HD 166734 a modern study of a O+O supergiant binary

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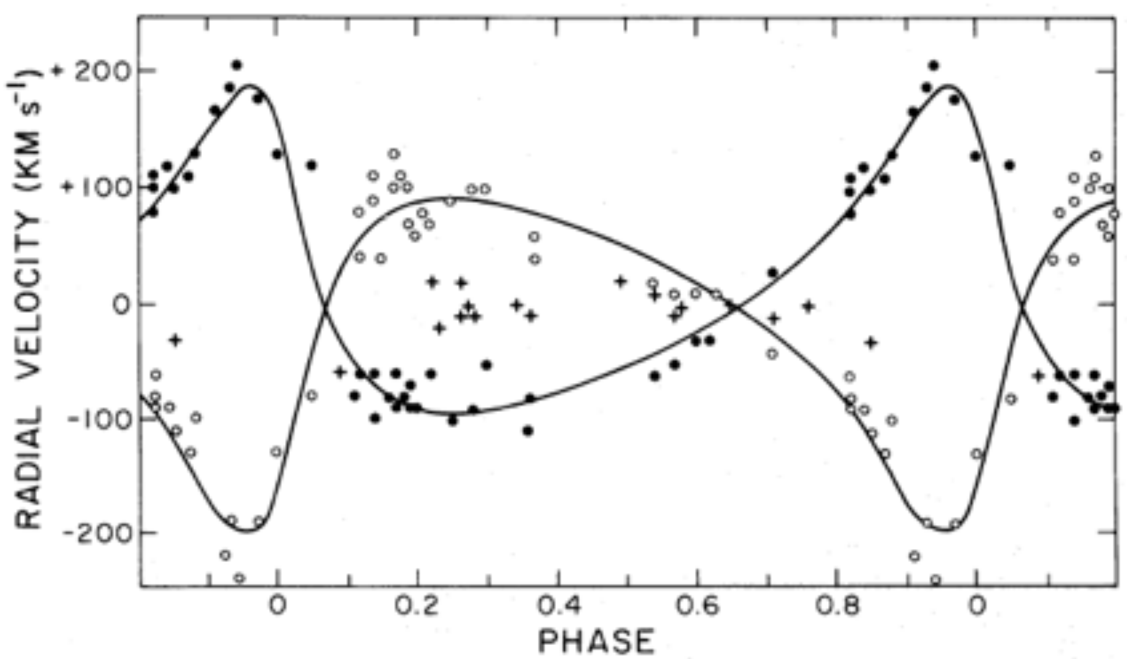
Overview

- History
- New analysis:
    - Spectroscopy
    - Photometry
    - Disentangling + Atmosphere modelling
    - Evolutionary status
- Conclusion

History

- Discovery: Wolff (1963)

- First orbital solution: Conti et al. (1980)



PHYSICAL PARAMETERS OF HD 166734

Spectral Type	Primary (O7 If)	Secondary (O9 I)
Radius ($R_\odot$)	23	24
V	$9^{\mathrm{m}}.0$	9.4 mag
M_v	$-7^{\mathrm{m}}.0$ (assumed)	-6.6 mag
Distance (kpc)	2.3	2.3
$v \sin i$ (km s^{-1})	80	80
$f(m)$ ($M_\odot$)	8.1	6.9
m $\sin^3 i$ ($M_\odot$)	29	31
a $\sin i$ ($M_\odot$)	90	85

- Observation of the light curve: Otero & Wils (2005)

History

- Discovery: Wolff (1963)
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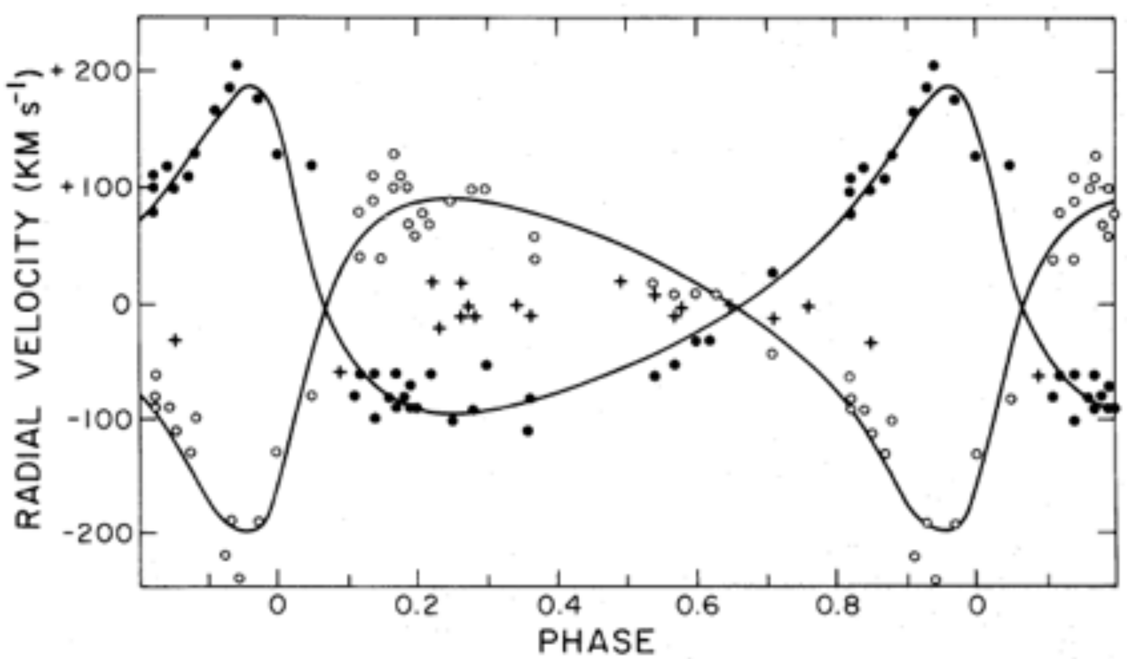
Period = 34.54 days



Physical Parameters of HD 166734

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Primary component less massive

- Observation of the light curve: Otero & Wils (2005)

New analysis

- Dataset:

