

$$\Psi(\nu) = \sum_k \phi_i(\nu_k) \phi_j(\nu - \nu_k) \delta\nu_k$$

also in continuous form

$$\Psi(\nu) = \int \phi_i(\nu') \phi_j(\nu - \nu') d\nu'$$

The convolution of two Gaussian functions, with standard deviations σ_1 and σ_2 , results in another Gaussian function with a width given by

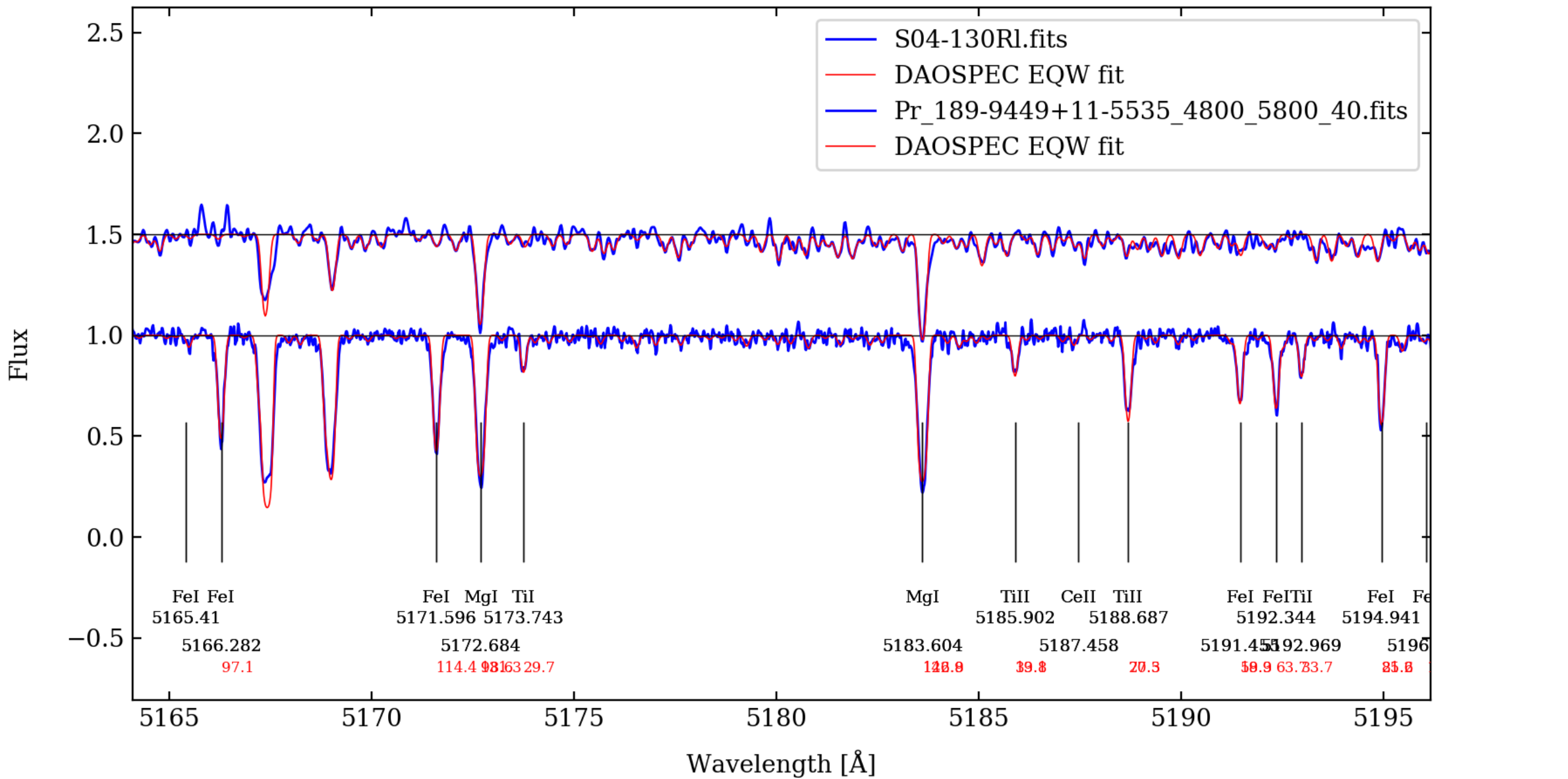
$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2}.$$

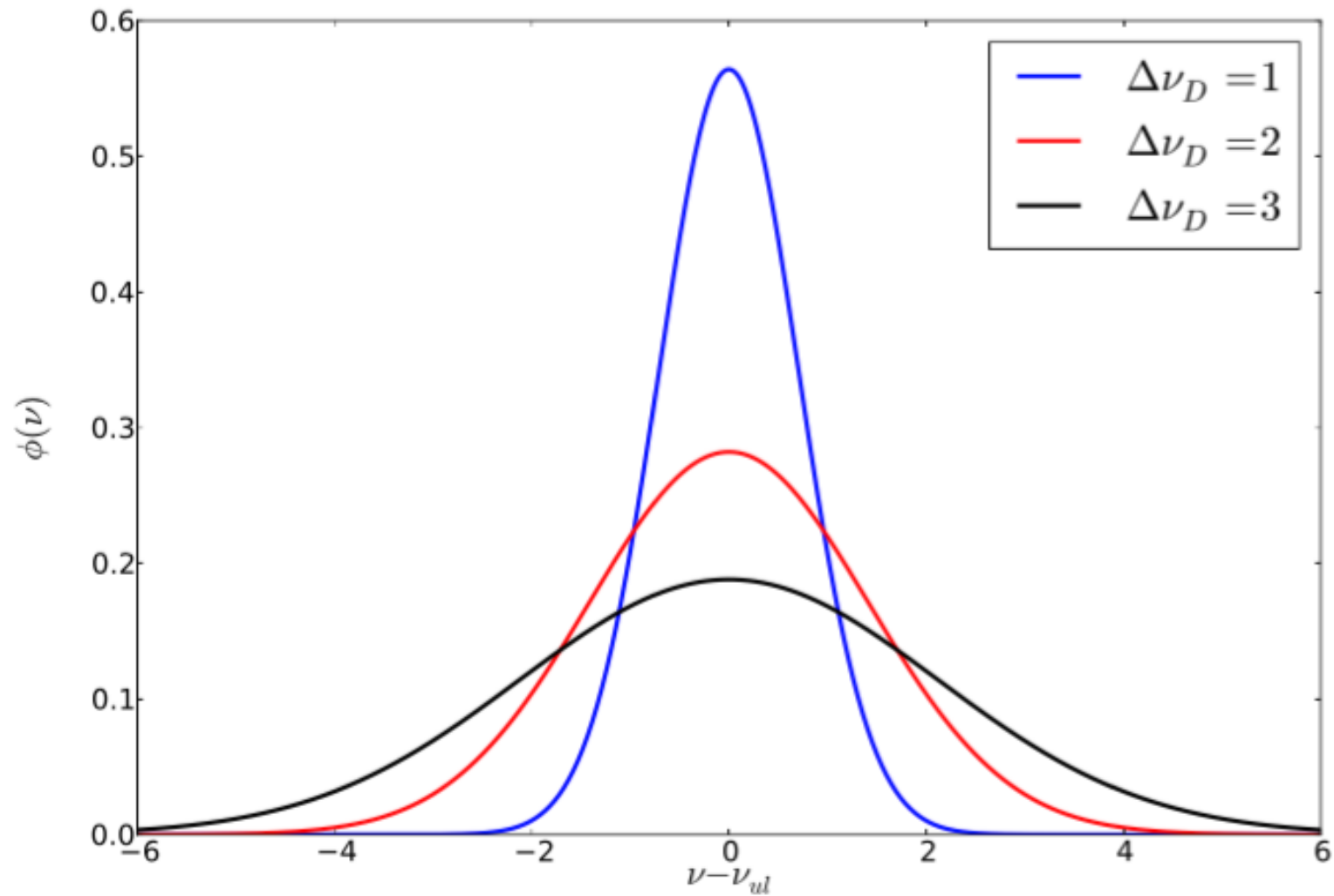
Similarly, the convolution of two Lorentzian profiles, with respective parameters γ_1 and γ_2 , also yields a Lorentzian profile characterized by

$$\gamma = \gamma_1 + \gamma_2.$$

We therefore identify two types of fundamental line profiles:

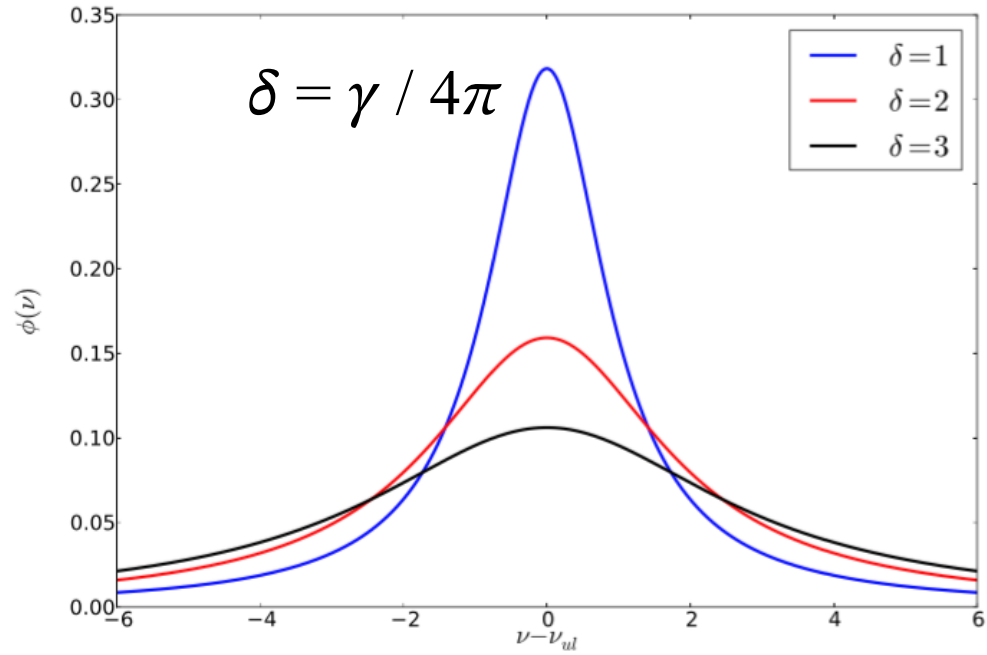
- (i) **Gaussian profiles**, associated with thermal and turbulent Doppler broadening; and
- (ii) **Lorentzian profiles**, resulting from natural and collisional broadening.





