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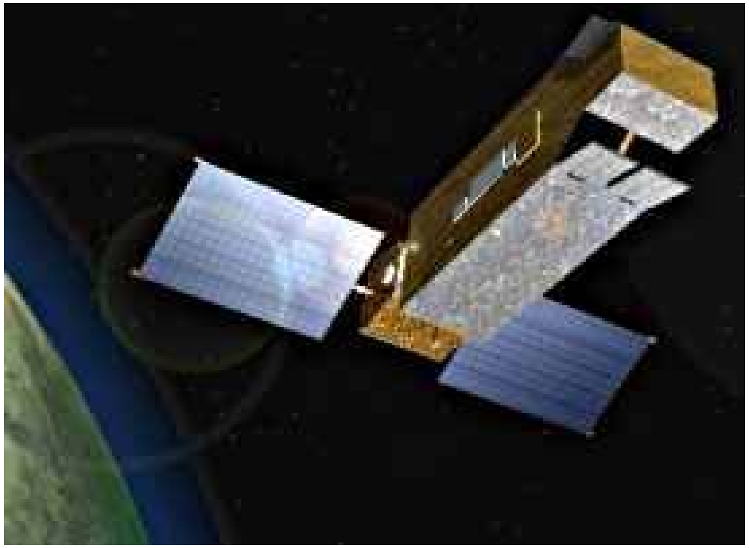
DEPARTMENT OF PHYSICS AND ASTRONOMY

FUV Line Identification



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FUV lines in white dwarf spectra

Can we distinguish between photospheric lines and ISM lines (without modelling)?

Should we rely on modelling alone to identify stellar content?

Why do we not detect the same line richness with FUSE as we do with HST?

Have we identified everything?

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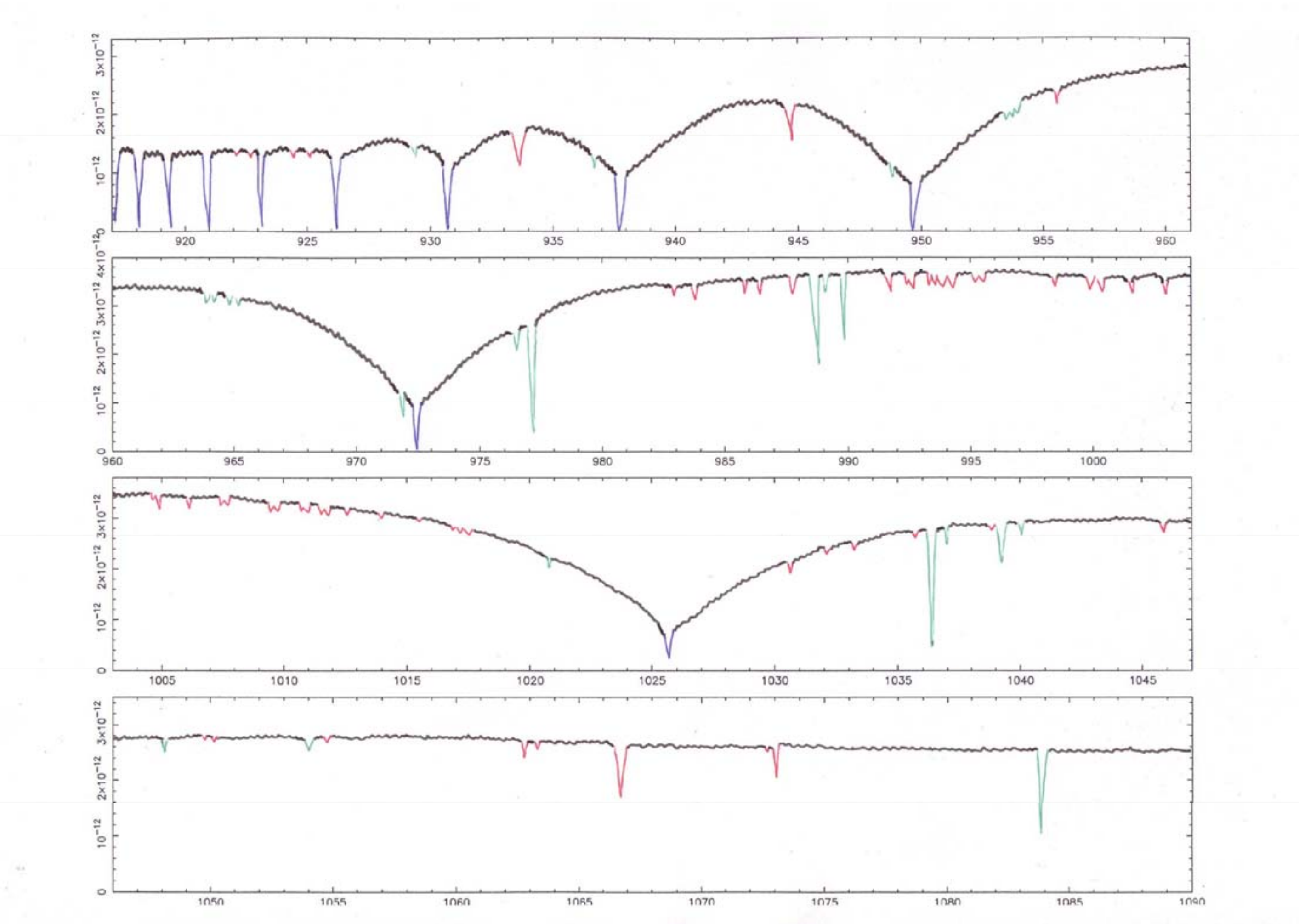
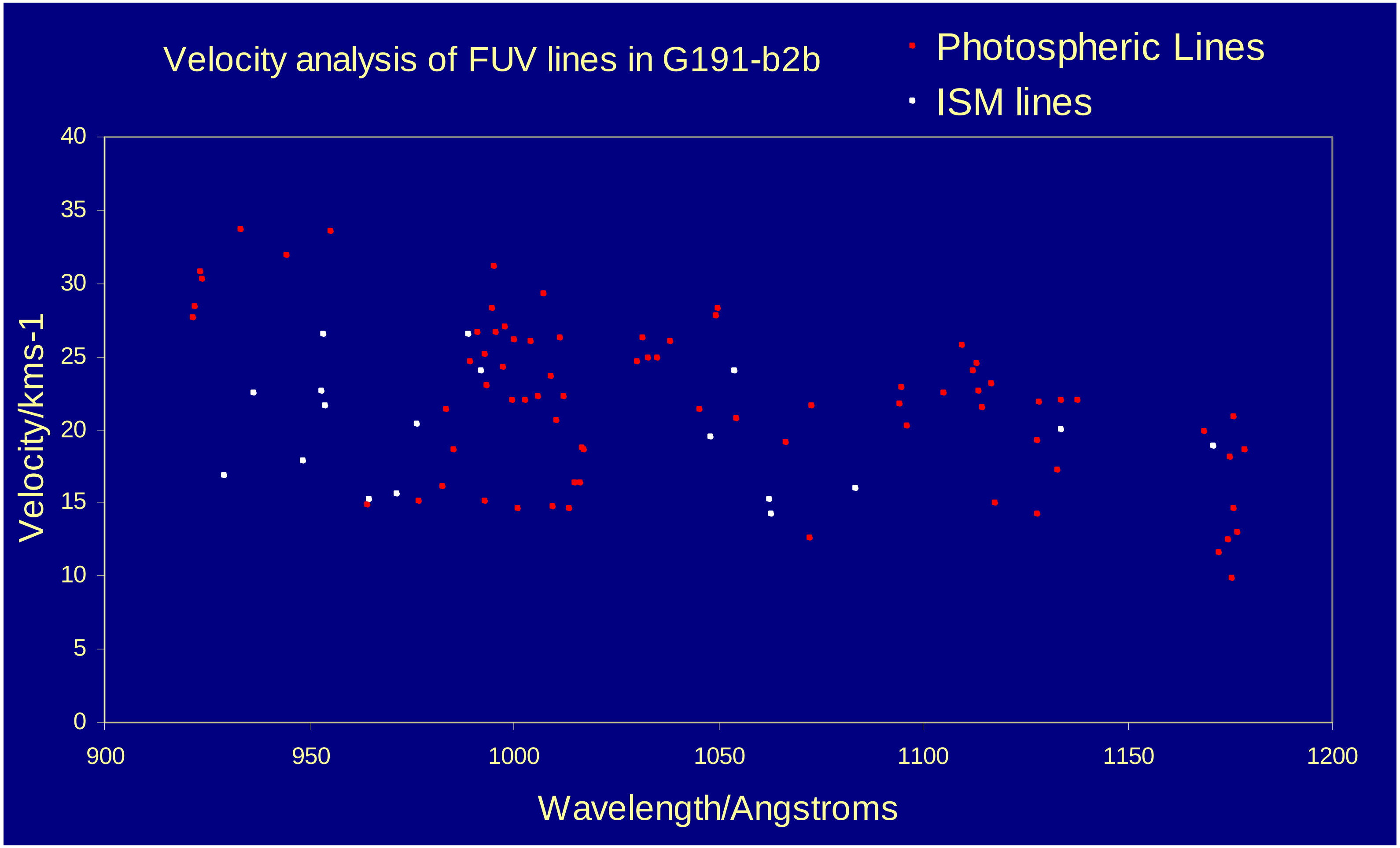
Introduction - The white dwarf spectrum in the FUV