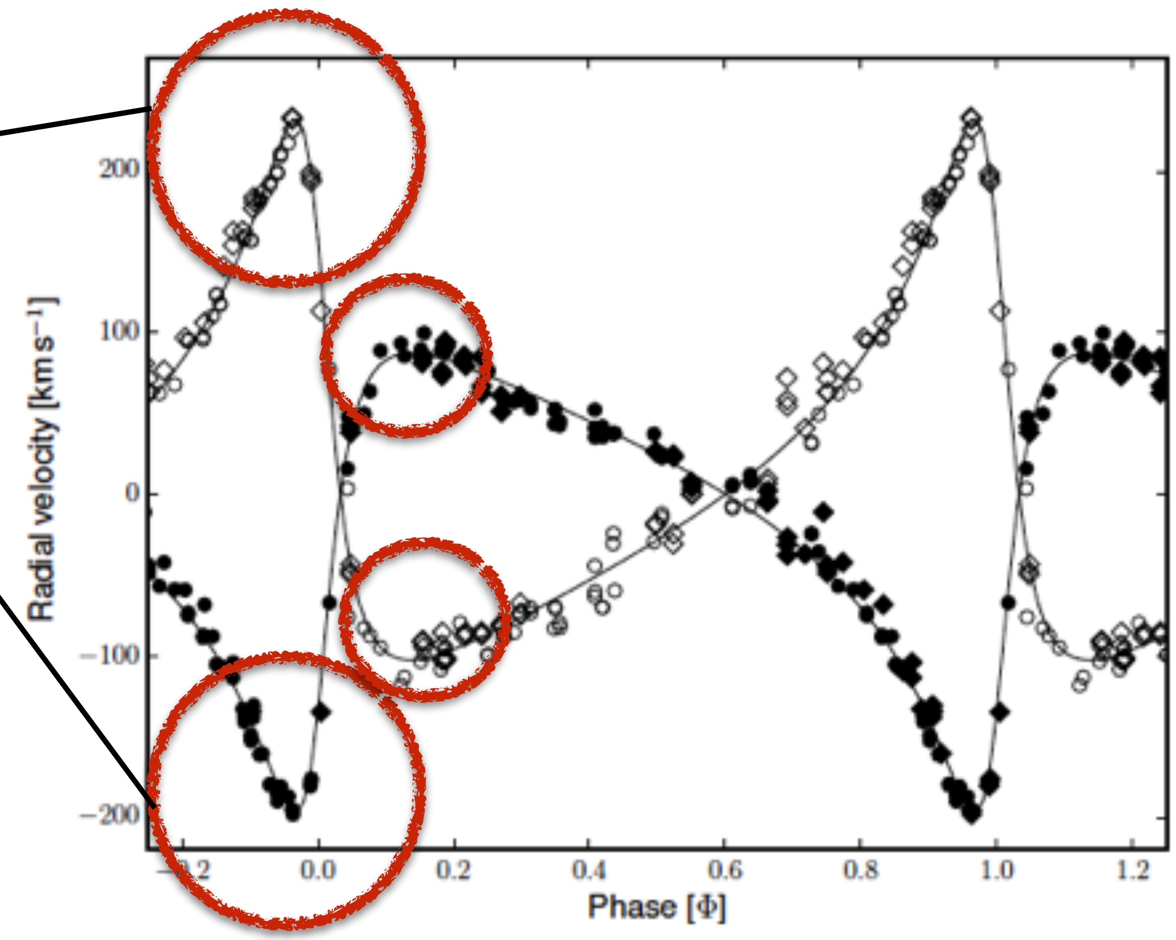
  ✓ FEROS spectra @ MPG/ESO 2.2m (La Silla, Chile)
  ✓ ESPRESSO spectra @ 2.12m (San Pedro Màrtir, Mexico)

  Total = 68 high-resolution + 61 mid-resolution spectra

- Orbital solution:

Better coverage of the extrema RVs

Better estimate of the minimum masses



New analysis

- Orbital solution:

Primary = O7.5 If
Secondary = O9 I(f)

Primary component now more massive

	SB2 solution	
	Primary	Secondary
P [day]	34.537723 ± 0.001330	
e	0.618 ± 0.005	
ω [°]	236.183 ± 0.786	
T_0 [HJD – 2 450 000]	2195.064 ± 0.036	
q (M_1/M_2)	1.179 ± 0.016	
γ [km s^{-1}]	-5.88 ± 0.89	7.12 ± 0.96
K [km s^{-1}]	142.01 ± 1.53	167.39 ± 1.79
$a \sin i$ [$R_\odot$]	76.23 ± 0.89	89.85 ± 1.05
$M \sin^3 i$ [$M_\odot$]	$\boxed{27.92} \pm 0.81$	$\boxed{23.69} \pm 0.68$
rms [km s^{-1}]	11.14	

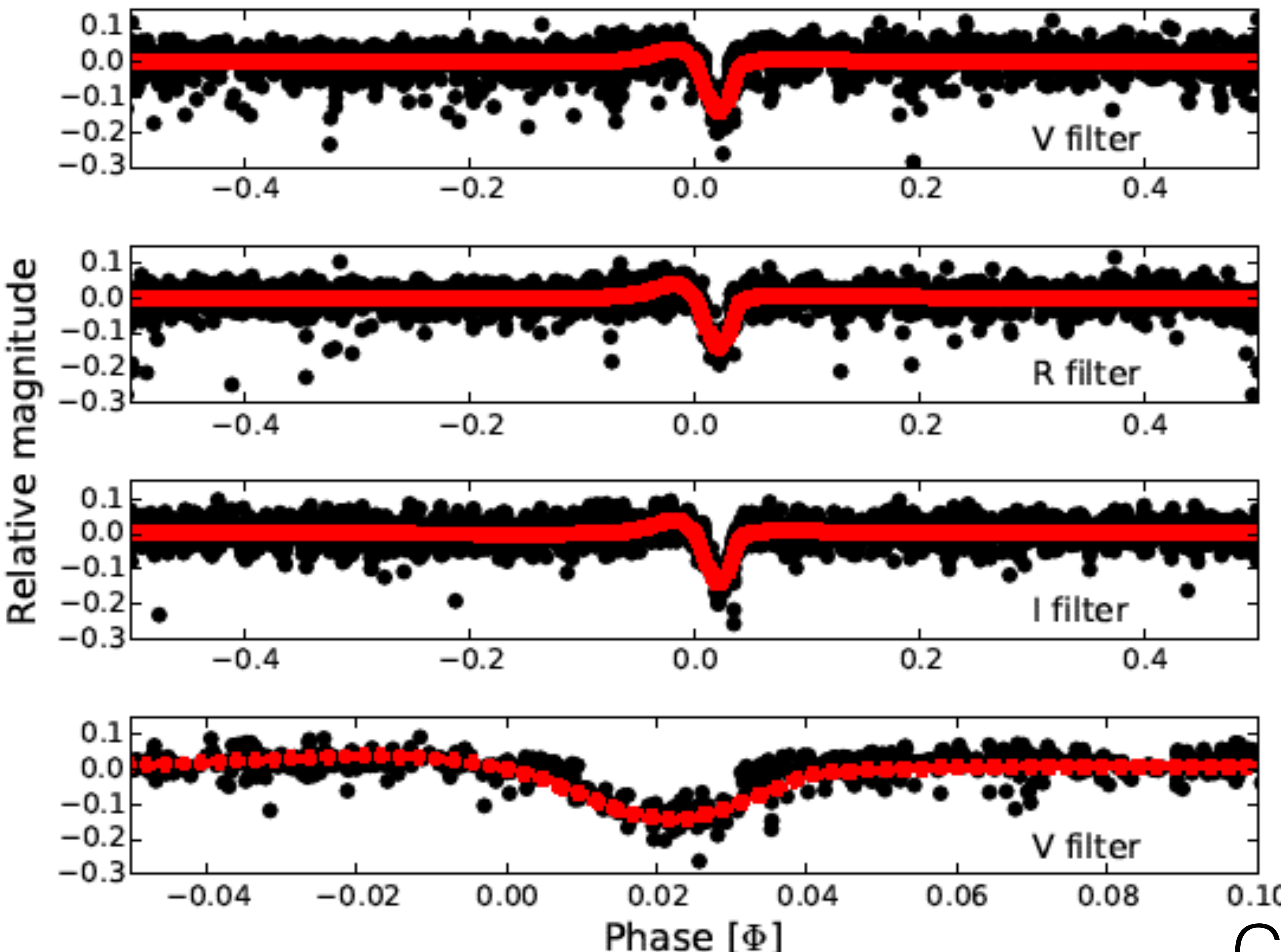
		All data	
Parameter	Units	WR	O
P	(d)	31.680 ± 0.013	
e		0.694 ± 0.005	
q	M_1/M_2	1.782 ± 0.030	
T	$-2450\,000$	6345.43 ± 0.32	
ω	(°)	287.8 ± 1.2	
K	(km s^{-1})	157.0 ± 2.3	279.8 ± 6.2
γ	(km s^{-1})	-32.8 ± 1.7	32.8 ± 2.9
$M \sin^3 i$	($M_\odot$)	65.3 ± 5.6	36.6 ± 1.9
rms	(km s^{-1})	8.44	

