Observational signatures of past mass-exchange episodes in massive binaries : The cases of LSS 3074 and HD 17505

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1. LSS 3074 (Raucq et al. 2016, in prep.)

1.1 System information

- Short-period O binary situated in or beyond the Coalsack region
- Orbital inclination of 50-55° (Haefner et al. 1994, IBVS, 3969, 1)
- Low minimum masses (8-9 $M_\odot$) (Morrell & Niemela 1990, ASP Conf. Series, 7, 57)

1.2 New orbital solution

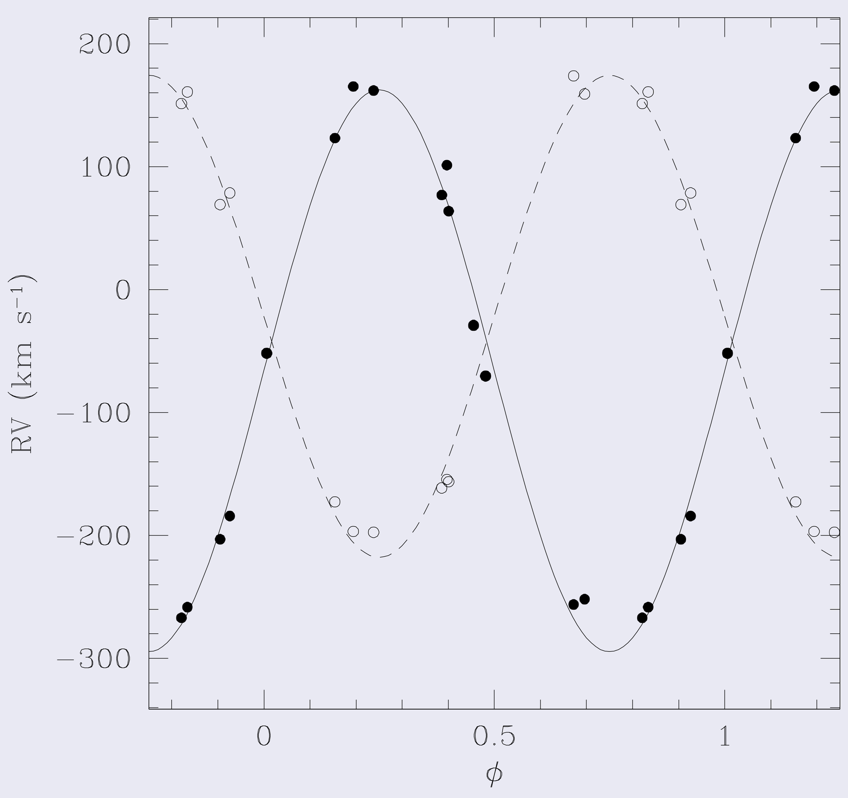

TABLE 1 : Orbital solution of LSS 3074.

	Primary	Secondary
Period (days)	2.1852 ± 0.0006	
T_0 (HJD - 2 450 000)	2000.851 ± 0.008	
γ (km s^{-1})	-66.0 ± 5.0	-21.7 ± 4.7
K (km s^{-1})	228.5 ± 7.1	196.0 ± 6.1
$a \sin i$ ($R_\odot$)	9.9 ± 0.3	8.5 ± 0.3
q = m_1/m_2	0.86 ± 0.04	
$m \sin^3 i$ ($M_\odot$)	8.0 ± 0.5	9.3 ± 0.7

FIGURE 1 : RV curves (primary in filled circles and secondary in empty circles).

1.3 Preparatory analysis

1. We separated the contributions from both stars through a disentangling method (Gonzalez & Levato 2006, A&A 448, 283).
2. Spectral types evaluated thanks to Conti's quantitative classification criteria for O-type stars (Conti & Alschuler 1971, ApJ, 170, 325; Conti & Frost 1977, ApJ, 212, 728).
   ⇒ Primary is an **O5.5 If**$^+$ and secondary is an **O6.5-7 If.**
3. Brightness ratio : $\frac{l_1}{l_2} = (\frac{EW_1}{EW_2})_{obs}(\frac{EW_{O7}}{EW_{O5.5}})_{mean}$
   ⇒ Mean brightness ratio : **2.50** ± **0.42.**

1.4 Spectral analysis

1. **Vsin(i)** through Fourier transform method : **110** and **127 km/s** for primary and secondary respectively.
2. **Macroturbulence velocities** (Gray 2008, "The Observation and Analysis of Stellar Photospheres", C.U.P.) : **20** and **50 km/s** for primary and secondary respectively.
3. Adjustment of individual spectra with the non-LTE model atmosphere code **CMFGEN** (Hillier & Miller 1998, ApJ, 496, 407).

