Spectral modeling of OB-type stars and wind momentum luminosity relationship.

Natalia Machuca Arroyo

Instituto de Física y Astronomía
Universidad de Valparaíso

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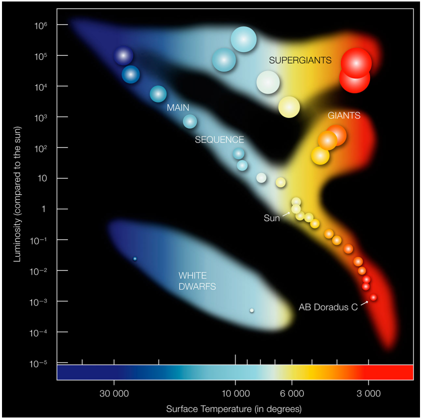
MASSIVE STARS GROUP
INSTITUTO DE FÍSICA Y ASTRONOMÍA
UNIVERSIDAD DE VALPARAÍSO

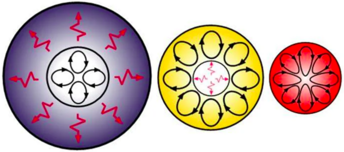
POEMS



ESO

Properties

- $T_{eff} \gtrsim 10000K$, $L > 10^4 L_\odot$, $M_{ZAMS} \gtrsim 8M_\odot$,
- Short lifetimes ($\sim 10^6$ yr)
- Rotational velocities over 40 km/s
- Radiation driven winds



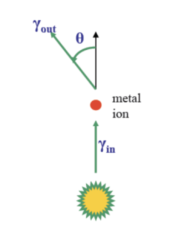
CAK Theory

RADIATION-DRIVEN WINDS IN Of STARS

JOHN I. CASTOR,* DAVID C. ABBOTT, AND RICHARD I. KLEIN
Joint Institute for Laboratory Astrophysics, University of Colorado and National Bureau of Standards
Received 1974 June 6

m-CAK

- Abbott (1982)
- Friend & Abbott (1986)
- Pauldrach et al. (1986)
- Finite disk correction



- Mass loss rate $\dot{M} = 4\pi r^2 \rho(r) v(r)$
- Terminal velocity (v_∞)

Assuming that:

- Winds are stationary.
- Forces involved: gravity, pressure y radiation.
- Viscosity and magnetic fields can be neglected.

POEMS

Assuming that:

- Winds are stationary.
- Forces involved: gravity, pressure y radiation.
- Viscosity and magnetic fields can be neglected.

Equation of motion

$$v\frac{dv}{dr} = \frac{1}{\rho}\frac{dp(r)}{dr} - \frac{GM_\star(1-\Gamma)}{r^2} + g_{es}\,k\,t^{-\alpha}\left(\frac{N_e}{W}\right)^{\delta}$$

- $0.01 \lesssim k \lesssim 0.60$ number of lines effectively contributing to the driving of the wind
- $0.45 \lesssim \alpha \lesssim 0.65$ ratio between line-force from optically thick lines and total line force
- $0.00 \lesssim \delta \lesssim 0.36$ changes in the ionization throughout the wind

fast solution

- O type stars
- High values of v_∞
- $\delta \lesssim 0.25$
- $v(r) = v_\infty \left(1 - \frac{R_\star}{r}\right)^\beta$

Pauldrach et al. (1986)

Ω-*slow* solution

- High rotation
- Equator of the stars
- Low values of v_∞
- $\Omega = v_{rot}/v_{crit} \gtrsim 60\% - 70\%$

Curé 2004

δ-*slow* solution

- Supergiants
- Low values of v_∞
- $\delta \gtrsim 0.28$

Curé et al. 2011

Characterization of a star

Stellar parameters: T_{eff}, $log(g)$, L, R, ...
Wind parameters: $\dot{M}$, v_∞, α, k, δ

code	Detail/ Surface[1]	TLUSTY[2]	PoWR[3]	PHOENIX[4]	CMFGEN[5]	WM-basic[6]	FASTWIND[7]
geometry	plane-parallel	plane-parallel	spherical	spherical/ pl.-parallel	spherical	spherical	spherical
blanketing	LTE	yes	yes	yes	yes	yes	approx.
diagnostic range	no limitations	no limitations	no limitations	no limitations	no limitations	UV	optical/IR
major application	BA stars with negl. winds	hot stars with negl. winds	WRs, OB-stars	cool stars, SNe	OB(A)-stars, WRs, SNe	hot stars w. dense winds, SNe	OB-stars, early A-sgs
comments	no wind	no wind	-	no clumping no X-rays	-	no clumping	no X-rays (in progress)
execution time	few minutes	hours	hours	hours	hours	1 to 2 h	few min. to 0.5 h

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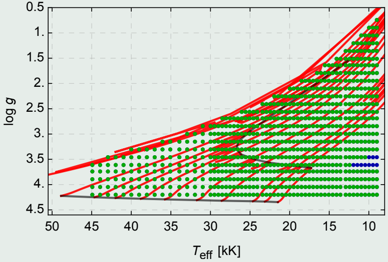
HYDWIND **(Curé, 2004)**

- Hydrodynamical code that solves stellar winds of massive stars in 1D
- Wind is treated as a stationary and isothermal fluid.
- Uses approximations to include effects of high rotation and gravity darkening.

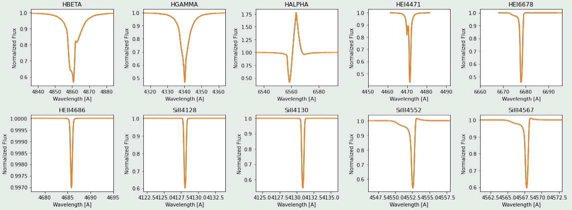
ISOSCELES: grId of Stellar atmOSphere and hydrodynamiC modELs for massivE Stars

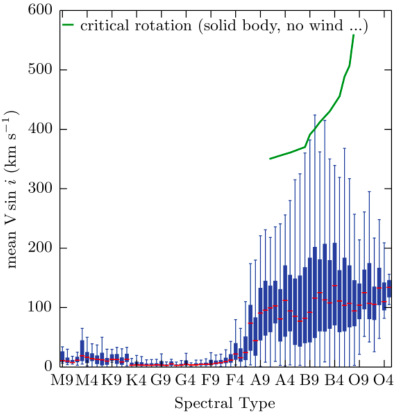


Parameter	Variation
T_{eff} [K]	9000 to 30000 steps of 500
	30000 a 45000 steps of 1000
$\log g$	$0.75^* < \log g < 4.20$ steps of 0.15
α	0.45, 0.51, 0.53, 0.55, 0.61, 0.65
k	0.05 to 1.0 steps of 0.05
δ	0, 0.04, 0.1, 0.14, 0.2, 0.24, 0.28, 0.29,
	0.3, 0.31, 0.32, 0.33, 0.34, 0.35
ξ [km/s]	1, 5, 10, 15, 20, 25
$\log_{\epsilon}$Si	7.21, 7.36, 7.51, 7.66, 7.81