WR21a
(Tramper et al. 2016)

New analysis

- Lightcurve in VRI filters

Taken with TAROT (La Silla, Chile, PI: Klotz)



Only one eclipse

$\Delta m = 0.22$ mag

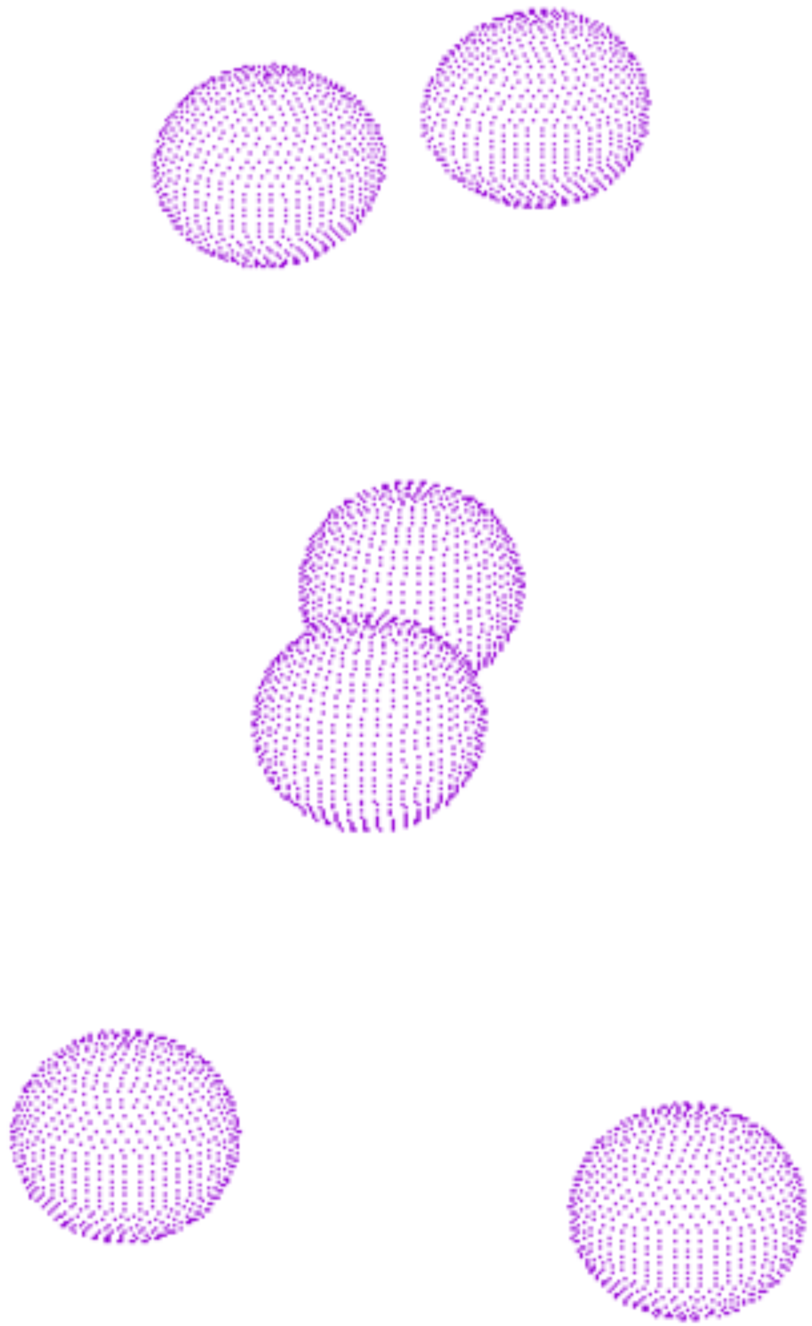
$\Delta\Phi \sim 0.04$

Eclipse @ Φ=0.024

Conjunction @ Φ=0.018

New analysis

- Lightcurve fitted with PHOEBE (Prsa & Zwitter, 2005)



	Primary	Secondary
i [°]	63.0 ± 2.7	
R_{mean} [$R_\odot$]	27.5 ± 2.3	26.8 ± 2.4
R_{pole} [$R_\odot$]	26.5 ± 2.0	25.9 ± 2.2
R_{point} [$R_\odot$]	31.6 ± 5.4	31.9 ± 7.3
R_{side} [$R_\odot$]	27.1 ± 2.1	26.0 ± 2.2
R_{back} [$R_\odot$]	28.8 ± 2.8	28.1 ± 2.8
M_{bol} [mag]	-9.85 ± 0.17	-9.58 ± 0.20
l_1/l_2	1.28 ± 0.14	

