RevMexAA (Serie de Conferencias), **38**, 30–32 (2010)

SPECTROSCOPIC SURVEY OF GALACTIC O AND WN STARS. OWN SURVEY: NEW BINARIES AND TRAPEZIUM-LIKE SYSTEMS

R. H. Barbá,[1,2] R. Gamen,[3] J. I. Arias,[1] N. Morrell,[4] J. Maíz Apellániz,[5] E. Alfaro,[5] N. Walborn,[6] and A. Sota[5,7]

RESUMEN

Las imágenes de gran resolución angular, las técnicas de *speckle* y la interferometría óptica/infrarroja permiten determinar las órbitas visuales de muchas estrellas masivas brillantes y cercanas. En ese sentido, la combinación de órbitas visuales con curvas de velocidad radial (VR) provee un método para derivar la órbita verdadera de un sistema binario, y así, la masa de cada componente estelar. La posibilidad de combinar órbitas visuales y espectroscópicas nos permite explorar un rango más amplio de sistemas con períodos largos (escalas de tiempo de meses a años). "OWN Survey" es un programa de monitoreo espectroscópico que incluye 240 estrellas O y WN del hemisferio austral. Hemos encontrado que más de cien de estas estrellas muestran variaciones de VR sobre los 10 km s^{-1}, lo que nos permitió descubrir 26 nuevas binarias. Uno de nuestros objetivos es derivar VRs con precisión mejor que 1 km s^{-1}. La naturaleza múltiple de la estrella de tipo O Herschel 36 se encuentra entre los descubrimientos más notables de este proyecto.

ABSTRACT

High-angular resolution imaging, speckle, optical or near-infrared interferometric techniques have been used to determine the visual orbits of many nearby bright massive stars. Moreover, the combination of visual orbits and radial-velocity (RV) curves provides a method to derive the *true* orbit of the system, and hence, masses for each stellar component. The possibility to combine visual/spectroscopic orbits leads to the exploration of wider systems with longer periods (months to years time-scale). We are conducting a spectroscopic monitoring survey of about 240 southern galactic O and WN stars (OWN Survey). More than one hundred stars show RV variations larger than 10 km s^{-1}, allowing us to discover 26 new spectroscopic binaries. One of our goals is to derive RVs with errors lower than 1 km s^{-1}. One of the more remarkable discoveries of the survey is the multiple nature of the O-type system Herschel 36.

Key Words: binaries: general — binaries: spectroscopic — stars: early-type — stars: Wolf-Rayet — techniques: high-angular resolution — techniques: radial velocities

1. INTRODUCTION

Massive stars of spectral type O and Wolf-Rayet (WR) are relatively "rare" objects compared with other stellar populations. In spite of their *small number*, massive stars are important in the dynamical and chemical evolution of galaxies, having an unquestionable effect upon their environment and playing a key role in the evolution of the Universe.

Recent years have seen a rapid progress in several fields in Astrophysics, rooted in the technological advances of satellites, telescopes and detectors. Although our knowledge about massive stars has been also favored for those improvements, our understanding of many of their physical parameters and evolution is still sketchy. Several parameters determine the evolution of massive stars. Among them, the mass is the most important, and observing binaries is the most direct way to obtain accurate stellar masses. Measuring masses through dynamical methods requires to know the period and physical properties of the orbit. Spectroscopic eclipsing binaries (or systems where the inclination of the orbit can be known in some way) are key objects, because they allow to determine individual masses directly. Eclipsing binaries favor the detection of close systems. Alternatively, high-angular resolution imaging, speckle, optical or near-infrared interferometric techniques are used to determine visual orbits of many nearby bright massive stars. Moreover, the combination of visual orbits and radial-velocity (RV) curves provides the possibility to derive the *true* orbit of the system, and hence, masses for each stellar component. The possibility to combine vi-

[1]Departamento de Física, Universidad de La Serena, Chile.
[2]ICATE-CONICET, San Juan, Argentina.
[3]Instituto de Astrofísica La Plata, La Plata, Argentina.
[4]Las Campanas Observatory, La Serena, Chile.
[5]Instituto de Astrofísica de Andalucía, Spain.
[6]Space Telescope Science Institute, Baltimore, MD, USA.
[7]Universidad Autónoma de Madrid, Spain.