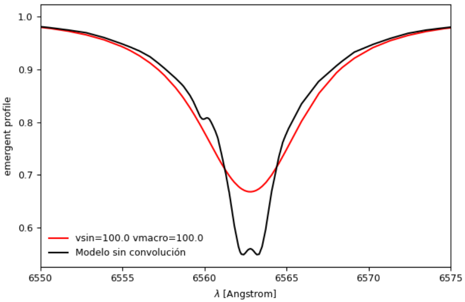
Result

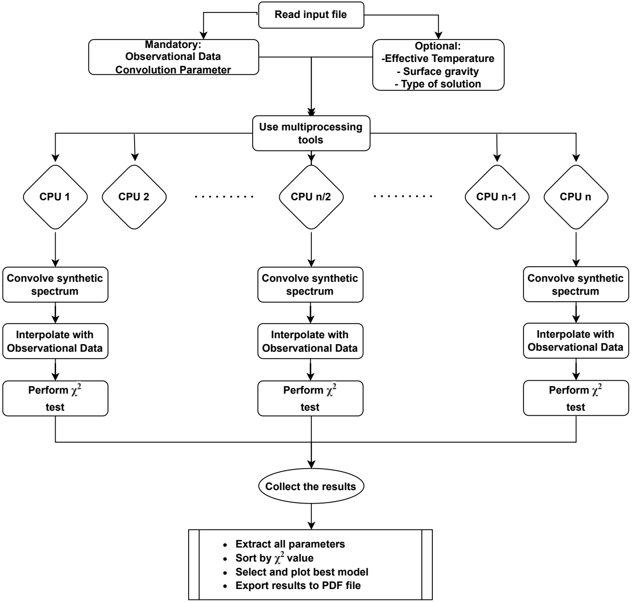
- $\sim$ 573.387 models
- 6 microturbulence velocities
- 56 spectral lines H, He, Si.



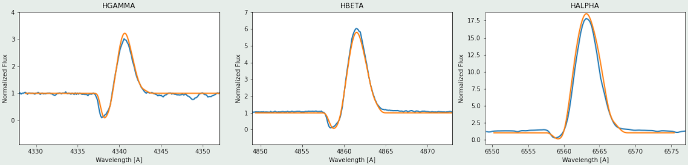


Glebocki R. & Gnacinski P. (2005)




Read input file
Mandatory:
Observational Data
Convolution Parameter
Optional:
-Effective Temperature
- Surface gravity
- Type of solution
Use multiprocessing tools
CPU 1
CPU 2
CPU n/2
CPU n-1
CPU n
Convolve synthetic spectrum
Interpolate with Observational Data
Perform χ^2 test
Convolve synthetic spectrum
Interpolate with Observational Data
Perform χ^2 test
Convolve synthetic spectrum
Interpolate with Observational Data
Perform χ^2 test
Collect the results
Extract all parameters
Sort by χ^2 value
Select and plot best model
Export results to PDF file

Example 1: Analysis of PCyg (B1 Ia)

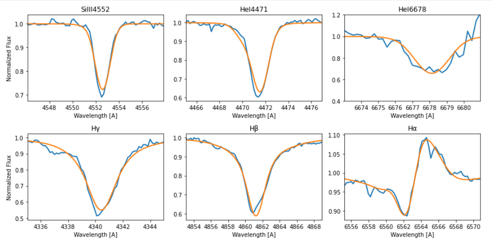


$T_{eff} = 13000$ K
$\log g = 1.35$

$\alpha = 0.57$
$k = 0.15$
$\delta = 0.24$

$\dot{M} = 3.68 \times 10^{-5} M_{\odot}/yr$
$v_{\infty} = 176$ km/s

Example 2: Analysis of HD99953 (B2 Ia)

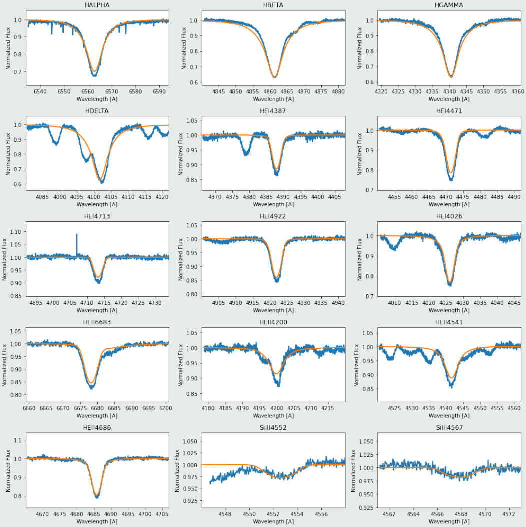


$T_{eff} = 18500$ K
$\log g = 2.40$

$\alpha = 0.53$
$k = 0.15$
$\delta = 0.34$

$\dot{M} = 2.44 \times 10^{-7} M_{\odot}/yr$
$v_{\infty} = 254$ km/s

Example 3: Analysis of HD14633 (O8.5 V)



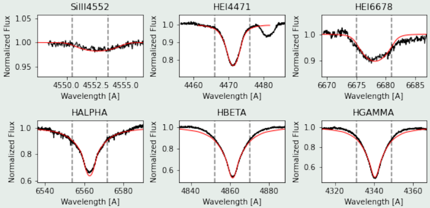
$T_{eff} = 36000$ K
$\log g = 4.05$

$\alpha = 0.51$
$k = 0.30$
$\delta = 0.10$

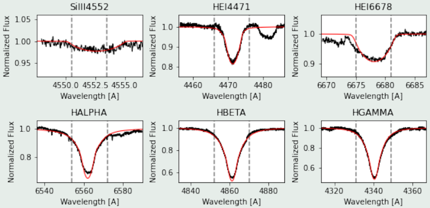
$\dot{M} = 3.08 \times 10^{-8} M_{\odot}/yr$
$v_{\infty} = 597.41$ km/s

Example 4: IACOB stars

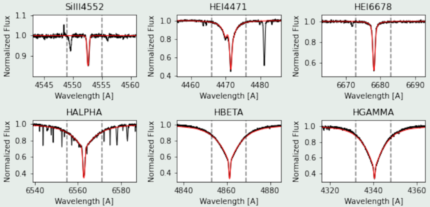
HD120315



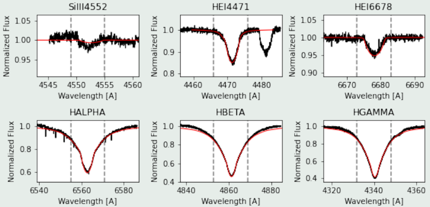
HD179406



HD176502

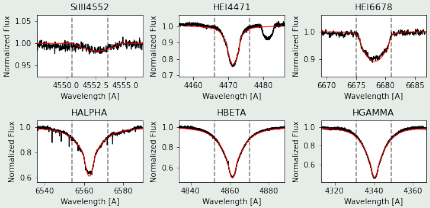


HD18604

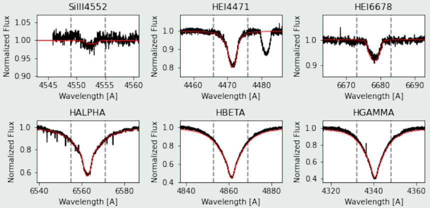


Example 5: IACOB stars

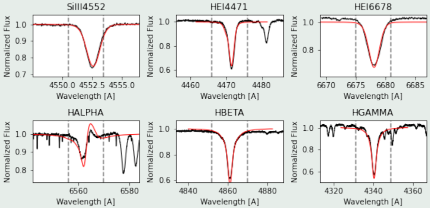
HD120315



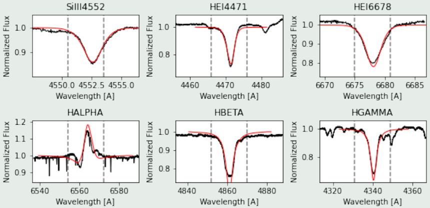
HD179406



HD176502



HD18604



Wind momentum definition

$$D_{mom} \equiv \dot{M} v_{\infty} \left(\frac{R_{\star}}{R\odot} \right)^{1/2}$$

Wind momentum Luminosity Relationship

Since the stellar winds of massive stars are driven by radiation, it is reasonable to expect that the mechanical momentum of the flowing material is related to the momentum of the radiation field.

$$D_{mom} \propto \left(\frac{L_{\star}}{L_{\odot}} \right)^{x}$$

x: the inverse of the slope of the line force distribution function corrected for ionization effects (Puls et al., 2000)

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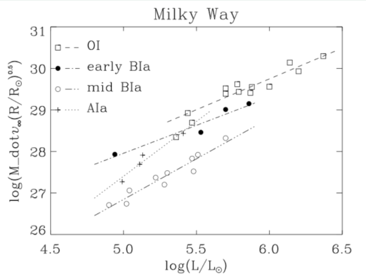
Distance Estimator

$v_\infty \propto v_{esc} \rightarrow$ ISM

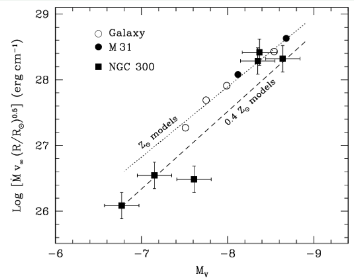
$\dot{M}$, D_{mom} along E.T.