$M_1 \sim 39.5\ M_\odot$

$M_2 \sim 33.5\ M_\odot$

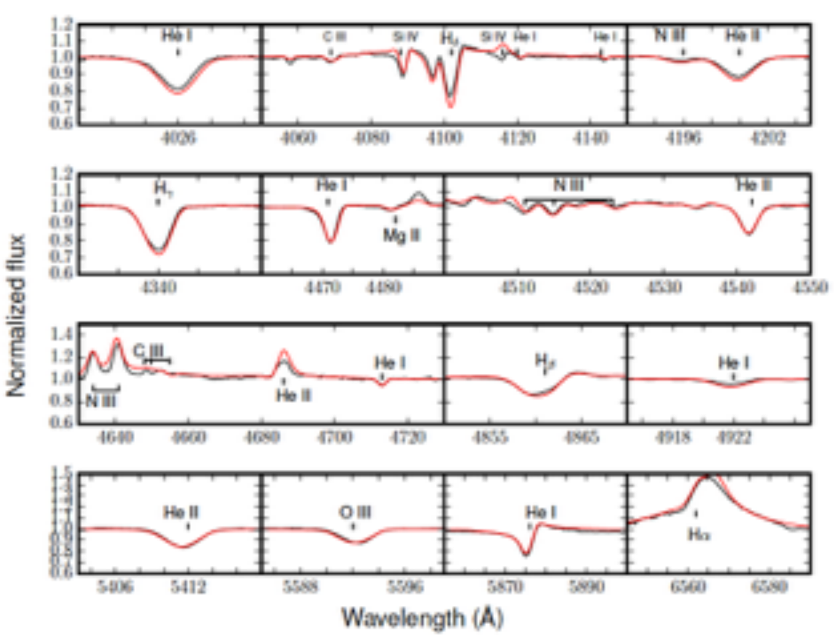
New analysis

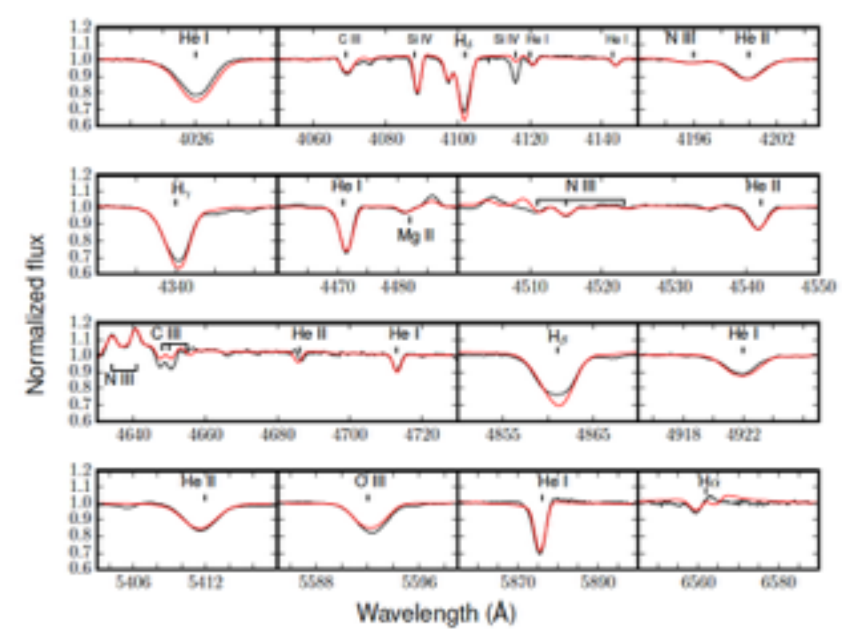
- Spectral disentangling + Atmosphere modelling

Fourier spectral disentangling
(Hadrava 1995, Ilijic et al. 2003)

CMFGEN
(Hillier & Miller 1998)

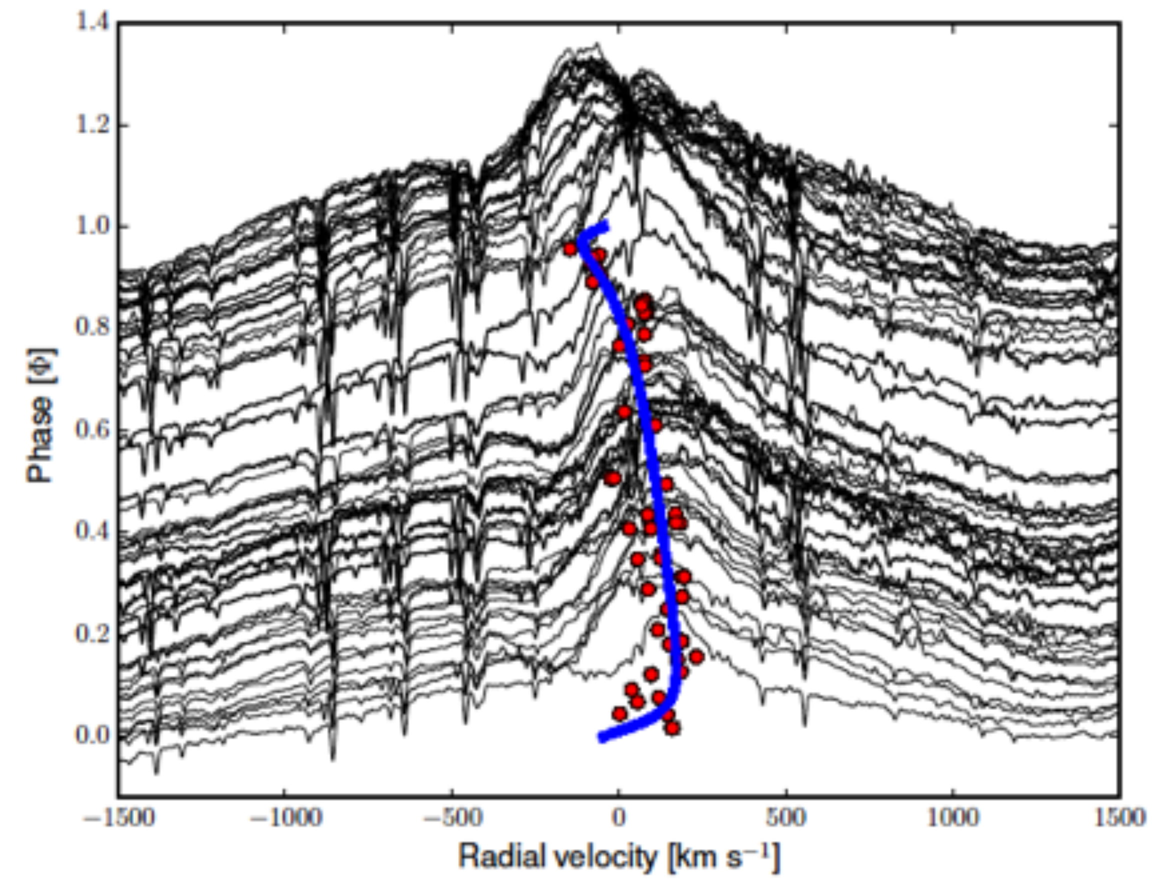
	Primary	Secondary
$T_{\rm eff}$ [K]	32000 ± 1000	30500 ± 1000
$\log g$ [cgs]	3.15 ± 0.10	3.10 ± 0.10
$\log(L/L_\odot)$	5.840 ± 0.092	5.732 ± 0.104
$\dot{M}/\sqrt{f}$ [$M_\odot$ yr^{-1}]	9.07×10^{-6}	3.02×10^{-6}
v_∞ [km s^{-1}]	1407	1348
f	0.07	0.07
$v_{\rm cl}$ [km s^{-1}]	30	30
β	1.0	1.0
$v \sin i$ [km s^{-1}]	95 ± 10	98 ± 10
$v_{\rm mac}$ [km s^{-1}]	65 ± 10	65 ± 10
$v_{\rm eq}$ [km s^{-1}]	107 ± 15	110 ± 15
M [$M_\odot$]	$39.5^{+5.4}_{-4.4}$	$33.5^{+4.6}_{-3.7}$
$M_{\rm spec}$ [$M_\odot$]	$37.7^{+29.2}_{-16.1}$	$31.8^{+26.6}_{-14.4}$