Introduction - Why some white dwarfs are better than others for absorption work



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Processing and candidate selection

- 90 white dwarfs from FUSE Multimission Archive, hosted by the Space Telescope Institute

The data has been calibrated using the calfuse pipeline version 2.0.5 or later, resulting in several spectra (covering different wavelength segments) per FUSE exposure. The exposures for each segment are then co-added, weighting each according to exposure time, and finally the segments are combined, weighted by their signal-to-noise ratio, to produce a single spectrum

High velocity component separation candidates

Physical Parameters

	Distance	Galactic Coordinates		Gravity	Temperature	Mass	Vphot	Vism
		l (deg)	b (deg)	logg	teff	M		
wd2350-706	92.0000	309.9147	-45.9375	8	69300		35.7200	-6.5300
wd2331-475	82.0000	334.8358	-64.8080	8.07	55812	0.743	22.4600	-0.7200
wd2211-495	53.0000	345.7883	-52.6217	7.52	64100	0.49	23.9300	-8.8700
wd2146-433	362.0000	357.18	-50.126	7.58	67912	0.574	18.1900	-12.3600
wd2013+400	141.0000	77.0018	3.1835	-	-		11.1400	-12.2600
wd1942+499	105.0000	83.0765	12.7465	7.97	34086	0.642	8.8800	-16.6500
wd1029+537	116.0000	157.5135	53.2437	7.77	46901	0.583	13.8000	-22.7800
wd1021+266	250.0000	205.7172	57.2139	-	-		9.4900	-7.1500
wd0621-376	78.0000	245.4061	-21.4282	7.27	58199	0.458	31.3300	13.1900
wd0229-481	-	266.6179	-61.5914	7.75	66394	0.623	22.9900	0.9000
wd0131-164	96.0000	167.2592	-75.1537	7.764	50047	0.588	10.8800	-8.6400
wd0050-332	58	299.1404	-84.1156	7.68	35816	0.516	11.0700	-14.9380
wd0501+524	59.0000	155.9533	7.0990	7.49	61193	0.43	21.4500	14.2500

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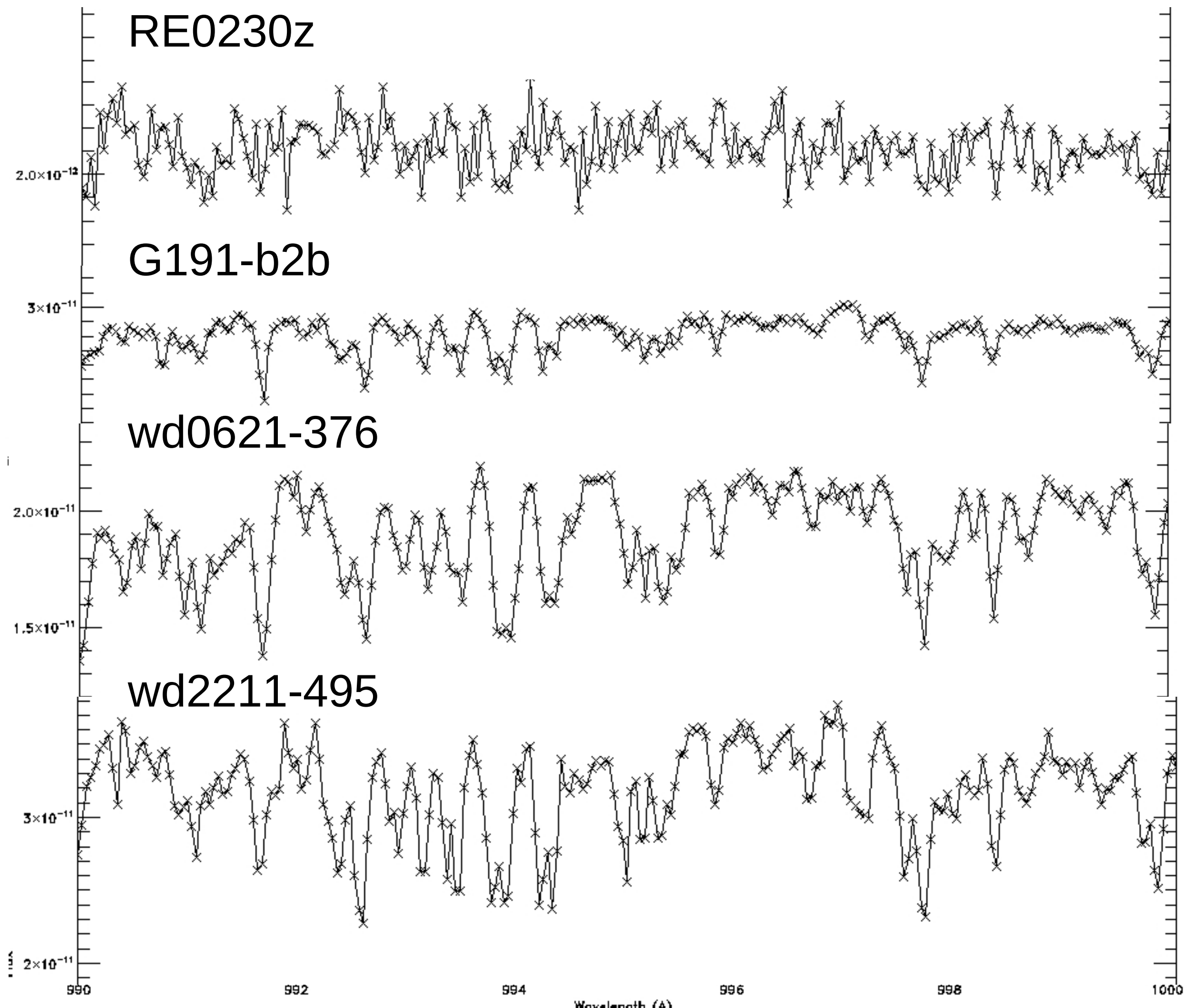
Finding the spectra forest in the FUV