Profils de Gauss(Doppler) pour $\Delta\nu_D = 1$ (bleu), $\Delta\nu_D = 2$ (rouge) et $\Delta\nu_D = 3$ (noir).
Les unités de $\Delta\nu_D$ sont les mêmes que celles de l'axe $\nu - \nu_{ul}$.

$$\gamma_{\text{tot}} = \gamma_{\text{naturelle}} + \gamma_{\text{coll}}$$



· Profils de Lorentz pour $\delta = 1$ (bleu), $\delta = 2$ (rouge) et $\delta = 3$ (noir). Les unités d sont les mêmes que celles de l'axe $\nu - \nu_{ul}$.

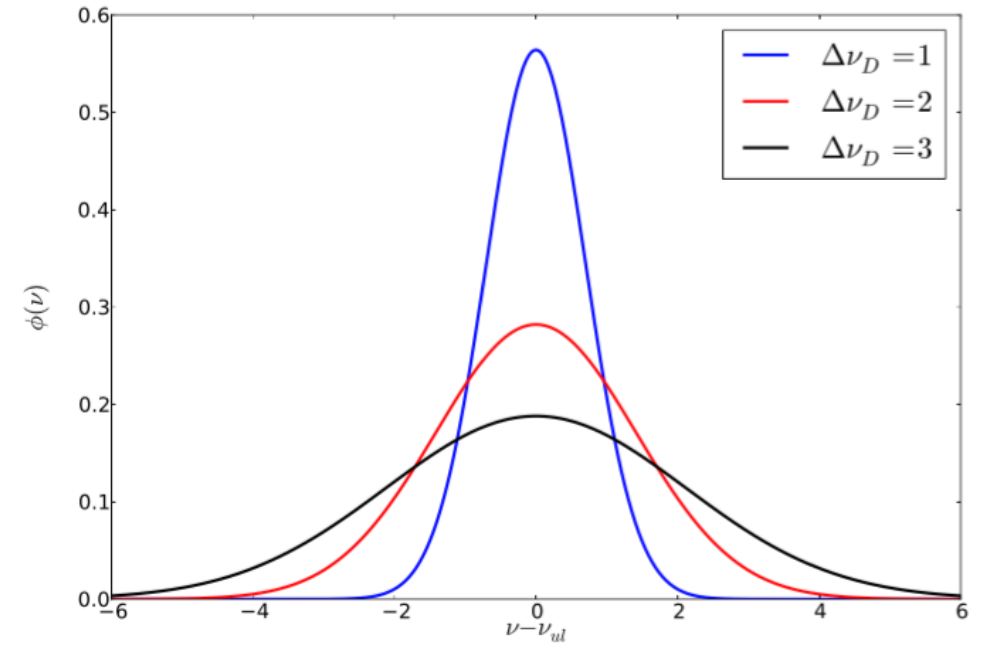
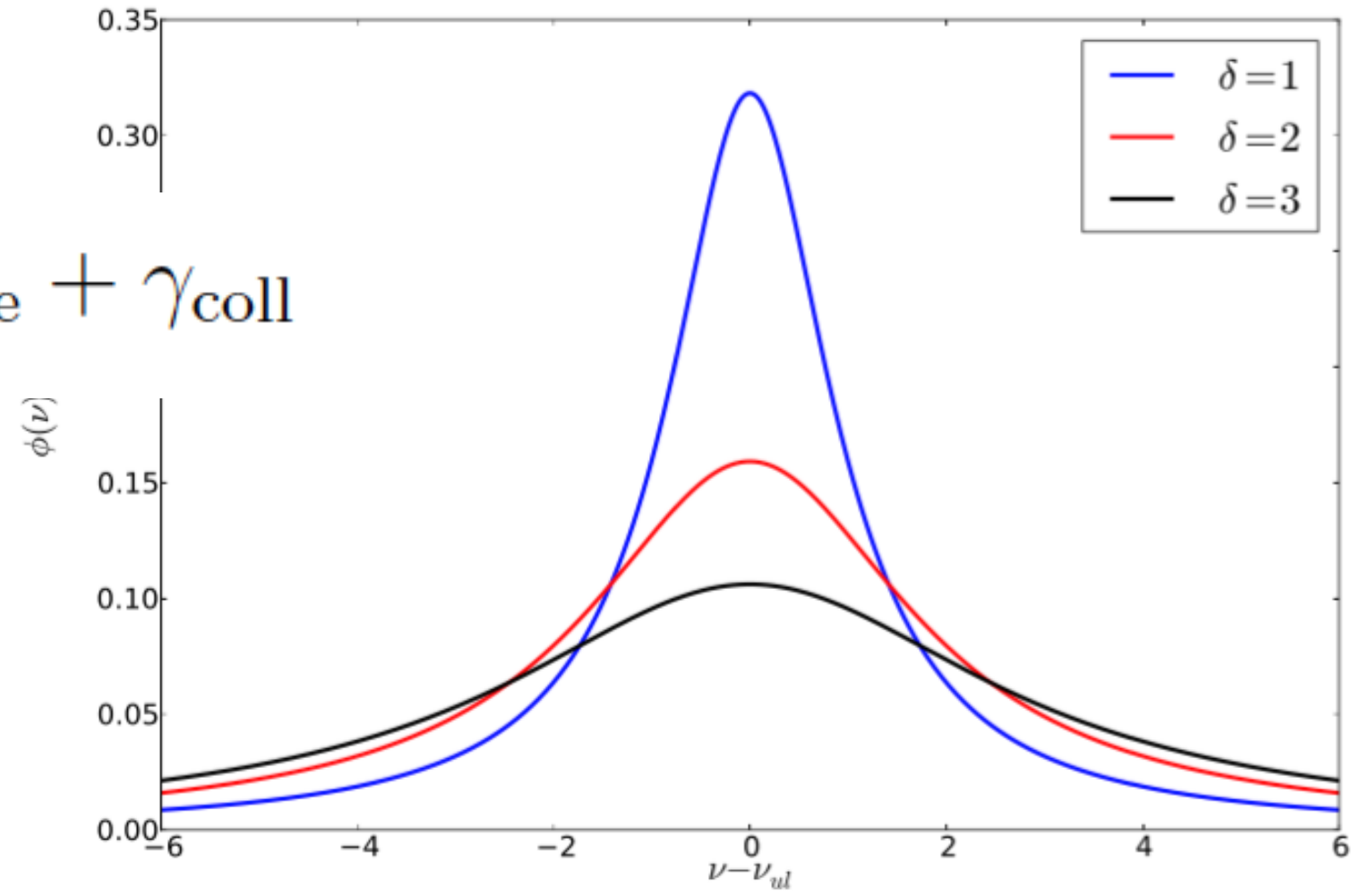


FIGURE 4.2 – Profils de Gauss (Eq. 4.2) pour $\Delta\nu_D = 1$ (bleu), $\Delta\nu_D = 2$ (rouge) et $\Delta\nu_D = 3$ (noir). Les unités de $\Delta\nu_D$ sont les mêmes que celles de l'axe $\nu - \nu_{ul}$.

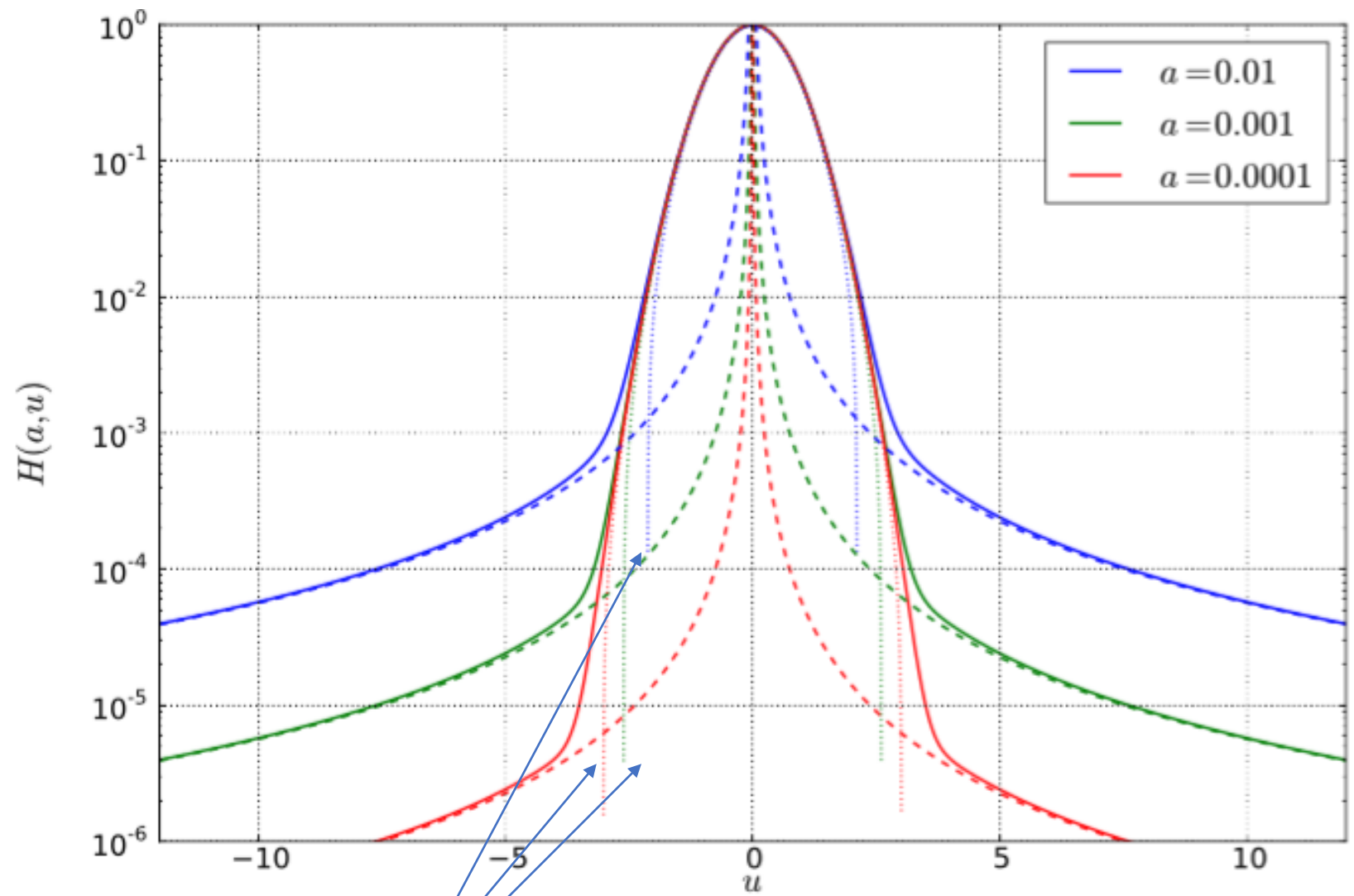
$$\gamma_{\text{tot}} = \gamma_{\text{naturelle}} + \gamma_{\text{coll}}$$

$$\delta = \gamma / 4\pi$$



· Profils de Lorentz pour $\delta = 1$ (bleu), $\delta = 2$ (rouge) et $\delta = 3$ (noir). Les unités de δ sont les mêmes que celles de l'axe $\nu - \nu_{ul}$.