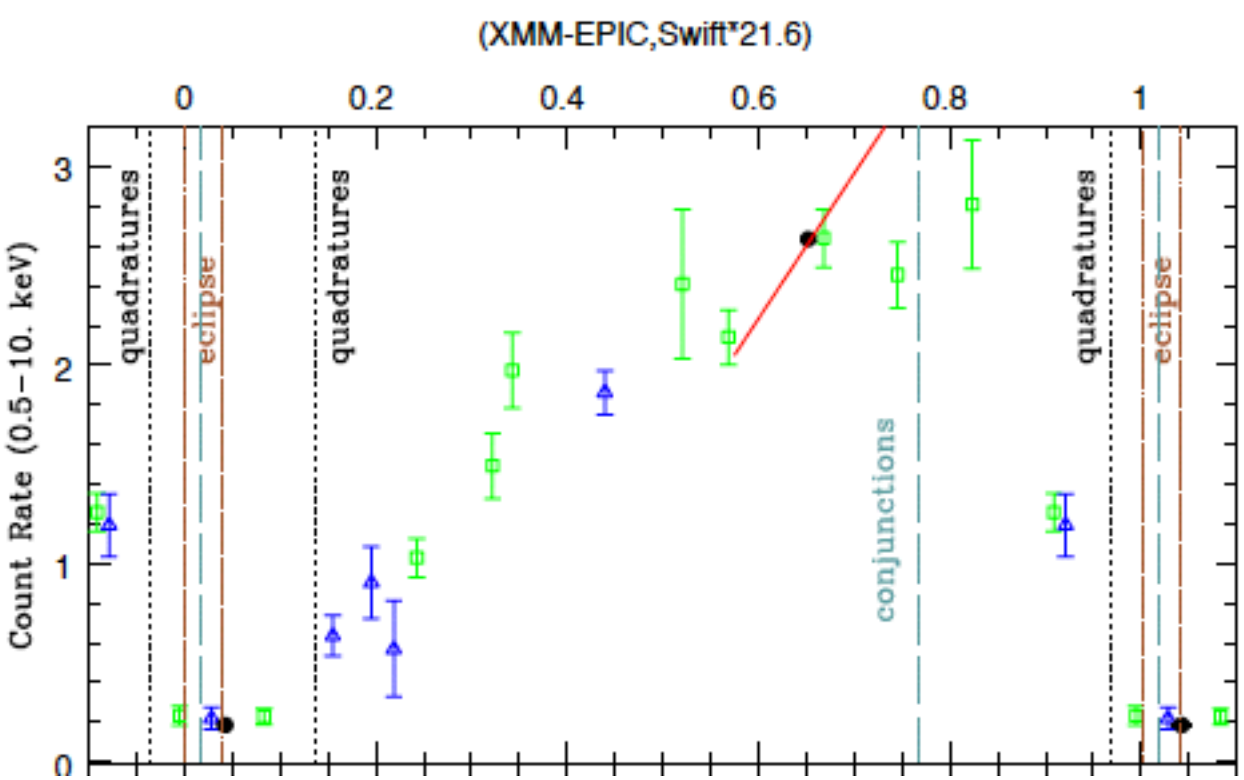


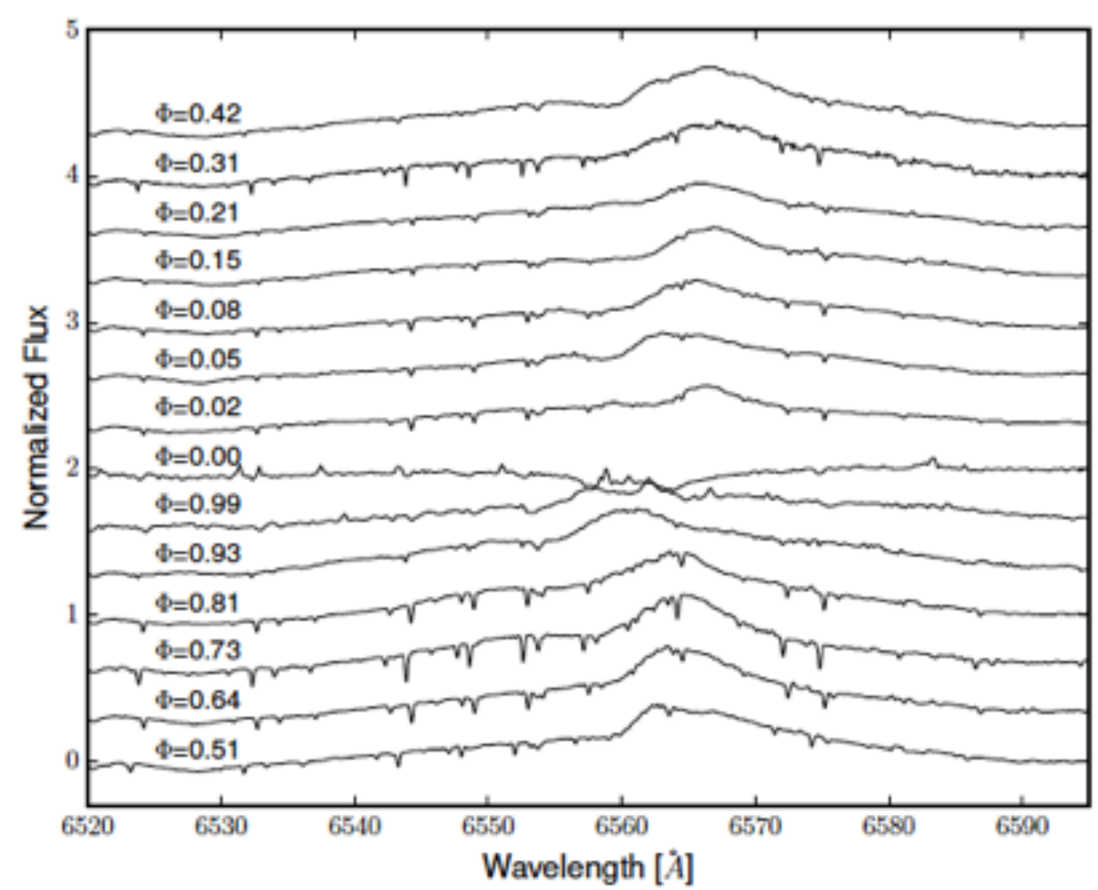


New analysis

- Stellar winds
  - ✓Hα emission follows the primary component
  - ✓ At periastron, the emission disappears







Nazé et al. (2017, A&A, in press)