- Co-addition of multiple observations reveals spectral forest



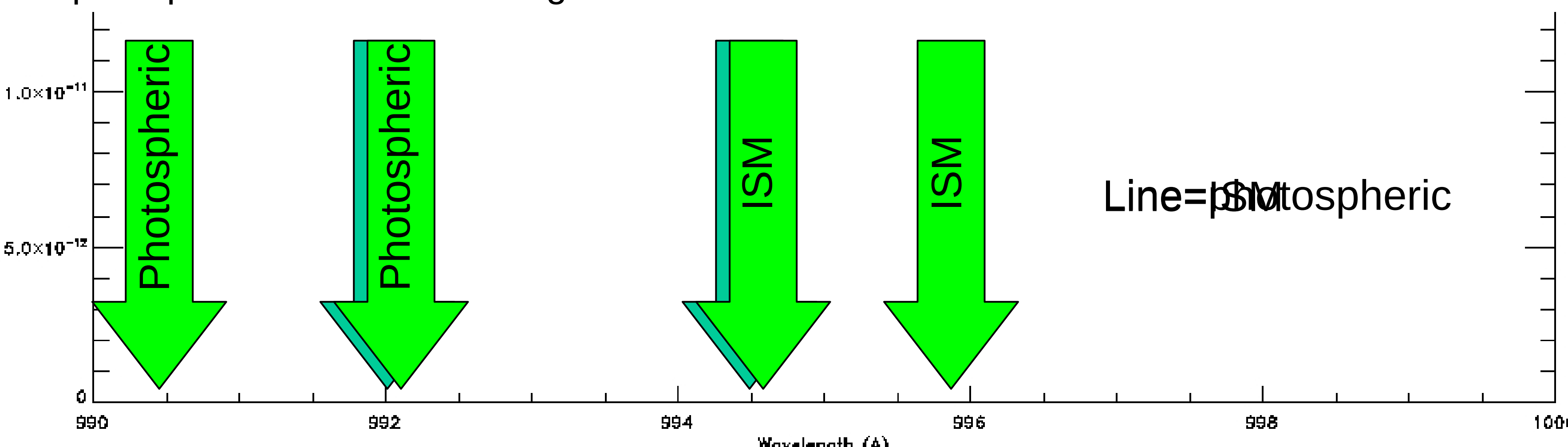
Velocity component identification

$$\lambda_0 = \frac{c\lambda}{c+v}$$

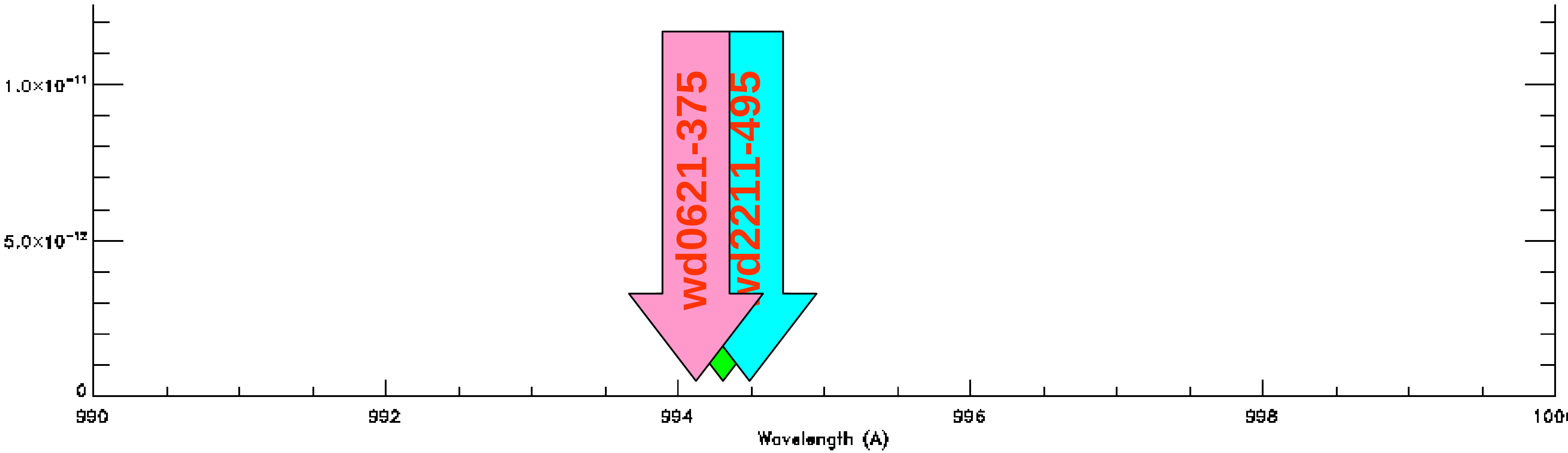
From well known lines we know an average velocity for the star and the ISM in that direction

Using multiple stars we can differentiate between an unknown line being Photospheric or ISM without even knowing what it is.