1.5 Results

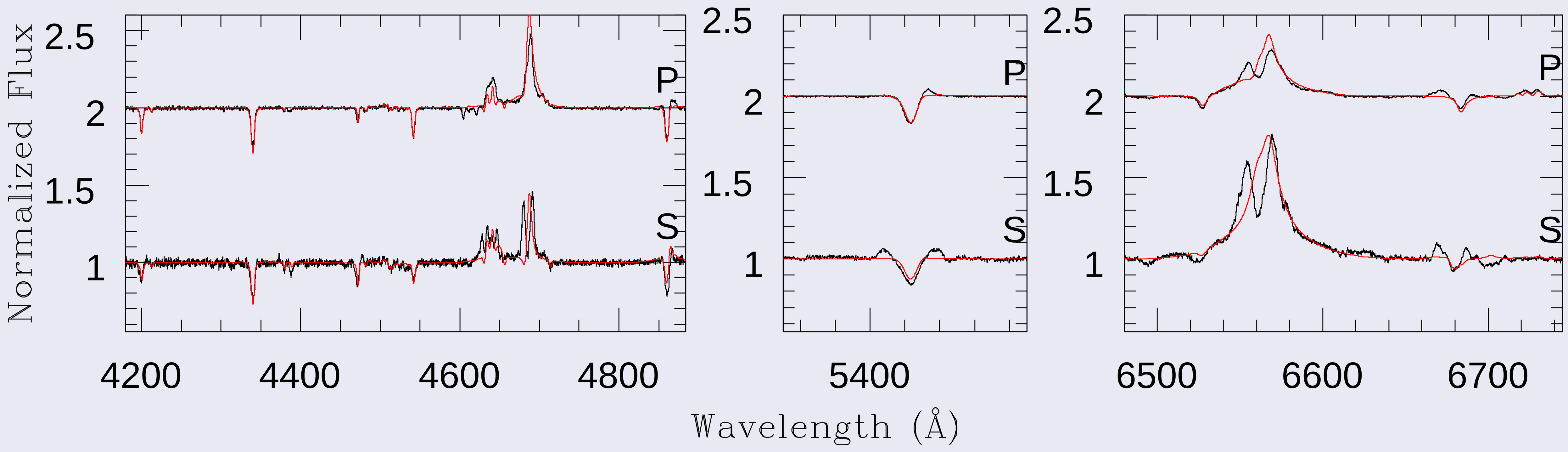

TABLE 2 : Chemical abundances of the stars as currently obtained with CMFGEN, compared to the solar abundances (Asplund et al. 2009, ARAA 47, 481).

	Primary	Secondary	Sun
He/H	0.25	0.09	0.089
C/H	≤ 6.05 × 10^{-5}	≤ 5.05 × 10^{-5}	2.69 × 10^{-4}
N/H	4.5 × 10^{-4}	2.4 × 10^{-4}	6.76 × 10^{-5}
O/H	≤ 9.67 × 10^{-5}	≤ 9.9 × 10^{-5}	4.90 × 10^{-4}

FIGURE 2 : Current best fit of parts of the primary (top) and secondary (bottom) spectra (black) with CMFGEN synthetic spectra (red).

TABLE 3 : Stellar parameters as currently derived from CMFGEN fits.

	Prim.	Sec.
M ($M_\odot$)	14.6	17.2
R ($R_\odot$)	7.5	8.2
$T_{\rm eff}$ (K)	39 900	34 100
log(g) (cgs)	3.82	3.83
L ($L_\odot$)	1.38 × 10^5	8.49 × 10^4

1.6 Discussion

Our orbital solution confirms the low minimum masses announced in the litterature for both components. This result is also confirmed by the low absolute masses obtained with our CMFGEN fit. An in depth comparison with theoretical evolutionary models will be performed to determine if such low masses can be explained by a massive loss of matter by the system during a RLOF episode.

Concerning the CMFGEN fit, we can see on Fig. 2 that the disentangled spectra display emission features that are difficult to recover with the models. This may be due to a strong wind-wind interaction within the system, as is common for massive binaries. The presence of N V $\lambda\lambda$ 4604 and 4620 indicates a rather hot primary. Nevertheless, the relative strength of He I and He II lines rather suggests a cooler star. In a close binary system such as LSS 3074, the surface temperature of the stars is most likely not uniform and it could happen that different lines form over different parts of the primary's surface. However, the good fit of the He I and He II lines, together with the well-reproduced wings of the Balmer lines tends to confirm the quality of our determination of the $T_{\rm eff}$ and log(g).