New analysis

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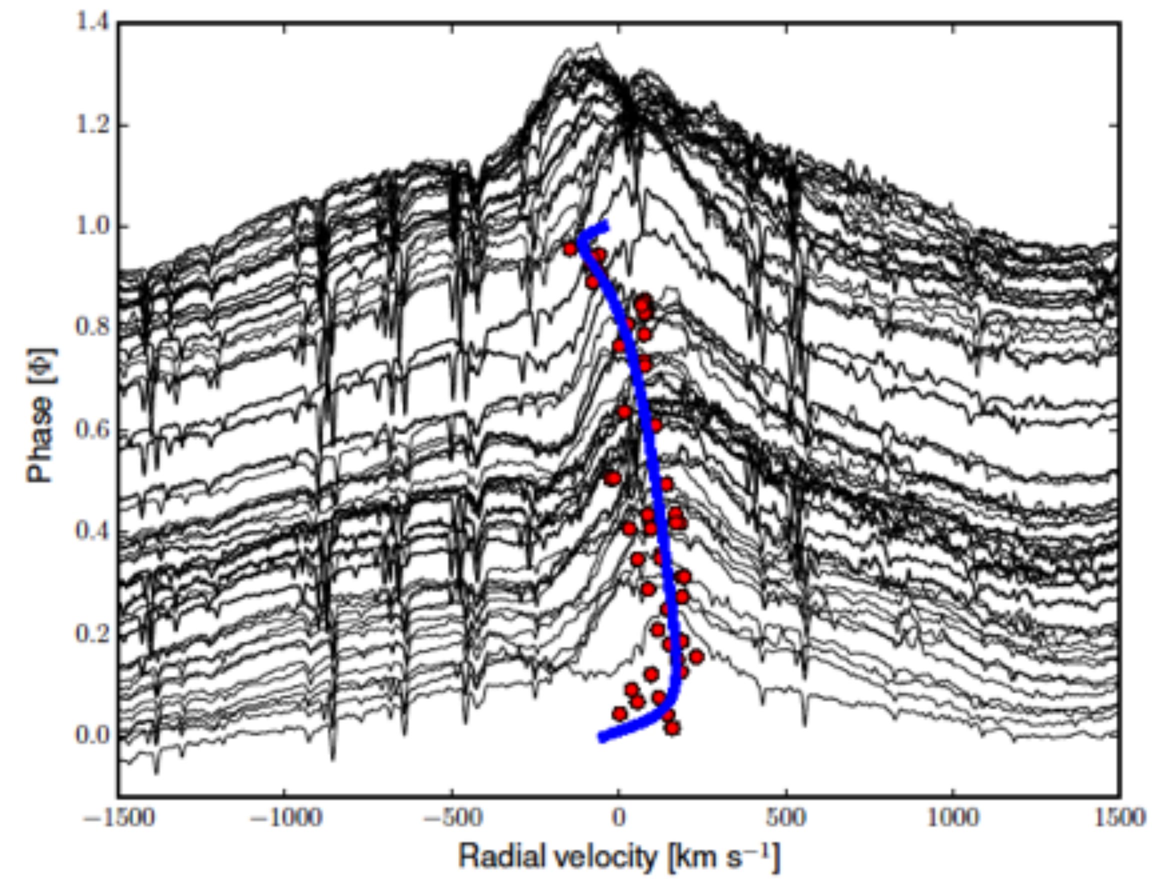
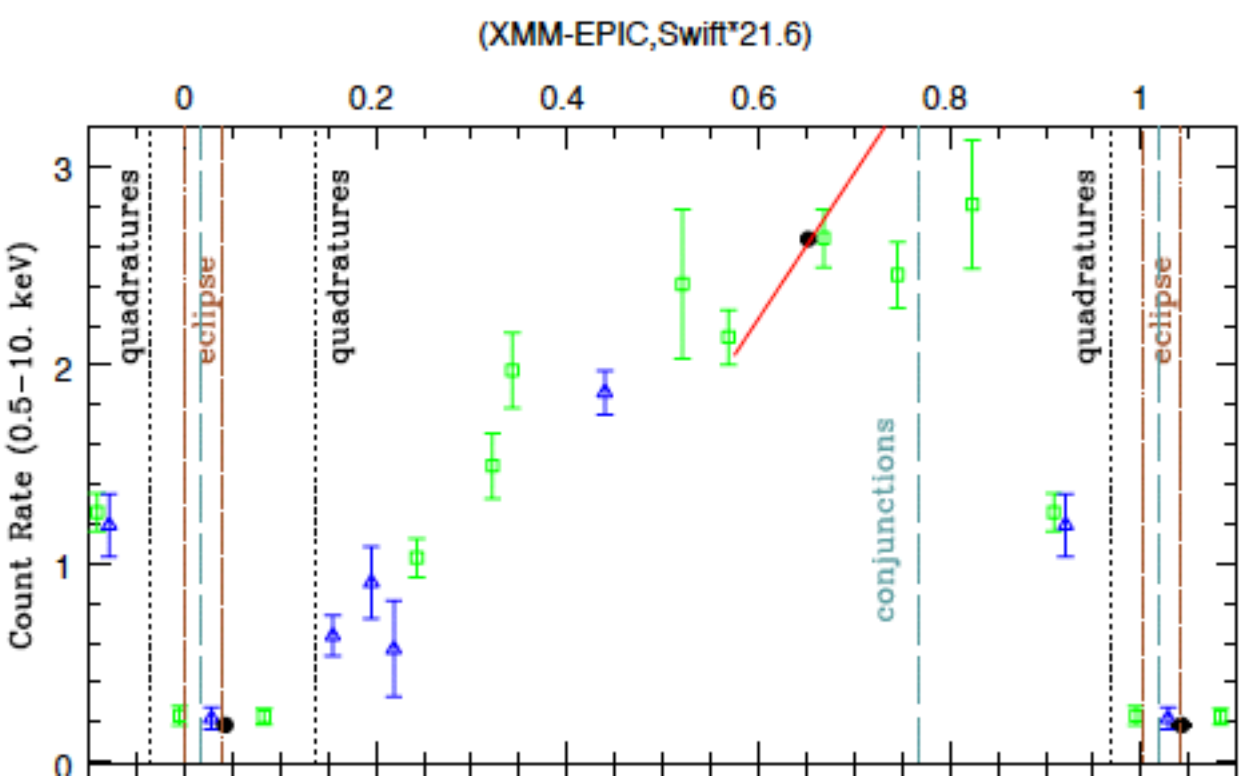
Not enough space between the stars for a stellar wind collision