Graph of predicted rest wavelength



Line Identification using multiple stars of different V_{phot}

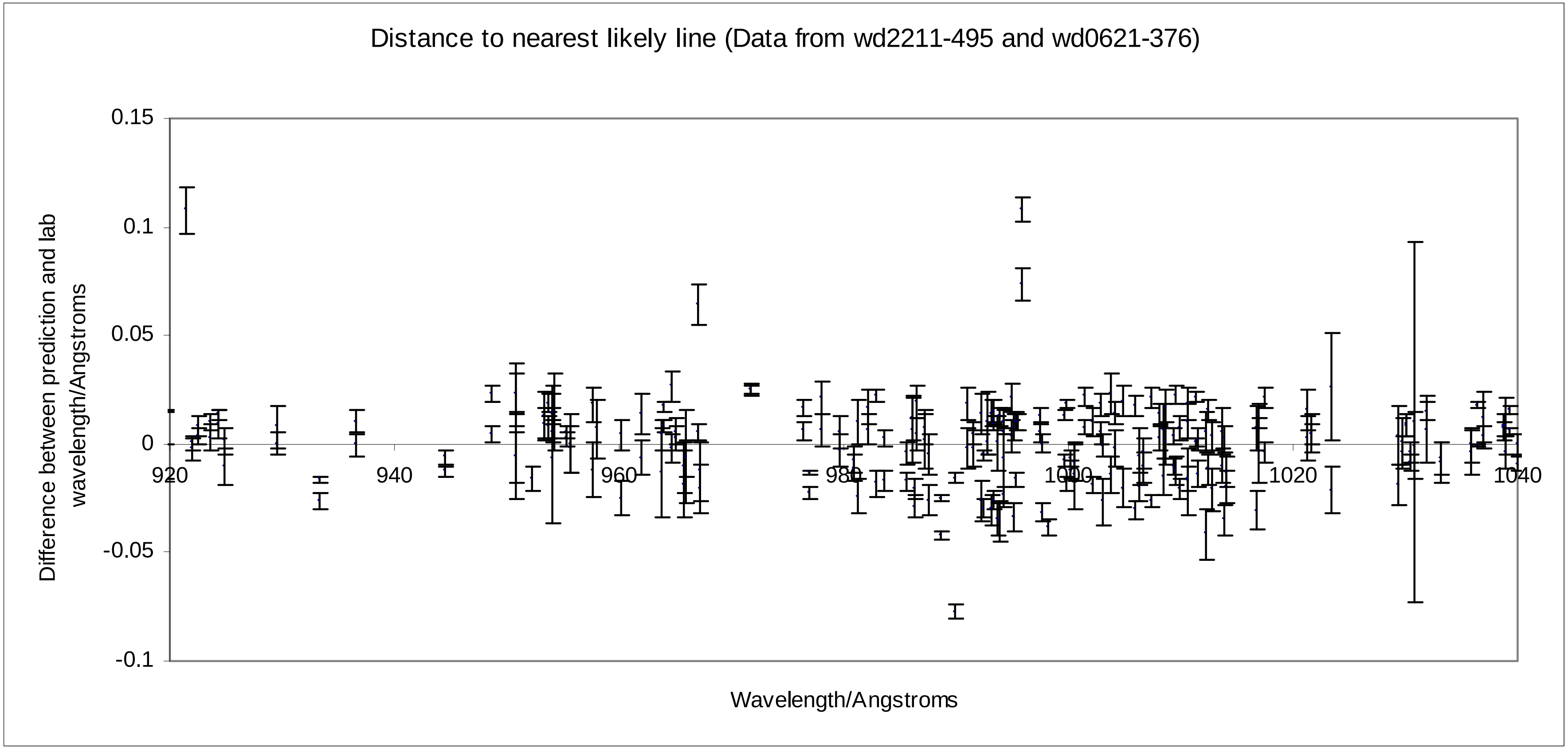


Calculate predicted Lab wavelength for all the stars that contain the line

<u>Reality Check</u>

- 5000 likely photospheric species in line list (Such as Ni IV, Fe V)
- A likely line should occur every 0.05 Angstrom

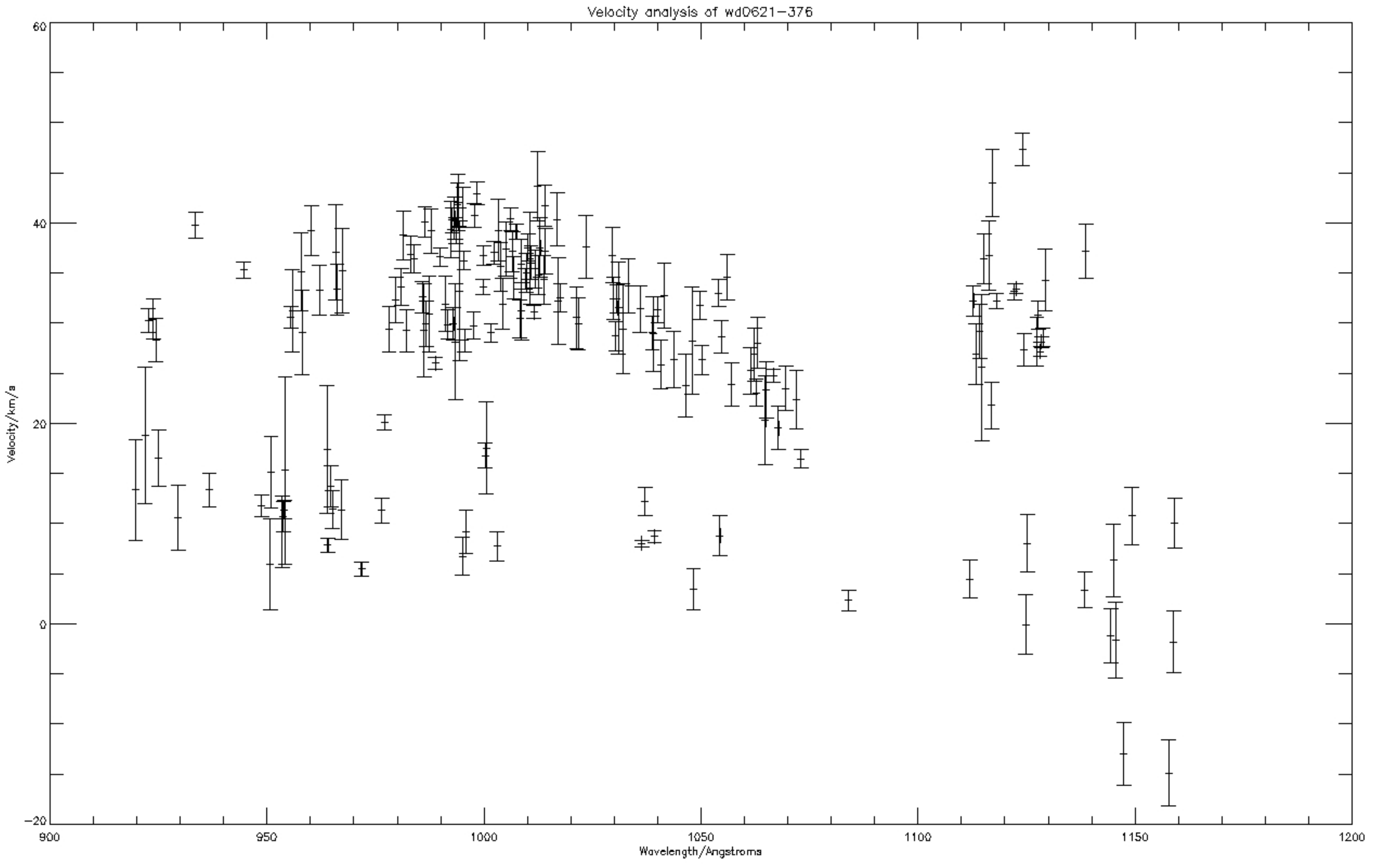
Difference between predicted rest wavelength and first likely line