Determining precisely the surface CNO abundances is more difficult : while we have a lot of N lines to work on, the C and O lines are very weak, or even not detectable in the spectra, resulting in upper limits for the associated abundances. Nevertheless, a clear enrichment in N and a depletion in C and O are detected, in line with the RLOF scenario.

2. HD 17505

2.1 System information

- Multiple system composed of 7 visual companions, member of the Cas OB6 association
- Central object composed of three O-stars
- Low excentricity orbit of the inner binary (e = 0.095, with an orbital period of 8.57 days)
- Orbital period of the tertiary < 61 years

2.2 Method

The disentangling does not work accuratelly because of the distant tertiary star.

1. We recombined the individual synthetic spectra of the three stars and adjusted the obtained spectrum of the triple system directly to the observations (work still in progress).
2. Then we will substract the third component to each observation.
3. Finally, we will disentangle the spectra of the inner binary components and study them as for LSS 3074.

2.3 Results

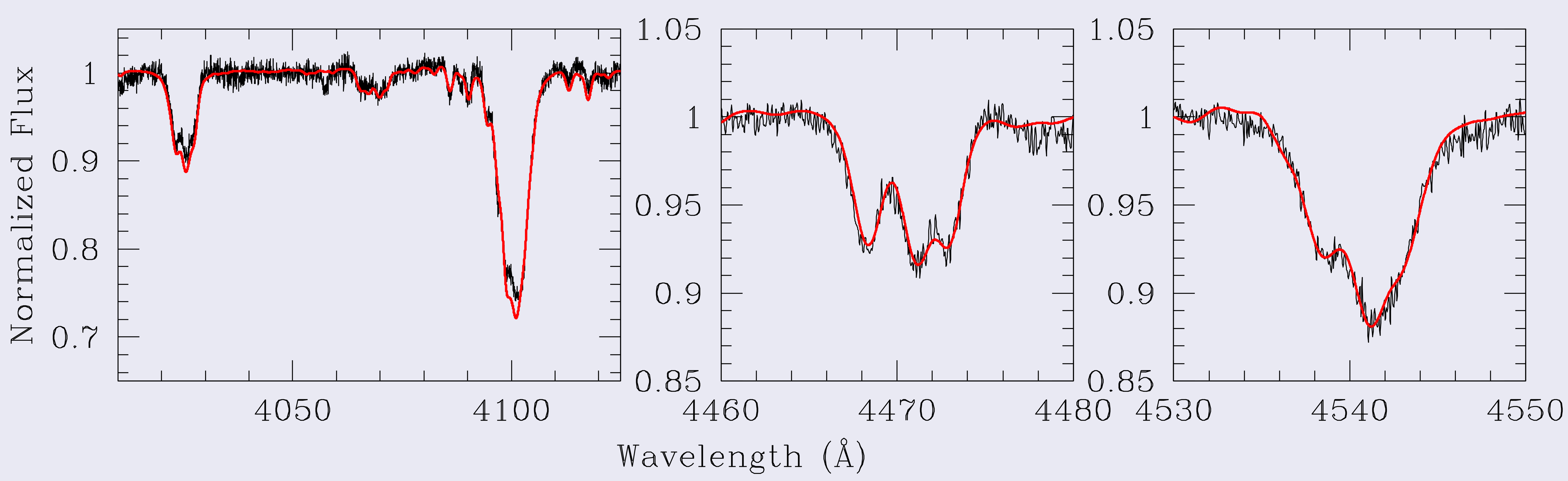

TABLE 4 : Stellar parameters of the stars as currently derived from CMFGEN fits.

	Prim.	Sec.	Ter.
M ($M_\odot$)	10.3	10.6	17.4
R ($R_\odot$)	7.2	7.3	13.9
$T_{\rm eff}$ (K)	37 500	37 200	34 600
log(g) (cgs)	3.70	3.70	3.30
L ($L_\odot$)	1.00 × 10^5	1.00 × 10^5	3.09 × 10^5

FIGURE 3 : Current best fit of parts of the observed spectrum (black) and CMFGEN modelised and recombined spectra (red).

2.4 Discussion

The HeI and HeII lines, as well as the width of the Balmer lines are well reproduced (Fig. 3). However, we can see in Table 4 that the surface gravities, and thus the associated stellar masses, are quite low compared to usual values for similar spectral types. We are currently investigating this preliminary result, and we will then investigate the CNO abundances.