Combinaison: Convolution and Voigt Profile

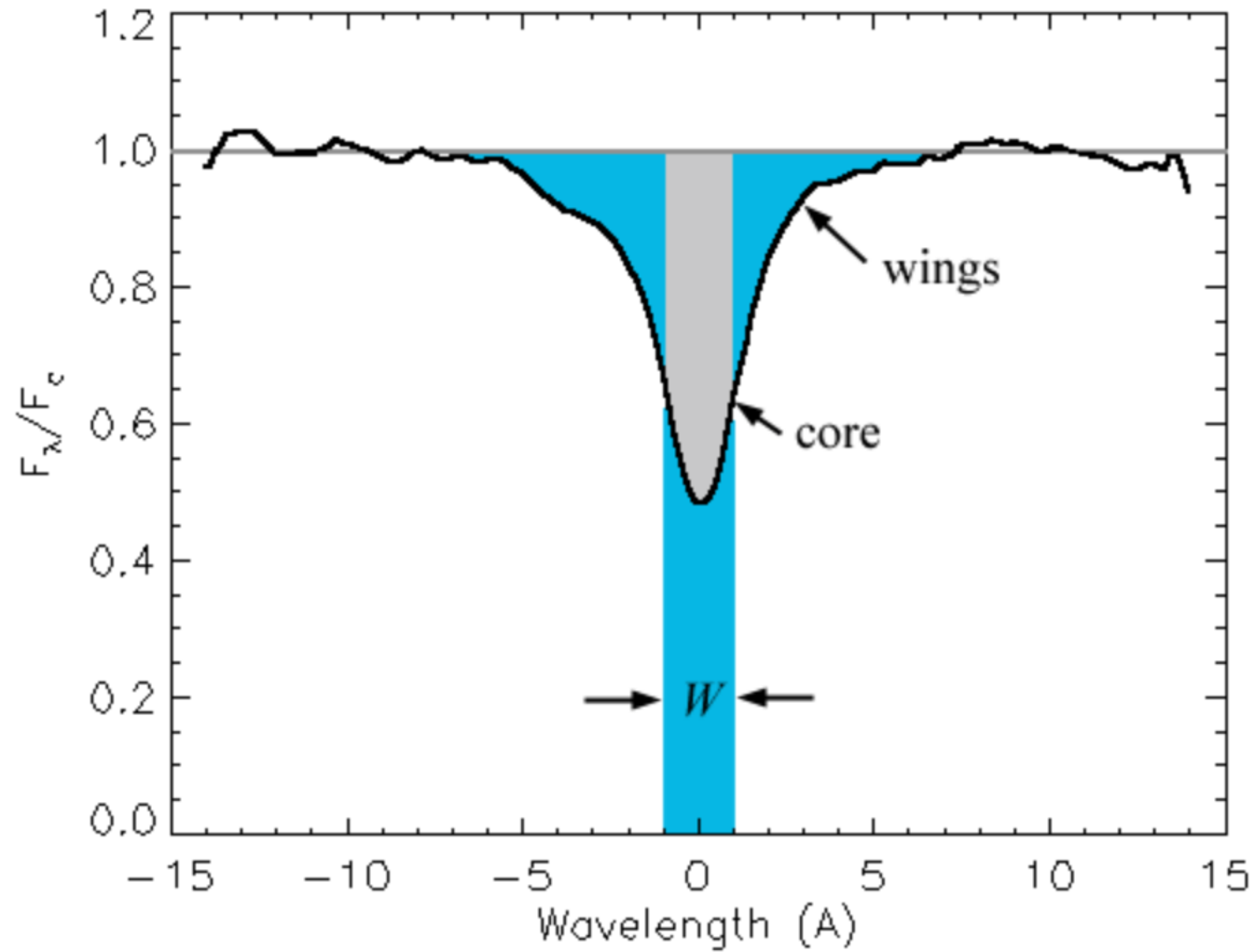


pour $u \rightarrow 0$, et en se limitant au premier ordre en a ,

$$H(u) \simeq e^{-u^2} - \frac{2a}{\sqrt{\pi}} (1 - 2u^2)$$

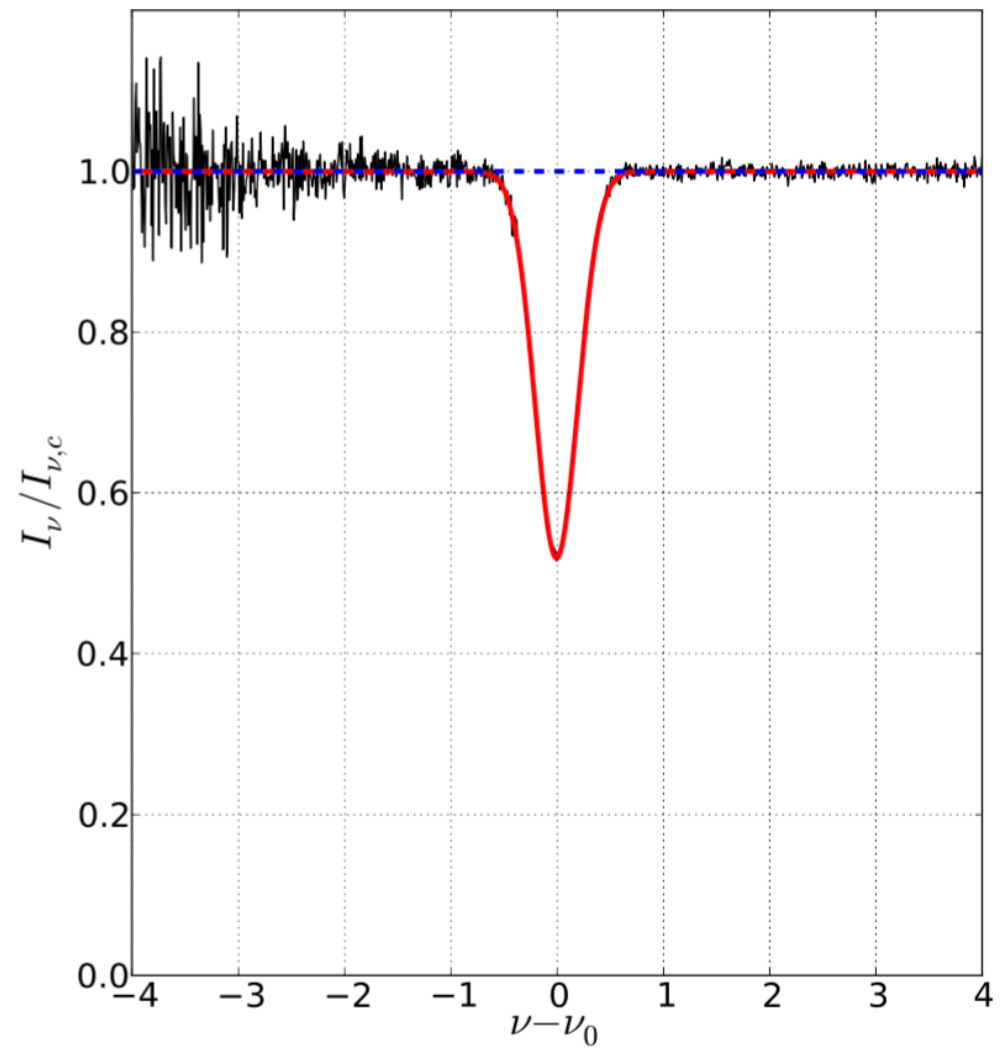
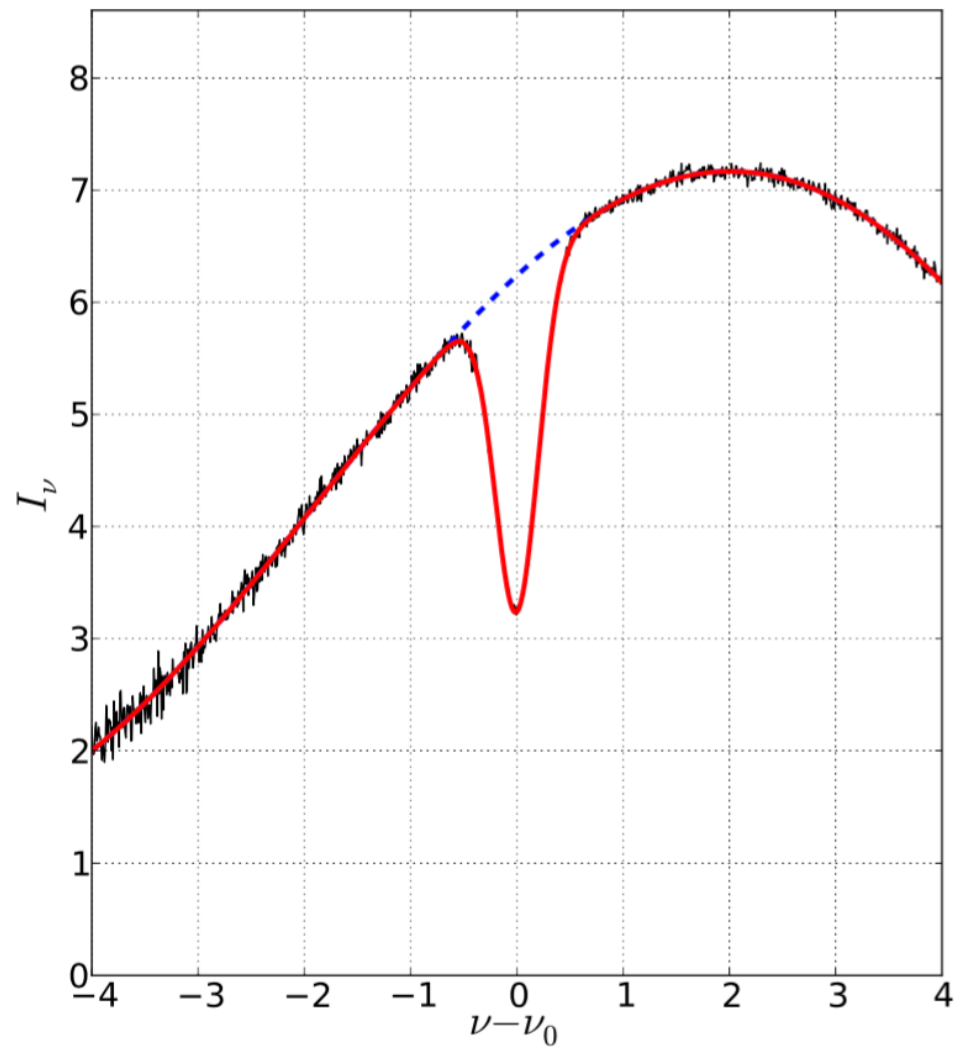
lorsque $u \gg 1$, toujours avec $a \ll 1$

$$H(a, u) \simeq \frac{1}{u^2} \frac{a}{\pi} \int_{-\infty}^{+\infty} e^{-y^2} dy = \frac{a}{\sqrt{\pi} u^2}$$