In 98% of cases a line is found before one is expected.

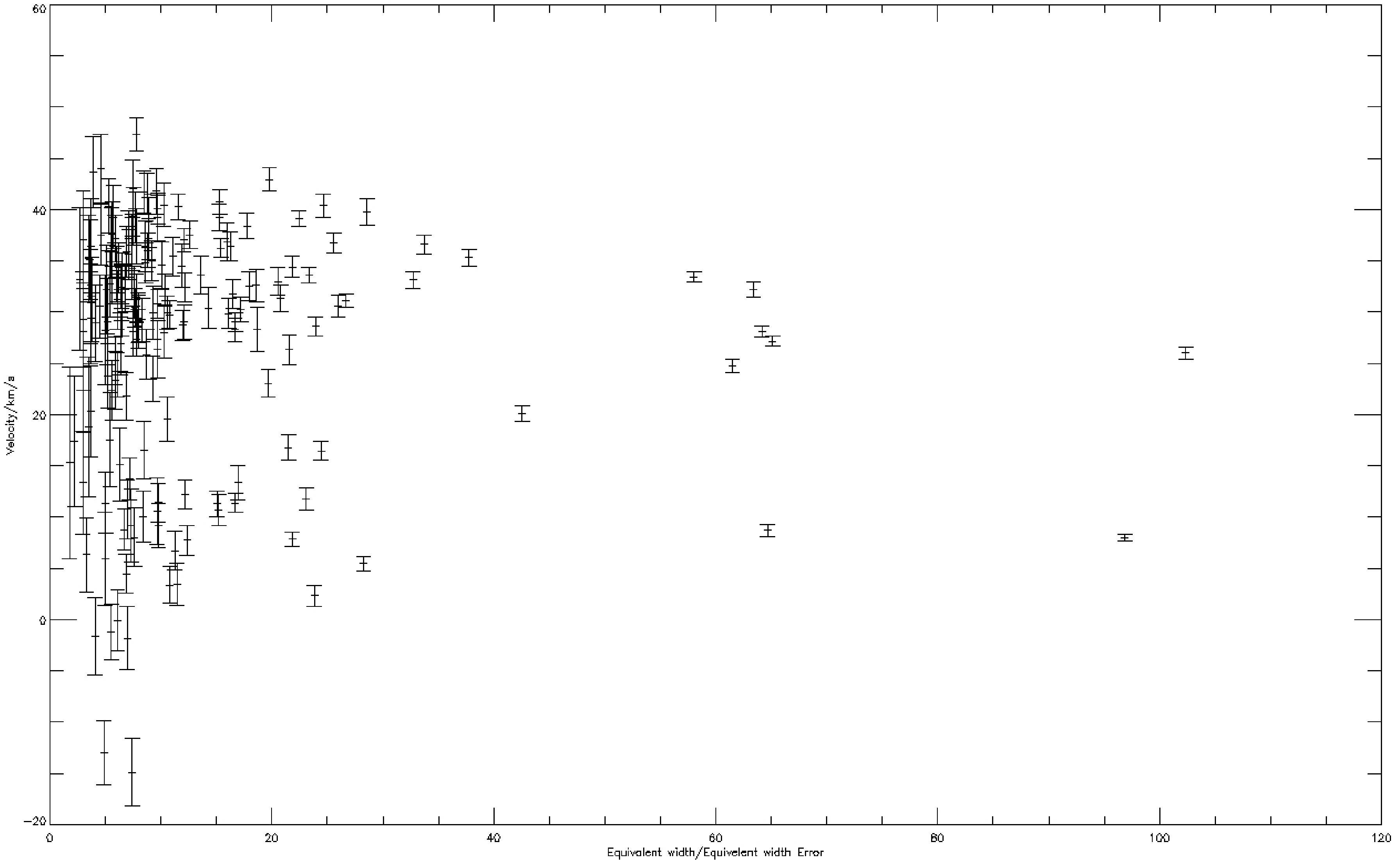
A line is normally found within 0.02 Angstroms of where one is predicted

Wavelength against velocity



Velocity plot distinguishes Photospheric and ISM lines in this star

Line strength against velocity for one star



Some spread in velocity as the lines become comparable in size to noise.

