

Binarity of the LBV HR Car

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Abstract. VLTI/AMBER and VLTI/PIONIER observations of the LBV HR Car show an interferometric signature that could not possibly be explained by an extended wind, more or less symmetrically distributed around a single object. Instead, observations both in the Br γ line and the H-band continuum are best explained by two point sources (or alternatively one point source and one slightly extended source) at about 2 mas separation and a contrast ratio of about 1:5. These observations establish that HR Car is a binary, but further interpretation will only be possible with future observations to constrain the orbit. Under the assumption that the current separation is close to the maximum one, the orbital period can be estimated to be of the order of 5 years, similar as in the η Car system. This would make HR Car the second such LBV binary.

Keywords. stars: individual (HR Car)

1. Introduction

Luminous Blue Variables (LBVs) are a brief phase in the evolution of massive stars, but a very important one. The giant eruption remains enigmatic, but the discovery of the flagship LBV η Car to be a five-year highly eccentric binary put focus on possible binarity induced mechanism for the giant outbursts, and prompted binarity searches among LBVs.

So far, however, while several wide LBV binaries were identified, LBV systems similar to η Car (relatively close and eccentric) have not been found, with the possible exception of the LBV candidate MWC 314 (Lobel *et al.* 2013; see as well the preliminary summary by Martayan *et al.* 2012). This is rather surprising as it is thought that given their very high multiplicity rate, more than 70% of all massive stars will exchange mass with a companion (Sana *et al.* 2012).

2. Observations

2.1. AMBER/VLTI OHANA Data

The LBV HR Car was observed as part of the OHANA sample (spectrally resolved 3-beam interferometry of Br γ with AMBER at the Very Large Telescope Interferometer, VLTI; see Rivinius *et al.*, this volume). The OHANA data obtained for HR Car showed a clear and temporally stable (over the months of observation) phase signature across the blue part of the emission line, but little to no visibility signature. This marks a photocentre displacement of the emission line with respect to the continuum. Such a displacement is hard to explain with the more-or-less symmetric, but variable wind of a single supergiant star. Ad-hoc explanations are:

- **A binary**, and the emission is associated with the secondary, not the primary;
- **A binary**, where part of the emission is formed at the location of the secondary, part at the location of the primary, and part in a wind collision zone;

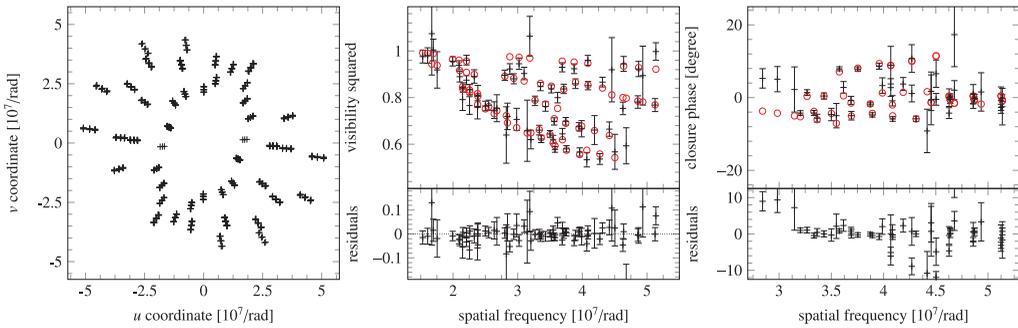


Figure 1. PIONIER observations of HR Car, showing uv -coverage, visibilities, and closure phases. Crosses mark the observed data, open circles the model, residuals are shown in the lower respective panels (computed with LITpro, see Tallon-Bosc *et al.* 2008).

- **A single star** with a dense nebular structure nearby that forms the hydrogen emission (possibly ejected in a previous eruption).

2.2. PIONIER Data

The available OHANA data would not allow further distinction of these hypotheses, so HR Car was observed with PIONIER. PIONIER is a 4-beam interferometric instrument working in the H -band continuum (Le Bouquin *et al.* 2011), and thus is not as sensitive to nebular contributions as OHANA observations.

Analysis of the obtained PIONIER data firmly establishes the presence of two different sources with a contrast ratio of about 1:5 and a separation of about 2 mas (Rivinius *et al.*, in prep.). Neither source is extended in itself, or only marginally so, i.e., the data strongly support the binary hypothesis (see Fig. 1).

Judging by the strength of the emission lines in various hydrogen lines and the appearance of the visual spectrum in general, a binary with a wind collision zone seems to be the most attractive. While this interpretation is work in progress, the pure proof of binarity was already delivered by the PIONIER observations.

2.3. Conclusions

At the estimated distance of HR Car (~ 5000 pc), observations indicate that the two components have a projected separation of ~ 10 AU. Assuming a total mass of the system of $\sim 40 M_{\odot}$, this separation would correspond roughly to an orbital period of about 5 years. A final value will depend on the eccentricity and inclination of the system. However, unless HR Car is a wide system seen at a very unfavourable (and unlikely) projection, it would be the second known η Car-like LBV binary. The proposed scenario of a wind-wind effect being responsible for the AMBER signature is similar to the model for the LBV candidate binary MWC 314 by Lobel *et al.* (2013).

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