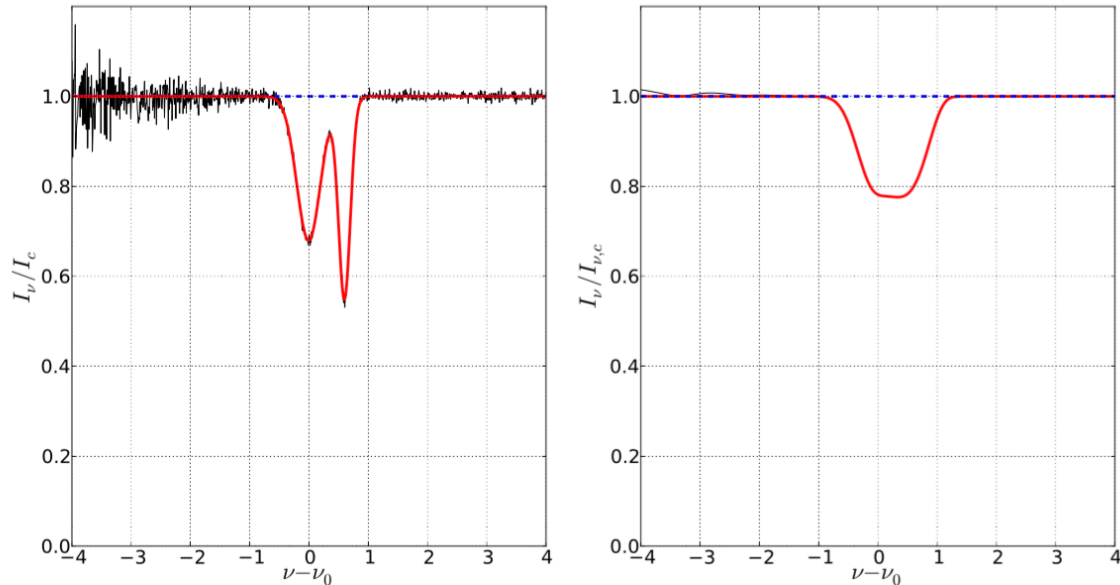
Profil de Voigt =
Doppler core
and
Lorentz wings

