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Very massive binaries in R 136

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Abstract. As recent observations have shown, luminous, hydrogen-rich WN5-7h stars (and their somewhat less extreme cousins, O3f/WN6 stars) are the most massive main-sequence stars known. However, not nearly enough very massive stars have been reliably weighed to yield a clear picture of the upper initial-mass function (IMF). We therefore have carried out repeated high-quality spectroscopy of four new O3f/WN6 and WN5-7h binaries in R136 in the LMC with GMOS at Gemini-South, to derive Keplerian orbits for both components, respectively, and thus to directly determine their masses. We also monitored binary candidates and other, previously unsurveyed stars, to increase the number of very massive stars that can be directly weighed.

Keywords. stars: fundamental parameters (masses), stars: Wolf-Rayet, (stars:) binaries: eclipsing, (stars:) binaries: spectroscopic

1. Introduction

How massive can the most massive stars get? So far, there is no clear answer to this question since very little is known about the top end of the initial-mass function (IMF) when it comes to the highest masses, mainly because very few of these stars have been observed yet. The most massive star directly weighed so far is NGC3603-A1 with 116 ± 33 $M_\odot$ Schnurr *et al.* (2008a). However, there is a severe lack of confirmed, dynamical masses from model-independent, Keplerian orbits of double-eclipsing binaries when it comes to masses above 40 $M_\odot$. One of the best locations to find very massive binaries is the greater 30 Doradus region, the famous Tarantula nebula in the LMC. The most massive stars do not have O-type, absorption-line spectra but resemble nitrogen-rich Wolf-Rayet stars (subtype WN5-7ha), i.e. they have an emission-line spectrum. Schnurr *et al.* (2008b) identified five WN binaries around R136, the ionizing cluster of 30 Dor, but were unable to detect the secondaries. Later, Schnurr *et al.* (2009a) reported that one of them, R145, could indeed be a very massive (>120 $M_\odot$) star, but had difficulties detecting the secondary, so the masses remain ill-constrained. Clearly, though, R145 is a key system for the study of very massive stars. Schnurr *et al.* (2009b) surveyed the WN5h stars in the very core of R136, but did only find one binary candidate, R136c (BAT99-112). However, the single central WN5h stars are suspected to have initial masses up to 320 $M_\odot$ Crowther *et al.* (2010), thereby exceeding the canonical upper-mass limit of 150 $M_\odot$ by a factor of two! Skalkowski *et al.* (unpublished) also reported many binaries and binary candidates among the "normal" O-star population around R136. Follow-up

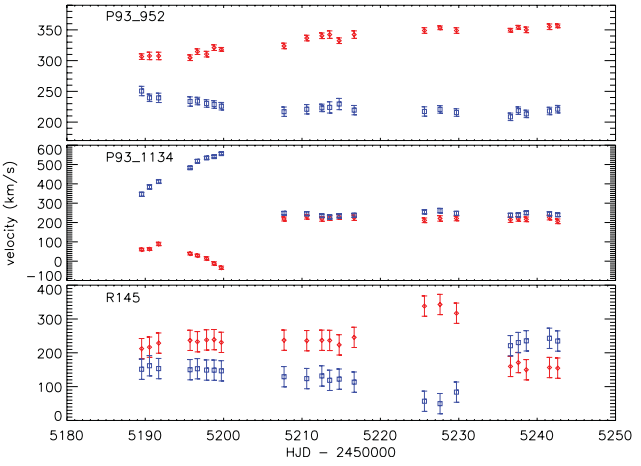

Figure 1. *Top*: RV curve of the primary (red diamonds) and the secondary (blue squares) of the binary system P93-952 (BAT99-107). *Middle*: Same for P93-1134 (BAT99-116). *Bottom*: Same for P93-1788 (R145).

observations are required to confirm binaries, to weigh them, and thus to "fill the gaps" of our knowledge of very massive stars.

2. Preliminary results

Among the O star of our sample, several binaries have been identified, viz. three SB1 (P93-930, P93-974 and P93-1140) and three SB2 systems (P93-805, P93-830 and P93-871). Also, two new binaries were found among the WN stars, i.e. P93-952 (BAT99-107) and P93-1134 (BAT99-116). P93-952 is a "weird" Of/WN star of uncertain spectral type. Moreover, atmosphere models do not yield satisfactory fits. It is moderately bright in X-rays. Schnurr *et al.* 2008b) reporte marginally variable radial velocities (RVs), but the RV curve (Fig. 1) shows that it is in fact a long-period binary consisting of two extreme O3f/WN6 stars! As for P93-1134 (BAT99-116), it is one of the X-ray brightest WN stars known (Portegies Zwart *et al.* 2002) and was suspected of having a compact companion (Schnurr *et al.* 2008b). Our new observations now show that it seems to be a highly eccentric binary containing two extreme emission-line O3f/WN6 stars (see Fig. 1)! Rapid photometry during one night does not find the tentative 1.5h periodicity that was reported in X-rays Guerrero & Chu (2008).

Also, new observations of R145 (BAT99-119) were obtained (Fig. 1). This star was previously found to be a 159-day binary with orbital inclination of $i = 40°$ (Schnurr *et al.* 2009a). Preliminary analysis of the new data suggest it's an equal-mass system consisting of two $\sim 120 M_{\odot}$ WN6ha stars, so potentially it's the most massive binary known so far!

References

Crowther, P. A., Schnurr, O., Hirschi, R., Yusof, N. *et al.* 2010, *MNRAS*, 408, 731
Guerrero, M. A. & Chu, Y.-H. 2008, *ApJS*, 177, 216
Schnurr, O., Casoli, J., Chené, A.-N., & Moffat, A. F. J. *et al.* 2008a, *MNRAS*, 389, L38
Schnurr, O., Moffat, A. F. J., St-Louis, N., & Morrell, N. I. *et al.* 2008b, *MNRAS*, 389, 806
Schnurr, O., Moffat, A. F. J., Villar-Sbaffi, A., & St-Louis, N. *et al.* 2009a, *MNRAS*, 395, 823
Schnurr, O., Chené, A.-N., Casoli, J., & Moffat, A. F. J. *et al.* 2009b, *MNRAS*, 397, 2049
Portegies Zwart, S. F., Pooley, D., & Lewin, W. H. G. 2002, *ApJ*, 574, 762

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