Previous studies of this relationship

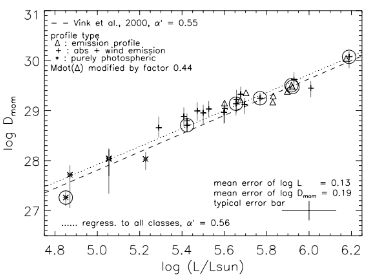
Kudritzki et al. 1999



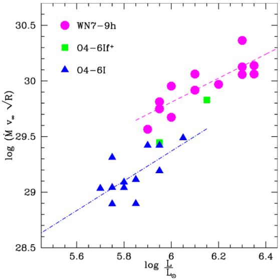
Bresolin et al. 2002



Vink et al. 2000



Martins et al. 2008



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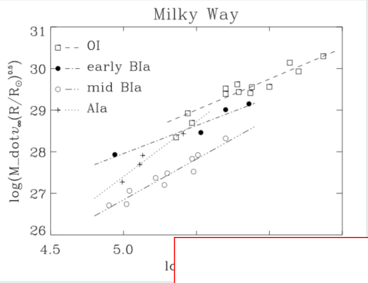
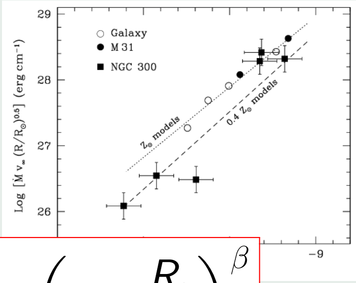
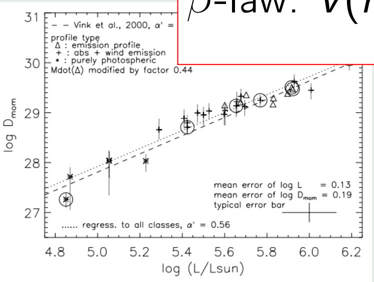


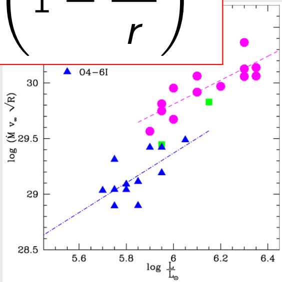
Bresolin et al. 2002



$$\beta\text{-law:}\ \ v(r) = v_\infty \left(1 - \frac{R_\star}{r}\right)^{\beta}$$

Vink et





IACOB + ISOSCELES

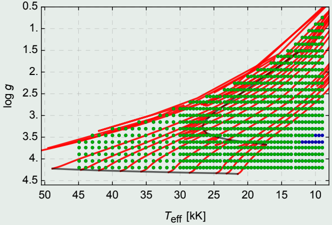
IACOB

IACOB Spectroscopic database

http://research.iac.es/proyecto/iacob/iacobcat/

- Sergio Simón-Díaz, Instituto de Astrofísica de Canarias
- Galactic massive stars
- 1000 O, B type stars optical spectra

ISOSCELES



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δ	0, 0.04, 0.1, 0.14, 0.2, 0.24,
	0.28, 0.29, 0.3, 0.31, 0.32, 0.33, 0.34, 0.35
ξ [km/s]	1, 5, 10, 15, 20, 25
$\log_\epsilon$Si	7.21, 7.36, 7.51, 7.66, 7.81

Name	SpType	vsini	vmac	Lum	Dmom	T	g	alpha	k	delta	Mdot	vinf	vmic
HD37128	**B0 Ia**	**48**	**111**	**182900**	**2.91E+27**	**19500**	**2.55**	**0.51**	**0.2**	**0.35**	**2.87E-07**	**263**	**10**
HD204172	**B0 Ib**	**58**	**106**	**158700**	**1.27E+27**	**19000**	**2.55**	**0.45**	**0.3**	**0.32**	**1.39E-07**	**239**	**10**
~~HD37020~~	~~B0 V~~	~~55~~	~~16~~	~~12880~~	~~9.02E+27~~	~~31000~~	~~4.2~~	~~0.65~~	~~0.6~~	~~0.04~~	~~2.29E-07~~	~~3140~~	~~5~~
~~HD37023~~	~~B0.2 V~~	~~48~~	~~12~~	~~13060~~	~~5.55E+27~~	~~22000~~	~~3.6~~	~~0.65~~	~~0.45~~	~~0.14~~	~~2.05E-07~~	~~1536~~	~~1~~
HD38771	**B0.5 Ia**	**49**	**92**	**96540**	**8.10E+26**	**24500**	**3.15**	**0.45**	**0.35**	**0.35**	**9.71E-08**	**318**	**10**
HD36862	B0.5V	76	19	3984	3.54E+26	25000	4.2	0.61	0.45	0.1	1.51E-08	2031	1
HD36960	**B0.5V**	**25**	**35**	**7394**	**1.89E+25**	**28000**	**4.2**	**0.51**	**0.5**	**0.33**	**2.62E-09**	**599**	**5**
HD24398	**B1 Ib**	**43**	**67**	**85950**	**3.27E+26**	**22000**	**3**	**0.45**	**0.35**	**0.32**	**3.80E-08**	**304**	**10**
~~HD54764~~	~~B1 Ib/II~~	~~125~~	~~81~~	~~81850~~	~~1.53E+29~~	~~20000~~	~~2.85~~	~~0.45~~	~~0.35~~	~~0.32~~	~~1.78E-08~~	~~279~~	~~10~~
HD36591	**B1 IV**	**9**	**18**	**7394**	**1.89E+25**	**28000**	**4.2**	**0.51**	**0.5**	**0.33**	**2.62E-09**	**599**	**1**
HD34989	B1 V	48	16	4439	4.10E+25	25500	4.2	0.55	0.3	0.1	2.13E-09	1659	1
HD35299	B1.5 V	4	15	2843	2.47E+25	23500	4.2	0.55	0.35	0.1	1.35E-09		1
HD36351	B1.5 V	29	14	1984	6.97E+24	22000	4.2	0.65	0.1	0.2	3.90E-10	1621	1
HD36959	B1.5 V	11	12	2843	2.47E+25	23500	4.2	0.55	0.35	0.1	1.35E-09	1616	1
HD37481	B1.5 V	74	14	3177	1.46E+26	22000	4.05	0.61	0.35	0.1	6.48E-09	1826	1
HD37744	B1.5 V	37	15	2843	2.47E+25	23500	4.2	0.55	0.35	0.1	1.35E-09	1616	1
~~HD14818~~	~~B2 Ia~~	~~46~~	~~58~~	~~209893~~	~~2.10E+27~~	~~20000~~	~~2.55~~	~~0.45~~	~~0.25~~	~~0.32~~	~~2.28E-07~~	~~237~~	~~1~~
HD206165	**B2 Ib**	**42**	**63**	**150000**	**1.73E+27**	**20500**	**2.7**	**0.45**	**0.3**	**0.3**	**1.85E-07**	**267**	**10**
HD31327	B2 II	35	52	86520	2.52E+28	17000	2.55	0.65	0.15	0	5.03E-07	1366	10
HD29248	B2 III	34	40	6486	8.48E+26	23000	3.9	0.61	0.5	0.2	4.66E-08	1284	1
HD35468	**B2 III**	**52**	**31**	**7191**	**1.66E+25**	**21500**	**3.75**	**0.51**	**0.6**	**0.33**	**2.30E-09**	**465**	**5**
HD37209	B2 IV	50	15	3189	2.80E+25	24000	4.2	0.61	0.15	0.1	1.23E-09	1993	1
HD35039	B2 IV-V	7	20	6761	5.20E+24	19500	3.6	0.51	0.15	0.1	2.99E-10	1027	1
HD36285	B2 IV-V	9	18	1750	2.57E+25	21500	4.2	0.65	0.2	0.2	1.46E-09	1614	1
HD35912	B2 V	11	20	1645	2.18E+25	19500	4.05	0.65	0.2	0.2	1.25E-09	1467	1
HD36430	B2 V	15	25	1027	1.57E+25	19500	4.2	0.65	0.2	0.14	7.89E-10	1886	1
HD36629	B2 V	7	17	1645	2.17E+25	19500	4.05	0.65	0.2	0.2	1.25E-09	1467	1
HD2905	**BC0.7 Ia**	**66**	**83**	**85950**	**2.40E+27**	**22000**	**3**	**0.51**	**0.3**	**0.35**	**2.52E-07**	**337**	**10**