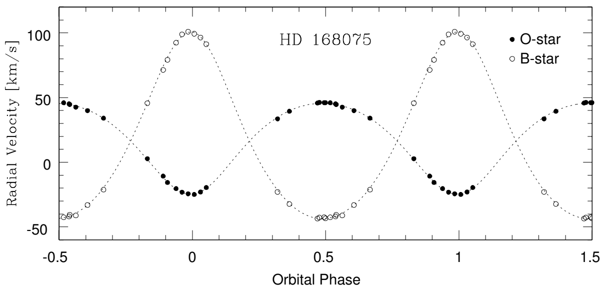

Fig. 1. RV-curve for the massive SB2 system HD 168075 (P = 43.27 d) derived using a spectral disentangling method. Note the excellent orbital fitting. Size of symbol is larger than error bars.

sual/spectroscopic orbits leads to the exploration of wider systems with longer periods (months to years time-scale). This fact is clearly demonstrated for example by the 25-year orbit of 15 Mon (Gies et al. 1993), and the recent results obtained for the 11-year orbit of θ^1 Ori C (Kraus et al. 2009). We must mention that visual orbits are often measured with high-precision, but RV orbits are determined with larger uncertainties, and thus, the errors in the derived masses are dominated by the spectroscopic data. This is specially important for massive stars due to the intrinsic problem of deriving accurate RVs. We also note that visual/spectroscopic orbits for long-period systems involve much observing time.

2. OWN SURVEY

We are conducting a spectroscopic monitoring of galactic O and WN stars selected from the Galactic O Star Catalogue (GOS, Maíz Apellániz et al. 2004) and the VII Catalogue of Galactic Wolf-Rayet Stars (van der Hucht 2001, 2006). This survey was officially started in 2006, and so far we have collected about 3000 spectra of 240 stars using high-resolution spectrographs at La Silla Observatory, Las Campanas Observatory, Cerro Tololo Inter-American Observatory (Chile), and the Complejo Astronómico El Leoncito (Argentina) (see Gamen et al. 2007). One of our goals is to obtain precise RVs of the observed sample in order to detect new binaries among those stars for which there is no indication of multiplicity in the above quoted catalogues.

During this workshop, Sana & Le Bouquin (2010) presented a nice sketch of a typical parameter space for orbits of massive stars and the access to them using different observational techniques. Their Figure 1 shows the complementary overlap between the RV spectroscopic technique and the VLTI facilities.

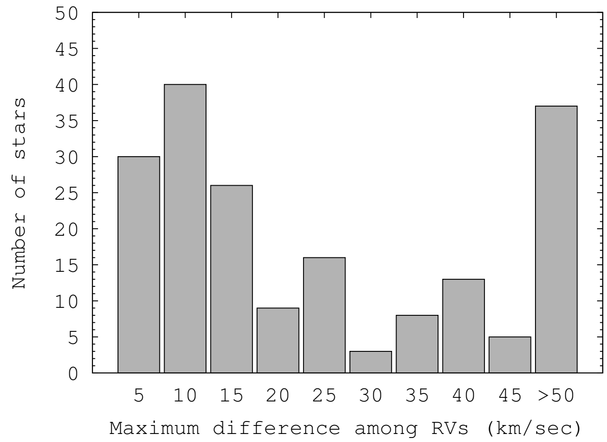

Fig. 2. Histogram of the maximum difference among RVs measured in the stars of our sample. Many stars present RV variations larger than 10 km s^{-1}, which is at least three times larger than the maximum expected error in RV measurements. Twenty-six of these RV variable stars are confirmed to be new spectroscopic binaries.