W = equivalent width

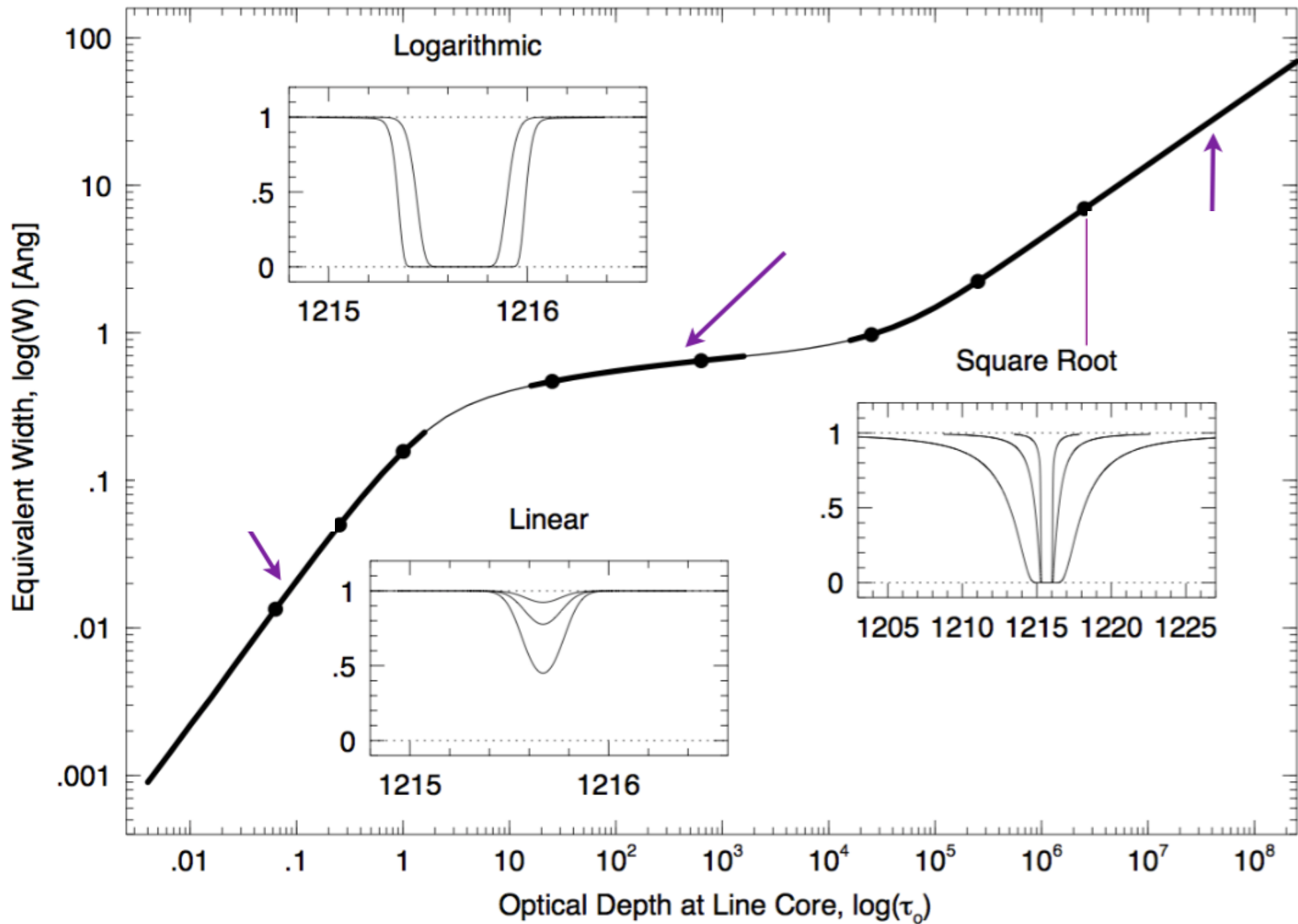


if $h = g * \phi$ with ϕ a normalized profile

$$\int h(x)dx = \int g(x)dx \times \int \phi(x)dx = \int g(x)dx$$



The equivalent width does not depend on the instrumental spectral resolution



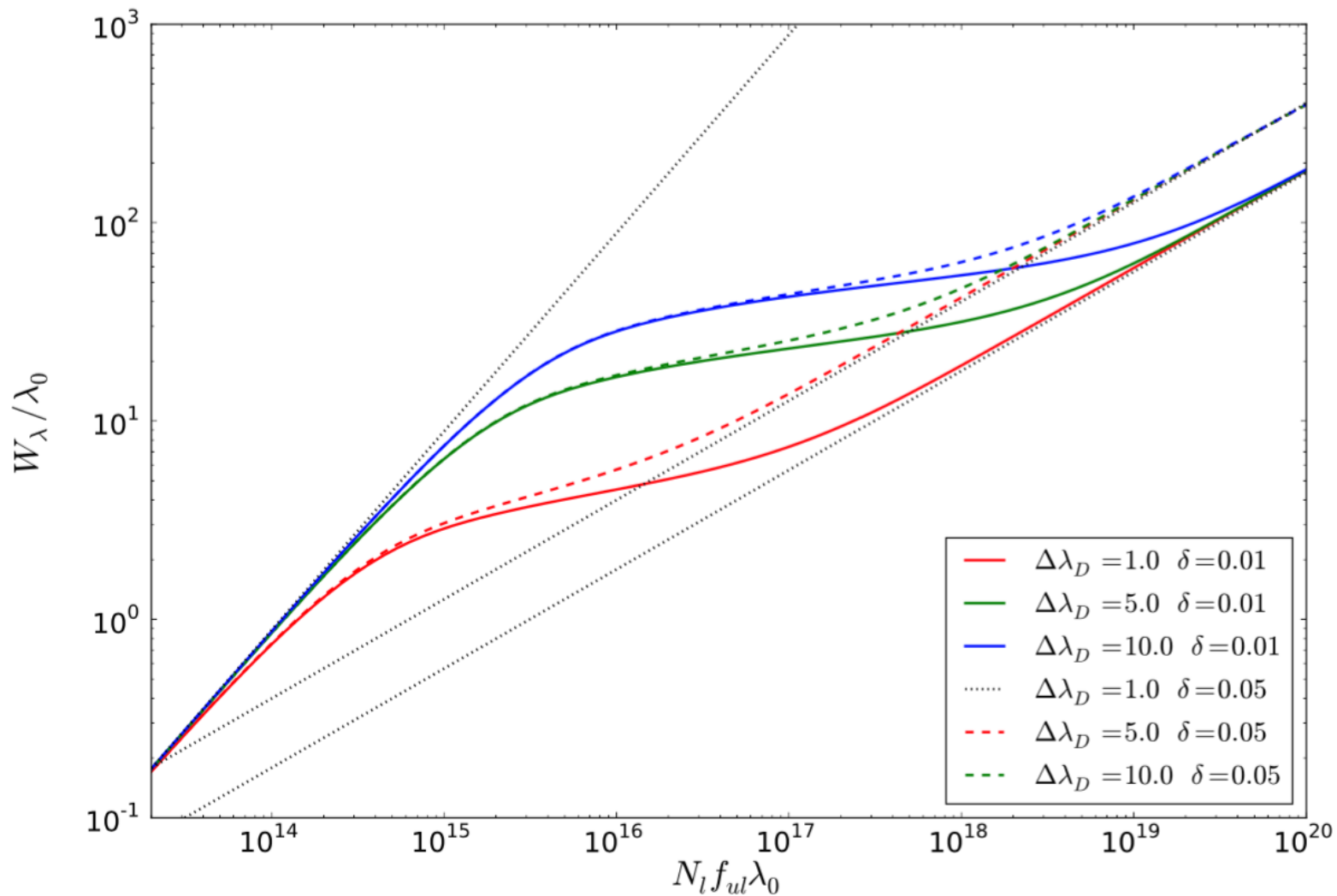
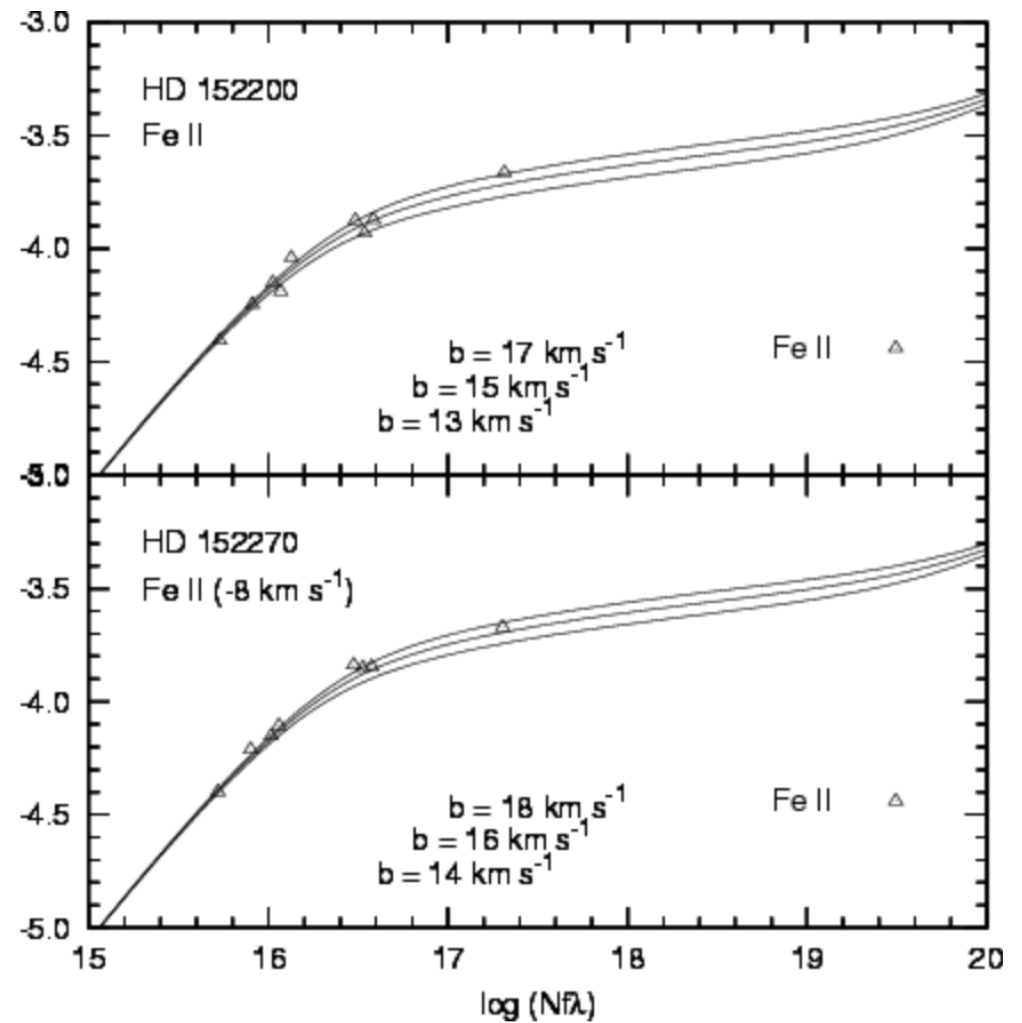
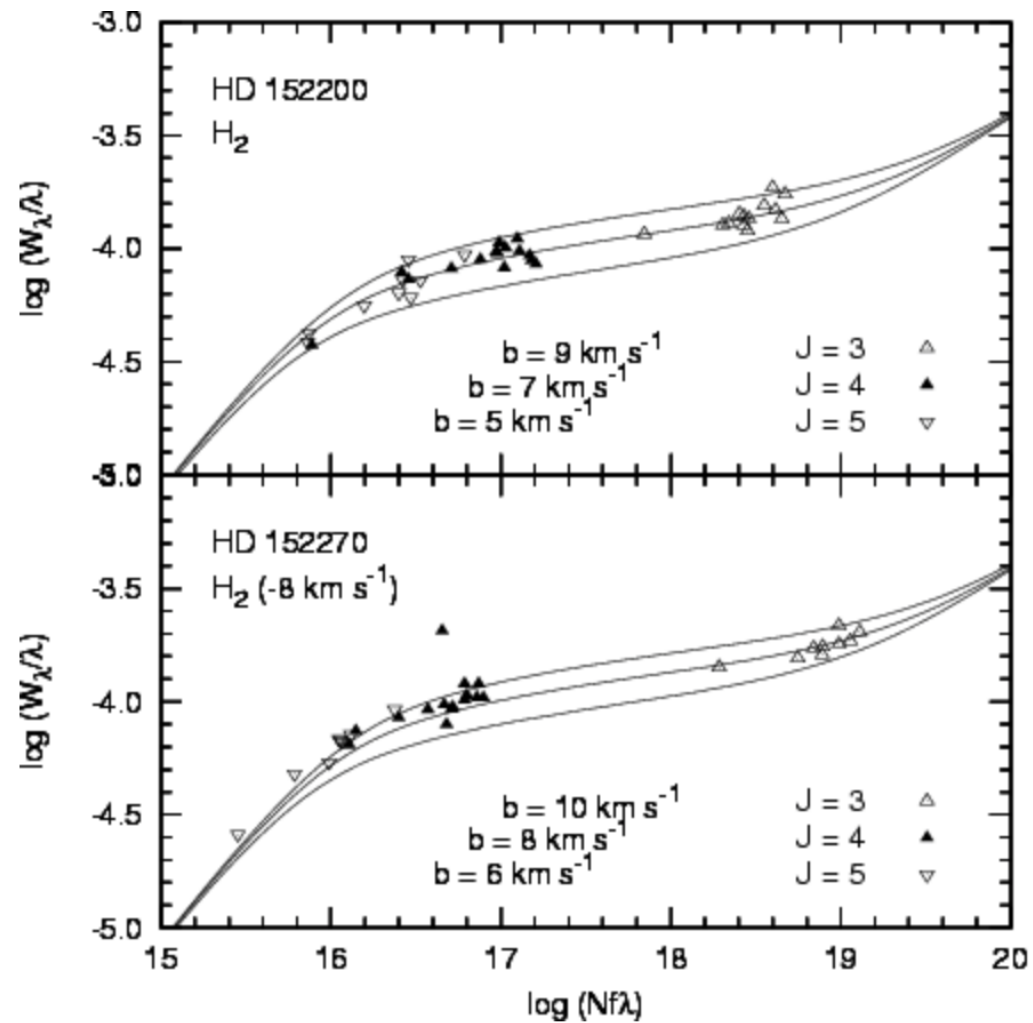


FIGURE 4.10 – Courbe de croissance théorique (largeur équivalente W_λ/λ_0 en fonction de la densité de colonne $N_l f_{ul} \lambda_0$, reliée à l'épaisseur optique au centre de la raie $\tau_{\nu,0}$) pour différentes valeurs de l'élargissement Doppler $\Delta\lambda_D$ et de la constante d'amortissement δ . Les comportements asymptotiques à $\tau_{\nu,0} \ll 1$ et $\tau_{\nu,0} \gg 1$ sont indiqués en pointillés.

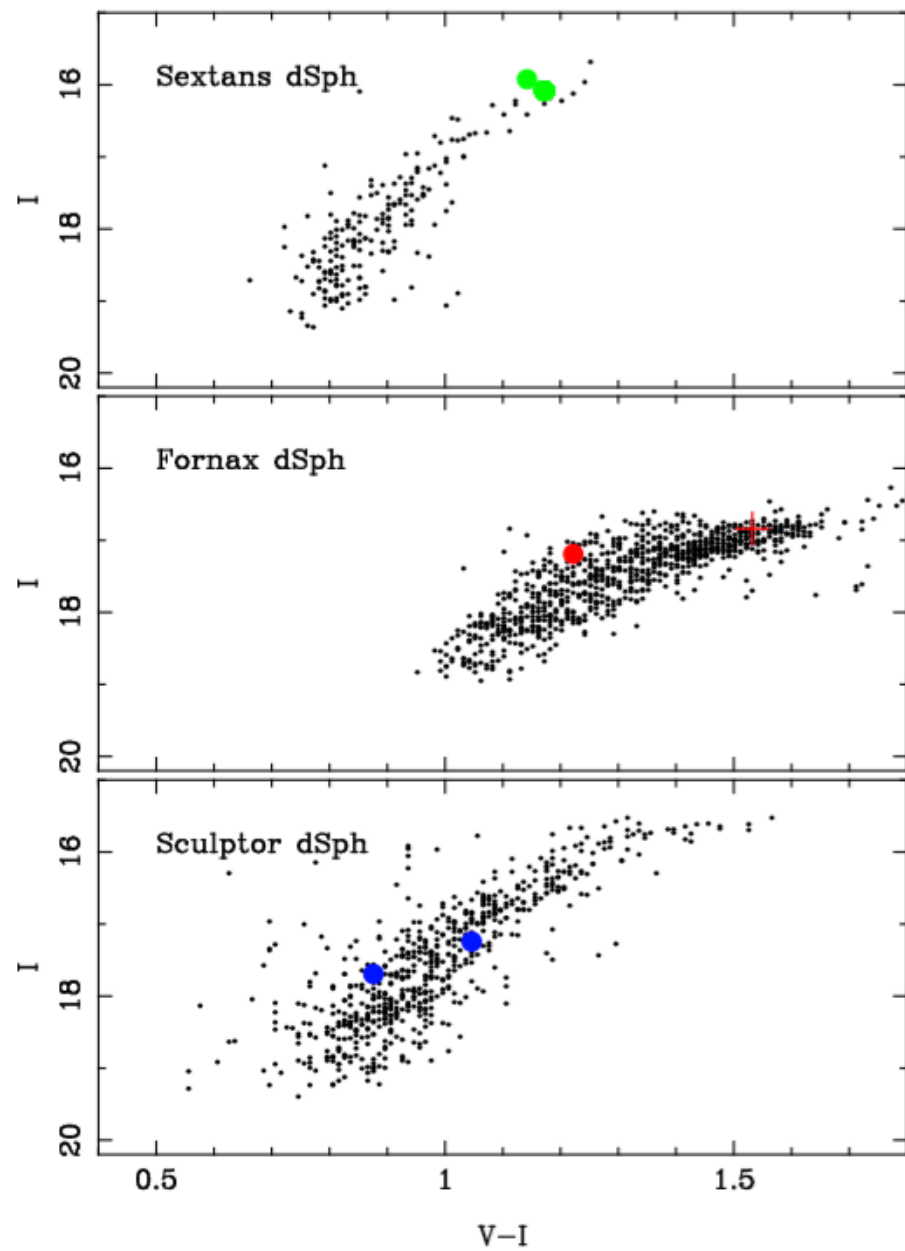


A&A 416, 251-262 (2004)
 DOI: 10.1051/0004-6361:20031714

b = Doppler parameter of the absorption

Intermediate scale structure of the interstellar medium towards NGC 6231 in Sco OB1 with FUSE[[]