POEMS

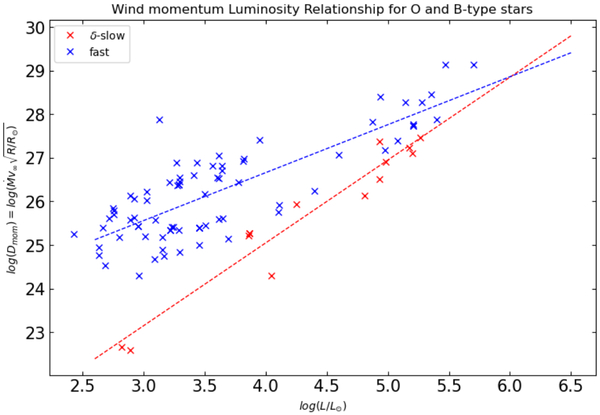
Name	SpType	vsini	vmac	Lum	Dmom	T	g	alpha	k	delta	Mdot	vinf
~~HD11415~~	~~B3 Vp~~	~~45~~	~~17~~	—	—	~~14~~	—	—	—	—	—	—
HD120315	**B3 V**	**155**	**63**	**778**	**3.90E+22**	**17000**	**4.05**	**0.55**	**0.55**	**0.35**	**6.82E-12**	**506**
~~HD135485~~	~~B3 V~~	~~14~~	~~13~~	~~569~~	~~4.95E+25~~	~~17500~~	~~4.2~~	~~0.65~~	~~0.6~~	~~0.14~~	~~2.68E-09~~	~~1824~~
~~HD156491~~	~~B3 III~~	~~264~~	~~107~~	—	—	~~15?~~	—	—	—	—	—	—
HD158304	B3 III	8	16	3663	6.43E+26	17000	3.75	0.65	0.45	0.14	2.77E-08	1561
HD160762	B3 IV	4	7	2718	7.64E+26	16500	3.6	0.65	0.6	0.1	3.00E-08	1599
HD162094	B3 V	109	27	1059	1.65E+26	16500	3.9	0.65	0.6	0.1	7.28E-09	1809
HD178849	B3 V	36	7	1932	2.40E+26	15500	3.6	0.65	0.6	0.24	1.54E-08	1002
HD179406	B3 V	158	9	8839	2.57E+27	14500	3	0.65	0.35	0.04	7.25E-08	1458
HD182568	B3 IV	105	20	4353	6.63E+26	16500	3.45	0.65	0.45	0.2	3.41E-08	1088
HD185423	B3 III	151	11	12720	5.70E+25	15500	3	0.55	0.1	0.04	2.16E-09	998
HD186660	B3 III	5	18	4145	3.97E+25	15000	3.3	0.65	0.1	0.14	1.73E-09	1176
~~HD192685~~	~~B3 V~~	~~184~~	~~95~~	—	—	~~18~~	—	—	—	—	—	—
HD198820	B3 III	33	6	4145	1.12E+27	15000	3.3	0.65	0.55	0.14	4.83E-08	1194
~~HD203025~~	~~B3 III~~	~~90~~	—	—	—	—	—	—	—	—	—	—
HD20365	B3 V	125	5	1434	7.88E+24	16000	3.75	0.55	0.6	0.2	6.45E-10	873
HD204536	B3 III	70	43	4145	3.39E+26	15000	3.3	0.61	0.55	0.2	3.02E-08	864
HD209008	B3 III	11	22	895	2.73E+25	16000	3.9	0.61	0.45	0.1	1.43E-09	1538
HD214432	**B3 V**	**150**	**190**	**663**	**4.61E+22**	**18000**	**4.2**	**0.55**	**0.6**	**0.35**	**8.26E-12**	**545**
HD21483	B3 III	123	11	6001	2.78E+26	17500	3.45	0.61	0.4	0.24	1.78E-08	855
HD218537	B3 V	150	40	778	1.33E+26	17000	4.05	0.65	0.6	0.04	4.84E-09	2427
HD220787	B3 III	26	15	1428	1.54E+25	19000	4.05	0.65	0.15	0.14	7.47E-10	1755
HD223229	B3 IV	31	24	2588	3.99E+26	15000	3.45	0.65	0.6	0.24	2.48E-08	932
HD23466	B3 V	59	89	778	3.77E+25	17000	4.05	0.61	0.6	0.1	1.99E-09	1673
~~HD23478~~	~~B3 IV~~	~~120~~	—	—	—	—	—	—	—	—	—	—
HD25204	B3 IV	52.5	214	4957	1.38E+25	15500	3.3	0.65	0.05	0.14	5.94E-10	1182
HD252409	B3 IV	41	10	1616	2.70E+26	15000	3.6	0.65	0.6	0.2	1.20E-08	1121
HD26912	B3 IV	52	21	1932	2.21E+25	15500	3.6	0.55	0.55	0.14	1.46E-09	971
HD32630	B3 V	86	8	1059	1.04E+26	16500	3.9	0.65	0.6	0.2	6.33E-09	1310
HD37055	B3 IV	71	9	413	9.61e	16500	4.2	0.55	0.3	0.04	5.60E-11	1727
HD37150	B3 IV	185	2	6640	9.36E+26	15000	3.15	0.65	0.25	0.04	2.72E-08	1574
HD37711	B3 IV	66	46	1703	2.60E+25	18000	3.9	0.65	0.25	0.24	1.69E-09	1185
HD41753	B3 IV	26	34	559	7.00E+25	16000	4.05	0.65	0.55	0.04	2.67E-09	2375
HD49567	**B3 II-III**	**42**	**162**	**11170**	**1.97E+24**	**16500**	**3.15**	**0.51**	**0.4**	**0.34**	**2.59E-10**	**335**
HD57539	B3 IV	163	95	2333	8.06E+23	13500	3.3	0.45	0.45	0.1	6.49E-11	663
HD66834	**B3 III**	**173**	**2**	**17950**	**8.62E+25**	**18000**	**3.15**	**0.51**	**0.55**	**0.35**	**1.07E-08**	**343**
HD69562	B3 III	18	4	485	3.37E+24	17000	4.2	0.65	0.1	0.04	1.31E-10	2566
HD79931	B3 III	67	28	1865	7.69E+26	10000	2.85	0.65	0.6	0	2.25E-08	1429