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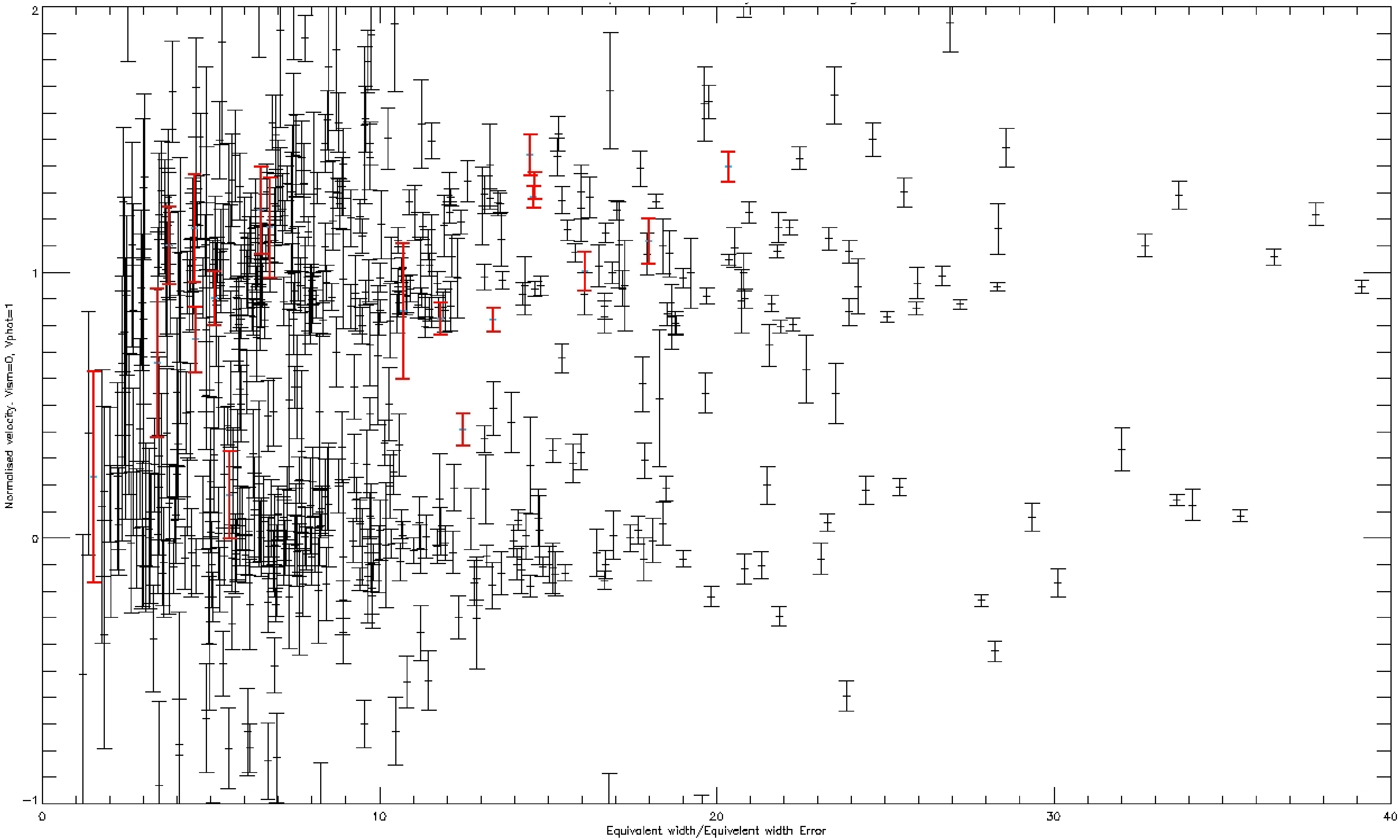
Line strength against normalised velocity for all stars



Velocity of 1031.912 & 1037.613 O VI lines suggest photospheric origin

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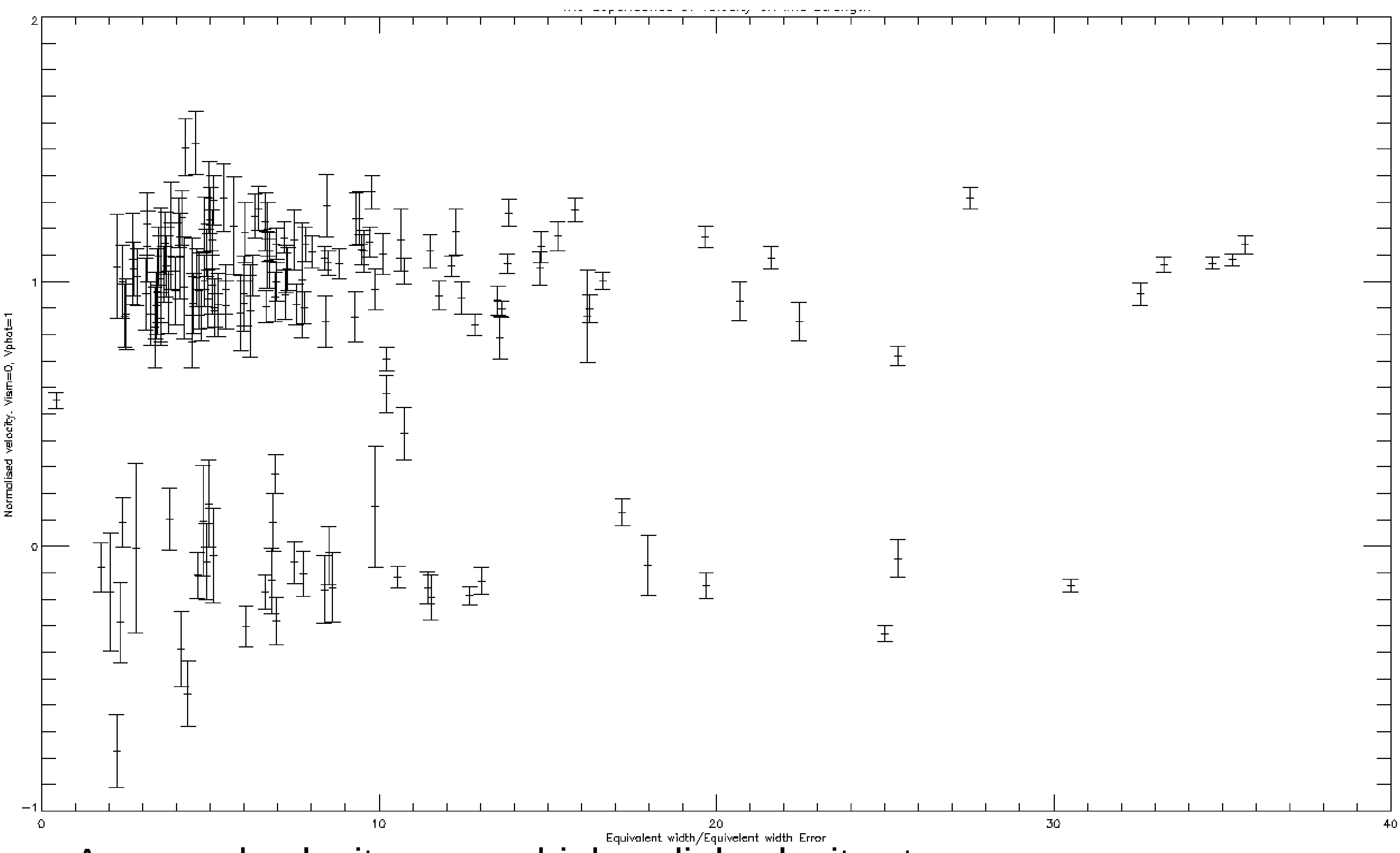
Line by line normalised velocity average



Averaged velocity across high radial velocity star reveals constantly outlying lines.