O. Marggraf - H. Bluhm - K. S. de Boer

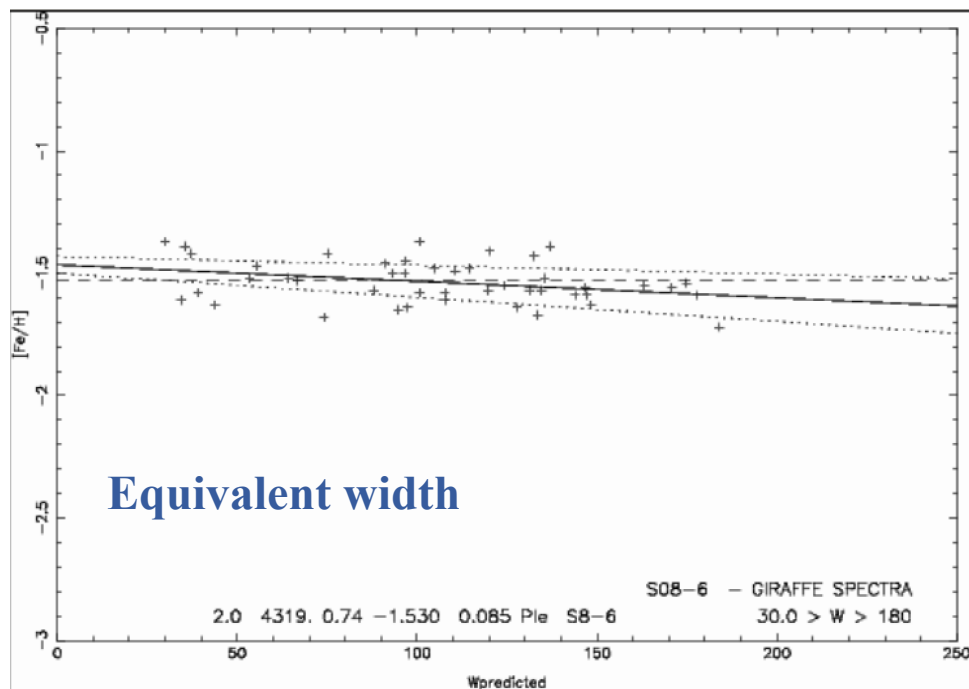
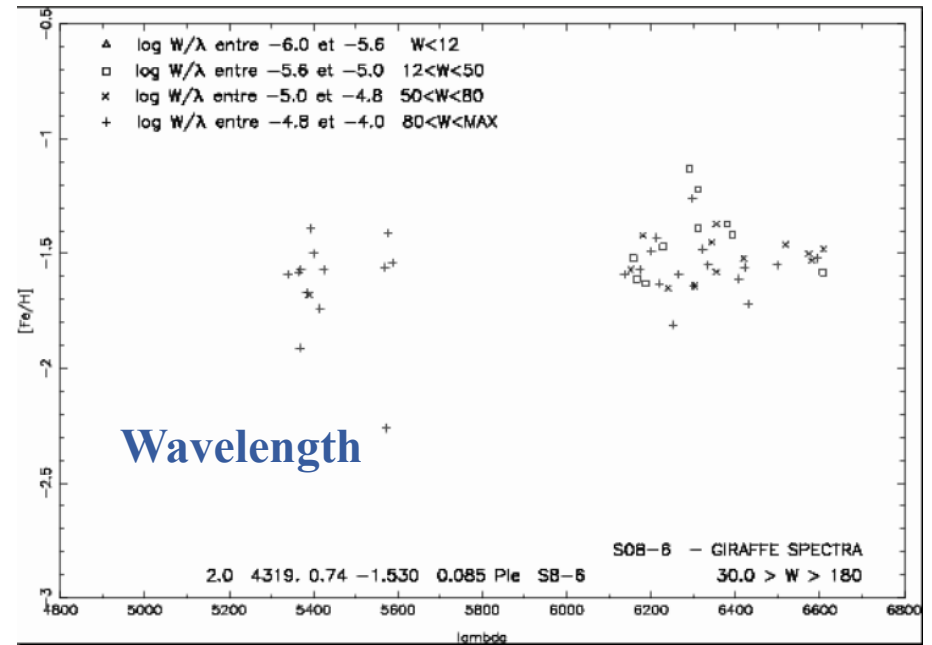
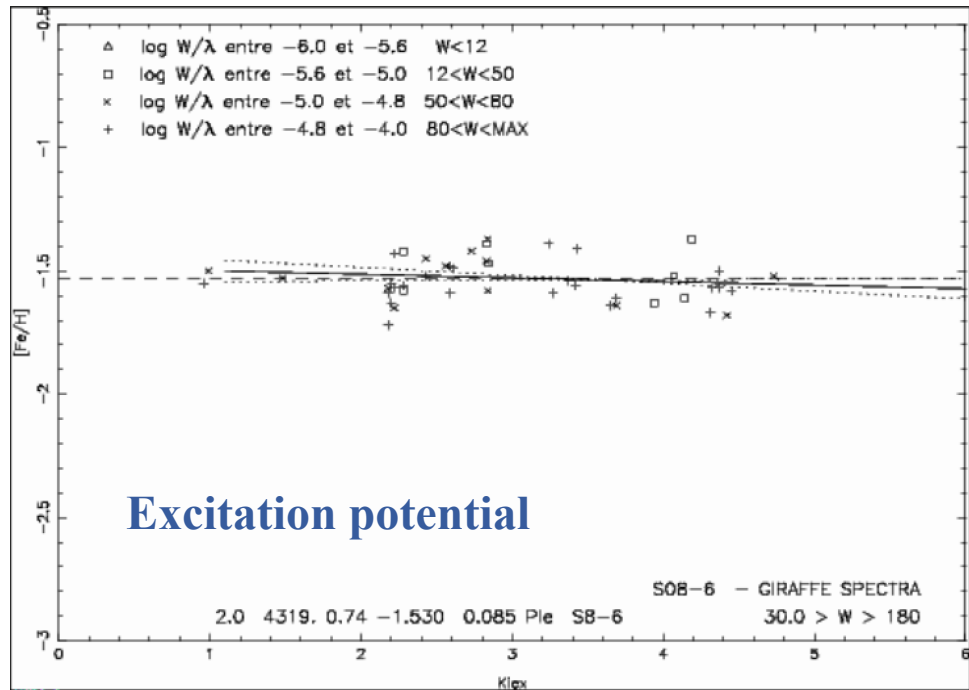


Tafelmeyer et al.: Extremely metal-poor stars in classical dSphs

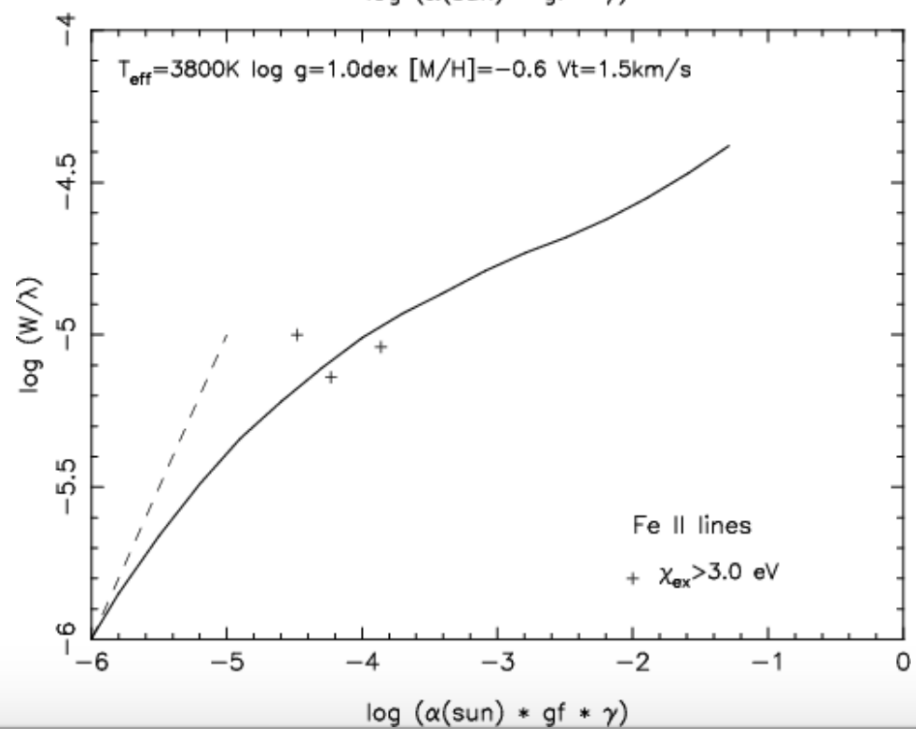
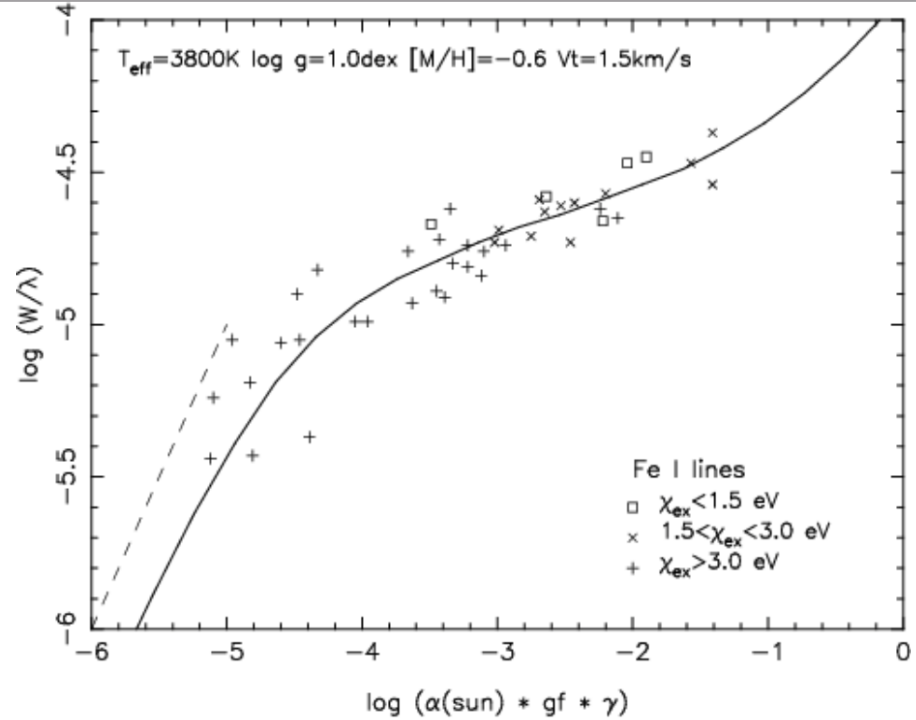
Fig. 2. Reddening corrected color-magnitude diagrams of Sextans, Fornax, and Sculptor for our galaxy members selected from their spectra in the CaT region.