Name	SpType	vsini	vmac	Lum	Dmom	T	g	alpha	k	delta	Mdot	vinf	vmic
HD21278	B4 V	44	15	629.7	1.48E+25	15000	3.9	0.65	0.45	0.24	1.09E-09	1114	1
HD27396	B4 IV	25	17	895.5	2.73E+25	16000	3.9	0.61	0.45	0.1	1.43E-09	1538	1
HD30211	B4 IV	133	170	2588	9.33E+23	15000	3.45	0.65	0.05	0.24	5.95E-11	907	10
~~HD37062~~	~~B4 V~~	~~21~~	~~10~~	—	—	—	—	—	—	—	—	—	—
HD74280	B4 V	105	8	4353	5.11E+26	16500	3.45	0.65	0.4	0.2	2.63E-08	1086	1
HD176502	B4 IV	15	14	1247	3.83E+25	17000	3.9	0.61	0.4	0.1	1.92E-09	1570	1
HD180554	B4 IV	42	74	1932	2.40E+26	15500	3.6	0.65	0.6	0.24	1.54E-08	1002	1
~~HD183144~~	~~B4 III~~	~~233~~	~~149~~	—	—	—	—	—	—	—	—	—	—
HD195986	B4 III	32	12	2845	1.00E+25	14000	3.3	0.65	0.1	0.2	5.58E-10	950	5
~~HD216200~~	~~B4 III~~	~~213~~	~~264~~	—	—	—	—	—	—	—	—	—	—

Name	SpType	vsini	vmac	Lum	Dmom	T	g	alpha	k	delta	Mdot	vinf	vmic
HD10205	B5 III	74	47	1965	2.90E+26	12000	3.15	0.65	0.55	0.14	1.39E-08	1040	1
HD11529	B5 III	30	25	1965	3.45E+26	12000	3.15	0.65	0.6	0.14	1.64E-08	1041	5
~~HD142990~~	~~B5 V~~	~~85~~	~~280~~	~~1434~~	~~3.59E+23~~	~~16000~~	~~3.75~~	~~0.45~~	~~0.5~~	~~0.1~~	~~3.02E-11~~	~~851~~	5
HD147394	B5 IV	30	12	838	9.14E+25	14500	3.75	0.65	0.6	0.14	4.77E-09	1422	1
HD147701	B5 III	19	30	432	1.37E+25	14000	3.9	0.61	0.6	0.1	7.91E-10	1468	1
~~HD157548~~	~~B5 III~~	—	—	—	—	—	—	—	—	—	—	—	—
~~HD176162~~	~~B5 IV~~	~~6~~	~~27~~	~~1776~~	~~2.35E+26~~	~~14000~~	~~3.45~~	~~0.65~~	~~0.6~~	~~0.2~~	~~1.35E-08~~	~~1029~~	~~1~~
HD184930	B5 III	67	25	2456	6.24E+26	12500	3.15	0.65	0.6	0.1	2.53E-08	1206	1
HD185330	B5 II-III	2	7	4872	9.76E+26	13000	3	0.61	0.55	0.04	3.47E-08	1204	5
HD188665	B5 V	100	7	1343	1.47E+26	14500	3.6	0.65	0.6	0.2	8.71E-09	1107	5
~~HD189775~~	~~B5 III~~	~~56~~	~~27~~	—	—	—	—	—	—	—	—	—	—
~~HD196662~~	~~B5 III~~	~~2~~	~~15~~	—	—	—	—	—	—	—	—	—	—
HD196740	B5 IV	261	79	2151	3.36E+26	14500	3.45	0.65	0.6	0.2	1.89E-08	1042	5
HD1976	B5 IV	123	219	2151	6.76E+23	14500	3.45	0.45	0.6	0.14	6.14E-11	644	10
~~HD198183~~	~~B5 V~~	~~132~~	~~161~~	~~2298~~	~~4.00E+26~~	~~16000~~	~~3.6~~	~~0.65~~	~~0.6~~	~~0.2~~	~~2.22E-08~~	~~1147~~	~~1~~
~~HD199081~~	~~B5 V~~	~~28~~	~~30~~	—	—	—	—	—	—	—	—	—	—
HD201912	B5 III	12	16	2588	1.29E+25	15000	3.45	0.55	0.35	0.14	8.36E-10	898	1
HD20418	B5 IV	278	124	2588	1.80E+24	15000	3.45	0.45	0.3	0.04	7.18E-11	875	5
~~HD209419~~	~~B5 III~~	~~19~~	~~18~~	—	—	—	—	—	—	—	—	—	—
HD211924	B5 IV	18	31	1776	9.47E+24	14000	3.45	0.61	0.25	0.2	6.31	890	1
HD212222	B5 V	33	18	2151	3.36E+26	14500	3.45	0.65	0.6	0.2	1.89E-08	1042	1
HD21428	B5 V	157	151	1616	5.44E+23	15000	3.6	0.51	0.2	0.1	3.76E-11	942	10

Name	SpType	vsini	vmac	Lum	Dmom	T	g	alpha	k	delta	Mdot	vinf	v
HD2729	B6 V	106	23	838.4	4.26E+25	14500	3.75	0.65	0.5	0.2	2.69E-09	1175	1
HD18604	B6 III	137	8	909	1.97e+24	13500	3.6	0.55	0.55	0.2	1.73E-10	771	5
HD23300	B6 V	17	17	838.4	1.14e+26	14500	3.75	0.65	0.6	0.1	5.20E-09	1625	1
~~HD23302~~	~~B6 III~~	~~182~~	~~11~~	—	—	~~14~~	—	—	—	—	—	—	—
HD23338	B6 IV	107	11	1456	5.54E+24	13500	3.45	0.55	0.4	0.14	3.84E-10	866	1
~~HD23480~~	~~B6 IV~~	~~276~~	~~2~~	—	—	—	—	—	—	—	—	—	—
HD24587	B6 V	33	2	269	1.81e+25	14000	4.05	0.65	0.6	0.1	9.52E-10	1813	5
HD28114	B6 IV	24	15	1343	7.43e+27	14500	3.6	0.65	0.5	0.24	5.01E-09	976	1
HD46075	B6 III	61	18	462	2.46e+25	13000	3.75	0.65	0.45	0.1	1.21E-09	1565	10
HD68099	B6 III	57	19	1227	4.72e+24	12000	3.3	0.65	0.15	0.2	2.90E-10	906	1
HD90994	B6 V	80	34	523	4.16e+25	14500	3.9	0.65	0.6	0.14	2.30E-09	1511	1
~~HD138749~~	~~B6 Vn~~	—	—	—	—	~~16~~	—	—	—	—	—	—	—
HD138764	B6 IV	16	20	432	8.99e+24	14000	3.9	0.65	0.5	0.24	6.99E-10	1087	1
HD155763	B6 III	44	20	1965	3.45e+26	12000	3.15	0.65	0.6	0.14	1.64E-08	1041	5
HD182255	B6 III	29	17	432	5.89e+24	14000	3.9	0.65	0.35	0.2	4.05E-10	1229	1
HD191243	B6 Ib	27	32	39400	1.16e+27	13500	2.4	0.65	0.05	0.04	2.84E-08	1035	10
~~HD192987~~	~~B6 III~~	~~123~~	~~36~~	—	—	—	—	—	—	—	—	—	—
HD195810	B6 III	56	16	1899	2.32e+26	13000	3.3	0.65	0.6	0.2	1.33E-08	944	1
HD197226	B6 III	96	19	567	6.08e+25	13500	3.75	0.65	0.6	0.1	2.92E-09	1584	1
~~HD220222~~	~~B6 III~~	~~120~~	~~65~~	—	—	~~13~~	—	—	—	—	—	—	—
HD225289	B6 III	47	25										