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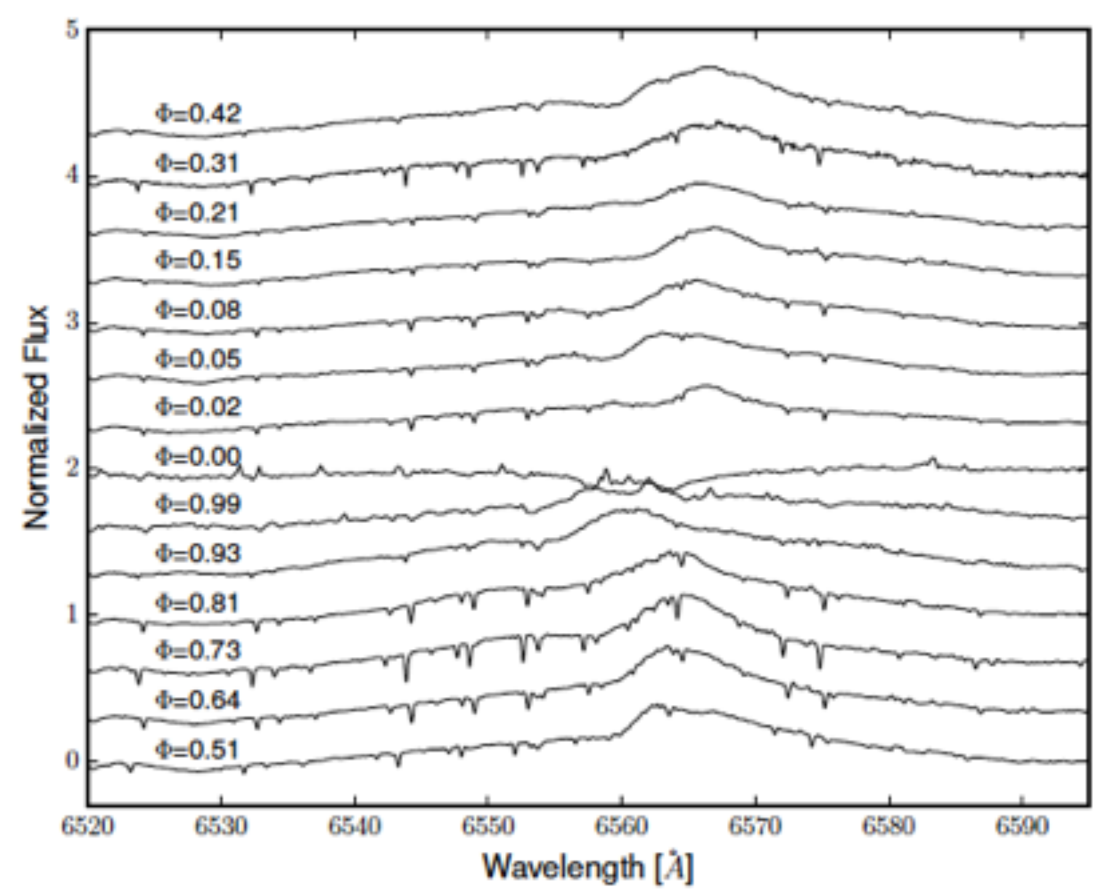
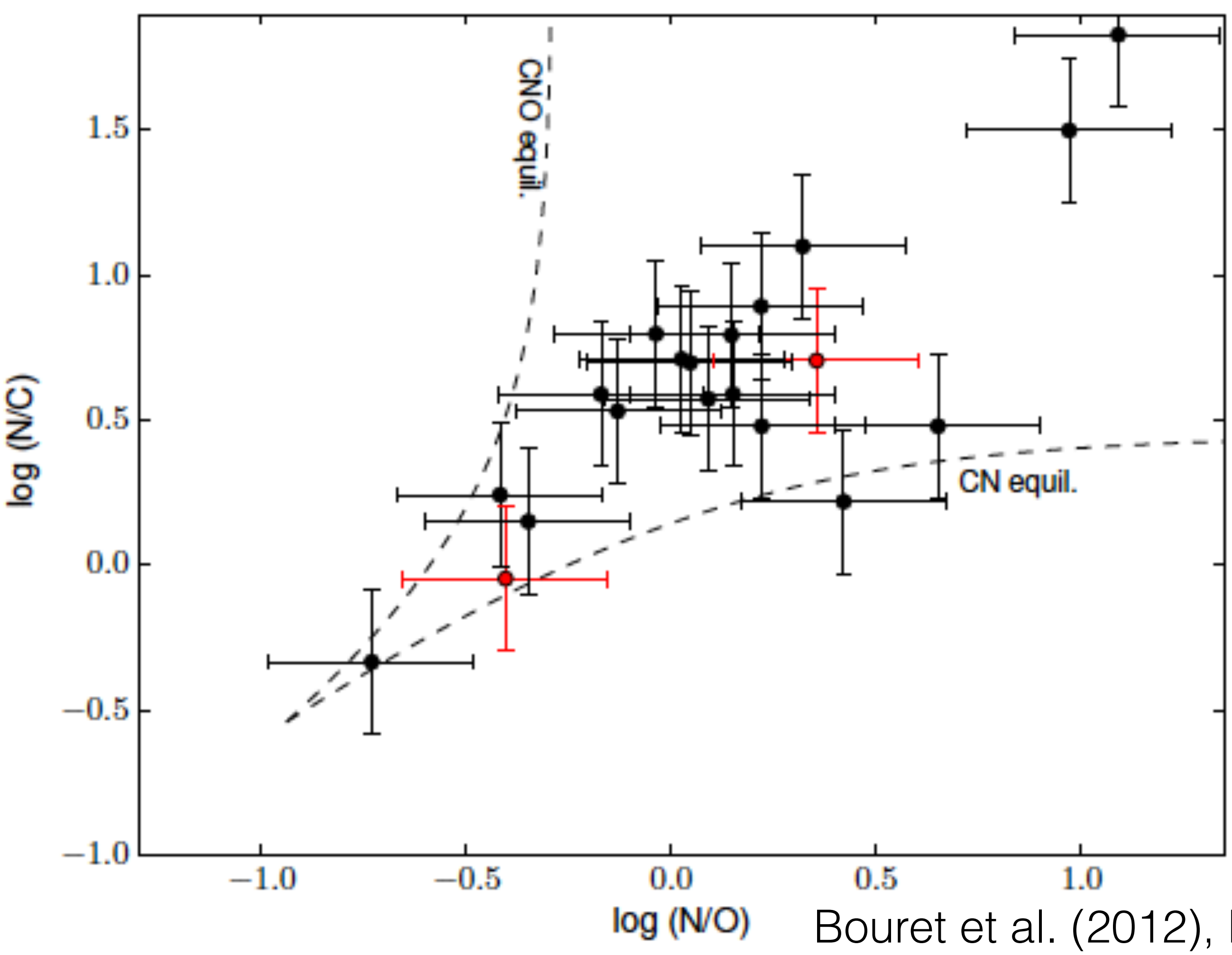


New analysis

- Evolutionary status

Chemical abundances:

	Primary	Secondary
He/H	0.12 ± 0.03	0.12 ± 0.03
C/H	$1.2 \pm 0.4 \times 10^{-4}$	$2.0 \pm 0.3 \times 10^{-4}$
N/H	$6.1 \pm 1.2 \times 10^{-4}$	$1.8 \pm 0.5 \times 10^{-4}$
O/H	$2.7 \pm 0.5 \times 10^{-4}$	$4.6 \pm 0.3 \times 10^{-4}$



Bouret et al. (2012), Martins et al. (2015)

New analysis

- Evolutionary status

From Geneva tracks

➡ Overshooting parameter = 0.1
➡ Initial rotational velocity ~ 300 km/s
➡ $Z = 0.014$

From Bonn tracks

➡ Overshooting parameter = 0.335
➡ Initial rotational velocity = 150 km/s
➡ $Z = 0.0088$