λ	EL	χ_{ex}	log(gf)	EW $\pm \Delta EW$			$\Delta_{scattering}$					
				S24-72	S11-04	Fnx05-42	Scl07-49		Scl07-50			
4404.75	FE1	1.56	-0.140			189.6 ³			93.1 \pm 4.9	0.09		
4415.13	FE1	1.61	-0.610						85.8 \pm 4.9	0.08		
4461.65	FE1	0.09	-3.200		209.0 ³	117.4 ³			70.1 \pm 6.0	0.06		
4871.32	FE1	2.87	-0.360	94.8 \pm 3.0	0.18	111.3 \pm 5.0	0.26	49.3 \pm 2.3	0.19	59.4 \pm 2.1	0.09	
4872.14	FE1	2.88	-0.570	79.4 \pm 4.0	0.17	80.3 \pm 5.7	0.25	46.1 \pm 2.6	0.19	50.1 \pm 4.3	0.08	
4891.49	FE1	2.85	-0.110			121.7 \pm 4.5	0.25	67.0 \pm 2.4	0.21	76.8 \pm 5.2	0.10	
4918.99	FE1	2.87	-0.340	95.2 \pm 3.4	0.17	110.3 \pm 2.6	0.24	65.0 \pm 4.4	0.20	65.1 \pm 2.4	0.09	
4920.50	FE1	2.83	0.070	114.4 \pm 5.5	0.17	130.2 \pm 4.4	0.24	77.1 \pm 3.0	0.21	96.2 \pm 3.1	0.11	
4939.69	FE1	0.86	-3.340					68.1 \pm 4.7	0.12			
4966.10	FE1	3.33	-0.890	41.4 \pm 3.6	0.11	41.5 \pm 2.6	0.17					
4994.13	FE1	0.92	-3.080	110.5 \pm 2.6	0.10	126.3 \pm 3.2	0.14	72.2 \pm 2.8	0.12			
5001.86	FE1	3.88	0.010	29.1 \pm 2.7	0.11	32.8 \pm 3.2	0.19					
5006.12	FE1	2.83	-0.628	88.5 \pm 3.3	0.15	101.4 \pm 4.0	0.22	41.7 \pm 2.3	0.15	55.6 \pm 4.9	0.08	
5041.07	FE1	0.96	-3.090	106.4 \pm 4.2	0.10	135.8 \pm 4.0	0.13	72.2 \pm 1.8	0.12			
5041.76	FE1	1.49	-2.200	106.3 \pm 3.3	0.11	131.2 \pm 4.3	0.15			70.3 \pm 4.1	0.07	
5049.82	FE1	2.28	-1.360	83.0 \pm 3.7	0.13	107.1 \pm 2.5	0.19	44.4 \pm 2.5	0.14	60.5 \pm 2.6	0.07	
5051.64	FE1	0.92	-2.800	125.3 \pm 3.7	0.09	148.4 \pm 3.8	0.13	102.9 \pm 3.7	0.12			
5068.77	FE1	2.94	-1.040	50.6 \pm 2.7	0.11	55.1 \pm 2.5	0.18					
5079.74	FE1	0.99	-3.220	96.4 \pm 3.6	0.09			67.8 \pm 3.8	0.11			
5083.34	FE1	0.96	-2.960	111.7 \pm 4.0	0.09	130.2 \pm 3.4	0.13	73.7 \pm 3.4	0.11			
5110.41	FE1	0.00	-3.760	156.8 \pm 5.2	0.07	165.5 \pm 4.5	0.10	119.2 \pm 3.6	0.08			
5123.72	FE1	1.01	-3.070	91.9 \pm 3.3	0.09	118.3 \pm 3.3	0.12	48.7 \pm 2.8	0.10			
5127.36	FE1	0.92	-3.310	96.7 \pm 4.0	0.09	114.1 \pm 5.2	0.12	54.0 \pm 2.4	0.10			
5150.84	FE1	0.99	-3.040	90.5 \pm 3.3	0.09	117.9 \pm 3.2	0.12	61.7 \pm 2.5	0.10			
5151.91	FE1	1.01	-3.320	87.1 \pm 3.6	0.09	95.6 \pm 3.8	0.12	48.9 \pm 3.1	0.10			
5162.29	FE1	4.18	0.020	31.2 \pm 3.2	0.10	33.9 \pm 2.0	0.17					
5166.28	FE1	0.00	-4.200	135.4 \pm 3.5	0.06	155.4 \pm 3.4	0.09	93.8 \pm 3.7	0.07			
5171.61	FE1	1.48	-1.751	132.5 \pm 2.4	0.09	141.3 \pm 3.5	0.13	97.4 \pm 3.3	0.12	97.4 \pm 3.6	0.07	
5191.46	FE1	3.04	-0.550	61.7 \pm 2.7	0.11	75.6 \pm 2.9	0.18	32.0 \pm 2.2	0.12	38.1 \pm 2.3	0.06	
5192.34	FE1	3.00	-0.520	68.2 \pm 2.5	0.11	80.1 \pm 3.6	0.18	40.1 \pm 3.4	0.13	51.7 \pm 3.1	0.06	
5194.94	FE1	1.56	-2.090	116.9 \pm 3.7	0.10	128.9 \pm 2.3	0.13	71.3 \pm 2.8	0.11	79.9 \pm 2.9	0.06	
5215.19	FE1	3.27	-0.930	33.5 \pm 1.5	0.10	40.9 \pm 2.9	0.13					
5216.28	FE1	1.61	-2.102	97.3 \pm 3.0	0.10	124.6 \pm 2.8	0.13	53.6 \pm 4.3	0.10	67.1 \pm 2.9	0.05	
5225.53	FE1	0.11	-4.790	79.6 \pm 3.5	0.06	101.3 \pm 3.9	0.08	31.3 \pm 2.9	0.07			
5254.96	FE1	0.11	-4.760	75.0 \pm 3.5	0.06	91.5 \pm 3.6	0.08					
5266.56	FE1	3.00	-0.390	86.7 \pm 2.5	0.11	95.4 \pm 2.8	0.17	43.3 \pm 2.3	0.12	53.9 \pm 2.7	0.06	
5269.54	FE1	0.86	-1.320	206.9 \pm 4.6	0.08	213.1 \pm 6.0	0.12	183.3 \pm 9.4	0.10			
5281.79	FE1	3.04	-0.830	46.8 \pm 2.6	0.08							
5283.62	FE1	3.24	-0.520	61.6 \pm 3.4	0.10	66.3 \pm 2.2	0.16					
5302.30	FE1	3.28	-0.880	34.0 \pm 2.7	0.08	51.9 \pm 2.3	0.14					
5307.37	FE1	1.61	-2.812	42.5 \pm 2.5	0.07	69.9 \pm 4.0	0.11					
5324.19	FE1	3.21	-0.100	78.7 \pm 2.5	0.11	98.8 \pm 3.3	0.17	43.6 \pm 2.5	0.12	50.0 \pm 3.9	0.05	
5328.04	FE1	0.92	-1.470					169.2 \pm 4.9	0.09			
5339.93	FE1	3.27	-0.680	47.0 \pm 2.9	0.08	57.0 \pm 1.9	0.14					
5367.48	FE1	4.42	0.550			33.8 \pm 1.6	0.10					
5369.96	FE1	4.37	0.540	33.8 \pm 3.1	0.08							
5371.50	FE1	0.96	-1.644	193.3 \pm 4.2	0.07	205.1 \pm 4.5	0.11	157.2 \pm 4.7	0.09		85.1 \pm 5.5	0.03