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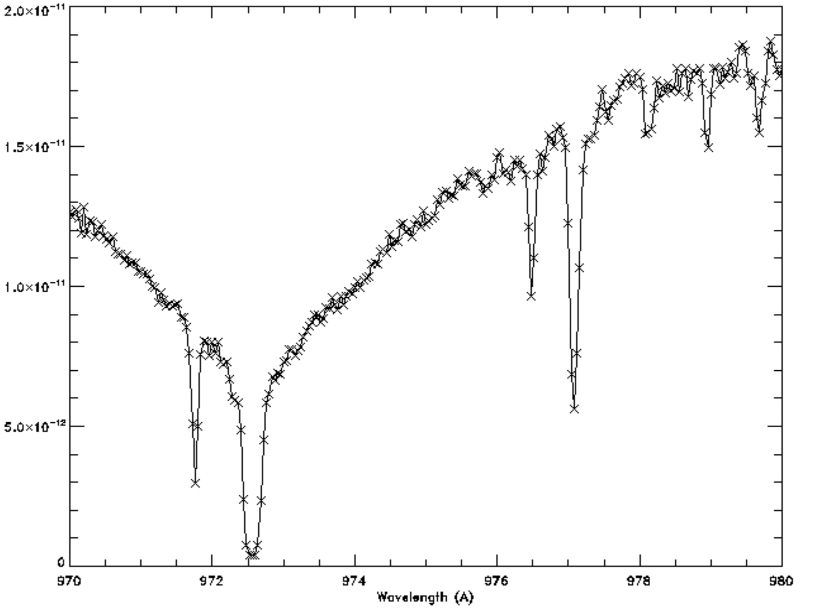
Outlying line feedback process

Outlying line velocities indicative of

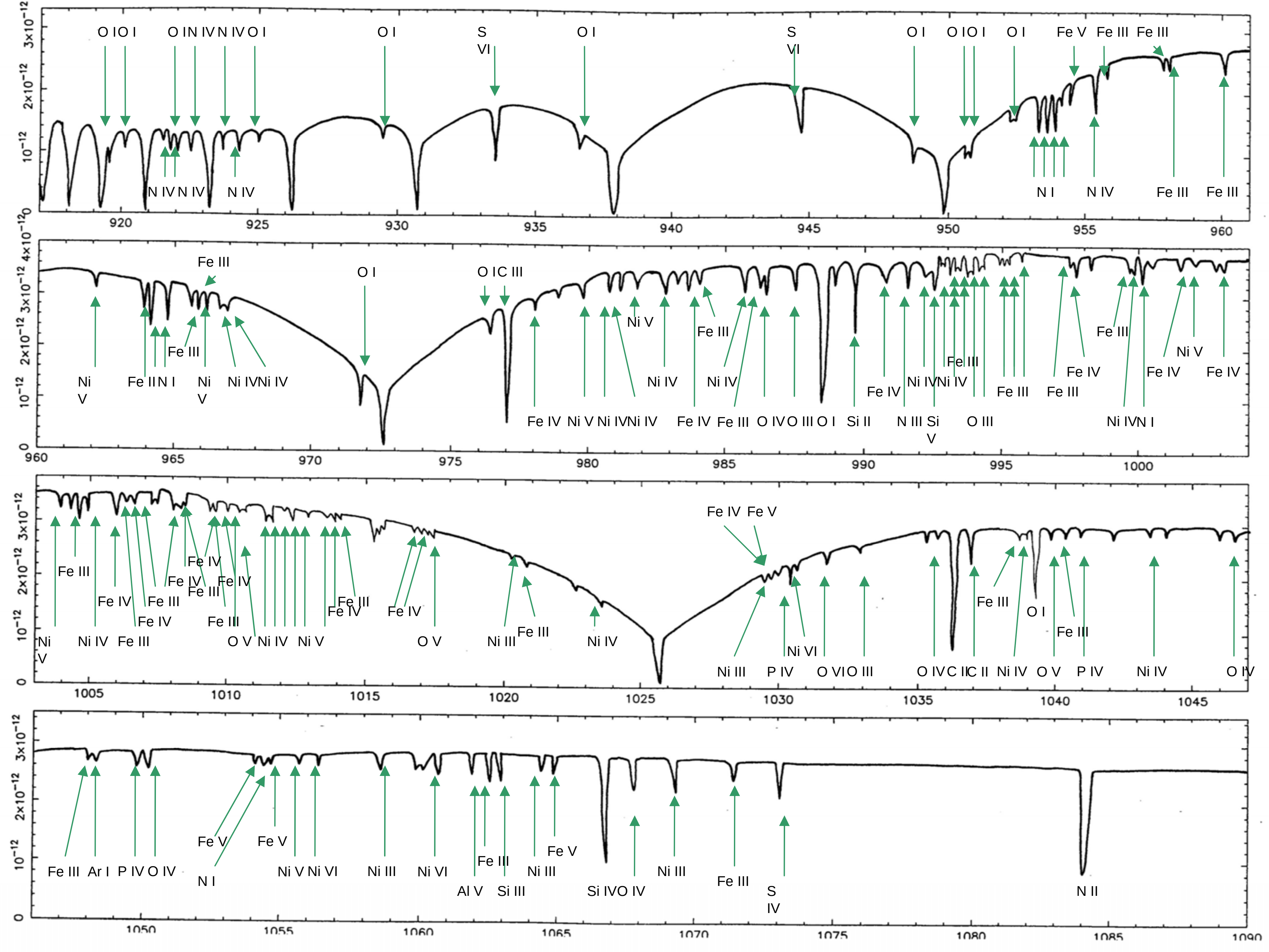
1.) Merged lines

2.) Lines with dual contributions

3.) Incorrect identifications



e.g. C III at 927.02 contains ISM and photospheric component. Apparent velocity therefore a blend of the two



O I O I O I
O I N IV N IV N IV O I
O I
S VI
O I
S VI
O I
O I O I O I
O I
Fe V Fe III Fe III
N IV N IV
N IV
N I
N IV
Fe III
Fe III
3x10⁻¹²
2x10⁻¹²
10⁻¹²
0
920
925
930
935
940
945
950
955
960
Fe III
O I
O I C III
Ni V
Fe II N I
Fe III
Ni V
Ni IV Ni IV
Fe IV
Ni V
Ni IV Ni IV
Ni V
Ni IV
Fe III
Ni IV
Fe IV
Fe III
O IV O III O I
Si II
Fe IV
N III Si V
Ni IV Ni IV
Fe III
O III
Fe III
Fe III
Fe IV
Fe III
Ni IV N I
Fe IV
Ni V
Fe IV
4x10⁻¹²
3x10⁻¹²
2x10⁻¹²
10⁻¹²
0
960
965
970
975
980
985
990
995
1000
Ni V
Fe III
Ni IV
Fe IV
Fe III
Fe IV
Fe III
Fe IV
Fe IV
Fe III
Fe IV
Fe III
O V
Ni IV
Ni V
Fe III
Fe IV
Fe IV
O V
Ni III
Fe III
Ni IV
Fe IV Fe V
Ni III
P IV
Ni VI
O VI O III
O IV C II C II
Fe III
Ni IV
O I
O V
Fe III
P IV
Ni IV
O IV
3x10⁻¹²
2x10⁻¹²
10⁻¹²
0
1005
1010
1015
1020
1025
1030
1035
1040
1045
Fe III
Ar I
P IV
O IV
Fe V
N I
Fe V
Ni V
Ni VI
Ni III
Ni VI
Al V
Fe III
Si III
Ni III
Fe V
Si IV O IV
Ni III
Fe III
S IV
N II
3x10⁻¹²
2x10⁻¹²
10⁻¹²
0
1050
1055
1060
1065
1070
1075
1080
1085
1090