Name	SpType	vsini	vmac	L	Dmom	T	g	alpha	k	delta	Mdot	vinf	vmic
HD14633	**O8.5 V**	**121**	**69**	**64100**	**1.36e+26**	**35000**	**3.9**	**0.51**	**0.15**	**0.35**	**1.51E-08**	**546**	**10**
HD14947	O4.5 If	114	22	296800	1.39e+29	39000	3.6	0.65	0.15	0.1	3.79E-06	1685	1
HD15570	O4 If	81	115	505600	1.38e+29	43000	3.6	0.55	0.2	0	4.52E-06	1356	10
HD188001	O7.5 Iab	69	100	191100	1.91E+28	33000	3.45	0.55	0.15	0.24	1.10E-06	757	10
~~HD188209~~	~~O9.5 Iab~~	~~57~~	~~75~~			~~27~~							
~~HD190429~~	~~O4 If~~	~~90~~	~~113~~	~~505600~~	~~1.38e+29~~	~~43000~~	~~3.6~~	~~0.55~~	~~0.2~~	~~0~~	~~4.52E-06~~	~~1356~~	~~10~~
HD192639	O7.5 Iabf	98	98	224900	2.81e+28	34000	3.45	0.61	0.1	0.24	1.33E-06	905	10
HD207198	O9 II	54	91	161500	5.44e+27	32000	3.45	0.45	0.25	0.14	3.19E-07	748	10
HD209975	O9 Ib	53	96	161500	5.89e+27	32000	3.45	0.45	0.25	0.2	4.15E-07	623	10
HD214680	**O9 V**	**16**	**41**	**24980**	**2.65e+23**	**35000**	**4.2**	**0.51**	**0.1**	**0.35**	**3.28E-11**	**619**	**10**
HD24431	O9III+B1.5V	49	81	74750	6.61e+27	36000	3.9	0.65	0.1	0.1	1.80E-07	2202	10
~~HD30614~~	~~O9 Ia~~	~~110~~	~~86~~			~~30~~							-
HD34078	O9.5 V	14	30	24980	1.77e+26	35000	4.2	0.45	0.4	0.14	1.16E-08	1172	1
HD34656	O7.5 II(f)	63	73	139000	1.87e+28	37000	3.75	0.65	0.1	0.14	5.68E-07	1743	10
HD36486	O9.5 II Nwk	122	96	161500	5.44e+27	32000	3.45	0.45	0.25	0.14	3.10E-07	748	10
HD36512	O9.7 V	15	29	12880	8.14e+25	31000	4.2	0.55	0.2	0.2	5.00E-09	1301	10
HD36861	O8 III((f))	60	60	119700	2.50e+27	36000	3.75	0.45	0.25	0.14	1.46E-07	911	10
HD46150	O5 V((f))	73	93	94870	1.48e+27	41000	4.05	0.45	0.25	0.2	1.05E-07	910	1
HD46223	O4 V((f))	51	112	252500	7.63e+27	45000	3.9	0.61	0.05	0.24	3.62E-07	1165	10
HD46966	**O8.5 IV**	**39**	**68**	**46660**	**3.47e+24**	**36000**	**4.05**	**0.51**	**0.1**	**0.35**	**4.00E-10**	**585**	**5**
~~HD47432~~	~~O9.7 Ib~~	~~99~~	~~59~~	~~161500~~	~~1.13e+28~~	~~32000~~	~~3.45~~	~~0.51~~	~~0.2~~	~~0.2~~	~~6.52E-07~~	~~761~~	~~10~~

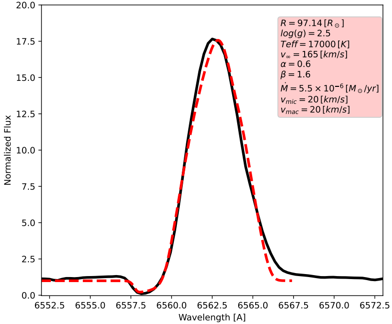


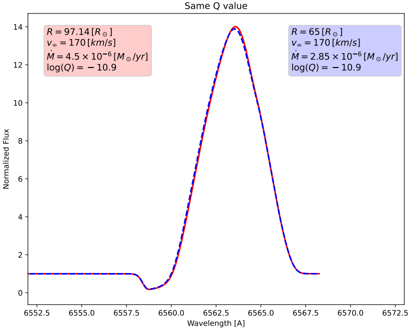
$$\log(D_{mom}) = 1.89 \pm 0.14 \log(L/L_\odot) + 17.45 \pm 0.65$$

$$\log(D_{mom}) = 1.10 \pm 0.1 \log(L/L_\odot) + 22.15 \pm 0.37$$

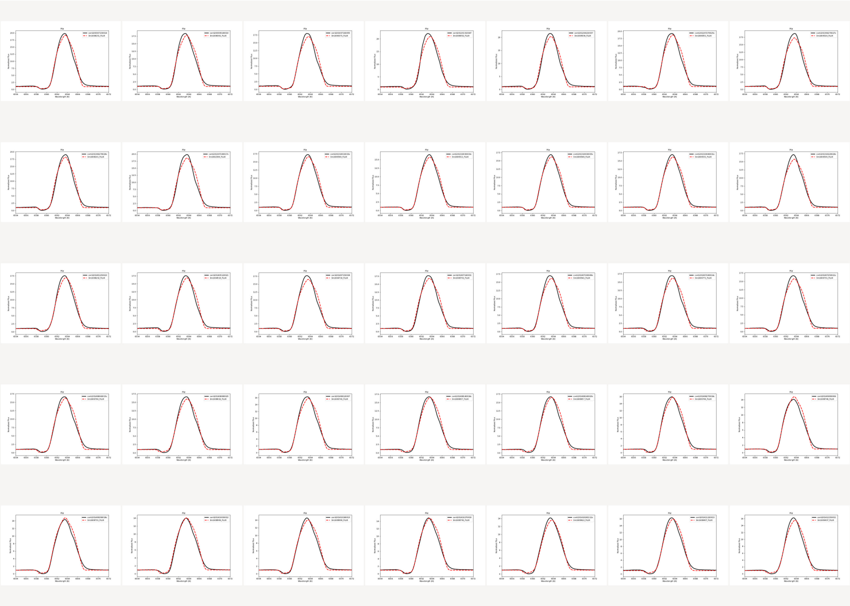
Project: Fitting synthetic Hα line-profiles to observations

Appel is a numerical code (Mihalas & Kunasz, 1978) that uses the equivalent-two-level-atom approach to solve the radiative transfer problem and the equations of statisctical equilibrium in the context of the multi-level hydrogen atom (6 levels). The radiative transfer equation is solved in the comoving frame of the flow.