λ	EL	χ_{ex}	log(gf)	$\Delta_{scattering}$											
				S24-72		S11-04		Fnx05-42		Sci07-49		Sci07-50			
6300.31	O1	0.00	-9.750	<11	0.02	<20	0.04	<9	0.03						
5889.97	NA1	0.00	0.122	306 ³		217.9 ±5.7	0.08	160.6 ±4.5	0.07	133.8 ±6.1	0.04	83.9 ±7.8	0.02		
5895.92	NA1	0.00	-0.190	284 ¹	0.05	196.4 ±3.0	0.07	143.2 ±4.7	0.07	125.0 ±2.0	0.04	66.2 ±5.0	0.02		
3829.35	MG1	2.71	-0.210									87.1 ¹	0.16		
3832.30	MG1	2.71	0.150									111.2 ¹	0.19		
5172.70	MG1	2.71	-0.390	213.0 ±5.9	0.12	248.6 ±9.9	0.17	188.0 ±4.4	0.15	178.5 ±5.2	0.09	94.1 ±4.5	0.04		
5183.60	MG1	2.72	-0.160	240.2 ±7.0	0.11	278.3 ±8.8	0.17	216.1 ±5.8	0.15	200.2 ±7.1	0.08	117.6 ±4.8	0.05		
5528.41	MG1	4.35	-0.357	55.5 ±2.2	0.08	82.6 ±2.2	0.16	44.9 ±1.7	0.11						
3944.01	AL1	0.00	-0.640			208.3 ±15.7	0.54	140.2 ±10.1	0.45			57.8 ±5.1	0.10		
3961.52	AL1	0.01	-0.340	179.9 ¹		213.9 ±22.6	0.54	158.6 ±20.5	0.45			72.3 ±4.8	0.11		
3905.52	SII	1.91	-1.090									99.8 ±8.4	0.16		
4102.94	SII	1.91	-2.920	130 ¹		139.4 ¹	0.56	67.1 ±6.7	0.53						
4226.73	CA1	0.00	0.240									100.2 ±3.0	0.11		
5588.75	CA1	2.52	0.210	57.7 ±5.9	0.08	46.8 ±5.4	0.12	22.1 ±1.8	0.09						
5857.45	CA1	2.93	0.230			32.0 ±2.7	0.09								
6102.73	CA1	1.88	-0.790	35.3 ±3.0	0.04	37.2 ±1.4	0.06								
6122.23	CA1	1.89	-0.320	68.7 ±3.1	0.05	79.8 ±2.8	0.07	65.0 ±3.9	0.06	53.7 ±3.5	0.03				
6162.17	CA1	1.90	-0.090			108.9 ±3.0	0.07	56.8 ±3.1	0.05						
6439.08	CA1	2.52	0.390	47.9 ±2.6	0.04	81.7 ±3.7	0.06			48.0 ±3.9	0.02				
4246.82	SC2	0.31	0.240					128.6 ±6.8	0.41			81.0 ±3.5	0.07		
4314.08	SC2	0.62	-0.100					109.2 ±6.2	0.42			41.2 ±3.7	0.05		
4400.39	SC2	0.61	-0.540					82.6 ±4.4	0.38						
5031.02	SC2	1.36	-0.400	40.4 ²	0.10	47.3 ²	0.18	25.8 ²	0.15	31.0 ²	0.06				
5526.79	SC2	1.77	0.030	48.5 ²	0.06	56.9 ²	0.12			40.0 ²	0.04				
4981.73	TI1	0.84	0.500	65.9 ±2.8	0.11	78.0 ±2.6	0.14	34.4 ±2.8	0.12	39.4 ±3.6	0.06				
4991.07	TI1	0.84	0.380	50.7 ±2.9	0.10	71.5 ±3.5	0.14	30.1 ±3.3	0.12	34.7 ±5.3	0.06				
4999.50	TI1	0.83	0.250	49.0 ±2.2	0.10	61.9 ±3.0	0.13	29.1 ±4.0	0.12	26.0 ±4.0	0.06				
5039.96	TI1	0.02	-1.130	34.9 ±2.2	0.08	49.9 ±2.7	0.09			26.0 ±5.0	0.05				
5064.65	TI1	0.05	-0.930			59.9 ±2.2	0.09			29.6 ±3.2	0.05				
5173.74	TI1	0.00	-1.120	29.1 ±3.4	0.07	50.0 ±2.6	0.08								
5192.97	TI1	0.02	-1.010	32.3 ±2.3	0.07	63.5 ±2.7	0.08								
5210.39	TI1	0.05	-0.580							30.1 ±3.8	0.04				
3913.47	TI2	1.12	-0.530									55.8 ±2.6	0.09		
4012.39	TI2	0.57	-1.610	100.0 ±10.8	0.40										
4028.34	TI2	1.89	-1.000					34.6 ±9.4	0.59						
4290.22	TI2	1.16	-1.120									40.0 ±4.0	0.05		
4300.05	TI2	1.18	-0.770									60.5 ±4.3	0.06		
4443.79	TI2	1.08	-0.710					116.3 ±10.2	0.39			51.6 ±2.5	0.05		
4450.48	TI2	1.08	-1.450					73.3 ±8.8	0.38						
4468.51	TI2	1.13	-0.620									57.8 ±2.5	0.05		
4501.27	TI2	1.12	-0.750									56.9 ±2.7	0.05		
4533.97	TI2	1.24	-0.770									56.3 ±3.1	0.05		
4563.76	TI2	1.22	-0.960									34.1 ±1.9	0.04		
4571.97	TI2	1.57	-0.520									35.8 ±2.6	0.04		
4865.61	TI2	1.12	-2.590	18.9 ±3.7	0.11	28.5 ±5.5	0.20								
5129.16	TI2	1.89	-1.390	44.8 ±4.5	0.10	53.7 ±2.2	0.19	24.0 ±2.3	0.14						
5154.07	TI2	1.57	-1.520			58.9 ±2.8	0.17								
5185.91	TI2	1.89	-1.350	46.8 ±3.1	0.09	49.3 ±2.4	0.17								
5188.68	TI2	1.58	-1.220	89.5 ±4.3	0.12			63.8 ±2.5	0.16	58.8	0.06				
5336.77	TI2	1.58	-1.700	62.7 ±5.0	0.08	68.1 ±2.5	0.16	29.0 ±4.0	0.11	38.1	0.05				
5381.01	TI2	1.57	-1.780	36.9 ±4.7	0.07	54.4 ±5.2	0.14								
5418.77	TI2	1.58	-2.110			42.2 ±1.8	0.13			23.1	0.04				
4254.33	CR1	0.00	-0.110									53.0 ±3.1	0.06		
4274.80	CR1	0.00	-0.230									39.8 ±2.8	0.06		



First estimates: T_{eff} , $\log g$, v_{turb}



Check that the model atmosphere is adequate

ID	T_{eff} (K)				phot	spec	log(g) phot	v_{mic} (km/s)
	$V - I$	$V - J$	$V - H$	$V - K_s$				
Sex24-72	4409	4393	4345	4432	4395	4430	0.75	2.2
Sex11-04	4547	4321	4263	4377	4377	4320	0.57	2.2
Fnx05-42	4446	4270	4331	4364	4353	4325	0.70	2.3
Scl07-49	4688	4625		4579	4631	4450	1.28	2.4
Scl07-50	5008	4723		4647	4793	4775	1.56	2.2

	FeI	FeII	C	OI	NaI	MgI	AlI	SiI	CaI	ScII	TiI	TiII	CrI	MnI	CoI	NiI	SrII	YII	BaII	EuII	
$\log\epsilon(\mathbf{X})_{\odot}$	7.50	7.50	8.55	8.87	6.33	7.58	6.47	7.55	6.36	3.17	5.02	5.02	5.67	5.39	4.92	6.25	2.97	2.24	2.13	0.51	
Sex24-72																					
Nb Lines	68	3			1	3	1	1	4	2	7	6	4	1	2	1	1			2	
[X/H]	-2.93	-2.86	-2.53	<-2.29	-2.60	-2.83	-3.43	-2.75	-2.81	-3.01	-3.12	-2.70	-3.31	-3.23	-3.12	-2.70	-3.14	<-3.45	-4.03	<-3.09	
[X/Fe]			0.40	<0.64	0.33	0.10	-0.5	0.18	0.12	-0.08	-0.19	0.23	-0.38	-0.30	-0.19	0.23	-0.21	<-0.52	-1.10	<-0.16	
Error	0.04	0.08	0.19		0.30	0.06	0.5	0.35	0.09	0.10	0.07	0.09	0.10	0.30	0.27	0.14	0.35	-	0.19		
Sex11-04																					
Nb Lines	66	4			2	3	2	1	6	2	7	7	4	1	2	1	1	1		2	
[X/H]	-2.94	-2.70	-3.94	<-2.08	-3.00	-2.63	-2.65	-2.47	-2.79	-3.00	-3.15	-2.72	-3.32	-3.47	-2.90	-3.00	-2.95	-3.38	-3.79	<-3.27	
[X/Fe]			-1.00	<0.86	-0.06	0.31	0.29	0.47	0.15	-0.06	-0.21	0.22	-0.38	-0.53	0.04	-0.06	-0.01	-0.44	-0.85	<-0.33	
Error	0.04	0.09	0.32		0.08	0.08	0.15	0.30	0.07	0.11	0.05	0.07	0.12	0.20	0.35	0.11	0.40	0.16	0.14		
Fnx05-42																					
Nb Lines	40	2			2	3	2	1	3	4	4	7	2	2	2	2	1			2	
[X/H]	-3.66	-3.42	-4.46	<-2.45	-3.69	-3.20	-3.88	-3.52	-3.15	-3.38	-3.71	-3.27	-4.25	-5.26	-3.91	-4.02	-2.84	<-3.18	-4.07	<-3.11	
[X/Fe]			-0.80	<1.21	-0.05	0.41	-0.22	0.14	0.53	0.28	-0.05	0.39	-0.59	-1.60	-0.25	-0.36	0.82	<0.48	-0.41	<0.55	
Error	0.04	0.08	0.23		0.07	0.08	0.21	0.14	0.12	0.09	0.07	0.08	0.13	0.18	0.25	0.20	0.20		0.16		
ScI07-49																					
Nb Lines	21	4			2	2			2	2	6	3	2			1					
[X/H]	-3.48	-3.22			-3.72	-3.26		<-2.05	-2.98	-3.08	-3.33	-3.03	-3.90			-3.25		<-3.51	<-4.44		
[X/Fe]					-0.24	0.22		<1.43	0.50	0.40	0.15	0.55	-0.42			0.23		<0.05	<-0.88		
Error	0.04	0.10			0.11	0.08			0.06	0.11	0.08	0.09	0.12			0.08					
ScI07-50																					
Lines	21	2			2	4	2	1	1	2		9	3	3	2	2	1			1	
[X/H]	-3.96	-4.08	-3.96		-4.03	-3.97	-4.63	-3.97	-4.45	-3.75		-3.75	-4.56	-4.91	-3.49	-4.33	-5.11	<-3.22	-4.80	<-2.57	
[X/Fe]			0.00		-0.07	-0.01	-0.67	-0.01	-0.49	0.21		0.21	-0.60	-0.95	0.47	-0.37	-1.15	<0.74	-0.84	<1.39	
Error	0.06	0.11	0.50		0.10	0.13	0.10	0.20	0.13	0.10		0.08	0.09	0.23	0.26	0.12	0.16		0.16		