Results from velocity analysis

- Spectral richness explainable with established chemical content.
- No exotics required

Ar I	1	Ni VI	5
C I	1	O I	12
C II	3	O III	5
C III	2	O IV	5
Fe I	1	O V	3
Fe II	8	O VI	2
Fe III	31	P IV	3
Fe IV	27	P V	2
N I	12	S II	1
N II	1	S IV	1
N III	2	S VI	2
N IV	5	Si II	1
Ni II	1	Si III	2
Ni III	6	Si IV	3
Ni IV	28	Si V	1

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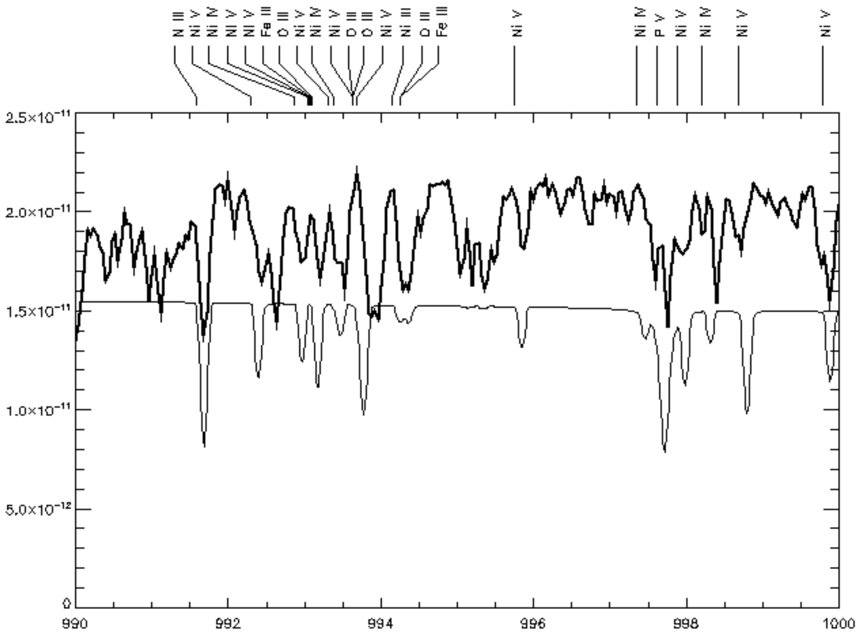
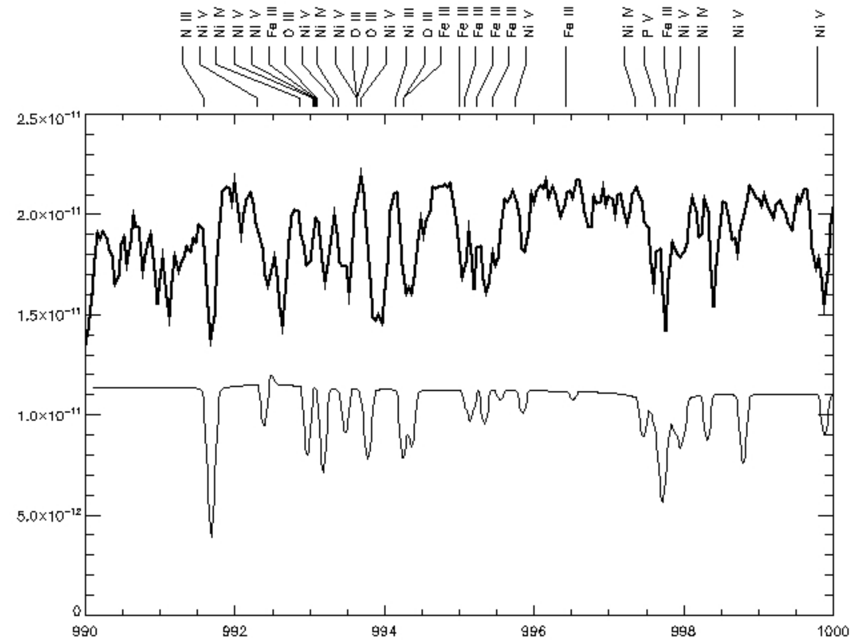
Spectral synthesis



Iron Nickel model T_{eff}62,000K



T_{eff}=49,000K

Forest modelled more accurately by synspec model 13,000K cooler than the stars effective temperature deduced from Lyman line fitting

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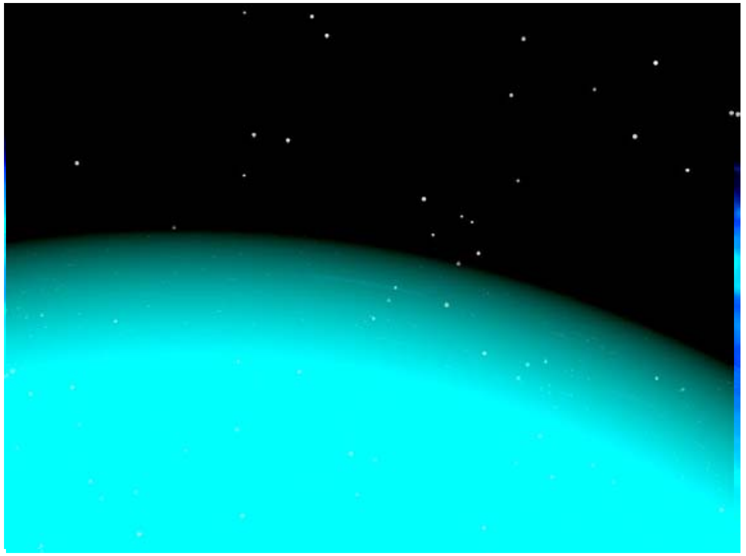
Conclusions – What this means for White Dwarfers

- Method for identifying lines
- No exotic elements required



- Spectral Synthesis of the spectral forest suggests stratification – discrepancy of temperature (and therefore depth) between line forming regions

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Conclusions – What this means for ISM studies

- Detected O VI is photospheric
- Method for distinguishing which velocity component an unidentified line belongs to
- No modelling of background source required.

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