Secondment at Ondrejov



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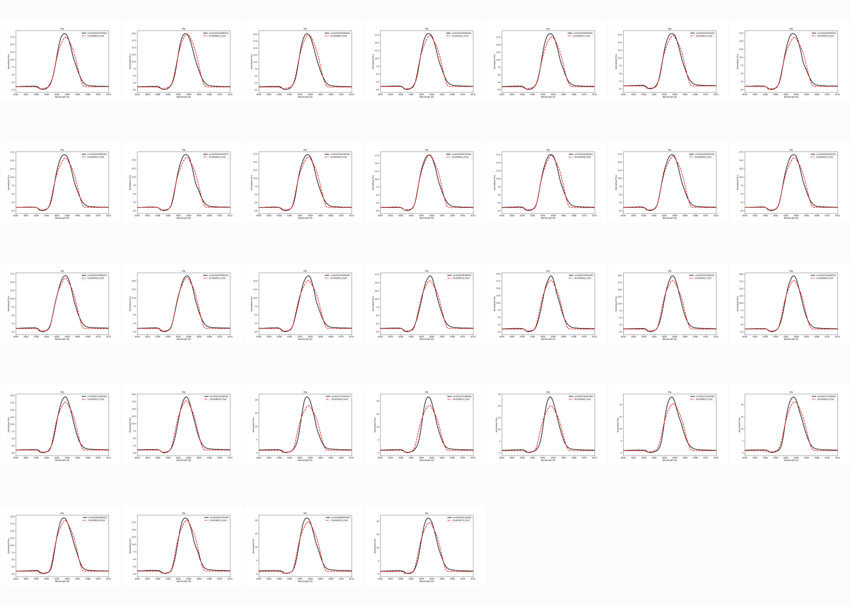
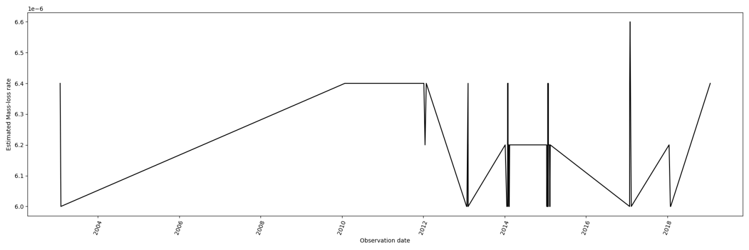


Mass loss



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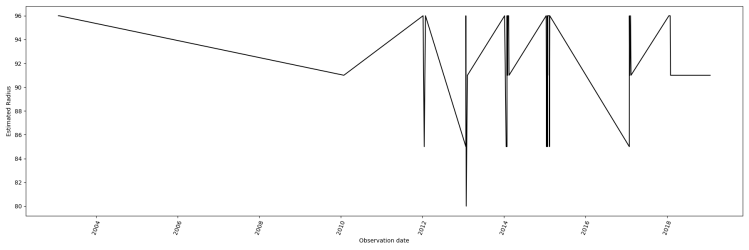
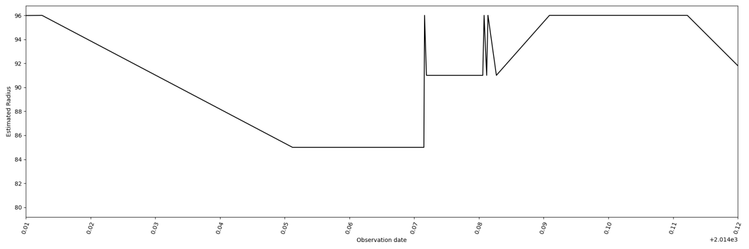


2014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Observation date
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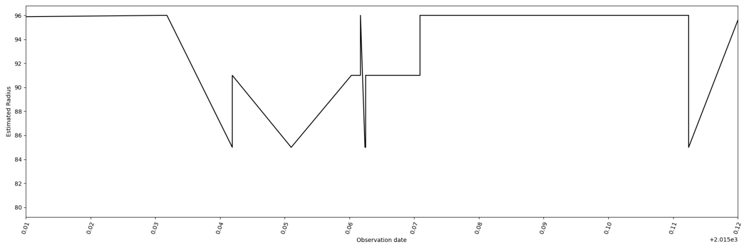
2015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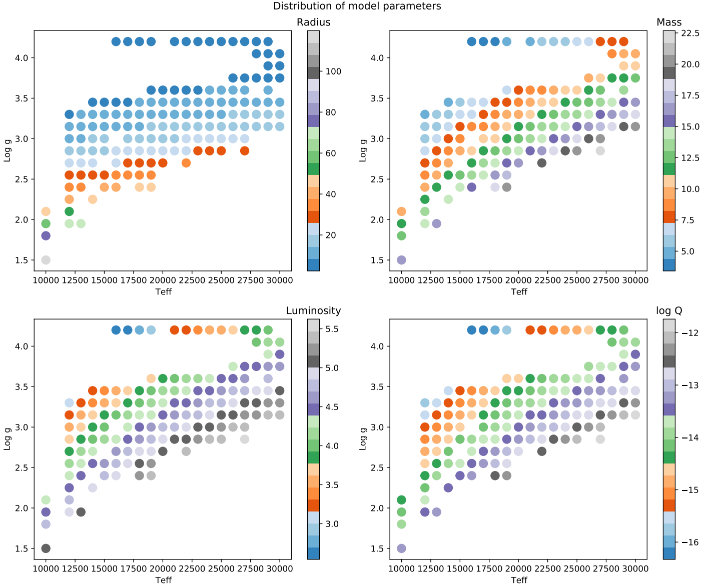
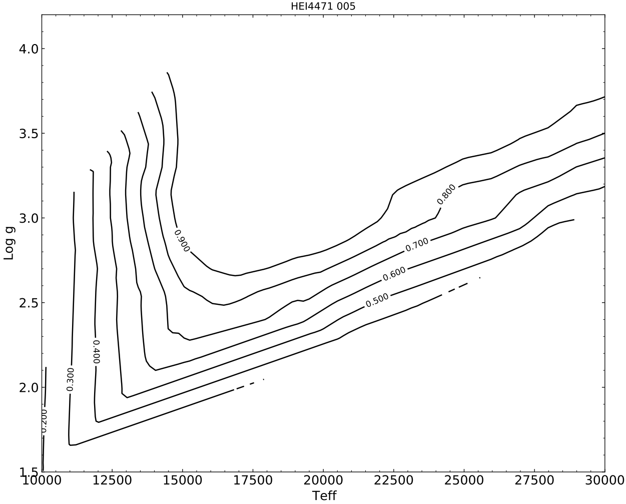
Secondment at Ondrejov

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2.0
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20000
22500
25000
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30000
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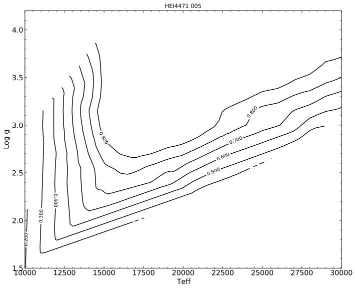
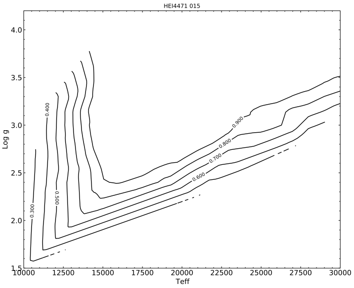
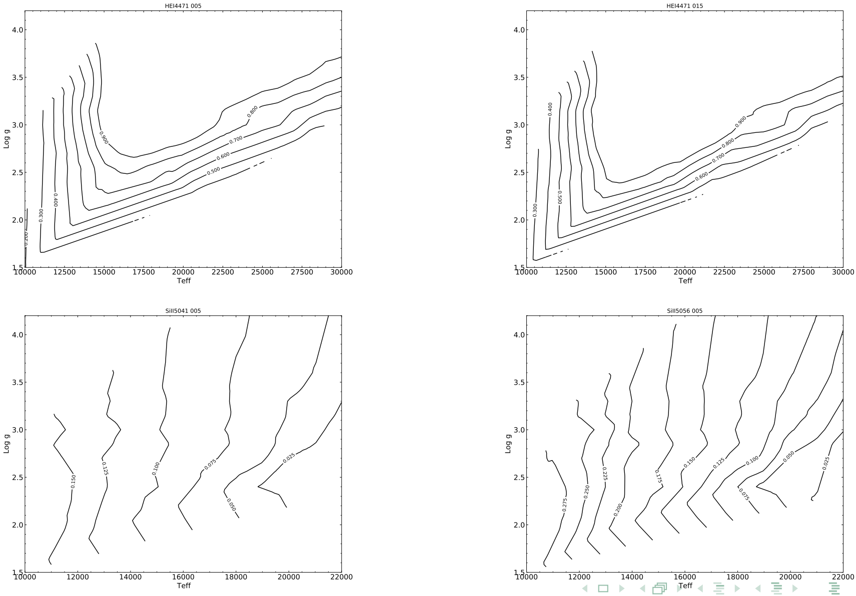
0.500
0.600
0.700
0.800
0.900

