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Masses of the astrometric SB2 ζ Ori A†

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Abstract. We report the first dynamic mass for an O-type supergiant, the interferometrically resolved SB2 system ζ Ori A (O9.5Ib+B0/1). The separation of the system excludes any previous mass-transfer, ensuring that the derived masses can be compared to single star evolutionary tracks.

Keywords. stars: binaries, stars: early-type, stars: fundamental parameters (masses)

1. Introduction

Stellar masses in the upper HRD are notoriously hard to constrain. Very few masses are known independently from stellar evolution or wind models, mostly using eclipsing SB2 systems. For stars that have already evolved away from the main sequence, this is a problematic technique, though: These are usually quite narrow short period systems, which means that the possibility of mass transfer via overflow having altered the evolutionary paths is high. Interferometry is in principle able to overcome this problem in cases where the orbit can be measured for an SB2.

Hummel *et al.* (2000) found the O9.5 Ib primary of ζ Ori A to be a multiple star. In addition to the well known B-component of spectral type B0 at V = 3.77mag, several arcseconds away, they found another companion (Ab) 40 mas away, about 2 mag fainter than the primary (Aa), i.e. the magnitude of Ab is similar to that of component B.

2. Observations

Additional Interferometric observations to complete the orbit coverage (Fig. 1, right). were obtained at the NPOI in Flagstaff, Arizona. Spectroscopic observations were taken with the echelle instruments HEROS and FEROS.

In the spectra all He I lines as well as He II 4686 have a relatively narrow core with varying RV in one sense, while the line wings are shifted in anti-phase wrt. the cores. This is the signature of an SB2 binary. For some lines (almost) exclusive formation in the O9.5 component can be assumed. The best candidates are the He II lines, typically not seen in B-type stars, except He II 4686. The radial velocities of this line were measured with Gaussian fits to the line center (Fig. 1, left). There are as well very weak and rather narrow lines that are not expected in the O9 Ib star. These narrow lines are RV variable in the same sense as the cores of stronger lines, i.e. they belong to the companion and are indicative for an early type B star.

In addition to Gaussian fits, the RV curve was also measured by spectral disentangling with VO-KOREL, a virtual observatory tool based on the KOREL code by Hadrava (1995).

† Based on observations under ESO programs 076.C-0431, 080.A-9021, and 083.D-0589.

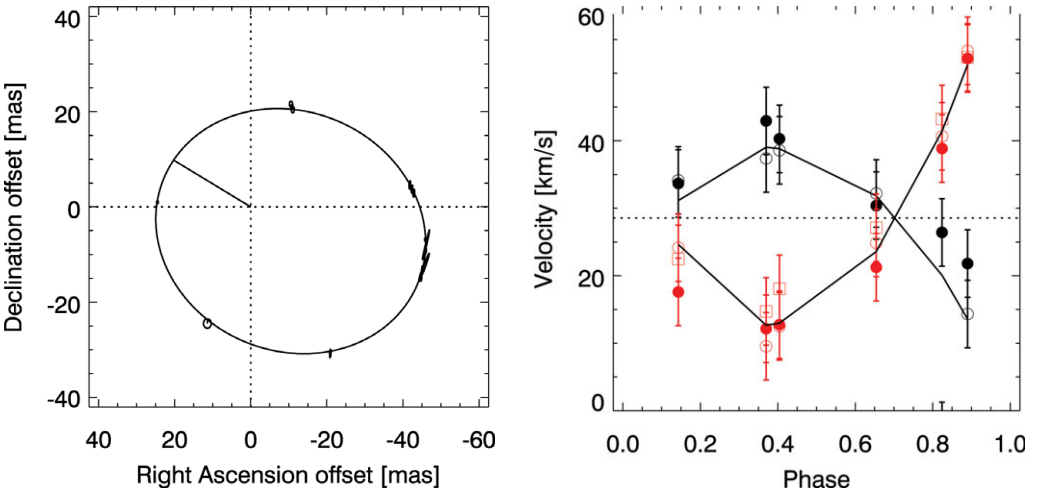

Figure 1. *Left panel*: The interferometric orbit. The periastron is marked by the line from the origin to the orbit. The secondary progresses clockwise. *Right panel*: he measured RVs of both components. The filled disks are Gaussian centers (He II and O II. The other RVs are from spectral disentangling of O II 4940 (rectangles) and He I 6678 (circles)

3. Spectro-interferometric parameters

The orbital parameters were derived from a simultaneous fit to the **interferometric** and spectroscopic data:

$P_{\rm orb.}$	2677.5 ± 6.9 d	inclination	$137.9 \pm 1.1°$
Primary periastron date	JD=2 452 747.9 ± 5.2	semi-major axis	36.1 ± 0.3 mas
Eccentricity	0.34 ± 0.01	q	0.66
Periastron long.	$208.4 \pm 1.1°$	γ	28.6 km/s
Ascending Node	$86 \pm 0.8°$		
$M_{\rm Aa}$	$24.8 \pm 5.6\,{\rm M}_\odot$	$M_{\rm Ab}$	$16.4 \pm 4.9\,{\rm M}_\odot$

This is the first directly measured (preliminary) mass for an O-type supergiant unaffected by mass transfer, as well being the first application of the interferometric/SB2 technique to an O-star binary. The 09.5 Ib star ζ Ori Aa was found to have a mass of:

$$\boldsymbol{M_{\zeta\,\rm Ori\ Aa} = 24.8 \pm 5.6\,{\rm M}_\odot}$$

We as well give a mass for its early B-type companion Ab, which is $16.4_\odot$. This value is in reasonable agreement with the estimate of the companion to be a little evolved very early B-type star. The mass of ζ Ori Aa is also in good agreement with the theoretically expected value for its spectral type, i.e. its track mass.

We stress that this is still a preliminary determination, based on only a few spectral lines and not yet using all available spectroscopic data. Taking advantage of the full wavelength range of the available echelle data, it will be possible to determine the radial velocity curve of both components with much higher confidence.

References

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