It seems necessary to achieve high-precision in the RV measurements of massive stars for spectroscopic techniques to be comparatively valuable when combined with astrometric speckle/interferometric observations. This issue is not so simple since stellar profiles in massive stars are often affected by significant rotation, emission, macroscopic motions, turbulence, etc. Our commitment is to achieve an absolute accuracy below 1 km s^{-1}, which would allow, in favorable cases, to discover spectroscopic binaries with periods as long as years, and systems with very low mass-ratio. The RV curve for the SB2 system HD 168075 (Figure 1, Barbá et al., in preparation) represents an example of such a high precision, achieved with the combined procedures of spectral disentangling (González & Levato 2006) and stellar atmosphere models. The rms error derived from the RV curve fit is of the order of 0.5 km s^{-1}, and the error in each individual RV measurement is about 1 km s^{-1}.

3. NEW BINARIES AND MULTIPLE SYSTEMS

This huge spectroscopic database (which is enlarged with spectra from CTIO, CASLEO, and ESO, obtained over the past several decades) leads to the discovery of new binaries with orbital periods spanning from one day to hundreds of days. Recent results were published for some massive binaries, as are the cases of WR25 (Gamen et al. 2006) and WR21a (Niemela et al. 2008). Additional information on some of the new binaries is presented in Gamen et al. (2007).

At the moment we have observed 186 O- and WN-type stars with no prior clear evidence of binarity, using four échelle spectrographs in, at least, three different observing runs. Figure 2 shows the histogram of maximun difference in RV for this sample. About 60% of the sample presents RV variations larger than 10 km s^{-1}. These changes could be related to binarity, specially for those stars with variations over 30 km s^{-1} (59 stars, 32%). Among these stars, we have discovered 26 new spectroscopic binaries. For other RV variable stars, we do not have enough data yet to derive period estimations.

Special attention deserves the zero-age main-sequence (ZAMS) star Herschel 36 (H36), the ionizing source of the Hourglass Nebula (HN) in M8 (Arias et al. 2006). In many senses, the HN resembles the Orion Nebula, with H36 playing a similar role to that of θ^1 Ori C. We have discovered that H36 consists of, at least, three spectroscopic components (Arias et al. 2010). Two of them form a close O+B pair with a period of $P = 1.5$ d. The third brighter O-type star shows a larger period of $P \sim 500$ d, as well as RV variations with one-day timescale. These kinds of massive trapezium-like young systems are potentially interesting sources for VLTI facilities.

RHB wish to thank the SOC for the invitation to participate in this illuminating workshop. Also, RHB acknowledges financial support from DIULS Project CD08102.

REFERENCES

Arias, J. I., Barbá, R. H., Morrell, N. I., Maíz Apellániz, J., & Rubio, M. 2006, MNRAS, 366, 739

Arias, J. I., Barbá, R. H., Gamen, R., Morrell, N. I., Maíz Apellániz, J., Alfaro, E., Walborn, N. R., & Sota, A. 2010, ApJ, 710, L30

Gamen, R. C., et al. 2006, A&A, 460, 777

Gamen, R., Barbá, R., Morrell, N., Arias, J., Maíz Apellániz, J., Sota, A., Walborn, N., Alfaro, E. 2007, Bol. Asoc. Arg. Astron., 50, 105

Gies, D. R., et al. 1993, AJ, 106, 2072

González, J. F., & Levato, H. 2006, A&A, 448, 283

Kraus, S., et al. 2009, A&A, 497, 195

Maíz-Apellániz, J., Walborn, N. R., Galué, H. A., & Wei, L. H. 2004, ApJS, 151, 103

Niemela, V. S., Gamen, R. C., Barbá, R. H., Fernández Lajús, E., Benaglia, P., Solivella, G. R., Reig, P., & Coe, M.J. 2008, MNRAS, 389, 1447

Sana, H., & Le Bouquin, J.-B. 2010, RevMexAA (SC), 38, 27

van der Hucht, K. 2001, NewA Rev., 45, 135

__________. 2006, A&A, 458, 453