New analysis

- Evolutionary status

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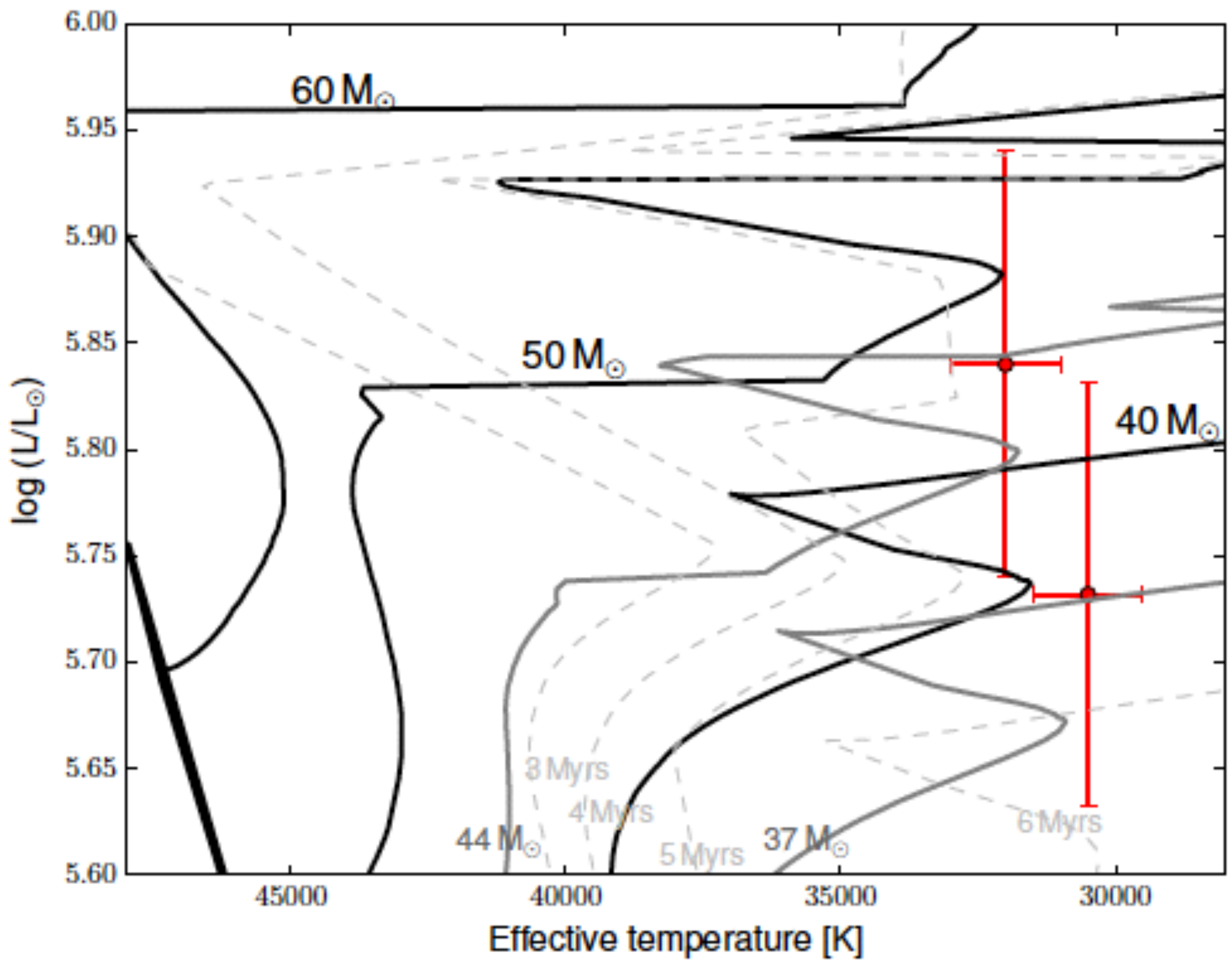

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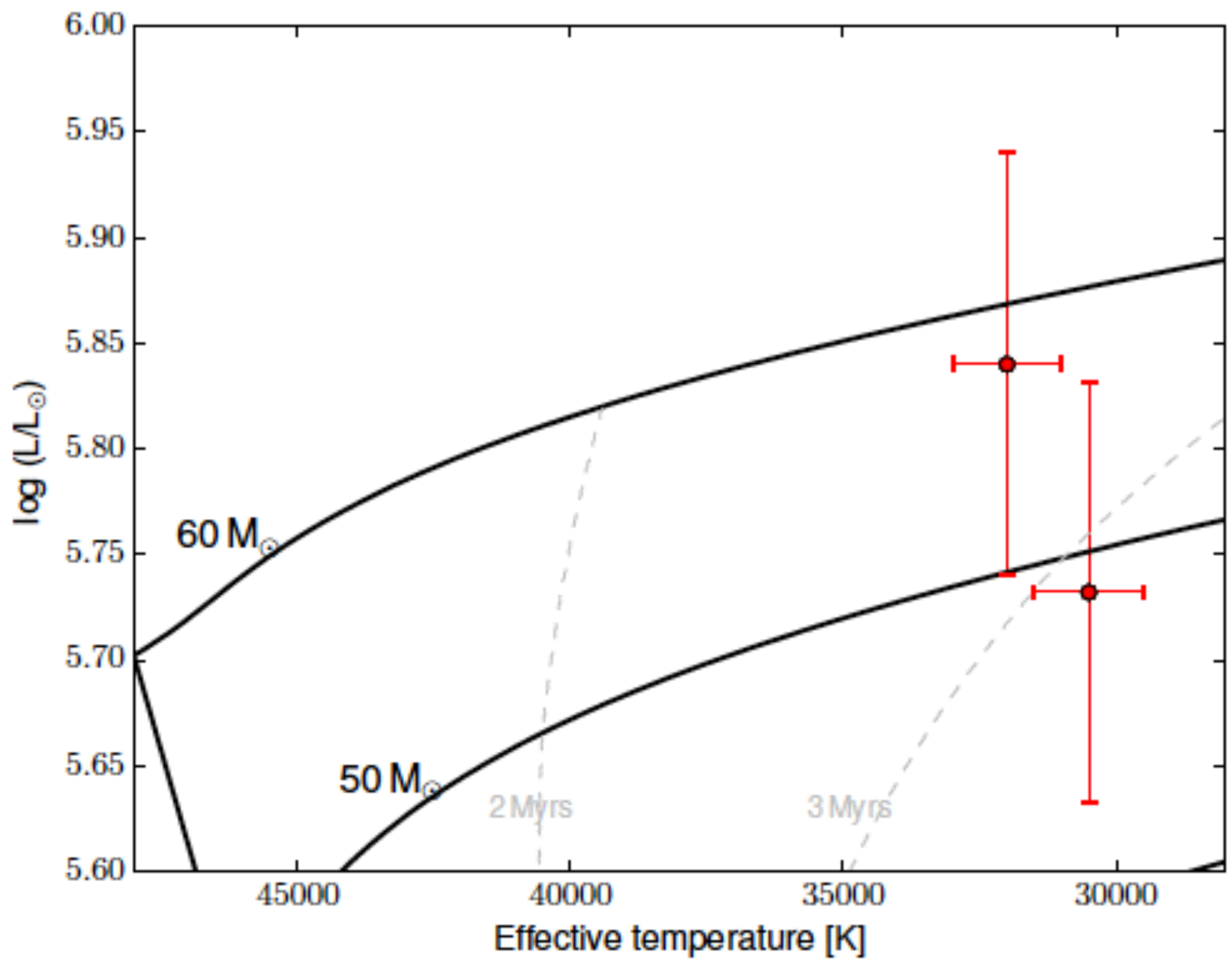

For a comparison between evolutionary tracks, see Martins & Palacios (2013)

New analysis

- Evolutionary status

From Geneva tracks

Primary:

➡Initial mass = 44.0 $M_\odot$
➡Age = 5.2 Myrs
➡Actual mass = 34.5 $M_\odot$
➡Actual equatorial velocity = 15 km/s

Secondary:

➡Initial mass = 37.0 $M_\odot$
➡Age = 6.0 Myrs
➡Actual mass = 31.0 $M_\odot$
➡Actual equatorial velocity = 18 km/s

From Bonn tracks

BONNSAI (Schneider et al. 2014)

Primary:

➡ Initial mass = 56.1 $M_\odot$
➡Age = 3.0 Myrs
➡Actual mass = 47.8 $M_\odot$
➡Actual equatorial velocity = 110 km/s

Secondary:

➡ Initial mass = 47.4 $M_\odot$
➡Age = 3.5 Myrs
➡Actual mass = 41.2 $M_\odot$
➡Actual equatorial velocity = 110 km/s

Conclusion

- Complete analysis of HD166734.
- Not only one correct evolutionary code.
- More of similar systems (high eccentricity, long period, supergiant objects) because they are excellent tests for evolutionary models.