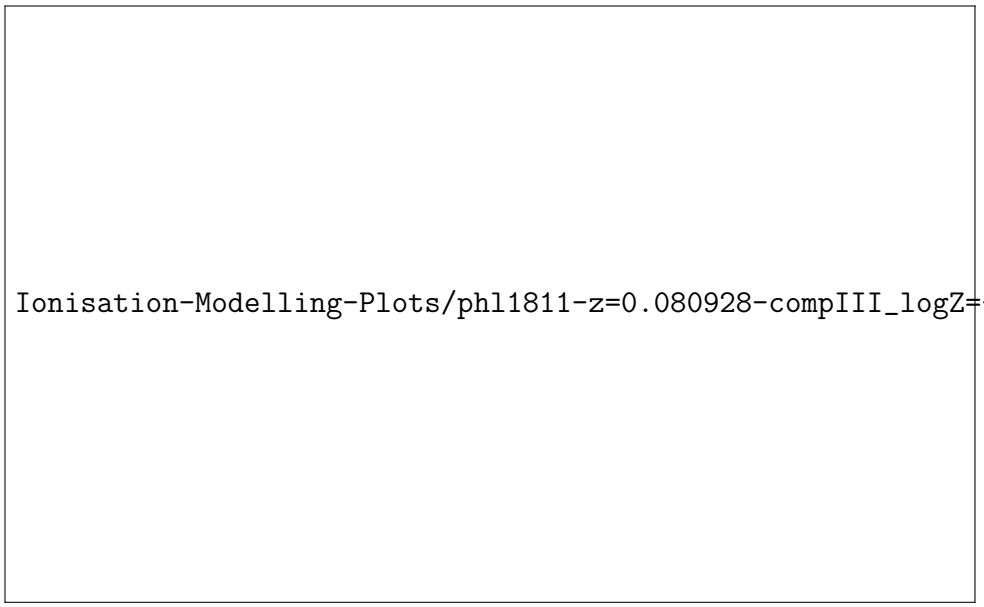


Figure 73: N(H I)=18.02, C II, C IV, Si II and Si IV, log Z_{ref}=-1

Some statistics

O VI absorbers

Total no. of absorbers : 16

CI : 14 + 1 tentative

PI : 1 (one component is PI and other is CI, so this is included in above 14 CI absorbers)

BLA +ve : 14

BLA -ve or tentative : 2 - one has b values of 23, 9 and other absorber has 22,16,16

For, one absorber ionisation state (PG0003 z_{abs}=0.386089) couldn't be inferred.

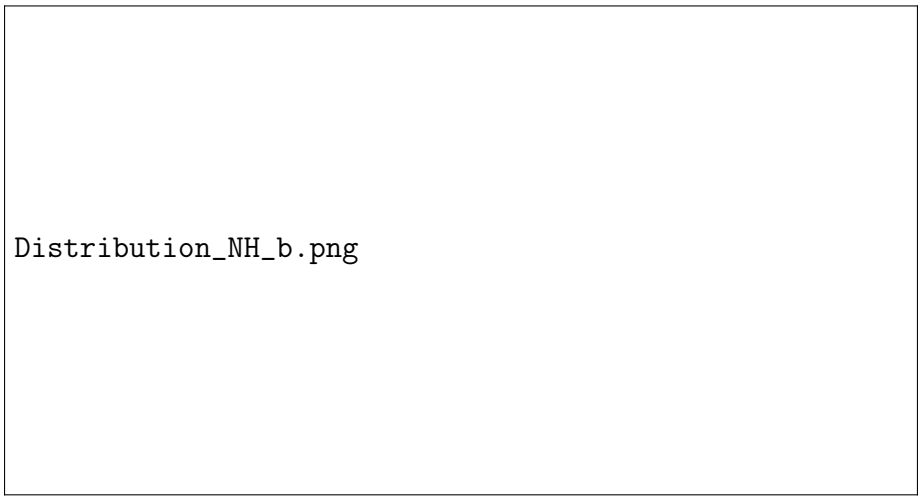


Figure 74: Distribution of column density and doppler parameters of the Lyman lines in the 17 absorbers

Figure 75: Doppler parameter vs. Column density. Horizontal black dashed line shows the doppler parameter of 40 km s^{-1}

Figure 76: b(O VI) vs. b(H I). Grey filled circles are measurements from Danforth et al. (2016).

Figure 77: Distribution of temperature calculated from Doppler parameters of H I and O VI lines.

Figure 78: Ionisation modelling solutions (n_H, Z) for all 26 components of O VI absorbers.

Figure 79: O VI column density predictions.

Figure 80: Variation of N(H I) with n_H

Figure 81: Variation of N(H I) with Z