Secondment at Ondrejov



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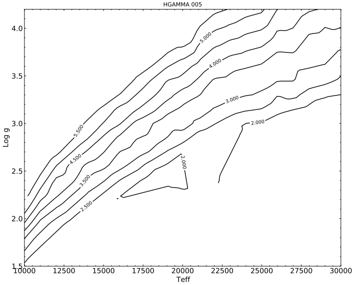
Log g
Teff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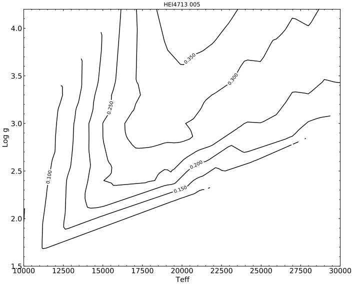
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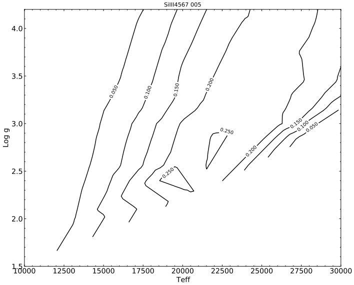
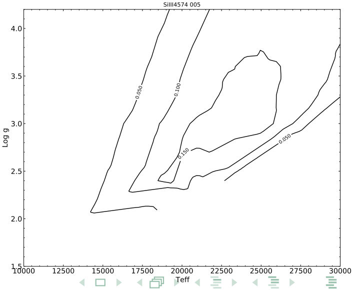
3.5
4.0
10000
12500
15000
17500
20000
22500
25000
27500
30000


SiIII4567 005
Log g
Teff
0.050
0.100
0.150
0.200
0.250
1.5
2.0
2.5
3.0
3.5
4.0
10000
12500
15000
17500
20000
22500
25000
27500
30000


SiIII4574 005
Log g
Teff
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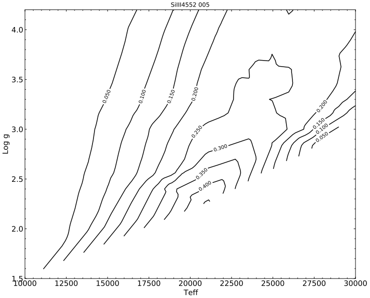
0.100
0.150
1.5
2.0
2.5
3.0
3.5
4.0
10000
12500
15000
17500
20000
22500
25000
27500
30000


SiIII4552 005
Log g
Teff
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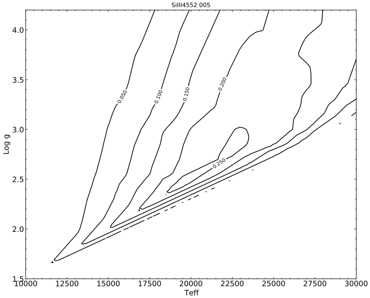
0.100
0.150
0.200
0.250
0.300
0.350
0.400


SiIII4552 005
Log g
Teff
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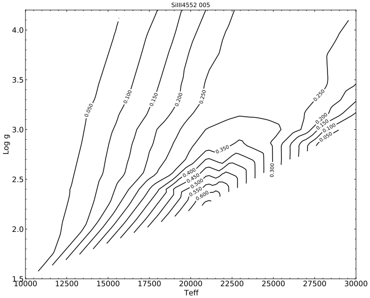
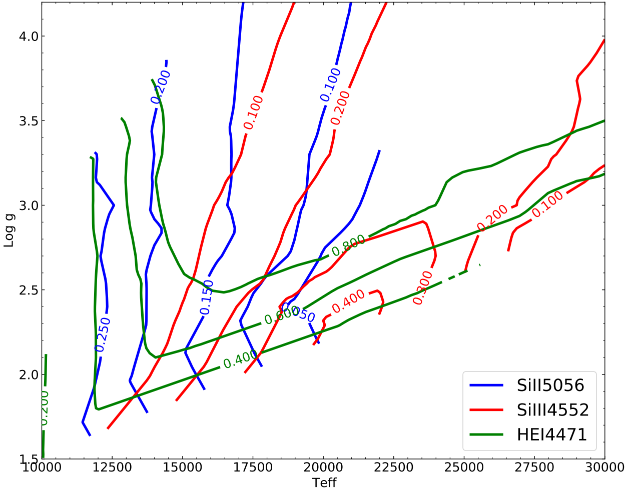
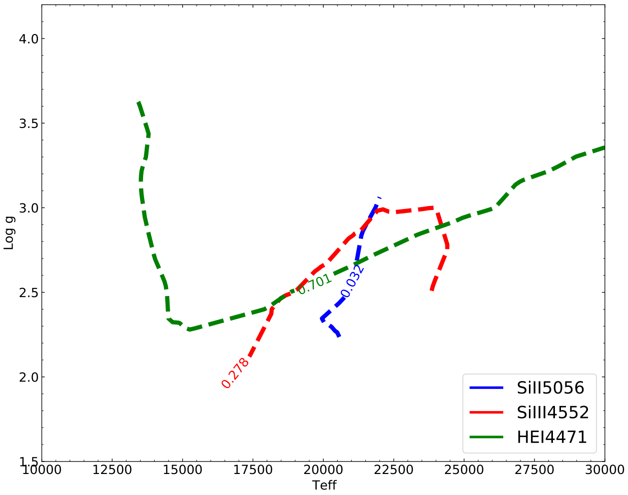
0.100
0.150
0.200
0.250


SiIII4552 005
Log g
Teff
0.050
0.100
0.150
0.200
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600


SiII5056
SiIII4552
HEI4471
Log g
Teff
4.0
3.5
3.0
2.5
2.0
1.5
10000
12500
15000
17500
20000
22500
25000
27500
30000
0.250
0.200
0.150
0.100
0.050
0.100
0.200
0.300
0.400
0.200
0.100
0.200
0.400
0.600
0.800



Log g
Teff
4.0
3.5
3.0
2.5
2.0
1.5
10000
12500
15000
17500
20000
22500
25000
27500
30000
0.278
0.701
0.032
SiII5056
SiIII4552
HEI4471

- The calibration of the WLR (still in progress) has been done for the first time with the correct hydrodynamic and we've found a clear dependency on the type of solution.
- B supergiant stars are better modeled with δ-slow solutions and are needed to better constrain the WLR.
- We have a powerful tool to model most of O, B or A-type stars using the ISOSCELES grid.
- Secondment:
  - I test the invariant Q value.
  - I gained new skills in using another atmosphere code.
  - I learned about equivalent widths and their importance in the study of observational data.

Contact: natalia.machuca@postgrado.uv.cl